# Datex-Ohmeda

# S/5™ M-Modules

# Technical Reference Manual

All specifications are subject to change without notice.

Document No. M1025359
June 2005

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551
Fax 1-608-222-9147

GE Healthcare Finland Oy
Helsinki, Finland
P.O. Box 900
FIN-00031 GE, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com www.gehealthcare.com

**Responsibility of the manufacturer**

GE Healthcare Finland Oy(GE) is responsible for the safety, reliability and performance of the equipment only if:

– modifications, service and repairs are carried out by personnel authorized by GE.

– the electrical installation complies with appropriate requirements.

– the equipment is used in accordance with the User's Guide and serviced and maintained in accordance with the Technical Reference Manual.

**Trademarks**

Datex, Ohmeda, S/5, D-lite, D-lite+, Pedi-lite, Pedi-lite+, Mini D-fend, D-fend, D-fend+, OxyTip+, MemCard, ComWheel, EarSat, FingerSat, FlexSat, Patient$O_2$, Entropy, Patient Spirometry and Tonometrics are trademarks of GE Healthcare Finland Oy. All other product and company names are property of their respective owners.

**Copyright**

# Master Table of Contents

## Technical Reference Manual, S/5™ M-Modules

## M1025359

### For S/5™ Anesthesia Monitor and Critical Care Monitor and S/5™ Compact Anesthesia Monitor and Compact Critical Care Monitor

# INTRODUCTION

This Technical Reference Manual provides information for the maintenance and service of the Datex-Ohmeda S/5™ M-Modules, record keeping keyboard, remote controllers and Device Interfacing System. These Datex-Ohmeda devices are designed for use with S/5™ Anesthesia Monitor, S/5™ Critical Care Montor, S/5™ Compact Anesthesia Monitor, and S/5™ Compact Critical Care Monitor.

Please see also the *Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

For more detailed information about compatibility with different monitor software types and levels se the "*Introduction*" chapter of the slot of the module or other device.

**S/5™ parameter modules, Device Interfacing Solution, Record keeping keyboard and Remote Controller**

# Notes to the reader

This Technical Reference Manual is intended for service personnel and engineers who will perform service and maintenance procedures on the Datex-Ohmeda S/5 Anesthesia Monitor,S/5 Critical Care Monitor, S/5 Compact Anesthesia Monitor or S/5 Compact Critical Care Monitor.

This Technical Reference Manual completes the Technical Reference Manual of the S/5 Anesthesia Monitor and S/5 Critical Care Monitor or S/5 Compact Anesthesia Monitor and S/5 Compact Critical Care Monitor.

- Document number M1025359 is the order number for the whole printed manual. This manual includes Technical Reference Manual Slots and every slot has own document number.
- The Technical Reference Manual, S/5 Modules gives detailed descriptions of paramter modules and other products that can be used with all S/5 modular monitors. Service check for each product is included in these slots.

For monitor or system specific information see:
The Technical Reference Manual of the S/5 Anesthesia Monitor and S/5 Critical Care Monitor or The Technical Reference Manual of S/5 Compact Anesthesia Monitor and S/5 Compact Critical Care Monitor.

The manufacturer reserves the right to change product specifications without prior notice. Although the information in this manual is believed to be accurate and reliable, the manufacturer assumes no responsibility for its use.

GE Healthcare Finland Oy (GE) assumes no responsibility for the use or reliability of its software in equipment that is not furnished by GE.

## Conventions used

Throughout this manual, the following conventions are used to distinguish procedures or elements of text:

Sign the check form after performing the procedure.

**Hard Keys** Hard key names on the Command Board, the Remote Controller, and modules are written in bold D-O Sans (12 pt) typeface, e.g. **ECG**.

***Menu Items*** Menu items are written in bold italic, D-O Sans (11 pt) typeface, e.g. ***ECG Setup.***

‘Messages’ Messages displayed on the screen are enclosed in single quotes, e.g. ‘Please wait’.

*Chapters* When referring to different chapters in the same manual, the chapter name is written in italic typeface and is enclosed in double quotes, e.g. chapter “*Cleaning and Care.*”

*Other documents*

When referring to different documents, the document name is written in italic typeface, e.g. refer to *User’s Reference Manual*.

Hypertext links Hypertext links on PDF versions are written in blue color.

**WARNING** Warnings are written in bold typeface (13 pt), for example:

**WARNING** **Use only hospital-grade electrical outlets and power cord.**

CAUTION Cautions are written in the following way (13 pt):

CAUTION The circuit boards contain sensitive integrated circuits that can be damaged by an electrostatic discharge. Careful handling of the boards is therefore essential.

# Datex-Ohmeda Hemodynamic modules
# S/5™ NE12STPR Module, M-NE12STPR (rev. 02)
# S/5™ NE12STR Module, M-NE12STR (rev. 02)
# S/5™ NE12TPR Module, M-NE12TPR (rev. 02)
# S/5™ NESTPR Module, M-NESTPR (rev. 01)
# S/5™ NESTR Module, M-NESTR (rev. 01)
# S/5™ NETPR Module, M-NETPR (rev. 01)
# S/5™ ESTPR Module, M-ESTPR (rev. 04)
# S/5™ ESTR Module, M-ESTR (rev. 04)
# S/5™ ETPR Module, M-ETPR (rev. 04)

## Technical Reference Manual Slot


All specifications are subject to change without notice.

Document No. 800 1008-6

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## HEMODYNAMIC MODULES

# TABLE OF FIGURES

This page intentionally left blank.

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the hemodynamic modules. The S/5 M-ESTPR/-ESTR/-ETPR and S/5 M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR are double width modules designed for use with S/5 monitors. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

Please refer to the *Technical Reference Manual* of the S/5 monitor for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The M-ESTPR/-ESTR/-ETPR and M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR modules provide general hemodynamic parameters


**Figure 1** **S/5 NE12STPR Module, M-NE12STPR**

NOTE: Do not use identical modules in the same monitor simultaneously. The following modules are considered identical:
M-ESTP/-EST/-ETP,
M-ESTPR/-ESTR/-ETPR,
M-NESTPR/-NESTR/-NETPR,
M-NE12STPR/-NE12STR/-NE12TPR

**Table 1** **Options of S/5 hemodynamic modules**

| | Parameter | NE12STPR | NESTPR | NE(12) STR | NE(12) TPR | ESTPR | ESTR | ETPR |
|---|---|---|---|---|---|---|---|---|
| **12** | 12-lead ECG | • | | (•) | (•) | | | |
| **N** | NIBP | • | • | • | • | | | |
| **E** | ECG | • | • | • | • | • | • | • |
| **S** | Pulse oximetry | • | • | • | | • | • | |
| **T** | Two temperatures | • | • | • | • | • | • | • |
| **P** | Two invasive blood pressures | • | • | | • | • | | • |
| **R** | Impedance respiration | • | • | • | • | • | • | • |

NOTE: 12-lead ECG measurement requires Display Controller, B-DISP.

NOTE: M-ESTP rev. 01, M-EST rev. 00 and M-ETP rev. 00 work only with S-STD93, S-STD94, S-ARK94, S-STD95, S-ARK95, S-STD96 and S-ARK96 software.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size | 75 × 180 × 112 mm |
| W × D × H | 3.0 × 7.1 × 4.4 in |
| Operation temperature | 10 to 40 °C / 50 to 104 °F |

**@ M-ESTPR/-ETPR/-ESTR**

| | |
|---|---|
| Module weight | 0.6 kg / 1.3 lbs |
| Power consumption | 6 W |

**@ M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR**

| | |
|---|---|
| Module weight | 1 kg |
| Power consumption | about 9 W |

## 1.2 Typical performance

### 1.2.1 NIBP

NOTE:Non-invasive blood pressure measurement is intended for patients weighing over 5 kg (11 lb.)

Oscillometric measurement principle.

| | | |
|---|---|---|
| Measurement range | adult | 25 to 260 mmHg |
| | child | 25 to 195 mmHg |
| | infant | 15 to 145 mmHg |
| Pulse rate range accepted | 30 to 250 bpm | |
| Measurement interval | 1, 2.5, 3, 5, 10, 15, 30, 60 min (=1h), 2h, 4h | |
| Typical measuring time | adult | 23 s |
| | infant | 20 s |
| Initial inflation pressure | adult | 185 ±10 mmHg |
| | child | 150 ±10 mmHg |
| | infant | 120 ±10 mmHg |
| Venous stasis | adult | 80 ±10 mmHg / 2 min. |
| | child | 60 ±10 mmHg / 2 min. |
| | infant | 40 ±10 mmHg / 1 min. |
| Cuff widths | please see *User's Guide* | |

## 1.2.2 ECG

| | |
|---|---|
| Lead selection, 12-lead ECG | I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6 |
| Lead selection, oher modules | I, II, III, aVR, aVL, aVF, V |
| Sweep speeds | 12.5, 25, 50 mm/sec |

**DISPLAY FILTER**

| | |
|---|---|
| Diagnostic, 12-lead ECG | 0.05 to 150 Hz |
| Diagnostic, other modules | 0.05 to 100 Hz |
| Monitoring | 0.5 to 30 Hz (-3 dB, with 50 Hz reject filter)<br>0.5 to 40 Hz (-3 dB, with 60 Hz reject filter) |
| ST filter | 0.05 to 30 Hz (-3 dB, with 50 Hz reject filter)<br>0.05 to 40 Hz (-3 dB, with 60 Hz reject filter) |

**HEART RATE FROM ECG**

| | |
|---|---|
| Range | 30 to 250 bpm |
| Accuracy | ±5 bpm or ±5 %, whichever is greater |
| Resolution | 1 bpm |
| Update interval | 5 s |
| Averaging time | 10 s |

**ST LEVELS (in main software)**

| | |
|---|---|
| ST level range | -9 to +9 mm (-0.9 to +0.9 mV) |
| Resolution | 0.1 mm (0.01 mV) |
| Averaging | calculated from 8 QRS |

**SYNCHRONIZATION**

| | |
|---|---|
| Direct ECG | analog output of ECG, 1 V/1 mV |
| Pacer | 5 V and 0.5 to 2.5 ms pulse, < 30 ms after pacer peak |
| Defibrillator | 5 V and 10 ms pulse, < 35 ms after R-point synchronization |

## 1.2.3 Pulse oximetry

| | |
|---|---|
| Measurement range | 40 to 100 % |
| Accuracy | 100 to 80 %, ±2 digits |
| (% $SpO_2$ ±1 SD)[1] | 80 to 50 %, ±3 digits<br>50 to 40 %, unspecified |
| Display resolution | 1 digit = 1 % of $SpO_2$ |
| Display averaging time | 20, 10 sec, beat-to-beat |
| Pulse beep pitch | varies with $SpO_2$ level |

The monitor is calibrated over the measurement range against functional saturation $SpO_2$ func.

**PULSE RATE FROM PLETH**

| | |
|---|---|
| Measurement range | 30 to 250 bpm |
| Accuracy | 30 to 100, ±5 bpm,<br>100 to 250, ±5 % |
| Resolution | 1 bpm |
| Display averaging | 10 s |

[1] 1 SD (standard deviation) = 68 % of all readings in the specified range in stable conditions.

Adjustable pulse beep volume.

**PLETH WAVEFORM**

| | |
|---|---|
| Scales | 2, 5, 10, 20, 50 mod%, Auto |

Start up scale is 20 mod% if AUTO is not selected to be the default setting.

### 1.2.4 Temperature

| | |
|---|---|
| Measurement range | 10 to 45 °C (50 to 113 °F) |

(In rev. ESTP 03/ EST 02/ETP 02 or earlier: 15 to 45 °C (59 to 113 °F))

| | |
|---|---|
| Measurement accuracy | ±0.1 °C (25 to 45.0 °C) |
| | ±0.2 °C (10 to 24.9 °C) |
| Display resolution | 0.1 °C (0.1 °F) |
| Temperature test | automatic (every 10 min) |
| Probe type | compatible with YSI 400 series |

### 1.2.5 Invasive blood pressure

| | |
|---|---|
| Measurement range | -40 to 320 mmHg |
| Measurement accuracy | ±2 mmHg or ±5 % |
| Zero adjustment range | ±150 mmHg |
| Calibration range | ±20 % |
| Scales | upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10 % of selected upper limit below zero. |
| Sweep speed | 12.5, 25, 50 mm/s |

**DIGITAL DISPLAY**

| | |
|---|---|
| Range | -40 to 320 mmHg |
| Resolution | ±1 mmHg |

**WAVEFORM DISPLAY**

| | |
|---|---|
| Range | -30 to 300 mmHg |

**PULSE RATE FROM ARTERIAL PRESSURE**

| | |
|---|---|
| Measurement range | 30 to 250 bpm |
| Resolution | 1 bpm |
| Accuracy | ±5 bpm or ±5 % whichever is greater |

### 1.2.6 Respiration

NOTE:The respiration measurement is intended for patients over three years old

| | |
|---|---|
| Measurement range | 4 to 120 bpm |
| Accuracy | ±5 bpm or ±5 % |
| Resolution | 1 bpm |
| Averaging time | 30 s |
| Update interval | 10 s |

**RESPIRATION WAVEFORM**

| | |
|---|---|
| Sweep Speeds | 6.25 mm/s and 0.625 mm/s |

# 1.3 Technical specifications

## 1.3.1 NIBP

| | |
|---|---|
| Deflation rate, PR dep. | 5 to 13 mmHg/s |
| Inflation time | 20 to 185 mmHg, 1 to 5 s |

Automatic software control, max. inflation pressure

| | |
|---|---|
| adult | 280 ±10 mmHg |
| child | 200 ±10 mmHg |
| infant | 150 ±10 mmHg |

Over pressure limit, stops measurement after 2 seconds

| | |
|---|---|
| adult | 320 mmHg |
| child | 220 mmHg |
| infant | 165 mmHg |

The safety valve limits the maximum cuff pressure to 320 mmHg in adult/child mode or 165 mmHg in infant mode. Independent timing circuit limits pressurizing (>15 mmHg) time to 2 minutes 10 seconds maximum in adult/child mode, and 1 minute 5 seconds in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, inflation pressure is increased typically 50 mmHg.

| | | |
|---|---|---|
| Max. measurement time | adult | 2 min |
| | child | 2 min |
| | infant | 1 min |

Pressure transducer accuracy is better than ±3 mmHg or ±2 % whichever is greater.
Max. error ±4 mmHg.

| | |
|---|---|
| Protection against electrical shock | Type BF defibrillation proof |

## 1.3.2 ECG

| | |
|---|---|
| Defibrillation protection | 5000 V, 360 J |
| Recovery time | 2 s |
| Input impedance | >2.5 MΩ (10 Hz) |
| CMRR | >100 dB (ST) |
| System noise | <40 µV (p-p, RTI) |
| Allowable offset | ±300 mVDC |
| Gain range | 0.2 to 5.0 cm/mV |
| Pacemaker pulse detection | 2 to 500 mV, 0.5 to 2 ms pulses |
| Protection against electrical shock | Type CF defibrillator proof |

### 1.3.3 Pulse oximetry

| | |
|---|---|
| Protection against electrical shock | Type BF defibrillation proof |

### 1.3.4 Temperature

| | |
|---|---|
| Measurement accuracy | ±0.1 °C (25.0 to 45.0 °C)<br>±0.2 °C (10.0 to 24.9 °C) |
| Protection against electrical shock | Type CF defibrillation proof |

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please refer to the transducer/probe specification.

### 1.3.5 Invasive blood pressure

**DIGITAL DISPLAY AVERAGING**

Digital displays Art and P1 are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

| | |
|---|---|
| Accuracy | ±5 % or ±2 mmHg, whichever is greater |
| Transducer and input sensitivity | 5 µV/V/mmHg |
| Input voltage | 5VDC<br>max current 20 mA |
| Filter | 0 to 4 - 22 Hz adjustable |
| Zero set accuracy | ±1 mmHg |
| Calibration resolution | ±1 mmHg |
| Zero time | less than 15 s |
| Protection against electrical shock | Type CF defibrillation proof |

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please refer to the transducer/probe specification.

### 1.3.6 Respiration

| | |
|---|---|
| Excitation frequency, 12-lead ECG | 62.5 kHz |
| Excitation frequency, other modules | 31.25 kHz |
| Breath detection | automatic, range 0.3 to 6 Ω manually adjustable minimum detection: 0.2, 0.4, 0.6, 0.8, 1.0 |
| Input dynamic range | 0.2 to 6 Ω |
| Input impedance range | 100 to 5000 Ω |
| Respiration Rate | min. 4 bpm<br>max. 120 bpm |
| Lead off detection | >3 MΩ |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 NIBP

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for the NIBP measurement:

- M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR (or M-NIBP) module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

### 2.1.2 ECG

Electrocardiography analyzes the electrical activity of the heart by measuring the electrical potential produced with electrodes placed on the surface of the body.

ECG reflects:

- electrical activity of the heart
- normal/abnormal function of the heart
- effects of anesthesia on heart function
- effects of surgery on heart function

See the *User's Guide* or the*User's Reference Manual* for electrodes positions and other information.

### 2.1.3 Pulse oximetry

A pulse oximeter measures the light absorption of blood at two wavelengths, one in the near infrared (about 900 nm) and the other in the red region (about 660 nm) of the light spectrum. These wavelengths are emitted by LEDs in the $SpO_2$ probe, the light is transmitted through peripheral tissue and is finally detected by a PIN-diode opposite the LEDs in the probe. The pulse oximeter derives the oxygen saturation ($SpO_2$) using an empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation $SaO_2$.

In order to measure the arterial saturation accurately, pulse oximeters use the component of light absorption giving variations synchronous with heart beat as primary information on the arterial saturation.

A general limitation of pulse oximetry is that due to the use of only two wavelengths only two hemoglobin species can be discriminated by the measurement.

The modern pulse oximeters are empirically calibrated either against fractional saturation $SaO_2$frac;

$$SaO_2frac = \frac{HbO_2}{HbO_2 + Hb + Dyshemoglobin}$$ **Formula 1**

or against functional saturation $SaO_2$func;

$$SaO_2func = \frac{HbO_2}{HbO_2 + Hb}$$ **Formula 2**

Functional saturation is more insensitive to changes of carboxyhemoglobin and methemoglobin concentrations in blood.

The oxygen saturation percentage $SpO_2$ measured by the Datex-Ohmeda module is calibrated against functional saturation $SaO_2$func. The advantage of this method is that the accuracy of $SpO_2$ measurement relative to $SaO_2$func can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method, pulse oximeters are not able to correctly measure oxygen content of the arterial blood at elevated carboxyhemoglobin or methemoglobin levels.

## Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

## Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

## Probe

The standard probe is a finger clamp probe which contains the light source LEDs in one half and the photodiode detector in the other half. Different kinds of probes are available from Datex-Ohmeda.

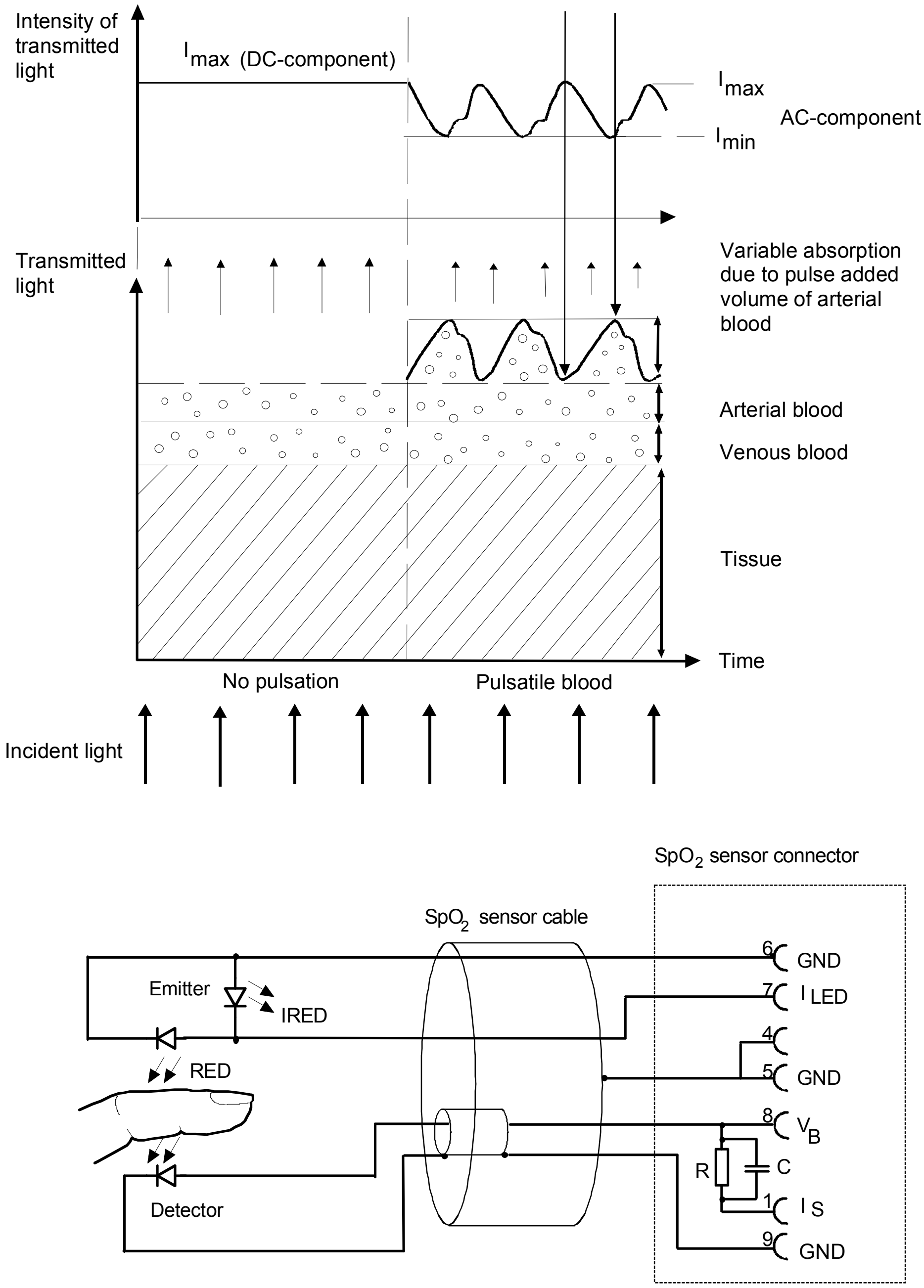



**Figure 2** **Absorption of infrared light in the finger probe parts layout and schematic diagram**

## 2.1.4 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called NTC (Negative Temperature Coefficient) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it
- Applying a constant current through the resistor and measuring the voltage that is

generated across it.

In Datex-Ohmeda modules the two methods are combined in the form of a voltage divider. The NTC-resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

### 2.1.5 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

### 2.1.6 Respiration

Impedance respiration is measured across the thorax between ECG electrodes. The respiration signal is made by supplying current between the electrodes and by measuring the differential current from the electrodes. The signal measured is the impedance change caused by breathing. From these impedance changes, respiration rate is calculated, and the respiration waveform is displayed on the screen.

## 2.2 Main components

### 2.2.1 M-ESTPR/-ETPR/-ESTR modules

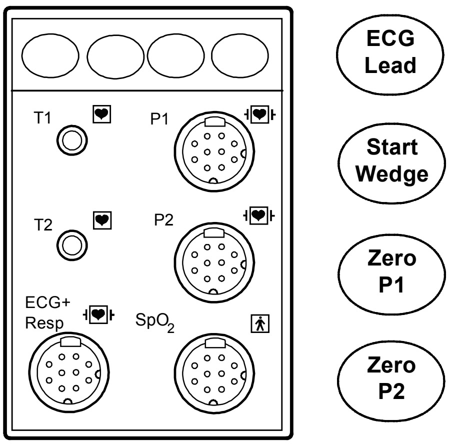



**Figure 3** **Front panel of M-ESTPR**

The **M-ESTPR, M-ETPR, and M-ESTR modules** contain two main PC boards, the STP board and the ECG board. They work independently. Both of them have their own processor and software EPROM. Some components on the boards are not used in ETPR and ESTR modules.

In the **M-ESTPR module**, additionally, there are two small boards, the SP input and the ECG input boards, attached to the front panel of the module. The front panel has six connectors and four keys.

The connectors are two for temperature measurement, two for invasive blood pressure measurement, one for ECG, and one for $SpO_2$ measurement. The keys are for ECG lead, Start Wedge, P1 zero, and P2 zero.

In the **M-ETPR module**, there are two small boards, the ECG input board and the 2P input board attached to the front panel of the module. The front panel has five connectors and four keys. The connectors are two for temperature measurement, two for invasive blood pressure measurement, and one for ECG measurement. The keys are for ECG lead, Start Wedge, P1 zero, and P2 zero.

In the **M-ESTR module**, there are two small boards: the S input board and the ECG input board, attached to the front panel of the module. The front panel has four connectors and one key. The connectors are two for temperature measurement, one for ECG, and one for $SpO_2$ measurement. The key is for ECG lead select.

NOTE: M-ESTP rev. 03, M-ETP rev. 02 and M-EST rev. 02 and all earlier revisions have separate T and SP input boards.

### 2.2.2 M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR modules

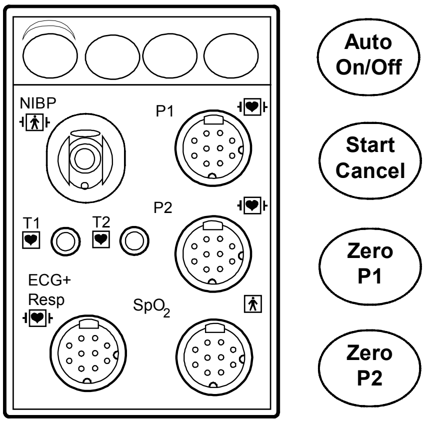



**Figure 4 Front panel of M-NESTPR**

The **M-NESTPR, M-NETPR, and M-NESTR modules** contain three main PC boards, the STP board, the ECG board, and the NIBP board. They work independently. Each of these has their own processor and software EPROM.

The **M-NE12STPR, M-NE12TPR, and M-NE12STR** contain three main PC boards, The STP board, the ECG board and the NIBP board. They work independently. Each of them has their own processor. The STP board and NIBP board have software EPROM. In the ECG board the software is in flash memory. The STP and NIBP boards are the same as in M-NESTPR module but the ECG board and ECG input board are different.

In the **M-NESTPR module**, there are two small boards, the SP input and the ECG input board attached to the front panel of the module. The front panel has seven connectors and four keys. The connectors are two for temperature measurement, two for invasive blood pressure measurement, one for ECG, one for NIBP, and one for $SpO_2$ measurement. The keys are for NIBP Auto On/Off, NIBP Start/Cancel, P1 zero, and P2 zero. The structure of **M-NE12STPR** is similar except the ECG board and ECG input board are different.

In the **M-NETPR module**, there are two small boards, the 2P input board and the ECG input board, attached to the front panel of the module. The front panel has six connectors and four keys. The connectors are two for temperature measurement, two for invasive blood pressure measurement, one for ECG, and one for NIBP. The keys are for Auto On/Off, Start/Cancel, P1 zero, and P2 zero. The structure of **M-NE12TPR** is similar except the ECG board and ECG input board are different.

In the **M-NESTR module**, there are two small boards, the ECG input board and the S input board, attached to the front panel of the module. The front panel has five connectors and two keys. The connectors are two for temperature measurement, and one for $SpO_2$ measurement, one for ECG, and one for NIBP. The keys are for Auto On/Off, Start/Cancel. The structure of **M-NE12STR** is similar except the ECG board and ECG input board are different.

## 2.2.3 NIBP board

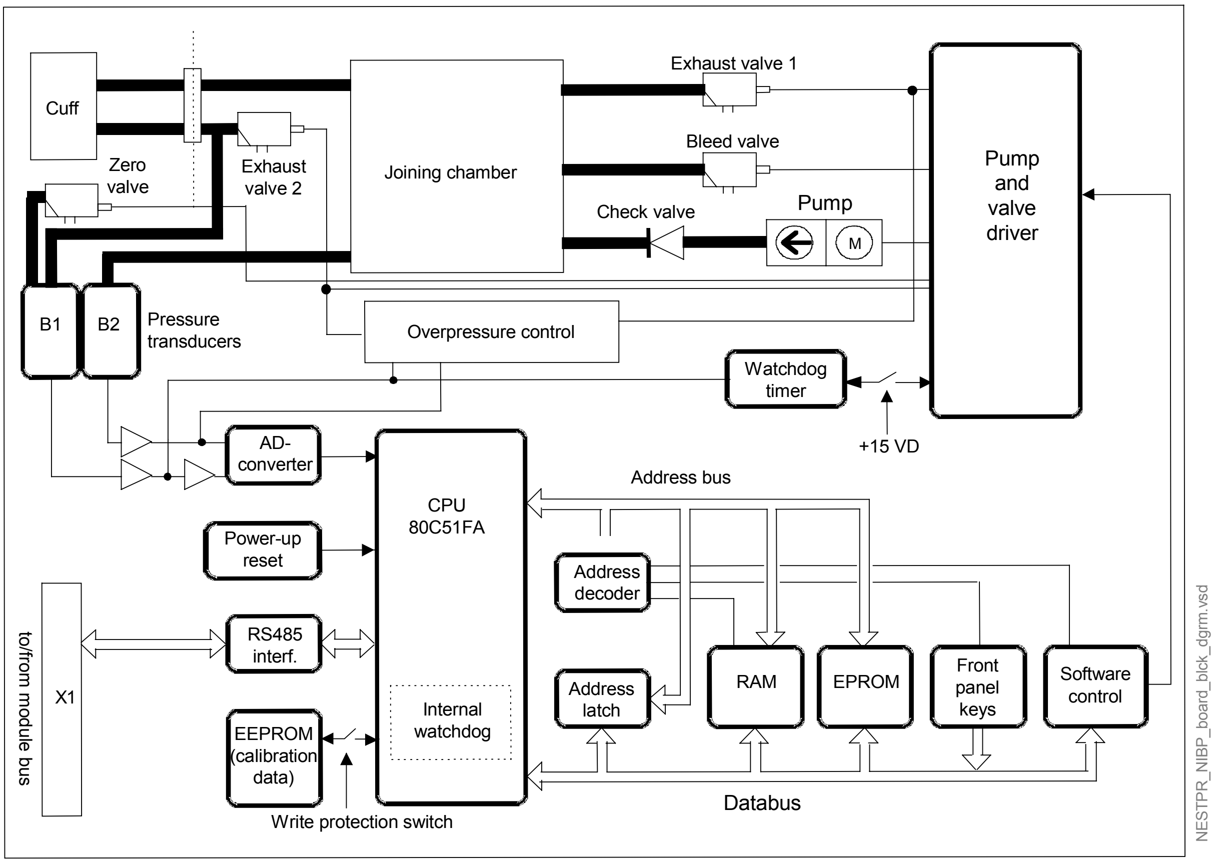



**Figure 5** **NIBP board functional block diagram**

### Pressure transducers

The NIBP board contains two pressure transducers. They are of piezoresistive type. One is used for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement (B1). The other is used for detection of cuff hose type, cuff loose and cuff occlusion situations etc. (B2). The transducers are internally temperature compensated. They are supplied by a constant voltage and their output voltage changes up to 40 mV max. (50 kPa, 375 mmHg).

## Signal processing

Two signals from the pressure transducers are amplified and sent to the A/D converter. After the converter, digitized signals are sent to the microprocessor for data processing. Before the converter, one of the signals is used to adjust the offset to the pressure safety level.

The NIBP board is controlled with a 80C51FA microprocessor at 16 MHz oscillator frequency.

## Memory

NIBP program memory (EPROM) size is 128k × 8. RAM size is 32k × 8 bit and it stores variable values of the NIBP measurement. EEPROM is size 64 × 16 bit and is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and module serial number.

## Software control

Software controls valves and pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used at pump/valve failures.

In addition to external RS485 reset line the microprocessor system is equipped with its own power-up reset. See the section in the ECG board's description: *"RS485 communication"*

## Watchdog timer

The NIBP board is equipped with a software independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than the preset time. As soon as the cuff pressure rises over a specified pressure limit, timer starts counting. The timer is adjusted to stop the pump and open the valves after 2 minutes 10 seconds in adult/child mode and after 1 minute 5 seconds in infant mode.

## Valves

Exhaust valves are used for emptying the cuff and the joining chamber after the measurement. Exhaust valve 1 is also used as safety valve in infant mode. The valve opens at 165 mmHg. Exhaust valve 2 is also used as safety valve in adult mode and opens at 320 mmHg.
The bleed valve is used for emptying the cuff during measurement. The zero valve is used for connecting the pressure transducer B1 to open air.

## Power supply section

All connections are established via 25-pin connector (D-type, female). The module needs +5 V, ±15 V, and +15 VD (dirty) power supply to operate. The pump and the valves use separate +15 VD power line. The supply voltages are generated in the power supply section of the S/5 monitor. The reference voltages ±5 $V_{ref}$ and +10 $V_{ref}$ are generated on the NIBP board.

## 2.2.4 ECG board in 3-and 5-lead measurement

Patient signals are connected to overload protection circuits (resistors and gas-filled surge arresters) and analog switches to instrumentation amplifiers. Then the signals are amplified by 480 and limited by slew rate. Then they are A/D-converted, analyzed and transferred to module bus in digital form.

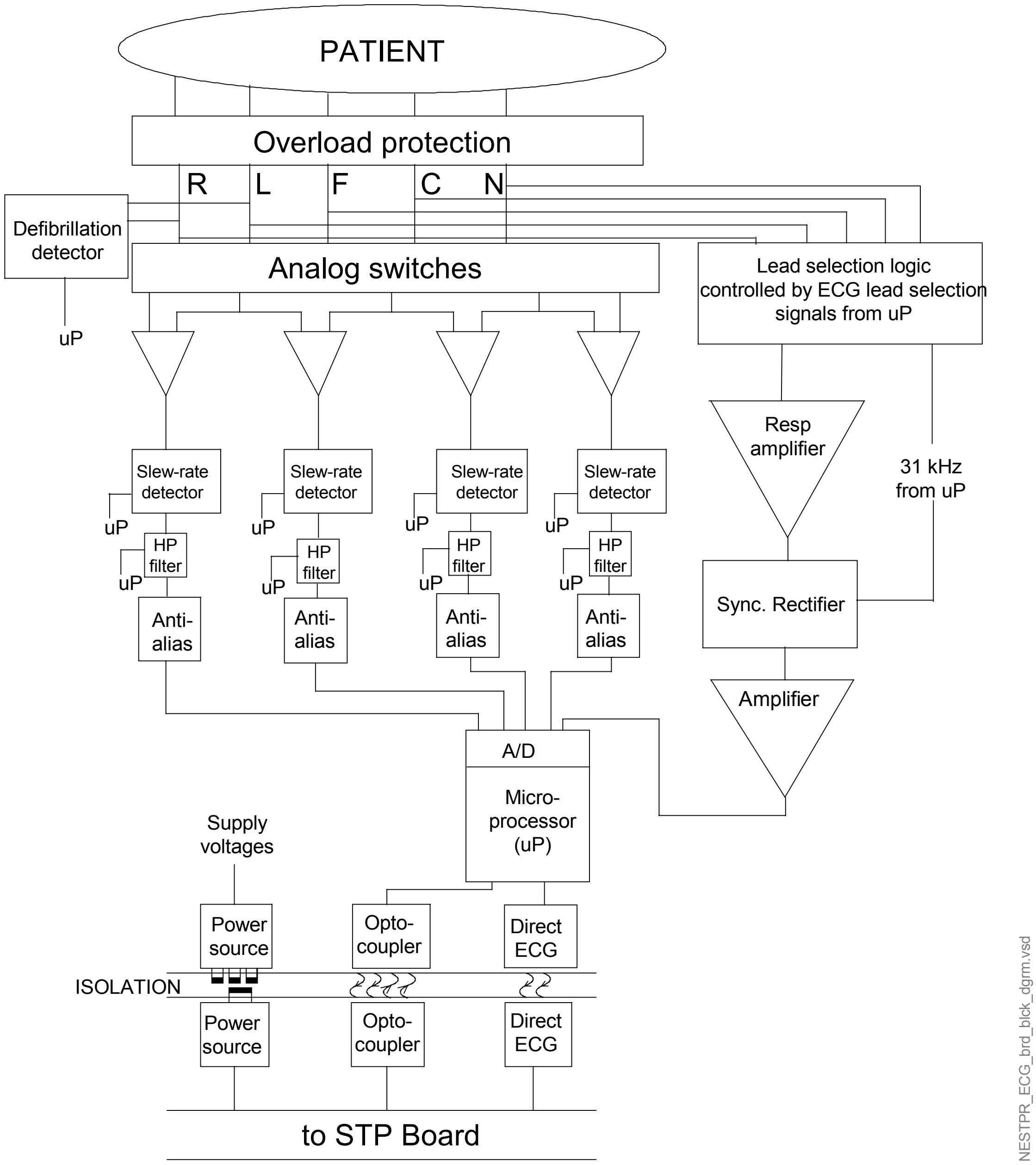



**Figure 6** **3- and 5- lead ECG board block diagram**

## Analog ECG section

The ECG cable is connected to connector pins E1 to E6 on the input board which contains an overload protection circuit. Leads are connected to amplifiers via analog switches. States of the switches depend on the cable type. Lead-off, noise and pacemaker are detected by a slew rate detector. Lower frequency is determined by high pass (HP) filter 0.5 Hz (monitor bandwidth) or 0.05 Hz (diagnostic or ST- bandwidth).

## Respiration section

**3-lead cable**

The analog switches control the current supply source of the impedance respiration measurement, and the lead selection for the 3-lead cable can be seen from the following table:

**Table 2 Lead selection and coding for the 3-lead cable**

| Selected lead | Current source between | Signal measured from |
|---|---|---|
| I | R - L | N |
| II | R - N | L |
| III | L - N | R |

| Position on body surface | IEC standard coding | AAMI standard coding |
|---|---|---|
| right arm | R = red | RA = white |
| left arm | L = yellow | LA = black |
| left leg | F = green | LL = red |

**5-lead cable**

When the 5-lead cable is used, the current source is between L-F and the signal is measured from the N, independently on the lead selection.

The respiration amplifier consist of the operational amplifiers, and the components around them. There is an analog switch for controlling the gain of the first stage of the preamplifier. Synchronous rectifier consists of the analog switches, which are used for detecting the respiration signal from 31 kHz amplitude modulated raw signal. The amplifier stage consists of the differential amplifier and the last amplifier. The differential amplifier consists of the operational amplifiers and the components around them. This stage is AC-coupled on both sides for minimising the offset voltages. The last amplifier is used for amplifying the signal derived from differential amplifier stage. The respiration signal is zeroed at the beginning of the measurement. Zeroing is also used for fast recovering the measurement after the motion artefact. This is done in amplifier section.

NOTE: The respiration measurement is switched OFF for 20 seconds when defibrillation is detected at the defibrillation detector.

## Microprocessor section

Microprocessor contains RAM and EPROM memories. The processor uses external EEPROM memory. The microprocessor's internal 8-channel A/D-converter converts the ECG-signals to digital form. See the section in ECG board's description: *"RS485 communication*

## Serial communication

Communication with the module bus is made through RXD and TXD pins. See the section in STP board's description: *"Serial communication".*

### Isolated section

The patient isolation of ECG is 5 kV.

NOTE: The isolation has been changed from the earlier revisions.

**WARNING** **Do not touch battery-operated monitor during defibrillation procedure.**

See the *"Isolated section"* in STP board description.

### Power supply section

See the *"Power supply section"* in STP board description.
There is a test connector (X20) on the board for voltages +5 VREF, +5 V, +12 V, GND and -12 V.

## 2.2.5 ECG board in 12-lead measurement

The 12-lead ECG measurement consists of the functions, which are shown in the figure 7. All functions are located in the ECG board except the front panel connector and the ECG input board.

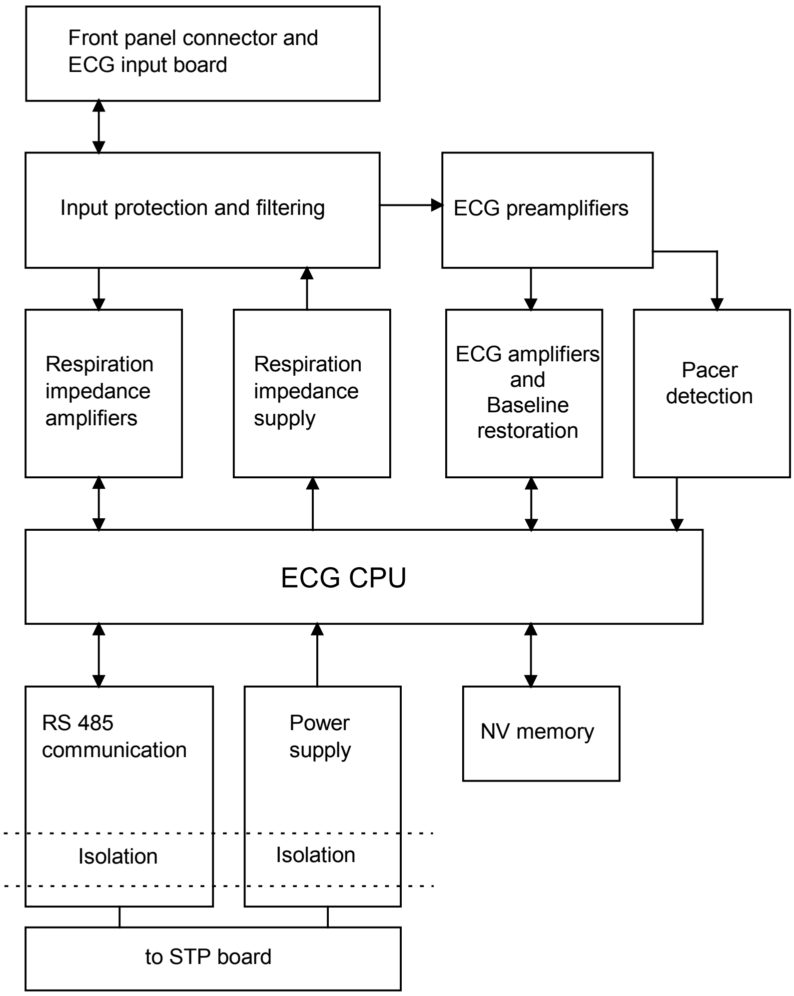



**Figure 7** **12-lead ECG measurement block diagram**

## Front panel connector and ECG input board

The connector for the 12-lead ECG cable is a green 12 pin Nicolay type connector. 3- or 5-lead cables with blue connectors cannot be connected to this connector. The ECG input board contains high voltage resistors and a connector for ECG board.

## Input protection and filtering

The input protection is implemented with protection diodes, which are connected to analog power supply voltage and ground. The input filtering for ECG measurement is done with discrete components. The measured signal is AC-coupled for respiration measurement. The signal from the respiration supply is AC coupled. There are also the overload protection diodes for respiration measurement supply.

## ECG preamplifiers

The buffer amplifiers are used for each lead except N/RL. The leads off detection is implemented by measuring the level of the input buffer amplifiers with A/D converter of CPU. The ECG signals are measured using differential amplifiers.

## ECG amplifiers and baseline restoration

The function of the ECG amplifiers and baseline restoration is to amplify the signal and to restore the baseline of the signal in the middle of the display after the change of the signal level e.g. after the change of the DC offset voltage.

## Pacer detection

Pacer detection has been made by using two slew rate detector circuits. The pacer detection amplifiers have been realized at the front of the slew rate detectors independently from the ECG measuring channels.

## Respiration impedance supply

The 62.5 kHz sine wave generator is used as the respiration measurement signal supply. Analog switches are used for connecting the sine wave to the ECG leads to be measured.

## Respiration impedance amplifiers

Buffer amplifiers are used in respiration measurement. Analog switches are used for selecting the measurement leads. There are also additional amplifiers for increasing the respiration signal gain. Respiration is always measured between R and F, independently on the ECG lead selection.

## ECG CPU

The CPU is a 16 bit H8/3048 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

### RS485 communication

The communication to the CPU board of the monitor uses RS485 protocol. The RS485 driver circuits are optically isolated from the processor of the module. PWM signal is used for direct ECG signal. Direct ECG signal is available from the X2 connector of the UPI board or from the PT module.

### Power supply

The ECG board has a driver controlled half bridge switching power supply with 5 kV isolation. The supply voltages have been regulated with linear regulators.

## 2.2.6 ECG filtering

The S/5 monitors have three ECG filtering modes:

| | |
|---|---|
| MONITORING | 0.5 to 30 Hz (with 50 Hz reject filter)<br>0.5 to 40 Hz (with 60 Hz reject filter) |
| DIAGNOSTIC 12-lead ECG | 0.05 to 150 Hz |
| DIAGNOSTIC other modules | 0.05 to 100 Hz |
| ST FILTER | 0.05 to 30 Hz (with 50 Hz reject filter)<br>0.05 to 40 Hz (with 60 Hz reject filter) |

The purpose of filtering is to reduce high frequency noise and low frequency (e.g. respiratory) movement artifacts.

Monitor filter is used in normal monitoring. Diagnostic filter is used if more accurate diagnostic information is needed. ST filter gives more accurate information of ST segment, but reduces high frequency noise.

The high-pass filters 0.5 Hz and 0.05 Hz are done with hardware. The monitor sends a command to the hemodynamic module determining which of the corner frequencies 0.5 Hz or 0.05 Hz is to be used.

The 50 Hz and 60 Hz reject filters are both low-pass filters with zero at 50 Hz or 60 Hz correspondingly and they are done with software. They are for the mains supply filtering. When these filters are used, 3 dB value for low-pass filter is 30 Hz or 40 Hz.

In diagnostic mode the upper frequency is limited by hardware and the -3 dB frequency is 100 Hz for 3 or 5 lead ECG measurement. For 12 lead ECG the upper frequency is 150 Hz and it is limited by software.

## 2.2.7 STP board

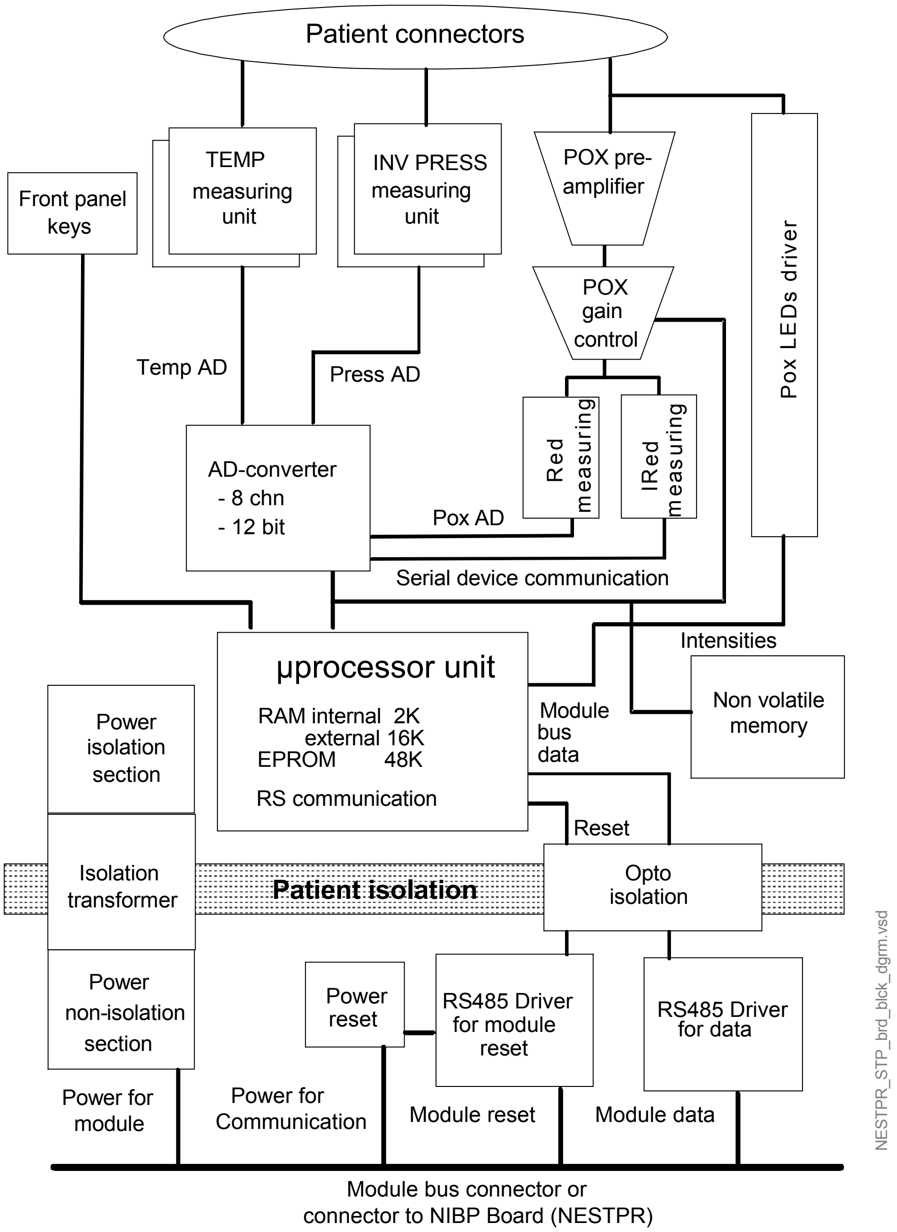



**Figure 8 STP board block diagram**

### Microprocessor unit

An Intel 80C196KC-16 processor is used. There are external memories, an 8-bit data bus, a 16 MHz oscillator, an open collector reset, and a watchdog timer. Three A/D-converters within the processor are used. The processor's internal UART communicates with the CPU board.

High speed I/O is used to obtain pulse control sequence necessary for pulse oximetry measurement. It gets its timing clock from the oscillator.

## Temperature measurement unit

The value of the NTC-resistor in the probe depends on the patient's temperature. It is measured with the following principle described below.

The temperature signal(s) is produced by voltage dividers, part of which is the patient probe (YSI 400-series thermistor). The output is amplified by the calibrated amplifier(s) whose offset voltage makes its output spread on both sides of zero. A wider output range (measurement range) means better resolution.

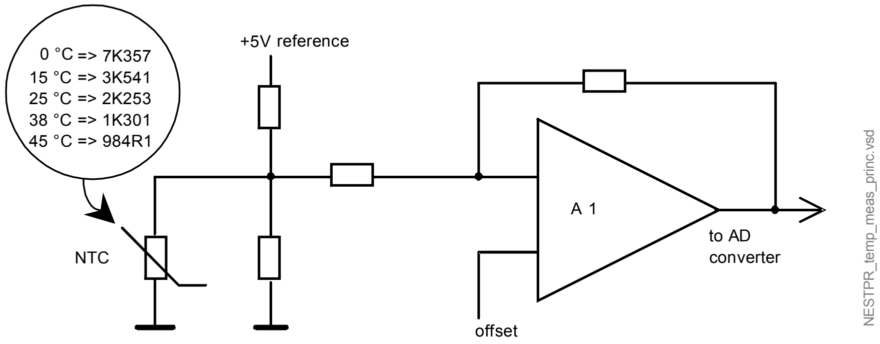



**Figure 9 Temperature measurement principle**

## Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. From the bridge connection a differential voltage, which depends on pressure and supplied voltage, is calculated (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\text{ V}$, where $U_{in}$ is 5 V

$\Rightarrow U_{out} = 25\text{ V} \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set so that the level of the signal transferred to A/D converter stays within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

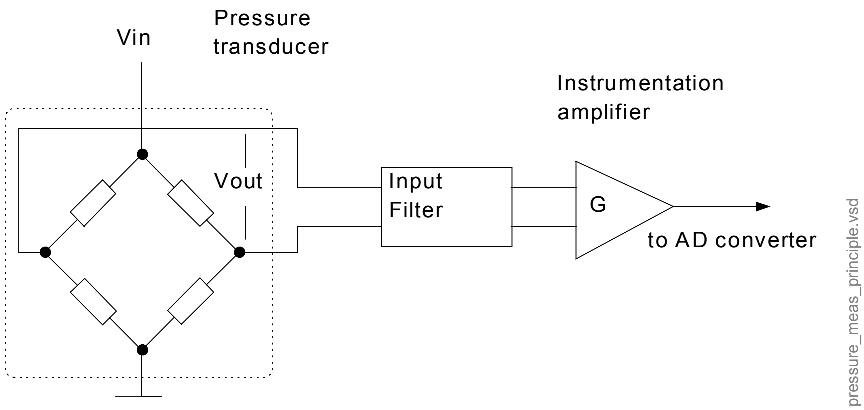



**Figure 10 Pressure measurement principle**

## Pulse oximetry measurement section

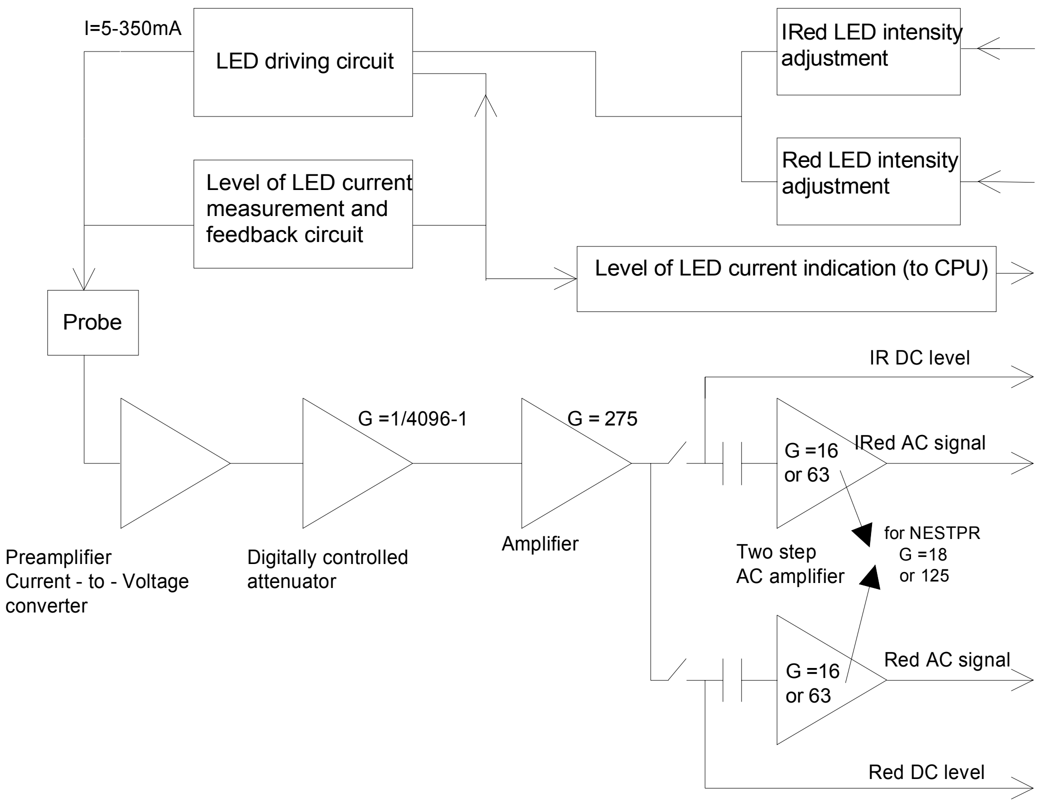



**Figure 11 Pulse oximetry measurement block diagram**

### LED control signals

The processor sends pulse width modulated signals, IRED intensity and RED intensity, which are converted to DC voltages and filtered. Using switches either RED or IRED intensity is sent to the amplifier in LED driving circuit.

### LED driving circuit

The voltage difference which corresponds to LED current, is measured by the differential amplifier circuit and its output is sent back to the processor in 0 to 5 V level. There are feedback circuits from LED current measurement and LED intensity control.

Background light is measured by picking up a sample from the signal. The sample is modified to 0 to 5 V level and sent to the processor.

### Measured signal preamplification

The preamplifier is current-to-voltage converter with gain selection. A higher gain is used for measuring thin tissue.

### Digitally controlled amplifier

The D/A converter is a digitally controlled amplifier after which there is another constant amplifier.

### Red and infrared channel separation

Red and infrared channels are separated from each other by switches. An operational amplifier functions as a buffer and after this the infrared DC signal is sent to the processor. A capacitor separates theC signal from the DC and the AC signal is sent to the processor after amplification. There is a switch to choose the amplification constant.

### Serial communication

Serial communication between the module and the frame is done by an RS485 type bus whose buffers get their supply voltage (+5 VDC) from the frame and in the isolation section get the supply voltage (+5 V) from the isolated power supply.

The serial communication buffers are controlled by a Reset signal so that when the Reset is active, the buffer does not transfer data.

Reset is also RS485 type and additionally, there is an auxiliary logic power reset, which keeps the reset active for about 500 ms despite the state of reset in the module bus. Time constant determines the power-up reset time. There are components to prevent the module from sending data during reset. Data transmission rate is 500 kbps.

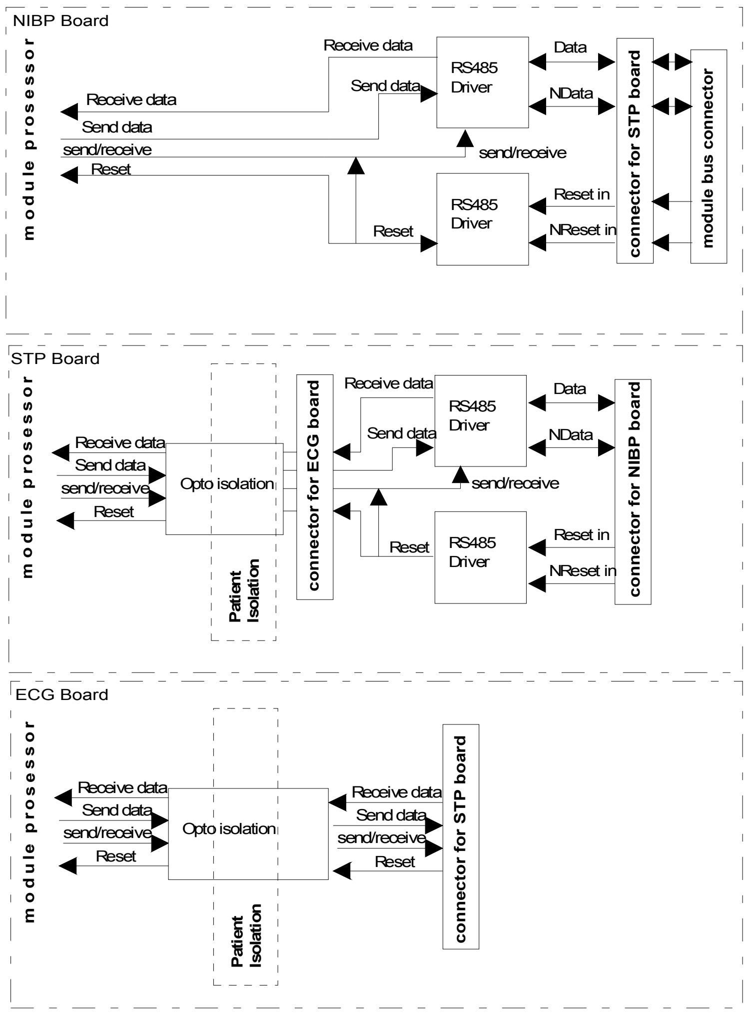



**Figure 12 Serial communication and opto isolation of M-NESTPR/-NE12STPR**

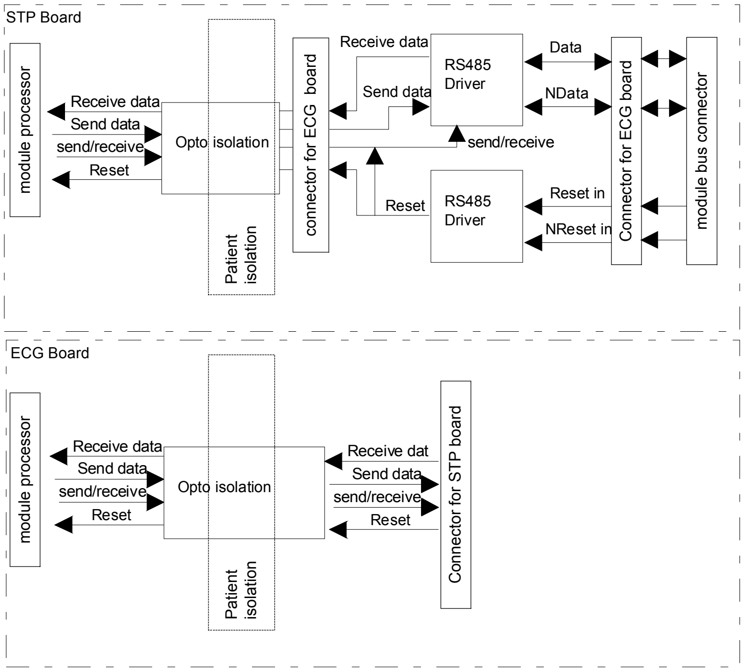



**Figure 13 Serial communication and opto isolation of M-ESTPR**

## Isolated section

There are two opto isolators. The signal is processed on a logical high-low level even though the outputs of the opto isolators are analog signals in the isolated section.

The reset line is an open collector type with a pull-up resistor. Thus the processor is able to use its internal watch-dog function.

## Power supply section

The isolated supply voltage of the module is developed from +15 Vdirty voltage from the Central Unit. The power supply is a switched-mode circuit, where the FET transistor switch is controlled by an oscillator using bipolar timer. The frequency of the oscillator is about 30 kHz and pulse ratio 50 %. Controlling the FET switch is slowed to suppress spurious interference.

A special pulse transformer is used in the circuit. In the secondary circuit normal linear regulators are used except for +5 V (low drop type linear regulator).

# 2.3 Connectors and signals

## 2.3.1 Module bus connector

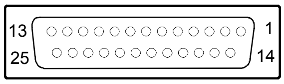



**Figure 14 Module bus connector (X1) pin layout**

**Table 3 Module bus connector description**

| Pin No | I/O | Signal | Note |
|---|---|---|---|
| 1 | I | RESET_RS485 | |
| 2 | I | -15 VDC | ** |
| 3 | I | +15 VDIRTY | |
| 4 | I | +15 VDC | ** |
| 5 | I/O | -DATA_RS485 | |
| 6 | I/O | DATA_RS485 | |
| 7 | | Ground & Shield | |
| 8 | I | -RESET_RS485 | |
| 9 | I | CTSB | * |
| 10 | O | RTSB | * |
| 11 | I | RXDB | * |
| 12 | O | TXDB | * |
| 13 | | Ground & Shield | |
| 14 | I | +32 VDIRTY | * |
| 15 | I | GroundDIRTY | |
| 16 | I | CTSC | * |
| 17 | O | RTSC | * |
| 18 | I | RXDC | * |
| 19 | O | TXDC | * |
| 20 | | ON/STANDBY | * |
| 21 | O | PWM_ECG | |
| 22 | | RXDD_RS232 | * |
| 23 | | TXDD_RS232 | * |
| 24 | I | +5 VDC | |
| 25 | I | +5 VDC | |

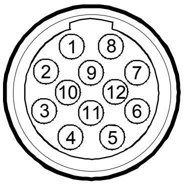
* = Not used

** = Used only by M-ESTPR, M-ETPR, M-ESTR and M-NIBP modules

## 2.3.2 Front panel connectors

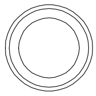
**Table 4 Front panel connectors**

**12-lead ECG connector**



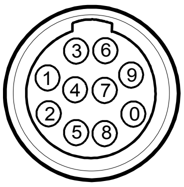
| Pin No | Signal |
|---|---|
| 1 | Right arm electrode (R) |
| 2 | Left arm electrode (L) |
| 3 | N |
| 4 | Left leg electrode (F) |
| 5 | Chest electrode (C1) |
| 6 | Chest electrode (C2) |
| 7 | Chest electrode (C3) |
| 8 | Chest electrode (C4) |
| 9 | Chest electrode (C5) |
| 10 | Chest electrode (C6) |
| 11 | Cable type |
| 12 | Ground |

**Temp connector (T1, T2)**



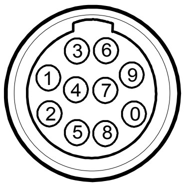
| Pin No | Signal |
|---|---|
| 1 | Temperature probe |
| 2 | Temperature probe |

**ECG connector (ECG)**



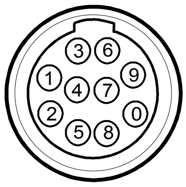
| Pin No | Signal |
|---|---|
| 1 | Right arm electrode (R) |
| 2 | Left arm electrode (L) |
| 3 | Right leg electrode (RL) |
| 4 | Left leg electrode (F) |
| 5 | Chest electrode (C) |
| 6 | Cable shield |
| 7 | Not connected |
| 8 | 3/5 lead identification |
| 9 | Lead connection check |
| 10 | Ground |

**$SpO_2$ connector ($SpO_2$)**



| Pin No | Signal |
|---|---|
| 1 | Feedback resistor |
| 2 | Ground |
| 3 | Not Connected |
| 4 | Cable shield + probe identification ground |
| 5 | Probe identification |
| 6 | LED drive ground |
| 7 | LED drive current |
| 8 | Input signal current |
| 9 | Ground |
| 10 | Ground |

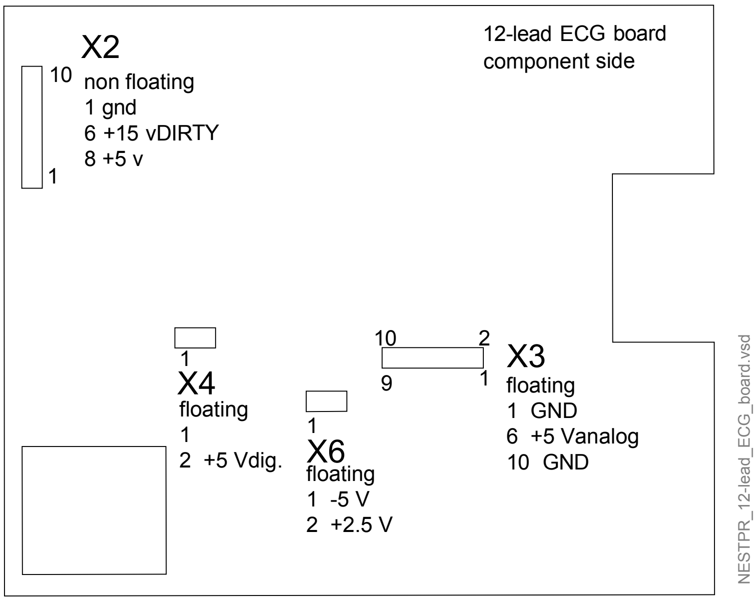
**Invasive blood pressure connectors (P1, P2)**



| Pin No | Signal |
|---|---|
| 1 | Pressure + |
| 2 | Pressure - |
| 3 | Polarisation - (ground) |
| 4 | Polarisation + |
| 5 | Not connected |
| 6 | Not connected |
| 7 | Not connected |
| 8 | Not connected |
| 9 | Ground |
| 10 | Cable detection |

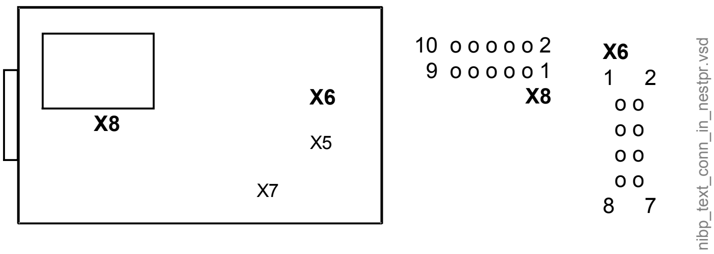
## 2.3.3 Test points on boards

### 12-lead ECG board




### NIBP board

There are test pad blocks on solder side. X8 and X6 pads and voltages are:




| **X8** | |
|---|---|
| **Pin No** | **Signal** |
| 1 | GND |
| 2 | WD out |
| 3 | reset |
| 4 | +5 V |
| 5 | +15 V dirty |
| 6 | +15 V |
| 7 | -15 V |
| 8 | - |
| 9 | - |
| 10 | GND |

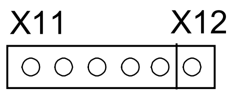
| **X6** | |
|---|---|
| **Pin No** | **Signal** |
| 1 | GND |
| 2 | A1 output |
| 3 | - 5 V |
| 4 | +5 V ref |
| 5 | B1 out - (A1 input) |
| 6 | B1 out + |
| 7 | B2 out + |
| 8 | B2 out - |

## ECG and STP board

There are identical test pin blocks both on STP and ECG boards. Pins and voltages are as follows:

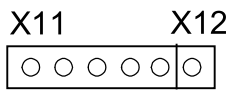
**ESTPR**

| | | |
|---|---|---|
| X11 | pin 1 | +5 Vref |
| | pin 2 | +5 V |
| | pin 3 | +12 V |
| | pin 4 | Gnd |
| | pin 5 | -12 V |
| X12 | pin 1 | -5 V (STP board only) |




**NESTPR**

| | | |
|---|---|---|
| X11 | pin 1 | +5 Vref |
| | pin 2 | +5 V |
| | pin 3 | +7 V |
| | pin 4 | Gnd |
| | pin 5 | -7 V |
| X12 | pin 1 | -5 V (STP board only) |



# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the hemodynamic modules is limited to replacing faulty printed circuit boards or mechanical parts. Faulty printed circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair, however, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark in the instructions means that the performed procedure should be signed in the check form.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Patient simulator | - | |
| Pressure manometer | - | |
| Temperature test set | 884515 | |
| 3-lead ECG trunk cable | | |
| 5-lead ECG cable | | |
| 10-leadwire ECG cable | | |
| $SpO_2$ finger probe | OXY-F4-N or SAS-F4 | |
| InvBP transducer | | |
| Adult NIBP cuff & hose | | |
| Infant NIBP cuff & hose | | |
| Screwdriver | | |

### 3.2.2 Recommended parts

| Part | Order No. | Notes |
|---|---|---|
| NIBP pump filter | 57142 | |

## All modules

Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:

- screws are tightened properly
- cables are connected properly
- all IC's that are on sockets are attached properly
- EMC covers are attached properly
- there are no loose objects inside the module

2. Check external parts:

- the front cover and the front panel sticker are intact
- all connectors are intact and are attached properly
- the module box, the latch and the spring pin are intact

3. Replace the NIBP pump filter in NE12STPR/NE12TPR/NE12STR/NESTPR/NETPR/NESTR modules, if necessary.

- Reattach the module box and check that the latch is moving properly.
- Switch the monitor on and wait until the monitoring screen appears. Configure the monitor screen so that all the needed parameters are shown, for example as follows:

**Monitor Setup** - ***Waveform Fields - Field 1 - ECG1***
***Field 2 - ECG2***
***Field 3 - P1***
***Field 4 - P2***
***Field 5 - Pleth***
***Field 6 - Resp***
***Digit Fields - Lower Field 2 - NIBP***
***Lower Field 3 - T1+T2***

4. Plug in the module. Check that it goes in smoothly and locks up properly

5. Check that the module is recognized, i.e. all needed parameter information, except invasive blood pressure, starts to show on the screen.

Preset ECG, Respiration, InvBP and $SpO_2$ measurement settings:

**ECG** - ***ECG Setup - Hr Source - Auto***
***Pacemaker - Show***

**Others** - ***Resp Setup - Size - 1.0***
***Resp Rate Source - Auto***
***Measurement - On***
***Detection Limit - Auto***

**Invasive Pressures** - ***P1 'Art' Setup - Label - Art***
***P2 'Cvp' Setup - Label - Cvp***

**Pulse Oximetry** - ***Pleth Scale - Auto***

## ECG measurement

6. Enter the service menu:

**Monitor Setup** - ***Install/Service*** (password 16-4-34) -
***Service*** (password 26-23-8) - ***Parameters***

Take down the information regarding module software by selecting ***Scroll Vers*** and turning the ComWheel.

7. Enter the ESTP : ECG service menu:

Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second. Check also that the ECG/RESP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' state all OK.

8. Check the front panel membrane key **ECG Lead** (not available in NE12STPR/NESTPR type modules).
Press the key at least for two seconds. Check that the selected ECG lead is changing on the screen and the state for 'Button' in the service menu.

9. Check that the power frequency value has been set according to the current mains power frequency. Change the setting by selecting ***Power Freq***, if necessary.

   ✍

10. @ M-ESTPR, M-ETPR , M-ESTR, M-NESTPR, M-NETPR and M-NESTR modules: connect a 5-lead ECG cable to the module. Check that the 'Cable type' shows 5 lead. If it shows 3 lead, make sure the used 5-lead ECG cable contains the necessary wiring for cable recognition (pins 0, 8 and 9 connected together).

    @ M-NE12STPR, M-NE12TPR and M-NE12STR modules: connect a 10-leadwire ECG cable to the module. Connect limb lead electrodes and one electrode from the chest lead set to the same potential. Check that the 'Cable type' shows 10 lead.

    ✍

11. Connect a 3-lead ECG trunk cable without a lead set to the module. Check that the message "Leads off" is displayed on the screen.

    ✍

12. Check that all the electrodes show OFF in the service menu and the message 'Leads Off' is shown on the screen.

    Connect all the leads together, for example to a suitable screwdriver. Check that all the electrodes show ON and the message 'Asystole' appears.

    Disconnect one of the leads and check that the corresponding electrode in the service menu shows OFF within 10 seconds from the disconnection, then reconnect the lead. Check the rest of the leads using the same method.

    NOTE: When the ground lead (black) is disconnected all the electrodes should show OFF.

    NOTE: The 'Asystole' and 'Different leads off' messages are shown using certain priority, so even one of the leads is disconnected, the lead related 'Leads off' message may not appear onto the screen.

    NOTE: When RA, LA or LL electrode is disconnected, all six V electrodes show OFF.

    NOTE: With NESTPR/ESTPR type modules and 5 lead cable the state of V2, V3, V4, V5 and V6 electrodes follow the state of the V electrode.

    ✍

13. Connect the leads to a patient simulator.
    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    ECG - BASE - BPM - 160
    PACE - WAVE - NSR

    Check that normal ECG waveform is shown, the HR -value is 160 (±5) and the 'Pacer count' -value is not increasing in the service menu. Check the lead selections by pressing the **ECG Lead** key on the module (not available in NE12STPR/NESTPR type modules).

ECG - PACE - WAVE - ASNC

Check that pacemaker spikes are shown on the ECG waveform, the 'HR' -value changes to 75 (±5) and the 'Pacer count' -value is increasing according to shown pacemaker spikes.

Set the pacemaker option off:

ECG - PACE - WAVE - NSR

## Respiration measurement

13. Check that the 'Resp Available' and 'RESP Measurement' show both ON in the ESTP: ECG service menu.

14. Check the respiration measurement with a patient simulator.

The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

BASELINE IMPEDANCE -switch - 500
LEAD SELECT-switch - II/RL-LL

RESP - WAVE - NORM
RATE - 20
OHMS - 1.0
RATIO - 1/1
APNEA - OFF
SHIFT - OFF

Check that the RESP waveform is shown and the 'RR' -value is 20 (±5). Change the position of the BASELINE IMPEDANCE -switch and check that appropriate RESP waveform and 'RR' -value are shown again within 30 seconds.

RESP - APNEA - 32 S

Check that the monitor gives the APNEA -alarm.

NOTE: Make sure that only the ECG leads are connected to the simulator during the apnea -test. If other cables are connected at the same time, the respiration signal from the simulator may be disturbed, and therefore, the APNEA -alarm may not be activated.

NOTE: When you have ECG service menu open, spikes will appear on the respiration waveform. These spikes represent the threshold level for detecting inspiration and expiration.

## Temperature measurement

15. Enter the ESTP : STP service menu:

    ***Parameters - ESTP : STP***

    Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second. Check also that the STP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' show all OK.

16. Check that the 'Cable' and 'Probe' show OFF for both channels, T1 and T2, when no probes are connected.

    Connect a temperature test plug into the connector T1. Check that the 'Cable' and 'Probe' for T1 show ON and the corresponding temperature value appears onto the monitor screen. Perform the same check also for the channel T2.

17. Check the temperature calibrations using temperature test plugs.
    If the deviation on a temperature reading on the screen is more than 0.1 °C, calibrate the temperature channels according to the instructions in the chapter *3.4.3 Temperature calibration*.

18. Activate the temperature test by selecting ***Temp Test*** from the menu and pressing the ComWheel twice. When the message 'Performing temp test' disappears from the digit field, check that no error messages appear and 'Temp error' shows OFF for both channels in the service menu.

19. Check that the module configuration has been set correctly. The configuration in use is shown beside the text 'Configuration' in the service menu and it can be either STP, ST or TP. Change the configuration in the ***Calibrations*** menu, if necessary.

## Invasive blood pressure measurement

20. Check the front panel membrane keys that are related to the InvBP or temperature measurement.
    Press each of the keys at least for one second. Check that the pressed key is identified, i.e. one of the texts for 'Buttons' changes from OFF to ON in the service menu.

21. Check that the 'Cable' and 'Probe' for P1 show OFF. Plug a cable with an invasive blood pressure transducer into the front panel connector P1 and check that the 'Cable' and

'Probe' show ON and the corresponding pressure waveform appears onto the screen.

Perform the same check also for the InvBP channel P2.

22. Calibrate the InvBP channels P1 and P2 according to the instructions in the chapter *3.4.4. Invasive pressure calibration*

23. Check the InvBP channels with a patient simulator.

The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

SENSITIVITY -switch - 5 μV/V/mmHg

ECG - BASE - BPM - 60 - BP - 1 - WAVE - ATM
2 - WAVE - ATM

Restore the normal monitoring screen by pressing the key **Normal Screen**.

Connect cables from the channels BP1 and BP2 to the module connectors P1 and P2. Zero the InvBP channels by pressing the keys ZERO P1 and ZERO P2 on the module front panel.

BP - 1 - WAVE - ART
2 - WAVE - CVP

Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 120/80 (±3 mmHg) for the channel P1 and 15/10 (±2 mmHg) for the channel P2.

Check that HR- value is calculated from P1 when ECG is not measured (ECG cable disconnected).

## $SpO_2$ measurement

24. Check that the message 'No probe' is shown when no $SpO_2$ sensor is connected to the module. Connect a $SpO_2$ finger probe to the module. Check that the message 'Probe off' is shown when the probe is not connected to a finger.

25. Connect the $SpO_2$ probe onto your finger. Check that the reading of 95-99 and $SpO_2$ waveform appear. Check that HR- value is calculated from $SpO_2$ when ECG and InvBP (P1) are not measured.

## Non Invasive Blood Pressure measurement

26. Enter the NIBP module service menu:
    ***Parameters - NIBP***

    Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' show all OK.

    ✍

27. Check the front panel membrane keys.

    Select ***Buttons/Leds***.

    Press each of the two NIBP related membrane keys at least for one second. Check that the pressed key is identified, i.e. the corresponding text changes from OFF to ON in the menu.

    ✍

28. Check the pump and valves.

    Highlight ***Pneumatics*** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

    Select ***Start Pump*** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

    Highlight ***Open Exh1***. Press the ComWheel and check that the pressure inside the tubing system starts to drop then press the ComWheel again. Check the other exhaust valve by the same way by selecting ***Open Exh2*** from the menu.
    If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

    Highlight ***Set Valve***. Press the ComWheel and set the value under the text 'Pulse Valve' to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting ***Previous Menu***.

    ✍

29. Check the NIBP tubing system for leakages.

    Select ***Calibrations*** from the NIBP service menu.

    Connect the pressure manometer to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 265 mmHg and then the pump stops.
    Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 6 mmHg per one minute. Release the pressure by pressing the ComWheel once more.

    ✍

30. Calibration check.

    Recalibrate the NIBP measurement according to the instructions in the chapter 3.4 Adjustment and Calibration. *Calibration*,Remember to set the calibration protection back on after the calibration.

    Disconnect the pressure manometer. Select ***Calibrations*** and then highlight ***Calibration Check***. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ±10 mmHg.

    Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

    ✍

31. Check the watchdog timer activation pressure.

    Select ***Pneumatics*** from the NIBP service menu.

    Keep the pressure manometer connected to the cuff connector. Pump up the pressure very slowly and note the value on the manometer when your hear a signal from the loudspeaker. The pressure at where the watchdog timer should activate with an audible signal is 13 mmHg (11 to 15 mmHg). Adjust the limit with the trimmer on the NIBP board, if necessary.

    ✍

32. Check the watchdog timer.

    Select ***Watchdog*** from the NIBP service menu.

    Check the watchdog timer in the adult mode. Activate the timer by highlighting ***Test ADULT*** and then pressing the ComWheel. Check that the time beside the text 'Watchdog Interval' starts to run. Wait until you hear a signal from the loudspeaker and then check the time again. The time from the adult test should fall within 120 to 140 seconds.

    Check the watchdog timer also in the infant mode by first selecting ***Test INFANT*** from the menu. The time from the infant test should fall within 60 to 70 seconds.

33. Check the safety valve.

    Select ***Safety Valve*** from the NIBP service menu.
    Keep the pressure manometer connected to the cuff connector.

    NOTE: Make sure your pressure manometer can be used to measure pressures over 300 mmHg. If such a pressure manometer is not available, perform the check with an adult cuff that is connected around some round object, for example a calibration gas bottle.

    Highlight ***Start Test***. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated. Check the pressure values 'Max press' and '2 s after stop' for both transducers. All the values should be within 290 - 330 mmHg.

    Highlight ***ADULT***. Press the ComWheel and check that the text changes now to ***INFANT***. Select ***Start Test*** and wait until the pump stops and the pressure values on the screen have been updated. Check that the values 'Max press' and '2 s after stop' are all now within 154 to 165 mmHg.

    Return to the normal monitoring mode by pressing **Normal Screen**.

34. Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses.
    Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message 'Cuff loose' appears on the screen within 30 seconds.
    Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message 'Cuff occlusion' appears on the screen within 30 seconds.

    Check that automatic inflation limits are in use:

    **NIBP** ***- NIBP Setup - Inflation Limits - Auto - Previous Menu***

35. Connect the cuff onto your arm, highlight ***Start Ven.Stasis*** in the NIBP menu and press the ComWheel. Check the module identifies the cuff, i.e. the text 'Adult' appears into the NIBP digit field for a short moment.

    Keep the pressure inside the cuff for about half a minute in order to find out that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.

36. Keep the cuff on your arm and perform one NIBP measurement. Check that the module gives a reasonable measuring result.

37. Connect an infant cuff to cuff connector and wrap it around your fingers.
    Start NIBP measurement and check that the module identifies the cuff, i.e. the text 'Infant' appears into the NIBP digit field. Cancel the measurement after the cuff identification.

## All modules

38. Perform electrical safety check and leakage current test.

39. Check that the module functions normally after the performed electrical safety check.

40. Clean the module with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

### 3.3.1 M-ESTPR, M-ESTR, and M-ETPR modules

Disassemble the M-ESTPR/-ESTR/-ETPR module in the following way. See the exploded view of the module in 6.1.1.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearwards and detach it from the main body. Be careful with loose latch and spring pin for locking.
3. To detach the ECG board, remove four screws, disconnect the ribbon cable from the STP board, and the ribbon cable from the front panel. Slide the board rearward to disconnect the fixed 10-pin connector from the ECG input board.
4. To detach the STP board, remove two screws and disconnect the two connectors from the SP input board. The T-input connector cables must be disconnected as well.

CAUTION When reassembling the module, make sure that all cables are reconnected properly.

### 3.3.2 M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR modules

Disassemble the M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR module in the following way. See the exploded view of the module in 6.1.3.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearwards and detach it from the main body. Be careful with loose latch and spring pin for locking.
3. To detach the ECG board, detach four screws, disconnect ribbon cable from the STP board (supply voltage), and ribbon cable from the ECG input board.
4. When the ECG board is removed, the STP board can be detached by removing four screws, disconnecting the cable from the membrane keypad, the cable from the temperature connectors, and cables from the SP input board. Also disconnect the NIBP hoses and the ribbon cable from the NIBP board.
5. When the ECG board and the STP board are removed, the NIBP board can be detached by removing four screws. The joining chamber can be detached by removing three screws and disconnecting the hoses from the pressure transducers and the pump. The pump can be detached by removing two screws. If the filter for the air inlet of the pump is removed, it must be replaced.

# 3.4 Adjustments and calibrations

## 3.4.1 Pressure safety level detection “OFFSET”

Remove two screws at the rear of the module. Remove the module box. Connect first the service cable (e.g. a long Gas Interface Cable) to the module connector inside the monitor frame and then to the rear connector of the module. Turn the monitor on. Enter to the NIBP service menu and select ***Pneumatics***. Pump reference pressure 13 mmHg into the module.
Adjust the trimmer until AD5 signal sign changes from negative to positive. Re-check the adjustement, then lock the trimmer with for example nail polish.

## 3.4.2 NIBP calibrations

The electronics of the NIBP pressure measurement is calibrated at the factory. Zeroing pressure is automatically maintained by the processor. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced.

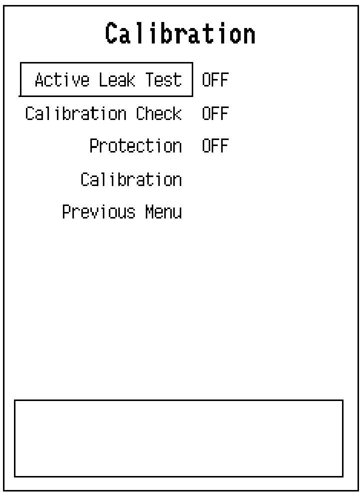
Check the NIBP measurement, and recalibrate if necessary , once a year. The checking and recalibrating can be done in the NIBP service menu.

The calibration of the primary pressure channel can also be checked from the NIBP setup menu (***NIBP - NIBP Setup - Calibration Check***). In this case the auto zeroing is performed at start - remove hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

Check the intake air filter as part of the calibration check.. Change the filter if it is visibly dirty.

### Calibration check

1. Enter ***Calibration*** menu.




2. Select ***Calibration Check*** and press the ComWheel.
3. Connect an external precision manometer to the module.

4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display:

**Table 5 NIBP calibration check pressures**

| Pressure | Max. error | Example |
|---|---|---|
| 0 mmHg | ±9 mmHg (=zero offset) | -2 |
| 100 mmHg | 100 + zero offset ±2 mmHg | 98 ±2 |
| 200 mmHg | 200 + zero offset ±3 mmHg | 198 ±2 |

If the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, we recommend recalibrating the module when the error of B2 is larger than specified above to ensure best possible operation.

## Calibration

1. Enter ***Calibration*** menu.
2. Remove hoses from front panel connector to enable proper zeroing.
3. Select ***Calibration***. If it is not available, perform the steps A, B, and C.

NOTE: Do not pull out the NIBP module from the monitor frame. The module must be in the frame during the whole procedure.

A. Turn the toggle switch at the bottom of the NIBP module to enable the calibration. Turn the switch to the right by, for example, a sharp pencil. This enables menu selection ***Protection***. The message 'Calibration switch ON!' appears.

B. Select ***Protection OFF*** in the Calibration menu and press the ComWheel.

C. Return the toggle switch to the left. Menu selection ***Calibration*** is now enabled, and ***Protection*** is disabled. When the calibration is enabled, a message 'Calibration not protected' appears.

- Start Calibration by pressing the ComWheel. Messages 'Zeroing' and 'Zeroed' will appear in the NIBP message field. After this a pressure bar will appear.
- Connect an external mercury manometer with pump to module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure about 200 mmHg according to the manometer. Calibration is possible in the range 150 to 300 mmHg.
- Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, press the ComWheel to confirm the calibration. The message 'Calibrating' will appear onto the NIBP digit field. After a few seconds it is followed by 'Calibrated', which means that the calibration has succeeded, and the new calibration data has been saved into EEPROM.

- NOTE! When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct (i.e. change the value for example one step higher and then back one step lower). “Calibrated” text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

  – To set the protection on:
    Turn the toggle switch to the right. Select ***Protection ON*** and push the ComWheel. Then turn the toggle switch back to the left.

- Remove the module from the frame and plug it back again. Then perform ***Calibration check*** (see the preceding page) to verify the new calibration.

### 3.4.3 Temperature calibration

NOTE: For the temperature calibration, separate, accurate test plugs (25 °C and 45 °C) are needed. A test set of two plugs is available from Datex-Ohmeda, order code 884515.

Calibrate temperature when measured test values deviate more than ±0.1 °C, and always after STP board replacement.

1. Enter ESTPR: STP service menu.
2. Enter ***Calibrations*** menu.
3. Press the protect button at the bottom of the module and choose OFF in protect mode. Release the button.
4. Select ***Calibrate T1/Calibrate T2***.
5. Insert calibration plug (25 °C) into T1/T2 connector.
6. Press the ComWheel.
7. Insert calibration plug (45 °C) into T1/T2 connector.
8. Press the ComWheel.
9. Press in the protect button at the bottom of the module and choose ON in protect mode. Release the button.

### 3.4.4 Invasive pressure calibration

Calibrate invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer, and when STP board is replaced.

1. Enter ESTPR: the STP service menu.
   (**Monitor Setup**, ***Install/Service*** (password 16-4-34), ***Service*** (password 26-23-8), ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Connect a pressure transducer with a pressure manometer to the P1/P2 connector. Choose ***Calibrate P1*** or ***Calibrate P2***. Leave the transducer to room air pressure.
4. Press the ComWheel to start zeroing.

5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The message ‘Calibrated’ will appear on the display.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting charts

See also the *User's Reference Manual* for more troubleshooting procedures.

### 4.1.1 NIBP

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| No NIBP value displayed | NIBP not selected on screen. | Check monitor setup. |
| NIBP menu fading | No M-NE(12)STPR module, module not properly connected, or NIBP and NE(12)STPR module connected at the same time. | Plug in the module. |
| Artifacts-message | Unsuccessful measurement due to patient movement or shivering. | |
| Weak pulsation-message | Weak or unstable oscillation pulses due to:<br>• artifacts (accurate diastolic pressure difficult to measure)<br>• marked arrhythmia<br>• marked drop in diastolic pressure<br>• diastolic pressure difficult to measure<br>• improper cuff position or attachment<br>• too few pulses detected<br>• weak or unusual blood circulation<br>• may give systolic value | Check patient condition and retry.<br>Check any leaks and retry.<br>Use proper size of cuff. Check attachment. |
| Call service<br>Error X-message | NIBP hardware error.<br>X = error number. | See the description of the error message code in 4.1.2, the causes and the solutions listed in the next chapter. |

| **TROUBLE** | **CAUSE** | **TREATMENT** |
|---|---|---|
| Cuff loose-message | 1. Hose and/or cuff not connected. | 1. Connect the hose and the cuff. |
| | 2. Hose and cuff connected. Reasons: | 2. |
| | – cuff loosely wrapped | – tighten the cuff |
| | – leakage in cuff or hose | – replace cuff/hose |
| | – leakage inside module | – check internal tubing and air chamber, and fix if necessary |
| | – pump does not work | – check pump connector; if OK, replace pump |
| | – no pulses during the last three measurements | – check cuff positioning |
| Air leakage-message | 1. Hose or cuff leaking. Reasons: | 1. Replace cuff |
| | – cuff damaged | – replace cuff |
| | – cuff connector damaged | – replace cuff connector (if the fault is in hose connector,) |
| | – O-ring damaged or missing | – replace O-ring |
| | – hose double connector damaged | – replace hose |
| | 2. Hose and cuff OK. Reasons: | 2. Connect or replace tube |
| | – leakage inside the module | – replace the whole tubing |
| | – tube disconnected or damaged | – fix connections |
| | – air chamber leaking | – |
| | – tubes or valve(s) damaged | – replace tubes/valve(s) |
| Unable to measure Sys-message | Systolic blood pressure probably higher than the maximum inflation pressure. | Automatic retrial with increased pressure. |

| **TROUBLE** | **CAUSE** | **TREATMENT** |
|---|---|---|
| Cuff occlusion-message | 1. Cuff and/or hose occluded. Reason: | 1. |
| | – cuff tube kinked | – straighten tube |
| | – tube inside module kinked | – straighten tube |
| | – occlusion inside/outside module | – remove occlusion |
| | 2. Cuff, hose, and tubes OK. Reason: | 2. |
| | – fault in pressure transducer | – replace the NIBP board |
| | – fault in A/D converter | – replace the NIBP board |
| | – faulty calibration | – check calibration |
| | – missing voltages | – recalibrate |
| Calibration switch on - message | EEPROM protection switch at the bottom of the module is turned to right. | Enables setting the protection OFF in the Calibration menu. Turn switch to left if you are not going to calibrate. |
| Calibration not protected - message. | Calibration protection is set to OFF. | Set the protection ON in the NIBP Calibration menu. |

### 4.1.2 NIBP error code explanation

| Code | Explanation | Treatment |
|---|---|---|
| 0 | RAM failure; memory failure | Change NIBP board. |
| 1 | ROM checksum error; memory failure | Change NIBP board. |
| 2 | +15 V failure | Check short circuits. Change NIBP board. |
| 3 | -15 V failure | Check short circuits. Change NIBP board. |
| 4 | EEPROM protection switch error (only with S-STD93) | Turn the toggle switch to the left at the bottom of the module. |
| 5 | Calibration not protected. (only with S-STD93) | Protect calibration by selecting Protection ON in the NIBP calibration menu. |
| 6 | ADC error | ADC circuit failure. Change NIBP board. |
| 7 | Watchdog time too short | Change NIBP board. |
| 8 | Watchdog time too long | Change NIBP board. |
| 9 | Watchdog activated | Change NIBP board. |
| 10 | EEPROM checksum error; memory failure | Change NIBP board. |
| 11 | Auto zero range exceeded | Calibrate NIBP. |
| 12 | Communication break; temporal break down of communication from monitor detected | Automatic recovery |
| 13 | - | - |
| 14 | Too early Auto Start (needs 25 seconds without pressure) | |

### 4.1.3 ECG

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| HR numerical display shows '---' | No heart rate available. | If no ECG waveform, check LEADS OFF message and connect the leads. |
| | | If ECG waveform exists, check heart rate source e.g. in the ECG Setup menu behind ECG key. |
| Unacceptable ECG waveform | Poor electrode or poor electrode skin contact. | Electrodes from different manufacturers are used. /Too much/little gel is used. |
| | Poor electrode condition. | Electrodes are dried out. |
| | Improper site of electrodes. | Check that electrodes are not placed over bones, active muscles, or layers of fat. |
| | Improper skin preparation. | Remove body hair. Clean attachment site carefully with alcohol. |
| | Improper bandwidth filter. | Check filter. |
| No ECG trace | Waveform not selected on screen. | Press the **Monitor Setup** key and make adjustments. |
| | Module not plugged in correctly. | Plug in. |
| Noise-message | High frequency or 50/60 Hz noise. | Isolate noise source. |

### 4.1.4 Pulse oximetry ($SpO_2$)

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Message 'NO PROBE' | No probe connected to the monitor. | Check probe connections. |
| | Probe faulty. | Change the probe. |
| Message 'PROBE OFF' though probe properly attached to the patient | Unsuitable site. | Try another site. |
| | Probe faulty. | Try another probe. |
| | Probe connection cable not connected to probe. | Connect the cable to probe. |
| Finger probe falls off | 1. Probe is slippery. | 1. Wipe with 70 % isopropyl alcohol and allow to dry. |

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| | 2. Finger is too thin or thick. | 2. Try other fingers, or other probe types. |
| Weak signal artifacts | Poor perfusion. | Try another place. |
| | Movement artifacts. | |
| | Shivering. | |
| Message ‘NO PULSE’ | Pulse search > 20 sec. and low $SpO_2$ or low pulse rate. | Try other fingers. |
| Message ‘ARTIFACT’ | Pulse modulation exceeds the present scale. | Try another place or another probe. |
| Message ‘CHECK PROBE’ | DC value not in balance. | Try another probe. |
| Message ‘POOR SIGNAL’ | Modulation (Red or Ired) < 0.25 % | Patient may be cold. |
| Message ‘FAULTY PROBE’ | Probe is faulty. | Change the probe. |
| No $SpO_2$ | No waveform selected on screen. | Check selected $SpO_2$ waveforms by pressing **Monitor Setup** key and selecting ***Modify waveforms***. |
| | Wrong configuration setting. | Check the configuration settings from the ESTPR:STP/Calibrations menu (**Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***) |

### 4.1.5 Temperature

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Message ‘TEMPERATURE ERROR’ | Faulty calibration. | Perform calibration. If it does not help, check that front panel connector is properly connected to STP board. |
| No temperature displayed | Wrong type of probe. | Use correct probe. |
| | Temperature out of measurable range. | The range is between 10 and 45 °C. |
| | Temperature calibration not protected. | Set the protection ON in the Service Menu. |

### 4.1.6 Invasive blood pressure

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Abnormally low pressure | Transducer wrongly positioned. | Check mid-heart level and reposition transducer. |
| No pressure | Defective transducer. | Check transducer. |
| | No pressure module plugged in. | Check the module. |
| | No waveform selected on screen. | Check selected pressure waveforms by pressing Monitor Setup key and selecting modify waveforms. |
| | | Check that pressure transducer is open to patient. |
| | Wrong configuration setting | Check the configuration setting from the ESTP:STP/Calibrations menu (**Monitor Setup** ***- Install/Service - Service - Parameters***) |
| Not zeroed -message | Measurement on, channel not zeroed. | Zero the channel. |
| Zeroing failed -message | Unsuccessful zeroing of P1 /P2 (number field). | Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel. |
| | | Offset is > 150 mmHg. Open the transducer to air and zero the channel. |
| | | Defective transducer. Replace it and zero the channel. |
| Calibration failed -message | Unsuccessful calibrating of P1/P2 (number field), possibly due to pulsating waveform | Turn the transducer to sphygmomanometer and try again (zeroing takes place first). |
| | | Gain is beyond the limits (± 20 % of the default gain). Replace the transducer. |
| Out of range < 40 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. |
| Out of range > 320 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. The patient may also have high pressure. |
| Zero adj. > 100 mmHg | Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain). | Check transducer. The waveform may hit the top and the numeric display not shown. |

| **TROUBLE** | **CAUSE** | **TREATMENT** |
|---|---|---|
| Out of range | Measured pressure is beyond the internal measurement range of the module. | The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel. |

### 4.1.7 Impedance respiration

| **TROUBLE** | **CAUSE** | **TREATMENT** |
|---|---|---|
| No resp trace | Waveform not selected on the screen | Press the Monitor Setup key and make adjustments |
| | Module not plugged in correctly | Plug in |
| Unacceptable resp waveform | Poor electrode or poor electrode skin contact | Electrodes from different manufacturers are used. Too much/little gel is used. |
| | Poor electrode condition | Electrodes are dried out. |
| | Improper site of electrodes | Check that electrodes are not placed over bones, active muscles, or layers of fat. |
| | Improper skin preparation | Remove body hair. Clean attachment site carefully with alcohol. |
| Message: ‘SMALL RESP CURVE’ | Respiration signal is very small | With 3-lead cable in ESTPR/NESTPR try another lead connection I, II, III or try 5-lead cable. |
| Message: ‘APNEA ALARM’, and respiration waveform normal | Respiration source is $CO_2$ | Check respiration source and change it to correct one. |

## 4.2 Troubleshooting flowcharts

### 4.2.1 M-NE12STPR and M-NESTPR module troubleshooting

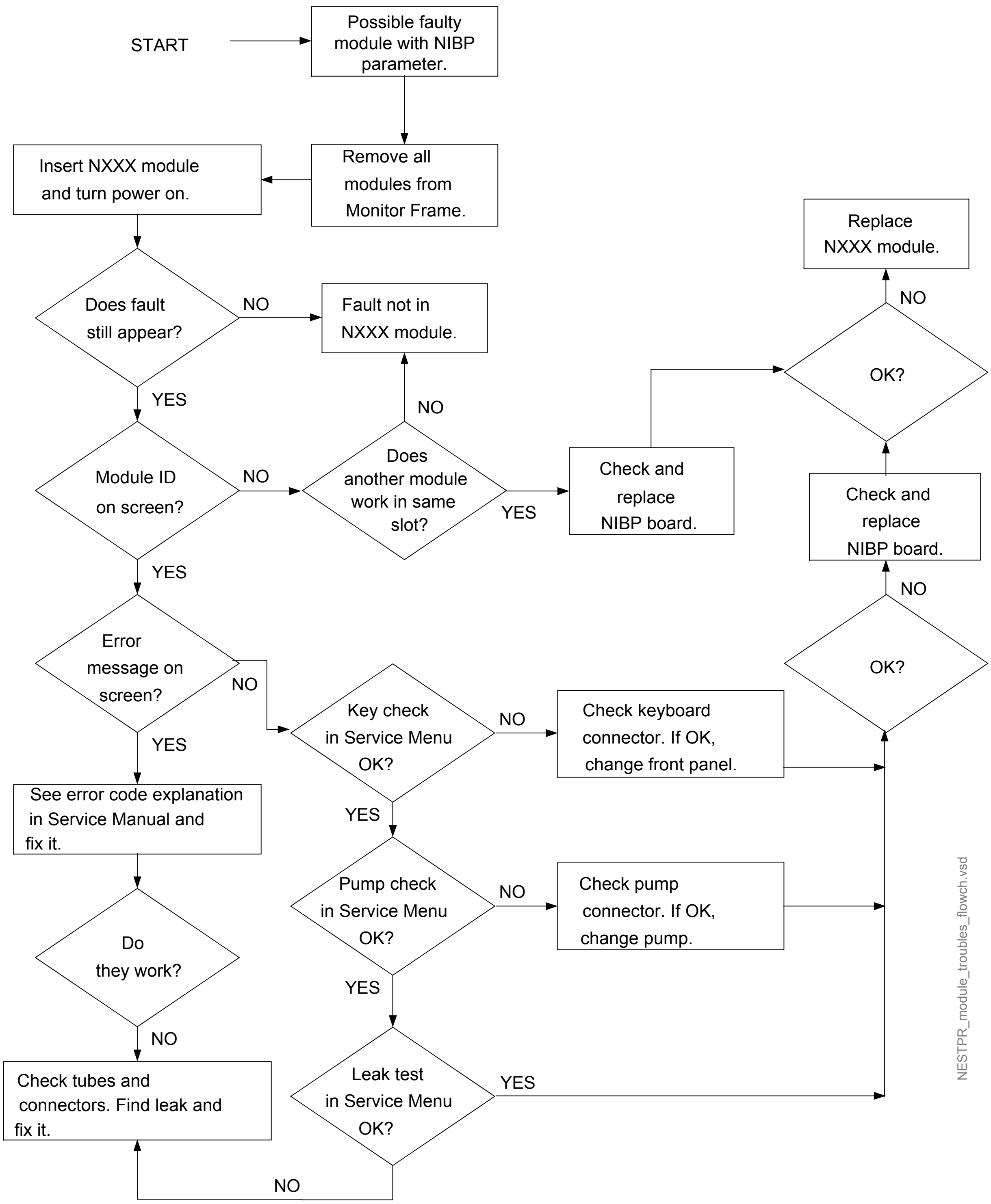



**Figure 15 M-NE12STPR and M-NESTPR module troubleshooting flowchart**

## 4.2.2 M-ESTPR, M-ESTR, and M-ETPR module troubleshooting

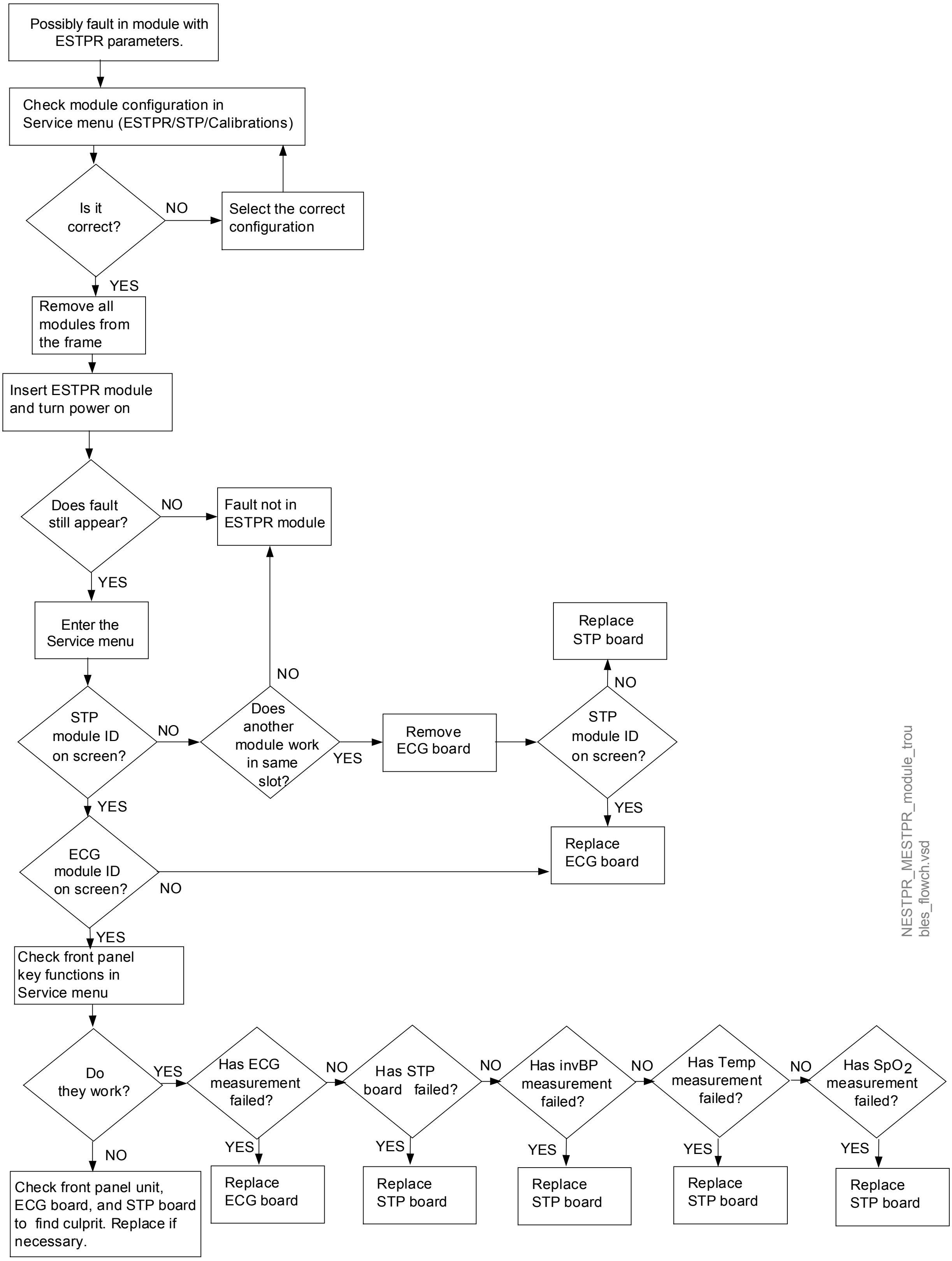
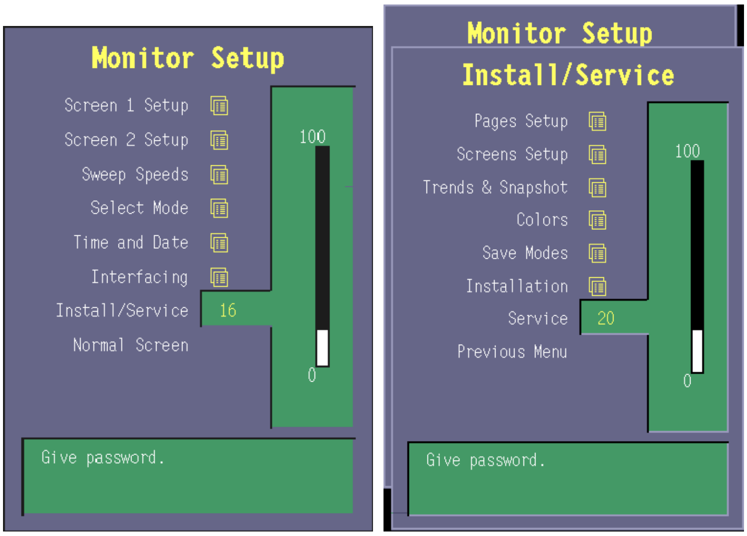
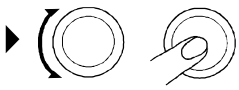



**Figure 16 M-ESTPR Module Troubleshooting Flowchart**

# 5 SERVICE MENU

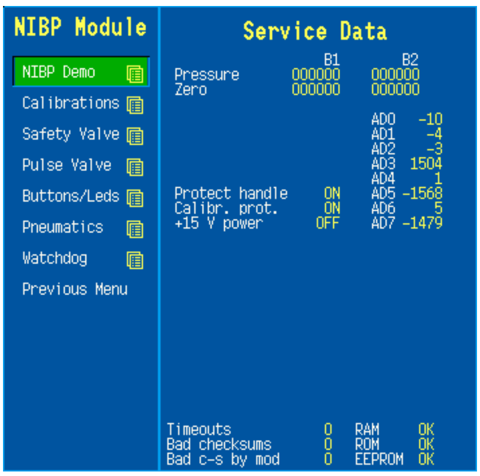
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



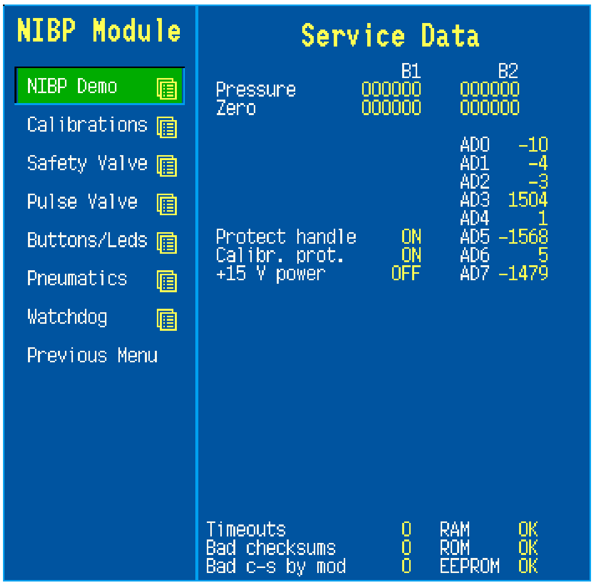



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters - NIBP***.

NOTE: Parameter values in Service Data fields are for reference only on this chapter.



## 5.1 NIBP service menu




### Service Data

**Pressure** shows measured pressure multiplied by 10.
**Zero** shows pressure at auto zeroing multiplied by 10 and changes between +20 and -20 mmHg. Absolute pressure is the sum of **Pressure** and **Zero**.

**Protect handle** indicates hardware protection for EEPROM memory. It should be ON all the time in normal operation. If it is OFF data can not be read from or written to EEPROM, only the calibration protection can be set or reset by software. It can be turned to OFF by turning the toggle switch to the right at the bottom of the module, which also enables ***Protection ON/OFF*** menu selection in the calibration menu.
**Calibr. prot.** shows software calibration protection and it should be OFF to enable calibration.

**+15 V power** indicates the condition of the supply voltage +15 Vdirty for the pump and valves. It exists (ON) or not (OFF) depending on service menu function. The supply voltage can be turned on by selecting the previous Menu and then the desired menu again.

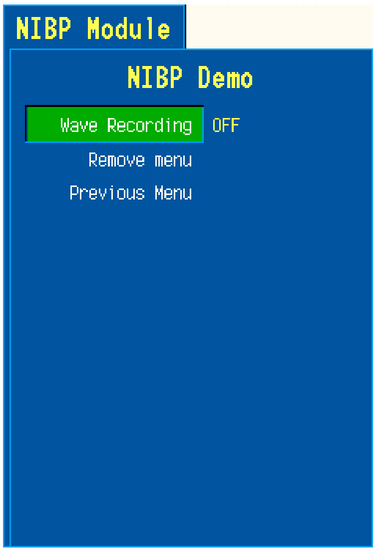
**AD0** to **AD7** show the values of each eight channels of A/D converter.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum in the EPROM is in accordance with the one the software has calculated.

**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.1.1 NIBP demo menu



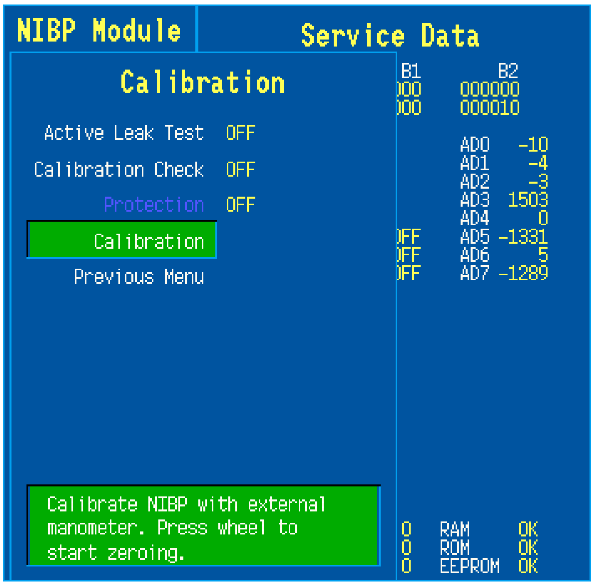

A service menu for demonstrating the oscillometric method of NIBP measurement. The menu shows the realtime pressure signals that are measured from the NIBP cuff. The measurement result is shown in the adjoining digit field.

**Wave Recording** **Wave Recording** is for selecting the recording option. If ON is selected, the pressure signals are recorded in realtime onto the M-REC paper.

**Remove menu** **Remove menu** widens the displayed waveform area.

**Previous Menu** The menu can be closed by selecting the **Previous Menu** or just by pressing the ComWheel if the **Remove menu** was selected.

### 5.1.2 NIBP calibration menu




**Active Leak Test** Wrap an adult cuff around a pipe and connect the cuff to the module. Select the active leak test (ON). The module automatically pumps a pressure of 260 mmHg into the cuff. Wait for several seconds until the pressure stabilizes. Then check that the pressure reading does not drop more than 6 mmHg per minute. If it does, leaking point(s) should be detected and fixed. Cancel the test by selecting Active leak test OFF.

**Calibration Check**

After the calibration check is selected (ON), manually pump pressure into the module and make sure that the same pressure values are shown both on the display and on manometer. Pressure of both pressure channels B1 and B2 are shown. Note that if the display shows +2 mmHg at zero pressure and if you pumped +200 mmHg into the module, the display should show +202 mmHg.

**Protection** Software calibration protection (ON/OFF). Select OFF when calibrating. Protection can be set to ON or OFF only when the toggle switch at the bottom of the module is set to the right.

**Calibration** Calibration selection is available only when protection is OFF.

NIBP calibration can be performed in the NIBP Service menu as follows:

NOTE: Both channels B1 and B2 must be calibrated simultaneously.

1. If **Protection** is ON change it to OFF by first turning the toggle switch to the right at the bottom of the module, which enables the **Protection** selection. Then turn the toggle switch to the left to enable **Calibration**.

NOTE : Do not disconnect the module from the frame when turning the switch. The module must be in the frame during the whole procedure.

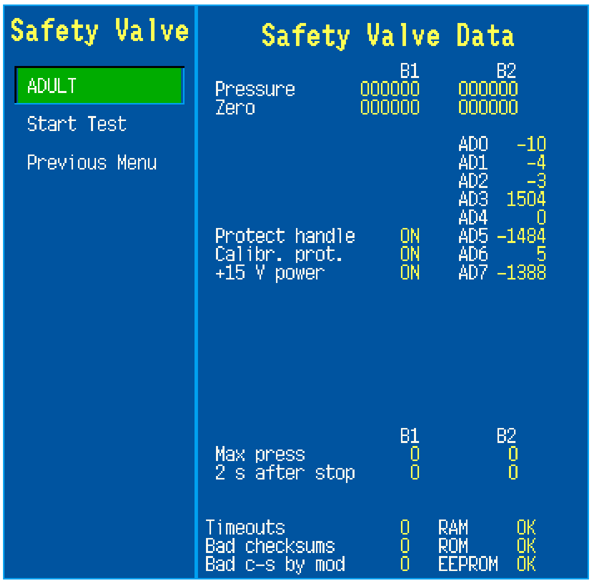
NOTE: When the switch is at the right, the NIBP field shows an error message ‘Calibration switch on!’.

NOTE: When calibration is enabled, a message ‘Calibration not protected’ appears.

2. For proper zeroing to take place, remove the hose from the front panel connector. Select ***Calibration*** and push the ComWheel. Messages ‘Zeroing’ and ‘Zeroed’ will appear in the NIBP message field. After this a pressure bar will appear beside the menu.

3. Connect an external mercury manometer with pump to module through the both tubes of the hose. Pump up to about 200 mmHg pressure (range of 150 to 300 mmHg allowed) according to the manometer. Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel.
4. When the values are equal, push the ComWheel to confirm the calibration. First the message 'Calibrating' will appear in the digit fields for NIBP followed after a few seconds 'Calibrated', which means that the calibration data has now been saved.
   NOTE! When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct (i.e. change the value for example one step higher and then back one step lower). "Calibrated" text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.
5. Use the bottom switch to enable **Protection** setting and set it ON, and finally disable **Protection** setting.

### 5.1.3 NIBP safety valve menu




**Start Test** **Start test** is for starting and **Stop test** is for stopping the Safety Valve test.

### Safety Valve Data

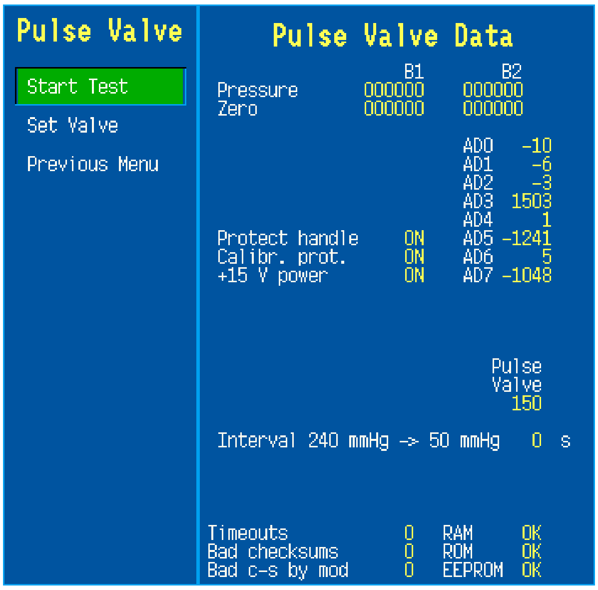
See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

**Max. press** and **2 s after stop** show the measured values at Safety Valve test.

**Safety Valve Test Adult/Infant**
Wrap an adult cuff around a pipe and connect the cuff to the module. Highlight **Start test** and give the ComWheel a push. The test ends automatically or when **Stop test** (appears in place of **Start test**) is pushed.

**Max. press** indicates the pressure at which the safety valve opens and is normally 310 ±15 mmHg for adult and 150 mmHg ±15 mmHg for infant. **2 s after stop** indicates the pressure at 2 seconds after the pump has stopped and is normally > 280 mmHg for adult and > 120 mmHg for infant. If the value is less, check leakage by the active leak test.

## 5.1.4 NIBP pulse valve menu




**Start Test** **Start test** is for starting and **Stop test** is for stopping the test.

**Set Valve** **Set Valve** lets you adjust the opening of the pulse valve.

## Pulse Valve Data

See NIBP Service menu in chapter 5.1 for information on general items Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0 to **AD7** as well as **Timeouts etc.**

### Pulse Valve Checking

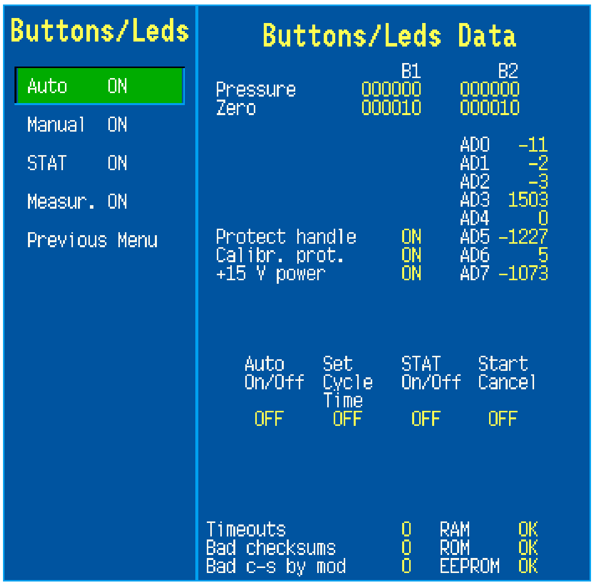
Wrap an adult cuff around a pipe and connect the cuff to the module. Select the **Start test** and push the ComWheel. The pressure rises beyond 240 mmHg and stops. The pulse valve opens. The module counts the time it takes for the pressure to go down from 240 mmHg to 50 mmHg and displays it on the screen. The test can be manually stopped by selecting **Stop test**.

The valve can be adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First select Set Valve and push the ComWheel. See the pulse valve value and adjust it by turning the ComWheel. Then push the ComWheel to confirm the value.

The '**Interval 240 mmHg -> 50 mmHg**' time should be less than 60 seconds when the valve is '150' and less than 10 when fully opened (255). When fully closed (0), the system should be airtight and the pressure does not drop. Depending on an individual, the pulse valve may remain closed up to approx. value 100.

If the measured time deviates much from those above, then the pulse valve or its tubes are faulty.

### 5.1.5 NIBP buttons/leds menu



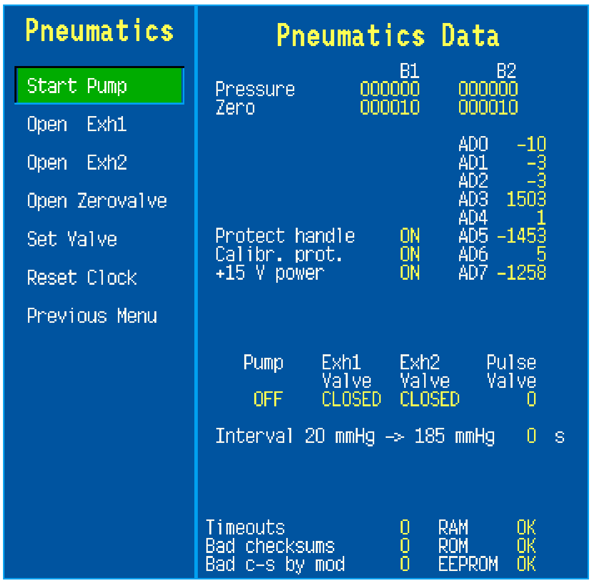

The selections ***Auto ON/OFF***, ***Manual ON/OFF***, ***STAT ON/OFF***, and ***Measur. ON/OFF*** have no effect on the module.

### Buttons/Leds Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

**Buttons Checking**
The front panel keys function is confirmed by pressing the key and observing OFF turns to ON at **Auto On/Off**, and **Start Cancel**.

## 5.1.6 NIBP pneumatics menu




**Start Pump/Stop Pump**

A manual control for the pump. The selection changes to **Stop Pump** when the pump turns on.

**Open Exh1/Close Exh1**

A manual control for the exhaust valve 1. The selection changes to Close Exh1 when the valve is opened.

**Open Exh2/Close Exh2**

A manual control for the exhaust valve 2. The selection changes to **Close Exh2** when the valve is opened.

**Set Valve** With **Set Valve**, the opening of the pulse valve is adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First push the ComWheel, then turn it to adjust the value on screen and finally push to set the value.

**Reset Clock** **Reset Clock** will zero the time on the display.

### Pneumatics Data field

See NIBP service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

**Pump, Exh1 Valve**, and **Exh2 Valve** show their states.

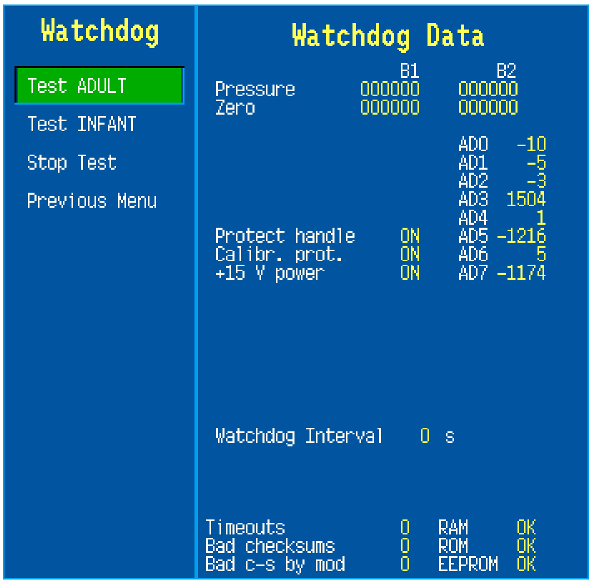
**Pulse Valve** shows how much the valve is opened (0 to 255) during Valve Setting.

**Interval 20 mmHg -> 185 mmHg Checking**
Select the **Start pump** at different combinations of the valves open/closed and push the ComWheel. The module counts the time it takes for the pressure to go up from 20 mmHg to 185 mmHg and displays it. When all the valves are closed, the pump should be able to pump the pressure in about 1 to 4 seconds into an adult cuff wrapped around a pipe. The pump does not stop without selecting the **Stop Pump** by pushing the ComWheel.

**Watchdog BEEP**
Connect manometer to the front panel and pump pressure into the module. When the AD5 value

changes from negative to positive value (at about 13 mmHg) a beep is heard. This is the watchdog threshold pressure. Beyond this pressure the watchdog is active and cut pressures at about 2 min. (adult).

### 5.1.7 NIBP watchdog menu




**Test ADULT** — **Test ADULT** is to test watchdog timer in adult mode (120 to 140 seconds).

**Test INFANT** — **Test INFANT** is to test watchdog timer in infant mode (about 60 to 70 seconds).

**Stop Test** — Stop Test is for stopping the test.

### Watchdog Data field

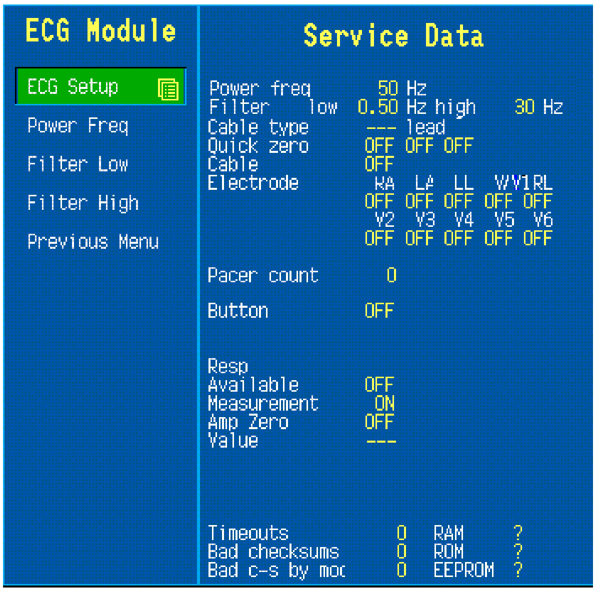
See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts etc.**

**Watchdog Interval** shows the time the +15 Vdirty stays on during the test.

**Adult watchdog time testing**
Select ***Test ADULT*** and push the ComWheel. Watchdog interval starts counting up seconds and keeps on counting as long as the +15 Vdirty is on. The time should be 120 to 140 seconds.

**Infant watchdog time testing**
Select ***Test INFANT*** and push the ComWheel. Watchdog interval starts counting up seconds and keeps on counting as long as the +15 Vdirty is on. The time should be 60 to 70 seconds.

## 5.2 ECG service menu




**Power freq** Set power frequency; 50 Hz/60 Hz.

**Filter low** Set filter low frequency; 0.05 Hz/0.5 Hz.

**Filter high** Set filter high frequency; 30 Hz (40 Hz if power freq is 60 Hz) / 100 Hz or 150 Hz @ NE12STPR.

### Service Data field

**Power freq, and Cable type** show the values chosen or detected, **Filter low and high** defines the selected filter (Monitor/Diagnostic/ST).

**Quick zero** @ NESTPR and ESTPR modules is ON when the signal in any of the three internal amplifier goes beyond scale, and therefore, a capacitor connected to the related channel discharges overvoltage. At least one of **Quick zero** values is OFF when 3-lead cable is used. All three values are OFF when 5-lead cable is used. **Quick zero** also takes place when lead is changed in 3-lead measurement. @ NE12STPR **Quick zero** is on if any of the ECG amplifiers goes beyond the scale.

**Cable** shows ON when an ECG cable is connected.

**Electrode** shows ON when each of these electrodes are connected.
**Pacer count** is a running number for pacemaker users.

The front panel ECG key function is confirmed by pressing the key and observing OFF turns to ON at **Button**.

NOTE: M-NE12STPR and M-NESTPR Module does not consist ECG key.

**Resp Available** indicates that ECG hardware is capable of measuring impedance respiration.

**Measurement** shows ON when the respiration measurement is on.

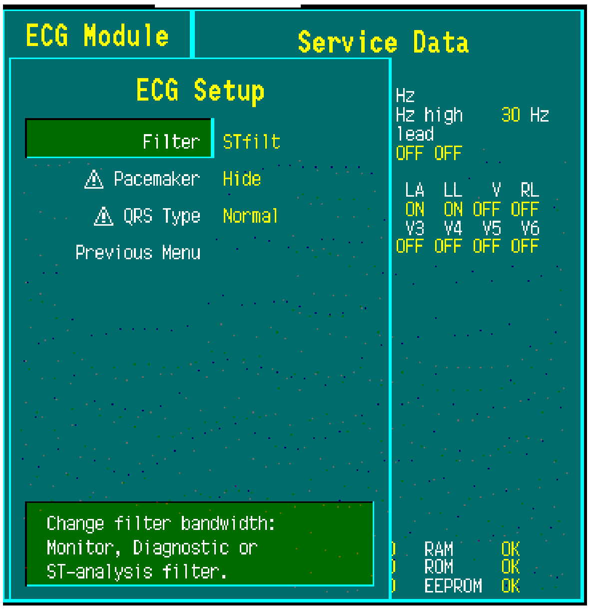
**Amp zero** shows ON when zeroing of the respiration amplifier takes place.

Waveform **VALUE** will be updated in one second interval.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum at the EPROM is in accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.2.1 ECG setup menu




**Filter**

Filters the ECG signal high frequency noise and slow respiratory artefacts.

**Monit** (monitor) filter is used in routine monitoring. It effectively filters the artefacts caused by the electrosurgery unit and respiration.

**Diagn** (diagnostic) filter is used if more accurate information of the waveform is needed (e.g., of P-wave or AV block). The diagnostic filter is more susceptible to both high frequencies and baseline wander than monitor filter.

**STfilt** (ST filter) permits more accurate information of ST segment. It filters the high frequency artefacts caused by electrosurgery unit but catches the slow changes in ST segment. The ST filter is more susceptible to baseline wander than the monitor filter.

**Pacemaker**

Selects how to display the pacing pulse of cardiac pacemaker. The selections are **Show, Hide**, **ON R** and **Sensit**.

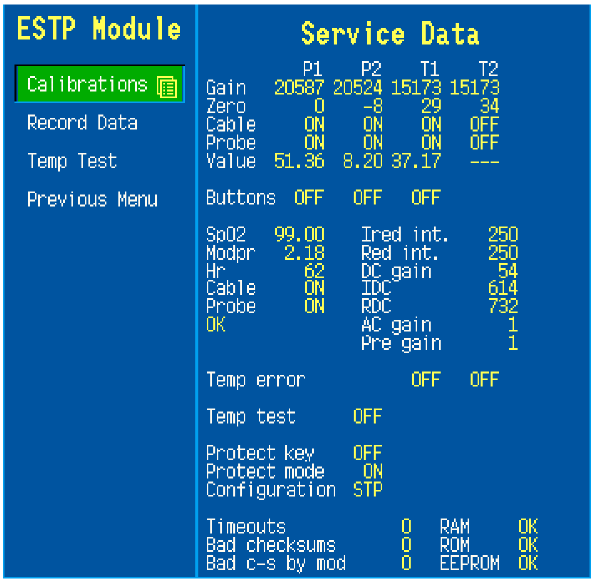
**Hide**, the pacing pulse is filtered away from ECG data.

**Show**, the pacer pulse is filtered away from ECG data but the pulse is displayed as a constant height marker.

**ON R,** pacing pulses are not filtered away from ECG data. This improves ECG monitoring with A-V pacemaker patients, as QRS complexes are counted even if the pacing pulse hits the QRS complex. However, during asystole the monitor may count pacing pulses as heart beats.

**Sensit** selection uses a more sensitive pacemaker detection. Pacemaker spike is displayed on ECG.

## 5.3 STP service menu




**Record Data** Record Data prints out the shown service data and board information (id, serial number and sw id) onto the recorder module, M-REC.

**Temp Test** **Temp Test** activates the automatic temperature test for the temperature channels T1 and T2. The result from the test is shown in the service data field.

NOTE: The Temp Test needs to be selected twice before the test starts.

### Service Data field

**Gain** is a coefficient to compensate gain error. Usually the values for P1 and P2 are between 17000 and 25000 and for T1 and T2 between 13000 and 14300. **Zero** indicates offset compensation value of each parameter in A/D converter. Typically the values for P1 and P2 are within ±1000 and for T1 and T2 between -150 and +300. Calibrate if zero and/or gain value is outside the ranges.

**Cable** shows ON when a corresponding cable is connected to the front panel and **Probe** shows ON when a corresponding probe is connected to the cable.

Under **Value** the measured numeric values are displayed simultaneously. Pressure values are real time values and shown in mmHg. Temperature values are shown in degrees Celsius.

The front panel STP keys functions are confirmed by pressing each key and observing OFF turns to ON at **Button**.

**$SpO_2$** shows measured beat-to-beat $SpO_2$ value. **Modpr** is a modulation % that indicates AC/DC ratio in the measured signal. **Hr** is a pulse rate calculated from every beat.

**Cable** and **Probe** can be either OFF or ON, and these indicate the state PROBE OFF.
Under them there is a message field for $SpO_2$. It can be OK, PULSE SEARCH, NO PROBE, PROBE OFF, NO PULSE, ARTEFACT, POOR SIGNAL, or CHECK PROBE.

Balance between leds is adjusted by changing the intensity of red/infrared. Intensity of infrared (**Ired int.**) is in the range of 40 to 255 and red intensity (**red int.**)is in the range of 40 to 255.

**DC gain** shows the gain of DC signal adjusted by the module.

**IDC** is the value of infrared signal.

**RDC** is the dc value of red signal.

**AC gain** is the gain of infrared and red ac signals. AC gain values can be 1 or 0. Value 1 means high ac gain and 0 means low gain.

**Pre gain** is a preamplifier gain for infrared and red signals. Pre gain values can be 1 or 0. Value 1 means normal operation. Value 0 means that signal levels are very low and extra gain is taken into use.

**Temp error** shows the status of the temperature test. No errors found shows the status (OFF) and errors found (ON).

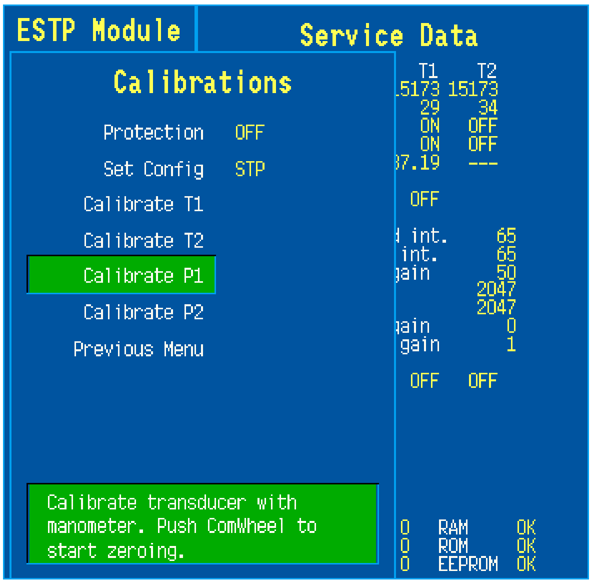
**Protect key** shows normally OFF but turns to ON when the button at the bottom of the module is pressed.

**Protect mode** is normally ON. It turns to OFF when Protect is switched to OFF for the temperature calibration in Calibration Menu.
**Configuration** shows the chosen module configuration: TP, ST, or STP.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor’s inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum at the EPROM is in accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.3.1 STP calibration menu




**Protection** Protection for the configuration and temperature calibrations can be set ON and OFF only when protect button at the bottom of the module is pressed.

**Set Config** The module configuration should be set according to the module type. The setting is possible only when the protection is set OFF. The available selections are TP, ST or STP. The configuration setting should be checked if the STP board is replaced.

**Calibrate T1 / Calibrate T2**

The functions are for calibrating the temperature channels T1 and T2. The calibrations are possible only when the protection is set OFF. The temperature calibration requires accurate test plugs of value 25 °C and 45 °C.

Calibration:

1. Select ***Calibrate T1/Calibrate T2***
2. Insert the test plug 25 °C into the T1/T2 connector
3. Press the ComWheel
4. Insert the test plug 45 °C into the T1/T2 connector
5. Press the ComWheel

**Calibrate P1/Calibrate P2**

The functions are for calibrating the invasive blood pressure channels P1 and P2. The calibrations require a pressure transducer (with an appropriate cable) and a pressure manometer.

1. Connect the pressure transducer with the pressure manometer to the P1/P2 connector. Select ***Calibrate P1/Calibrate P2***. Leave the transducer to room air pressure.
2. Press the ComWheel to start zeroing.
3. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
4. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel.

# 6 SPARE PARTS

## 6.1 Spare parts list

### 6.1.1 M-ESTP rev. 01, M-ETP rev. 00, M-EST rev. 00

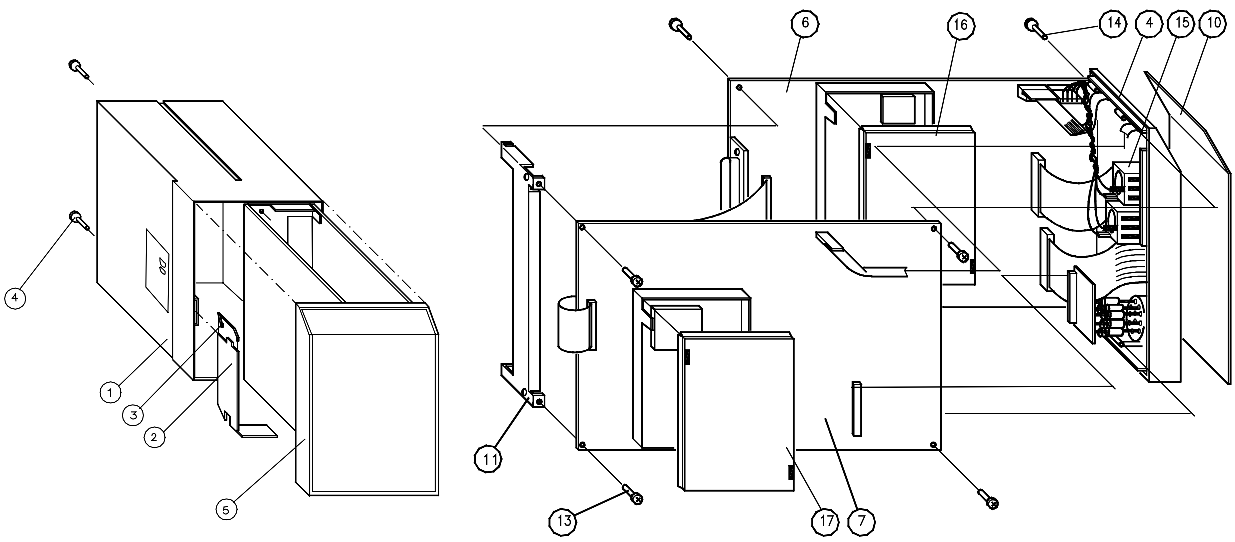



**Figure 17 Exploded view of M-ESTP Module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (wide) | 886168 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front mask unit, M-EST (rev.00) | 880946 | |
| 5 | Front mask unit, M-EST (rev.01-02) | 882129 | |
| 5 | Front mask unit, M-EST (rev.03-04) | 887155 | |
| 5 | Front mask unit, M-ESTP (rev. 01) | 880337 | |
| 5 | Front mask unit, M-ESTP (rev.02-03) | 882127 | |
| 5 | Front mask unit, M-ESTP (rev.04-05) | 887153 | |
| 5 | Front mask unit, M-ESTPR (rev.03-04) | 894161 | |
| 5 | Front mask unit, M-ESTR (rev.03-04) | 894162 | |
| 5 | Front mask unit, M-ETP (rev.00) | 880941 | |
| 5 | Front mask unit, M-ETP (rev.01-02) | 882128 | |
| 5 | Front mask unit, M-ETP (rev.03-04) | 887154 | |
| 5 | Front mask unit, M-ETPR (rev.03-04) | 894163 | |
| 6 | PP board, M-PP, M-ESTPR | 891442 | 8000801 |
| 6 | STP board, M-ESTPR | 8000801 | 8002575 |
| 6 | STP board, M-ESTP (rev.01), M-P (rev.00-01) | 880339 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 6 | STP board, M-ESTP (rev.03-05), M-P(rev.02) | 882627 | |
| 6 | STP board, M-ESTPR | 8002575 | |
| 6 | STP board (rev.02) | 882130 | 882627 |
| 7 | ECG board | 884609 | 888956 |
| 7 | ECG board, M-ESTP | 888957 | |
| 7 | ECG board, M-ESTP (rev.03) | 883119 | 888957 |
| 7 | ECG board, M-ESTP (rev.04) | 886748 | 888957 |
| 7 | ECG board, M-ESTP(rev.01) | 880338 | |
| 7 | ECG board,M-ESTP (rev.02) | 882025 | 888957 |
| 7 | ECG/RESP board, M-ESTPR (Rev.02) | 888956 | |
| 8 | Membrane keypad | 879374 | |
| 10 | Front Panel sticker, DA ; M-ESTPR (rev.01-03) | 892207 | 898504 |
| 10 | Front Panel sticker, DA ; M-ESTPR (rev.04) ; S/5 | 898504 | |
| 10 | Front Panel sticker, DA ; M-ESTR (rev.01-03) | 892208 | 898565 |
| 10 | Front Panel sticker, DA ; M-ESTR (rev.04) ; S/5 | 898565 | |
| 10 | Front Panel sticker, DA ; M-ETPR (rev.01-03) | 892209 | 898578 |
| 10 | Front Panel sticker, DA ; M-ETPR (rev.04) ; S/5 | 898578 | |
| 10 | Front Panel sticker, DE ; M-EST (rev.00) | 880453 | |
| 10 | Front Panel sticker, DE ; M-EST (rev.01--) | 881961 | |
| 10 | Front Panel sticker, DE ; M-ESTP (rev.01) | 880552 | |
| 10 | Front Panel sticker, DE ; M-ESTP (rev.02--) | 881955 | |
| 10 | Front Panel sticker, DE ; M-ESTPR (rev.04) ; S/5 | 898495 | |
| 10 | Front Panel sticker, DE ; M-ESTPR (rev.01-03) | 886966 | 898495 |
| 10 | Front Panel sticker, DE ; M-ESTR (rev.01-03) | 886968 | 898556 |
| 10 | Front Panel sticker, DE ; M-ESTR (rev.04) ; S/5 | 898556 | |
| 10 | Front Panel sticker, DE ; M-ETP (rev.00) | 880560 | |
| 10 | Front Panel sticker, DE ; M-ETP (rev.01--) | 881958 | |
| 10 | Front Panel sticker, DE ; M-ETPR (rev.01-03) | 886967 | 898569 |
| 10 | Front Panel sticker, DE ; M-ETPR (rev.04) ; S/5 | 898569 | |
| 10 | Front Panel sticker, EN ; M-EST (rev.00) | 880138 | |
| 10 | Front Panel sticker, EN ; M-EST (rev.01--) | 881959 | |
| 10 | Front Panel sticker, EN ; M-ESTP (rev.01) | 879481 | |
| 10 | Front Panel sticker, EN ; M-ESTP (rev.02--) | 881953 | |
| 10 | Front Panel sticker, EN ; M-ESTPR (rev.01-03) | 886603 | 898494 |
| 10 | Front Panel sticker, EN ; M-ESTPR (rev.04) ; S/5 | 898494 | |
| 10 | Front Panel sticker, EN ; M-ESTR (rev.01-03) | 886605 | 898555 |
| 10 | Front Panel sticker, EN ; M-ESTR (rev.04) ; S/5 | 898555 | |
| 10 | Front Panel sticker, EN ; M-ETP (rev.00) | 880428 | |
| 10 | Front Panel sticker, EN ; M-ETP (rev.01--) | 881956 | |
| 10 | Front Panel sticker, EN ; M-ETPR (rev.01-03) | 886604 | 898568 |
| 10 | Front Panel sticker, EN ; M-ETPR (rev.04) ; S/5 | 898568 | |
| 10 | Front Panel sticker, ES ; M-EST (rev.01--) | 885044 | |
| 10 | Front Panel sticker, ES ; M-ESTP (rev.02--) | 884200 | |
| 10 | Front Panel sticker, ES ; M-ESTPR (rev.01-03) | 886943 | 898498 |
| 10 | Front Panel sticker, ES ; M-ESTPR (rev.04) ; S/5 | 898498 | |
| 10 | Front Panel sticker, ES ; M-ESTR (rev.01-03) | 886945 | 898559 |
| 10 | Front Panel sticker, ES ; M-ESTR (rev.04) ; S/5 | 898559 | |
| 10 | Front Panel sticker, ES ; M-ETP (rev.01--) | 885043 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 10 | Front Panel sticker, ES ; M-ETPR (rev.01-03) | 886944 | 898572 |
| 10 | Front Panel sticker, ES ; M-ETPR (rev.04) ; S/5 | 898572 | |
| 10 | Front Panel sticker, FI ; M-ESTPR (rev.01-03) | 888868 | 898501 |
| 10 | Front Panel sticker, FI ; M-ESTPR (rev.04) ; S/5 | 898501 | |
| 10 | Front Panel sticker, FI ; M-ESTR (rev.01-03) | 888870 | 898562 |
| 10 | Front Panel sticker, FI ; M-ESTR (rev.04) ; S/5 | 898562 | |
| 10 | Front Panel sticker, FI ; M-ETPR (rev.01-03) | 888869 | 898575 |
| 10 | Front Panel sticker, FI ; M-ETPR (rev.04) ; S/5 | 898575 | |
| 10 | Front Panel sticker, FR ; M-EST (rev.00) | 880140 | |
| 10 | Front Panel sticker, FR ; M-EST (rev.01--) | 881960 | |
| 10 | Front Panel sticker, FR ; M-ESTP (rev.01) | 880158 | |
| 10 | Front Panel sticker, FR : M-ESTP (rev.02--) | 881954 | |
| 10 | Front Panel sticker, FR ; M-ESTPR (rev.01-03) | 886963 | 898496 |
| 10 | Front Panel sticker, FR ; M-ESTPR (rev.04) ; S/5 | 898496 | |
| 10 | Front Panel sticker, FR ; M-ESTR (rev.01-03) | 886964 | 898557 |
| 10 | Front Panel sticker, FR ; M-ESTR (rev.04) ; S/5 | 898557 | |
| 10 | Front Panel sticker, FR ; M-ETP (rev.00) | 880429 | |
| 10 | Front Panel sticker, FR ; M-ETP (rev.01--) | 881957 | |
| 10 | Front Panel sticker, FR ; M-ETPR (rev.01-03) | 886965 | 898570 |
| 10 | Front Panel sticker, FR ; M-ETPR (rev.04) ; S/5 | 898570 | |
| 10 | Front Panel sticker, IT ; M-EST (rev.01--) | 886755 | |
| 10 | Front Panel sticker, IT ; M-ESTP (rev.02--) | 886753 | |
| 10 | Front Panel sticker, IT ; M-ESTPR (rev.01-03) | 886925 | 898499 |
| 10 | Front Panel sticker, IT ; M-ESTPR (rev.04) ; S/5 | 898499 | |
| 10 | Front Panel sticker, IT ; M-ESTR (rev.01-03) | 886927 | 898560 |
| 10 | Front Panel sticker, IT ; M-ESTR (rev.04) ; S/5 | 898560 | |
| 10 | Front Panel sticker, IT ; M-ETP (rev.01--) | 886754 | |
| 10 | Front Panel sticker, IT ; M-ETPR (rev.01-03) | 886926 | 898573 |
| 10 | Front Panel sticker, IT ; M-ETPR (rev.04) ; S/5 | 898573 | |
| 10 | Front Panel sticker, JA ; M-ESTPR (rev.01-03) | 888303 | 898505 |
| 10 | Front Panel sticker, JA ; M-ESTPR (rev.04) ; S/5 | 898505 | |
| 10 | Front Panel sticker, JA ; M-ESTR (rev.01-03) | 888304 | 898566 |
| 10 | Front Panel sticker, JA ; M-ESTR (rev.04) ; S/5 | 898566 | |
| 10 | Front Panel sticker, JA ; M-ETPR (rev.01-03) | 888305 | 898579 |
| 10 | Front Panel sticker, JA ; M-ETPR (rev.04) ; S/5 | 898579 | |
| 10 | Front Panel sticker, NL ; M-EST (rev.01--) | 886045 | |
| 10 | Front Panel sticker, NL ; M-ESTP (rev.02--) | 886044 | |
| 10 | Front Panel sticker, NL ; M-ESTPR (rev.01-03) | 886937 | 898497 |
| 10 | Front Panel sticker, NL ; M-ESTPR (rev.04) ; S/5 | 898497 | |
| 10 | Front Panel sticker, NL ; M-ESTR (rev.01-03) | 886939 | 898558 |
| 10 | Front Panel sticker, NL ; M-ESTR (rev.04) ; S/5 | 898558 | |
| 10 | Front Panel sticker, NL ; M-ETP (rev.01--) | 886046 | |
| 10 | Front Panel sticker, NL ; M-ETPR (rev.01-03) | 886938 | 898571 |
| 10 | Front Panel sticker, NL ; M-ETPR (rev.04) ; S/5 | 898571 | |
| 10 | Front Panel sticker, NO ; M-ESTPR (rev.01-03) | 893554 | 898503 |
| 10 | Front Panel sticker, NO ; M-ESTPR (rev.04) ; S/5 | 898503 | |
| 10 | Front Panel sticker, NO ; M-ESTR (rev.01-03) | 893556 | 898564 |
| 10 | Front Panel sticker, NO ; M-ESTR (rev.04) ; S/5 | 898564 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 10 | Front Panel sticker, NO ; M-ETPR (rev.01-03) | 893555 | 898577 |
| 10 | Front Panel sticker, NO ; M-ETPR (rev.04) ; S/5 | 898577 | |
| 10 | Front Panel sticker, PT ; M-ESTPR (rev.01-03) | 895249 | 898500 |
| 10 | Front Panel sticker, PT ; M-ESTPR (rev.04) ; S/5 | 898500 | |
| 10 | Front Panel sticker, PT ; M-ESTR (rev.01-03) | 895250 | 898561 |
| 10 | Front Panel sticker, PT ; M-ESTR (rev.04) ; S/5 | 898561 | |
| 10 | Front Panel sticker, PT ; M-ETPR (rev.01-03) | 895251 | 898574 |
| 10 | Front Panel sticker, PT ; M-ETPR (rev.04) ; S/5 | 898574 | |
| 10 | Front Panel sticker, SV ; M-EST (rev.01--) | 885859 | |
| 10 | Front Panel sticker, SV ; M-ESTP (rev.02--) | 885857 | |
| 10 | Front Panel sticker, SV ; M-ESTPR (rev.01-03) | 886928 | 898502 |
| 10 | Front Panel sticker, SV ; M-ESTPR (rev.04) ; S/5 | 898502 | |
| 10 | Front Panel sticker, SV ; M-ESTR (rev.01-03) | 886930 | 898563 |
| 10 | Front Panel sticker, SV ; M-ESTR (rev.04) ; S/5 | 898563 | |
| 10 | Front Panel sticker, SV ; M-ETP (rev.01--) | 885856 | |
| 10 | Front Panel sticker, SV ; M-ETPR (rev.01-03) | 886929 | 898576 |
| 10 | Front Panel sticker, SV ; M-ETPR (rev.04) ; S/5 | 898576 | |
| 11 | Metal frame | 879183 | |
| 11 | Metal frame | 879184 | |
| 13 | Cross cylinder-head screw M3x6 | 61721 | |
| 14 | Cross cylinder-head scerw M3x12 | 628700 | |
| 15 | T-Input Board, M-ESTP (rev.02-03) | 882090 | |
| 15 | T-Input connectors | 887152 | |
| 16 | EMC cover | 884099 | |
| 17 | EMC cover | 886818 | |

A front panel unit includes all the connectors and input boards.

NOTE: The STP board 882627 can be used as a replacement only with STP software 884342.

NOTE: The ECG board 888957 can be used as a replacement only with ECG software 883806.

NOTE: The STP board 891442 can be used as a replacement only with STP software 891401.

NOTE: The STP board 8000801 includes the STP software 8000717.

NOTE: The STP board 8002575 includes the STP software 8002573.

## 6.1.2 M-NESTPR rev. 00, M-NETPR rev. 00, M-NESTR rev. 00

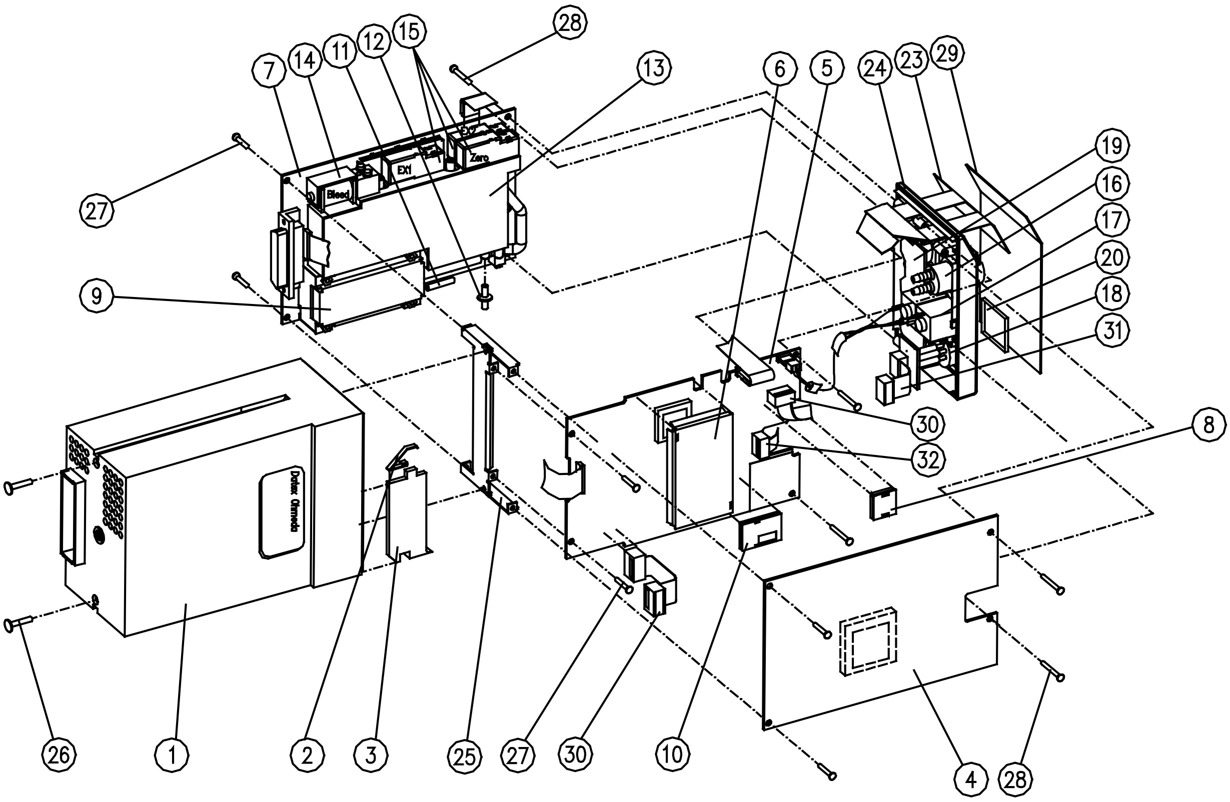



**Figure 18 Exploded view of M-NESTPR Module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (wide) | 886168 | |
| 2 | Spring pin | 879182 | |
| 3 | Latch for module box | 879181 | |
| 4 | ECG/RESP board, M-NESTPR (rev.00) | 889988 | |
| 5 | STP board M-NESTPR (rev.00) | 890007 | 8000800 |
| 5 | STP board M-NESTPR (rev.00) | 890007 | 8002574 |
| 5 | STP-board | 8000800 | 8002574 |
| 5 | STP-board, M-NE12STPR | 8002574 | |
| 6 | EMC cover | 884099 | |
| 7 | NIPB board, M-NESTPR (rev.00) | 887520 | |
| | NIBP board software | 888237 | |
| 8 | EMC cover | 892305 | |
| 9 | NIPB pump, M-NESTPR, M-NIBP (rev.04) | 889993 | |
| 10 | EMC cover | 892307 | |
| 11 | Air filter (NIBP) | 57142 | |
| 12 | Check valve | 58542 | |
| 13 | Damping chamber, M-NESTPR, M-NIBP (rev.04) | 888240 | |
| 14 | Bleed valve, M-NESTPR, M-NIBP (rev.04) | 58566 | |
| 15 | Magnetic valve | 58562 | |
| 16 | NIBP Cuff connector | 64654 | |
| 17 | T-Input connectors | 887152 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 18 | ECG Input Board, M-NESTPR (rev.00) | 889985 | |
| 19 | P Input Board, M-NESTPR (rev.00) | 890834 | |
| 19 | SP Input Board, M-NESTPR (rev.00) | 890006 | |
| 19 | SPO2 Input Board, M-NESTR (rev.00), M-MRIP (rev.00) | 890833 | |
| 20 | Fitting plate | 879510 | |
| 23 | Membrane keypad | 888242 | |
| 24 | Front panel unit, M-NESTPR | 888273 | |
| 24 | Front panel unit, M-NESTR | 891748 | |
| 24 | Front panel unit, M-NETPR | 891772 | |
| 25 | Metal frame | 888230 | |
| 26 | Cross recess screw M3x8 black | 616215 | |
| 27 | Cross cylinder-head screw M3x6 | 61721 | |
| 27 | Cross cylinder-head screw M3x6 | 61721 | |
| 28 | Cross cylinder-head scerw M3x12 | 628700 | |
| 28 | Cross cylinder-head scerw M3x12 | 628700 | |
| 29 | Front Panel sticker, DA ; M-NESTPR (rev.00) | 892204 | 898429 |
| 29 | Front Panel sticker, DA ; M-NESTPR (rev.01) ; S/5 | 898429 | |
| 29 | Front Panel sticker, DA ; M-NESTR (rev.00) | 892205 | 898458 |
| 29 | Front Panel sticker, DA ; M-NESTR (rev.01) ; S/5 | 898458 | |
| 29 | Front Panel sticker, DA ; M-NETPR (rev.00) | 892206 | 898492 |
| 29 | Front Panel sticker, DA ; M-NETPR (rev.01) ; S/5 | 898492 | |
| 29 | Front Panel sticker, DE ; M-NESTPR (rev.00) | 891166 | 898420 |
| 29 | Front Panel sticker, DE ; M-NESTPR (rev.01) ; S/5 | 898420 | |
| 29 | Front Panel sticker, DE ; M-NESTR (rev.00) | 891671 | 898449 |
| 29 | Front Panel sticker, DE ; M-NESTR (rev.01) ; S/5 | 898449 | |
| 29 | Front Panel sticker, DE ; M-NETPR (rev.00) | 891678 | 898483 |
| 29 | Front Panel sticker, DE ; M-NETPR (rev.01) ; S/5 | 898483 | |
| 29 | Front Panel sticker, EN ; M-NESTPR (rev.00) | 889264 | 898419 |
| 29 | Front Panel sticker, EN ; M-NESTPR (rev.01) ; S/5 | 898419 | |
| 29 | Front Panel sticker, EN ; M-NESTR (rev.00) | 891456 | 898448 |
| 29 | Front Panel sticker, EN ; M-NESTR (rev.01) ; S/5 | 898448 | |
| 29 | Front Panel sticker, EN ; M-NETPR (rev.00) | 891457 | 898482 |
| 29 | Front Panel sticker, EN ; M-NETPR (rev.01) ; S/5 | 898482 | |
| 29 | Front Panel sticker, ES ; M-NESTPR (rev.00) | 891171 | 898423 |
| 29 | Front Panel sticker, ES ; M-NESTPR (rev.01) ; S/5 | 898423 | |
| 29 | Front Panel sticker, ES ; M-NESTR (rev.00) | 891674 | 898452 |
| 29 | Front Panel sticker, ES ; M-NESTR (rev.01) ; S/5 | 898452 | |
| 29 | Front Panel sticker, ES ; M-NETPR (rev.00) | 891681 | 898486 |
| 29 | Front Panel sticker, ES ; M-NETPR (rev.01) ; S/5 | 898486 | |
| 29 | Front Panel sticker, FI ; M-NESTPR (rev.00) | 891170 | 898426 |
| 29 | Front Panel sticker, FI ; M-NESTPR (rev.01) ; S/5 | 898426 | |
| 29 | Front Panel sticker, FI ; M-NESTR (rev.00) | 891676 | 898455 |
| 29 | Front Panel sticker, FI ; M-NESTR (rev.01) ; S/5 | 898455 | |
| 29 | Front Panel sticker, FI ; M-NETPR (rev.00) | 891683 | 898489 |
| 29 | Front Panel sticker, FI ; M-NETPR (rev.01) ; S/5 | 898489 | |
| 29 | Front Panel sticker, FR ; M-NESTPR (rev.00) | 891167 | 898421 |
| 29 | Front Panel sticker, FR ; M-NESTPR (rev.01) ; S/5 | 898421 | |
| 29 | Front Panel sticker, FR ; M-NESTR (rev.00) | 891672 | 898450 |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 29 | Front Panel sticker, FR ; M-NESTR (rev.01) ; S/5 | 898450 | |
| 29 | Front Panel sticker, FR ; M-NETPR (rev.00) | 891679 | 898484 |
| 29 | Front Panel sticker, FR ; M-NETPR (rev.01) ; S/5 | 898484 | |
| 29 | Front Panel sticker, IT ; M-NESTPR (rev.00) | 891172 | 898424 |
| 29 | Front Panel sticker, IT ; M-NESTPR (rev.01) ; S/5 | 898424 | |
| 29 | Front Panel sticker, IT ; M-NESTR (rev.00) | 891675 | 898453 |
| 29 | Front Panel sticker, IT ; M-NESTR (rev.01) ; S/5 | 898453 | |
| 29 | Front Panel sticker, IT ; M-NETPR (rev.00) | 891682 | 898487 |
| 29 | Front Panel sticker, IT ; M-NETPR (rev.01) ; S/5 | 898487 | |
| 29 | Front Panel sticker, JA ; M-NESTPR (rev.00) | 894963 | 898430 |
| 29 | Front Panel sticker, JA ; M-NESTPR (rev.01) ; S/5 | 898430 | |
| 29 | Front Panel sticker, JA ; M-NESTR (rev.00) | 894964 | 898459 |
| 29 | Front Panel sticker, JA ; M-NESTR (rev.01) ; S/5 | 898459 | |
| 29 | Front Panel sticker, JA ; M-NETPR (rev.00) | 894965 | 8000380 |
| 29 | Front Panel Sticker, JA ; M-NETPR (rev.01) ; S/5 | 8000380 | |
| 29 | Front Panel sticker, NL ; M-NESTPR (rev.00) | 891168 | 898422 |
| 29 | Front Panel sticker, NL ; M-NESTPR (rev.01) ; S/5 | 898422 | |
| 29 | Front Panel sticker, NL ; M-NESTR (rev.00) | 891673 | 898451 |
| 29 | Front Panel sticker, NL ; M-NESTR (rev.01) ; S/5 | 898451 | |
| 29 | Front Panel sticker, NL ; M-NETPR (rev.00) | 891680 | 898485 |
| 29 | Front Panel sticker, NL ; M-NETPR (rev.01) ; S/5 | 898485 | |
| 29 | Front Panel sticker, NO ; M-NESTPR (rev.00) | 893566 | 898428 |
| 29 | Front Panel sticker, NO ; M-NESTPR (rev.01) ; S/5 | 898428 | |
| 29 | Front Panel sticker, NO ; M-NESTR (rev.00) | 893568 | 898457 |
| 29 | Front Panel sticker, NO ; M-NESTR (rev.01) ; S/5 | 898457 | |
| 29 | Front Panel sticker, NO ; M-NETPR (rev.00) | 893567 | 898491 |
| 29 | Front Panel sticker, NO ; M-NETPR (rev.01) ; S/5 | 898491 | |
| 29 | Front Panel sticker, PT ; M-NESTPR (rev.00) | 895234 | 898425 |
| 29 | Front Panel sticker, PT ; M-NESTPR (rev.01) ; S/5 | 898425 | |
| 29 | Front Panel sticker, PT ; M-NESTR (rev.00) | 895235 | 898454 |
| 29 | Front Panel sticker, PT ; M-NESTR (rev.01) ; S/5 | 898454 | |
| 29 | Front Panel sticker, PT ; M-NETPR (rev.00) | 895236 | 898488 |
| 29 | Front Panel sticker, PT ; M-NETPR (rev.01) ; S/5 | 898488 | |
| 29 | Front Panel sticker, SV ; M-NESTPR (rev.00) | 891169 | 898427 |
| 29 | Front Panel sticker, SV ; M-NESTPR (rev.01) ; S/5 | 898427 | |
| 29 | Front Panel sticker, SV ; M-NESTR (rev.00) | 891677 | 898456 |
| 29 | Front Panel sticker, SV ; M-NESTR (rev.01) ; S/5 | 898456 | |
| 29 | Front Panel sticker, SV ; M-NETPR (rev.00) | 891684 | 898427 |
| 29 | Front Panel sticker, SV ; M-NETPR (rev.01) ; S/5 | 898490 | |
| 30 | Flat cable, STP | 890874 | |
| 30 | Flat cable, STP | 890874 | |
| 31 | Flat cable, ECG | 890876 | |
| 32 | Flat cable, M-PP | 891573 | |

A front panel unit includes all the connectors and input boards.

NOTE: The STP board 890007 can be used as a replacement only with STP software 891401.

NOTE: The STP board 8000800 includes the STP software 8000717.

NOTE: The STP board 8002574 includes the STP software 8002573.

## 6.1.3 M-NE12STPR rev. 00, M-NE12STR rev. 00, M-NE12TPR rev. 00

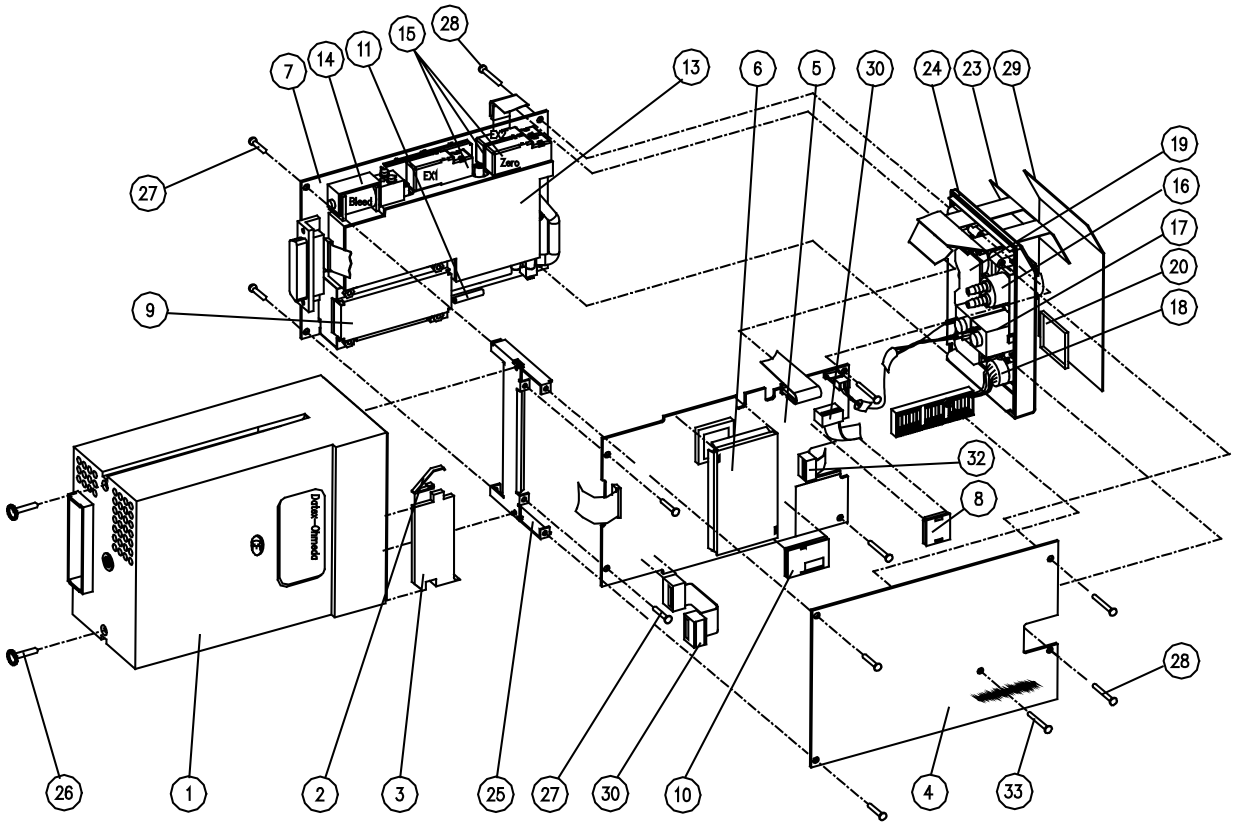



**Figure 19 Exploded view of M-NE12STPR Module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (wide) | 886168 | |
| 2 | Spring pin | 879182 | |
| 3 | Latch for module box | 879181 | |
| 4 | 12-LEAD ECG Board, M-NE12STPR | 894284 | 8000995 |
| 4 | 12-LEAD ECG BOARD II, N-NE12STPR | 8000995 | |
| 5 | STP board M-NESTPR (rev.00) | 890007 | 8000800 |
| 5 | STP board M-NESTPR (rev.00) | 890007 | 8002574 |
| 5 | STP-board | 8000800 | 8002574 |
| 5 | STP-board, M-NE12STPR | 8002574 | |
| 6 | EMC cover | 884099 | |
| 7 | NIPB board, M-NESTPR (rev.00) | 887520 | |
| | NIBP board software | 888237 | |
| 8 | EMC cover | 892305 | |
| 9 | NIPB pump, M-NESTPR, M-NIBP (rev.04) | 889993 | |
| 10 | EMC cover | 892307 | |
| 11 | Air filter (NIBP) | 57142 | |
| 13 | Damping chamber, M-NESTPR, M-NIBP (rev.04) | 888240 | |
| 14 | Bleed valve, M-NESTPR, M-NIBP (rev.04) | 58566 | |
| 15 | Magnetic valve | 58562 | |
| 16 | NIBP Cuff connector | 64654 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 17 | T-Input connectors | 887152 | |
| 18 | 12-lead ECG Input Unit | 896913 | |
| 19 | P Input Board, M-NESTPR (rev.00) | 890834 | |
| 19 | SP Input Board, M-NESTPR (rev.00) | 890006 | |
| 19 | SPO2 Input Board, M-NESTR (rev.00), M-MRIP (rev.00) | 890833 | |
| 20 | Fitting plate | 879510 | |
| 23 | Membrane keypad | 888242 | |
| 24 | Front Mask Unit, M-NE12STPR | 896910 | |
| 24 | Front Mask Unit, M-NE12STR | 896911 | |
| 24 | Front Mask Unit, M-NE12TPR | 896912 | |
| 25 | Metal frame | 888230 | |
| 26 | Cross recess screw M3x8 black | 616215 | |
| 27 | Cross cylinder-head screw M3x6 | 61721 | |
| 27 | Cross cylinder-head screw M3x6 | 61721 | |
| 28 | Cross cylinder-head scerw M3x12 | 628700 | |
| 28 | Cross cylinder-head scerw M3x12 | 628700 | |
| 29 | Front Panel sticker, DA ; M-NE12STPR (rev.00) | 897718 | 898442 |
| 29 | Front Panel sticker, DA ; M-NE12STPR (rev.01) ; S/5 | 898442 | |
| 29 | Front Panel sticker, DA ; M-NE12STR (rev.00) | 897622 | 898470 |
| 29 | Front Panel sticker, DA ; M-NE12STR (rev.01) ; S/5 | 898470 | |
| 29 | Front Panel sticker, DA ; M-NE12TPR (rev.00) | 897655 | 898481 |
| 29 | Front Panel sticker, DA ; M-NE12TPR (rev.01) ; S/5 | 898481 | |
| 29 | Front Panel sticker, DE ; M-NE12STPR (rev.00) | 897709 | 898433 |
| 29 | Front Panel sticker, DE ; M-NE12STPR (rev.01) ; S/5 | 898433 | |
| 29 | Front Panel sticker, DE ; M-NE12STR (rev.00) | 897613 | 898461 |
| 29 | Front Panel sticker, DE ; M-NE12STR (rev.01) ; S/5 | 898461 | |
| 29 | Front panel sticker, DE ; M-NE12TPR (rev.00) | 897646 | 898472 |
| 29 | Front Panel sticker, DE ; M-NE12TPR (rev.01) ; S/5 | 898472 | |
| 29 | Front Panel sticker, EN ; M-NE12STPR (rev.00) | 896985 | 898432 |
| 29 | Front Panel sticker, EN ; M-NE12STPR (rev.01) ; S/5 | 898432 | |
| 29 | Front Panel sticker, EN ; M-NE12STR (rev.00) | 896986 | 898460 |
| 29 | Front Panel sticker, EN ; M-NE12STR (rev.01) ; S/5 | 898460 | |
| 29 | Front Panel sticker, EN ; M-NE12TPR (rev.00) | 896987 | 898471 |
| 29 | Front Panel sticker, EN ; M-NE12TPR (rev.01) ; S/5 | 898471 | |
| 29 | Front Panel sticker, ES ; M-NE12STPR (rev.00) | 897712 | 898436 |
| 29 | Front Panel sticker, ES ; M-NE12STPR (rev.01) ; S/5 | 898436 | |
| 29 | Front Panel sticker, ES ; M-NE12STR (rev.00) | 897616 | 898464 |
| 29 | Front Panel sticker, ES ; M-NE12STR (rev.01) ; S/5 | 898464 | |
| 29 | Front Panel sticker, ES ; M-NE12TPR (rev.00) | 897649 | 898475 |
| 29 | Front Panel sticker, ES ; M-NE12TPR (rev.01) ; S/5 | 898475 | |
| 29 | Front Panel sticker, FI ; M-NE12STPR (rev.00) | 897715 | 898439 |
| 29 | Front Panel sticker, FI ; M-NE12STPR (rev.01) ; S/5 | 898439 | |
| 29 | Front Panel sticker, FI ; M-NE12STR (rev.00) | 897619 | 898467 |
| 29 | Front Panel sticker, FI ; M-NE12STR (rev.01) ; S/5 | 898467 | |
| 29 | Front Panel sticker, FI ; M-NE12TPR (rev.00) | 897652 | 898478 |
| 29 | Front Panel sticker, FI ; M-NE12TPR (rev.01) ; S/5 | 898478 | |
| 29 | Front Panel sticker, FR ; M-NE12STPR (rev.00) | 897710 | 898434 |
| 29 | Front Panel sticker, FR ; M-NE12STPR (rev.01) ; S/5 | 898434 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 29 | Front Panel sticker, FR ; M-NE12STR (rev.00) | 897614 | 898462 |
| 29 | Front Panel sticker, FR ; M-NE12STR (rev.01) ; S/5 | 898462 | |
| 29 | Front Panel sticker, FR ; M-NE12TPR (rev.00) | 897647 | 898473 |
| 29 | Front Panel sticker, FR ; M-NE12TPR (rev.01) ; S/5 | 898473 | |
| 29 | Front Panel sticker, IT ; M-NE12STPR (rev.00) | 897713 | 898437 |
| 29 | Front Panel sticker, IT ; M-NE12STPR (rev.01) ; S/5 | 898437 | |
| 29 | Front Panel sticker, IT ; M-NE12STR (rev.00) | 897617 | 898465 |
| 29 | Front Panel sticker, IT ; M-NE12STR (rev.01) ; S/5 | 898465 | |
| 29 | Front Panel sticker, IT ; M-NE12TPR (rev.00) | 897650 | 898476 |
| 29 | Front Panel sticker, IT ; M-NE12TPR (rev.01) ; S/5 | 898476 | |
| 29 | Front Panel sticker, JA ; M-NE12STPR (rev.00) | 897719 | 8000377 |
| 29 | Front Panel sticker, JA ; M-NE12STPR (rev.01) ; S/5 | 8000377 | |
| 29 | Front Panel sticker, JA ; M-NE12STR (rev.00) | 897623 | 8000378 |
| 29 | Front Panel sticker, JA ; M-NE12STR (rev.01) ; S/5 | 8000378 | |
| 29 | Front Panel sticker, JA ; M-NE12TPR (rev.00) | 897656 | 8000379 |
| 29 | Front Panel sticker, JA ; M-NE12TPR (rev.01) ; S/5 | 8000379 | |
| 29 | Front Panel sticker, NL ; M-NE12STPR (rev.00) | 897711 | 898435 |
| 29 | Front Panel sticker, NL ; M-NE12STPR (rev.01) ; S/5 | 898435 | |
| 29 | Front Panel sticker, NL ; M-NE12STR (rev.00) | 897615 | 898463 |
| 29 | Front Panel sticker, NL ; M-NE12STR (rev.01) ; S/5 | 898463 | |
| 29 | Front Panel sticker, NL ; M-NE12TPR (rev.00) | 897648 | 898474 |
| 29 | Front Panel sticker, NL ; M-NE12TPR (rev.01) ; S/5 | 898474 | |
| 29 | Front Panel sticker, NO ; M-NE12STPR (rev.00) | 897717 | 898441 |
| 29 | Front Panel sticker, NO ; M-NE12STPR (rev.01) ; S/5 | 898441 | |
| 29 | Front Panel sticker, NO ; M-NE12STR (rev.00) | 897621 | 898469 |
| 29 | Front Panel sticker, NO ; M-NE12STR (rev.01) ; S/5 | 898469 | |
| 29 | Front Panel sticker, NO ; M-NE12TPR (rev.00) | 897654 | 898480 |
| 29 | Front Panel sticker, NO ; M-NE12TPR (rev.01) ; S/5 | 898480 | |
| 29 | Front Panel sticker, PT ; M-NE12STPR (rev.00) | 897714 | 898438 |
| 29 | Front Panel sticker, PT ; M-NE12STPR (rev.01) ; S/5 | 898438 | |
| 29 | Front Panel sticker, PT ; M-NE12STR (rev.00) | 897618 | 898466 |
| 29 | Front Panel sticker, PT ; M-NE12STR (rev.01) ; S/5 | 898466 | |
| 29 | Front Panel sticker, PT ; M-NE12TPR (rev.00) | 897651 | 898477 |
| 29 | Front Panel sticker, PT ; M-NE12TPR (rev.01) ; S/5 | 898477 | |
| 29 | Front Panel sticker, SV ; M-NE12STPR (rev.00) | 897716 | 898440 |
| 29 | Front Panel sticker, SV ; M-NE12STPR (rev.01) ; S/5 | 898440 | |
| 29 | Front Panel sticker, SV ; M-NE12STR (rev.00) | 897620 | 898468 |
| 29 | Front Panel sticker, SV ; M-NE12STR (rev.01) ; S/5 | 898468 | |
| 29 | Front Panel sticker, SV ; M-NE12TPR (rev.00) | 897653 | 898479 |
| 29 | Front Panel sticker, SV ; M-NE12TPR (rev.01) ; S/5 | 898479 | |
| 30 | Flat cable, STP | 890874 | |
| 30 | Flat cable, STP | 890874 | |
| 32 | Flat cable, M-PP | 891573 | |
| 33 | Cross cylinder head screw M3x4 | 61719 | |

# 7 EARLIER REVISIONS

For service information on the earlier revisions, please refer to:

| Module revision | Manual | Note! |
|---|---|---|
| ESTP Module revision 01 | Service Manual p/n 880850 | |
| ETP Module revision 00 | Service Manual p/n 880850 | |
| ESTP Module revision 02 | Service Manual p/n 882580 | |
| ETP and EST Modules revision 01 | Service Manual p/n 882580 | |
| ESTP Module revision 03-04,<br>and ETP and EST Modules revision 02-03<br>NE12STPR Module, M-NE12STPR (rev. 00)<br>NE12STR Module, M-NE12STR (rev. 00)<br>NE12TPR Module, M-NE12TPR (rev. 00)<br>NESTPR Module, M-NESTPR (rev. 00)<br>NESTR Module, M-NESTR (rev. 00)<br>NETPR Module, M-NETPR (rev. 00)<br>ESTPR Module, M-ESTPR (rev. 03)<br>ESTR Module, M-ESTR (rev. 03)<br>ETPR Module, M-ETPR (rev. 03) | Technical Reference Manual Slot 896620-1. | Main manual is 896 624. |

# APPENDIX A

This page intentionally left blank.

# SERVICE CHECK FORM

# DATEX-OHMEDA HEMODYNAMIC MODULES

| | | | | | |
|---|---|---|---|---|---|
| Customer | | | | | |
| Service | | Module type | | S/N | |
| Service engineer | | | | Date | |

OK = Test OK

N.A. = Test not applicable

Fail = Test Failed

**All modules**

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. NIBP pump filter | ☐ | ☐ | ☐ | 4. Installation | ☐ | ☐ | ☐ |
| 5. Recognition | ☐ | ☐ | ☐ | | | | |

Notes

**ECG measurement**

S/N

6. Module software (serial numbers)

| | |
|---|---|
| ECG/RESP | |
| STP | |
| NIBP | |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 7. Communication and memories | ☐ | ☐ | ☐ | 8. Membrane key | ☐ | ☐ | ☐ |
| 9. Power frequency | ☐ | ☐ | ☐ | 10. Cable recognition | ☐ | ☐ | ☐ |
| 11. Lead detection | ☐ | ☐ | ☐ | 12. Test with patient simulator | ☐ | ☐ | ☐ |

Notes

**RESP measurement**

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 13. RESP measurement recognition | ☐ | ☐ | ☐ | 14. Test with patient simulator | ☐ | ☐ | ☐ |

Notes

**TEMP measurement**

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 15. Communication and memories | ☐ | ☐ | ☐ | 16. Temperature probe detection | ☐ | ☐ | ☐ |
| 17. Calibration check | ☐ | ☐ | ☐ | 18. Temp test -function | ☐ | ☐ | ☐ |
| 19. Configuration STP/ST/TP | ☐ | ☐ | ☐ | | | | |

Notes

**InvBP measurement**

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 20. Membrane keys | ☐ | ☐ | ☐ | 21. Cable and transducer detection | ☐ | ☐ | ☐ |
| 22. Calibration | ☐ | ☐ | ☐ | 23. Test with patient simulator | ☐ | ☐ | ☐ |

Notes

**$SpO_2$ measurement**

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 24. $SpO_2$ probe detection | ☐ | ☐ | ☐ | 25. Test measurement | ☐ | ☐ | ☐ |

Notes

**NIBP measurement**

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 26. Communication and memories | ☐ | ☐ | ☐ | 27. Membrane keys | ☐ | ☐ | ☐ |
| 28. Pump and valves | ☐ | ☐ | ☐ | | | | |

| | | |
|---|---|---|
| 29. Leak test | | ≤ 6 mmHg/min |

30. Calibration check

| | Measured B1 | Measured B2 | Allowed range |
|---|---|---|---|
| 0 mmHg | | | ± 9 mmHg |
| 100 mmHg | | | 100 + z.o. ± 2 mmHg |
| 200 mmHg | | | 200 + z.o. ± 3 mmHg |
| 260 mmHg | | | 260 + z.o. ± 4 mmHg |

z.o. = zero offset at 0 mmHg pressure

| | | |
|---|---|---|
| 31. Watchdog timer activation pressure | | 11 to 15 mmHg |

32. Watchdog timer

| | | |
|---|---|---|
| Adult | | 120 to 140 s |
| Infant | | 60 to 70 s |

33. Safety valve functions

| | B1 | B2 | Allowed range |
|---|---|---|---|
| 'Max press' ADULT | | | 290 to 330 mmHg |
| '2 s after stop' ADULT | | | 290 to 330 mmHg |
| 'Max press' INFANT | | | 154 to 165 mmHg |
| '2 s after stop' INFANT | | | 154 to 165 mmHg |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 34. Cuff related messages | ☐ | ☐ | ☐ | 35. Adult cuff detection | ☐ | ☐ | ☐ |
| 36. Test measurement | ☐ | ☐ | ☐ | 37.Infant cuff detection | ☐ | ☐ | ☐ |

Notes ______________________________

**All modules**

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 38. Electrical safety check | ☐ | ☐ | ☐ | 39. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 40. Final cleaning | ☐ | ☐ | ☐ | | | | |

Notes ______________________________

**Notes** ______________________________

______________________________

**Used Spare Parts** __________ __________ __________

__________ __________ __________

**Signature** ______________________________

# Datex-Ohmeda Compact Airway modules

# S/5™ Compact Airway Module, M-CAiOVX (rev. 02)
# S/5™ Compact Airway Module, M-CAiOV (rev. 04)
# S/5™ Compact Airway Module, M-CAiO (rev. 03)
# S/5™ Compact Airway Module, M-COVX (rev. 03)
# S/5™ Compact Airway Module, M-COV (rev. 04)
# S/5™ Compact Airway Module, M-CO (rev. 03)
# S/5™ Compact Airway Module, M-C (rev. 02)

# Technical Reference Manual Slot


All specifications are subject to change without notice.

Document No. 800 1009-5

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147

www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division,
Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## S/5 Compact Airway Modules

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Compact Airway modules. The Compact Airway modules are double width plug-in modules. M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, M-CAiOVX and M-CAiOVX/SERVICE are designed for use with the S/5 monitors. Later in this manual modules may be refered to without the S/5 system nomenclature for simplicity.

Please also see the*Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The Compact Airway modules provide airway and respiratory measurements.

Letters in the module name stand for:
M = plug-in module, C = $CO_2$ and $N_2O$, O = patient $O_2$, V = patient spirometry, X = gas exchange, A = anesthetic agents, and i = agent identification

## About M-CAiOVX/SERVICE module

The M-CAiOVX/SERVICE module is meant for service purposes only. It can be used as a loan module if the module in the hospital should be sent to the factory for repair. The specifications that apply to the M-CAiOVX apply also to the M-CAiOVX/SERVICE module. Module differences: the colour of the front mask is green, the front panel has a “SERVICE” text and there are no front panel keys equipped.

**Table 1 Options for Compact Airway modules**

| **Modules** | **Parameters/measurements** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **$CO_2$** | **$N_2O$** | **$O_2$** | **Anesthetic agents** | **Agent ID** | **Spirometry** | **Gas exchange** |
| **M-CAiOVX** | • | • | • | • | • | • | • |
| **M-CAiOV** | • | • | • | • | • | • | |
| **M-CAiO** | • | • | • | • | • | | |
| **M-COV** | • | • | • | | | • | |
| **M-COVX** | • | • | • | | | • | • |
| **M-CO** | • | • | • | | | | |
| **M-C** | • | • | | | | | |
| **M-CAiOVX/SERVICE** | • | • | • | • | • | • | • |

NOTE: Do not use identical modules in the same monitor simultaneously. The M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, M-CAiOVX , M-CAiOVX/SERVICE and M-miniC are considered identical modules.

NOTE: The Compact Airway Module or Single-width Airway Module and Airway Module, G-XXXX, cannot be used simultaneously in the same monitor.

NOTE: The Compact Airway modules cannot be used in the Extension Frame, F-EXT4.

NOTE: Anesthetic agents and $N_2O$ values are not displayed with Critical Care main software, but when present in the module they are calculated for compensation of $CO_2$ and $O_2$.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 75 × 228 × 112 mm, 2.9 × 9.0 × 4.4 in |
| Module weight | 1.6 kg/3.7 lbs |
| Operating temperature | +10...+40 °C |
| Storage temperature | -25...+70 °C |
| Atmospheric pressure | 666...1060 hPa /<br>(67...106 kPa)<br>(500...800 mmHg)<br>(666...1060 mbar) |
| Humidity | 10...95 % non-condensing (in airway 0...100 %, condensing) |
| Power consumption | 12.6 W Prms, 14.6 W momentary |

Protection against electrical shock
Type BF

## 1.2 Typical performance

### 1.2.1 $CO_2$

| | |
|---|---|
| Measurement range | 0...15 vol% (0...15 kPa, 0...113 mmHg) |
| Measurement rise time | < 400 ms typical |
| Accuracy | ±(0.2 vol% +2 % of reading) |
| Gas cross effects | < 0.2 vol% ($O_2$, $N_2O$, anesthetic agents) |

If $CO_2$ concentration is below 0.1%, 0.0% is displayed.

### 1.2.2 $O_2$

| | |
|---|---|
| Measurement range | 0 to 100 vol% |
| Measurement rise time | < 400 ms typically |
| Accuracy | ±(1 vol% +2% of reading) |
| Gas cross effects | < 1 vol%; anesthetic agents<br>< 2 vol%; $N_2O$ |
| $O_2$ Fi-Et difference | resolution 0.1 vol% |

### 1.2.3 $N_2O$

| | |
|---|---|
| Measurement range | 0 to 100 %; $N_2O$ |
| Measurement rise time | < 450 ms typically |
| Accuracy | ±(2 vol% +2% of reading) |
| Gas cross effects | < 2 vol%; anesthetic agents |

### 1.2.4 Respiration Rate (RR)

| | |
|---|---|
| Measurement range | 4...60 breaths/min |
| Detection criteria | 1 % variation in $CO_2$ |

### 1.2.5 Anesthetic Agents (AA)

| | |
|---|---|
| Measuring range | |
| Hal, Enf, Iso | 0 to 6 vol% |
| Sev | 0 to 8 vol% |
| Des | 0 to 20 vol% |

| | |
|---|---|
| Measurement rise time | < 400 ms typically |
| Accuracy | ±(0.15 vol% +5% of reading) |
| Gas cross effects | < 0.15 vol% $N_2O$ |

Resolution is two digits when the AA concentration is below 1.0 vol%.
If AA concentration is below 0.1 vol%, 0.0% is displayed.

| | |
|---|---|
| Identification threshold | 0.15 vol% typically |
| Identification time | < 20 s (for pure agents) |

Mixture identification threshold for 2. agent:
0.2 vol% +10% of total conc.

### 1.2.6 MAC

| | |
|---|---|
| Range | 0...9.9 MAC |

Equation:

$$MAC(AA) = \frac{\%(ETAA)}{x(AA)} + \frac{\%ETN_2O}{100}$$

**Formula 1**

where x(AA): Hal=0.75 %, Enf=1.7 %, Iso=1.15 %, Sev=2.05 %, Des=6.0 %.

## 1.3 Gas specifications

| | |
|---|---|
| Airway humidity | 0...100 %, condensing |
| Sampling rate | 200 ±20 ml/min. (sampling line 2-3 m, normal conditions) |
| Sampling delay | 2.5 seconds typical with a 3 m sampling line |
| Total system response time | 2.9 seconds typical with a 3 m sampling line, including sampling delay and rise time |
| Display update rate | breath-by-breath |

Automatic compensation for pressure, $CO_2$-$N_2O$ and $CO_2$-$O_2$ collision broadening effect.

| | |
|---|---|
| Warm up time | 2 min. for operation with $CO_2$, $O_2$, and $N_2O$<br>5 min. for operation of anesthetic agents<br>30 min. for full specifications |
| Autozeroing interval | Immediately after 'calibrating gas sensor' and 2, 5, 10, 15, 30, 45, 60 minutes after start-up, then every 60 minutes |

### 1.3.1 Normal conditions

Accuracy specifications apply in normal conditions (after 30 minutes warm-up period):

| | |
|---|---|
| Ambient temperature | 18...28 °C, within ±5 °C of calibration |
| Ambient pressure | 500...800 mmHg, ±50 mmHg of cal. |
| Ambient humidity | 20...80 % RH, ±20 % RH of cal. |

Non-disturbing gases

- Ethanol $C_2H_5OH$(< 0.3%)
- Acetone (< 0.1%)
- Methane $CH_4$ (< 0.2%)
- Nitrogen $N_2$
- Carbon monoxide CO
- Nitric Oxide NO (< 200 ppm)
- water vapor

Maximum effect on readings

- $CO_2$ < 0.2 vol%
- $O_2$, $N_2O$ < 2 vol%
- anesthetic agents < 0.15 vol%

Effect of Helium decreases $CO_2$ readings < 0.6 vol% typically

### 1.3.2 Conditions exceeding normal

Accuracy specifications under the following conditions; ❶❷❸❹:

| | |
|---|---|
| ❶ Ambient temperature | 10...40 °C, within ±5 °C of calibration |
| Ambient pressure | 500...800 mmHg, ±50 mmHg of calibration |
| Ambient humidity | 10...98 % RH, ±20 % RH of calibration |

❷ During warm-up 2 to 10 minutes (anesthetic agents 5-10 minutes), under normal conditions

❸ During warm-up 10 to 30 minutes, under normal conditions

❹ N2O > 85%, under normal conditions

| | **Accuracy under different conditions (see above)** | | |
|---|---|---|---|
| | Condition ❶ and ❸ | Condition ❷ | Condition ❹ |
| **$CO_2$** | ±(0.3 vol% + 4 % of reading) (at 5 vol% error ±0.5 vol%) | ±(0.4 vol% + 7 % of reading) (at 5 vol% error ±0.75 vol%) | |
| **$O_2$** | ±(2 vol% + 2% of reading) | ±(3 vol% + 3% of reading) | |
| **$N_2O$** | ±(3 vol% + 3% of reading) | ±(3 vol% + 5% of reading) | ± (2vol% + 8% of reading) |
| **Agents: Hal, Enf, Iso,Sev, Des** | ±(0.2 vol% + 10% of reading) | ±(0.3 vol% + 10% of reading) | |

## 1.4 Patient spirometry specifications

### 1.4.1 Normal conditions

Accuracy specifications apply in normal conditions (after 10 minutes warm-up period):

| | |
|---|---|
| Ambient temperature | 10...40 °C |
| Ambient pressure | 500...800 mmHg |
| Ambient humidity | 10...98 %RH |
| Airway humidity | 10...100 %RH |
| Respiration rate | 4...35 breaths/min (adults) |
| | 4...50 breaths/min (pediatric) |
| I:E ratio | 1:4.5...2:1 |
| Intubation tube | 5.5...10 mm (adults), 3...6 mm (pediatric) |

### Airway pressures ($P_{aw}$, $P_{peak}$, $P_{plat}$, $PEEP_e$, $PEEP_{iStat}$, $PEEP_{iDyn}$, $P_{mean}$)

| | |
|---|---|
| Measurement range | -20...+100 $cmH_2O$ |
| Resolution | 0.5 $cmH_2O$ |
| Accuracy | ±1 $cmH_2O$ |

### Airway flow

| | |
|---|---|
| Measurement range | 1.5...100 l/min (adults) |
| (for both directions) | 0.25...25 l/min (pediatric) |

### Tidal volume

| | |
|---|---|
| Measurement range | 150...2000 ml (adults), 15...300 ml (pediatric) |
| Resolution | 1 ml |
| Accuracy | ±6 % or 30 ml (adult), ±6 % or 4 ml (pediatric) |

### Minute volume

| | |
|---|---|
| Measurement range | 2...20 l/min (adults), 0.5...5 l/min (pediatric) |
| Resolution | 0.1 l/min |

### Compliance

| | |
|---|---|
| Measurement range | 4...100 ml/$cmH_2O$ (adult), 1...100 ml/$cmH_2O$ (pediatric) |
| Resolution | 1 ml/$cmH_2O$ (adult), 0.1 ml/$cmH_2O$ (pediatric) |

### Airway resistance

| | |
|---|---|
| Measurement range | 0...40 $cmH_2O$/ l/s |
| Resolution | 1 $cmH_2O$/ l/s |

### Other parameters

Specifications apply in conditions listed in patient spirometry specifications.

### Dead space of the sensor

9.5 ml (adult), 2.5 ml (pediatric)

### Resistance of the sensor

0.5 $cmH_2O$ @ 30 l/min (adult), 1.0 $cmH_2O$ @ 10 l/min (pediatric)

### 1.4.2 Conditions exceeding normal

Accuracy specifications under the following condition (during warm-up 2 to 10 minutes):

### Airway Pressure($P_{aw}$)

| | |
|---|---|
| Accuracy | ±2 $cmH_2O$ |

### Tidal volume

| | |
|---|---|
| Accuracy | ±10 % or 100 ml (adult), ±10 % or 10 ml (pediatric) |

## 1.5 Gas exchange specifications

Mathemathical integration of airway flow and gas concentration for intubated, mechanically ventilated and/or partly spontaneously breathing patients.

NOTE: These specifications apply only when a 2 meter gas sampling line is used, and a Y-piece with a physical dead space less than 8 ml.

NOTE: These specifications only apply if the $FiO_2$ level delivered to the patient is varing by less than 0.2 % during the inspiratory cycle at the measurement point.

### 1.5.1 $VO_2$ and $VCO_2$

| | |
|---|---|
| Measurement range | 50...1000 ml/min |
| Resolution | 10 ml/min |
| Accuracy | ±10 % or 10 ml; when $FiO_2 < 65$ % |
| | ±15 % or 15 ml; when 65 % < $FiO_2 < 85$ % |

### 1.5.2 RQ

| | |
|---|---|
| Measurement range | 0.6...1.2 |
| Resolution | 0.05 |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 $CO_2$, $N_2O$, and agent measurement

TPX is a side stream gas analyzer, measuring real time concentrations of $CO_2$, $N_2O$ and anesthetic agents (Halothane, Enflurane, Isoflurane, Desflurane, and Sevoflurane).

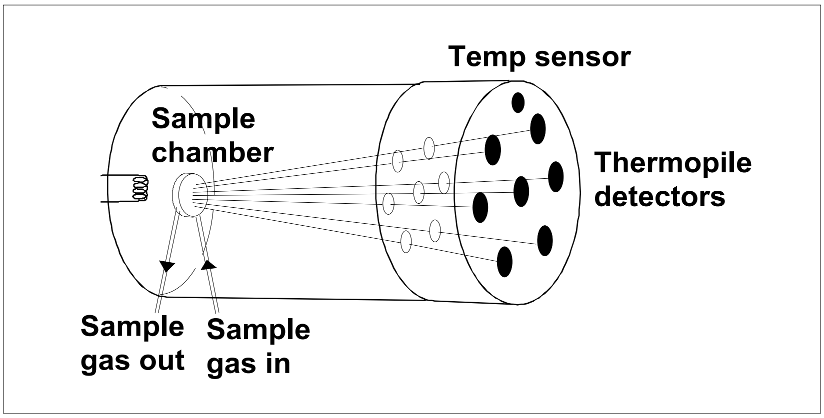



**Figure 1 TPX sensor principle**

Anesthetic agents or mixtures of two anesthetic agents are automatically identified and concentrations of the identified agents are measured. TPX also detects mixtures of more than two agents and issues an alarm.

TPX is a nondispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters.

The infrared radiation detectors are thermopiles.

Concentrations of $CO_2$ and $N_2O$ are calculated from absorption measured at 3-5 $\mu$m.

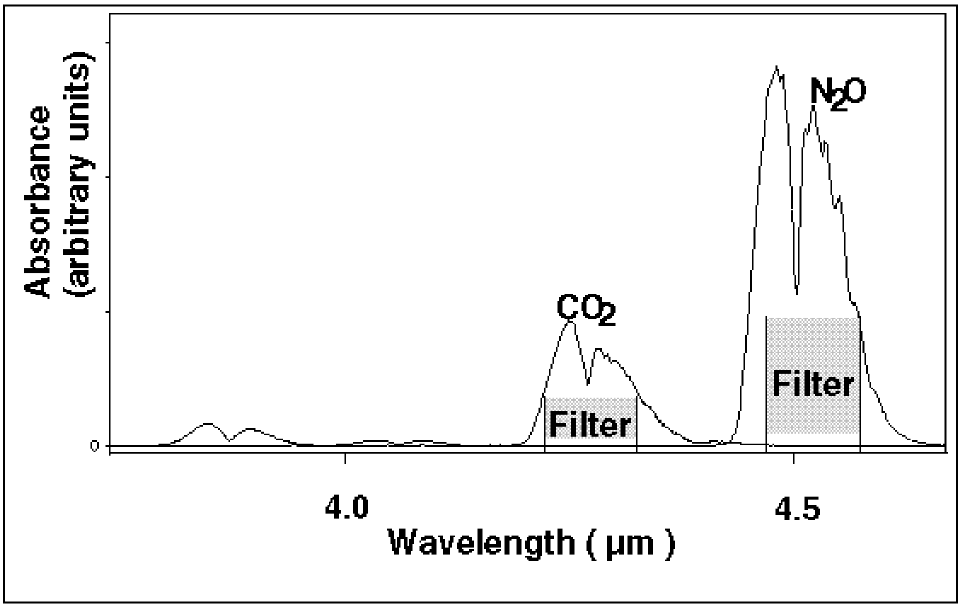



**Figure 2 Absorbance of $N_2O$ and $CO_2$**

Identification of anesthetic agents and calculation of their concentrations is performed by measuring absorptions at five wavelengths in the 8-9 µm band and solving the concentrations from a set of five equations.

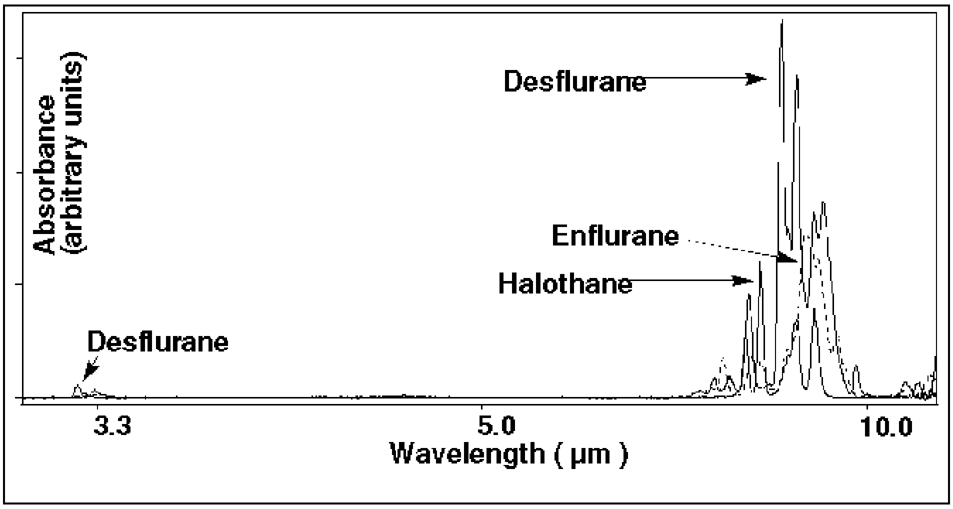



**Figure 3 Infrared absorbance of AAs**

The measuring accuracy is achieved utilizing numerous software compensations. The compensation parameters are determined individually for each TPX during the factory calibration.

### 2.1.2 $O_2$ measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer is generated in a measuring cell with a strong magnetic field that is switched on and off at a frequency of 165 Hz. The output signal is a DC voltage proportional to the $O_2$ concentration difference between the two gases to be measured.

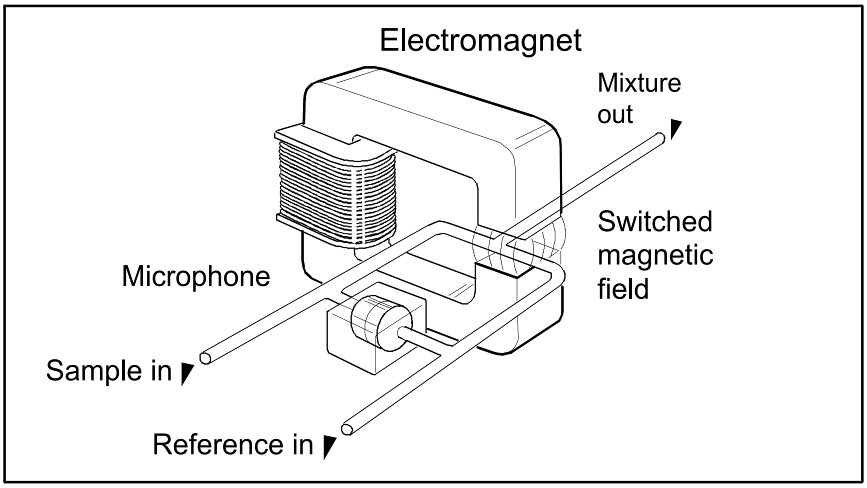



**Figure 4 $O_2$ measurement principle**

### 2.1.3 Patient spirometry

In mechanical ventilation breaths are delivered to the patient by a ventilator with a proper tidal volume (TV), respiration rate (RR), and inspiration / expiration ratio in time (I:E) determined by the settings of the ventilator.
The Patient Spirometry monitors patient ventilation. The following parameters are displayed:

- Expiratory and inspiratory tidal volume (TV) in ml
- Expiratory and inspiratory minute volume (MV) in l/min
- Expiratory spontaneous minute volume in l/min
- Inspiration/expiration ratio (I:E)

### Airway pressure

- Peak pressure ($P_{peak}$)
- Mean airway pressure ($P_{mean}$); available only in S/5 Critical Care and Compact Critical Care monitors
- End inspiratory pressure ($P_{plat}$)
- PEEPi, PEEPe; available only in S/5 Critical Care and Compact Critical Care monitors
- Total positive end expiratory pressure ($PEEP_{tot}$); available only in S/5 Anesthesia and Compact Anesthesia monitors
- Real time airway pressure waveform ($P_{aw}$)
- Static Positive end expiratory pressures (Static $PEEP_i$ and Static $PEEP_e$); available only in S/5 Critical Care and Compact Critical Care monitors

- Static Plateau pressure (Static Pplat); available only in S/5 Critical Care and Compact Critical Care monitors
- Static Compliance (Static Compl); available only in S/5 Critical Care and Compact Critical Care monitors

PEEP, $P_{peak}$, $P_{mean}$, and $P_{plat}$ are measured by pressure transducer on the PVX board. Atmospheric pressure is used as a reference in measurement. The pressure measurement is made from the airway part that is closest to the patient between patient circuit and intubation tube.

$PEEP_i$=intrinsic PEEP, $PEEP_{tot}$-$PEEP_e$

Static pressure measurement maneuvres are automatically identified based on a increased zero flow period at the end of the inspiration or expiration.

Static Compliance is calculated if Static PEEP and Static $P_{plat}$ measurements were made within a 2 minute period.

## Airway flow

- Real time flow waveform (V')
- Compliance (Compl)
- Airway resistance (Raw)
- Pressure volume loop
- Flow volume loop

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The pressure signal obtained is linearized and corrected according to the density of the gas. Speed of flow is calculated from these pressure values and the TV value is then integrated. The MV value is calculated and averaged using TV and RR (respiratory rate) values.

**Compliance and airway resistance**
Compliance is calculated for each breath from the equation

$$Compl = \frac{TV_{exp}}{P_{plat} - PEEP_i - PEEP_e}$$ **Formula 2**

Compliance describes how large a pressure difference is needed to deliver a certain amount of gas to the patient.

The airway resistance, Raw, is calculated using an equation, that describes the kinetics of the gas flow between the lungs and the D-lite. The equation states that the pressure at the D-lite can at any moment of the breath be approximated using the equation

$P(t) = Raw \times V'(t) + V(t)/Compl + PEEPe + PEEPi$ **Formula 3**

where P(t), V'(t) and V(t) are the pressure, flow and volume measured at the D-lite at a time t, Raw is the airway resistance, Compl is the compliance and $PEEP_e$+$PEEP_i$ is the total positive end expiratory pressure ($PEEP_{tot}$).

## D-lite

Patient Spirometry uses specific sensors called D-lite+/D-lite and Pedi-lite+/Pedi-lite flow sensors. Different types of sensors are available: adult sensor for measuring adults and pediatric sensor for children. Both are available as reusable and disposable versions.
D-lite and Pedi-lite adapters are designed to measure kinetic pressure by two-sided Pitot tube. Velocity is calculated from pressure difference according to Bernoulli's equation. Flow is then determined using the calculated velocity.

$$v = \sqrt{\frac{2 \times dP}{\rho}}$$ (from Bernoulli's equation) **Formula 4**

$$F = v \times A,$$

where:

F = flow (l/min), v = velocity (m/s), A = cross area ($m^2$), dP = pressure difference ($cmH_2O$),
$\rho$ = density ($kg/m^3$)

Finally the volume information is obtained by integrating the flow signal.

## 2.1.4 Gas exchange measurement

The gas exchange measurement uses the D-lite flow sensor and the gas sampler.

The basic data which is needed to obtain $O_2$ consumption and $CO_2$ production are **volumes** and **concentrations**.

Concentrations have been corrected for delay and deformation during the transport of the gas sample in a sidestream gas measurement sensor.

To obtain the amount of $O_2$ consumed in ml/min, the amount which is exhaled is subtracted from the amount that is inhaled.

To obtain the amount of $CO_2$ producted in ml/min, the amount which is inhaled is subtracted from the amount that is exhaled.

These amounts can be obtained by multiplying each measured volume piece (dv) by the corresponding gas concentration:

$$VO_2 = \int_{insp} fo_2 dv - \int_{exp} fo_2 dv$$ **Formula 5**

and

$$VCO_2 = \int_{exp} fco_2 dv - \int_{insp} fco_2 dv$$ **Formula 6**

Using inspiratory and expiratory minute volumes $MV_i$ and $MV_e$ and volume-weighted inspiratory concentrations fi and fe these equations can be rewritten as:

$$VO_2 = fi_{O_2} \times MV_i - fe_{O_2} \times MV_e \quad [ml/min]$$ **Formula 7**

$VCO_2 = fe_{CO_2} \times MV_e - fi_{CO_2} \times MV_i$ [ml/min] **Formula 8**

To obtain results which are less sensitive to errors in volume measurements, the so-called *Haldane transformation* is used. This means taking advantage of the fact that the patient is not consuming nor producing nitrogen: the amount of nitrogen inhaled is equal to the amount exhaled $fi_{N2} \times MV_i = fe_{N2} \times MV_e$.
$VO_2$ and $VCO_2$ can then be written as:

$VO_2 = (fi_{O_2} - f_{Hald} \times fe_{O_2})MV_i$ [ml/min] **Formula 9**

$VCO_2 = (f_{Hald} \times fe_{CO_2} - fi_{CO_2})MV_i$ [ml/min] **Formula 10**

with

$f_{Hald} = (1 - fi_{CO2} - fi_{O2} - fi_{N2O} - fi_{Ane1} - fi_{Ane2}) / (1 - fe_{CO2} - fe_{O2} - fe_{N2O} - fe_{Ane1} - fe_{Ane2})$

$EE = (5.5 \times VCO_2) + (1.76 \times VO_2) + (1.99 \times Un)$ [kcal/day] **Formula 11**

with Un=Urea Nitrogen Excretion = 13 g/day (for adults only).

## 2.2 Main components

The compact airway modules consist of:

- Gas sampling system
- TPX measuring unit
- OM measuring unit
- PVX measuring unit
- CPU board
- OM board
- PVX board

### 2.2.1 Gas sampling system

The sampling system takes care of drawing a gas sample into the analyzers at a fixed rate.

The gas sampling system samples the measured air to the module, and removes water and impurities from it. A sampling line is connected to the water trap. The pump draws gas through the sampling line to gas measuring units. After the measurements, the gas is exhausted from sample gas out connector.

The M-COVX and M-CAiOVX modules have a different gas sampling system compared to the other modules. A number of flow restrictors have been changed to create a bigger pressure difference with ambient pressure in the gas sensors. The sample flow is however about the same (200 ml/min).

A larger pressure difference makes the deformations of the gas concentration curves less sensitive to high variations of the airway pressures thus meeting also the accuracy requirements of gas exchange for these applications.

## D-fend™

The sample is drawn through a sampling line. Then gas enters the monitor through the water trap, where it is divided into two flows, a main flow and a side flow. The main flow goes into the analyzers. This flow is separated from the patient side by a hydrophobic filter. The side flow creates a slight subatmospheric pressure within the D-fend water trap which causes fluid removed by the hydrophobic filter to collect in the bottle.

## Zero valve and absorber

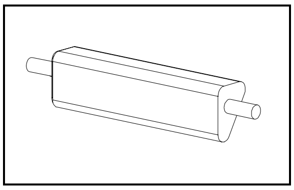


**Figure 5 Absorber**

The main flow passes through a magnetic valve before proceeding to the analyzers. This valve is activated to establish the zero points for the TPX and OM units. When the valve is activated, room air is drawn through the absorber into the internal system and the gas sensors. Paralyme is used as an absorbent.

## Nafion™ tubes [1)]

A nafion tube is used between the water trap and the zero valve to balance the sample gas humidity with that of ambient air. The tube will prevent errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases. Another nafion tube is used between the absorper and the pneumatic unit to prevent humidity caused by absorb of $CO_2$.

## Gas analyzers

After the zero valve and nafion tube the gas passes through TPX and OM units. The oxygen sensor has two inputs. One input accepts the main flow and the other draws in room air for reference. Both gas flows exit from a single port.

## Sample flow differential pressure transducer

The sample flow differential pressure transducer measures pressure drop across OM inlet restrictor and calculates sample flow from the pressure difference.

## Working pressure transducer

The working pressure transducer measures absolute working pressure between the TPX unit and OM unit. It is used for messages: ‘sample line blocked’, ‘check D-fend’, ‘replace D-fend’ and ‘check sample gas outlet’.

[1)] Nafion is a trademark of Perma Pure Inc.

## Pneumatic unit

The pneumatic unit contains zeroing valve, occlusion valve and tubing connections. There is a series of restrictors and chambers forming a pneumatic filter to prevent pressure oscillations from the pump to reach the measuring units. The occlusion valve connection to room air includes a dust filter and the zero valve connection to room air includes an absorber.

## Connection block

The connection block contains sample gas outlet connector and OM unit reference gas inlet. The inlet is equipped with a dust filter.

## Occlusion valve

The valve is activated when the sampling line gets occluded. The main flow is then diverted to the side flow of the D-fend water trap to faster remove the occlusion.

## Sampling pump and damping chamber

The gas sampling pump is a membrane pump that is run by a brushless DC-motor. Sample flow is measured with a differential pressure transducer across a known restriction. The motor is automatically controlled to maintain a constant flow, even when the D-fend water trap ages and starts to get occluded. It also enables use of sample tubes with varying lengths and diameters.

The damping chamber is used to even out the pulsating flow and silence the exhaust flow.

NOTE: In no occasion is the flow reversed towards patient.

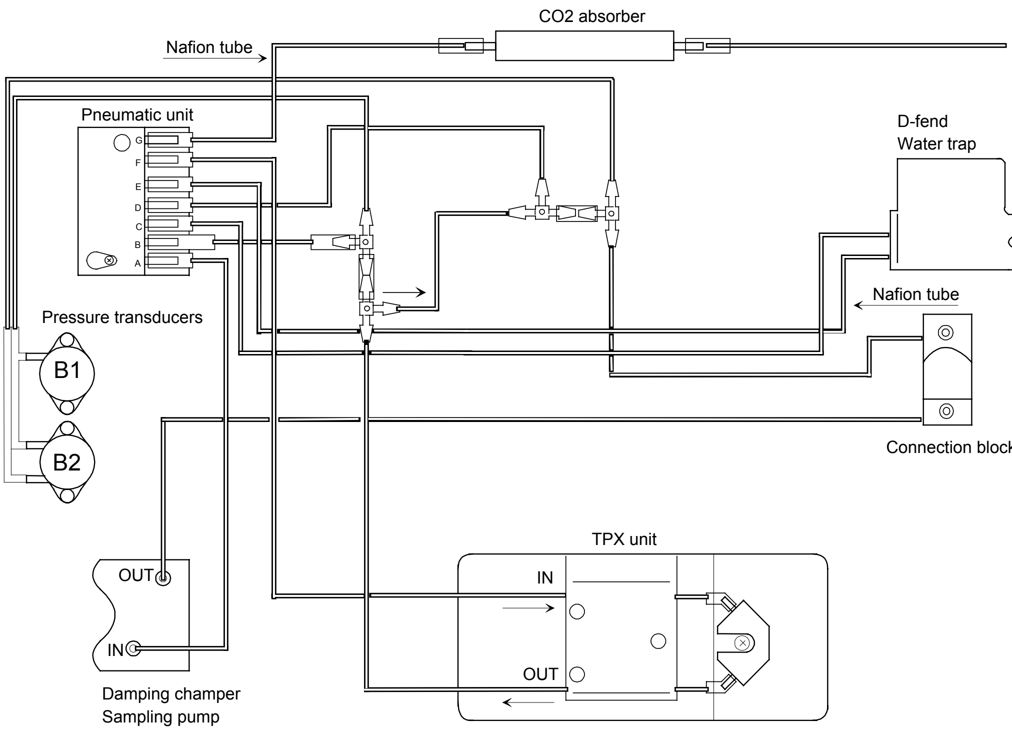



**Figure 6** **Gas sampling system layout, M-C**

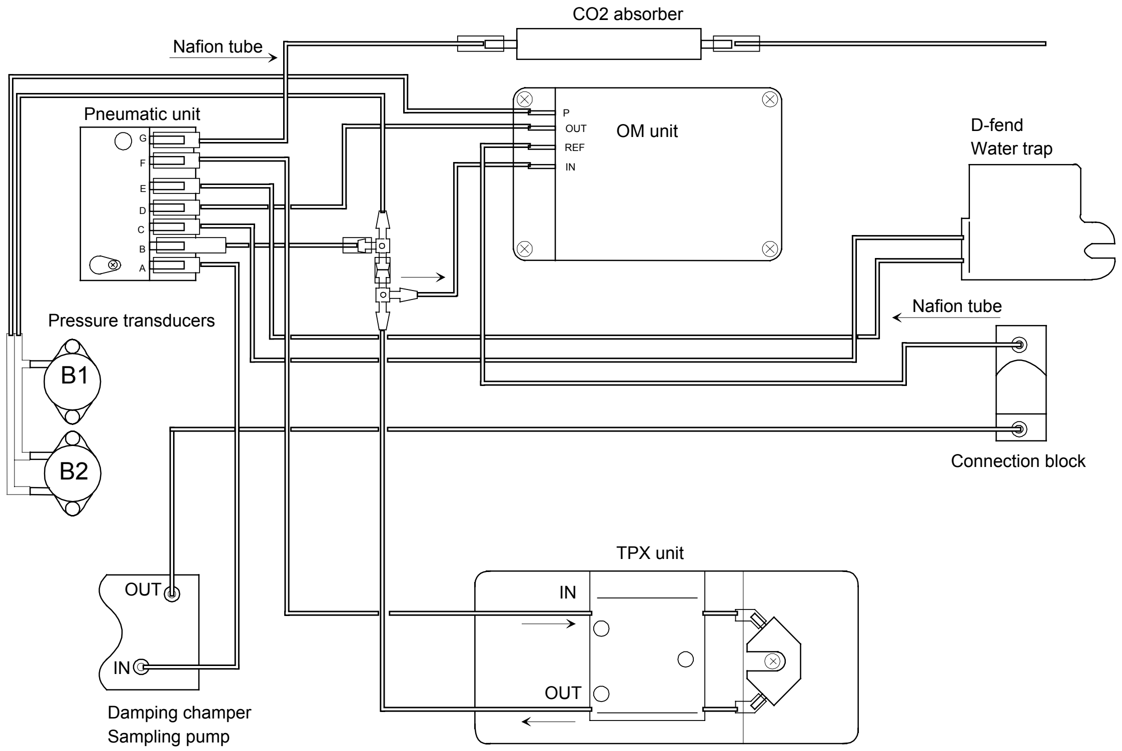
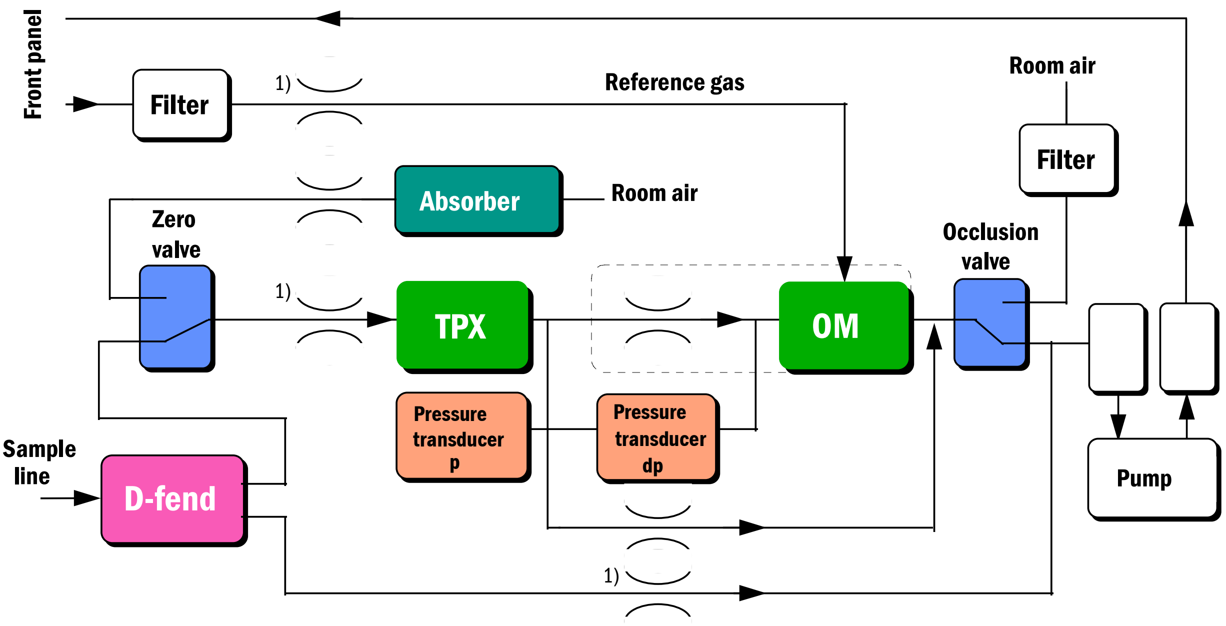



**Figure 7** **Gas sampling system layout, M-CAiOV, M-CAiOVX, M-CAiO, M-COVX, M-COV, M-CO**




Tubing marked with 1) is thinner in M-CAiOVX and M-COVX module.

**Figure 8** **Gas tubing layout**

### 2.2.2 TPX measuring unit

The TPX unit is a non dispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters. The IR lamp is a 4 W filament, surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 4 mm length.

From the sample chamber, radiation goes into seven tubular light guides with reflective inner surfaces. At the other end of each light guide, there is a thermopile detector with an optical filter in front of it.

The Temp sensor measures the TPX units' temperature and it is used for temperature compensation.

The TPX unit includes a TPX board located at the end of the unit. Its function is to connect the 7 thermopile signals and the temperature sensor signal to the CPU board.

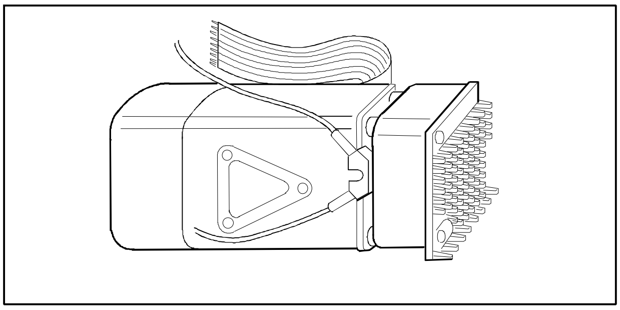


**Figure 9 TPX measuring unit**

### 2.2.3 OM measuring unit

The oxygen measurement is based on paramagnetic susceptibility. The gas and the reference gas, which usually is room air, are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 165 Hz.

An alternating differential pressure is generated between the sample and reference inputs due to forces acting to the oxygen molecules in a magnetic field gradient.

The pressure is measured with a sensitive differential transducer, rectified with a synchronous detector and amplified to produce a DC voltage proportional to the oxygen partial pressure difference of the two gases.

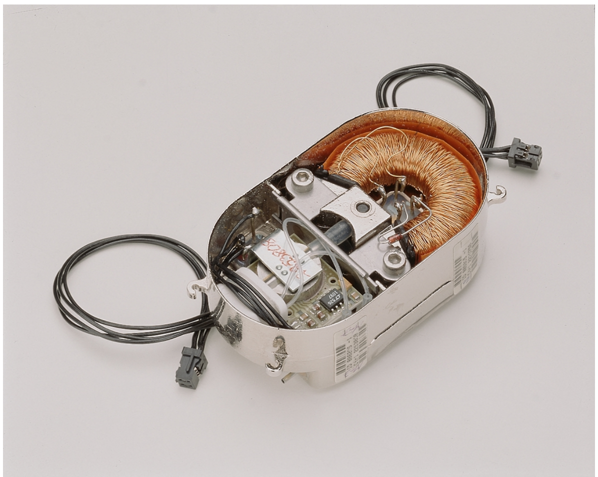


**Figure 10 OM measuring unit**

### 2.2.4 PVX measuring unit

NOTE: Never apply overpressure or negative pressure of more than 300 $cmH_2O$ to the flow and volume tubing. Differential pressure max 25 cmH2O on one port at a time e.g. when connecting tubes.

When Patient Spirometry is used, a special sensor, D-lite, replaces the normal airway adapter in the patient circuit. A double lumen tubing is attached to the two connectors on the adapter and on the module front panel.

The Patient Spirometry provides patient respiration monitoring capabilities using the D-lite and Pedi-lite flow sensors.

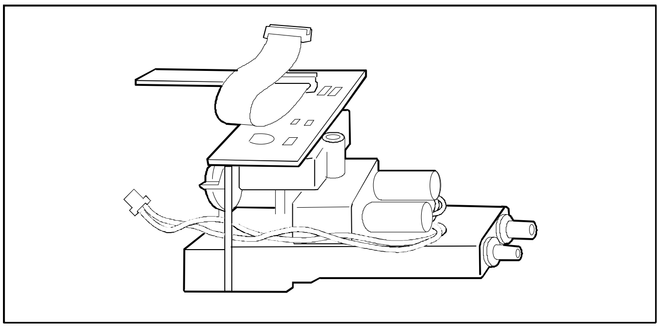


**Figure 11 PVX measuring unit**

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The signal is then linearized and corrected according to the density of the gas. Speed of the flow is calculated from the pressure and TV is integrated from it.
Patient Spirometry consists of airway connections, two pressure transducers, valves and preamplifiers. The preamplifiers are connected to the A/D-converter on module main CPU.
The breathing flow of a patient passing through the D-lite adapter creates a pressure difference. This pressure difference is measured by pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer B2.

### 2.2.5 Gas exchange

The gas exchange measurement uses the concentrations measured by the TPX measurement unit and the $O_2$ measurement unit, in combination with the flow from the PVX measurement unit. The gas exchange calculation is done by software.

CAUTION The gas exchange measurement in the M-CAiOVX and M-COVX modules works accurately only with 2-meter gas sampling lines.

### 2.2.6 CPU board

The CPU board contains the processor and memories and A/D-converters that are common to the whole module. The CPU board also contains preamplifiers of TPX-sensor and drivers for valves, fan, pump and lamp. The module is connected to the module bus through a RS-485 serial channel.

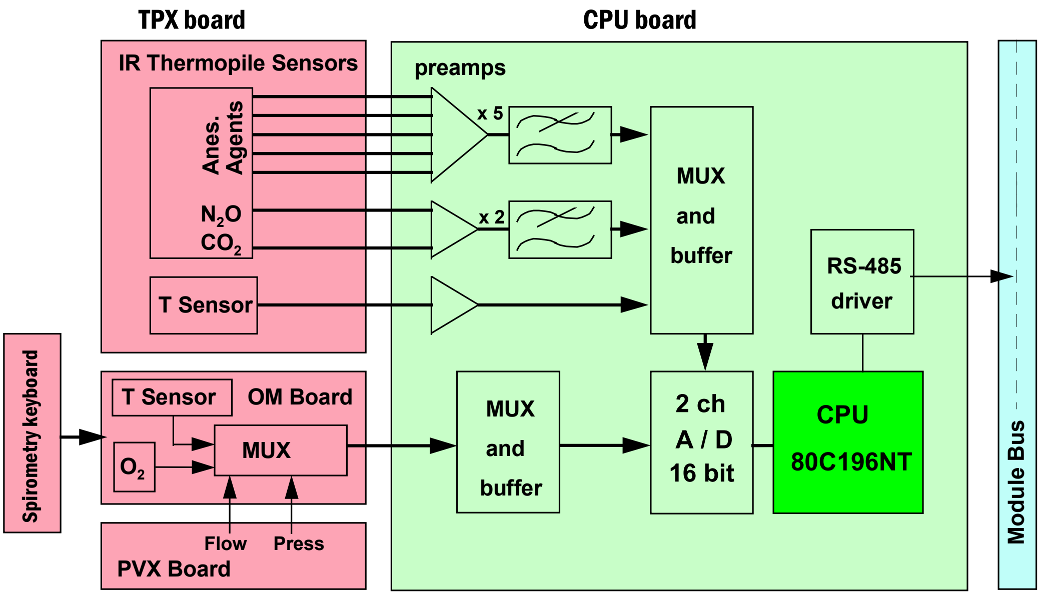



**Figure 12 Signal processing**

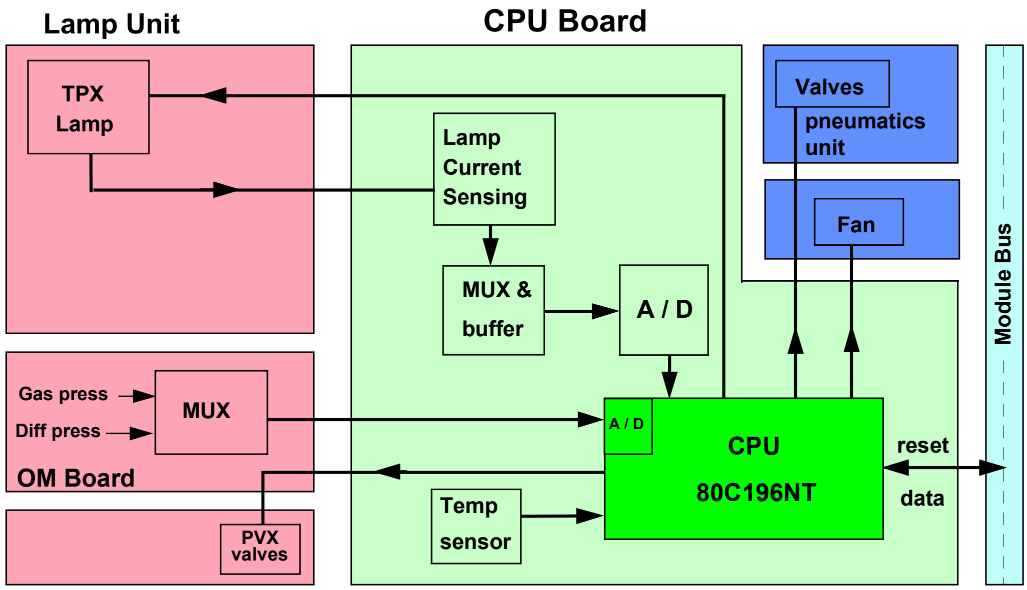



**Figure 13 Control logic**

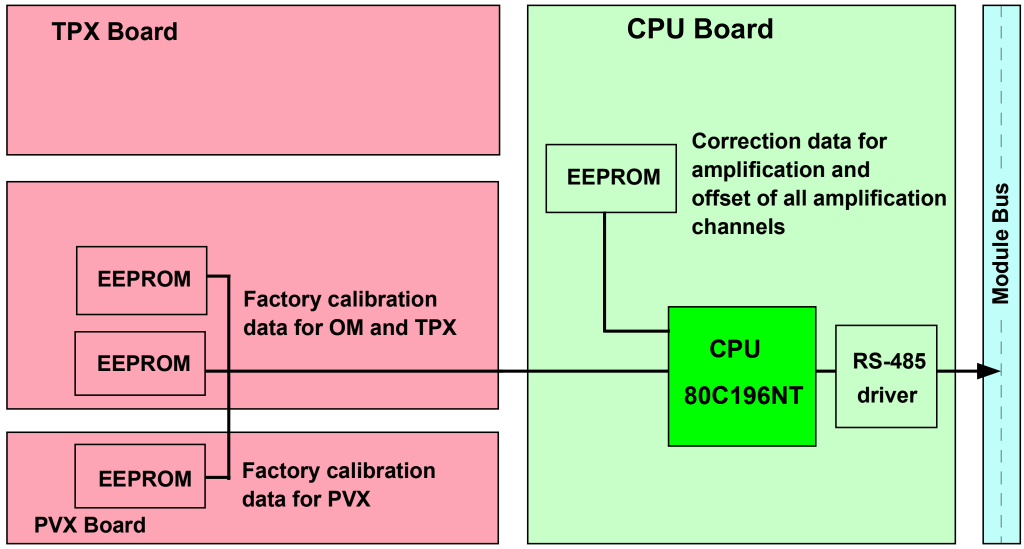



**Figure 14 Calibration data stored in EEPROM**

## 2.2.7 OM board

The Oxygen board contains the specific electronics for the oxygen sensor. Sample flow measurement and sampling system pressure sensors are on this board. It also contains EEPROM's that store calibration data of both TPX and OM-sensors. The spirometry keyboard connection is on this board.

## 2.2.8 PVX board

The Spirometry board is connected to the oxygen board. It contains pressure sensors for airway pressure and flow measurement differential pressure and preamplifiers for those. Calibration data of spirometry is stored on it's own EEPROM.

## 2.3 Connectors and signals

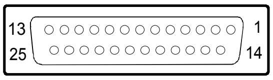



**Figure 15 Module bus connector pin layout**

**Table 2 Module bus connector pin description**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET RS485 |
| 2 | I | -15 VDC |
| 3 | I | +15 VDIRTY |
| 4 | I | +15VDC |
| 5 | I/O | -DATA RS485 |
| 6 | I/O | DATA RS485 |
| 7 | | Ground and Shield |
| 8 | I | -RESET RS485 |
| 9 | | n/c |
| 10 | | n/c |
| 11 | | n/c |
| 12 | | n/c |
| 13 | | Ground and Shield |
| 14 | I | +24/+32 VDIRTY depends on power supply (not used) |
| 15 | I | Ground DIRTY |
| 16 | | n/c |
| 17 | | n/c |
| 18 | | n/c |
| 19 | | n/c |
| 20 | I | GASFR (not used) |
| 21 | I | CTSD (not used) |
| 22 | I | TXDD (not used) |
| 23 | O | RXDD (not used) |
| 24 | I | +5 VDC |
| 25 | I | +5 VDC DIRTY, for infrared lamps |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the compact airway modules is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

CAUTION The module electronics can only be repaired and calibrated at the factory.

### 3.1.1 OM measuring unit

CAUTION Due to the complicated and sensitive mechanical construction of the $O_2$ measuring unit , no repairs should be attempted inside the unit.

### 3.1.2 TPX measuring unit

CAUTION The TPX photometer and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. The information provided is for reference only.

### 3.1.3 OM, TPX, and PVX measuring unit

CAUTION The OM, TPX, and PVX measuring units can be repaired only at the factory.

### 3.1.4 Serviceable or exchangeable parts

- Absorber
- D-fend
- Nafion tubes
- Fan filter
- Fan
- CPU board
- CPU software
- PVX Unit including PVX board
- Pump

NOTE: After any component replacement see chapter *Adjustments and calibrations*.

# 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form, *APPENDIX A* , which should be filled in when performing the procedures.

The mark  in the instructions means that the check form should be signed after performing the procedure.

## 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Screwdriver | | |
| Ambient pressure manometer | | |
| Flowmeter | | |
| Flow cassette 50/1.1 | 873812 | |
| Extra silicon tubing | | |
| Calibration gas and the regulator | 755583 (gas)<br>755534* | for M-CAiOVX/M-CAiOV/M-CAiO |
| Calibration gas and the regulator | 755587 (gas)<br>755534* | for M-COVX |
| Calibration gas and the regulator | 755581 (gas)<br>755534* | for M-COV/M-CO/M-C |
| Gas Interface Cable 2.5 m / 8 ft | 884299 | |

*NOTE: Ensure that the calibration gas and the regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required.
See  Calibration gas regulator flow check

## 3.2.2 Recommended parts

| Part | Order No. | Notes |
|---|---|---|
| Absorber | 895933 | |
| D-fend | 876446 | |
| D-fend+ | 881319 | for M-COVX |
| Sampling line 3 m/10 ft | 73319 | anesthesia gas sampling line |
| Sampling line 2 m/7 ft | 73318 | for M-CAiOVX/M-COVX |
| D-lite / Pedi-lite | 733950/73393 | |

| Part | Order No. | Notes |
|---|---|---|
| D-lite+ | | for condensing active humidification circuits |
| Spirometry tube 2 m | 890031 | |
| Spirometry tube 3 m | 884101 | |
| D-fend O-ring (2 pcs) | 65312 | |
| Filter (3 pcs) | 886136 | 1 pcs @ latest revisions |
| Filter assembly | 896025 | @ latest revisions |
| Nafion tubes (2 pcs) | 733382 | |
| Fan filter | 886236 | |

## All modules

Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly
   - the front cover grounding pins are not bent against the CPU board
   - there are no loose objects inside the module

   NOTE: The tubes that are connected to the Oxygen board pressure transducers should not be pressed too deep.
   NOTE: Make sure that tubes are not in contact with the sampling pump or the $O_2$ sensor, or its springs.

2. Check external parts:
   - the front cover and the front panel stickers are intact
   - all connectors are intact and are attached properly
   - the D-fend latch is moving properly
   - the module box, the latch and the spring pin are intact

3. Clean or replace the fan filter.

4. Detach the D-fend. Check the condition of the rubber O-rings on the metal D-fend connectors, located in the Compact Airway Module front cover.
   If necessary, detach the connectors by first disconnecting the tubes, then removing the locking rings from the back of the front cover.

NOTE: The O-rings are recommended to be replaced annually.

5. Check that flow of air through the filters in the reference gas connection block (1 pc) and in the pneumatic unit (1 or 2 pcs) is not obstructed.

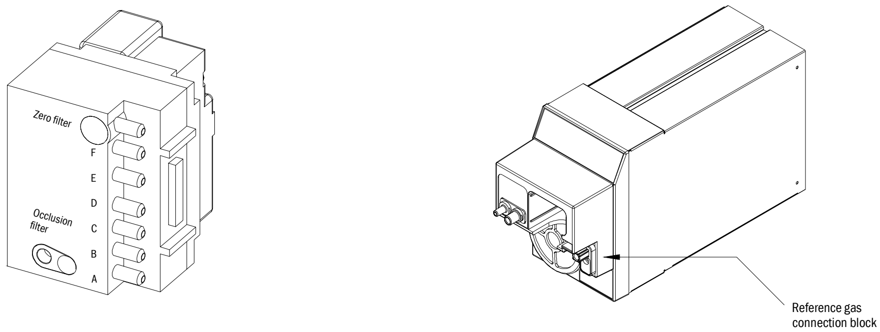



**Figure 16 Pneumatic unit and reference gas connection block**

NOTE: The filters should be replaced annually.

- Replace the old D-fend and sampling line with new ones.

NOTE: Use only Datex-Ohmeda sampling lines in order to ensure proper function.
2 m/7 ft sampling line should be used with M-COVX and M-CAiOVX.

- Connect the Compact Airway Module to the Central Unit's Module motherboard using the Gas interface cable (the grounding plates of the cable should be removed).
- Turn the monitor on.
- Configure the monitor screen so that all the needed parameters are shown, for example as follows:

**Monitor Setup** - ***Screen 1 Setup - Waveform fields - Field 1 - Paw***
***Field 2 - Flow***
***Field 3 - Off***
***Field 4 - O2***
***Field 5 - AA***
***Field 6 - CO2***
***Digit Fields***
***Lower Field 1 - Gases***

- Preset the following gas measurement settings (if available):

***Airway Gas - Select Agent - Hal***
***Spirometry Setup - Scaling Vol***
***Paw Scale - 20***
***Flow Scale - 15***

6. Check that the fan is running.

7. Wait until the message 'Calibrating gas sensor' disappears from the screen, then enter the Service menu.

   **Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Take down the information regarding Compact Airway Module software.

8. Enter the Compact Airway Module service menu.

   ***Parameters - Gas Unit - General***

   Check that the shown module configuration corresponds with the used Compact Airway Module type.

9. Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' -values are not increasing faster than by 5 per second.
   If one of the values is increasing faster it indicates a failure in module bus communication.

10. Enter the service menu ***Gases***:

    ***Gas Unit - Gases***

    Check that the flow measurement offset, i.e. the shown sample 'Zero' -value is within ±10 ml/min.

11. Check that the shown 'Ambient' -value corresponds with the current ambient pressure (±20 mmHg).

12. Check the zero valve.
    Feed calibration gas and check that the gas readings in the service menu correspond with the values on the gas bottle sticker. Keep feeding gas, then activate the zero valve from the menu. The $CO_2$ ($N_2O$, AA) reading should drop back near 0 %, the $O_2$ reading near 21 %.

13. Perform the steam test for the Nafion tubes, or replace those by new. Replace the $CO_2$ absorber, if necessary.

    NOTE: The Nafion tubes are recommended to be replaced annually. In case of exchanging the absorber it is recommended to replaced also this nafion tube.
    NOTE: The $CO_2$ absorber is recommended to be replaced once in four years.

14. Perform sampling system leak test.

    Prevent the module from performing the normal occlusion functions, i.e. controlling the valves, by turning the pump first off, then on again from the menu.

    Block the reference gas connector at the front panel.
    Connect a flow cassette with high flow resistance value (50/1.1) to the end of the sampling line and start following the 'Amb-Work' -value in the service menu. When the value exceeds 170 mmHg connect the other port of the flow cassette to the sample gas out connector and switch the pump off.
    Wait until pressure inside the sampling system is stabilized then notice the shown 'Amb-Work' -value. The value, i.e. the pressure inside the sampling system should not drop more than 6 mmHg in one minute.

    If the pressure drops more, first ensure the made connections and repeat the test.

15. Check the flow rates.

    Wait until the 'Sample Flow' -value is back near 200 ml /min.
    Connect a flowmeter to the 3 meter sampling line (use a 2 meter sampling line for M-CAiOVX and M-COVX) and check that the flow (the flowmeter reading) is within the following range:

| | |
|---|---|
| Sampling flow (ml/min) | 180...220 |

    If necessary, readjust the sampling flow:
    Select 'Sample gain adj' from the menu. To increase the sampling flow, turn the ComWheel counterclockwise, to decrease the flow, turn the ComWheel clockwise.
    A change of 0.050 in the 'Gain' -value changes the flow approximately 10 ml/min.
    After you have changed the gain, wait until the 'Sample Flow' -value on the screen gets back near the original then check the flowmeter reading again.

    Connect the flowmeter to the reference gas connector, check that the flow is within the following range:

| Reference flow (ml/min) | M-CAiOVX/ M-COVX | M-C | Others |
|---|---|---|---|
| | 27...40 | 25...45 | 31...45 |
| | (with 2m sampling line) | (with 3m sampling line) | (with 3m sampling line) |

    Activate the zero valve on from the service menu. The 'Sample Flow' -value should not change more than 20 ml/min. If the absorber is connected the value is 30 ml/min.

16. Check that the 'Amb-Work' -value in the service menu is within the following range:

| Amb-Work (mmHg) | M-CAiOVX/M-COVX | Others |
|---|---|---|
| | 70...115 | 40...75 |

17. Perform the gas calibration.

**Airway Gas** - ***Gas Calibration***

NOTE: Calibration is not recommended until 30 minutes warm-up time has elapsed.
Use calibration gas 755587 (5 % $CO_2$, 95 % $O_2$) for calibrating Airway Module, M-COVX, and calibration gas 755583 (2 % Desflurane, 5 % $CO_2$, 33 % $N_2O$, 55 % $O_2$, balance $N_2$) for M-CAiOVX/M-CAiOV/M-CAiO,
and calibration gas 755581 (5 % $CO_2$, 40 % $N_2O$, 55 % $O_2$) for calibrating M-COV/M-CO/M-C.

NOTE: You can calibrate the modules M-CO and M-COV with the same calibration gas as the M-COVX module, but M-C must always be calibrated with the gas 755581.

NOTE: For correct measurement values, modules need different amounts of oxygen in the calibration mixture. If you do not use the recommended calibration gases, the calibration will not succeed.

18. Perform the fall time measurement in the GASES service menu.

**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters - Gas Unit - Gases***
Activate the measurement by selecting Fall Time Meas from the service menu. Feed calibration gas until the message 'Feed' near the fall time values changes to 'READY'. If necessary, repeat the same procedure to get all the values on the screen.

Check that the measured values are within the following ranges:
$CO_2$ fall time < 400 ms
$O_2$ fall time < 400 ms
$CO_2$-$O_2$ delay < 800 ms

## Anesthesia Agent measurement

19. Agent ID reliability.
    Feed calibration gas (order code 755583) continuously for at least 30 seconds and check that the 'ID' in the service menu shows 'DES' and that the value for 'ID unrel.' is lower than 50.

    If the value is higher, repeat the gas calibration and check the value again.

## Patient Spirometry measurement

20. Enter the service menu ***Spirometry***:

    ***Gas Unit - Spirometry***

    Connect a clean Spirometry tube to the module and a clean D-lite to the other end of the tube. Block the D-lite's sampling line port, for example with a Luer stopper.

    NOTE: Make sure that the date marking on the D-lite is 10/94 or newer.

    Take the D-lite into your hand and occlude both ends tightly with your fingers (or with both hands). Pressing creates a pressure inside the D-lite. Check that pressure near 5 $cmH_2O$ is generated (the 'Aw Pressure' -value in the service menu).

    If the system leaks heavily, no pressure will be generated.

    If there is a small leak in the connections, the monitor will measure a pressure difference which is then interpreted as flow and seen on the monitor screen. The pressure waveform (and the 'Aw Pressure' -value) decreases slowly and the flow waveform (the 'Flow' -value) either goes above, or below the zero line, depending on which of the connectors is leaking.

    In case of leakage, first check all the connections and try again.

21. Remove the blockage from the sampling line port and connect the sampling line. Breath through the wider side of the D-lite. Check that the flow waveform moves downwards when you breath in, and upwards when you breath out.

22. If possible, check the Side Stream Spirometry measurement also with the Spirometry Tester (order code 884202). Follow the instructions that are supplied with the tester.

## All modules

Turn the monitor off, disconnect the Gas interface cable and reassemble the module. Remember to attach the plastic cover against the CPU board before installing the module box.

NOTE: When reassembling the module make sure that the tubes are not pinched between the module box and internal parts.

23. Perform electrical safety check and leakage current test.

    Install the Compact Airway Module into the Central Unit, turn the monitor on and wait until the message 'Calibrating gas sensor' disappears from the screen.

24. Block the tip of the sampling line by your finger and check that the message 'Sample line blocked' appears onto the monitor screen within 60 seconds.

25. Detach the D-fend and check that the messages 'Check D-fend' appears onto the monitor screen within 30 seconds.

    Reattach the D-fend. Simulate at least 5 breaths by feeding calibration gas into the sampling line. Check that the shown gas information is correct.

26. Check that the monitor shows the message 'Apnea' within 30 seconds after you have stopped feeding the gas.

27. Turn the monitor off, disconnect and clean the module.

    - Fill in all necessary documents.
    - It is recommended that you fill in the PM sticker, since the service check includes all the Planned Maintenance actions. Attach it to a suitable place on the module box.

## 3.3 Disassembly and reassembly

Disassemble the compact airway module in the following way. See also the exploded view of the module.

1. Remove two screws from the back of the module.
2. Pull the module box slowly backwards and detach it from the main body.

Reassembling is essentially reversing what was described above.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

CAUTION While reassembling the module, make sure that the grounding pins of the front unit EMC shield are in contact contact with the module box. Bend the pins carefully, if necessary.

### 3.3.1 PVX unit

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and the other cable of the TPX unit from CPU board.
4. Disconnect OM unit's cables, spirometry keyboard cable and PVX unit's cables from the OM board.
5. Detach the front panel from the module chassis (1 screw).
6. Detach the PVX unit from the front panel (1 screw).
7. Reassembling is essentially reversing what was described above.

### 3.3.2 Pump unit

1. Remove the module box.
2. Cut off the pump's clamp (panduit).
3. Unplug the hoses of the pump.
4. Disconnect the pump's cable from CPU board. Pass the cable under the pneumatic unit by lifting it.
5. Reassembling is essentially reversing what was described above.

### 3.3.3 CPU board

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and both cables of the TPX

unit from CPU board.

4. Detach the CPU board from the OM board.
5. Reassembling is essentially reversing what was described above.

### 3.3.4 Software of CPU board

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and the other cable of the TPX unit from CPU board.
4. Detach the CPU board from the OM board.
5. Detach the software from the CPU board.
6. Reassembling is essentially reversing what was described above.

### 3.3.5 Instructions after replacing software or CPU board

After replacing the software or CPU board:

- perform the sampling system leak test.
- perform the occlusion test
- perform the gas calibration.
- perform Fall time Measurement

## 3.4 Adjustments and calibrations

See *User's Reference Manual* for normal gas calibration instructions.

### 3.4.1 Gas sampling system adjustment

NOTE: Let the monitor run for 15 minutes before measuring flow rates.

For the flow rate measurements a flowmeter with a low flow resistance and capability to measure low flow rates is required. A normal length of sampling line has to be connected to the monitor as it has a considerable effect on the flow.

### 3.4.2 Flow rate measurement

**If any flow rates are not correct, first replace the D-fend water trap. Then recheck the incorrect flows.**

Sampling flow rate is measured by rotameter at the sampling line. The rate should be between 180 and 220 ml/min. The flow rate is adjusted in the Gas Service Menu with 'Sample Gain Adj.'.

Reference flow of the oxygen measuring unit are checked as follows:
Connect rotameter to the Gas Ref. inlet on the front panel. The flow rate should be between 31 and 45 ml/min (M-CAiOVX/M-COVX: 27-40 ml/min, M-C: 24-45 ml/min). The flow rate is not adjustable.

### 3.4.3 Flow rate adjustment

NOTE: Before adjusting the sampling flow make sure there is no leakage in the sampling system.

Refer to chapter *3.2 Service check,* step 15; Check the flow rates.

### 3.4.4 Gas calibration

NOTE: Ensure that the calibration gas and the regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required.

The gas calibration is performed in the ***Airway Gas*** menu. Please refer *User's Reference Manual.*

### Calibration gas regulator flow check

Interval: every 12 months

Regulator flow specification:

REF 755533 & 755534: 260 – 410 ml/min at 1-10 bar cylinder pressure
REF 755530: 260 – 410ml/min at 5-7psi cylinder pressure

Tools needed: calibration gas ca, regulator, piece of sislicon hose and a flow meter. Datex-Ohmeda recommends use of TSI 4140 Flow Meter.

Insert the calibration gas regulator on the gas cylinder. Connect a silicon hose between the regulator and the flow meter. Block the regulator overflow port and open the regulator. Check the flow rate from the flow meter and verify that the flow is within the specification.

### 3.4.5 Flow calibration

The PVX measuring unit is calibrated at the factory and due to the unit's design calibration is not regularly needed. The calibration data is saved into the board's EEPROM. In case calibration is needed, it is recommended to perform the calibration both with adult values using the D-lite, and with pediatric values using Pedi-lite.

1. Connect a spirometry tube with a D-lite sensor to the compact airway module. To improve the accuracy, the endotracheal tube and all accessories, which normally are in use, should be attached also during the calibration.
2. Enter the Gas Unit service menu: **Monitor Setup** - ***Install Service - Service - Parameters***. Enter the Spirometry menu.
3. After the flow is zeroed ('Zero OK' message displayed ) attach a preferably spirometry tester to the flow sensor (D-lite or Pedi-lite). Select the sensor type.
4. Perform the calibration according to the tester instructions. Observe the values of inspired and expired tidal volumes.
5. Adjust the reading to match the calibration volume (about 1000 ml for the D-lite and 300 ml for the Pedi-lite). Adjust Exp Flow Gain and Insp Flow Gain values in proportion to the difference between measured values and the spirometry tester reading.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting charts

| Trouble | Possible cause/treatment |
|---|---|
| No response to breathing | Sampling line or water trap blocked or loose, or improperly attached.<br>Water trap container full.<br>See the gas sampling system troubleshooting. |
| SENSOR INOP. -message | The temperature is too high, check fan and filter at the front panel<br>Communication error, check timeout and bad checksum values at the service menu |
| xx ZEROING ERROR -message | Gas zeroing failed. Condensation or residual gases are affecting zero measurement. Allow module to run drawing room air for half an hour and calibrate again. |
| CHECK D-FEND -message<br>(Air leak-message)[1] | Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage. |
| REPLACE D-FEND -message<br>(Replace water trap -message)[1] | Indicates residue build-up on the water trap membrane. This decreases air flow. Replace the D-fend. |
| REBREATHING-message<br>($FiCO_2$ high -message)[1] | $CO_2$ concentration in inspiratory air is too high. Possibly $CO_2$ absorber in ventilation is saturated. Change the ventilation absorber. |
| SAMPLE LINE BLOCKED-message<br>(Air leak -message)[1] | Sampling line or water trap is occluded. Water trap container is full. If occlusion persists check internal tubing for blockages. |
| (SELECT AGENT -message)[1] | No anesthetic agent is selected though delivery is started. Vaporizer valve is broken, or traces of cleaning or disinfecting agent in the water trap container affecting the readouts. Let the container dry properly after disinfection before use. |
| No response to any gas | Sampling line, water trap, or internal tubing blocked or loose, or improperly attached.<br>Occlusion or zero valve malfunction. Pump failure. Supply voltage missing. Serial communication error. |

| Trouble | Possible cause/treatment |
|---|---|
| Sudden increase in gas display | Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates. |
| Abnormally high<br>response to all gases<br>(or abnormally low) or sudden<br>occlusion warning | Pressure transducer failure. |

[1] @ earlier revisions

| Trouble | Possible cause/treatment |
|---|---|
| Strong drift in all gases | Leak in sampling line or internal tubing (especially in conjunction with too low readings). |
| MVexp << MVinsp message | Leak in patient circuit between patient and D-lite, or in the patient lungs, or leak in tubes from D-lite to module. Check D-lite connection and D-lite tubing. |
| (Disconnection)[1)]<br>(MVexp < 0.5 l/min message)[1)]<br>Low volumes | Too small tidal volumes for accurate measurement (not shown during Apnea). Gas sampling is working correctly. Check D-lite connections and D-lite tubing. |

### 4.1.1 $CO_2$ measurement

| Problem | Possible clinical cause | Possible technical cause | Action |
|---|---|---|---|
| too low $ETCO_2$ value | • sudden decrease in circulation<br>• pulmonary embolism<br>• hyperventilation<br>• very large dead-space<br>• large shunting | • leak in sampling system<br>• calibration error<br>• high by-pass flow from ventilator | • check all connections<br>• check calibration |
| too high $ETCO_2$ | • hypoventilation<br>• increased metabolism | • D-fend contaminated<br>• calibration error | • change D-fend<br>• check calibration |
| waveform clipped | • | • incorrect scaling | • change scale |
| no response to breathing | • apnea<br>• (disconnection)[1)] | • sampling line or water trap loose or blocked (air leak)[1)]<br>• sample gas outlet blocked | • check all connections<br>• check that outlet is open |
| $ETCO_2$ overscale >15 % (>20 %)[1)]<br>Shown untill 32 %, specified range 0...15 % | • abnormally high $ETCO_2$ (permissive hypercapnia) | • $CO_2$ sensor contaminated<br>• D-fend malfunction | • call service technician<br>• change D-fend |
| $ETCO_2$>$PaCO_2$ | • unit is mmHg or kPa and $ETCO_2$ is close to arterial $PCO_2$ | • “dry gas” as default | • change to “wet gas” by using install/service menu |

[1)] @ earlier revisions

### 4.1.2 Patient spirometry

| Problem | Possible clinical cause | Possible technical cause | Action |
|---|---|---|---|
| insp TV>exp TV | • leak in lungs<br>• ET tube cuff leak | • spirometry tube leak<br>• water inside D-lite or tubings<br>• another side stream gas sampling between D-lite and patient<br>• D-fend leaks | • check leakages -- perform leak test<br>• change tubings and D-lite<br>• don't use active humidification<br>• connect gas sampling only and always to D-lite<br>• check D-fend |
| exp TV> insp TV | | • spirometry tube leak | • check leakages -- perform leak test |
| | | • water inside D-lite or tubings | • change tubings and D-lite<br>• don't use active humidification |
| loop overscale | | • wrong scale selected | • change scaling |
| monitored volumes < set volumes | | • leak between ventilator and D-lite | • check ventilator connections |
| strongly vibrating loop | • mucus in ET tube | - | • suction the patient |
| | | • water or secretions in hoses or D-lite | • change dry D-lite and/or empty the water from hoses |
| too large or too small volumes | | • wrong mode vs sensor selection<br>• incompatible between selected sensor and sensor used | • check mode and sensor<br>– D-lite for adult<br>– Pedi-lite for pediatric |

| Problem | Possible clinical cause | Possible technical cause | Action |
|---|---|---|---|
| fluctuating Raw | • mucus in airways or tubings<br>• breathing effort against the ventilator<br>• patient triggered breaths | • ventilator exp. valve causes fluctuations during exp. flow | |
| too high Raw | • kink in tubing<br>• mucus<br>• asthmatic patient<br>• bronchospasm | | |
| Raw value invalid | • spontaneous breaths<br>• breathing efforts against the ventilator<br>• patient triggered breaths | | |
| too high Ppeak | • bronchospasm<br>• patient is coughing<br>• patient breaths against the ventilator<br>• obstruction in airways<br>• HME obstructed | | |
| static PEEPi not measured | | • $CO_2$ measurement is not connected<br>• stat PEEPi measurement not selected[1)]<br>• exp. pause did not last at least 4 sec. | • connect $CO_2$ meas. to D-lite<br>• go to spirometry setup[1)] |
| Compl value invalid | • spontaneous breaths | | |

[1)] only @ earlier revisions

### 4.1.3 Gas exchange

| Problem | Possible clinical cause | Possible technical cause | Action |
|---|---|---|---|
| "Strange" values | • ventilation mode: BiPaP, CPAP with high continuous by-pass flow<br>• presence of $N_2O$ or anesthetic agents in ICU applications | | • gas exchange not measurable<br>• do not use $N_2O$ or AA in ICU, or use a M-CAiOVX module |
| Unphysiological $VO_2$ readings | • unstable $O_2$ delivery<br>– gas mixer | | • select oxygram and verify the stableness of the curve |
| | • RR over 35/min | • reference gas inlet port blocked | • check reference port |
| | | • gas sampling line longer than 2 m | • change 2 m sampling line |
| | | • dead space of Y-piece > 8 ml | • check the dead space of Y-piece |
| | | • gas sampling line connected to HME | • gas sampling line should ALWAYS be connected to D-lite |
| | | • D-lite incorrectly placed | • do not connect anything between D-lite and Y-piece<br>• ALWAYS connect D-lite between the HME and Y-piece |
| $VO_2$ value invalid,<br>no $VO_2$,<br>$FiO_2 > 85$ %,<br>$(FiO_2+FiN_2O) > 85$ % | • over range<br>• no $VO_2$ value<br>• 999 ml/min < $VO_2$ < 0 | | |

## 4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of dirt or other matter accumulating in the internal tubing.

The following checks should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system check and if necessary adjust the flow rate.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: The D-fend water trap should be replaced when the REPLACE D-FEND message appears during monitor startup.

NOTE: If any liquid has entered the TPX measuring unit due to water trap filter failure, contact Datex-Ohmeda Technical Services.

### 4.2.1 Sampling system leak test

1. Prevent the module from performing the normal occlusion functions, i.e. controlling the valves, by turning the pump first off, then on again from the menu.
2. Block the reference gas connector at the front panel.
3. Connect a flow cassette with high flow resistance value (50/1.1) to the end of the sampling line and start following the 'Amb-Work' -value in the service menu. When the value exceeds 170 mmHg connect the other port of the flow cassette to the sample gas out connector and switch the pump off.
4. Wait until pressure inside the sampling system is stabilized then notice the shown 'Amb-Work' -value. The value, i.e. the pressure inside the sampling system should not drop more than 6 mmHg in one minute.
5. If the pressure drops more, first ensure the connections you have made and repeat the test.

### 4.2.2 Steam test for the Nafion™ tubes

Choose Halothane as anesthetic agent and let the monitor sample room air. Then quickly feed air of 100 % relative humidity (for instance from a kettle in which you are boiling water) to the monitor. If the digital reading jumps as much as 0.1 % replace the Nafion tubes.

## 4.3 OM measuring unit troubleshooting

CAUTION Due to the complicated and sensitive mechanical construction of the oxygen measuring unit, no repairs should be attempted inside the unit. Instead, if the fault has been found in the measuring unit itself, the entire module should be replaced and the faulty module be sent to Datex-Ohmeda for repair.

In cases of no response to $O_2$ or strong drift, check the tubing for loose connections, blockages and leaks.

CAUTION Never apply overpressure to the $O_2$ measuring unit, as the pressure transducer may be permanently damaged.

If the $O_2$ signal is noisy, check the measurement unit suspension.

## 4.4 TPX measuring unit troubleshooting

CAUTION The TPX measuring unit can only be repaired and calibrated at the factory. In case of failure, the entire module should be replaced and the faulty module be sent to Datex-Ohmeda for repair.

## 4.5 PVX measuring unit troubleshooting

In case of failure the PVX unit can be replaced.

NOTE: Never apply overpressure or negative pressure of more than 300 $cmH_2O$ to the flow and volume tubing. Also never apply differential pressure of more than 25 mmHg on one PVX-connection at a time.

### 4.5.1 Spirometry tubing leak test

1. Select airway pressure (Paw) and flow waveforms (Flow) on the monitor screen.
2. Connect a clean spirometry tube to the module and a clean D-lite to the other end of the tube. Block the D-lite's sampling line port, for example with a luer stopper.

NOTE: Make sure that the date marking on the D-lite is 10/94 or newer.

3. Take the D-lite in your hand and occlude both ends tightly with your fingers (or with both hands). Pressing firmly with the fingers creates a pressure inside the D-lite.
4. Check that a pressure of at least 5 cmH2O is generated. If the system leaks heavily, no pressure will be generated. If there is a small leak in the connections, the monitor will measure a pressure difference which is then interpreted as flow and seen on the monitor screen. The pressure waveform decreases slowly and the flow waveform either goes above, or below the zero line, depending on which of the connectors leak.

## 4.6 CPU board troubleshooting

Due to the complexity of the large scale integrated circuitry there are few faults in the CPU digital electronics that can be located without special equipment.

Check only that RAM, EPROM, CPU, and other socketed ICs are properly installed.

## 4.7 Error messages

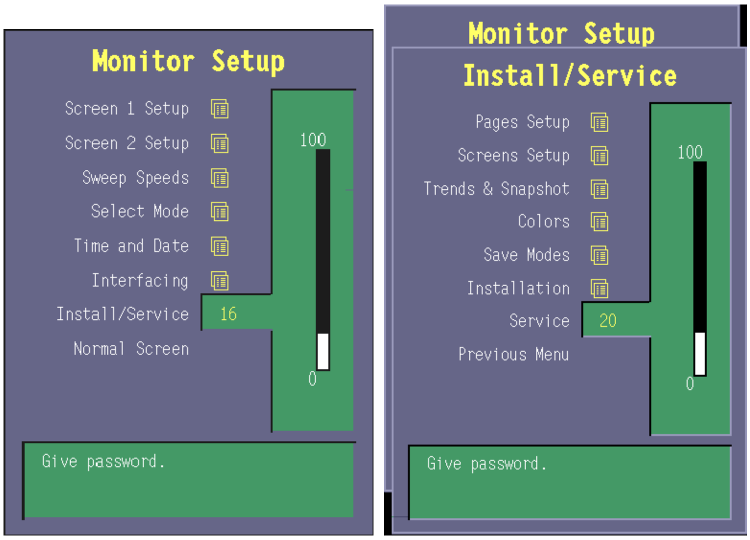
| Message | Explanation |
|---|---|
| Occlusion or Sample Line Blocked | The sample tube inside or outside the monitor is blocked or water trap is occluded. If occlusion persists, measured gas values disappear. |

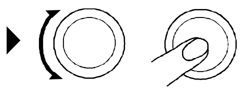
| | |
|---|---|
| Continuous occlusion. Check sampling line and D-fend. | Occlusion over 40 seconds. |
| Check D-Fend | -the water trap is not connected<br>-there is a leak in the sampling line inside the module. If air leak persists measured gas values disappear. |
| Air leak detected. Check water trap and sample gas out-flow. Press normal screen to continue. | Air leak over 40 seconds. |
| Replace D-fend (replace water trap)[1)] | Indicates residue build-up on the water trap membrane. This decreases air flow. |
| Gas calibration is not available during first 5 minutes/during occlusion/during air leak | Entering calibration is not allowed during 5 minutes after power up and during occlusion or air leak. |
| Gas out blocked | - Gas out connector on the front panel, or the exhaust line connected to it, is blocked.<br>- If the sample gas is returned to patient circuit the filter in the return kit may be occluded.<br>- Make sure the sample gas outlet is connected to an open scavenging system only where gas is removed in room pressure. |
| Select agent[1)] | No agent selected |
| Select agent[1)] | Mixture of agent is detected, but no agent is selected. |
| Check agent[1)] | Agent is selected manually, but it differs from the identified one. |
| Failure in Agent ID (unknown agent) | The agent ID has failed (due to a third agent). |
| Overrange | $FiO_2$ >100 % measured |
| Recalibration | Time out, fluctivating gases, gain adjusted “over” |
| **$CO_2$, $O_2$, AA, $N_2O$** | |
| Zero error | Unsuccessful zeroing. |
| Unstable, Calibr error | Unsuccessful calibration. |
| **Menu messages during calibration**: | |
| Zero error | Unsuccessful zeroing |
| Adjust | Calibration gas accepted and monitor is ready for adjusting the gas values to match the calibration gas concentration |
| Unstable | Unsuccessful calibration |

1) only @ earlier revisions

# 5 SERVICE MENU

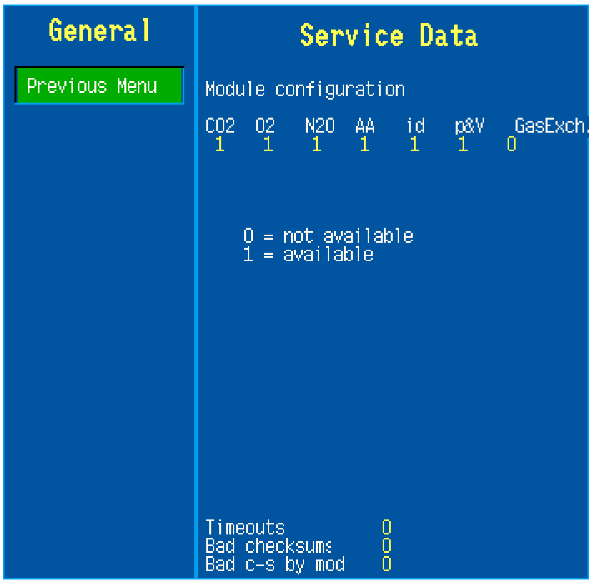
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



Press the **Monitor Setup** key - select ***Install/Service*** (password: 16-4-34) - select ***Service*** (password: 26-23-8) - select ***Parameters*** - select ***Gas Unit***.

## 5.1 General menu




**Service Data field**

**Module configuration** shows which measurement options are available, i.e. are detected by the module.

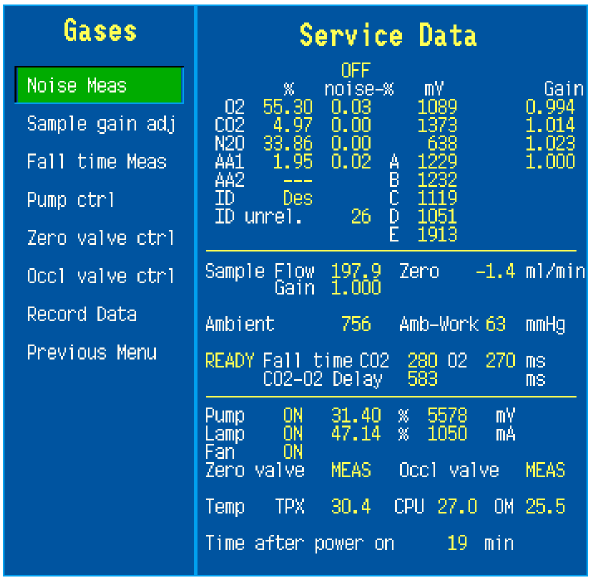
**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.

**Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.

**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.

The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure or module not in place. Also other modules can cause these numbers to rise.

## 5.2 Gases service menu




**Noise Meas** A selection for activating the noise measurement.

**Sample gain adj** A selection for adjusting the sampling pump gain, i.e. for for adjusting the sample flow measurement.

**Fall time Meas** A selection for activating the fall time measurement.

**Pump ctrl** A manual control for the sampling pump

**Zero valve ctrl** A manual control for the zero valve.

**Occl valve ctrl** A manual control for the occlusion valve.

**Record Data** Record Data prints out the shown service data and board information (id. serial number and software id.) onto the recorder module, M-REC.

### Service Data field

**$O_2$, $CO_2$, $N_2O$, AA** **%** -field shows realtime concentrations, **noise-%** is standard deviation of concentration.

**$O_2$, $CO_2$, $N_2O$, AA channels A-E**

**mV** -field: signal is scaled to mV, **Gain**: User gain. It is scaled as (User gain)/(Factory gain).

**ID** Shows the identified agent.

**ID unrel.** The shown value tells how **unreliable** the identification is. With pure agent the value is normally < 50.

**Sample Flow** **Sample Flow** is calculated from differential pressure and is adjusted by the module. **Zero** value as measured during initialization when the pump is off. **Gain**: sample flow measurement can be calibrated by adjusting the gain.

**Ambient** **Ambient**: ambient pressure is measured every 30 min. **Amb-Work**: ambient pressure - sampling system internal pressure.

**Fall time** $CO_2$ and $O_2$ in ms. For $N_2O$ and AA same as $CO_2$.

**$CO_2$-$O_2$ Delay** In ms. No delay between $CO_2$, $N_2O$, and agents.

**Pump** Can be toggled ON/OFF.
PWM output 0-100% is shown. Pump voltage is also shown.

**Lamp** The state, PWM control, and current of the lamp are shown.

**Fan** The state of the fan is shown.

**Zero and Occl valve**

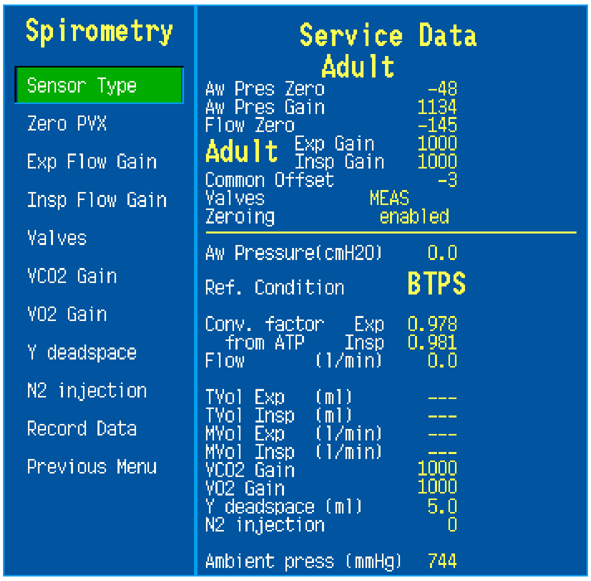
Can be toggled between measurement state (MEAS) and zeroing/occlusion states (ZERO/OCCL).

**Temp** Temperatures measured by the module from TPX, CPU, and OM.

**Time after power on**

In minutes after power on.

## 5.3 Spirometry service menu




Insp and exp flow gains can be adjusted if calibration is needed. Calibration pump or spirometry tester is used and readings are observed from display. If a deviation exists, gains are adjusted accordingly. Gain scaling is 1.000 when factory settings are in effect (1.050 in modules that contain the Gas Exchange measurement).

When Adjust key is pressed, a separate box for adjusting the value appears. During adjustment calibration values are sent to module. When comwheel is pressed, the values are permanently stored in EEPROM of module and the box disappears.

**Zero PVX** Start zeroing of the pressure sensors. Effects Aw Pres Zero and Flow Zero value.

**Exp Flow Gain / Insp Flow Gain**
Adjust the Flow sensor gains.

**Valves** Switch between MEASUREMENT and ZEROING

**VCO2 / VO2 Gain** Adjust the $VCO_2$ and $VO_2$ gain.

**Y deadspace** Adjust the Y-deadspace.

**N2 injection** Select between on (1) and off (0).

**Record Data** Record Data prints out the shown service data and board information (id. serial number and software id.) onto the recorder module, M-REC.

### Service Data field

- Sensor ADULT/PEDIATRIC according to selected measurement mode (sensor). Insp/Exp Flow Gains shown apply to the selected sensor.
- Aw Press Zero and Flow Zero are a result of zeroing in user service menu. In factory calibration menu they can be adjusted, but not permanently stored.
- Aw Press Gain is directly the value used in sw. It can be adjusted, but not permanently stored.

- Exp Flow and Insp Flow Gains are scaled as (user gain)/(factory gain). Exp and Insp Flow Gains can be adjusted also in user service menu.
- Common Offset is the compensation factor for pressure difference reading of the difference sensor when applying a equal pressure on both sides of the sensor.
- Valves can be changed between MEASUREMENT and ZEROING.
- Zeroing automatic zeroing either ENABLED or DISABLED (only factory service menu).
- Aw Pressure shows the real time value of airway pressure
- Condition shows in which reference conditions results are. With calibration pump or spirometry tester the results are always in ATP. If breathing is detected ($EtCO_2 > 1.0$ %), results are according to Flow & Vol Setup selection.
- Flow shows flow measurement value.
- TVol Exp, TVol Insp, MVol Exp and MVol Insp are shown to ease calibration. The numbers are the same as on main display. The former pump calibration procedure has been dropped out. We claim that calibration is not needed in routine clinical use, so a separate Flow calibration menu is not needed. Calibration can be done with the pump or spirometry tester. The results must be taken from the screen and gains adjusted accordingly.
- $VCO_2$ and $VO_2$ Gain shows a value near 1000, the correct gains have been measured in the factory.
- Y deadspace is the geometric volume in ml between the Y-piece and the D-lite. Default is 5 ml for a standard Y-piece (as delivered with Siemens 900C ventilators). Used for $VCO_2$ and $VO_2$ delay time corrections.
- Set $N_2$ injection to 1 during laboratory tests with a Spirometry tester and injection of $N_2$ gas (for scientific validations use only). At power on of the module, the value is always zero.
- Ambient pressure

# 6 SPARE PARTS

## 6.1 Spare parts list

NOTE: Accessories are listed in the Patient Monitor Supplies and Accessories catalogue.

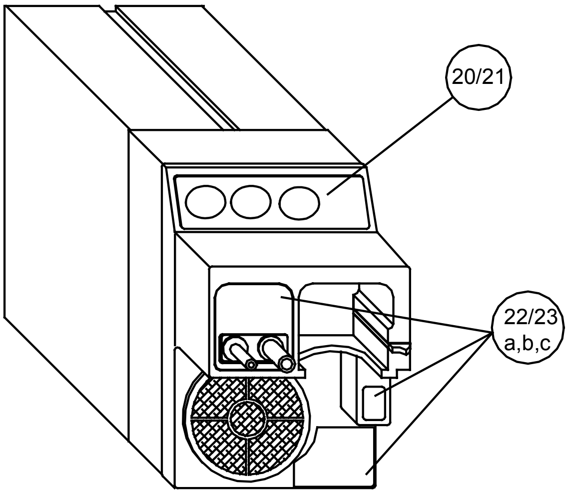



**Figure 17 Front panel stickers**

### 6.1.1 M-C rev. 00, M-CO rev. 00

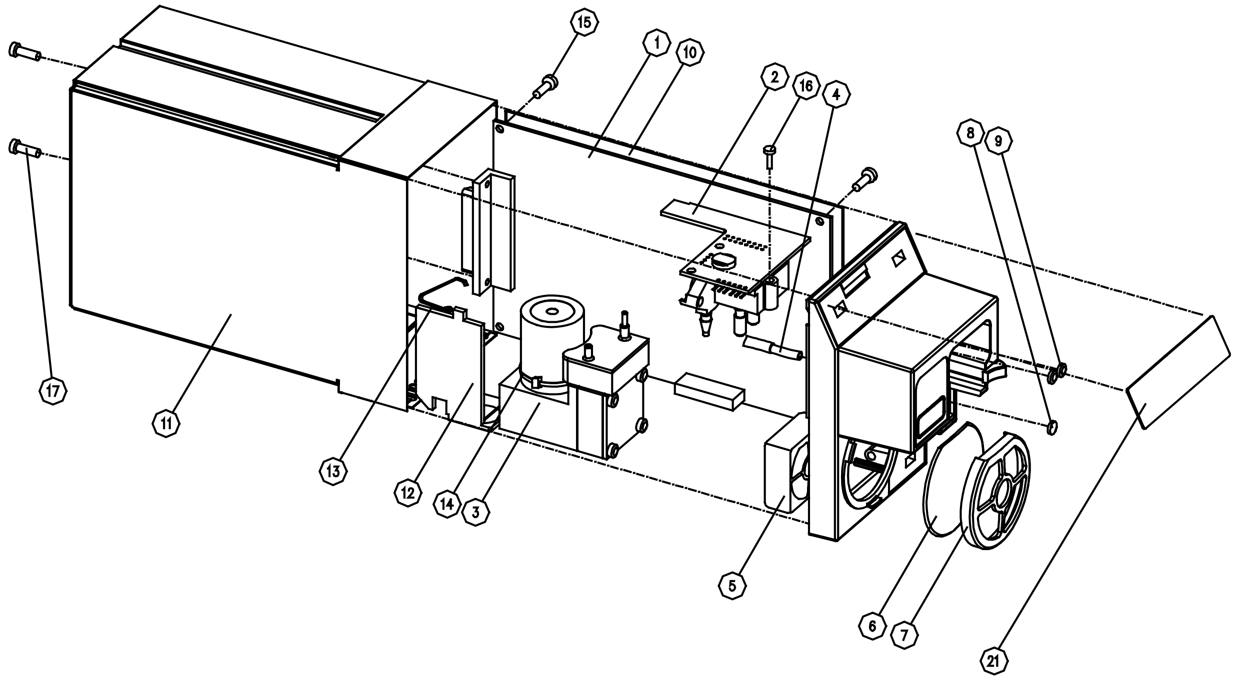



**Figure 18 Exploded view, M-C rev.00, M-CO rev.00, M-CaiO rev.00, M-COV rev. 01, M-CaiOV rev.01, M-COVX rev.00**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | CPU board, Compact Airway Module | 884313 | 8001806 |
| 2 | PVX unit, Compact Airway Module | 895946 | |
| 3 | Pump-air, 5-15VDC | 57313 | |
| 4 | Nafion tubing, 300mm | 733382 | |
| 5 | Fan, Compact Airway Module | 886213 | |
| 6 | Fan filter | 886236 | |
| 7 | Fan filter cover | 886659 | |
| 8 | Filter | 886136 | |
| 9 | O-ring 4.0x1.0 | 65312 | |
| 10 | Insulation plate | 890873 | |
| 11 | Module box (double width) | 887006 | 893225 |
| 11 | Module box (double width) | 893225 | |
| 12 | Latch for module box | 879181 | |
| 13 | Spring pin | 879182 | |
| 14 | Cable tie | 640013 | |
| 15 | Cross recess screw UNC 4-40 | 61841 | |
| 16 | Cross cylinder-head screw M3x6 | 61721 | |
| 17 | Cross cylinder-head screw M3x6 | 61721 | |
| 21 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 898624 |
| 21 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 8000204 |
| 22 | Front Panel sticker set, DA ; M-C (rev.00-01) | 892222 | 898516 |
| 22 | Front Panel sticker set, DA ; M-CO (rev.00-01) | 892223 | 898621 |

| | | | |
|---|---|---|---|
| 22 | Front Panel sticker set, DE ; M-C (rev.01-02) | 890695 | 898507 |
| 22 | Front Panel sticker set, DE ; M-CO (rev.00-01) | 890692 | 898612 |
| 22 | Front Panel sticker set, EN ; M-C (rev.00-01) | 890694 | 898506 |
| 22 | Front Panel sticker set, EN ; M-CO (rev.00-01) | 890691 | 898611 |
| 22 | Front Panel sticker set, ES ; M-C (rev.00-01) | 892240 | 898510 |
| 22 | Front Panel sticker set, ES ; M-CO (rev.00-01) | 892241 | 898615 |
| 22 | Front Panel sticker set, FI ; M-C (rev.00-01) | 892246 | 898513 |
| 22 | Front Panel sticker set, FI ; M-CO (rev.00-01) | 892247 | 898618 |
| 22 | Front Panel sticker set, FR ; M-C (rev.00-01) | 890696 | 898508 |
| 22 | Front Panel sticker set, FR ; M-CO (rev.00-01) | 890693 | 898613 |
| 22 | Front Panel sticker set, IT ; M-C (rev.00-01) | 892234 | 898511 |
| 22 | Front Panel sticker set, IT ; M-CO (rev.00-01) | 892235 | 898616 |
| 22 | Front Panel sticker set, JA ; M-C (rev.00-01) | 894986 | 898517 |
| 22 | Front Panel sticker set, JA ; M-CO (rev.00-01) | 894987 | 898622 |
| 22 | Front Panel sticker set, NL ; M-C (rev.00-01) | 892228 | 898509 |
| 22 | Front Panel sticker set, NL ; M-CO (rev.00-01) | 892229 | 898614 |
| 22 | Front Panel sticker set, NO ; M-C (rev.00-01) | 893544 | 898515 |
| 22 | Front Panel sticker set, NO ; M-CO (rev.00-01) | 893547 | 898620 |
| 22 | Front Panel sticker set, PT ; M-C (rev.00-01) | 895245 | 898512 |
| 22 | Front Panel sticker set, PT ; M-CO (rev.00-01) | 895246 | 898617 |
| 22 | Front Panel sticker set, SV ; M-C (rev.00-01) | 891101 | 898514 |
| 22 | Front Panel sticker set, SV ; M-CO (rev.00-01) | 891104 | 898619 |

### 6.1.2 M-C rev. 01-02, M-CO rev. 01-03

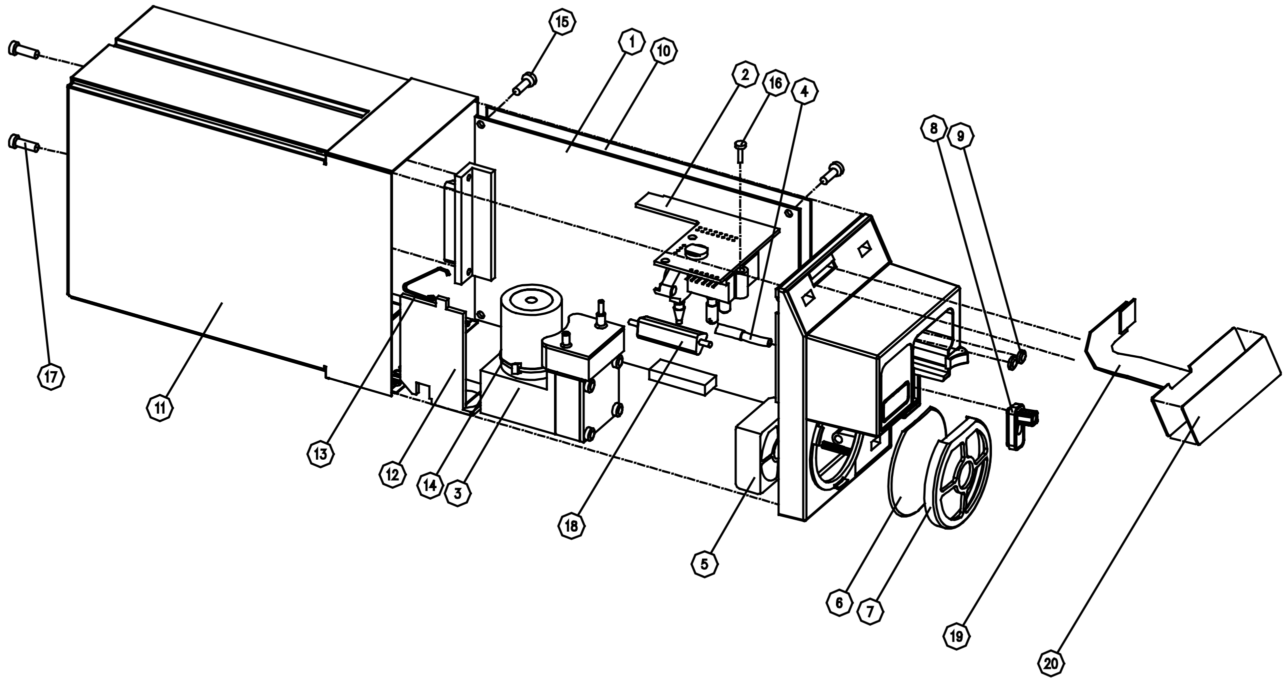



**Figure 19** **Exploded view M-C rev. 01-02, M-CO rev. 01-03, M-COV rev.02, M-COVX rev.01, M-CAiO rev.01, M-CAiOV rev. 02, M-CAiOVX rev.00**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | CPU board, Compact Airway Module | 884313 | 8001806 |
| 2 | PVX unit, Compact Airway Module | 895946 | |
| 3 | Pump-air, 5-15VDC | 57313 | |
| 4 | Nafion tubing, 300mm | 733382 | |
| 5 | Fan, Compact Airway Module | 886213 | |
| 6 | Fan filter | 886236 | |
| 7 | Fan filter cover | 886659 | |
| 8 | Ref. Gas and Output Connector | 886245 | |
| 8 | Ref. Gas Filter and Frame | 896025 | |
| 9 | O-ring 4.0x1.0 | 65312 | |
| 10 | Insulation plate | 890873 | |
| 11 | Module box (double width) | 893225 | |
| 12 | Latch for module box | 879181 | |
| 13 | Spring pin | 879182 | |
| 14 | Cable tie | 640013 | |
| 15 | Cross recess screw UNC 4-40 | 61841 | |
| 16 | Cross cylinder-head screw M3x6 | 61721 | |
| 17 | Cross cylinder-head screw M3x6 | 61721 | |
| 18 | Zero Absorber | 895933 | |
| 19 | Membrane keypad for spirometry modules | 895785 | |
| 20 | Front Panel sticker blanco, M-C(O), M-CAiO ; S/5 | 898624 | |
| 20 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 898624 |

| | | | |
|---|---|---|---|
| 20 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 8000204 |
| 23 | Front Panel sticker set, DA ; M-C (rev.00-01) | 892222 | 898516 |
| 23 | Front Panel sticker set, DA ; M-C (rev.02) ; S/5 | 898516 | |
| 23 | Front Panel sticker set, DA ; M-CO (rev.00-01) | 892223 | 898621 |
| 23 | Front Panel sticker set, DA ; M-CO (rev.02) ; S/5 | 898621 | |
| 23 | Front Panel sticker set, DE ; M-C (rev.01-02) | 890695 | 898507 |
| 23 | Front Panel sticker set, DE ; M-C (rev.02) ; S/5 | 898507 | |
| 23 | Front Panel sticker set, DE ; M-CO (rev.00-01) | 890692 | 898612 |
| 23 | Front Panel sticker set, DE ; M-CO (rev.02) ; S/5 | 898612 | |
| 23 | Front Panel sticker set, EN ; M-C (rev.00-01) | 890694 | 898506 |
| 23 | Front Panel sticker set, EN ; M-C (rev.02) ; S/5 | 898506 | |
| 23 | Front Panel sticker set, EN ; M-CO (rev.00-01) | 890691 | 898611 |
| 23 | Front Panel sticker set, EN ; M-CO (rev.02) ; S/5 | 898611 | |
| 23 | Front Panel sticker set, ES ; M-C (rev.00-01) | 892240 | 898510 |
| 23 | Front Panel sticker set, ES ; M-C (rev.02) ; S/5 | 898510 | |
| 23 | Front Panel sticker set, ES ; M-CO (rev.00-01) | 892241 | 898615 |
| 23 | Front Panel sticker set, ES ; M-CO (rev.02) ; S/5 | 898615 | |
| 23 | Front Panel sticker set, FI ; M-C (rev.00-01) | 892246 | 898513 |
| 23 | Front Panel sticker set, FI ; M-C (rev.02) ; S/5 | 898513 | |
| 23 | Front Panel sticker set, FI ; M-CO (rev.00-01) | 892247 | 898618 |
| 23 | Front Panel sticker set, FI ; M-CO (rev.02) ; S/5 | 898618 | |
| 23 | Front Panel sticker set, FR ; M-C (rev.00-01) | 890696 | 898508 |
| 23 | Front Panel sticker set, FR ; M-C (rev.02) ; S/5 | 898508 | |
| 23 | Front Panel sticker set, FR ; M-CO (rev.00-01) | 890693 | 898613 |
| 23 | Front Panel sticker set, FR ; M-CO (rev.02) ; S/5 | 898613 | |
| 23 | Front Panel sticker set, IT ; M-C (rev.00-01) | 892234 | 898511 |
| 23 | Front Panel sticker set, IT ; M-C (rev.02) ; S/5 | 898511 | |
| 23 | Front Panel sticker set, IT ; M-CO (rev.00-01) | 892235 | 898616 |
| 23 | Front Panel sticker set, IT ; M-CO (rev.02) ; S/5 | 898616 | |
| 23 | Front Panel sticker set, JA ; M-C (rev.00-01) | 894986 | 898517 |
| 23 | Front Panel sticker set, JA ; M-C (rev.02) ; S/5 | 898517 | |
| 23 | Front Panel sticker set, JA ; M-CO (rev.00-01) | 894987 | 898622 |
| 23 | Front Panel sticker set, JA ; M-CO (rev.02) ; S/5 | 898622 | |
| 23 | Front Panel sticker set, NL ; M-C (rev.00-01) | 892228 | 898509 |
| 23 | Front Panel sticker set, NL ; M-C (rev.02) ; S/5 | 898509 | |
| 23 | Front Panel sticker set, NL ; M-CO (rev.00-01) | 892229 | 898614 |
| 23 | Front Panel sticker set, NL ; M-CO (rev.02) ; S/5 | 898614 | |
| 23 | Front Panel sticker set, NO ; M-C (rev.00-01) | 893544 | 898515 |
| 23 | Front Panel sticker set, NO ; M-C (rev.02) ; S/5 | 898515 | |
| 23 | Front Panel sticker set, NO ; M-CO (rev.00-01) | 893547 | 898620 |
| 23 | Front Panel sticker set, NO ; M-CO (rev.02) ; S/5 | 898620 | |
| 23 | Front Panel sticker set, PT ; M-C (rev.00-01) | 895245 | 898512 |
| 23 | Front Panel sticker set, PT ; M-C (rev.02) ; S/5 | 898512 | |
| 23 | Front Panel sticker set, PT ; M-CO (rev.00-01) | 895246 | 898617 |
| 23 | Front Panel sticker set, PT ; M-CO (rev.02) ; S/5 | 898617 | |
| 23 | Front Panel sticker set, SV ; M-C (rev.00-01) | 891101 | 898514 |
| 23 | Front Panel sticker set, SV ; M-C (rev.02) ; S/5 | 898514 | |
| 23 | Front Panel sticker set, SV ; M-CO (rev.00-01) | 891104 | 898619 |
| 23 | Front Panel sticker set, SV ; M-CO (rev.02) ; S/5 | 898619 | |

### 6.1.3 M-CAiO rev. 00, M-CAiOV rev. 01

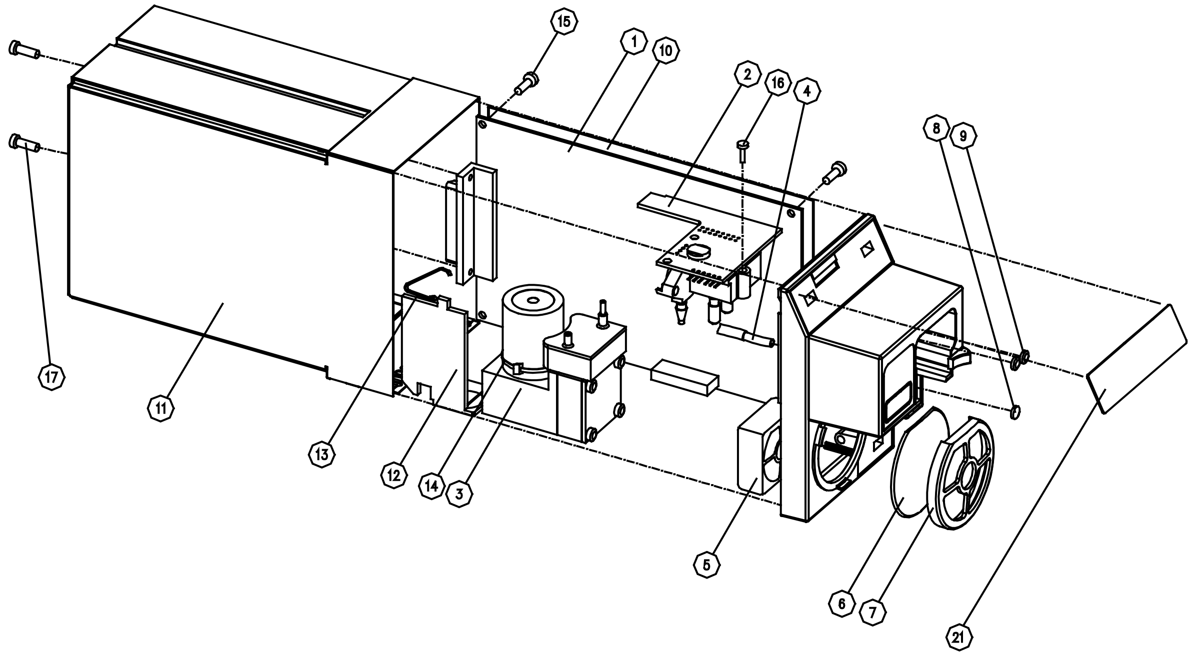



**Figure 20 Exploded view, M-C rev.00, M-CO rev.00, M-CAiO rev.00, M-COV rev. 01, M-CAiOV rev.01, M-COVX rev.00**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | CPU board, Compact Airway Module | 884313 | 8001806 |
| 2 | PVX unit, Compact Airway Module | 895946 | |
| 3 | Pump-air, 5-15VDC | 57313 | |
| 4 | Nafion tubing, 300mm | 733382 | |
| 5 | Fan, Compact Airway Module | 886213 | |
| 6 | Fan filter | 886236 | |
| 7 | Fan filter cover | 886659 | |
| 8 | Filter | 886136 | |
| 9 | O-ring 4.0x1.0 | 65312 | |
| 10 | Insulation plate | 890873 | |
| 11 | Module box (double width) | 887006 | 893225 |
| 11 | Module box (double width) | 893225 | |
| 12 | Latch for module box | 879181 | |
| 13 | Spring pin | 879182 | |
| 14 | Cable tie | 640013 | |
| 15 | Cross recess screw UNC 4-40 | 61841 | |
| 16 | Cross cylinder-head screw M3x6 | 61721 | |
| 17 | Cross cylinder-head screw M3x6 | 61721 | |
| 21 | Front Panel kerboard sticker, FI ; M-COV(X), M-CAiOV(X) | 897798 | 898634 |
| 21 | Front Panel keyboard sticker, DA ; M-COV(X), M-CAiOV(X) | 897801 | 898637 |
| 21 | Front Panel keyboard sticker, DE ; M-COV(X), M-CAiOV(X) | 897792 | 898628 |
| 21 | Front Panel keyboard sticker, EN ; M-COV(X), M-CAiOV(X) | 896331 | 898627 |
| 21 | Front Panel keyboard sticker, FR ; M-COV(X), M-CAiOV(X) | 897793 | 898629 |
| 21 | Front Panel keyboard sticker, IT ; M-COV(X), M-CAiOV(X) | 897796 | 898632 |

| | | | |
|---|---|---|---|
| 21 | Front Panel keyboard sticker, JA ; M-COV(X), M-CAiOV(X) | 897802 | 898638 |
| 21 | Front Panel keyboard sticker, NL ; M-COV(X), M-CAiOV(X) | 897794 | 898630 |
| 21 | Front Panel keyboard sticker, NO ; M-COV(X), M-CAiOV(X) | 897800 | 898636 |
| 21 | Front Panel keyboard sticker, PT ; M-COV(X), M-CAiOV(X) | 897797 | 898633 |
| 21 | Front Panel keyboard sticker, SV ; M-COV(X), M-CAiOV(X) | 897799 | 898635 |
| 21 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 898624 |
| 21 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 8000204 |
| 21 | Front Panelkeyboard sticker, ES ; M-COV(X), M-CAiOV(X) | 897795 | 898631 |
| 22 | Front Panel sticker set, DA ; M-CAiO (rev.00-01) | 892226 | 898528 |
| 22 | Front Panel sticker set, DA ; M-CAiOV (rev.01-02) | 892227 | 898540 |
| 22 | Front Panel sticker set, DE ; M-CAiO (rev.00-01) | 890686 | 898519 |
| 22 | Front Panel sticker set, DE ; M-CAiOV (rev.01-02) | 890683 | 898531 |
| 22 | Front Panel sticker set, EN ; M-CAiO (rev.00-01) | 890685 | 898518 |
| 22 | Front Panel sticker set, EN ; M-CAiOV (rev.01-02) | 887312 | 898530 |
| 22 | Front Panel sticker set, ES ; M-CAiO (rev.00-01) | 892244 | 898522 |
| 22 | Front Panel sticker set, ES ; M-CAiOV (rev.01-02) | 892245 | 898534 |
| 22 | Front Panel sticker set, FI ; M-CAiO (rev.00-01) | 892250 | 898525 |
| 22 | Front Panel sticker set, FI ; M-CAiOV (rev.01-02) | 892251 | 898537 |
| 22 | Front Panel sticker set, FR ; M-CAiO (rev.00-01) | 890687 | 898520 |
| 22 | Front Panel sticker set, FR ; M-CAiOV (rev.01-02) | 890684 | 898532 |
| 22 | Front Panel sticker set, IT ; M-CAiO (rev.00-01) | 892238 | 898523 |
| 22 | Front Panel sticker set, IT ; M-CAiOV (rev.01-02) | 892239 | 898535 |
| 22 | Front Panel sticker set, JA ; M-CAiO (rev.00-01) | 894991 | 898529 |
| 22 | Front Panel sticker set, JA ; M-CAiOV (rev.01-02) | 894990 | 898541 |
| 22 | Front Panel sticker set, NL ; M-CAiO (rev.00-01) | 892232 | 898521 |
| 22 | Front Panel sticker set, NL ; M-CAiOV (rev.01-02) | 892233 | 898533 |
| 22 | Front Panel sticker set, NO ; M-CAiO (rev.00-01) | 893543 | 898527 |
| 22 | Front Panel sticker set, NO ; M-CAiOV (rev.01-02) | 893542 | 898539 |
| 22 | Front Panel sticker set, PT ; M-CAiO (rev.00-01) | 895244 | 898524 |
| 22 | Front Panel sticker set, PT ; M-CAiOV (rev.01-02) | 895243 | 898536 |
| 22 | Front Panel sticker set, SV ; M-CAiO (rev.00-01) | 891100 | 898526 |
| 22 | Front Panel sticker set, SV ; M-CAiOV (rev.01-02) | 891099 | 898538 |

## 6.1.4 M-CAiO rev. 01-03, M-CAiOV rev. 02-04, M-CAiOVX rev. 00-02

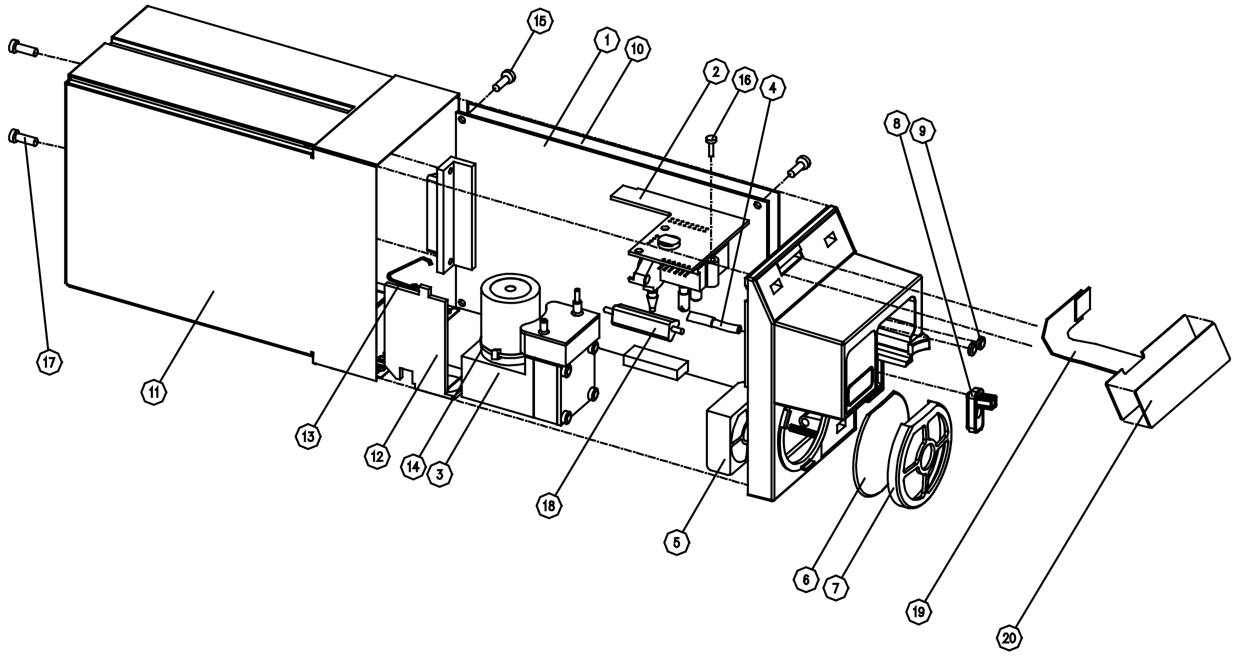



**Figure 21 Exploded view M-C rev. 01-02, M-CO rev. 01-03, M-COV rev.03, M-COVX rev.02, M-CAiO rev.02, M-CAiOV rev. 03, M-CAiOVX rev.01**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | CPU board, Compact Airway Module | 884313 | 8001806 |
| 2 | PVX unit, Compact Airway Module | 895946 | |
| 3 | Pump-air, 5-15VDC | 57313 | |
| 4 | Nafion tubing, 300mm | 733382 | |
| 5 | Fan, Compact Airway Module | 886213 | |
| 6 | Fan filter | 886236 | |
| 7 | Fan filter cover | 886659 | |
| 8 | Ref. Gas and Output Connector | 886245 | |
| 8 | Ref. Gas Filter and Frame | 896025 | |
| 9 | O-ring 4.0x1.0 | 65312 | |
| 10 | Insulation plate | 890873 | |
| 11 | Module box (double width) | 893225 | |
| 12 | Latch for module box | 879181 | |
| 13 | Spring pin | 879182 | |
| 14 | Cable tie | 640013 | |
| 15 | Cross recess screw UNC 4-40 | 61841 | |
| 16 | Cross cylinder-head screw M3x6 | 61721 | |
| 17 | Cross cylinder-head screw M3x6 | 61721 | |
| 18 | Zero Absorber | 895933 | |
| 19 | Membrane keypad for spirometry modules | 895785 | |
| 20 | Front Panel kerboard sticker, FI ; M-COV(X), M-CAiOV(X) | 897798 | 898634 |
| 20 | Front Panel keyboard sticker, DA ; M-COV(X), M-CAiOV(X) | 897801 | 898637 |
| 20 | Front Panel keyboard sticker, DE ; M-COV(X), M-CAiOV(X) | 897792 | 898628 |
| 20 | Front Panel keyboard sticker, EN ; M-COV(X), M-CAiOV(X) | 896331 | 898627 |

| | | | |
|---|---|---|---|
| 20 | Front Panel keyboard sticker, FR ; M-COV(X), M-CAiOV(X) | 897793 | 898629 |
| 20 | Front Panel keyboard sticker, IT ; M-COV(X), M-CAiOV(X) | 897796 | 898632 |
| 20 | Front Panel keyboard sticker, JA ; M-COV(X), M-CAiOV(X) | 897802 | 898638 |
| 20 | Front Panel keyboard sticker, NL ; M-COV(X), M-CAiOV(X) | 897794 | 898630 |
| 20 | Front Panel keyboard sticker, NO ; M-COV(X), M-CAiOV(X) | 897800 | 898636 |
| 20 | Front Panel keyboard sticker, PT ; M-COV(X), M-CAiOV(X) | 897797 | 898633 |
| 20 | Front Panel keyboard sticker, SV ; M-COV(X), M-CAiOV(X) | 897799 | 898635 |
| 20 | Front Panel sticker blanco, M-C(O), M-CAiO ; S/5 | 898624 | |
| 20 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 898624 |
| 20 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 8000204 |
| 20 | Front Panelkeyboard sticker, ES ; M-COV(X), M-CAiOV(X) | 897795 | 898631 |
| 20 | Service sticker (small) ; M-CAiOVX (rev.01) ; S/5 | 898623 | |
| 20 | Spirometry sticker, DA ; M-COV(X), M-CAiOV(X) ; S/5 | 898637 | |
| 20 | Spirometry sticker, DE ; M-COV(X), M-CAiOV(X) ; S/5 | 898628 | |
| 20 | Spirometry sticker, EN ; M-COV(X), M-CAiOV(X) ; S/5 | 898627 | |
| 20 | Spirometry sticker, ES ; M-COV(X), M-CAiOV(X) ; S/5 | 898631 | |
| 20 | Spirometry sticker, FI ; M-COV(X), M-CAiOV(X) ; S/5 | 898634 | |
| 20 | Spirometry sticker, FR ; M-COV(X), M-CAiOV(X) ; S/5 | 898629 | |
| 20 | Spirometry sticker, IT ; M-COV(X), M-CAiOV(X) ; S/5 | 898632 | |
| 20 | Spirometry sticker, JA ; M-COV(X), M-CAiOV(X) ; S/5 | 898638 | |
| 20 | Spirometry sticker, NL ; M-COV(X), M-CAiOV(X) ; S/5 | 898630 | |
| 20 | Spirometry sticker, NO ; M-COV(X), M-CAiOV(X) ; S/5 | 898636 | |
| 20 | Spirometry sticker, PT ; M-COV(X), M-CAiOV(X) ; S/5 | 898633 | |
| 20 | Spirometry sticker, SV ; M-COV(X), M-CAiOV(X) ; S/5 | 898635 | |
| 23 | Front Panel sticker set, DA ; M-CAiO (rev.00-01) | 892226 | 898528 |
| 23 | Front Panel sticker set, DA ; M-CAiO (rev.02) ; S/5 | 898528 | |
| 23 | Front Panel sticker set, DA ; M-CAiOV (rev.01-02) | 892227 | 898540 |
| 23 | Front Panel sticker set, DA ; M-CAiOV (rev.03) ; S/5 | 898540 | |
| 23 | Front Panel sticker set, DA ; M-CAiOVX (rev.00) | 897790 | 898552 |
| 23 | Front Panel sticker set, DA ; M-CAiOVX (rev.01) ; S/5 | 898552 | |
| 23 | Front Panel sticker set, DE ; M-CAiO (rev.00-01) | 890686 | 898519 |
| 23 | Front Panel sticker set, DE ; M-CAiO (rev.02) ; S/5 | 898519 | |
| 23 | Front Panel sticker set, DE ; M-CAiOV (rev.01-02) | 890683 | 898531 |
| 23 | Front Panel sticker set, DE ; M-CAiOV (rev.03) ; S/5 | 898531 | |
| 23 | Front Panel sticker set, DE ; M-CAiOVX (rev.00) | 897781 | 898543 |
| 23 | Front Panel sticker set, DE ; M-CAiOVX (rev.01) ; S/5 | 898543 | |
| 23 | Front Panel sticker set, EN ; M-CAiO (rev.00-01) | 890685 | 898518 |
| 23 | Front Panel sticker set, EN ; M-CAiO (rev.02) ; S/5 | 898518 | |
| 23 | Front Panel sticker set, EN ; M-CAiOV (rev.01-02) | 887312 | 898530 |
| 23 | Front Panel sticker set, EN ; M-CAiOV (rev.03) ; S/5 | 898530 | |
| 23 | Front Panel sticker set, EN ; M-CAiOVX, SERV. (rev.00) | 896594 | 898542 |
| 23 | Front Panel sticker set, EN ; M-CAiOVX, SERV. (rev.01) ; S/5 | 898542 | |
| 23 | Front Panel sticker set, EN ; M-CAiOVX, SERV. (rev.01) ; S/5 | 898542 | |
| 23 | Front Panel sticker set, ES ; M-CAiO (rev.00-01) | 892244 | 898522 |
| 23 | Front Panel sticker set, ES ; M-CAiO (rev.02) ; S/5 | 898522 | |
| 23 | Front Panel sticker set, ES ; M-CAiOV (rev.01-02) | 892245 | 898534 |
| 23 | Front Panel sticker set, ES ; M-CAiOV (rev.03) ; S/5 | 898534 | |
| 23 | Front Panel sticker set, ES ; M-CAiOVX (rev.00) | 897784 | 898546 |
| 23 | Front Panel sticker set, ES ; M-CAiOVX (rev.01) ; S/5 | 898546 | |
| 23 | Front Panel sticker set, FI ; M-CAiO (rev.00-01) | 892250 | 898525 |

| | | | |
|---|---|---|---|
| 23 | Front Panel sticker set, FI ; M-CAiO (rev.02) ; S/5 | 898525 | |
| 23 | Front Panel sticker set, FI ; M-CAiOV (rev.01-02) | 892251 | 898537 |
| 23 | Front Panel sticker set, FI ; M-CAiOV (rev.03) ; S/5 | 898537 | |
| 23 | Front Panel sticker set, FI ; M-CAiOVX (rev.00) | 897787 | 898549 |
| 23 | Front Panel sticker set, FI ; M-CAiOVX (rev.01) ; S/5 | 898549 | |
| 23 | Front Panel sticker set, FR ; M-CAiO (rev.00-01) | 890687 | 898520 |
| 23 | Front Panel sticker set, FR ; M-CAiO (rev.02) ; S/5 | 898520 | |
| 23 | Front Panel sticker set, FR ; M-CAiOV (rev.01-02) | 890684 | 898532 |
| 23 | Front Panel sticker set, FR ; M-CAiOV (rev.03) ; S/5 | 898532 | |
| 23 | Front Panel sticker set, FR ; M-CAiOVX (rev.00) | 897782 | 898544 |
| 23 | Front Panel sticker set, FR ; M-CAiOVX (rev.01) ; S/5 | 898544 | |
| 23 | Front Panel sticker set, IT ; M-CAiO (rev.00-01) | 892238 | 898523 |
| 23 | Front Panel sticker set, IT ; M-CAiO (rev.02) ; S/5 | 898523 | |
| 23 | Front Panel sticker set, IT ; M-CAiOV (rev.01-02) | 892239 | 898535 |
| 23 | Front Panel sticker set, IT ; M-CAiOV (rev.03) ; S/5 | 898535 | |
| 23 | Front Panel sticker set, IT ; M-CAiOVX (rev.00) | 897785 | 898547 |
| 23 | Front Panel sticker set, IT ; M-CAiOVX (rev.01) ; S/5 | 898547 | |
| 23 | Front Panel sticker set, JA ; M-CAiO (rev.00-01) | 894991 | 898529 |
| 23 | Front Panel sticker set, JA ; M-CAiO (rev.02) ; S/5 | 898529 | |
| 23 | Front Panel sticker set, JA ; M-CAiOV (rev.01-02) | 894990 | 898541 |
| 23 | Front Panel sticker set, JA ; M-CAiOV (rev.03) ; S/5 | 898541 | |
| 23 | Front Panel sticker set, JA ; M-CAiOVX (rev.01) ; S/5 | 898553 | |
| 23 | Front Panel sticker set, JA ;M-CAiOVX (rev.00) | 897791 | 898553 |
| 23 | Front Panel sticker set, NL ; M-CAiO (rev.00-01) | 892232 | 898521 |
| 23 | Front Panel sticker set, NL ; M-CAiO (rev.02) ; S/5 | 898521 | |
| 23 | Front Panel sticker set, NL ; M-CAiOV (rev.01-02) | 892233 | 898533 |
| 23 | Front Panel sticker set, NL ; M-CAiOV (rev.03) ; S/5 | 898533 | |
| 23 | Front Panel sticker set, NL ; M-CAiOVX (rev.00) | 897783 | 898545 |
| 23 | Front Panel sticker set, NL ; M-CAiOVX (rev.01) ; S/5 | 898545 | |
| 23 | Front Panel sticker set, NO ; M-CAiO (rev.00-01) | 893543 | 898527 |
| 23 | Front Panel sticker set, NO ; M-CAiO (rev.02) ; S/5 | 898527 | |
| 23 | Front Panel sticker set, NO ; M-CAiOV (rev.01-02) | 893542 | 898539 |
| 23 | Front Panel sticker set, NO ; M-CAiOV (rev.03) ; S/5 | 898539 | |
| 23 | Front Panel sticker set, NO ; M-CAiOVX (rev.00) | 897789 | 898551 |
| 23 | Front Panel sticker set, NO ; M-CAiOVX (rev.01) ; S/5 | 898551 | |
| 23 | Front Panel sticker set, PT ; M-CAiO (rev.00-01) | 895244 | 898524 |
| 23 | Front Panel sticker set, PT ; M-CAiO (rev.02) ; S/5 | 898524 | |
| 23 | Front Panel sticker set, PT ; M-CAiOV (rev.01-02) | 895243 | 898536 |
| 23 | Front Panel sticker set, PT ; M-CAiOV (rev.03) ; S/5 | 898536 | |
| 23 | Front Panel sticker set, PT ; M-CAiOVX (rev.00) | 897786 | 898548 |
| 23 | Front Panel sticker set, PT ; M-CAiOVX (rev.01) ; S/5 | 898548 | |
| 23 | Front Panel sticker set, SV ; M-CAiO (rev.00-01) | 891100 | 898526 |
| 23 | Front Panel sticker set, SV ; M-CAiO (rev.02) ; S/5 | 898526 | |
| 23 | Front Panel sticker set, SV ; M-CAiOV (rev.01-02) | 891099 | 898538 |
| 23 | Front Panel sticker set, SV ; M-CAiOV (rev.03) ; S/5 | 898538 | |
| 23 | Front Panel sticker set, SV ; M-CAiOVX (rev.00) | 897788 | 898550 |
| 23 | Front Panel sticker set, SV ; M-CAiOVX (rev.01) ; S/5 | 898550 | |

### 6.1.5 M-COV rev. 01, M-COVX rev. 00

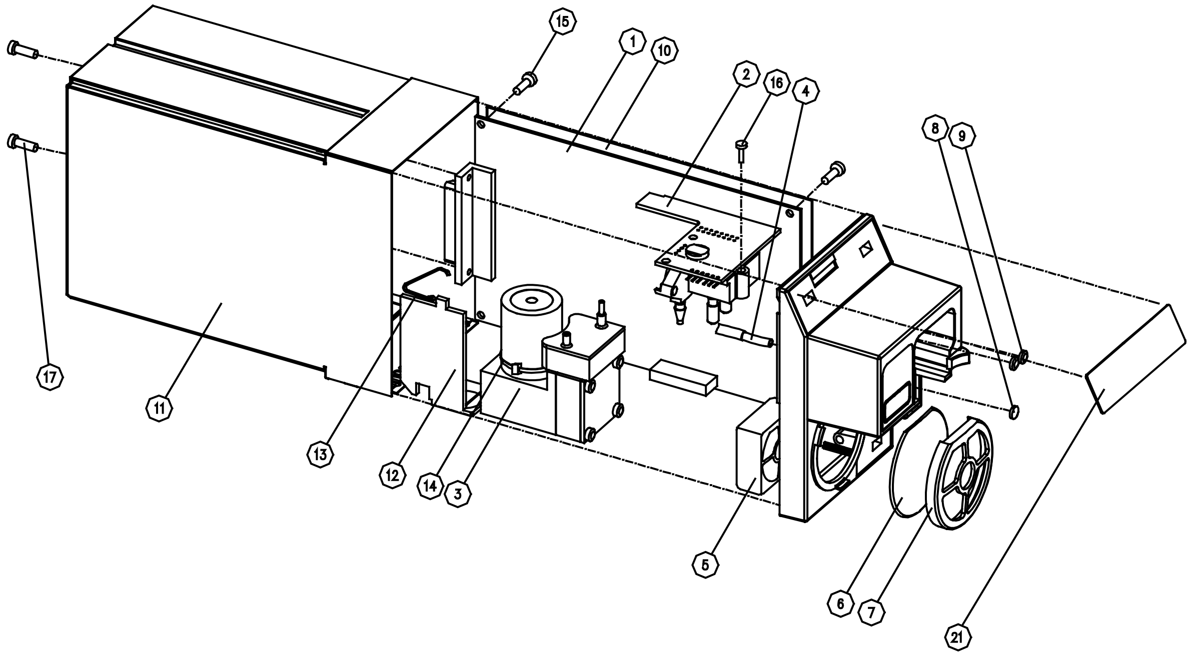



**Figure 22 Exploded view, M-C rev.00, M-CO rev.00, M-CAiO rev.00, M-COV rev. 01, M-CAiOV rev.01, M-COVX rev.00**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | CPU board, Compact Airway Module | 884313 | 8001806 |
| 2 | PVX unit, Compact Airway Module | 895946 | |
| 3 | Pump-air, 5-15VDC | 57313 | |
| 4 | Nafion tubing, 300mm | 733382 | |
| 5 | Fan, Compact Airway Module | 886213 | |
| 6 | Fan filter | 886236 | |
| 7 | Fan filter cover | 886659 | |
| 8 | Filter | 886136 | |
| 9 | O-ring 4.0x1.0 | 65312 | |
| 10 | Insulation plate | 890873 | |
| 11 | Module box (double width) | 887006 | 893225 |
| 11 | Module box (double width) | 893225 | |
| 12 | Latch for module box | 879181 | |
| 13 | Spring pin | 879182 | |
| 14 | Cable tie | 640013 | |
| 15 | Cross recess screw UNC 4-40 | 61841 | |
| 16 | Cross cylinder-head screw M3x6 | 61721 | |
| 17 | Cross cylinder-head screw M3x6 | 61721 | |
| 21 | Front Panel kerboard sticker, FI ; M-COV(X), M-CAiOV(X) | 897798 | 898634 |
| 21 | Front Panel keyboard sticker, DA ; M-COV(X), M-CAiOV(X) | 897801 | 898637 |
| 21 | Front Panel keyboard sticker, DE ; M-COV(X), M-CAiOV(X) | 897792 | 898628 |
| 21 | Front Panel keyboard sticker, EN ; M-COV(X), M-CAiOV(X) | 896331 | 898627 |
| 21 | Front Panel keyboard sticker, FR ; M-COV(X), M-CAiOV(X) | 897793 | 898629 |
| 21 | Front Panel keyboard sticker, IT ; M-COV(X), M-CAiOV(X) | 897796 | 898632 |

| | | | |
|---|---|---|---|
| 21 | Front Panel keyboard sticker, JA ; M-COV(X), M-CAiOV(X) | 897802 | 898638 |
| 21 | Front Panel keyboard sticker, NL ; M-COV(X), M-CAiOV(X) | 897794 | 898630 |
| 21 | Front Panel keyboard sticker, NO ; M-COV(X), M-CAiOV(X) | 897800 | 898636 |
| 21 | Front Panel keyboard sticker, PT ; M-COV(X), M-CAiOV(X) | 897797 | 898633 |
| 21 | Front Panel keyboard sticker, SV ; M-COV(X), M-CAiOV(X) | 897799 | 898635 |
| 21 | Front Panelkeyboard sticker, ES ; M-COV(X), M-CAiOV(X) | 897795 | 898631 |
| 22 | Front Panel sticker set, DA ; M-COV (rev.01-02) | 892224 | 898659 |
| 22 | Front Panel sticker set, DA ; M-COVX (rev.00-01) | 892225 | 898671 |
| 22 | Front Panel sticker set, DE ; M-COV (rev.01-02) | 890689 | 898650 |
| 22 | Front Panel sticker set, DE ; M-COVX (rev.00-01) | 890698 | 898662 |
| 22 | Front Panel sticker set, EN ; M-COV (rev.01-02) | 890688 | 898649 |
| 22 | Front Panel sticker set, EN ; M-COVX (rev.00-01) | 890697 | 898661 |
| 22 | Front Panel sticker set, ES ; M-COV (rev.01-02) | 892242 | 898653 |
| 22 | Front Panel sticker set, ES ; M-COVX (rev.00-01) | 892243 | 898665 |
| 22 | Front Panel sticker set, FI ; M-COV (rev.01-02) | 892248 | 898656 |
| 22 | Front Panel sticker set, FI ; M-COVX (rev.00-01) | 892249 | 898668 |
| 22 | Front Panel sticker set, FR ; M-COV (rev.01-02) | 890690 | 898651 |
| 22 | Front Panel sticker set, FR ; M-COVX (rev.00-01) | 890699 | 898663 |
| 22 | Front Panel sticker set, IT ; M-COV (rev.01-02) | 892236 | 898654 |
| 22 | Front Panel sticker set, IT ; M-COVX (rev.00-01) | 892237 | 898666 |
| 22 | Front Panel sticker set, JA ; M-COV (rev.01-02) | 894988 | 898660 |
| 22 | Front Panel sticker set, JA ; M-COVX (rev.00-01) | 894989 | 898672 |
| 22 | Front Panel sticker set, NL ; M-COV (rev.01-02) | 892230 | 898652 |
| 22 | Front Panel sticker set, NL ; M-COVX (rev.00-01) | 892231 | 898664 |
| 22 | Front Panel sticker set, NO ; M-COV (rev.01-02) | 893546 | 898658 |
| 22 | Front Panel sticker set, NO ; M-COVX (rev.00-01) | 893545 | 898670 |
| 22 | Front Panel sticker set, PT ; M-COV (rev.01-02) | 895247 | 898655 |
| 22 | Front Panel sticker set, PT ; M-COVX (rev.00-01) | 895248 | 898667 |
| 22 | Front Panel sticker set, SV ; M-COV (rev.01-02) | 891103 | 898657 |
| 22 | Front Panel sticker set, SV ; M-COVX (rev.00-01) | 891102 | 898669 |

### 6.1.6 M-COV rev 02-04, MCOVX rev. 01-03

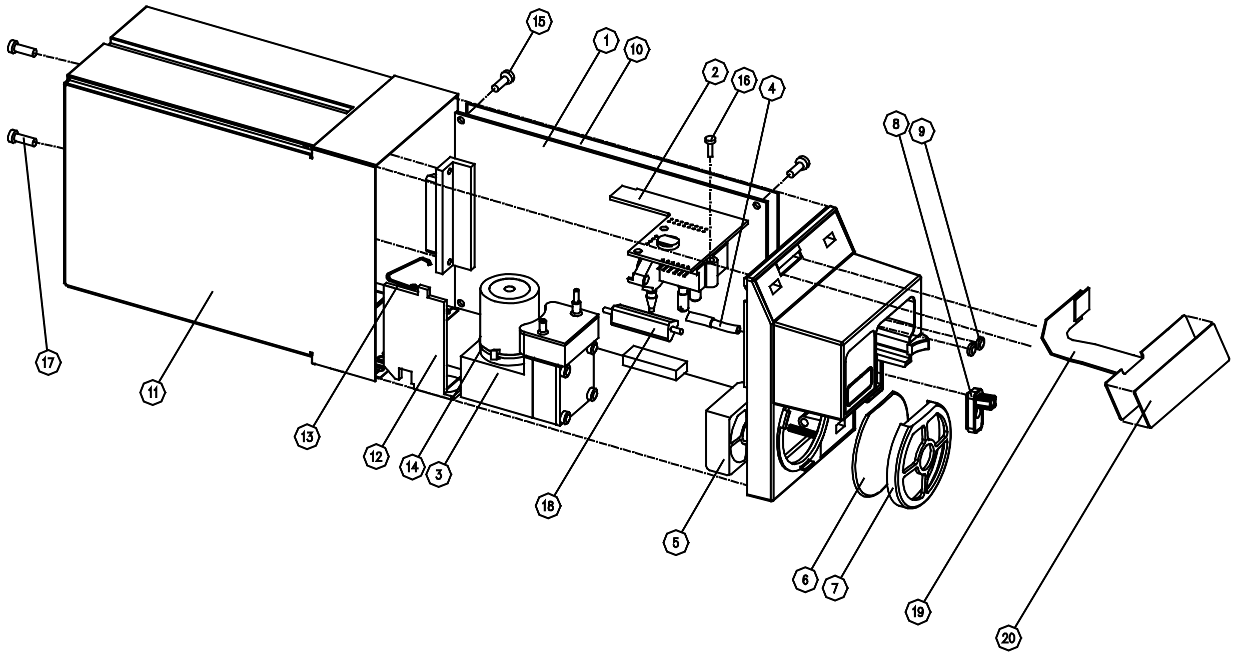



**Figure 23** **Exploded view M-C rev. 01-02, M-CO rev. 01-03, M-COV rev.04, M-COVX rev.03, M-CAiO rev.03, M-CAiOV rev. 04, M-CAiOVX rev.02**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | CPU board, Compact Airway Module | 884313 | 8001806 |
| 2 | PVX unit, Compact Airway Module | 895946 | |
| 3 | Pump-air, 5-15VDC | 57313 | |
| 4 | Nafion tubing, 300mm | 733382 | |
| 5 | Fan, Compact Airway Module | 886213 | |
| 6 | Fan filter | 886236 | |
| 7 | Fan filter cover | 886659 | |
| 8 | Ref. Gas and Output Connector | 886245 | |
| 8 | Ref. Gas Filter and Frame | 896025 | |
| 9 | O-ring 4.0x1.0 | 65312 | |
| 10 | Insulation plate | 890873 | |
| 11 | Module box (double width) | 893225 | |
| 12 | Latch for module box | 879181 | |
| 13 | Spring pin | 879182 | |
| 14 | Cable tie | 640013 | |
| 15 | Cross recess screw UNC 4-40 | 61841 | |
| 16 | Cross cylinder-head screw M3x6 | 61721 | |
| 17 | Cross cylinder-head screw M3x6 | 61721 | |
| 18 | Zero Absorber | 895933 | |
| 19 | Membrane keypad for spirometry modules | 895785 | |
| 20 | Front Panel kerboard sticker, FI ; M-COV(X), M-CAiOV(X) | 897798 | 898634 |
| 20 | Front Panel keyboard sticker, DA ; M-COV(X), M-CAiOV(X) | 897801 | 898637 |
| 20 | Front Panel keyboard sticker, DE ; M-COV(X), M-CAiOV(X) | 897792 | 898628 |
| 20 | Front Panel keyboard sticker, EN ; M-COV(X), M-CAiOV(X) | 896331 | 898627 |

| | | | |
|---|---|---|---|
| 20 | Front Panel keyboard sticker, FR ; M-COV(X), M-CAiOV(X) | 897793 | 898629 |
| 20 | Front Panel keyboard sticker, IT ; M-COV(X), M-CAiOV(X) | 897796 | 898632 |
| 20 | Front Panel keyboard sticker, JA ; M-COV(X), M-CAiOV(X) | 897802 | 898638 |
| 20 | Front Panel keyboard sticker, NL ; M-COV(X), M-CAiOV(X) | 897794 | 898630 |
| 20 | Front Panel keyboard sticker, NO ; M-COV(X), M-CAiOV(X) | 897800 | 898636 |
| 20 | Front Panel keyboard sticker, PT ; M-COV(X), M-CAiOV(X) | 897797 | 898633 |
| 20 | Front Panel keyboard sticker, SV ; M-COV(X), M-CAiOV(X) | 897799 | 898635 |
| 20 | Front Panelkeyboard sticker, ES ; M-COV(X), M-CAiOV(X) | 897795 | 898631 |
| 20 | Spirometry sticker, DA ; M-COV(X), M-CAiOV(X) ; S/5 | 898637 | |
| 20 | Spirometry sticker, DE ; M-COV(X), M-CAiOV(X) ; S/5 | 898628 | |
| 20 | Spirometry sticker, EN ; M-COV(X), M-CAiOV(X) ; S/5 | 898627 | |
| 20 | Spirometry sticker, ES ; M-COV(X), M-CAiOV(X) ; S/5 | 898631 | |
| 20 | Spirometry sticker, FI ; M-COV(X), M-CAiOV(X) ; S/5 | 898634 | |
| 20 | Spirometry sticker, FR ; M-COV(X), M-CAiOV(X) ; S/5 | 898629 | |
| 20 | Spirometry sticker, IT ; M-COV(X), M-CAiOV(X) ; S/5 | 898632 | |
| 20 | Spirometry sticker, JA ; M-COV(X), M-CAiOV(X) ; S/5 | 898638 | |
| 20 | Spirometry sticker, NL ; M-COV(X), M-CAiOV(X) ; S/5 | 898630 | |
| 20 | Spirometry sticker, NO ; M-COV(X), M-CAiOV(X) ; S/5 | 898636 | |
| 20 | Spirometry sticker, PT ; M-COV(X), M-CAiOV(X) ; S/5 | 898633 | |
| 20 | Spirometry sticker, SV ; M-COV(X), M-CAiOV(X) ; S/5 | 898635 | |
| 23 | Front Panel sticker set, DA ; M-COV (rev.01-02) | 892224 | 898659 |
| 23 | Front Panel sticker set, DA ; M-COV (rev.03) ; S/5 | 898659 | |
| 23 | Front Panel sticker set, DA ; M-COVX (rev.00-01) | 892225 | 898671 |
| 23 | Front Panel sticker set, DA ; M-COVX (rev.02) ; S/5 | 898671 | |
| 23 | Front Panel sticker set, DE ; M-COV (rev.01-02) | 890689 | 898650 |
| 23 | Front Panel sticker set, DE ; M-COV (rev.03) ; S/5 | 898650 | |
| 23 | Front Panel sticker set, DE ; M-COVX (rev.00-01) | 890698 | 898662 |
| 23 | Front Panel sticker set, DE ; M-COVX (rev.02) ; S/5 | 898662 | |
| 23 | Front Panel sticker set, EN ; M-COV (rev.01-02) | 890688 | 898649 |
| 23 | Front Panel sticker set, EN ; M-COV (rev.03) ; S/5 | 898649 | |
| 23 | Front Panel sticker set, EN ; M-COVX (rev.00-01) | 890697 | 898661 |
| 23 | Front Panel sticker set, EN ; M-COVX (rev.02) ; S/5 | 898661 | |
| 23 | Front Panel sticker set, ES ; M-COV (rev.01-02) | 892242 | 898653 |
| 23 | Front Panel sticker set, ES ; M-COV (rev.03) ; S/5 | 898653 | |
| 23 | Front Panel sticker set, ES ; M-COVX (rev.00-01) | 892243 | 898665 |
| 23 | Front Panel sticker set, ES ; M-COVX (rev.02) ; S/5 | 898665 | |
| 23 | Front Panel sticker set, FI ; M-COV (rev.01-02) | 892248 | 898656 |
| 23 | Front Panel sticker set, FI ; M-COV (rev.03) ; S/5 | 898656 | |
| 23 | Front Panel sticker set, FI ; M-COVX (rev.00-01) | 892249 | 898668 |
| 23 | Front Panel sticker set, FI ; M-COVX (rev.02) ; S/5 | 898668 | |
| 23 | Front Panel sticker set, FR ; M-COV (rev.01-02) | 890690 | 898651 |
| 23 | Front Panel sticker set, FR ; M-COV (rev.03) ; S/5 | 898651 | |
| 23 | Front Panel sticker set, FR ; M-COVX (rev.00-01) | 890699 | 898663 |
| 23 | Front Panel sticker set, FR ; M-COVX (rev.02) ; S/5 | 898663 | |
| 23 | Front Panel sticker set, IT ; M-COV (rev.01-02) | 892236 | 898654 |
| 23 | Front Panel sticker set, IT ; M-COV (rev.03) ; S/5 | 898654 | |
| 23 | Front Panel sticker set, IT ; M-COVX (rev.00-01) | 892237 | 898666 |
| 23 | Front Panel sticker set, IT ; M-COVX (rev.02) ; S/5 | 898666 | |
| 23 | Front Panel sticker set, JA ; M-COV (rev.01-02) | 894988 | 898660 |
| 23 | Front Panel sticker set, JA ; M-COV (rev.03) ; S/5 | 898660 | |

| | | | |
|---|---|---|---|
| 23 | Front Panel sticker set, JA ; M-COVX (rev.00-01) | 894989 | 898672 |
| 23 | Front Panel sticker set, JA ; M-COVX (rev.02) ; S/5 | 898672 | |
| 23 | Front Panel sticker set, NL ; M-COV (rev.01-02) | 892230 | 898652 |
| 23 | Front Panel sticker set, NL ; M-COV (rev.03) ; S/5 | 898652 | |
| 23 | Front Panel sticker set, NL ; M-COVX (rev.00-01) | 892231 | 898664 |
| 23 | Front Panel sticker set, NL ; M-COVX (rev.02) ; S/5 | 898664 | |
| 23 | Front Panel sticker set, NO ; M-COV (rev.01-02) | 893546 | 898658 |
| 23 | Front Panel sticker set, NO ; M-COV (rev.03) ; S/5 | 898658 | |
| 23 | Front Panel sticker set, NO ; M-COVX (rev.00-01) | 893545 | 898670 |
| 23 | Front Panel sticker set, NO ; M-COVX (rev.02) ; S/5 | 898670 | |
| 23 | Front Panel sticker set, PT ; M-COV (rev.01-02) | 895247 | 898655 |
| 23 | Front Panel sticker set, PT ; M-COV (rev.03) ; S/5 | 898655 | |
| 23 | Front Panel sticker set, PT ; M-COVX (rev.00-01) | 895248 | 898667 |
| 23 | Front Panel sticker set, PT ; M-COVX (rev.02) ; S/5 | 898667 | |
| 23 | Front Panel sticker set, SV ; M-COV (rev.01-02) | 891103 | 898657 |
| 23 | Front Panel sticker set, SV ; M-COV (rev.03) ; S/5 | 898657 | |
| 23 | Front Panel sticker set, SV ; M-COVX (rev.00-01) | 891102 | 898669 |
| 23 | Front Panel sticker set, SV ; M-COVX (rev.02) ; S/5 | 898669 | |

### 6.1.7 D-fend latch

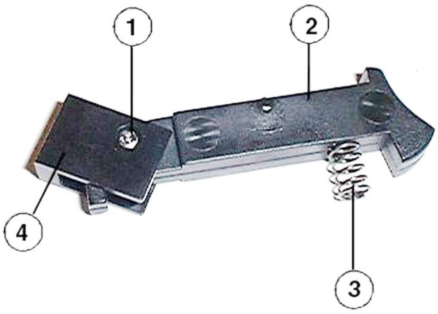



**Figure 24 D-fend latch**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | PIN, M-CAiOV | 887005 | |
| 2 | LATCH, M-CAiOV | 885493 | |
| 3 | Spring-comp | 64242 | |
| 4 | Hige, M-CAiOV | 886235 | |

# 7 EARLIER REVISIONS

| Revision | Manual slot/main manual | Note |
|---|---|---|
| Compact Airway Module, M-CAiOVX (rev. 00)<br>Compact Airway Module, M-CAiOV (rev. 02)<br>Compact Airway Module, M-CAiO (rev. 01)<br>Compact Airway Module, M-COVX (rev. 01)<br>Compact Airway Module, M-COV (rev. 02)<br>Compact Airway Module, M-CO (rev. 01)<br>Compact Airway Module, M-C (rev. 01) | 896 619/896 624 | |

# APPENDIX A

# SERVICE CHECK FORM
# Compact Airway modules

| | | | | | |
|---|---|---|---|---|---|
| Customer | | | | | |
| Service | | Module type | | S/N | |
| Service engineer | | | | Date | |

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

**All modules**

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Fan filter | ☐ | ☐ | ☐ | 4. D-fend O-rings | ☐ | ☐ | ☐ |
| 5. Other filters | ☐ | ☐ | ☐ | | | | |

Notes

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 6. Fan | ☐ | ☐ | ☐ | | | | |
| 7. Module software | GAS | | | | | | |
| 8. Module configuration | ☐ | ☐ | ☐ | 9. Module bus communication | ☐ | ☐ | ☐ |
| 10. Flow measurement offset | | | | | ±10 ml/min | | |
| 11. Ambient pressure | ☐ | ☐ | ☐ | 12. Zero valve | ☐ | ☐ | ☐ |
| 13. Special tubes | ☐ | ☐ | ☐ | $CO_2$ absorber | ☐ | ☐ | ☐ |
| 14. Leak test | | | | | ≤ 6 mmHg/min | | |
| 15. Flow rates | | | | | | | |
| Sampling flow | | | | | 180...220 ml/min | | |
| Reference flow (M-CAiOVX/M-COVX) | | | | | 27...40 ml/min | | |
| Reference flow (M-CAiOVX/M-COVX) | | | | | 27...40 ml/min | | |
| Reference flow (M-C) | | | | | 25...40 ml/min | | |
| Reference flow (M-C) | | | | | 24...45 ml/min | | |

| | | |
|---|---|---|
| Reference flow (others) | | 31...45 ml/min |
| Zeroing flow | | ±20 ml/min |

16. Working pressure

| | | |
|---|---|---|
| Amb-Work | | 40...75 mmHg |
| Amb-Work (M-CAiOVX/M-COVX) | | 70...115 mmHg |

| | OK | N.A. | Fail |
|---|---|---|---|
| 17. Gas calibration | ☐ | ☐ | ☐ |

18. Fall time measurement

| | | |
|---|---|---|
| $CO_2$ fall time | | < 400 ms |
| $O_2$ fall timeb | | < 400 ms |
| $CO_2$-$N_2O$ delay | | < 800 ms |

**AA option** S/N

| | | |
|---|---|---|
| 19. ID unrel. | | < 50 |

**Patient spirometry option** S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 20. Spirometry system leak test | ☐ | ☐ | ☐ | 21. Flow waveform | ☐ | ☐ | ☐ |
| 22. Spirometry tester | ☐ | ☐ | ☐ | | | | |

**All modules**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23. Electrical safety check | ☐ | ☐ | ☐ | 24. Occlusion detection | ☐ | ☐ | ☐ |
| 25. Air leak detection | ☐ | ☐ | ☐ | 26. Apnea detection | ☐ | ☐ | ☐ |
| 27. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes**

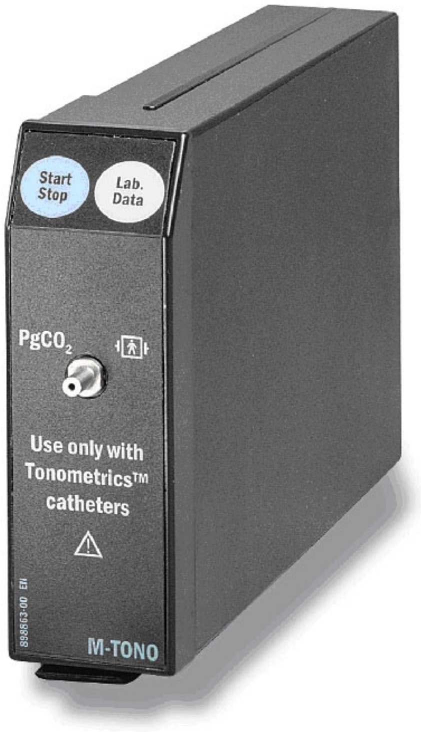
**Used Spare Parts**

**Signature**

# Datex-Ohmeda

# S/5™ Tonometry Module, M-TONO (rev. 01)

# Technical Reference Manual Slot




All specifications are subject to change without notice.

Document No. 800 1010-3

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 39411 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## S/5 Tonometry Module, M-TONO

# TABLE OF FIGURES



# TABLE OF TABLES

# INTRODUCTION

This slot provides information for maintenance and service of the Datex-Ohmeda S/5 Tonometry Module, M-TONO. Please also refer to the *Technical Reference Manual* of S/5 Monitor for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The S/5 Tonometry Module is single width plug-in module and is designed for use with the S/5 monitors. The module provides gastric tonometry measurement, i.e. it measures the gastrointestinal $CO_2$ concentration, $PgCO_2$.

The Tonometry Module contains the $CO_2$ gas concentration sensor and a gas sampling system to move gas between the patient's gastrointestinal tract and the sensors. The patient is connected to the module with a Tonometrics™ Catheter, which is inserted into the gastrointestinal tract.
A sample is taken at regular intervals to determine the $CO_2$ concentration of the gas.

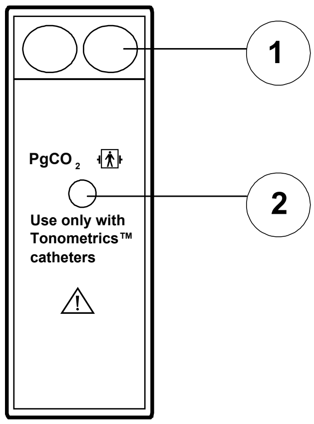
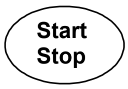
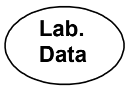



**Figure 1 Front panel of S/5 Tonometry Module, M-TONO**

(1) Direct module keys:




Starts/Stops the $PgCO_2$ measurement cycle.




Takes you to Lab Data menu to enter the blood gas values.

(2) Connector for the Tonometrics Catheter

NOTE: The S/5 Tonometry Module, M-TONO functions only with monitor software of level 99 or newer.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 37 × 190 × 112 mm, 1.5 × 7.5 × 4.4 in |
| Module weight | 0.5 kg / 1.1 lbs |
| Operating temperature | +10...+40 °C |
| Storage temperature | -25...+70 °C |
| Atmospheric pressure | 666...1060 hPa<br>(67...106 kPa/500...800 mmHg/666...1060 mbar) |
| Humidity | 10...90 % non-condensing |
| Power consumption | 0.7 W Prms, 9.0 W momentary |
| Protection against electrical shock | Type BF (IEC-60601-1) defibrillator-proof protection against electric shock |

## 1.2 Parameter specifications

Measurement interval is 10 minutes.

### 1.2.1 $PgCO_2$

| | |
|---|---|
| Measurement range | 0...30 kPa (0...228 mmHg) |
| Accuracy[1] | |
| in range 0...15 kPa (0...113 mmHg) | ±(0.5 kPa +5 % of reading)<br>±(4 mmHg +5 % of reading) |
| in range 15...30 kPa (113...228 mmHg) | 1.5 kPa ±15 % of reading<br>12 mmHg ±15 % of reading |

Accuracy specifications apply in normal conditions:
Measurement is done at least 30 minutes after catheter initialization and calibration has been checked within 2 weeks.

| | |
|---|---|
| Ambient temperature | 10...40 °C, within ±5 °C of calibration |
| Ambient pressure | 500...800 mmHg, ±50 mmHg of calibration |
| Ambient humidity | 10...90 %RH, ±20 %RH of calibration |

[1] These specifications only apply when TONO-8F, TONO-14F, TONO-16F, TONO-18F catheters with 13 mm biofilter are used.

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 $CO_2$ measurement

The $CO_2$ sensor measurement is based on the infrared (IR) absorption technique. $CO_2$ molecules absorb IR-light, that has a certain wave length (4.26 µm). This wavelength is selected from the incoming IR-light with a special optical bandpass filter. The IR-light passed through the measurement chamber and the filter and the signal is then detected with a thermopile.

The calculation of $CO_2$ concentration needs also the determination of the signal level, when there is no $CO_2$ in the measured gas. This procedure is the zeroing of the sensor. The zeroing is done with room air and it is always done before measuring the sample gas.

The $CO_2$ and zeroing gas measurements are done by pulsing the IR-lamp 3 times (lamp is on 2 seconds and off 2 seconds) and by measuring the thermopile signal during pulsing. The $CO_2$ concentration is defined then from these signals. In the definition of $CO_2$ partial pressure ($PgCO_2$), the influence of sensor temperature, measurement pressure, catheter pressure, gas mixing in tubings and the drop in water vapour pressure on the measurement result are compensated.

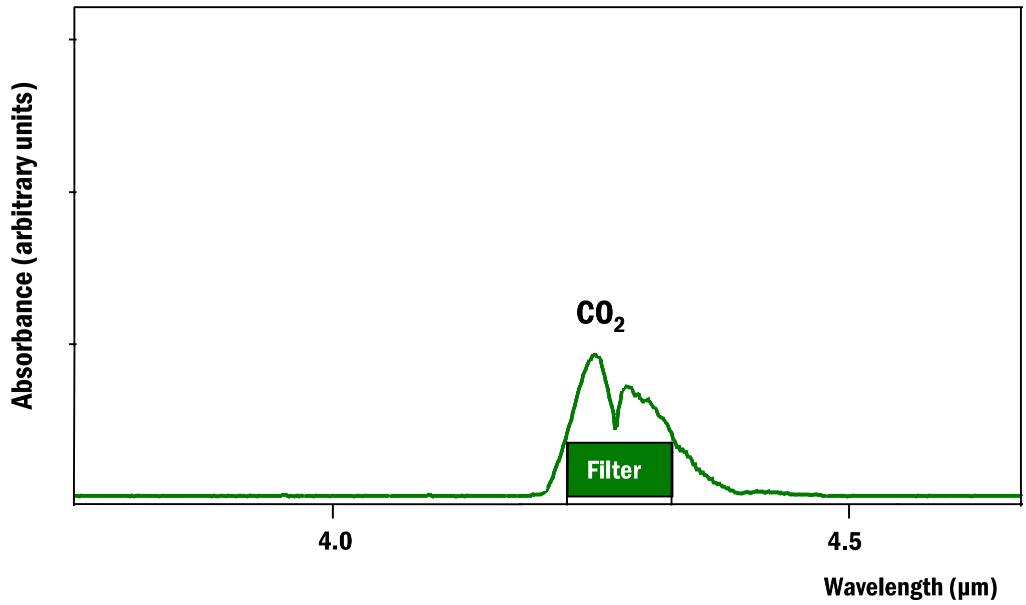



**Figure 2** **Absorbance of $CO_2$**

## 2.2 Main components

The tonometry module consist of:

- gas sampling system
- $CO_2$ measuring unit
- CPU board.

### 2.2.1 Gas sampling system

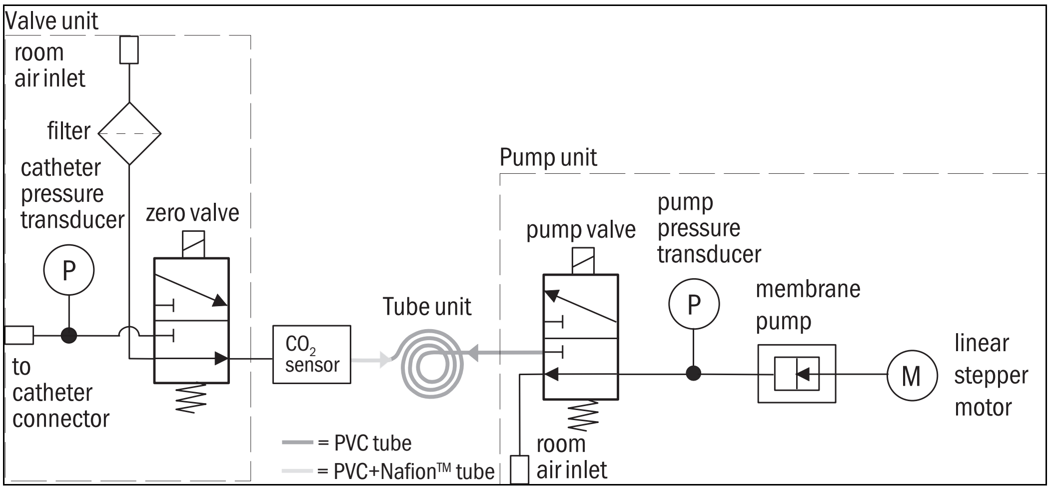



**Figure 3 Gas sampling system layout**

The tonometry measurement is done at regular intervals of 10 minutes. The measurement cycle starts with $CO_2$ sensor zeroing. Zeroing means flushing the gas measurement chamber with room air and measuring the signal level of IR-light passed through the room air. Right after zeroing the sensor, sample gas is aspirated from the tonometry catheter and the IR-signal passed through the sample gas is measured. The actual $CO_2$ concentration is determined from the measured zero signal and the $CO_2$ signal. After determining the catheter gas $CO_2$ the system ensures the catheter is emptied by creating a vacuum to empty any residual gas. After generating the vacuum, the tubing system is equilibrated close to the ambient pressure by switching the pump valve on and off. Thus, filling of the catheter is always done with the same amount of gas. The catheter is refilled with measured sample gas.

### Catheter pressure transducer

The catheter pressure transducer measures absolute catheter pressure.

### Zero valve

The valve is normally open to the room air. When sample gas is measured from the catheter, zero valve will be active.

### Sensor

After the zero valve the gas passes through $CO_2$ sensor.

## Nafion™ tube [1]

A nafion tube is used between the $CO_2$ sensor and tube unit to balance the sample gas humidity with that of ambient air. The $CO_2$ sensor measures humid gas and Nafion tube prevents humidity from increasing in the tubes.

## Tube unit

The tube unit is used between the nafion tube and pump unit to store the sample gas.

## Pump valve

The valve is normally open to room air. When $CO_2$ concentration is measured from the sample gas or from room air, the pump valve will be active.

## Pump pressure transducer

The working pressure transducer measures absolute pump pressure. It is used for the catheter empty message, catheter leakage message and unable to fill catheter message.

## Membrane pump and linear stepper motor

The gas sampling pump is a membrane pump that is run by a linear stepper motor. Sample volume is 4 ml.

## 2.2.2 $CO_2$ sensor

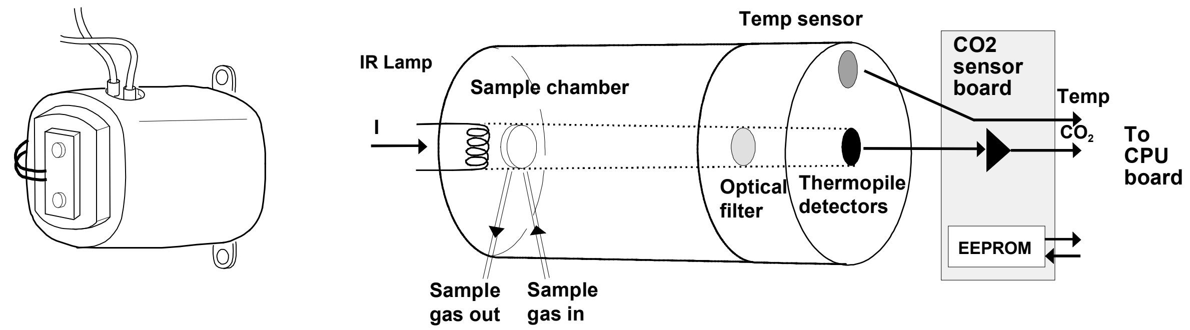



**Figure 4** **$CO_2$ sensor**

The $CO_2$ sensor is a non dispersive infrared analyzer, measuring absorption of the gas sample at $CO_2$ infrared wavelength, which is selected using optical narrow band filter. The IR lamp is a 500 mW filament, surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 3 mm length.

The $CO_2$ sensor contains own preamplifier board, which amplifies the thermopile signal. The preamplifier board also contains EEPROMs that store calibration data of $CO_2$ sensor.

The Temp sensor measures the temperature of the $CO_2$ unit and it is used for temparature compensation.

[1] Nafion is a trademark of Perma Pure Inc.

### 2.2.3 CPU board

The CPU board contains the processor, memories and AD-converter that are common to the whole module. The CPU board also contains preamplifiers of pressure sensors and drivers for valves, linear stepper motor and lamp. The module is connected to the module bus through an RS-485 serial channel.

The $CO_2$ sensor preamplifier board contains the EEPROM, preamplifier of IR thermopile sensors and temp sensor.

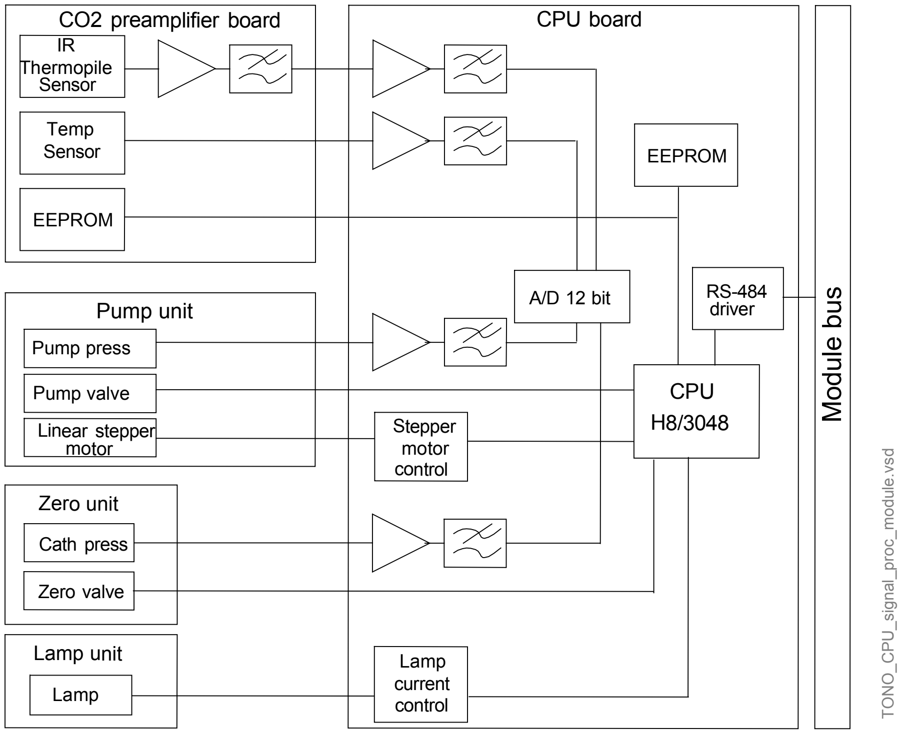



**Figure 5** **Signal processing of the module**

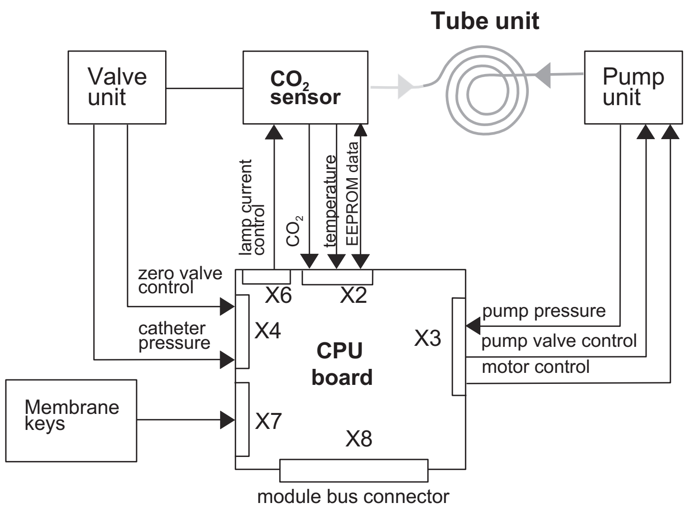



**Figure 6** **Signal and control logic**

## 2.3 Connectors and signals

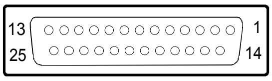



**Table 1** **Module bus connector**

| Pin No. | I/O | Signal |
|---|---|---|
| 1 | I | RESET RS485 |
| 2 | I | -15 VDC (not used) |
| 3 | I | +15 VDIRTY |
| 4 | I | +15VDC |
| 5 | I/O | -DATA RS485 |
| 6 | I/O | DATA RS485 |
| 7 | | Ground and Shield |
| 8 | I | -RESET RS485 |
| 9 | | n/c |
| 10 | | n/c |
| 11 | | n/c |
| 12 | | n/c |
| 13 | | Ground and Shield |
| 14 | I | +24/+32 VDIRTY Depends on power supply (not used) |
| 15 | I | Ground DIRTY |
| 16 | | n/c |
| 17 | | n/c |
| 18 | | n/c |
| 19 | | n/c |
| 20 | I | GASFR (not used) |
| 21 | I | CTSD (not used) |
| 22 | I | TXDD (not used) |
| 23 | O | RXDD (not used) |
| 24 | I | +5 VDC |
| 25 | I | +5 VDC |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the Tonometry module is limited to replacing faulty tubing or mechanical parts.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

CAUTION The module electronics can only be repaired and calibrated at the factory.

### 3.1.1 $CO_2$ sensor

CAUTION The $CO_2$ sensor can only be repaired at the factory. Attempts to repair the sensor elsewhere will adversely affect operation of the sensor. The information provided is for reference only.

### 3.1.2 Factory calibration data

CAUTION If there is any fault in the CPU board, pump unit, valve unit or $CO_2$ sensor, the module should be sent to the factory for repair. The CPU board contains calibration data for the pressure transducers in the pump unit and valve unit. The CO2 sensor preamplifier board contains calibration data for the sensor itself and for gas measurement electronics on the CPU board.

### 3.1.3 Serviceable or exchangeable parts

- nafion tube
- other tubings
- tube unit
- mechanical parts

NOTE: After any component replacement see chapter *Adjustments and calibrations*.

# 3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form, *APPENDIX A*, which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the checklist should be signed after performing the procedure.

## 3.2.1 Recommended tools

| **Tool** | **Order No.** | **Notes** |
|---|---|---|
| Screwdriver | - | |
| Pressure manometer | - | |
| Silicon tube | 73373 | Available in meters. |
| Calibration gas<br>Calibration gas regulator<br>Calibration sampling line | 755580<br>755534*<br>733251 | |
| Air pressure gauge | - | |
| Luer plug | | |
| Tonometrics™ catheter | | |

See order numbers for accessories in the *Patient Monitor Supplies and Accessories* catalogue.

*NOTE: Ensure that the calibration gas and regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required. For more information see *Adjustments and calibrations* chapter of Compact Airway modules slot.

## 3.2.2 Recommended parts

| **Part** | **Order No.** | **Notes** |
|---|---|---|
| Special tube, (Nafion) 300 mm | 733382 | |

Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - connectors are intact and are attached properly
   - the module box, latch and spring locking pin are intact

3. Replace the nafion tube.

   NOTE: The nafion tube should be replaced annually.

   - Reattach the module box and check that the latch moves properly.
   - Plug in the module. Check that it goes in smoothly and locks up properly
   - Turn the monitor on and wait until the normal monitoring screen appears.
   - Configure the monitor screen so that information regarding the tonometric measurement is shown, for example:

     **Monitor Setup** ***- Screen 1 Setup - Digit Fields -Lower Field 4 - PgCO2***

4. Check that the module is recognized, i.e. the $PgCO_2$ header with related information appears in the chosen digit field.

5. Enter the service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8)

   Record the information regarding the software of the tonometry module by selecting ***Scroll Vers*** and turning the ComWheel.

6. Enter the tonometric module service menu:

   ...***Parameters - More... - TONO***

   Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. 'RAM', 'ROM' and 'EEPROM' all state OK. Check that the general error status, module pneumatics error status, module hardware error status and testbit status are zero.

7. Check the front panel **Start-Stop** and **Lab. Data** membrane keys.
   Press each key for at least one second and check that the key being pressed is identified, i.e. the keyboard status changes.

8. Perform the pressure sensor calibration (***TONO - PressSensCal***), see instructions from section 3.4.1.*Pressure sensor calibration*

9. Perform the system test (***TONO - System Test***).

   1. Block the catheter port of the module airtight e.g. with a plug that is made for closing a syringe.

   2. Select ***Start Test***.

   3. Wait until the automatic test procedure is over. The results are given in the data field and descriptions of the tested parts are listed in table 8, see section 5.4 *System test*.

   The test can be interrupted at any time by selecting ***Stop Test***.

   NOTE: The system test takes about one minute to carry out.
   NOTE: Use a plug with very small volume to block the catheter port.

10. Perform the gas calibration (***TONO - Tonometry - PgCO2 Calibration***).

11. Connect the catheter to the tonometry module. Start tonometric measurement by pressing the **Start-Stop** key on the module.
    If measurement is turned on $PgCO_2$ time bat replaces the Meas Off text. Check that the catheter fills up. Stop the measurement by pressing the **Start-Stop** key.

12. Clean the module with suitable detergent.

Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the tonometry module in the following way. See also the exploded view of the module.

1. Remove two screws from the back of the module.
2. Pull the module box slowly backwards and detach it from the main body.

Reassembling is essentially reversing what was described above.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

### 3.3.1 Instructions after replacing tubings

After replacing any part of the tubings:

- perform the System test
- perform the PgCO2 calibration

## 3.4 Adjustments and calibrations

### 3.4.1 Pressure sensor calibration

Before the procedure:

- Find out what the ambient pressure is at the moment in [mmHg] or [mbar].
- Find a device with which you can apply a known pressure of about 100 mmHg to the catheter port. There are e.g. blood pressure gauges that will do. Make sure that it can be connected to a male luer connector.

1. The monitor prompts: ‘Make sure that catheter connector is open to room air and start calibration.’
   - Remove catheter, plug, pressure gauge or anything that is connected to catheter port of the module.
   - Select ***Start Calib***
2. The monitor prompts: ‘Calib started. Make sure that catheter connector is open to room air.’
   - Remove catheter, plug, pressure gauge or anything that is connected to catheter port of the module, if you haven’t done so already.
   - Wait a moment.
3. The monitor prompts ‘Adjust ambient pressure.’
   - Turn ComWheel to match the highlighted pressure value (or the corresponding value in mbar to the right of the mmHg reading) to the known ambient pressure.
   - Press ComWheel.
4. The monitor prompts: ‘Pump approximately 100 mmHg pressure and adjust cal. press. to match.’
   - Connect the blood pressure gauge to the catheter port.
   - Pump in a pressure between 95 and 105 mmHg.
   - Turn ComWheel to match the highlighted pressure value to the applied pressure.
   - Press ComWheel.
5. The monitor prompts ‘Store or discard new sensor gains and offsets.’
   - Turn ComWheel to display ***YES*** if you want to store the calibration factors or ***NO*** if you do not want to store them.
   - Press ComWheel.
6. The monitor prompts ‘Calibration finished.’

   Everything went OK and the calibration is finished.

   OR

   The monitor prompts: ‘Calibration pressure too close to ambient pressure.’

   The applied pressure was too small and you have to redo the calibration.

### 3.4.2 System test

1. Plug the catheter port of the module airtight e.g. with a plug that is made for closing a syringe.
2. Select ***Start Test***.
3. Wait till the automatic test procedure is over. The results are given in the data field and descriptions of the tested parts are listed in table 8, see section *System test*.

The test can be interrupted at any time by selecting ***Stop Test***.

NOTE: The system test takes about one minute to perform.

NOTE: Use a plug with very small volume to block the catheter port.

### 3.4.3 Pg$CO_2$ calibration

The gas calibration is performed in the **Others** ***- Tonometry*** or ...***Service - Parameters - More... - TONO - Tonometry*** submenu.

1. Connect the calibration gas sampling line to the regulator and to the module's catheter connector.
2. Press the **Others** key on the monitor keyboard.
3. Select ***Tonometry - PgCO2 Calibration***.
4. Wait until the text 'Start feeding gas and press ComWheel. Feed gas until Adjust message is displayed' appears. Open the regulator and start feeding gas. Press the ComWheel and continue feeding gas until the text 'Adjust' appears on the display.
5. Check that the displayed values match the values on the calibration gas container. Adjust with the ComWheel if necessary.
6. It is recommended that the airway gases be calibrated at the same time.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| Trouble | Possible cause and treatment |
|---|---|
| Tonometry module HW error. | Module hardware error. Return the module to the factory for repair. |
| Tonometrics catheter empty. | There is no gas in the tonometry catheter. It will be filled automatically during the next measurement. Occlusion in the catheter, or leak in the catheter or connector in the module. Check catheter. |
| Tonometrics catheter leakage. | The tonometry catheter is disconnected, the tubes are leaking inside the module or the catheter is leaking. Ensure proper catheter connection and have the internal leak repaired. |
| Unable to fill tonometrics catheter. | Occlusion in the catheter or the balloon is squeezed. Check catheter. |

## 4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, fault in pressure sensors, failure of the sampling pump or the magnetic valves.

The system test should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system check and if necessary adjust the pressure sensors.

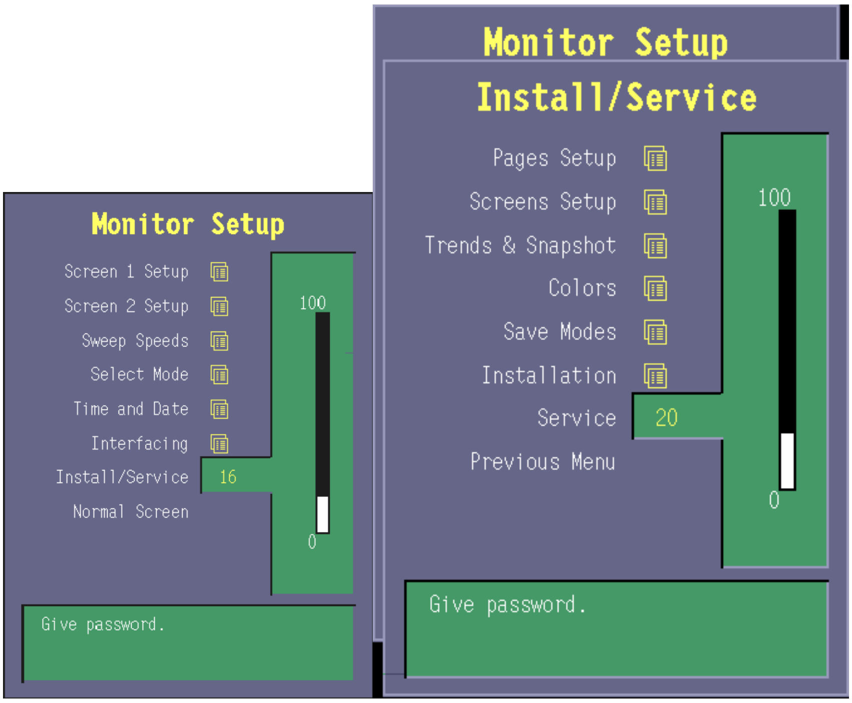
CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

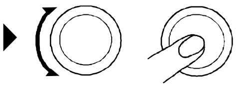
CAUTION If there is any fault in the CPU board, pump unit, valve unit or $CO_2$ sensor, the module should be sent to factory for repair. The CPU board contains calibration data for the pressure transducers in the pump unit and valve unit.

NOTE: If any liquid has entered the module, contact Datex-Ohmeda Technical Services.

# 5 SERVICE MENU

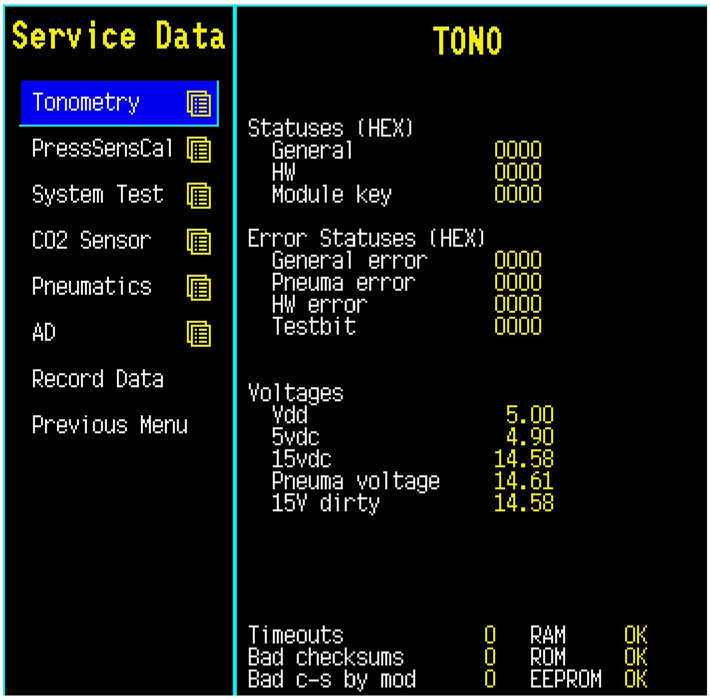
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password: 16-4-34).
3. Select ***Service*** (password: 26-23-8).
4. Select ***Parameters - More... - TONO***.

## 5.1 Tonometry service menu




### Service Data

**Tonometry** A selection to enter the Tonometry setup menu.

**PressSensCal** A selection to enter the module pressure sensor calibration menu.

**System Test** A selection to enter the module system test.

**CO2 Sensor** A selection to enter the module $CO_2$ sensor menu.

**Pneumatics** A selection to enter the module pneumatics menu.

**AD** A selection to enter the module AD value display.

**Record Data** A selection to print out the shown service data to the device defined in the ***...Service - Record Data*** menu.

**Previous Menu** A selection to return to the previous menu.

### TONO

**Statuses (HEX):** See *Appendix B; How to read HEX numbers*.

**General** Module general status. See table 2 to see the detailed description of the message.

**Table 2** **Module general status**

| | |
|---|---|
| bit 0-5 | Not used |
| bit 6 | State error |
| bit 7 | Communication failure |
| bit 8 | Power failure |
| bit 9 | Clock failure |

| | |
|---|---|
| bit 10 | EEPROM checksum failure |
| bit 11 | EEPROM writing failure |
| bit 12 | ROM failure |
| bit 13 | RAM failure |
| bit 14 | Test mode |
| bit 15 | Init mode |

**HW** Module hardware status. See table 3 to see the detailed description of the message.

**Table 3** **Module hardware status**

| | |
|---|---|
| bit 0 | Lamp ON |
| bit 1 | Stepper motor ON |
| bit 2 | Zeroing valve ON |
| bit 3 | Pump valve ON |
| bit 4-15 | Not used |

**Module key** Module keyboard status. See table 4 to see the detailed description of the message.

**Table 4** **Module keyboard status**

| | |
|---|---|
| bit 0 | Button 1 (start/stop) pressed |
| bit 1 | Button 2 (Lab.Data) pressed |
| bit 2-15 | Not used |

**Error Statuses (HEX):**

**General error** Module general error status. See table 5 to see the detailed description of the message.

**Table 5** **Module general error status**

| Bit | Description | Suggested service |
|---|---|---|
| bit 0-1 | Not used. | - |
| bit 2 | Zeroing error. Zero gas signal out of limits or pressure or temperature signal varying during measurement. | $CO_2$ sensor faulty. Send the module to the factory for repair. |
| bit 3 | $CO_2$ measurement error. $CO_2$ signal out of limits or pressure or temperature signal varying during measurement. | $CO_2$ sensor faulty. Send the module to the factory for repair. |
| bit 4 | Measurement error. Sensor temperature, measurement pressure or absorbance is out of limits. | $CO_2$ sensor faulty. Send the module to the factory for repair. |
| bit 5 | Calibration error. Failure in calibration. | Recalibrate. |
| bit 6 | Pneumatic error. | See pneumatic error status bits for details. |
| bit 7 | Lamp pulsing error. | $CO_2$ sensor faulty. Send the module to the factory for repair. |
| bit 8-15 | Not used. | - |

**Pneuma error** Module pneumatics error status. See table 6 to see the detailed description of the message.

**Table 6 Module pneumatics error status**

| Bit | Error label | Description | Suggested service |
|---|---|---|---|
| 0 | pumping error | Stepper motor is not able to generate negative pressure at the pump pressure sensor during zeroing. | Check the function of the stepper motor. |
| 1 | eq. to amb. press failed | Before filling the catheter, the pressure in the module tubing is equilibrated to the ambient pressure by switching the pump valve on and off. If ambient pressure is not reached, this error is shown. | Calibrate the pressure sensors. Check the pump valve function. |
| 2 | tubing/zero block occl | Pressure at the pump pressure sensor gets too low, when air is aspirated though the zeroing valve. | Check tubing/valves for occlusion. |
| 8 | press sens values differ | Pump pressure and catheter pressure readings differ more than 50 mbars. | Calibrate the pressure sensors. |
| 9 | pneuma fatal error | This error is shown, if the pneumatic error occurred is considered fatal. | Check for other pneumatics errors. |
| 10 | cath press too low | Catheter pressure reading is below reasonable pressure values. | Make sure that you are not applying too low pressure to the catheter connector. Calibrate the pressure sensors. |
| 11 | cath press too high | Catheter pressure reading is above reasonable pressure values. | Make sure that you are not applying too high pressure to the catheter connector. Calibrate the pressure sensors. |
| 12 | pump press too low | Pump pressure reading is below reasonable pressure values. | Make sure that you are not applying too low pressure to the catheter connector. Calibrate the pressure sensors. |
| 13 | pump press too high | Pump pressure reading is above reasonable values. | Make sure that you are not applying too high pressure to the catheter connector. Calibrate the pressure sensors. |

**HW error** Module hardware error status. See table 7 to see the detailed description of the message.

**Table 7 Module hardware error status**

| | |
|---|---|
| bit 0 | Lamp error |
| bit 1, 2, 3 | not used |
| bit 4 | CPU EEPROM error |
| bit 5 | Sensor EEPROM error |
| bit 6 | Internal AD converter error |
| bit 7 | External AD converter error |
| bit 8 | $CO_2$ termopile error |
| bit 9 | Reserved |
| bit 10 | Temperature detector error |
| bit 11 | Pump pressure sensor error |
| bit 12 | Catheter pressure sensor error |
| bit 13 | Pneumatic power failure |
| bit 14-15 | Not used |

**Testbit** Testbit is module production phase test status and is always 0000 (HEX). If testbit status is ≠ 0000 then the module should be returned to the factory.

**Voltages**

**Vdd**; 5 V digital units driving voltage received from the module frame.

**5vdc**; 5 Volts of the module derived internally from 15vdc.

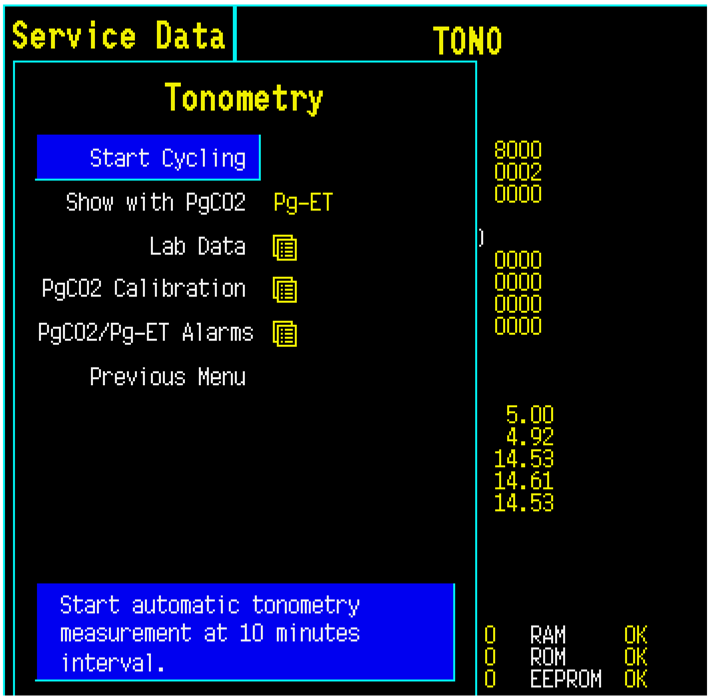
**15vdc**; 15 Volts of the module received from the module frame.

**Pneuma voltage**; 15 V voltage driving pneumatic elements of the module, derived from 15V dirty.

**15V dirty**; 15 V voltage received from the module frame.

## 5.2 Tonometry

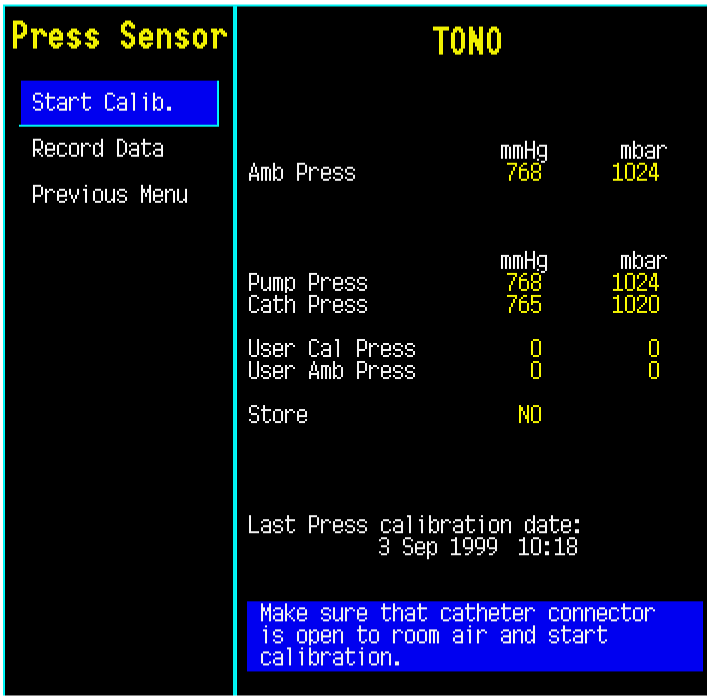
Another route to reach Tonometry setup menu. See the description in *User's Reference Manual*.




**PgCO2 Calibration**

See calibration instructions from section 3.4.3 *PgCO2 calibration.*

## 5.3 Press sensor calibration




### Press Sensor

**Start Calib.** A selection to start module pressure sensor calibration sequence. The procedure is guided online.

**Record Data** A selection to print out the shown service data to the device defined in the ***...Service - Record Data*** menu.

### TONO

**Amb Press**; ambient pressure measured by the pressure sensor. All the pressure values are given in both mmHg and mbar on this page.

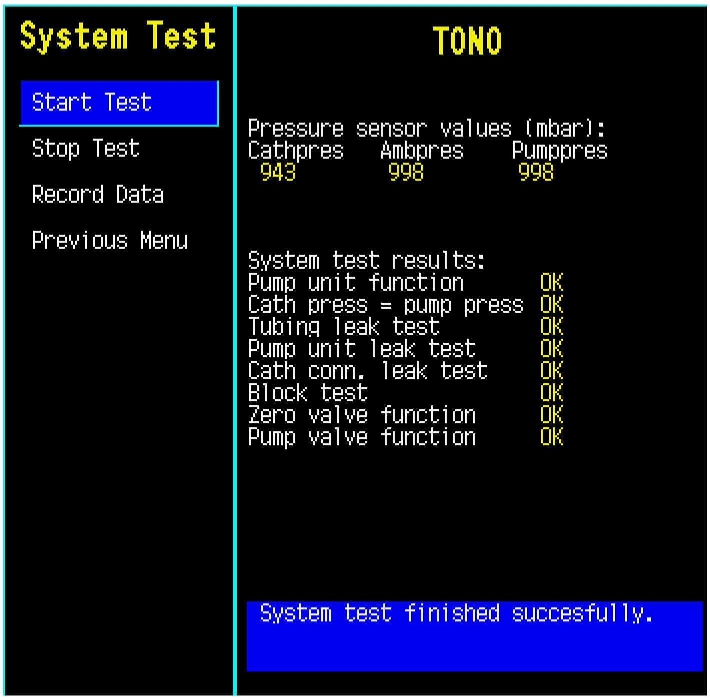
**Pump Press**; pressure measured from the pumping unit.
**Cath Press**; pressure measured from the catheter line.

**User Cal Press**; pressure that user sets during the calibration sequence accorging to the pressure that is applied to the catheter port. The set value should be close to 100 mmHg.
**User Amb Press**; pressure that user sets during the calibration sequence according to the current ambient pressure in the room.

**Store**; a selection for storing/discarding the newly gained calibration values.

**Last Press calibration date**; data read from the module that tells when the module was last calibrated.

## 5.4 System test




### System Test

**Start Test** A selection to start the automatic system test sequence. The procedure is guided online.

**Stop Test** A selection to stop the automatic system test sequence.

**Record Data** A selection to print out the shown service data to the device defined in the ***...Service - Record Data*** menu.

### TONO

**Cathpres**; pressure measured from the catheter line [mbar].
**Ambpres**; ambient pressure in the room [mbar].
**Pumppres**; pressure measured from the pumping unit [mbar].

**System test results**; detailed information of the test results of different system parts. The meaning of the messages:

- "OK" the part succesfully passed the test
- "FAIL" the part failed in the test
- "N/A" the test couldn't be carried out properly.

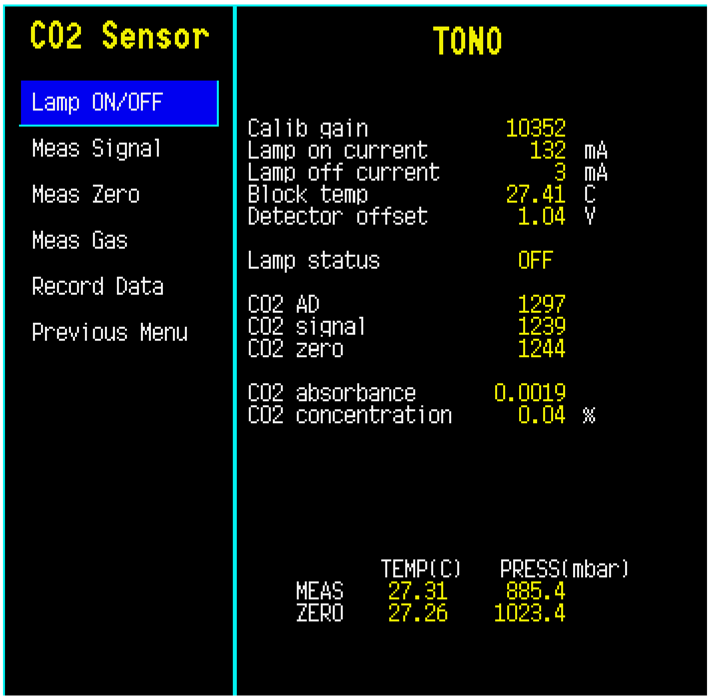
See table 8 to see the detailed description of the tested parts.

**Table 8 Description of system test**

| Test label | Description | If test fails |
|---|---|---|
| Pump unit function | Stepper motor aspirates/pushes room air through the zeroing valve. If stepper is working properly, it is able to generate small negative/positive pressure at the pump unit pressure sensor. | Check the function of stepper motor. |

| Test label | Description | If test fails |
|---|---|---|
| Cath press = pump press | Pump pressure sensor and catheter pressure sensor readings are compared at three pressures: at ambient pressure, at approx. +100 mbar and −100 mbar. | Calibrate the pressure sensors. |
| Tubing leak test | The air tightness of the module inner tubing from the zeroing valve to the pump valve is tested. | Check tubing and connections for leaks. |
| Pump unit leak test | The air tightness of the pump unit is tested. | Check pump unit for leaks. |
| Cath conn. leak test | The air tightness of the zeroing unit and catheter connector is tested. | Make sure, that the catheter connector is properly closed during the test. Check zeroing unit and the catheter connector for leaks. |
| Block test | Air is aspirated through the zeroing valve. If pressure at the pump pressure sensor drops too much, the tubing/valves from the zeroing valve to the pump pressure sensor is blocked. | Check the tubing/valves for blocks. |
| Zero valve function | Module pneumatic system pressurised and then zeroing valve is opened to the room air. If pressure does not drop, the zeroing valve may not be functioning. | Check the function of the zeroing valve. |
| Pump valve function | Module pneumatic system pressurised and then pump valve is opened to the room air. If pressure does not drop, the pump valve may not be functioning. | Check the function of the pump valve. |

## 5.5 $CO_2$ sensor




**$CO_2$ Sensor**

**Lamp ON/OFF** A selection to toggle sensor lamp on and off.

**Meas Signal** A selection to start automatic signal measurement sequence. This sequence measures sensor lamp signal levels.

**Meas Zero** A selection to start automatic zeroing measurement sequence.

**Meas Gas** A selection to start automatic gas measurement sequence. This sequence first performs the zeroing measurement. Then it measures the $CO_2$ concentration of the sample of arbitrary gas aspirated from the catheter port.

**Record Data** A selection to print out the shown service data to the device defined in the ***...Service - Record Data*** menu.

## TONO

**Calib gain**; $CO_2$ measurement gain factor that is set in calibration.
**Lamp on current**; sensor lamp current when lit.
**Lamp off current**; sensor lamp current when off.
**Block temp**; sensor temperature [°C] (in degrees centigrade).
**Detector offset**; $CO_2$ detector offset voltage.

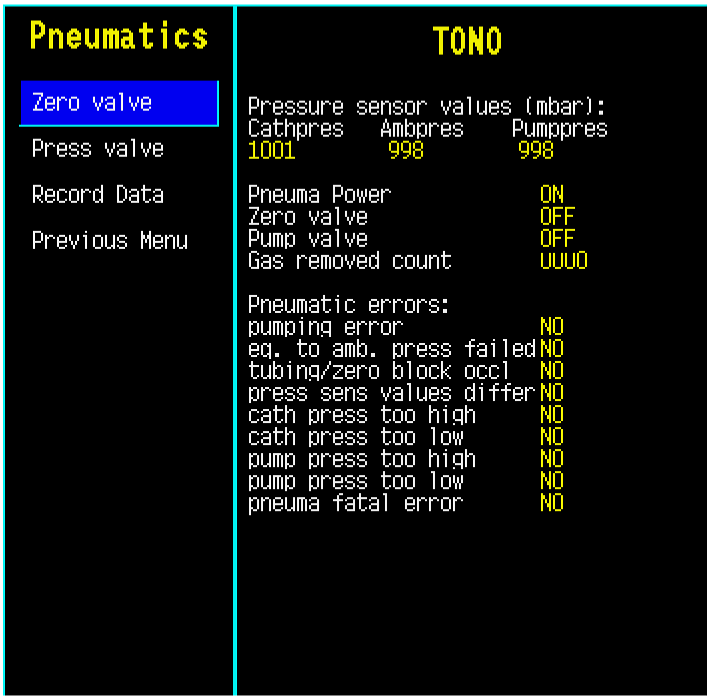
**Lamp status**; displays whether sensor lamp is on or off.

**CO2 AD**; signal from $CO_2$ sensor thermopile (AD counts).
**CO2 signal**; thermopile signal maximum – minimum when lamp is blinked (AD counts).
**CO2 zero**; thermopile signal maximum - minimum during sensor zeroing when lamp is blinked (AD counts).

**CO2 absorbance**; calculated light absorbance during $CO_2$ measurement.
**CO2 concentration**; $CO_2$ concentration (%) in sensor (does not include compensations related to catheter measurement).

**MEAS TEMP**; $CO_2$ sensor temperature during signal measurement [°C].
**MEAS PRESS**; $CO_2$ sensor pressure during signal measurement [mbar].
**ZERO TEMP**; $CO_2$ sensor temperature during zeroing measurement [°C].
**ZERO PRESS**; $CO_2$ sensor pressure during zeroing measurement [mbar].

## 5.6 Pneumatics




### Pneumatics

**Zero valve** A selection to toggle zero valve on/off.

**Press valve** A selection to toggle pump valve on/off.

**Record Data** A selection to print out the shown service data to the device defined in the ***...Service - Record Data*** menu.

### TONO

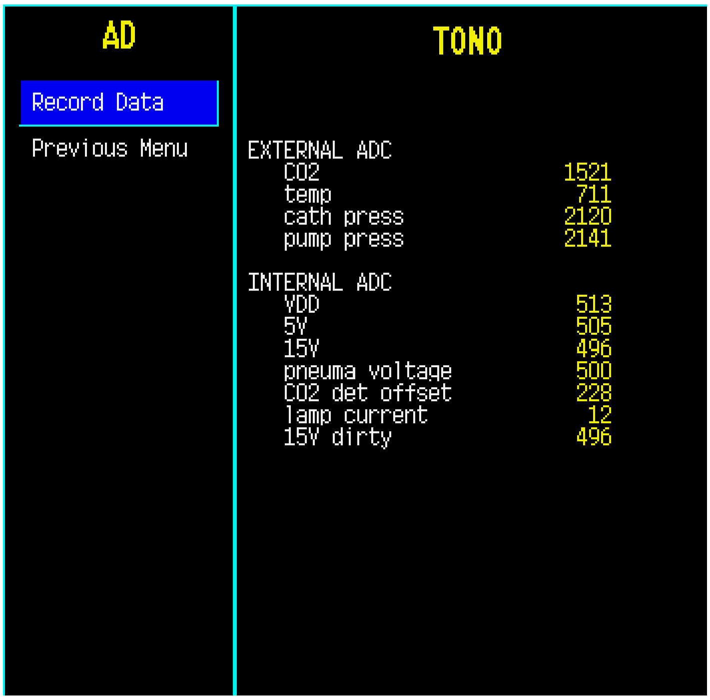
**Cathpres**; pressure measured from the catheter line [mbar].
**Ambpres**; ambient pressure in the room [mbar].
**Pumppres**; pressure measured from the pumping unit [mbar].

**Pneuma Power**; displays whether electricity has been connected to the pneumatics system or not.
**Zero valve**; displays whether zero valve is on or off.
**Pump valve**; displays whether pump valve is on or off.
**Gas removed count**; displays how many times gas is removed from catheter during measurement cycle.

**Pneumatic errors**; detailed information of the performance of different pneumatics system parts.
The meaning of the messages:
'NO' the part performed OK during the measurement = "this error did not occur"
'YES' the part failed during the measurement = "this error did occur."

See table 6 to see the detailed description of the tested parts.

## 5.7 AD




### AD

**Record Data** A selection to print out the shown service data to the device defined in the ***...Service - Record Data*** menu.

### TONO

All the numbers in this section are AD counts, i.e. computer internal data.

**EXTERNAL ADC**

**CO2**; $CO_2$ sensor $CO_2$ signal.
**temp**; $CO_2$ sensor temperature signal.
**cath press**; pressure measured from the catheter line.
**pump press**; pressure measured from the pumping unit.

**INTERNAL ADC**

**VDD**; 5 V digital units driving voltage received from the module frame.
**5V**; 5 Volts of the module derived internally from 15vdc.
**15V**; 15 Volts of the module received from the module frame.
**pneuma voltage**; 15 V voltage driving pneumatic elements of the module, derived from 15 V dirty.
**CO2 det offset**; $CO_2$ detector offset voltage.
**lamp current**; $CO_2$ sensor lamp current.
**15V dirty**; 15 V voltage received from the module frame.

# 6 SPARE PARTS

## 6.1 Spare parts list

NOTE: Accessories are listed in the *Patient Monitor Supplies and Accessories* catalogue.

### 6.1.1 Tonometry Module, rev. 00, 01

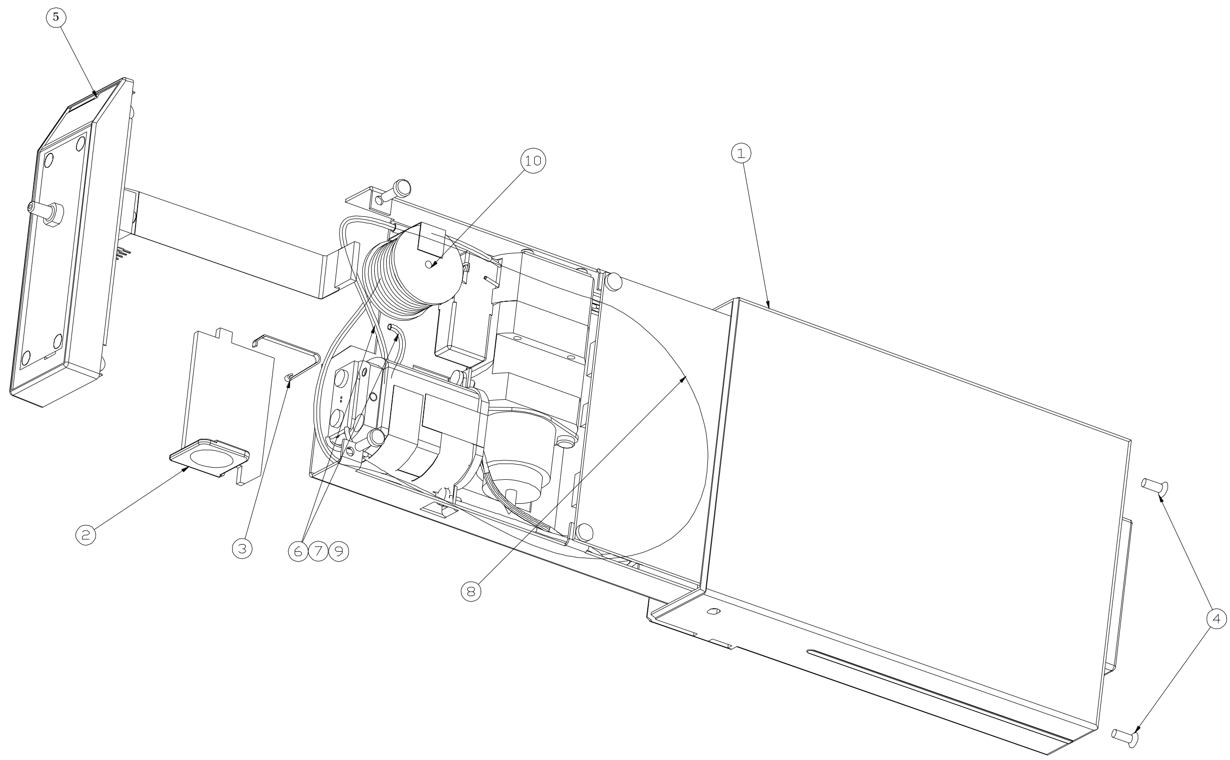



**Figure 7 Exploded view of S/5 Tonometry Module, M-TONO**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Membrane key | 896015 | |
| 6 | Hose-plastic,d=2/hole 1,transluc.vin | 73341 | |
| 7 | Hose-silicor,hole 1.7/wall 1.05 | 73373 | |
| 8 | Nafion tubing, 300mm | 733382 | |
| 9 | Pipe 10mm | 871925 | |
| 10 | Tube unit | 896981 | |
| 11 | Front Panel sticker, DA ; M-TONO (rev.00) | 897739 | 898873 |
| 11 | Front Panel sticker, DA ; M-TONO (rev.01) ; S/5 | 898873 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 11 | Front Panel sticker, DE ; M-TONO (rev.00) | 897730 | 898864 |
| 11 | Front Panel sticker, DE ; M-TONO (rev.01) ; S/5 | 898864 | |
| 11 | Front Panel sticker, EN ; M-TONO (rev.00) | 895683 | 898863 |
| 11 | Front Panel sticker, EN ; M-TONO (rev.01) ; S/5 | 898863 | |
| 11 | Front Panel sticker, ES ; M-TONO (rev.00) | 897733 | 898867 |
| 11 | Front Panel sticker, ES ; M-TONO (rev.01) ; S/5 | 898867 | |
| 11 | Front Panel sticker, FI ; M-TONO (rev.00) | 897736 | 898870 |
| 11 | Front Panel sticker, FI ; M-TONO (rev.01) ; S/5 | 898870 | |
| 11 | Front Panel sticker, FR ; M-TONO (rev.00) | 897731 | 898865 |
| 11 | Front Panel sticker, FR ; M-TONO (rev.01) ; S/5 | 898865 | |
| 11 | Front Panel sticker, IT ; M-TONO (rev.00) | 897734 | 898868 |
| 11 | Front Panel sticker, IT ; M-TONO (rev.01) ; S/5 | 898868 | |
| 11 | Front Panel sticker, JA ; M-TONO (rev.00) | 897740 | 8000385 |
| 11 | Front Panel sticker, JA ; M-TONO (rev.01) ; S/5 | 8000385 | |
| 11 | Front Panel sticker, NL ; M-TONO (rev.00) | 897732 | 898866 |
| 11 | Front Panel sticker, NL ; M-TONO (rev.01) ; S/5 | 898866 | |
| 11 | Front Panel sticker, NO ; M-TONO (rev.00) | 897738 | 898872 |
| 11 | Front Panel sticker, NO ; M-TONO (rev.01) ; S/5 | 898872 | |
| 11 | Front Panel sticker, PT ; M-TONO (rev.00) | 897735 | 898869 |
| 11 | Front Panel sticker, PT ; M-TONO (rev.01) ; S/5 | 898869 | |
| 11 | Front Panel sticker, SV ; M-TONO (rev.00) | 897737 | 898871 |
| 11 | Front Panel sticker, SV ; M-TONO (rev.01) ; S/5 | 898871 | |

# 7 EARLIER REVISIONS

| Revision | Manual slot | Note |
|---|---|---|
| Tonometry Module, M-TONO, rev. 00 | 896 621 | In main manual 896 624 |

# *APPENDIX A, SERVICE CHECK FORM*

# *APPENDIX B, HOW TO READ HEX NUMBERS*

# APPENDIX A, SERVICE CHECK FORM

## S/5 Tonometry Module, M-TONO

Customer ______________________________

Service ____________ Module type ____________ S/N ____________

Service engineer ______________________ Date ____________

☐ OK = Test OK

☐ N.A. = Test not applicable

☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Nafion tube | ☐ | ☐ | ☐ | 4. Recognition | ☐ | ☐ | ☐ |

Notes ______________________________

5. Module software [TONO] [ ]

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 6. Communication and memories | ☐ | ☐ | ☐ | 7. Membrane keys | ☐ | ☐ | ☐ |
| 8. Pressure sensor calibration | ☐ | ☐ | ☐ | 9. System test | ☐ | ☐ | ☐ |
| 10. Gas calibration | ☐ | ☐ | ☐ | 11. Measurement | ☐ | ☐ | ☐ |
| 12. Cleaning | ☐ | ☐ | ☐ | | | | |

Notes ______________________________

______________________________

**Used Spare Parts** ____________ ____________ ____________

____________ ____________ ____________

**Signature** ______________________________

# APPENDIX B, HOW TO READ HEX NUMBERS

Some statuses on Tonometry Module service pages are given as HEX (hexadecimal) numbers. To understand them, please read the following:

A HEX number has a base of 16 instead of 10. This means that every character in a number can have a value between 0 and 15. Numbers from 0 to 9 are displayed as if they were normal 10-based numbers. Numbers from 10 to 15 are displayed with letters from a to f or A to F respectively.

Every character of a HEX number expands into a binary code of four 0:s (zeroes) and 1:s (ones) as given in table 9. Four successive characters thus expand into four times four binary numbers. Here's an example:

We have a HEX number F3A1. We expand the number into binary code so that we first take the four binary digits that correspond to F, which are 1111. Then we write the four binaries that correspond to 3 (0011) after the first four. We now have 11110011. And so on.

Eventually, we have a string of 16 binary numbers, so called bits. HEX number F3A1 corresponds to a binary code of 1111 0011 1010 0001. Spaces are added here for legibility and to visualize the fact that every group of four bits corresponds to one HEX character.

The bits in a binary number are numbered from right to left always starting from 0 as follows:

| bit 15 | bit 14 | bit 13 | bit 12 | bit 11 | bit 10 | bit 9 | bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |

With this information and a table of status fields from section 5 "*SERVICE MENU"* we can translate a HEX status code into actual status messages. If a bit is 1 this means that the corresponding status/error condition is valid, whereas a 0 means that it is not.

**Table 9 HEX to binary conversion**

| HEX | binary | HEX | binary |
|---|---|---|---|
| 0 | 0000 | 8 | 1000 |
| 1 | 0001 | 9 | 1001 |
| 2 | 0010 | A | 1010 |
| 3 | 0011 | B | 1011 |
| 4 | 0100 | C | 1100 |
| 5 | 0101 | D | 1101 |
| 6 | 0110 | E | 1110 |
| 7 | 0111 | F | 1111 |

# Datex-Ohmeda

# S/5™ EEG Module, M-EEG (rev. 01)
# S/5™ EEG Headbox, N-EEG (rev. 01)

# Technical Reference Manual Slot


All specifications are subject to change without notice.

Document No. 8001011-4

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## EEG Module, M-EEG and EEG Headbox, N-EEG

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 EEG Module, M-EEG and Datex-Ohmeda S/5 EEG Headbox, N-EEG. The EEG module is a single width plug-in module designed for use with the S/5 monitors. Later in this manual modules may be refered to without the S/5 system nomenclature for simplicity.

Please also refer to the *Technical Reference Manual* of the S/5 monitor for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The EEG module and the EEG headbox together measure:

- electroencephalography (EEG)
- spontaneous facial muscular activity with frontal electromyography (FEMG)
- auditory evoked potentials (AEP)

The EEG Headbox, N-EEG, is responsible for EEG and FEMG signal amplification, filtering and digitization and electrode impedance measurement. It is situated close to the patient's head. The Headbox has connectors for the EEG leads, either for a referential or a bipolar montage, and for the AEP stimulation earphones.

The EEG module M-EEG creates auditory stimulus pulses and takes care of AEP signal processing. It has one connector for the EEG headbox.

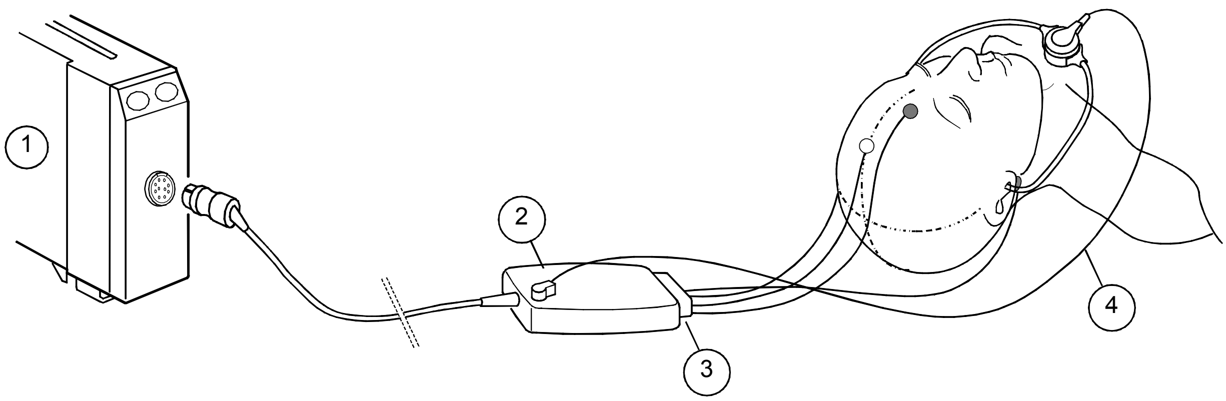



**Figure 1 Measurement setup**

(1) Module EEG, EP and FEMG measurement capability, M-EEG

(2) EEG Headbox and cable, N-EEG

(3) EEG leadset: preconfigured or own montage
- EEG electrodes (cup, needle or stick-on)

For AEP, earphones (4) are required.

NOTE: The S/5 EEG Module, M-EEG and Headbox N-EEG functions only with monitor software of level 99 or newer.

# 1 SPECIFICATIONS

## 1.1 General specifications

### 1.1.1 Headbox

| | |
|---|---|
| Box size, W × D × H | 96 × 170 × 34 mm/3.8 × 6.7 × 1.3 in |
| Box weight | 0.5 kg/1.1 lbs |
| Power consumption | 1.9 W |

### 1.1.2 Module

| | |
|---|---|
| Module size, W × D × H | 37 × 180 × 112 mm/1.5 × 7.1 × 4.4 in |
| Module weight | 0.37 kg/0.8 lbs |
| Power consumption | 3.1 W |

## 1.2 Technical specifications

### 1.2.1 EEG

| | |
|---|---|
| Amplification | 10 000 |
| Resolution | 60 nV |
| Max amplitude | 800 $\mu V_{pp}$ |
| Sampling frequency | 100 Hz per channel |
| Range | ±400 μV |
| Frequency range | 0.5...30 Hz |
| Input impedance | 8 MΩ @ 10 Hz |
| Noise level | <0.5 μV rms from 0.5 Hz to 30 Hz |
| CMRR | >100 dB @ 50 Hz |
| Parameters from power spectrum | SEF, MF, relative power in frequency bands |
| Burst suppression | calculated burst-suppression ratio (BSR) |
| Defibrillation protection | 5000V, 360 J |
| Allowable Input Offset | ±300 mV |

### 1.2.2 AEP

| | |
|---|---|
| Amplification | 10 000 |
| Resolution | 60 nV |
| Max amplitude | 1000 $\mu V_{pp}$ |
| **Stimulation** | |
| Click (condensating) | duration 100 µs |
| Frequency | 1.1...9.1 Hz (1 Hz steps) @ 10 ms measurement |
| | 1.1...8.1 Hz (1 Hz steps) @ 100 ms measurement |
| Intensity | 10...90 dB nHL, 10 dB steps |
| **Measurement** | |
| Sampling frequency | 2400 Hz for MLAEP/ 4800 for BAEP |
| Frequency range | 0.5...1000 Hz |
| Highpass filter | off/10/30/50/75/100/150 Hz |
| Single average: | |
| Averaged responses | 100...2000 stimuli |
| Moving average: | |
| Gross average | 100...2000 stimuli |
| Update interval | after every 100 stimuli (200, when gross average is 2000) |

### 1.2.3 EMG

| | |
|---|---|
| Amplification | 50 000 |
| Resolution | 100 nV |
| Max amplitude | 100 $\mu V_{pp}$ |
| Frequency range | 60...300 Hz |
| Amplitude | Root Mean Square (RMS) |

### 1.2.4 Impedance measurement

| | |
|---|---|
| Measurement frequency | 75 Hz |
| Current | 10 µA |
| Range | 0...30 kΩ |
| Resolution | 100 Ω |
| Accuracy | ±1k or ±10 % whichever is greater |
| Measurement time, all leads | 3 s |
| Start of measurement | manual/automatic |
| Leads off detection | >3 MΩ, continuous |

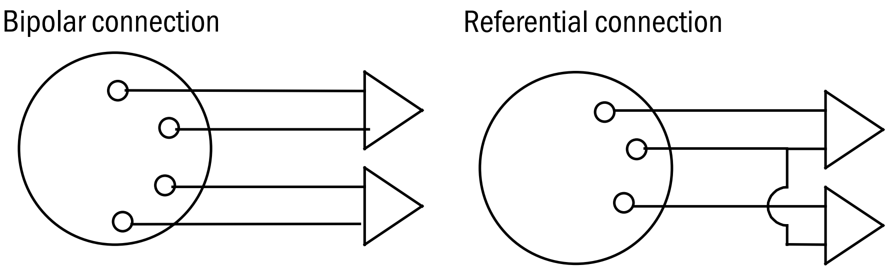
# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 EEG

EEG is a differential voltage signal measured from electrodes attached to the patient's skin. EEG measures the spontaneous electrical activity of the brain. This electrical activity reflects the state of the brain.

Electrode connections can be made with two different principles: bipolar or referential montage. In bipolar montage every channel has two electrodes and the signal is the potential difference between these two electrodes. In a referential montage the referential electrode delivers its potential to every channel's minus-input. The signal is the potential difference between this common reference electrode and the electrode connected to the plus input. The purpose of the ground electrode is to reduce common mode noise. It cannot be used as referential electrode.




The EEG signal is amplified, antialias filtered, digitized and software filtered. After that the EEG signal is displayed on the screen and various characteristics are calculated from it. These include spectrum, rms amplitude, spectral edge frequency, median frequency, burst-suppression ratio and percentage of total power in four different bands: theta (1...4 Hz), delta (5...9 Hz), alpha (9...13 Hz) and beta (>13 Hz).

### 2.1.2 FEMG

FEMG is electrical signal originating from facial muscles. In the headbox the signal of channel 1 is divided into two different amplification and filtering paths. One is the EEG path and the other is the FEMG path. The FEMG signal has a much broader spectrum than the EEG and it overlaps with the EEG at low frequencies. Because of this the rms amplitude of FEMG signal is calculated from the frequency band 60...300 Hz. Mains power frequency and its harmonics are digitally filtered away to reject noise interference from power lines.

### 2.1.3 AEP

AEP is an electrical response of the nervous system to external auditory stimulus. It is measured using the same electrodes as in the EEG measurement, but the sampling frequency and bandwidth are different. The electrical signal resulting from one stimulus is weaker than the spontaneous activity of the brain. To overcome this the stimulus is repeated several times (100...2000), and an average of all responses is calculated. Responses containing large artefacts are removed from the average to improve the signal to noise ratio.

### 2.1.4 Impedance measurement

The impedance measurement is performed from one channel at a time and the EEG or EP measurement is stopped during the impedance measurement.

Differences in electrode impedance causes common mode noise coupling to the measured signal. To minimize this the electrode impedance is measured and a warning of unsatisfactory impedance level is generated when necessary. The impedance of an electrode is measured by applying a known current through the electrode and measuring the voltage drop over the electrode. This way the impedance of a single electrode can be resolved instead of a sum impedance of an electrode pair.

## 2.2 Main components

### 2.2.1 Neuro board

The Neuro board consists of the following functional sections:

- audio stimulator
- microprocessor for stimulation and measurement control, and for counting the measurement results
- two serial communication drivers

The serial bus speed to monitor is 500 kbps and the bus itself is half duplex, i.e. data can be transferred to both directions but only one way at a time.

The serial bus speed to the headbox is 500 kbps and the bus is full duplex i.e. data can be transferred to both directions at the same time.

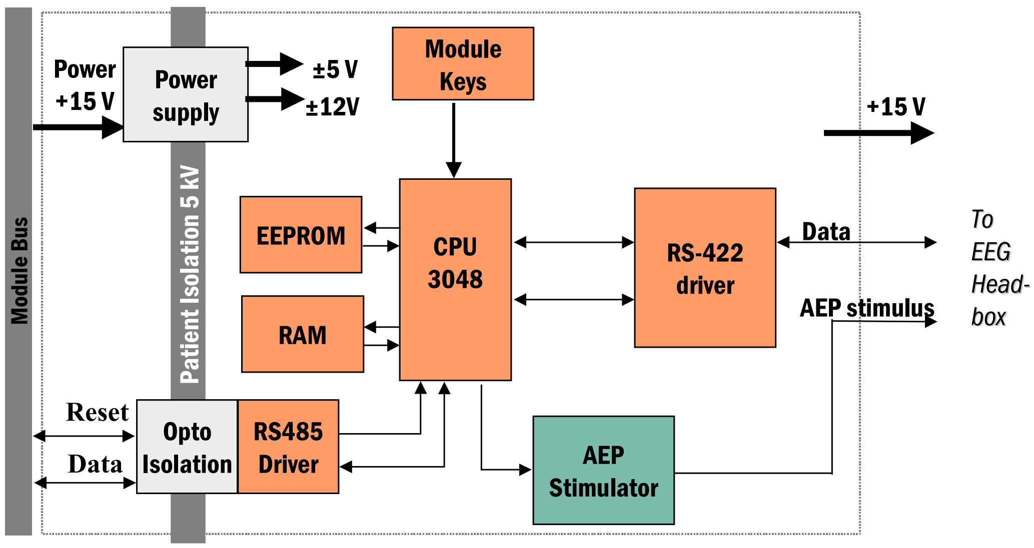



**Figure 2** **Neuro board block diagram**

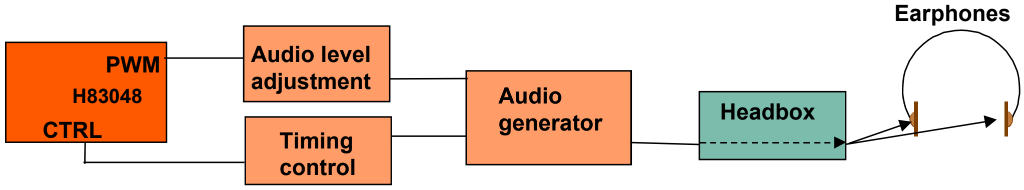



**Figure 3** **Audio stimulator circuitry**

### 2.2.2 Headbox board

The Headbox board consists of the following functional sections:

- input protection
- EEG amplifiers and filters
- FEMG amplifier and filter
- current feeding circuitry and amplifiers for impedance measurement
- microprocessor
- serial communication

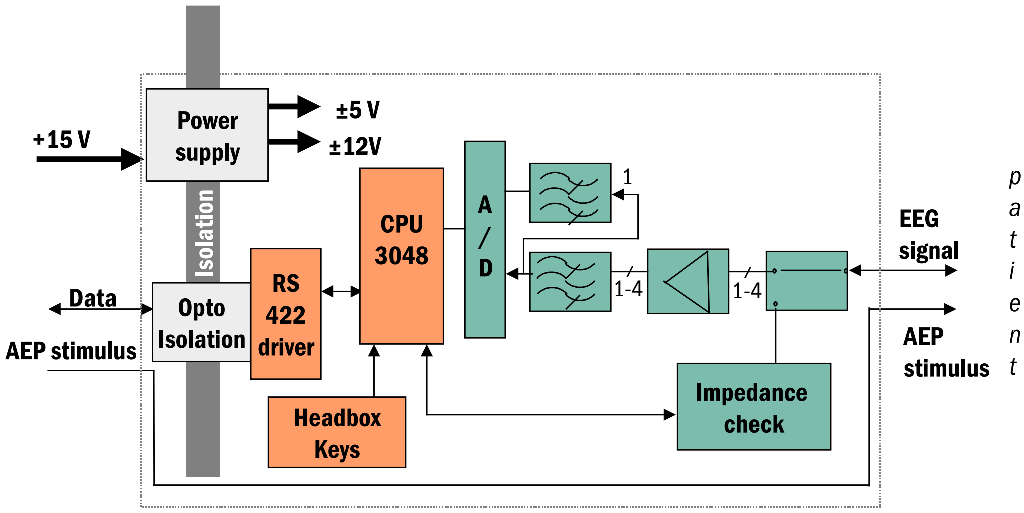



**Figure 4** **EEG headbox board block diagram**

# 2.3 Connectors and signals

## 2.3.1 Module bus connector

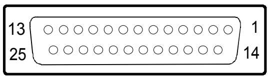
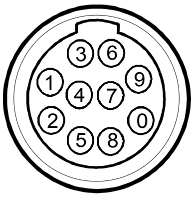



**Table 1 Module bus connector (X1) pin description**

| Pin No. | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485 |
| 2 | I | -15 VDC |
| 3 | I | +15 VDIRTY |
| 4 | I | +15 VDC |
| 5 | I/O | -DATA_RS485 |
| 6 | I/O | DATA_RS485 |
| 7 | - | Ground & Shield |
| 8 | I | -RESET_RS485 |
| 9 | I | CTSB |
| 10 | O | RTSB |
| 11 | I | RXDB |
| 12 | O | TXDB |
| 13 | - | Ground & Shield |
| 14 | I | +32 VDIRTY |
| 15 | I | GroundDIRTY |
| 16 | I | CTSC |
| 17 | O | RTSC |
| 18 | I | RXDC |
| 19 | O | TXDC |
| 20 | - | ON/STANDBY |
| 21 | - | PWM_ECG |
| 22 | - | RXDD_RS232 |
| 23 | - | TXDD_RS232 |
| 24 | I | +5 VDC |
| 25 | I | +5 VDC |

## 2.3.2 Module front panel connectors

**Table 2** **Headbox connector**



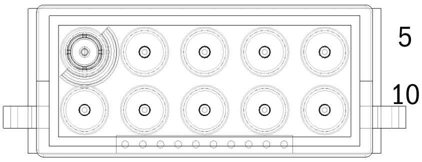

| Pin No. | Signal |
|---|---|
| 1 | Ground |
| 2 | Ground |
| 3 | +15 V |
| 4 | TXD+ |
| 5 | EP Audio |
| 6 | Power sync 43 kHz |
| 7 | RXD+ |
| 8 | EP Sync |
| 9 | RXD- |
| 0 | TXD- |

## 2.3.3 Headbox input connector

**Table 3** **Headbox input connector**

1

6



5

10

| Pin No. | Signal |
|---|---|
| 1 | Lead set id |
| 2 | 1+ |
| 3 | 2+ |
| 4 | 3+ |
| 5 | 4+ |
| 6 | Ground |
| 7 | 1- / Ref |
| 8 | 2- |
| 9 | 3- |
| 10 | 4- |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the M-EEG and N-EEG is limited to replacing faulty circuit boards or mechanical parts. Faulty circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

The Datex-Ohmeda EEG Simulator (order No. 90502) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check is recommended to be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form, *Appendix A*, which should be filled in when performing the procedures.

The mark in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| EEG simulator | 90502 | |
| Screwdriver | | |
| Earphones | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring pin for locking.
- Detach also the cover of the EEG headbox by removing the four screws from the bottom of the box. Be careful with the two wired connectors in the circuit board attached to the cover.

1. Check internal parts of the module and the headbox:
   - screws are tightened properly
   - cables are connected properly
   - the EMC cover is attached properly in the module
   - there are no loose objects inside the module or the headbox

2. Check external parts of the module:
   - the front cover and the front panel sticker are intact
   - connectors are intact and are attached properly
   - the module box, latch and spring pin for locking are intact

3. Check external parts of the headbox
   - cover and the base of the headbox are intact
   - the headbox sticker is intact
   - connectors are intact and attached properly

   ✍

- Reattach the module box and the cover of the EEG headbox.
- Turn the monitor on and wait until the normal monitoring screen appears.
- Configure the monitor screen so that information regarding the EEG measurement is shown:

**Monitor Setup** - ***Screen 1 Setup - Waveform Fields - Field 1 - EEG1***
**Monitor Setup** - ***Screen 1 Setup - Waveform Fields - Field 2 - EEG2***
**Monitor Setup** - ***Screen 1 Setup - Waveform Fields - Field 3 - EEG3***
**Monitor Setup** - ***Screen 1 Setup - Waveform Fields - Field 4 - EEG4***

**Others** - ***EEG - Montage - EEG Channels - 4***
**Others** - ***EEG - Montage - Montage type - Bip***
**Others** - ***EEG - EEG Setup - Numeric 1 - MF***
**Others** - ***EEG - EEG Setup - Numeric 2 - Ampl.***

4. Plug in the module. Check that it goes in smoothly and locks up properly

   ✍

5. Check that the module is recognized, i.e. the EEG header with related information appears in the chosen waveform fields and 'Headbox off' message is shown on the four fields.

   ✍

6. Connect the headbox to the module. Check that the headbox is recognized i.e. message 'EEG measurement off' is shown on the four waveform fields. If the EEG leads are connected 'EEG measurement off' message disappears after 15 seconds.

   ✍

7. Enter the service menu:

   **Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Record the information regarding the software of M-EEG and N-EEG by selecting SCROLL VERS and turning the ComWheel.

   ✍

8. Enter the EEG module service menu:

   ***Parameters - More... - EEG & EP***

   Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. 'RAM', 'ROM' and 'EEPROM' all state OK.

   ✍

9. Check that the 'HB Mod Timeouts', 'HB Mod Bad Checksum' and 'Mod HB Bad Checksum' values are not increasing faster than by 5 per second. Check that the memory of the headbox has passed the internal memory test, i.e. 'HB Rom Error' in the headbox view states 0.

   ✍

10. Check the **EP Start/Stop** and **Imp. Check** membrane keys both of the module and the headbox. Go to module view and press each key for at least one second and check that the key being pressed is identified, i.e. the corresponding text is highlighted in the service menu. Repeat in headbox view with headbox keys.

    ✍

11. Select 10 kΩ as imped. pos. and imped. neg. value on the simulator. Go to ***EEG & EP*** service menu and select ***Check Electr.*** From the headbox view check that the impedances in all four channels are 10 kΩ ±1 kΩ.

    ✍

12. Connect the EEG simulator to the headbox. Select 2 kΩ as imped. pos. and imped. neg. value on the simulator. Select 10 Hz 200 µV sinewave on the simulator and check that all the four waveforms have same form. Check that the size of the waveforms is 200 $\mu V_{pp}$ ±5 µV. Check that the MF value is 10 ±0.5 Hz. Check that the amp value is 71 µV ±3 µV.

    ✍

13. Select 75 Hz 50 µV signal on the simulator. Check that the FEMG value is 16 ±3 µV.

    ✍

- Preset the AEP measurement settings:

  **Others**

  ***EP - Cycle - Cont.***
  ***EP - AEP Setup - AEP Channels - 2***
  ***EP - AEP Setup - Responses -100***
  ***EP - AEP Setup - Stim. Frequency - 1.1Hz***
  ***EP - AEP Setup - Stim. Intensity - 60 dB***
  ***EP - AEP Setup - Sweep length - 100 ms***

14. Plug in the earphones to the headbox. Be careful with load stimulation from the earphones when starting AEP stimulation. Start AEP stimulation by pressing the **EP Start/Stop** button on the module. Check that the clicking sound comes from the earphones in 1.1 Hz frequency. Stop the stimulation by pressing again the **EP Start/Stop** button on the module. Check that the clicking stopped.

- Modify the AEP measurement settings:

  **Others**

  ***EP - AEP Setup - Stim. Frequency - 8.1Hz***
  ***EP - AEP Setup - Stim. Intensity - 90 dB***
  ***EP - EP Size - 1***

15. Connect the AEP testing cable between the simulator and the headbox. Select 2 kΩ as imped. pos. and imped. neg. value on the simulator. Select 40 µV amplitude in the EP waves menu on the simulator and start AEP measurement in the **Others** *- **EP*** menu. Wait until you get the response on the display. Check that the shape of the response is one period of a sine wave. Save EP and adjust the markers to minimum and maximum level of the response curve in both channels. Check that the amplitude is 40 µV ±5 µV.

16. Perform an electrical safety check and a leakage current test.

17. Check that the module functions normally after performing the electrical safety check.

18. Clean the module with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

### 3.3.1 M-EEG

Disassemble the M-EEG in the following way. See Figure 7 Exploded view of module box and EEG module

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with the loose latch and spring locking pin.
3. Detach the Neuro board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

### 3.3.2 N-EEG

Disassemble the N-EEG in the following way. See Figure 8 Exploded view of headbox.

1. Remove the four screws from the bottom of the headbox.
2. Lift off the cover and disconnect the two cables connected to the EEG headbox board.
3. Disconnect the module-headbox cable and the headbox input unit connectors from the EEG headbox board.
4. Remove the four screws on the corners of the EEG headbox board and detach the EEG headbox board.

To reassemble the N-EEG, reverse the order of the disassembly steps.

CAUTION When reassembling the headbox, make sure that the cables are reconnected properly.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| **Trouble** | **Cause** | **Treatment** |
|---|---|---|
| No EEG waveforms on screen. | EEG waveforms not selected on screen. | Press Monitor Setup key and select EEG waveforms on the screen. |
| No EEG waveforms on screen and 'EEG measurement off' message shown in the number field. | Electrodes not attached properly to skin or electrode cables not connected to headbox. | Check electrodes and electrode cables. |
| All EEG Waveforms not drawn on screen even if electrodes and cables are OK. | The number of channels chosen on montage setup is smaller than the number of channels connected to patient. | Check that the number of channels in menu **Others** -***EEG - Montage*** is same as the number of channels connected to patient. |
| Number fields show '---' and message 'High EMG' is displayed. | Patient has high muscle activity in the head region or noise from some equipment is coupling to electrode cables. | Relax the patient or remove the noise source. |
| EEG signal looks noisy and artefact message is displayed in the number fields. | Electrodes are poorly connected or electrical interference is coupling to electrode cables. | Check the electrodes and electrode impedances. Remove noise sources if necessary. |
| Leads off message is shown on other channels than channel 1 in referential connection. | The montage chosen in monitor is not referential. | Change the montage to referential from monitor menu **Others** -***EEG - Montage***. |
| Electrode impedance measurement is not available on menus. | EEG measurement is off. | EEG measurement starts 15 seconds after first electrode pair is connected. |
| Electrode impedance measurement is not available on menus. | EP measurement is on. | Wait until EP measurement ends or stop EP measurement. |
| Electrode impedances show '---' and check ground electrode message is displayed on number fields after impedance measurement. | Ground electrode is poorly connected to patient or ground electrode cable is not connected to headbox. | Check the electrode and cable. If the electrode has too high impedance (>50k) the measurement fails even if the electrode is properly attached. Cure for this is to use better electrodes or prepare the skin better. |
| Electrode impedances show '---' | The electrode impedances are too high and out of measurement range. | Prepare the skin better or use better electrodes. |
| Start EP measurement not available on EP menu. | The EEG measurement is off. | Connect electrodes and wait 15 seconds and the measurement starts. |
| EP measurement parameters cannot be changed. | The EP measurement is on. | Stop EP measurement. |
| All or most of the EP epochs are rejected (Rej. counter on EP screen increases more rapidly than Ave. counter). | The signal has too much noise/artefacts in EP measurement band. Especially coupled 50/60 Hz is not shown on EEG waveform because of filtering, but may be present in EP signal. | Check that electrode impedances are below 5k and the impedances of the same channel are close to one another. If this does not help then try to remove noise sources. |
| EP wave is shown only on one channel even if two channels EP measurement is selected. | Leads are off in the channel where the EP wave is not shown. | Check the electrodes and electrode cables. |
| No clicks can be heard from earphones. | The earphones connector is not in place. | Check that the earphones plug is firmly pushed into the headbox's earphone connector. |

## 4.2 Troubleshooting flowcharts

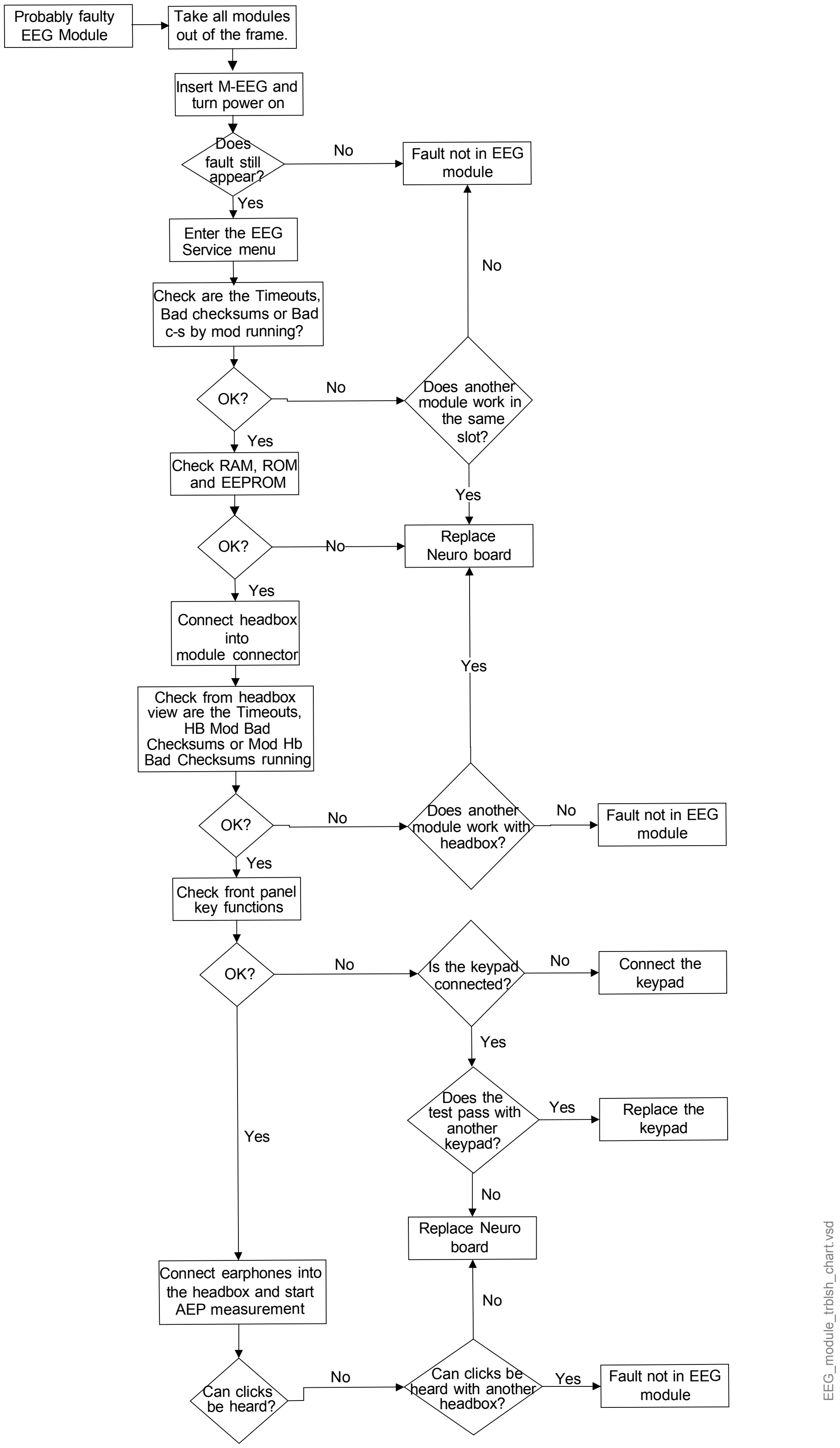



**Figure 5** **EEG module troubleshooting flowchart**

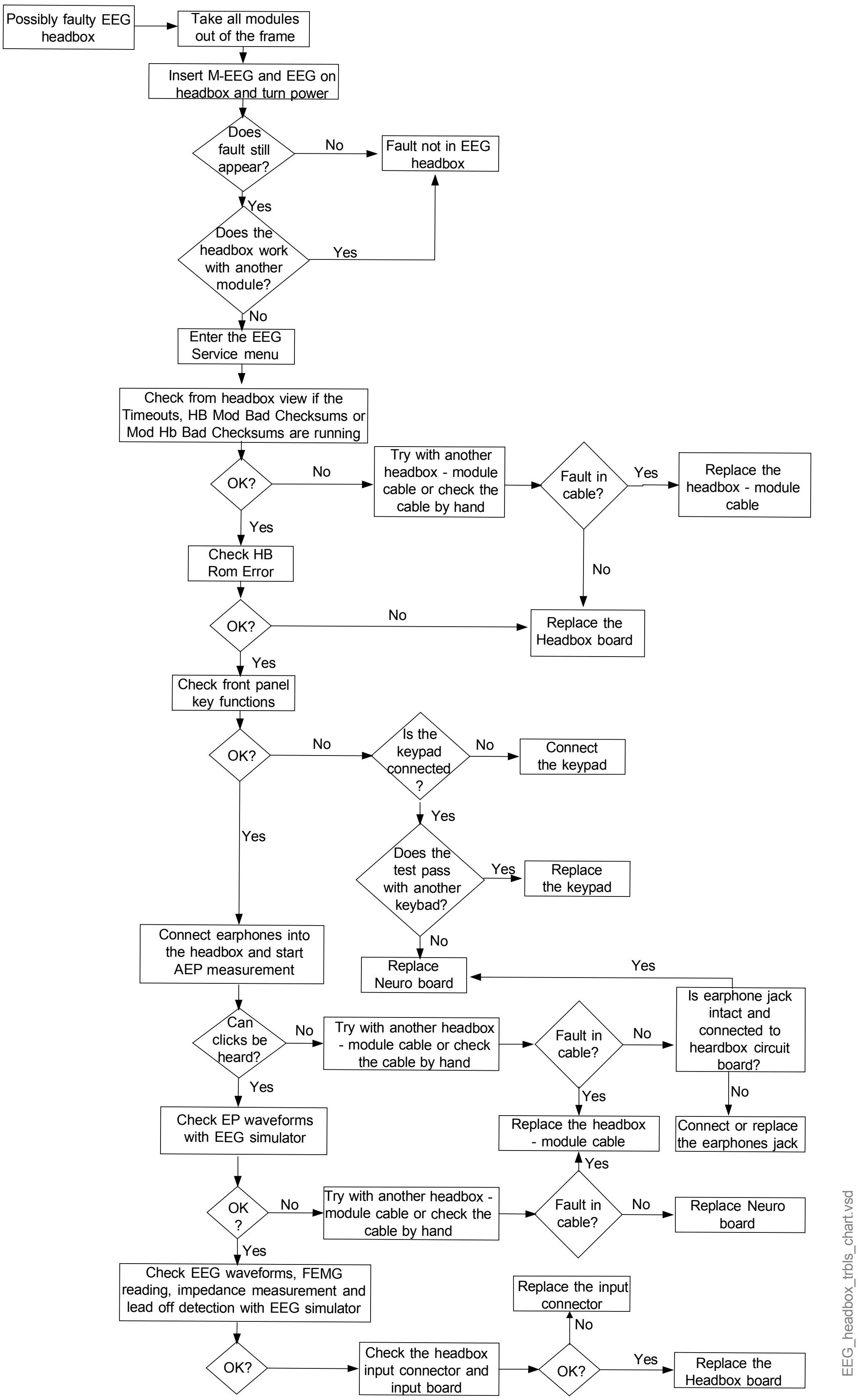
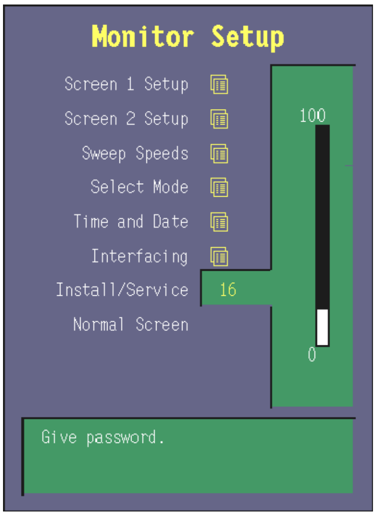
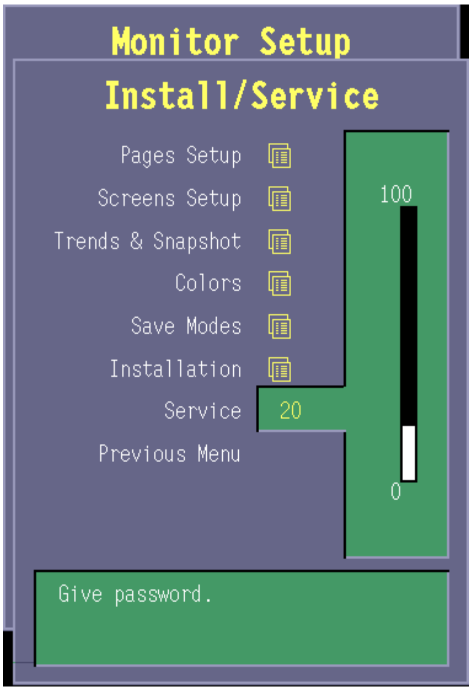


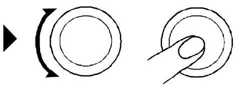

**Figure 6** **Headbox troubleshooting flowchart**

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.

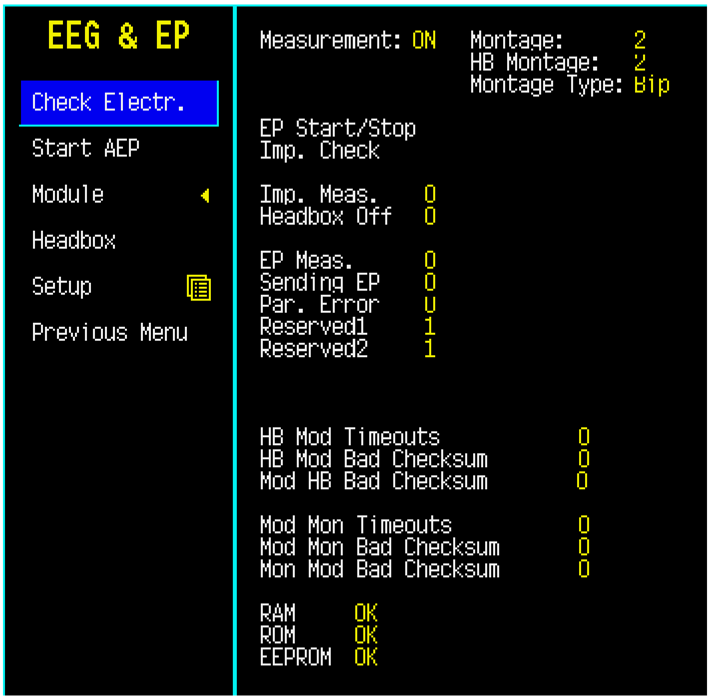


Press the **Monitor Setup** key - select ***Install/Service*** (password: 16-4-34) - select ***Service*** (password: 26-23-8) - select ***Parameters - More... - EEG & EP***.

## 5.1 EEG & EP service menu




### EEG & EP

**Check Electr.** Headbox measures impedance of electrodes. Works same way as from EEG menu or headbox/module button.

**Start AEP** AEP measurement is started with current AEP settings.

**Module** Service data is changed to module view (some of the data in this view is though from headbox).

**Measurement** shows whether the EEG measurement is ON or OFF. Measurement should start by itself when the leads have been on about 15 seconds.
**Montage** shows the active montage in monitor.
**HB Montage** shows the montage attached to headbox. 0 means no montage, 1 basic, 2 general, 3 AEP, 4 Mont4 etc. up to 8, which means Mont8.
**Montage type** shows whether the montage is bipolar or referenced.

**EP Start/Stop** is highlighted when the EP Start/Stop button is pressed in headbox or module.
**Imp. Check** is highlighted when the Imp. Check button is pressed in headbox or module.

**Imp. Meas.** shows 1 if the impedance measurement is on in the module.
**Headbox Off** shows 1 if the headbox cable is not connected to module.

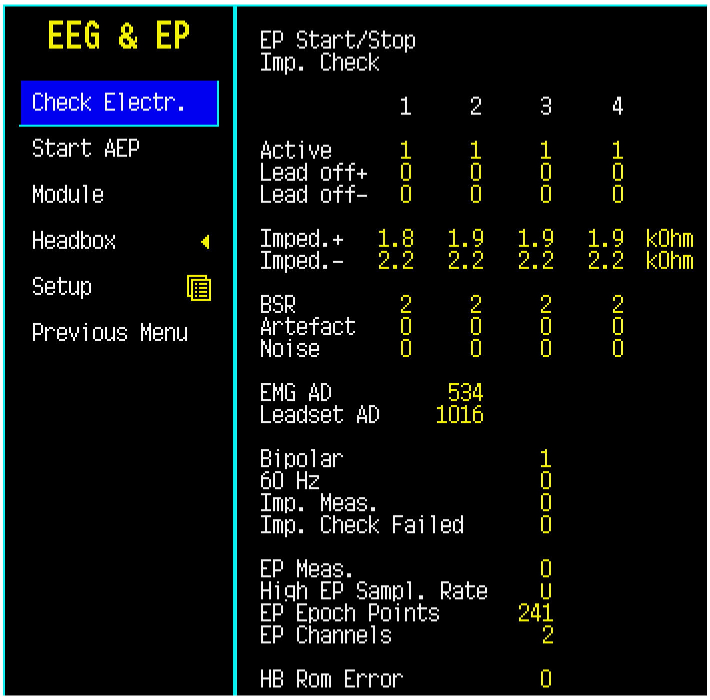
**EP Meas.** shows 1 if the evoked potential measurement is active in module.
**Sending EP** shows 1 if the module has acquired 100/200 new epochs and is sending them to monitor.
**Par. Error** shows 1 if the evoked potential parameters active in module are conflicting with each other.
**Reserved 1** is reserved for future use.
**Reserved 2** is reserved for future use.

**HB Mod Timeouts** is a cumulative number that indicates how many times the headbox has not responded to module's inquiry.
**HB Mod Bad Checksum** is a cumulative number that indicates how many times there has been an error in the message from headbox to module.
**Mod HB Bad Checksum** is 1 if there has been errors in the messages from module to headbox.

**Mod Mon Timeouts** is a cumulative number that indicates how many times the module has not responded to monitor's inquiry.
**Mod Mon Bad Checksum** is a cumulative number that indicates how many times there has been an error in the message from module to monitor.
**Mon Mod Bad Checksum** is a cumulative number that indicates how many times there has been an error in the message from monitor to module.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum at the EPROM is accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in permanent memory are valid.
The states in memory checks are **OK, Fail** or **?** (module not in place or a communication error).

**Headbox** Service data is changed to headbox view.




**EP Start/Stop** is highlighted when the EP Start/Stop button is pressed in headbox or module.
**Imp. Check** is highlighted when the Imp. Check button is pressed in headbox or module.

**Active** shows 1 if the channel is active.
**Lead off+** shows the lead off status of all plus electrodes. 0 means that the lead is on and 1 that the lead is off.
**Lead off-** shows the lead off status of all minus electrodes. 0 means that the lead is on and 1 that the lead is off.

**Imped+** shows the impedance of plus electrodes of last impedance check in all channels.
**Imped-** shows the impedance of minus electrodes of last impedance check in all channels.

**BSR** shows the burst-suppression classification of EEG waveforms. 0 means artifact, 1 suppression, 2 burst and 3 invalid (the EEG is not classified).
**Artefact** shows the artefact status of all channels. 0 means that there are no artefacts on the signal and 1 means that there are artefatcs.
**Noise** shows 1 if the activity of FEMG is too high for clean EEG signal and that EEG is not probably reliable.

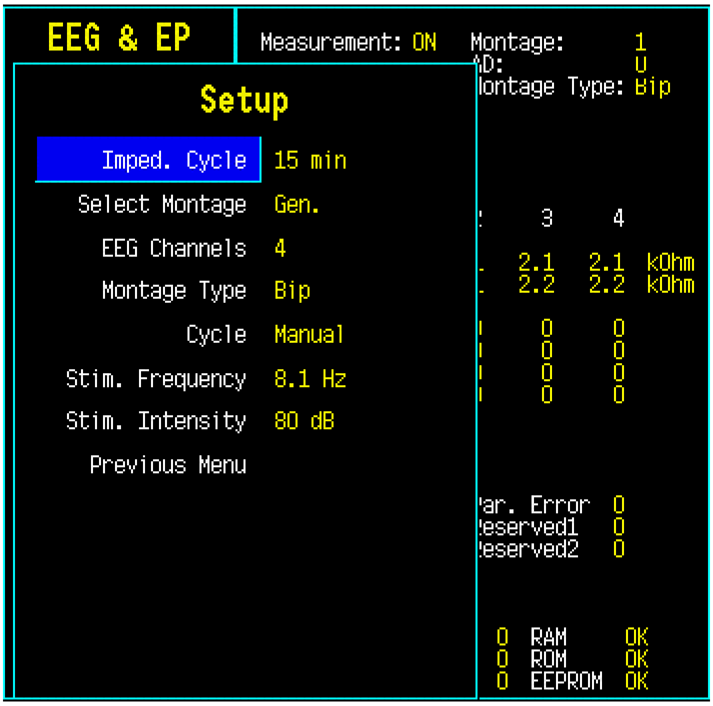
**EMG AD** shows the latest AD conversion result of FEMG signal without any filtering or scaling.
**Leadset AD** shows the latest AD conversion result of lead set signal without any scaling.

**Bipolar** shows the montage type that is active in module and headbox. 1 means bipolar and 0 referenced.
**60 Hz** is 1 if the power frequency filter is set for 60 Hz power frequency.
**Imp. Meas.** shows 1 if the impedance measurement is on in the headbox.
**Imp. Check Failed** shows 1 if the impedance check has failed.

**EP Meas.** shows 1 if the evoked potential measurement is active in headbox.
**High EP Sampl. Rate** shows 1 if the headbox uses higher sampling rate for 10 ms EP measurement.
**EP Epoch Points** shows the number of samples collected for each epoch.
**EP Channels** shows the number of channels used in EP measurement.

**Hb ROM Error** is 1 if the checksum at the EPROM is not accordance with the one the software has calculated.

**Setup**




The items in setup menu are collection of items in normal EEG and EP menus. There are no special service settings in this menu.

**Imp. Cycle** Impedance measurement repetition time.

**Select Montage** Selection of headbox's electrode configuration.

**EEG Channels** Number of active channels in EEG measurement.

**Montage Type** Selection of bipolar (Bip)/referenced (Ref) montage.

**Cycle** EP measurement repetition time.

**Stim. Frequency** Ep measurement's stimulation frequency.

**Stim. Intensity** Intensity of EP stimulus.

# 6 SPARE PARTS

## 6.1 Spare part list

NOTE: Accessories are listed in the *Patient monitor and supplies catalogue*.

### 6.1.1 M-EEG rev. 00, 01

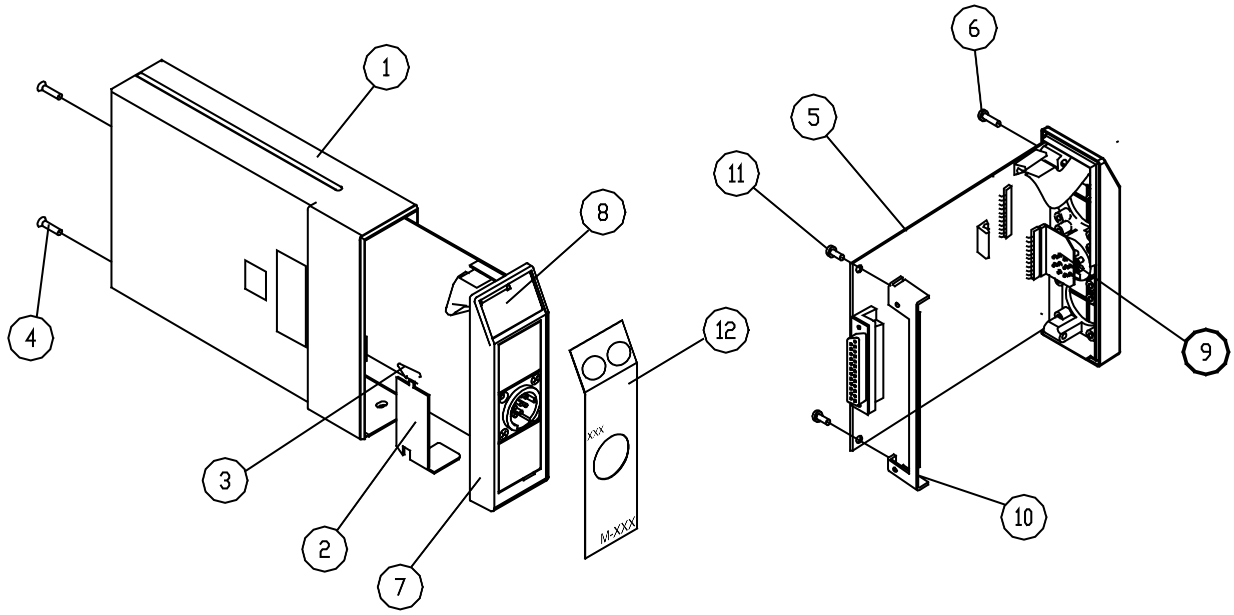



**Figure 7 Exploded view of module box and EEG module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Neuro board, ( M-EEG) | 898806 | |
| 6 | Cross cylinder-head scerw M3x12 | 628700 | |
| 7 | Front mask unit, M-EEG (rev.00-01) | 896484 | |
| 8 | Membrane keypad | 880101 | |
| 9 | EEG input board | 896571 | |
| 10 | Metal frame | 879184 | |
| 11 | Cross cylinder-head screw M3x6 | 61721 | |
| 12 | Front Panel sticker, DA ; M-EEG (rev.00) | 897344 | |
| 12 | Front Panel sticker, DA ; M-EEG (rev.01) ; S/5 | 898693 | |
| 12 | Front Panel sticker, DE ; M-EEG (rev.00) | 897345 | 898684 |
| 12 | Front Panel sticker, DE ; M-EEG (rev.01) ; S/5 | 898684 | |
| 12 | Front Panel sticker, EN ; M-EEG (rev.00) | 897343 | 898683 |
| 12 | Front Panel sticker, EN ; M-EEG (rev.01) ; S/5 | 898683 | |
| 12 | Front Panel sticker, ES ; M-EEG (rev.00) | 897346 | 898687 |
| 12 | Front Panel sticker, ES ; M-EEG (rev.01) ; S/5 | 898687 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 12 | Front Panel sticker, FI ; M-EEG (rev.00) | 897347 | 898690 |
| 12 | Front Panel sticker, FI ; M-EEG (rev.01) ; S/5 | 898690 | |
| 12 | Front Panel sticker, FR ; M-EEG (rev.00) | 897348 | 898685 |
| 12 | Front Panel sticker, FR ; M-EEG (rev.01) ; S/5 | 898685 | |
| 12 | Front Panel sticker, IT ; M-EEG (rev.00) | 897349 | 898688 |
| 12 | Front Panel sticker, IT ; M-EEG (rev.01) ; S/5 | 898688 | |
| 12 | Front Panel sticker, JA ; M-EEG (rev.01) ; S/5 | 8000381 | |
| 12 | Front Panel sticker, NL ; M-EEG (rev.00) | 897350 | 898686 |
| 12 | Front Panel sticker, NL ; M-EEG (rev.01) ; S/5 | 898686 | |
| 12 | Front Panel sticker, NO ; M-EEG (rev.00) | 897351 | |
| 12 | Front Panel sticker, NO ; M-EEG (rev.01) ; S/5 | 898692 | |
| 12 | Front Panel sticker, PT ; M-EEG (rev.00) | 897352 | 898689 |
| 12 | Front Panel sticker, PT ; M-EEG (rev.01) ; S/5 | 898689 | |
| 12 | Front Panel sticker, SV ; M-EEG (rev.00) | 897353 | |
| 12 | Front Panel sticker, SV ; M-EEG (rev.01) ; S/5 | 898691 | |

## 6.1.2 N-EEG rev. 00, 01

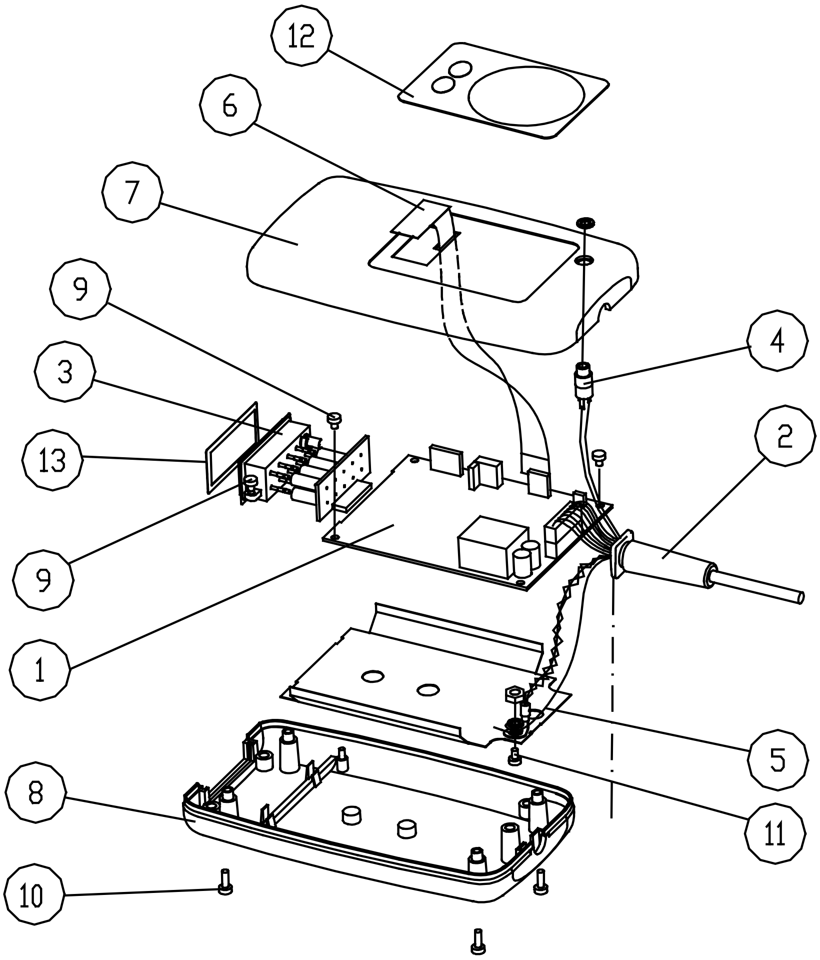



**Figure 8 Exploded view of headbox**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | EEG headbox board, N-EEG | 898805 | |
| 2 | Module-headbox cable, N-EEG | 895610 | |
| 3 | Headbox input unit | 896558 | |
| 4 | AEP-connector, N-EEG | 896461 | 895610 |
| 5 | EMC cover | 898276 | |
| 6 | Membrane keypad | 880101 | |
| 7 | Cover | 896457 | |
| 8 | Bottom side of N-EEG | 896557 | |
| 9 | Cross cyl. head screw M3x6 | 61515 | 617210 |
| 10 | Cross cylinder head screw M3x12 | 61736 | |
| 11 | Cross cylinder head screw M3x12 zinc-coated | 61721 | |
| 12 | Front Panel sticker, DA ; N-EEG (rev.01) ; S/5 | 898708 | |
| 12 | Front Panel sticker, DE ; N-EEG (rev.01) ; S/5 | 898699 | |
| 12 | Front Panel sticker, EN ; N-EEG (rev.01) ; S/5 | 898698 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 12 | Front Panel sticker, ES ; N-EEG (rev.01) ; S/5 | 898702 | |
| 12 | Front Panel sticker, FI ; N-EEG (rev.01) ; S/5 | 898705 | |
| 12 | Front Panel sticker, FR ; N-EEG (rev.01) ; S/5 | 898700 | |
| 12 | Front Panel sticker, IT ; N-EEG (rev.01) ; S/5 | 898703 | |
| 12 | Front Panel sticker, JA ; N-EEG (rev.01) ; S/5 | 8000382 | |
| 12 | Front Panel sticker, NL ; N-EEG (rev.01) ; S/5 | 898701 | |
| 12 | Front Panel sticker, NO ; N-EEG (rev.01) ; S/5 | 898707 | |
| 12 | Front Panel sticker, PT ; N-EEG (rev.01) ; S/5 | 898704 | |
| 12 | Front Panel sticker, SV ; N-EEG (rev.01) ; S/5 | 898706 | |
| 12 | Headbox sticker, DA ; N-EEG (rev.00) | 897266 | |
| 12 | Headbox sticker, DE ; N-EEG (rev.00) | 897267 | |
| 12 | Headbox sticker, EN ; N-EEG (rev.00) | 896512 | |
| 12 | Headbox sticker, ES ; N-EEG (rev.00) | 897268 | |
| 12 | Headbox sticker, FI ; N-EEG (rev.00) | 897269 | |
| 12 | Headbox sticker, FR ; N-EEG (rev.00) | 897270 | |
| 12 | Headbox sticker, IT ; N-EEG (rev.00) | 897271 | |
| 12 | Headbox sticker, NL ; N-EEG (rev.00) | 897272 | |
| 12 | Headbox sticker, NO ; N-EEG (rev.00) | 897273 | |
| 12 | Headbox sticker, PT ; N-EEG (rev.00) | 897274 | |
| 12 | Headbox sticker, SV N-EEG (rev.00) | 897275 | |
| 13 | Electrode sticker, DA ; N-EEG (rev.01) ; S/5 | 898207 | |
| 13 | Electrode sticker, DE, EN, FI, ; N-EEG (rev.01) ; S/5 | 897858 | |
| 13 | Electrode sticker, ES ; N-EEG (rev.01) ; S/5 | 898203 | |
| 13 | Electrode sticker, FR ; N-EEG (rev.01) ; S/5 | 898201 | |
| 13 | Electrode sticker, IT ; N-EEG (rev.01) ; S/5 | 898204 | |
| 13 | Electrode sticker, JA ; N-EEG (rev.01) ; S/5 | 8000393 | |
| 13 | Electrode sticker, NL ; N-EEG (rev.01) ; S/5 | 898202 | |
| 13 | Electrode sticker, NO ; N-EEG (rev.01) ; S/5 | 898208 | |
| 13 | Electrode sticker, PT ; N-EEG (rev.01) ; S/5 | 898205 | |
| 13 | Electrode sticker, SV ; N-EEG (rev.01) ; S/5 | 898206 | |

# 7 EARLIER REVISIONS

| Revision | Manual slot/main manual | Note |
|---|---|---|
| M-EEG rev. 00 and N-EEG rev. 00 | 896622-1/896624 | |

# APPENDIX A

This page intentionally left blank.

# SERVICE CHECK FORM

## EEG Module, M-EEG and EEG Headbox, N-EEG

Customer ______________________________

Service ____________ Module type ____________ S/N ____________

Service engineer ______________________ Date ____________

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts of module | ☐ | ☐ | ☐ |
| 3. External parts of headbox | ☐ | ☐ | ☐ | 4. Installation | ☐ | ☐ | ☐ |
| 5. Recognition of module | ☐ | ☐ | ☐ | 6. Recognition of headbox | ☐ | ☐ | ☐ |
| 8. Communication and memories of module | ☐ | ☐ | ☐ | 9. Communication and memories of headbox | ☐ | ☐ | ☐ |
| 10. Membrane keys | ☐ | ☐ | ☐ | | | | |

7. Module software

| | |
|---|---|
| M-EEG | |
| N-EEG | |

11. Impedances

| | + | - | |
|---|---|---|---|
| Channel 1 | | | 9...11 kΩ |
| Channel 2 | | | 9...11 kΩ |
| Channel 3 | | | 9...11 kΩ |
| Channel 4 | | | 9...11 kΩ |

12. Checks with simulator

| | | Allowed range |
|---|---|---|
| Waveforms | | 195...205 $\mu V_{pp}$ |
| MF | | 9.5...10.5 Hz |
| Amp value | | 68...74 $\mu V$ |

13. FEMG value

| | | |
|---|---|---|
| FEMG | | 13...19 $\mu V$ |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 14. AEP stimulation | ☐ | ☐ | ☐ | | | | |
| 15. AEP response | | | | | | | |
| Channel 1 | | | | | 35...45 μV | | |
| Channel 2 | | | | | 35...45 μV | | |
| 16. Electrical safety check | ☐ | ☐ | ☐ | 17. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 18. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes** ____________________

**Used Spare Parts** ____________ ____________ ____________

**Signature** ____________________

# Datex-Ohmeda Cardiac Output Modules

# S/5™ Cardiac Output and $SvO_2$ Module, M-COPSv (Rev. 01)
# S/5™ Cardiac Output Module, M-COP (Rev. 03)

# Technical Reference Manual Slot


All specifications are subject to change without notice.


Document No. 8001012-4

October 2003



Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147

www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Cardiac Output Modules, M-COP and M-COPSv

# TABLE OF FIGURES

# INTRODUCTION

This section provides information for the maintenance and service of Cardiac Output Modules, M-COP and M-COPSv. Cardiac Output Modules, M-COP and M-COPSv are single width plug-in modules designed for use with the S/5 monitors. Later in this manual modules may be refered to without the S/5 system nomenclature for simplicity.

Please also refer to the *Technical Reference Manual* of the S/5 monitor for information related to the system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

Both modules M-COP and M-COPSv provide

- Cardiac output (C.O.)
- Right ventricular ejection fraction (REF)
- Invasive blood pressure (InvBP) measurement

Additionally, the COPSv module provides venous oxygen saturation ($SvO_2$) measurement.

NOTE: Do not use identical modules in the same monitor simultaneously. These modules are considered as identical and would cause communication errors if used in the same system.


**Figure 1 Cardiac Output Module, M-COP, and Cardiac Output and $SvO_2$ Module, M-COPSv**

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size (W × D × H) | 37 × 180 × 112 mm / 1.5 × 7.1 × 4.4 in |
| Module weight | 0.35 kg / 0.8 lbs |
| Power consumption, M-COP | Approximately 3.5 W |
| Power consumption, M-COPSv | Approximately 5 W |

## 1.2 Typical performance

### 1.2.1 C.O.

| | |
|---|---|
| Measurement range | 0.1...20 l/min |
| Display resolution | 0.01 l/min |
| Repeatability | ±2 % or ±0.02 l/min whichever is greater (measured from electrically generated flow curves) |
| Max. change in blood temp | 2.99 °C |

Injectate temp range (with Edward Lifesciences Corp. compatible probes)
0...25.5 °C ±0.3 °C
25.5...27.0 °C ±0.5 °C

Blood temp range (with Edward Lifesciences Corp. compatible catheters)
17.5...30.9 °C ±0.5°C
31.0...43.0 °C ±0.3°C

| | |
|---|---|
| Protection against electric shock | type CF defibrillation proof |

**REF**

| | |
|---|---|
| Repeatability (Measuring range 10-60 %) | ±2 % |

### 1.2.2 $SvO_2$

| | |
|---|---|
| Accuracy (Measuring range 30-95 %) | ±2 % |

Equal to standard deviation when using in-vivo calibration.

### 1.2.3 InvBP

| | |
|---|---|
| Measurement range | -40...+320 mmHg |
| Zero adjustment range | ±150 mmHg |
| Calibration range | ±20 % |

| | |
|---|---|
| Scales | Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10 % of selected upper limit below zero. |
| Sweep speed | 12.5, 25, 50 mm/s |
| **DIGITAL DISPLAY** | |
| Range | -40...+320 mmHg |
| Resolution | ±1 mmHg |
| **WAVEFORM DISPLAY** | |
| Range | -30...+300 mmHg |
| **PULSE RATE** | |
| Measurement range | 30...250 bpm |
| Resolution | 1 bpm |
| Accuracy | ±5 % or ±5 bpm whichever is greater |
| Respiration artifact rejection | |

## 1.3 Technical specifications

The digital display is averaged over 5 seconds and updated at 5 second intervals.

| | |
|---|---|
| Accuracy | ±5 % or ±2 mmHg, whichever is greater |
| Transducer and input sensitivity | 5 µV/V/mmHg |
| Input voltage | 5VDC<br>max current 20 mA |
| Nonlinearity | <1 %, 0 to 200 mmHg<br><2 %, -40 to 0 and 200 to 320 mmHg |
| Filter<br>adjustable upper limit | 0...22 Hz (-3 dB),<br>4...22 Hz |
| Zero set accuracy | ±1 mmHg |
| Calibration resolution | ±1 mmHg |
| Zero time | < 15 sec |
| Protection against electric shock | type CF defibrillation proof |

NOTE: The accuracy of the measurement may be different from the specified accuracy, depending on the transducer/probe used. Please check the transducer/probe specification.

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 Cardiac output and REF

Cardiac output measurement is done using the principle of thermodilution. During measurement the catheter lies in the heart, with an injection port in the right atrium (RA) and a thermistor, which is to monitor blood temperature, in the pulmonary artery (PA). A small, known amount of thermal indicator is injected into the RA and is mixed with the blood on its way to the PA. The catheter thermistor measures the decrease in blood temperature as the blood flows past the thermistor in the PA.

The information is stored in the module and the cardiac output is calculated from the area beneath the time-temperature Cardiac Output Measurement Curve, as shown in figure 2.

The area under the time-temperature curve is inversely proportional to the flow rate which corresponds to cardiac output.

The cardiac output is calculated from the equation:

$C.O.= (1.08\ C_T\ 60\ V_i(T_B\text{-}T_i))/(T_Bdt + C)$

where:

| | |
|---|---|
| C.O. = | cardiac output in liters/minute |
| 1.08 = | factor comparing the density and specific heat of 5% dextrose solution in water to those of blood. |
| $C_T$ = | correction factor for the injectate temperature rise as it passes through the catheter and its dead space |
| 60 = | seconds/minute |
| $V_i$ = | injectate volume in liters |
| $T_B$ = | baseline blood temperature (°C) |
| Ti = | injectate temperature |
| $T_Bdt$ = | area under time-temperature curve between time o and x, where x is the time when the curve has dropped to 30% of its peak value. |
| C = | area beneath time-temperature curve between x and the end of the curve. |

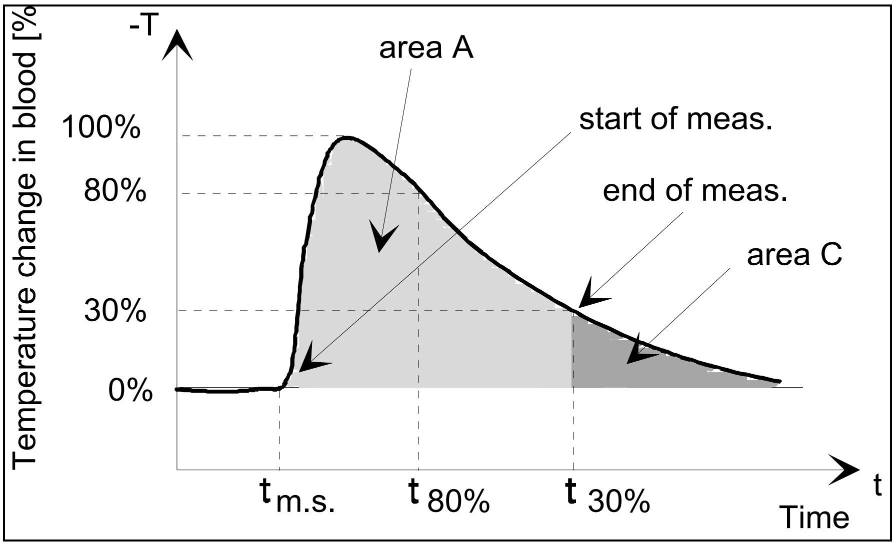



**Figure 2 Cardiac output measurement curve**

A = area derived by integration of the time-temperature curve

C = area beneath the time-temperature curve between $t_{30}$% and end of the curve. Computation based on an exponential fit to the curve between $t_{80}$% of the peak and $t_{30}$%.

REF (right ventricular ejection fraction) measurement is a part of the time-temperature (thermodilution) cardiac output measurement. Ejection fraction is determined using an exponential technique by synchronizing sensed R-waves with points of temperature changes on the time-temperature curve. Once ejection fraction, cardiac output, and heart rate are known, right ventricular volumes may be calculated. The measurement requires a Baxter-Edwards fast response thermistor catheter and an ECG module to synchronize R-wave detection to the time-temperature curves.

### 2.1.2 $SvO_2$ measurement

The COPSv module measures $SvO_2$ when coupled with a Baxter-Edwards OM-2E optical module and a Swan-Ganz oximetry catheter. To measure $SvO_2$, the system utilizes a spectrophotometric technique involving the use of light emitting diodes (LEDs) that produce red (660 nm) and infrared (810 nm) light. The light is transmitted to the blood through a single plastic optical fiber in the oximetry catheter and reflected back through a separate optical fiber to a photodetector in the optical module. The light is electrically transmitted to the COPSv module and analyzed to determine $SvO_2$.

The oximetry portion of the system measures $SvO_2$ in the pulmonary artery by detecting color changes in the red blood cells. When pulses of red and infrared light are transmitted through the oximetry catheter, the light is reflected from the red blood cells and transmitted back through the catheter to the optical module. The amount of light reflected at each wavelength depends primarily on the color of the blood and the number of red blood cells. Since the number of red blood cells in the blood affects the amount of reflected light, the differences are compensated for when the patient's total hemoglobin value is entered. The optical module stores and transfers $SvO_2$ calibration data. $SvO_2$ values can be affected by the presence of methemeglobin or carboxyhemoglobin which imitate the absorption characteristics of $HbO_2$. Large concentrations of methemoglobin or carboxyhemoglobin could then cause a falsely elevated $SvO_2$. In cases where dysfunctional hemoglobins are suspected, $SvO_2$ should be interpreted with caution.

### 2.1.3 Invasive blood pressure measurement

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The pressure transducer is placed at the same level with the heart, and electrically zeroed.

The pressure transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that blood pressure data and blood pressure waveforms can be displayed.

## 2.2 Main components

The Cardiac Output Module, M-COP consist of a COP circuit board and two input boards - a CO input board and a P input board, attached to the front panel.

The Cardiac Output and $SvO_2$ Module, M-COPSv, consist of a COPSv circuit board and three input boards - a CO input board, a $SvO_2$ input board and a P input board, attached to the front panel.

The front panels are shown in figure 3.

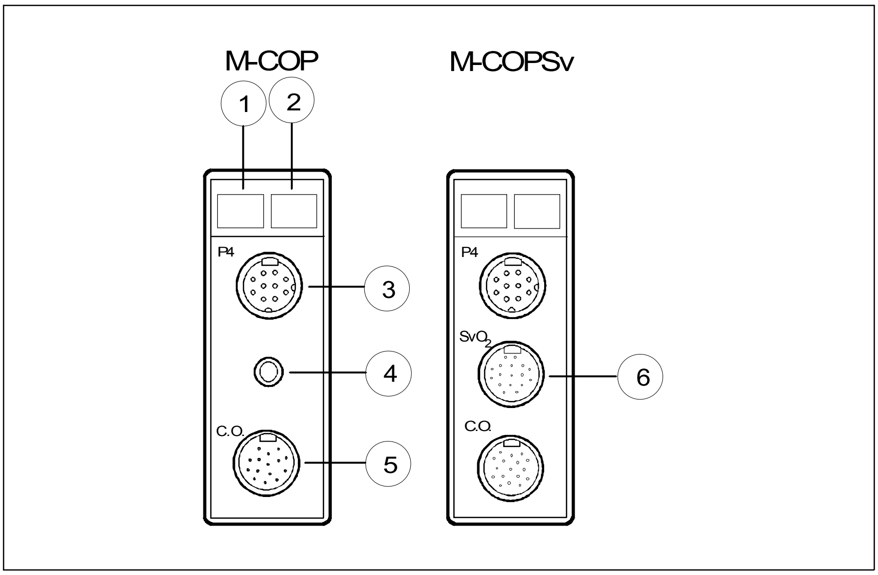



**Figure 3 Front panels of Cardiac Output Modules, M-COP and M-COPSv**

(1) Key for pressure zeroing (Zero P4)

(2) Key for cardiac output measurement (Start C.O.)

(3) Connector for invasive blood pressure measurement

(4) Connector for C.O. self test

(5) Connector for C.O. measurement

(6) Connector for $SvO_2$ measurement

### 2.2.1 COP board

The COP board consists of the following functional sections.

- Processor
- Cardiac output measurement
- Cardiac output self test
- Invasive blood pressure measurement
- Serial communication
- Isolation
- Power supply

#### Processor section

The microprocessor uses the Intel 80C196KC-16 CPU which includes three A/D converters and a UART. The microprocessor uses external memories, an 8-bit data bus, a 16 MHz oscillator, and a watchdog timer. The three A/D-converters within the CPU convert the analog input signals to digital. The internal UART communicates and transfers data between the module and the CPU board in the monitor.

#### Cardiac output measurement section

The catheter and the probe contain an NTC resistor that reacts to temperature change.

The temperature dependent voltage across the NTC resistor is amplified and an offset value is added to it. The resultant signal is then regulated into a ±5 V range by voltage slicing and sent to an A/D converter.

Because the temperature measurements are calibrated digitally and non-linearity of catheter/probe is compensated for by software, ambient temperature change after calibration is the only factor that may influence the measurement.

#### Cardiac output self test

The Cardiac Output Module, M-COP contains a C.O. Self Test connector.

When the cable is connected to the C.O. Self Test connector, the microprocessor starts the test program automatically. First, the microprocessor measures 30 °C, then it activates test circuits and measures 37 °C and 41 °C.

If the values are not correct 'Cable fault' is displayed and there is a fault is either in the module or in the catheter connecting cable.

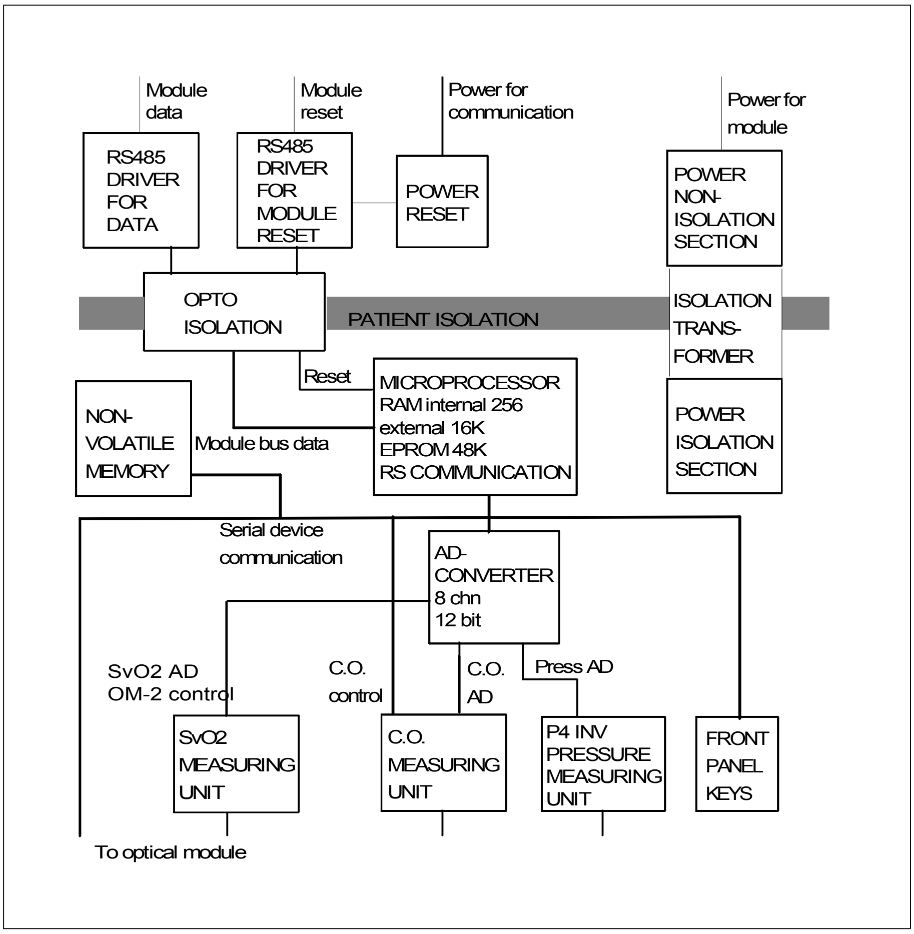



**Figure 4** **COPSv board block diagram, on COP board the $SvO_2$ section is excluded**

## Invasive blood pressure measurement section

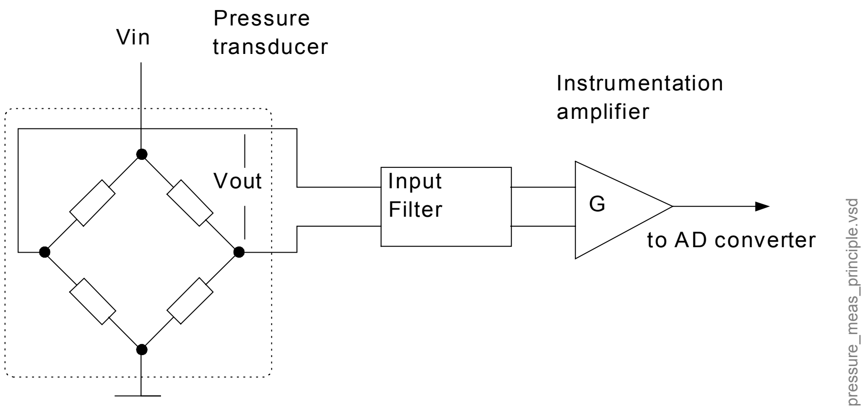



**Figure 5** **Pressure transducer principle of operation**

An isolated +5 V supply is connected to the input of the pressure transducer bridge circuit. From the bridge circuit output a differential voltage, which depends on blood pressure and input supply voltage, is calculated using the following formula:

Uout = Uin x Pressure x 5 V, where Uin = 5 V $\Rightarrow$ Uout = 25 V x Pressure [mmHg]

Pressure amplification is performed by the instrumentation amplifier. The gain of the amplifier is set so that the level of the signal transferred to the A/D converter stays within the measurement range even when there are circumstantial offsets or offsets caused by the pressure transducer. The input filter before the amplifier attenuates high frequency disturbances.

A FET switch cuts the measurement current and detects the existence of the pressure transducer. The existence of the pressure transducer is also checked digitally by a jumper next to the connector.

## Serial communication

Serial communication between the Cardiac Output Module and the Central Unit Frame is via an RS485 type bus. The communication bus drivers are powered from the Module Bus. The module isolation section is powered (+5 V) from the isolated power supply.

The communication drivers are controlled by a Reset signal such that when the Reset is active the drivers do not transfer data.

In addition to the RS485 reset there is a logic power-up reset, which holds for approximately 500 ms regardless of the state of the RS485 reset. A time constant determines the power-up reset time. The power-up reset also prevents the module from sending data to the Module Bus. The data transmission rate is 500 kbps.

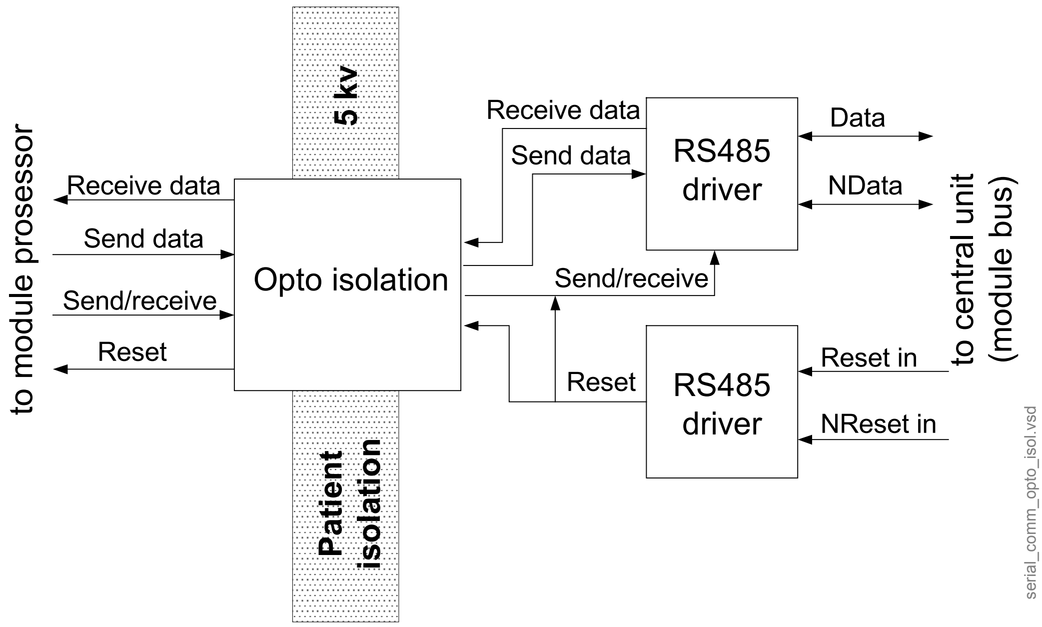



**Figure 6 Serial communication and opto isolation**

## Isolation section

There are two opto isolators, one for data and one for the reset signal. Signals are processed on logical high-low levels even though the output of the opto isolators in the isolation section are analog signals.

The reset line is an open collector type, with a pull-up resistor so that the microprocessor is able to use its internal watchdog function.

### Power supply section

The module isolated power supply is developed from the +15 Vdirty (non isolated) supply from the Central Unit power supply.

The isolated power supply is a switched-mode circuit, where an FET switch is controlled by an oscillator using a bipolar timer. The frequency of the oscillator is approximately 30 kHz, with a pulse ratio of 50%; switching of the FET is slow to suppress spurious interference. A special isolation pulse transformer is used in the circuit. The transformer secondary circuit uses normal linear regulators except for +5 V which uses a low drop type linear regulator.

## 2.2.2 COPSv board

The COPSv board consists of the same functional sections as the COP board, except for the cardiac output self test section. Additionally, the COPSv board consists of the $SvO_2$ measurement section.

### $SvO_2$ measurement section

The $SvO_2$ algorithm is a part of the COPSv module software. The algorithm consists of five different parts; initialization, calibrations, signal processing and $SvO_2$ calculation, automatic gain control, and signal quality analysis.

**Initialization**
When the optical module is connected to the COPSv module, a number of start-up procedures are performed prior to normal operation. These procedures include transfer of calibration factors from the optical module to the COPSv module and initialization of LED currents.

**Calibration**
The system is calibrated according to either in-vitro or in-vivo calibration. In-vitro calibration is performed before the oximetry catheter is removed from the package with the catheter tip still inside the calibration cup. The resulting calibration factor is calculated on the basis of the measured ratio of red and infrared signals and the ideal ratio for the calibration cup. In-vivo calibration is performed when the catheter is inserted into the patient’s pulmonary artery. The resulting calibration factor is based on the measured ratio of red and infrared signal and the Hgb and $SvO_2$ values measured in a laboratory. If the calibration is skipped, the result of an old calibration is used instead and the “Not calibrated” message is displayed in the $SvO_2$ number field.

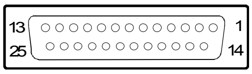
**Signal processing and $SvO_2$ calculation**
The reflected red and infrared signals transferred from the optical module to the COPSv module are filtered, and $SvO_2$ is calculated on the basis of the ratio of the two signals.

**Automatic gain control**
The intensity of the red and infrared signals can be amplified by four different gains. The gain is selected automatically to achieve optimal signal levels.

**Signal quality**
The reflected red and infrared signals are checked for wall contact artifacts, pulsatility and intensity shifts. An index is calculated to indicate the signal quality. 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal. Please refer to the service menu section for more information.

# 2.3 Connectors and signals

## 2.3.1 Module bus connector

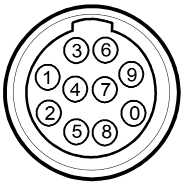



| Pin | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485* |
| 2 | I | -15 VDC* |
| 3 | I | +15 VDIRTY* |
| 4 | I | +15 VDC* |
| 5 | I/O | -DATA_RS485* |
| 6 | I/O | DATA_RS485* |
| 7 | - | Ground & Shield* |
| 8 | I | -RESET_RS485* |
| 9 | I | CTSB |
| 10 | O | RTSB |
| 11 | I | RXDB |
| 12 | O | TXDB |
| 13 | - | Ground & Shield* |
| 14 | I | +32 VDIRTY |
| 15 | I | GroundDIRTY* |
| 16 | I | CTSC |
| 17 | O | RTSC |
| 18 | I | RXDC |
| 19 | O | TXDC |
| 20 | - | ON/STANDBY |
| 21 | - | BITOIN |
| 22 | - | RXDD_RS232 |
| 23 | - | TXDD_RS232 |
| 24 | I | +5 VDC* |
| 25 | I | +5 VDC* |

*Used in the M-COP module

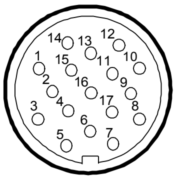
## 2.3.2 Front panel connectors

### Invasive blood pressure connector (P4)



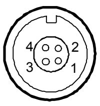

| Pin | Signal |
|---|---|
| 1 | Pressure 4 + |
| 2 | Pressure 4 - |
| 3 | Polarization - (ground) |
| 4 | Polarization + |
| 5 | Not connected |
| 6 | Not connected |
| 7 | Not connected |
| 8 | Not connected |
| 9 | Ground |
| 0 | Cable detection |

### Cardiac output connector (C.O.)



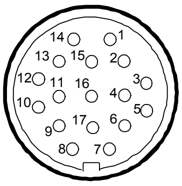

| Pin | Signal |
|---|---|
| 1 | BAB |
| 2 | THB |
| 3 | BAC |
| 4 | Not connected |
| 5 | Shield |
| 6 | Not connected |
| 7 | THD |
| 8 | THA |
| 9 | THC |
| 10 | BAA |
| 11 | Not connected |
| 12 | Not connected |
| 13 | Not connected |
| 14 | FL |
| 15 | Not connected |
| 16 | Not connected |
| 17 | Not connected |

### C.O. Self Test connector (C.O. Test)




| Pin | Signal |
|---|---|
| 1 | CTC |
| 2 | CTA |
| 3 | CTB |
| 4 | CTD |

## $SvO_2$ connector ($SvO_2$)




| Pin | Signal |
|---|---|
| 1 | IR_CATHODE |
| 2 | CE |
| 3 | SK |
| 4 | DATA_OUT |
| 5 | CHASSIS_GND |
| 6 | SVO2_GND |
| 7 | HEATER_RTN |
| 8 | REMOTE_OUT |
| 9 | +V_OPT |
| 10 | TEMP_SENSOR |
| 11 | HEATER_HI |
| 12 | LOCAL_OUT |
| 13 | REF_RTN |
| 14 | LED_ANODE |
| 15 | RED_CATHODE |
| 16 | DATA_IN |
| 17 | -V_OPT |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the M-COP and M-COPSv modules is limited to replacing faulty mechanical parts. The COP board and the COPSv board cannot be replaced, and all calibrations can only be done at the factory.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with the appropriate tools and equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Patient simulator | | |
| $SvO_2$ simulator | 890121 | |
| Pressure manometer | | |
| InvBP transducer | | |
| Catheter connecting cable | | |
| Screwdriver | | |

### All modules

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring locking pin.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - all socket mounted IC’s are inserted properly
   - EMC covers are attached properly
   - there are no loose objects inside the module

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box, latch and spring locking pin are intact

✍

- Reattach the module box and check that the latch moves properly.
- Turn the monitor on and wait until the monitoring screen appears.
- Configure the monitor screen so that all the required parameters are shown, for example :

  **Monitor Setup** ***- Screen 1 Setup - Waveform Fields - Field 4 - P4***
  ***Digit Fields - Field 4 - SvO$_2$***

- Preset the C.O., SvO$_2$ and InvBP measurement settings:

  **Others** ***- C.O. View - C.O. Setup - Scale - 1.0 °C***
  ***Injectate Volume - 10 ml***
  ***Measurement Mode - SET***
  ***SvO$_2$ - Update Hgb - 115 g/l***

  **Invasive Pressures** ***- P4 Setup - Label - PA***

3. Plug in the module. Check that it goes in smoothly and locks up properly.

   ✍

4. Check that the module is recognized by entering the C.O. View menu:

   **Others** ***- C.O. View***

   Check that the message “No Catheter” is shown in the middle of the menu and the message “No cable” in the digit field for SvO$_2$, if it is an M-COPSv module.

   ✍

5. Enter the service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8)

   Take down the information regarding COP software by selecting SCROLL VERS and turning the ComWheel.

   ✍

6. Enter the COP module service menu:

   ***Parameters - COP***

   Check that the “Timeouts”, “Bad checksums” and “Bad c-s by mod” values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. “RAM”, “ROM” and “EEPROM” all show OK.

   ✍

## Invasive blood pressure measurement

7. Check the front panel membrane key ZERO P4.
   Press the key for at least one second. Check that the key being pressed is identified, i.e. the information on the service menu under “Button” - “P4” changes from OFF to ON.

8. Check that “Cable” and “Probe” for P4 show OFF. Plug a cable with an invasive blood pressure transducer into the front panel connector P4 and check that “Cable” and “Probe” show ON and the corresponding pressure waveform appears on the screen.

9. Calibrate InvBP channel P4 according to the instructions in the Technical Reference Manual.

10. Return to the normal monitoring screen by pressing the “Normal Screen” key on the Command Board. Check the InvBP channel with a patient simulator.
    The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

    SENSITIVITY -switch; 5 µV/V/mmHg

    ECG - BASE - BPM - 60
    BP - 3 - WAVE - ATM

    Connect the cable from channel BP3 to module connector P4. Zero the InvBP channel P4 by pressing the ZERO P4 key on the module front panel.

    BP - 3 - WAVE - PA

    Check that appropriate InvBP waveforms are shown and the InvBP value is approximately 25/10 (±2 mmHg) for channel P4 (PA).

## $SvO_2$ measurement

11. Enter the COP module service menu. Check that the $SvO_2$ values “Meas. state”, “OM fail” and “OM temp.” all show NO OM.

    Turn the $SvO_2$ simulator’s pulsation switch to “Medium” and the range switch to “Normal pulse”. Connect the simulator to the module and check that the messages “Initializing, please wait”, “Warming up” and “Not calibrated” appear in the digit field for $SvO_2$.

    Initializing, please wait --> Warming up --> Not calibrated

    Check that “Meas. state” has changed to NORMAL and “OM fail” and “OM temp.” show OK.

    NOTE: “OM temp.” may show UNSTABLE at first, but the message should change to OK within a half a minute.

    ✍

12. Perform an In-Vitro -calibration. Keep the $SvO_2$ simulator connected to the module and turn the pulsation switch to “No pulse”.

    Enter the $SvO_2$ -menu:

    **Others** - ***$SvO_2$***

    Highlight the CALIBRATE IN VITRO text and press the ComWheel to start the calibration. Wait until the text “Start $SvO_2$” appears in the menu.

    Turn the $SvO_2$ simulator pulsation switch to “Normal Pulse” and complete the calibration by pressing the ComWheel again. Wait until the text “Calibrating” disappears from the digit field for $SvO_2$.

    Check that the calibration date for In-Vitro calibration was updated correctly and the $SvO_2$ reading on the screen is 81 % (±2).

    ✍

13. Turn the $SvO_2$ simulator pulsation switch to “No pulse” and check that the message “Check cath. position” appears in the digit field for $SvO_2$ and the message “$SvO_2$ poor signal” appears in the message field within one minute.

    Turn the pulsation switch to “High pulse” and check that the two messages remain on the screen.

    Turn the pulsation switch back to “Normal pulse” and check that the messages disappear within one minute.

    ✍

## Cardiac Output measurement

14. Check the front panel START C.O membrane key.
Enter the COP module service menu. Press the key for at least one second and check that it is identified, i.e. the information on the service menu under “Button” - “C.O.” changes from OFF to ON.

- Enter the “C.O. View” menu:

  **Others** ***- C.O. View***

  Connect a catheter connecting cable to module connector C.O.

15. If the module contains the C.O. Test connector (M-COP), attach the catheter connector of the connecting cable to the C.O. Test connector. Check that the message “Cable OK” appears on the menu after the self-test.

    No Catheter --> Self Test in Progress --> Cable OK

    If the message “Cable fault” appears, exchange the cable and perform the same again.

16. Check the C.O. measurement with a patient simulator.

    The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

    C.O. - BASE - 37 °
    WAVE

    Leave the WAVE menu open on the simulator. Connect the catheter connecting cable (both connectors) to the simulator’s C.O. box. Highlight the text START C.O. SET on the C.O. View menu.
    Press the ComWheel to start the measurement. When the text “Inject now!” appears on the menu, select the setting 5 l/min (F3) from the medSim 300 simulator. Check that the thermodilution curve displayed returns to the base level on the screen. Complete all 6 measurements .

    NOTE: The medSim 300 simulator may give an inaccurate C.O. signal immediately after it has been turned on and after each new simulator setting. This property of the simulator must be taken into account when interpreting the C.O. results.

17. When the set is complete, exclude the first measurement from the average using the C.O. View menu functions:
***Edit Average - Exclude Curves - 1***
Press the ComWheel to exclude the first curve. Check that each of the remaining results is within ±2 % of the new average.

### All modules

17. Perform an electrical safety check and a leakage current test.

    ✍

18. Check that the module functions normally after performing the electrical safety check.

    ✍

19. Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the Cardiac Output Modules ,M-COP and M-COPSv, in the following way. (see the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearwards and remove it from main body. Be careful with the loose latch and spring locking pin.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

# 3.4 Adjustments and calibrations

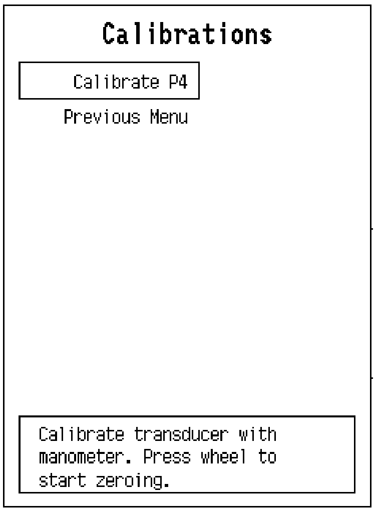
## 3.4.1 Cardiac output calibration

The cardiac output calibration can be performed only at the factory.

## 3.4.2 Invasive pressure calibration

Calibrate invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer.

1. Enter the COP service menu (**Monitor Setup** *- **Install/Service - Service - Parameters***)
2. Enter the ***Calibrations*** menu.




3. Connect a pressure transducer with a pressure manometer to the P4 connector. Select ‘Calibrate P4’ from the menu. Leave the transducer at room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel.
   A tolerance of ±1 mmHg is allowed.
7. The text ‘calibrated’ will appear on the display.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting charts

### 4.1.1 Cardiac Output

| Trouble | Cause | Treatment |
|---|---|---|
| NO CATHETER-message | Catheter or cable not connected. | Connect catheter (cable). |
| | Catheter or cable faulty. | Check by self-test. Change catheter or cable. |
| | Blood temp out of range. | Check blood temp is within range. |
| Tinj OFF-message | No injectate temp probe. | Connect probe. |
| | Probe faulty. | Change probe. |
| | Wrong type of probe. | Use Baxter compatible inj. temp probe. |
| | Temp out of range. | Check blood temp is within range. |

### 4.1.2 $SvO_2$

| Trouble | Cause | Treatment |
|---|---|---|
| Faulty cable | Factory calibration of the optical module corrupted.<br>Red or infrared transmit error, currents cannot be adjusted to factory defaults. | Replace optical module. |
| No cable | No optical module connected. | Connect optical module. |
| Insufficient signal | Loose catheter connection.<br>Optical module failure.<br>Catheter kinked or damaged. | Check connection.<br>Replace optical module.<br>Calibrate In vivo or replace catheter if necessary. |
| Warming up | Temperature of the optical module has not yet reached the optimum value or optical module failure or COPSv module failure. | Please wait. If it takes longer than 20 minutes replace optical module or COPSv module. |
| Poor $SvO_2$ signal | Signal pulsatility, wall contact or intensity shift signal quality level at 3. | Check number field message for problem “Check catheter position” or “Intensity shift”. |

### 4.1.3 InvBP

| Trouble | Cause | Treatment |
|---|---|---|
| Abnormally low pressure | Transducer wrongly positioned. | Check mid-heart level and reposition transducer. |
| No pressure | Defective transducer.<br>No pressure module plugged in.<br>No waveform selected on screen. | Check transducer.<br>Check the module.<br>To select the desired pressure waveforms press Monitor Setup key and select modify waveforms.<br>Check that the pressure transducer is open to the patient. |
| Not zeroed-message | Measurement on, channel not zeroed. | Zero the channel. |
| Zeroing failed-message | Unsuccessful zeroing of P4 (number field). | Possibly due to pulsating pressure waveform. Open the transducer to room air and zero the channel.<br>Offset is > 150 mmHg. Open the transducer to room air and zero the channel.<br>Defective transducer. Replace and zero the channel. |
| Calibration failed-message | Unsuccessful calibrating of P4 (number field). | Pulsating waveform. Turn the transducer to sphygmomanometer and try again (zeroing takes place first).<br>Gain is beyond the limits (±20 % of the default gain) of the module. Replace the transducer. |
| Out of range ≤ 40 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. |
| Out of range > 320 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. The patient may also have high blood pressure. |
| Zero adj. > 100 mmHg | Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain). | Check transducer. The waveform may hit the top and the numeric display not shown. |
| Out of range | Measured pressure is beyond the internal measurement range of the module. | The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel. |

See also the troubleshooting flowchart on the next page.

## 4.2 Troubleshooting flowchart

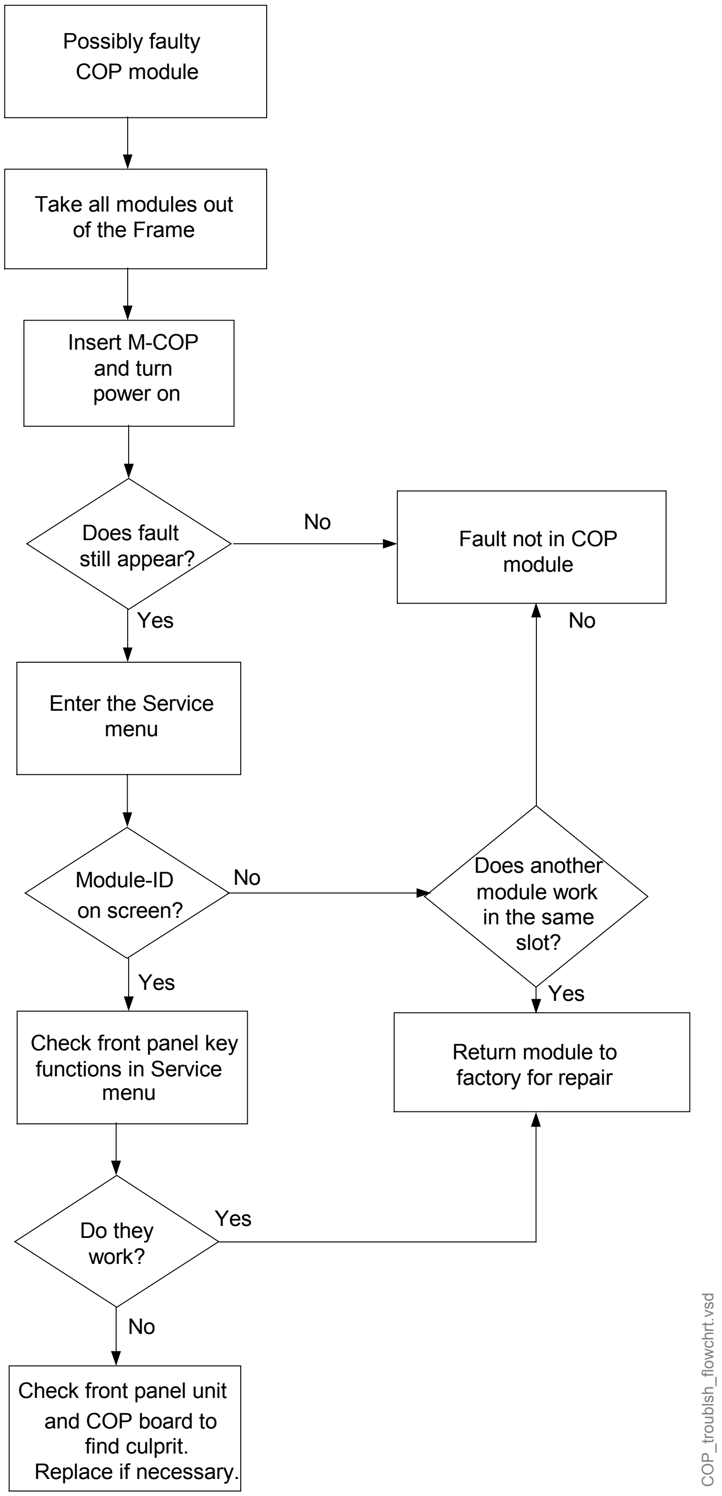
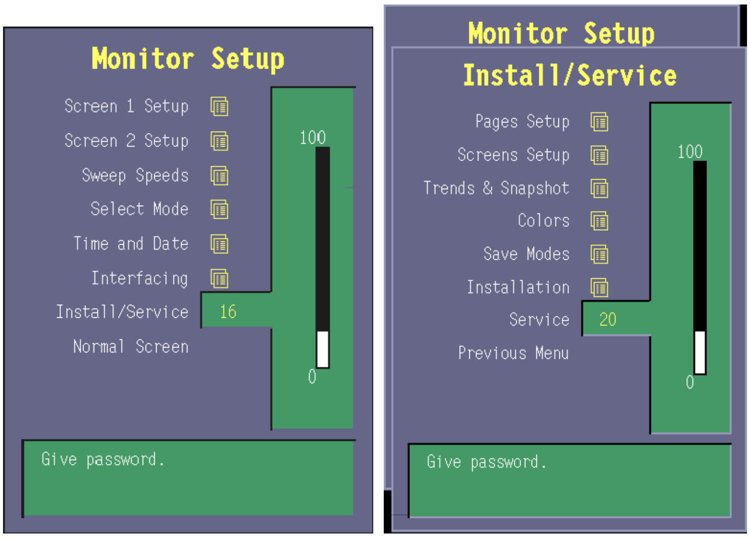
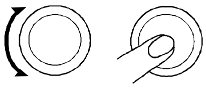



**Figure 7 Cardiac Output Module troubleshooting flowchart**

# 5 SERVICE MENU

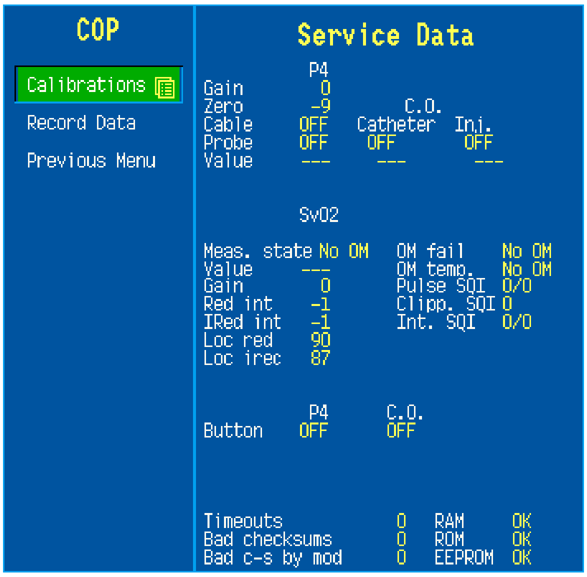
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters***.
5. Select ***COP***.

## 5.1 COP Menu




### COP

**Record Data** **Record Data** prints out the service data and module information (id. serial number and software id.) on the Recorder Module, M-REC.

### Service Data

**P4**

**Gain** is a coefficient to compensate for gain error. Typically the value is between 17000 and 25000. Calibrate if the zero and/or gain value is outside the ranges.

**Zero** indicates the offset compensation value of each parameter in the A/D converter. Usually the value is within ±1000.

**Cable** shows ON when the corresponding cable is connected to the front panel and **Probe** shows ON when the corresponding probe is connected to the cable.

**Value shows** the measured numeric values simultaneously. Pressure value is a real time value and shown in mmHg.

**Probe** items **Catheter** (ON/OFF) and **Inj.** (FT, BATH, or OFF) indicate connections and **Value** indicates the measured temperatures in 0.01 °C increments.

**SvO2**

**Meas. state:** Measurement status shows: No optical module (No OM) connected, initializing the optical module (Init OM), normal measurement state (Normal) and failed module (OM fail).

**Value** is a measured $SvO_2$ value.

**Gain** is the gain of the remote red and infrared signals (0, 1, 2 or 3)

**Red int**: Reflected red intensity

**Ired int**: Reflected infrared intensity

**Loc red**: Local red intensity

**Loc ired**: Local infrared intensity

**OM fail**: Reason why initialization OK (OK), can't read EEPROM of the optical module correctly (EEPROM), can't adjust LED current to get required local signal (Transmit).

**OM temp**: Temperature of the optical module OK (OK), temp under 43 °C (Under), temp over 47 °C (Over).

**Pulse SQI**: Signal quality index for pulsing (low pulse/high pulse). 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal.

**Clipp. SQI**: Signal quality index for wall artifact. 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal.

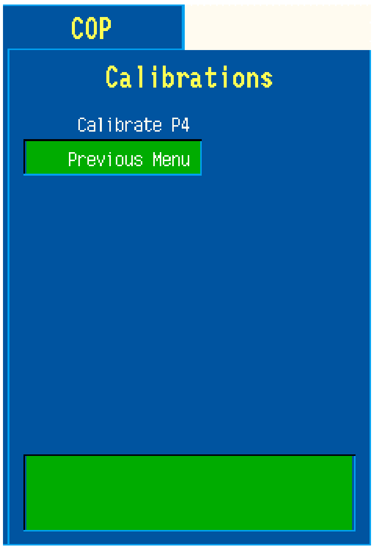
**Int. SQI**: Signal quality index for intensity shift from previous calibration or Hgb update (intensity decreased/increased) 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal.

**Button:** The front panel Zero P4 and Start C.O. key functions can be confirmed by pressing the key and checking that the relevant OFF message turns to ON.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.
**Bad checksums** is a cumulative number that indicates how many times communication from the module to the monitor has failed.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) during normal operation indicates either serial communication failure or the module is not in place.

**RAM** indicates the state of the external RAM memory.
**ROM** indicates whether the checksum at the EPROM is in accordance with the software calculated value.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.1.1 COP calibration menu




#### Calibrate P4

This function is for calibrating the invasive blood pressure channel P4.
The calibration requires a pressure transducer (with an appropriate cable) and a pressure manometer.

Calibration:

1. Connect the pressure transducer with the pressure manometer to the P4 connector. Select Calibrate P4. Leave the transducer at room air pressure.
2. Press the ComWheel to start zeroing.
3. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
4. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel.

# 6 SPARE PARTS

## 6.1 Spare parts list

NOTE: Accessories are listed in the *Patient Monitor Supplies and Accessories*.

### 6.1.1 Cardiac Output Module, M-COP Rev. 00 – 03

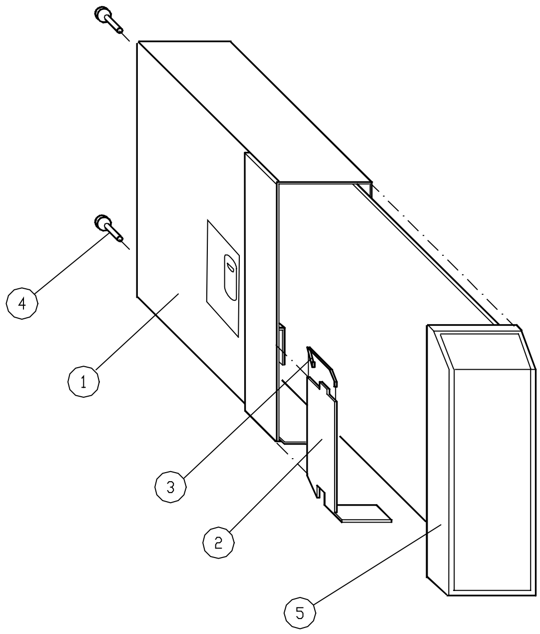



**Figure 8 Single width module box, Cardiac Output Module, M-COP**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 11 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel unit, M-COP | 881191 | |
| | Front panel cover for M-COP (w/o connectors) | 880895 | |

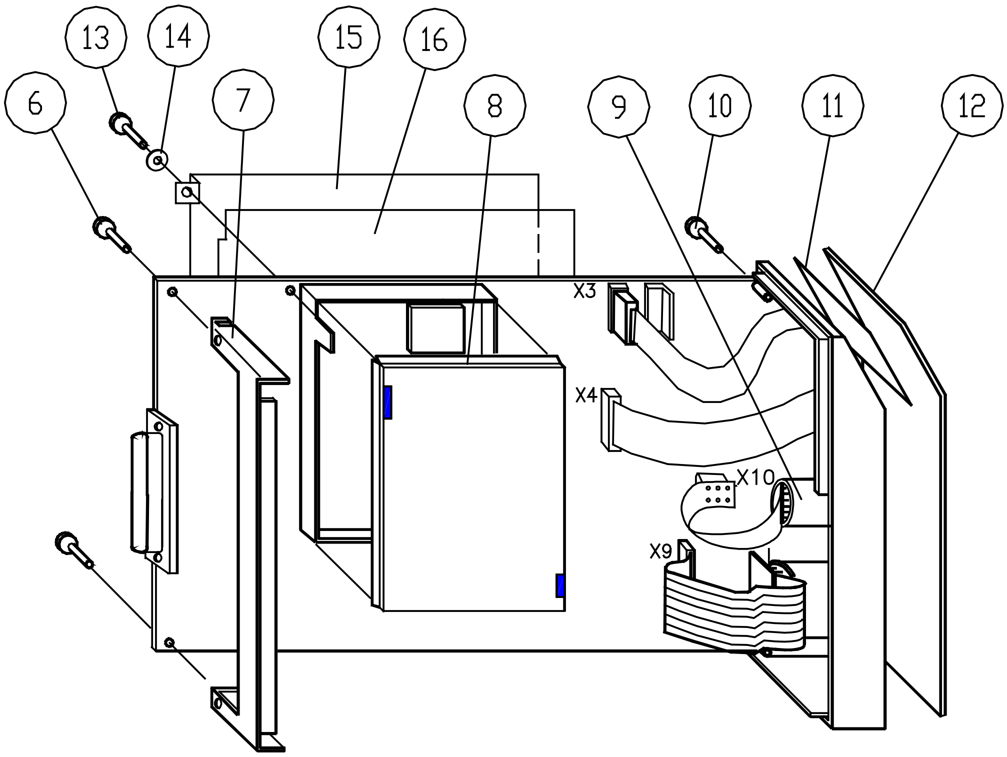



**Figure 9 Cardiac Output Module, M-COP**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 6 | Cross cylinder-head screw M3x6 | 61721 | |
| 7 | Metal frame | 879184 | |
| 8 | EMC cover | 884099 | |
| 9 | C.O. Test connector, M-COP | 546215 | |
| 10 | Cross cylinder-head scerw M3x12 | 628700 | |
| 11 | Membrane keypad | 880101 | |
| 12 | Front Panel sticker, DA ; M-COP (rev.02) | 892213 | 898732 |
| 12 | Front Panel sticker, DA ; M-COP (rev.03); S/5 | 898732 | |
| 12 | Front Panel sticker, DE ; M-COP (rev.02) | 880978 | 898723 |
| 12 | Front Panel sticker, DE ; M-COP (rev.03); S/5 | 898723 | |
| 12 | Front Panel sticker, EN ; M-COP (rev.02) | 880770 | 898722 |
| 12 | Front Panel sticker, EN ; M-COP (rev.03); S/5 | 898722 | |
| 12 | Front Panel sticker, ES ; M-COP (rev.02) | 884387 | 898726 |
| 12 | Front Panel sticker, ES ; M-COP (rev.03); S/5 | 898726 | |
| 12 | Front Panel sticker, FI ; M-COP (rev.02) | 888871 | 898729 |
| 12 | Front Panel sticker, FI ; M-COP (rev.03); S/5 | 898729 | |
| 12 | Front Panel sticker, FR ; M-COP (rev.02) | 881271 | 898724 |
| 12 | Front Panel sticker, FR ; M-COP (rev.03); S/5 | 898724 | |
| 12 | Front Panel sticker, IT ; M-COP (rev.02) | 886757 | 898727 |
| 12 | Front Panel sticker, IT ; M-COP (rev.03); S/5 | 898727 | |
| 12 | Front Panel sticker, JA ; M-COP (rev.02) | 888309 | 898733 |
| 12 | Front Panel sticker, JA ; M-COP (rev.03); S/5 | 898733 | |
| 12 | Front Panel sticker, NL ; M-COP (rev.02) | 886064 | 898725 |
| 12 | Front Panel sticker, NL ; M-COP (rev.03); S/5 | 898725 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 12 | Front Panel sticker, NO ; M-COP (rev.02) | 893557 | 898731 |
| 12 | Front Panel sticker, NO ; M-COP (rev.03); S/5 | 898731 | |
| 12 | Front Panel sticker, PT ; M-COP (rev.02) | 895253 | 898728 |
| 12 | Front Panel sticker, PT ; M-COP (rev.03); S/5 | 898728 | |
| 12 | Front Panel sticker, SV ; M-COP (rev.02) | 885871 | 898730 |
| 12 | Front Panel sticker, SV ; M-COP (rev.03); S/5 | 898730 | |
| 13 | Cross cylinder-head screw M3x16 | 628710 | |
| 14 | Star washer | 63611 | |
| 15 | Protection plate | 883946 | |
| 16 | Insulation plate for 883946 | 884121 | |

### 6.1.2 Cardiac Output and $SvO_2$ Module, M-COPSv Rev. 00 -01

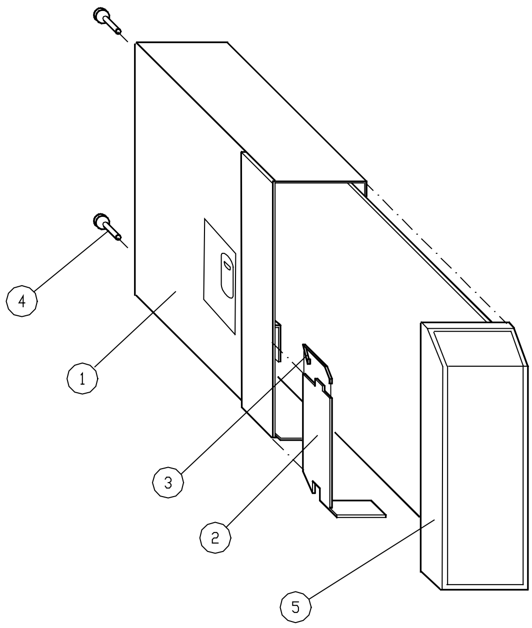



**Figure 10 Single width module box, Cardiac Output and $SvO_2$ Module, M-COPSv**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | | | |

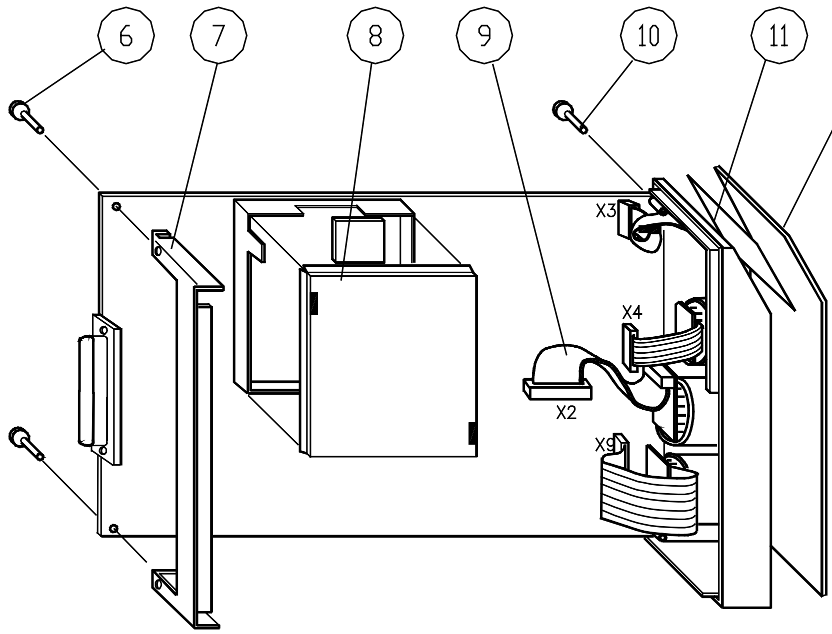



**Figure 11 Cardiac Output and $SvO_2$ Module, M-COPSv**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 6 | Cross cylinder-head screw M3x6 | 61721 | |
| 7 | Metal frame | 879184 | |
| 8 | EMC cover | 884099 | |
| 9 | SVO2 cable | 888546 | |
| 10 | Cross cylinder-head scerw M3x12 | 628700 | |
| 11 | Membrane keypad | 880101 | |
| 12 | Front Panel sticker, DA ; M-COPSv (rev.00) | 892214 | 898787 |
| 12 | Front Panel sticker, DA ; M-COPSv (rev.01) ; S/5 | 898787 | |
| 12 | Front Panel sticker, DE ; M-COPSv (rev.00) | 889550 | 898778 |
| 12 | Front Panel sticker, DE ; M-COPSv (rev.01) ; S/5 | 898778 | |
| 12 | Front Panel sticker, EN ; M-COPSv (rev.00) | 887376 | 898777 |
| 12 | Front Panel sticker, EN ; M-COPSv (rev.01) ; S/5 | 898777 | |
| 12 | Front Panel sticker, ES ; M-COPSv (rev.00) | 889555 | 898781 |
| 12 | Front Panel sticker, ES ; M-COPSv (rev.01) ; S/5 | 898781 | |
| 12 | Front Panel sticker, FI ; M-COPSv (rev.00) | 889554 | 898784 |
| 12 | Front Panel sticker, FI ; M-COPSv (rev.01) ; S/5 | 898784 | |
| 12 | Front Panel sticker, FR ; M-COPSv (rev.00) | 889551 | 898779 |
| 12 | Front Panel sticker, FR ; M-COPSv (rev.01) ; S/5 | 898779 | |
| 12 | Front Panel sticker, IT ; M-COPSv (rev.00) | 889556 | 898782 |
| 12 | Front Panel sticker, IT ; M-COPSv (rev.01) ; S/5 | 898782 | |
| 12 | Front Panel sticker, JA ; M-COPSv (rev.00) | 890212 | 898788 |
| 12 | Front Panel sticker, JA ; M-COPSv (rev.01) ; S/5 | 898788 | |
| 12 | Front Panel sticker, NL ; M-COPSv (rev.00) | 889552 | 898780 |
| 12 | Front Panel sticker, NL ; M-COPSv (rev.01) ; S/5 | 898780 | |
| 12 | Front Panel sticker, NO ; M-COPSv (rev.00) | 893558 | 898786 |
| 12 | Front Panel sticker, NO ; M-COPSv (rev.01) ; S/5 | 898786 | |
| 12 | Front Panel sticker, PT ; M-COPSv (rev.00) | 895239 | 898783 |
| 12 | Front Panel sticker, PT ; M-COPSv (rev.01) ; S/5 | 898783 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 12 | Front Panel sticker, SV ; M-COPSv (rev.00) | 889553 | 898785 |
| 12 | Front Panel sticker, SV ; M-COPSv (rev.01) ; S/5 | 898785 | |

# 7 EARLIER REVISIONS

This manual supports all earlier Cardiac Output Module revisions.

# APPENDIX A

# SERVICE CHECK FORM

## Cardiac Output Modules, M-COP and M-COPSv

Customer ____________________

Service ____________ Module type ____________ S/N ____________

Service engineer ____________________ Date ____________

☐ OK = Test OK    ☐ N.A. = Test not applicable    ☐ Fail = Test Failed

**All modules**

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | 4. Recognition | ☐ | ☐ | ☐ |
| 5. Module software | COP | | | | | | |
| 6. Communication and memories | ☐ | ☐ | ☐ | | | | |

Notes ____________________

**InvBP measurement**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7. Membrane keys | ☐ | ☐ | ☐ | 8. External parts | ☐ | ☐ | ☐ |
| 9. Calibration | ☐ | ☐ | ☐ | 10. Test with patient simulator | ☐ | ☐ | ☐ |

Notes ____________________

**$SvO_2$ measurement**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11. Membrane keys | ☐ | ☐ | ☐ | 12. Calibration | ☐ | ☐ | ☐ |
| 13. $SvO_2$ messages | ☐ | ☐ | ☐ | | | | |

Notes ____________________

**C.O. measurement**

14. Membrane keys ☐ ☐ ☐

15. Self test ☐ ☐ ☐

16. Test with patient simulator ☐ ☐ ☐

Notes ______

17. Electrical safety check ☐ ☐ ☐

18. Functioning after electrical safety check ☐ ☐ ☐

19. Final cleaning ☐ ☐ ☐

Notes ______

**Notes** ______

**Used Spare Parts** ______ ______ ______

**Signature** ______

# Datex-Ohmeda Pressure Modules

# S/5™ Pressure Temp Module, M-PT (Rev. 02)
# S/5™ Pressure Module, M-P (Rev. 04)

# Technical Reference Manual Slot


All specifications are subject to change without notice.


Document No. 800 1013-4

October 2003



Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Pressure Module, M-P, Pressure Temp Module, M-PT

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda the Pressure Module, M-P, and Pressure Temp Module, M-PT. The M-P and M-PT modules are single width plug-in modules designed for use with the S/5 monitors. Later in this manual modules may be refered to without the S/5 system nomenclature for simplicity..

Please also refer to the *Technical Reference Manual* of the S/5 monitor for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

Both modules provide invasive pressure measurement. Additionally, the M-PT-module provides temperature measurement. The M-PT module also has a connector for direct ECG and pressure signal output.

NOTE: Do not use identical modules in the same monitoring system. The modules M-P and M-PT are considered as identical modules.


**Figure 1** **Datex-Ohmeda M-PT and M-P Module**

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 37 × 180 × 112 mm / 1.5 × 7.1 × 4.4 in |
| Module weight | 0.35 kg / 0.8 lbs |
| Power consumption | Approximately 3.5 W |

## 1.2 Typical performance

### 1.2.1 InvBP

| | |
|---|---|
| Measurement range | -40...+320 mmHg |
| Accuracy | ±5 % or ±2 mmHg, whichever is greater |
| Zero adjustment range | ±150 mmHg |
| Calibration range | ±20 % |
| Scales | Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10 % of selected upper limit below zero. |
| Sweep speed | 12.5, 25, 50 mm/s |

DIGITAL DISPLAY

| | |
|---|---|
| Range | -40...+320 mmHg |
| Resolution | ±1 mmHg |

WAVEFORM DISPLAY

| | |
|---|---|
| Range | -30...+300 mmHg |

HEART RATE FROM ARTERIAL PRESSURE

| | |
|---|---|
| Measurement range | 30...250 bpm |
| Resolution | 1 bpm |
| Accuracy | ±5 bpm or ±5 %, whichever is greater |

### 1.2.2 Temperature

| | |
|---|---|
| Measurement range | 10...45 °C (50...113 °F) |
| Display resolution | 0.1 °C (0.1 °F) |
| Temperature test | Automatic (every 10 min.) |

YSI 400 probe compatible

### 1.2.3 Signal output

| | |
|---|---|
| ECG out | 1 V/mV |
| Pressure P3 out | 1 V/100 mmHg, (0...300 mmHg) |

# 1.3 Technical specifications

## 1.3.1 InvBP

| | |
|---|---|
| Accuracy | ±5 % or ±2 mmHg, whichever is greater |
| Transducer and input sensitivity | 5 µV/V/mmHg |
| Input voltage | 5VDC<br>max current 20 mA |
| Nonlinearity | <1 %, 0 to 200 mmHg<br><2 %, -40 to 0 and 200 to 320 mmHg |
| Filter | 0...4 - 22 Hz adjustable |
| Zero set accuracy | ±1 mmHg |
| Calibration resolution | ±1 mmHg |
| Zero time | less than 15 sec |
| Protection against electrical shock | Type CF defibrillation proof |

DIGITAL DISPLAY AVERAGING
Art and P1 digital displays are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

NOTE: The accuracy of the measurement may be different from that specified, depending on the transducer/probe being used. Please check the transducer/probe specification.

## 1.3.2 Temperature

| | |
|---|---|
| Measurement accuracy | ±0.1 °C (25.0...45.0 °C)<br>±0.2 °C (10.0...24.9 °C) |
| Protection against electrical shock | Type CF |

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please check the transducer/probe specification.

## 1.3.3 Signal output

| | | |
|---|---|---|
| Max. delay: | ECG1 | 15 ms |
| | Pressure P3 | 25 ms (0...300 mmHg) |
| Pressure offset error | max. 10 mmHg | |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

### 2.1.2 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called Negative Temperature Coefficient (NTC) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it.
- Applying a constant current to flow through the resistor and measuring the voltage that is generated across it.

In the S/5 module the two methods are combined in the form of a voltage divider. The NTC-resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

## 2.2 Main components

The M-PT module consists of the following main parts:

- PT board
- Two connectors for YSI 400 series temperature probes; temperature channels T3 and T4.
- Nicolay-type connector for an invasive blood pressure sensor; invasive blood pressure channel P3.
- Key for pressure zeroing.
- DIN-type connector for two direct ECG output signals and pressure 3.

NOTE: These output-signals are non-floating

The M-P module consists of the following main parts:

- PT board
- Nicolay-type connector for an invasive blood pressure sensor; invasive blood pressure channel P3.

- Key for pressure zeroing.

Communication between the module and the central unit is established through RS485 serial interface.

The power supply voltages to the module are generated in the power supply section of the monitor's Central Unit. All electrical connections between the module and the Central Unit are established via 25-pin D-type connector on the backside of the module.

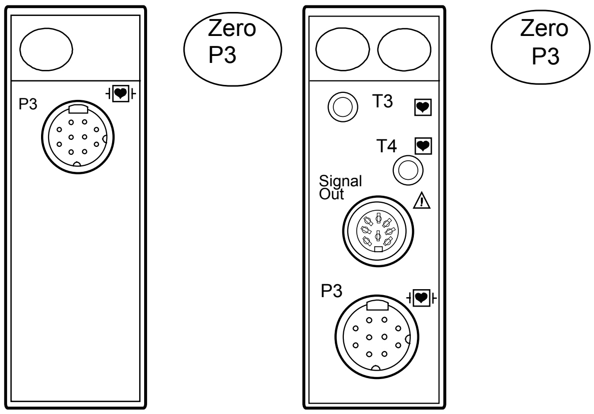



**Figure 2 Front panel of M-P and M-PT Module**

## 2.2.1 PT board

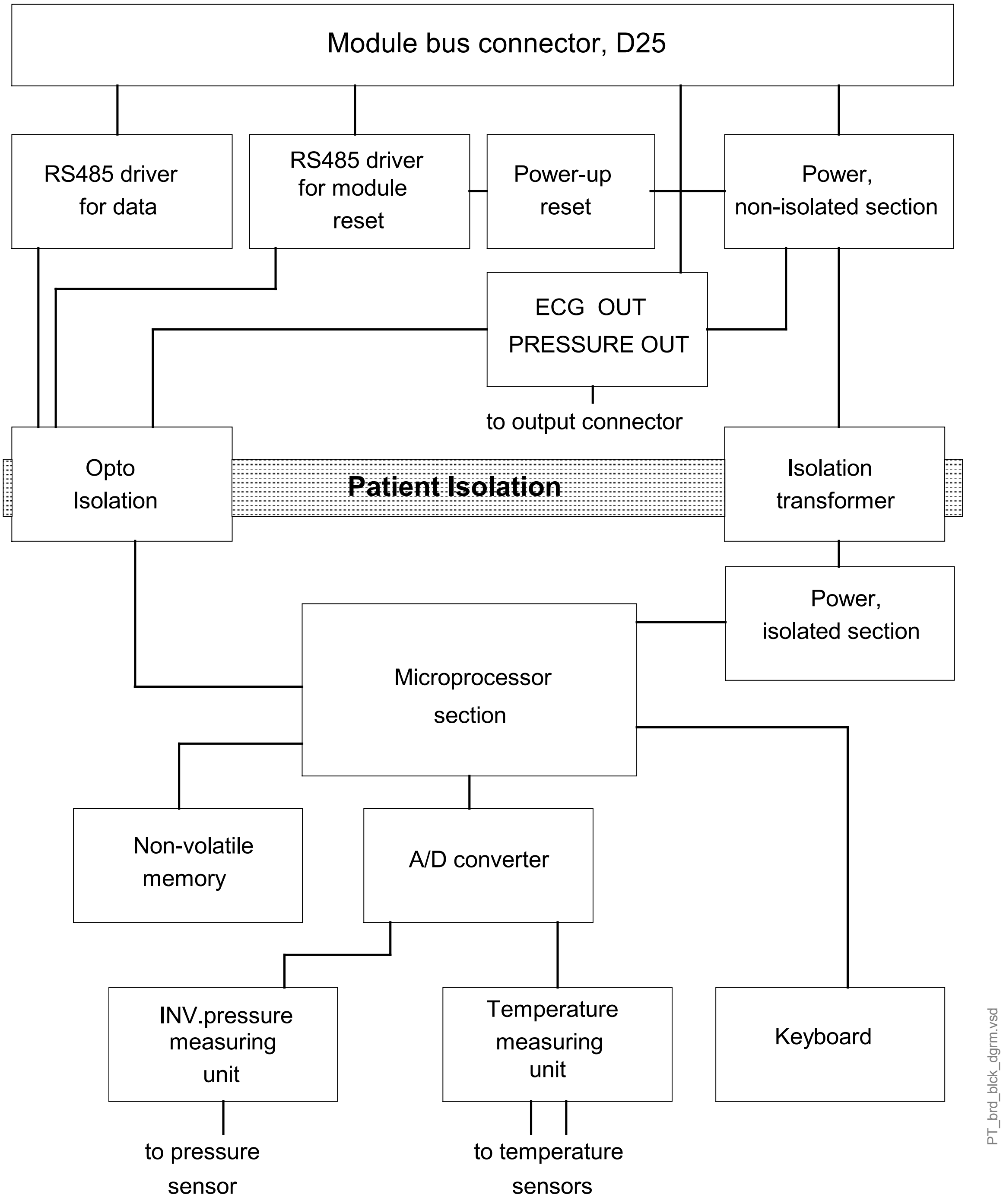



**Figure 3 PT board block diagram**

## ECG and pressure signal prosessing

The PT-module has the Signal Out connector, for output of analog ECG and pressure signals.

The analog ECG-output signals are made by detecting the pulse-width modulated (PWM) ECG signal of the module bus. The module detects the presence of pacemaker pulses by following the ECG module. Every time the pacer pulse has been detected, the microprocessor of the M-PT module generates a 2.5 ms pacer pulse which is added to the analog ECG signal.

The PRESSURE OUT signal is generated from the P3 invasive pressure signal of the M-PT module. The P3 signal is transmitted as a pulse width modulated (PWM) signal over the patient isolation. The analog signal is generated by low-pass filtering the PWM signal.

## Microprocessor unit

The microprocessor uses the Intel 80C196KC-16 which includes three A/D converters and a UART. There are external memories, an 8-bit data bus, a 16 MHz oscillator, an open collector reset, and a watchdog timer. The internal UART communicates and transfers data between the module and the CPU board in the monitor.

High speed I/O is used to obtain pulse control sequence necessary for the pulse oximetry measurement. It receives its timing clock from the oscillator.

## Invasive blood pressure measurement unit

An isolated +5 V supply is connected to the input of the pressure transducer bridge circuit. From the bridge circuit output a differential voltage, which depends on blood pressure and input supply voltage, is calculated using the following formula:

Uout = Uin $\times$ Pressure $\times$ 5 V

where Uin = 5 V

Uout = 25 V $\times$ Pressure [mmHg]

Pressure amplification is performed by the instrumentation amplifier. The gain of the amplifier is set so that the level of the signal transferred to the A/D converter stays within the measurement range even when there are circumstantial offsets or offsets caused by the pressure transducer. The input filter before the amplifier attenuates high frequency disturbances.

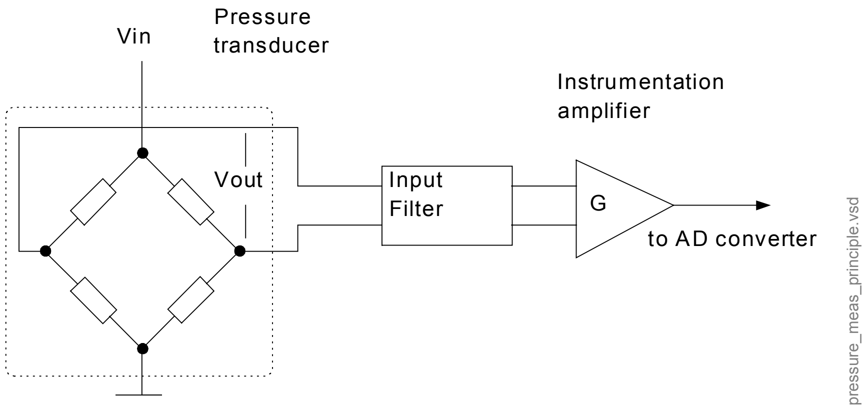



**Figure 4** **Pressure transducer principle of operation**

## Temperature measurement unit

The value of the NTC-resistor in the probe depends on the patient's temperature. It is measured with the following principle:

The temperature signal(s) is produced by voltage dividers, part of which is the patient probe (YSI 400-series thermistor). The output is amplified by the calibrated amplifier(s) whose offset voltage makes its output spread on both sides of zero. A wider output range (measurement range) means better resolution.

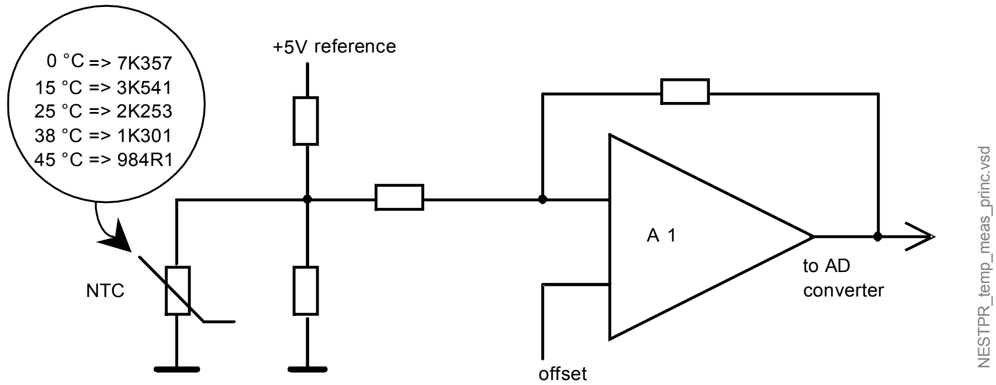



**Figure 5 Temperature measurement principle**

## Serial communication

Serial communication between the module and the Central Unit is via an RS485 type bus whose buffers get their supply voltage (+5 VDC) from the Central Unit and in the isolation section get the supply voltage (+5 V) from the isolated power supply.

The communication drivers are controlled by a reset signal such that when the reset is active the drivers do not transfer data.

Reset is also a RS485 type and additionally, there is an auxiliary logic power reset, which keeps the reset active for about 500 ms despite the state of reset in the module bus. A time constant determines the power-up reset time. There are components to prevent the module from sending data during reset. The data transmission rate is 500 kbps.

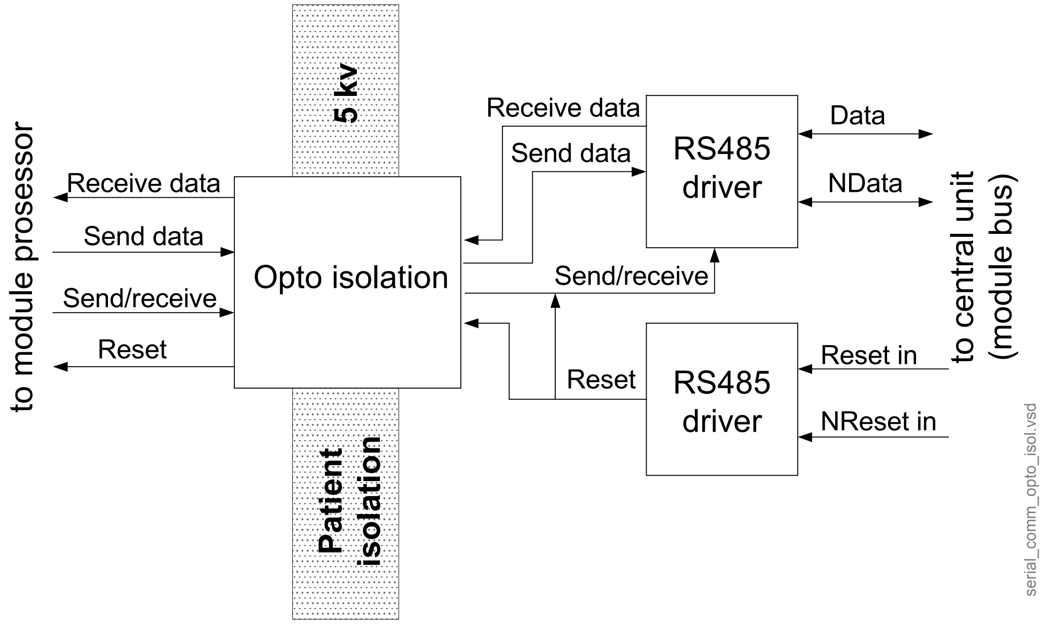



**Figure 6 Serial communication and opto isolation section**

## Isolated section

There are two opto isolators, one for data and one for the reset signal. Signals are processed on logical high-low levels even though the output of the opto isolators in the isolation section are analog signals.

The reset line is an open collector type with a pull-up resistor so that the microprocessor is able to use its internal watchdog function.

## Power supply section

The isolated supply voltage of the module is developed from the +15 Vdirty voltage from the Central Unit. The power supply is a switched-mode circuit, where FET transistor switch is controlled by an oscillator using bipolar timer. The frequency of the oscillator is about 30 kHz and pulse ratio 50 %. Controlling the FET switch is slowed to suppress spurious interference.

A special pulse transformer is used in the circuit. The transformer secondary circuit uses normal linear regulators except for +5 V which uses a low drop type linear regulator.

# 2.3 Connectors and signals

## 2.3.1 Module bus connector

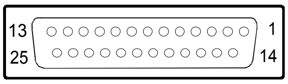


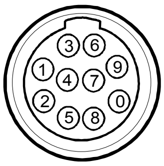

**Figure 7 Module bus connector (X1)**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485* |
| 2 | I | -15 VDC* |
| 3 | I | +15 VDIRTY* |
| 4 | I | +15 Vin* |
| 5 | I/O | NDATA_RS485* |
| 6 | I/O | DATA_RS485* |
| 7 | | Ground* |
| 8 | I | NRESET_RS485* |
| 9 | I | CTSB |
| 10 | O | RTSB |
| 11 | I | RXDB |
| 12 | O | TXDB |
| 13 | | Ground* |
| 14 | I | +32 VDIRTY |
| 15 | I | GroundDIRTY* |
| 16 | I | CTSC |
| 17 | O | RTSC |
| 18 | I | RXDC |
| 19 | O | TXDC |
| 20 | | ON/STANDBY |
| 21 | O | PWM_ECG* |
| 22 | | RXDD_RS232 |
| 23 | | TXDD_RS232 |
| 24 | I | +5 VDCin* |
| 25 | I | +5 VDC* |

* Used in the M-PT module

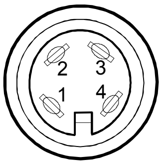
## 2.3.2 Front panel connectors

### Pressure connector (P3)




| Pin No | Signal |
|---|---|
| 1 | Pressure 3 + |
| 2 | Pressure 3 - |
| 3 | Polarization - (ground) |
| 4 | Polarization + |
| 5 | Not connected |
| 6 | Not connected |
| 7 | Not connected |
| 8 | Not connected |
| 9 | Ground |
| 10 | Cable detection |

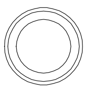
### Signal out connector (Sync. out)




| Pin No | Signal |
|---|---|
| 1 | ECG out, 1 V/ 1 mV |
| 2 | Pressure out, 1 V/ 100 mmHg |
| 3 | ECG out, 1 V/ 1 mV |
| 4 | Ground |

NOTE: The ECG out signal is not available with modules M-ESTP rev. 01, M-EST rev. 00 and M-ETP rev. 00.

### Temp connector (T1, T2)



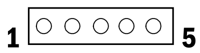
| Pin No | Signal |
|---|---|
| 1 | Temperature probe |
| 2 | Temperature probe |

## 2.3.3 Other connectors

### Keyboard connector (X3)

| Pin No | Signal | Notes |
|---|---|---|
| 1 | N/C | Not connected |
| 2 | COSWITCH | Not used |
| 3 | PSWITCH | for zeroing of P3 |
| 4 | fGND | Floating GND |
| 5 | fGND | Floating GND |

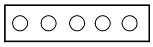
**X3**



## Pressure sensor connector (X4)

| Pin No board | Pin No fr.panel | Signal | Notes |
|---|---|---|---|
| 1 | 0 | PCABEL | 5V if cable not connected |
| 2 | 4 | PCURRENT | Pulsed supply to sensor |
| 3 | 3,9 | P3- | Signal from the sensor |
| 4 | 1 | P3+ | Signal from the sensor |
| 5 | 2 | fGND | Floating GND |

**X4**

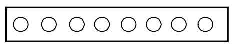
1  5

When the board is used in the M-PT module, there are the following connectors connected on the board in addition to X1 and X4.

## Signal out connector (X5)

| Pin No board | Pin No fr.panel | Signal | Notes |
|---|---|---|---|
| 1 | - | ECG OUT | ECG to (e.g.) IABP |
| 2 | - | N/C | Not connected |
| 3 | 4 | GND | +5VDCin GND |
| 4 | 1 | ECG OUT | ECG to (e.g.) defib. |
| 5 | - | N/C | Not connected |
| 6 | 3 | ECG OUT | ECG to (e.g.) IABP |
| 7 | 2 | P OUT | P3 to (e.g.) IABP |
| 8 | GND | GND | +5VDCin GND |

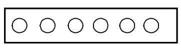
**X5**

1  8

## Connector for temperature probes (X8)

| Pin No | Signal | Notes |
|---|---|---|
| 1 | T3 | - |
| 2 | T4 | - |
| 3 | fGND | Floating GND |
| 4 | CON | Low if PT |
| 5 | fGND | Floating GND |
| 6 | GND | Floating GND |

**X8**

1  6

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the M-P and M-PT modules is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check list should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| M-NE(12)STPR/M-ESTPR/M-ESTP | | Not M-ESTP Rev. 01, M-EST Rev. 00 or M-ETP Rev. 00 |
| Patient simulator | | |
| Pressure manometer | | |
| Temperature test set | 884515 | |
| InvBP transducer | | |
| Oscilloscope | | |
| Screwdriver | | |

## All modules

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring locking pin.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - all socket mounted IC's are inserted properly
   - EMC covers are attached properly
   - there are no loose objects inside the module

   ✍

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box, latch and spring locking pin are intact

   ✍

- Reattach the module box and check that the latch is moving properly.
- Switch the monitor on and wait until the monitoring screen appears.
  Configure the monitor screen so that all the needed parameters are shown, for example as follows:

  **Monitor Setup** ***- Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
  ***Field 2 - P1***
  ***Field 3 - P3***
  ***Field 4 - P5***
  ***Digit Fields***
  ***Field 4 - T3+T4***

3. Plug in the module. Check that it goes in smoothly and locks up properly.

   ✍

- Preset InvBP measurement settings:

  **Invasive Pressures** ***- P1 'Art' Setup - Label - Art***
  ***P3 Setup - Label – PA***

4. Enter the service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service -*** (password 26-23-8)

   Take down the information regarding module software by selecting SCROLL VERS and turning the ComWheel.

5. Enter the P/PT service menu (according to the tested module):

   ***Parameters - P/PT***

   Check that the "Timeouts", "Bad checksums" and "Bad c-s by mod" values are not increasing faster than by 5 per second. Check also that the module memories have passed the internal memory test, i.e. the "RAM", "ROM" and "EEPROM" show all OK.

## Invasive blood pressure measurement

6. Check the front panel membrane key.
   Press the key at least for one second. Check that the pressed key is identified, i.e. the text for "Button" changes from OFF to ON in the service menu.

7. Check that the "Cable" and "Probe" show OFF.

   Plug a cable with an invasive blood pressure transducer into the front panel connector P3. Check that the "Cable" and "Probe" show ON and the pressure

8. waveform field appears onto the monitor screen..

   NOTE: Test both invasive blood pressure channels with M-PP.

9. Calibrate the InvBP channel according to the instructions in the Technical Reference Manual.

10. Check that the module configuration is correct with P and PT modules.
    The configuration in use is shown beside the text "Configuration" in the service menu and it can be either BP or PT.

    Change the configuration in the CALIBRATIONS -menu, if necessary.

11. Check the InvBP channels with a patient simulator
The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

    SENSITIVITY switch position: 5 μV/V/mmHg

    ECG - BASE - BPM - 60
    BP - 2 - WAVE - ATM

    connect a cable from the channel BP3 to the connector P3.

    Ccheck that appropriate InvBP waveform is shown and the InvBP value is approximately 25/10 (±2 mmHg).

## Modules with temperature measurement

11. Check that the "Cable" and "Probe" show OFF for the channels T3 and T4 when no probes are connected.

    Connect a temperature test plug into the connector T3. Check that the "Cable" and "Probe" for T3 show ON and the corresponding temperature value appears onto the screen.

    Perform the same check also for the channel T4.

12. Check the temperature calibrations using temperature test plugs.
If the deviation on a temperature reading on the screen is more then 0.1 °C, calibrate the temperature channels according to the instructions in the Technical Reference Manual.

13. Activate the temperature test by selecting TEMP TEST from the menu and pressing the ComWheel twice. When the message "Performing temp test" disappears from the digit field for T3+T4, check that no error messages appear and "Temp error" shows OFF for both channels in the menu.

## Modules with signal output connector

- Preset InvBP and ECG measurement settings:

  **Invasive Pressures** ***- P3 Setup - Label - Art***

  **ECG** ***- ECG1 LEAD -I***

  Connect a patient simulator to the connector P3 and to the connector ECG on the used M-NE(12)STPR/M-ESTPR/M-ESTP.

  The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

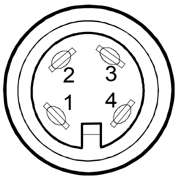
  SENSITIVITY switch position: 5 μV/V/mmHg

  BP - 1 - WAVE - ART

  ECG - BASE - BPM - 160
  PACE - WAVE - NSR

  Use the channel BP1 for the connector P3.

14. Connect an oscilloscope between the signal out connector pins 1 (ECG out) and 4 (Ground).




Check that an analog signal which corresponds with the ECG waveform on the screen comes out. The output signal's ratio to the actual ECG signal should be around 1V/1mV.

Check that a similar output signal is coming out also from the pin 3 (ECG out).

15. Connect the oscilloscope between the signal out connector pins 2 (Pressure out) and 4 (Ground).

    Check that an analog signal which corresponds with the InvBP waveform on the screen comes out. The output signal's ratio to the actual InvBP signal should be around 1V/100mmHg.

### All modules

16. Perform electrical safety check and leakage current test.

    ✍

17. Check that the module functions normally after the performed electrical safety check.

    ✍

18. Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the M-P and M-PT modules in the following way. See the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly backwards and detach it from main body. Be careful with loose latch and spring pin for locking.
3. To detach the PT board. The board can be removed by detaching two screws on the folio side of the board near the front panel and disconnecting the two ribbon cables coming from the front panel.

To reassemble the module, reverse the order of the disassembly steps.

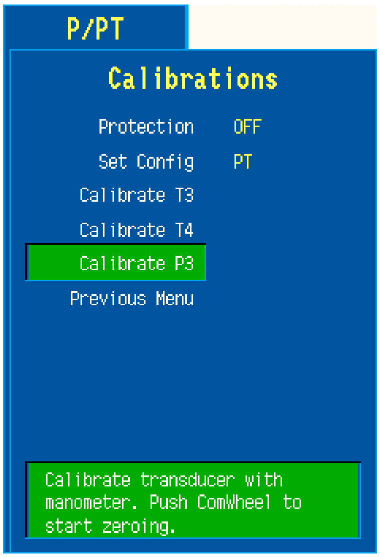
CAUTION When reassembling the module, make sure that all cables are connected properly.

# 3.4 Adjustments and calibrations

## 3.4.1 Invasive pressure calibration

Perform pressure calibration whenever the pressure transducer (probe) is replaced with different type of transducer.

1. Enter P/PT service menu: **Monitor Setup - *Install/Service - Service - Parameters***
2. Enter Calibrations menu.




3. Connect a pressure transducer with a pressure manometer to the P3 connector. Select Calibrate P3. Leave the transducer to room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg...300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The text 'calibrated' will appear on the display.

## 3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate test plugs (25 °C and 45 °C) are necessary. A test set of two plugs is available from Datex-Ohmeda, order code 884515.

Performe temperature calibration whenever the measured values deviate more than ±0.1.

1. Enter P/PT service menu (Monitor Setup, Install/Service, Service, Parameters).
2. Enter Calibrations menu.
3. Press the protect button at the bottom of the module and select OFF protect mode. Release the button.
4. Select Calibrate T3/Calibrate T4.

5. Insert calibration plug (25 °C) into T3/T4 connector.
6. Press the ComWheel.
7. Insert calibration plug (45 °C) into T3/T4 connector.
8. Press the ComWheel.
9. Press in the protect button at the bottom of the module and select ON protect mode. Release the button.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

See also the *User's Reference Manual* for more troubleshooting procedures.

### 4.1.1 Invasive blood pressure

| Trouble | Cause | Treatment |
|---|---|---|
| Abnormally low pressure | Transducer wrongly positioned. | Check mid-heart level and reposition transducer. |
| No pressure | Defective transducer. | Check transducer. |
| | No pressure module plugged in. | Check the module. |
| | No waveform selected on screen. | Check selected pressure waveforms by pressing Monitor Setup key and selecting modify waveforms.<br>Check that pressure transducer open to patient. |
| Not zeroed-message | Measurement on, channel not zeroed. | Zero the channel. |
| Zeroing failed-message | Unsuccessful zeroing of P3 (number field). | Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel.<br>Offset is > 150 mmHg. Open the transducer to air and zero the channel.<br>Defective transducer. Replace it and zero the channel. |
| Calibration failed-message | Unsuccessful calibrating of P3 (number field), possibly due to pulsating waveform. | Turn the transducer to sphygmomanometer and try again (zeroing takes place first).<br>Gain is beyond the limits (±20 % of the default gain). Replace the transducer. |
| Out of range ≤40 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. |
| Out of range >320 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. The patient may also have high pressure. |
| Zero adj. >100 mmHg | Offset when zeroing is >100 mmHg (but <150 mmHg) from the absolute zero of the module (with default gain). | Check transducer. The waveform may hit the top and the numeric display not shown. |
| Out of range | Measured pressure is beyond the internal measurement range of the module. | The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel. |

### 4.1.2 Temperature

| Trouble | Cause | Treatment |
|---|---|---|
| Message<br>'TEMPERATURE ERROR' | Faulty calibration. | Perform calibration. If it does not help, check that front panel connectors are properly connected to STP board. |
| No temperature displayed | Wrong type of probe.<br>Temperature out of measurable range.<br>Temperature calibration not protected. | Use correct probe.<br>The range is between 10 and 45 °C.<br>Set the Protection ON in the Service Menu. |

## 4.2 Troubleshooting flowchart

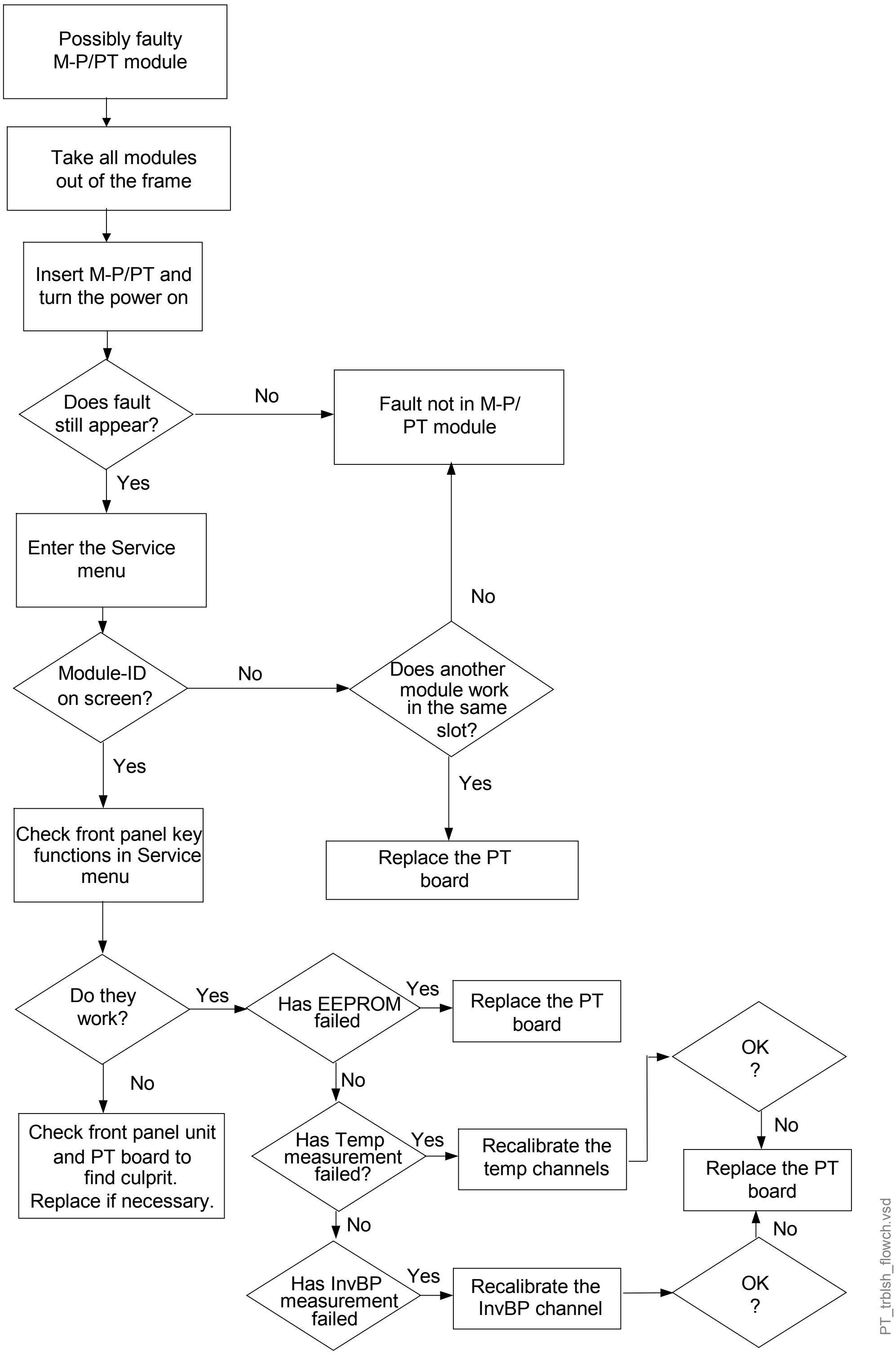
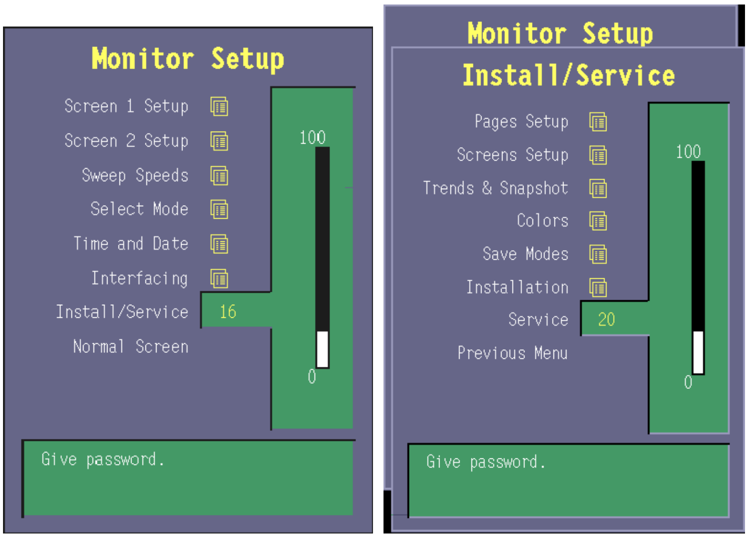
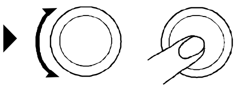



**Figure 8** **Troubleshooting flowchart**

# 5 SERVICE MENU

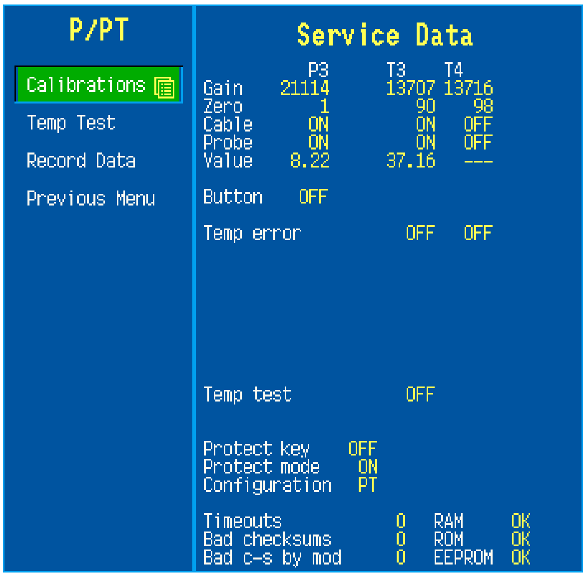
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters***.
5. Select ***P/PT module***.

## 5.1 P/PT menu




**Calibrations** See section 5.2 "*Calibrations menu*."

**Record Data** Record Data prints out the shown service data and board information (id., serial number, and software id.) onto the recorder module, M-REC.

**Service Data**

**Gain** is a coefficient to compensate gain error. Usually the value for P3 is between 17000 and 25000 and for T3 and T4 between 13000 and 14300. **Zero** indicates offset compensation value of each parameter in A/D converter. Typically the values for P3 is within ±1000 and for T3 and T4 between -150 and +300. Calibrate if zero and/or gain value is outside the ranges.

**Cable** shows ON when the corresponding cable is connected to the front panel and **Probe** shows ON when the corresponding probe is connected to the cable.

Under **Value** the measured numeric values are displayed simultaneously. Pressure value is a real time value and shown in mmHg.

**Button**; the front panel key function can be confirmed by pressing the key and checking that OFF turns to ON.

**Temp error** shows whether the calibration of the temperature was successful or not.

**Protect key** shows normally OFF but turns to ON when the button at the bottom of the module is pressed.

**Protect mode** is normally ON. It turns to OFF when Protect is switched to OFF for the temperature calibration in Calibration Menu.

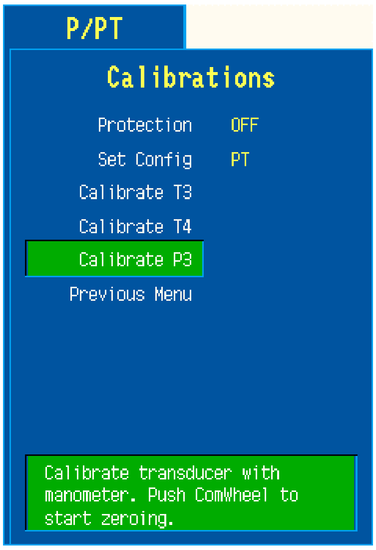
**Configuration** shows the chosen module configuration: BP or PT.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.
**Bad checksums** is also a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero

values do not indicate a failure, but the continuous counting (more than 5 per second) during the normal operation indicates either serial communication failure or module not in place.

**RAM** indicates the state of the RAM memory. **ROM** indicates whether the checksum in the EPROM is in accordance with the one the software has calculated. **EEPROM** indicates if the values stored in the permanent memory are valid. The state is either **OK, Fail** or **?** (module not in place or a communication error).

## 5.2 P/PT calibration menu




**Protection** Protection for the configuration and temperature calibrations can be set ON and OFF only when protect button at the bottom of the module is pressed.

**Set Config** The module configuration should be set according to the module type. The setting is possible only when the protection is set OFF. The available selections are BP or PT.

The configuration setting should be checked if the PT board is replaced.

**Calibrate T3 and Calibrate T4**

The functions are for calibrating the temperature channels T3 and T4. The calibrations are possible only when the protection is set OFF. The temperature calibration requires accurate test plugs of value 25 °C and 45 °C.

Calibration:

1. Select Calibrate T3 / Calibrate T4
2. Insert the test plug 25 °C into the T3 / T4 connector
3. Press the ComWheel
4. Insert the test plug 45 °C into the T3 / T4 connector
5. Press the ComWheel

**Calibrate P3** The function is for calibrating the invasive blood pressure channel P3.

The calibration requires a pressure transducer (with an appropriate cable) and a pressure manometer.

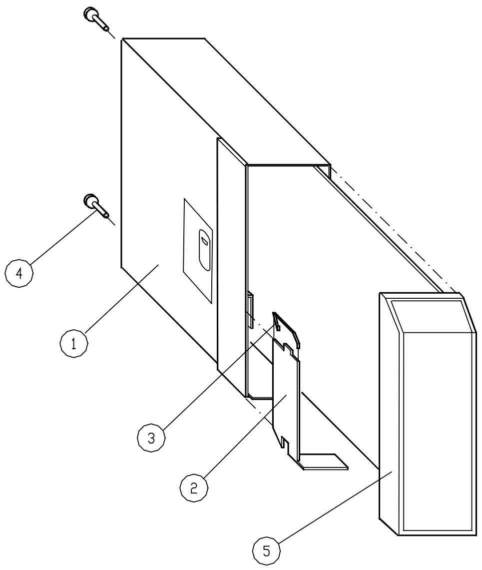
Calibration:

1. Connect the pressure transducer with the pressure manometer to the P3 connector. Select Calibrate P3. Leave the transducer to room air pressure.
2. Press the ComWheel to start zeroing.
3. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
4. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel.

# 6 SPARE PARTS

NOTE: Accessories are listed in the *Patient Monitor Supplies and Accessories*.

## 6.1 Pressure Module, M-P, Rev. 00, 01, 02, 03, 04



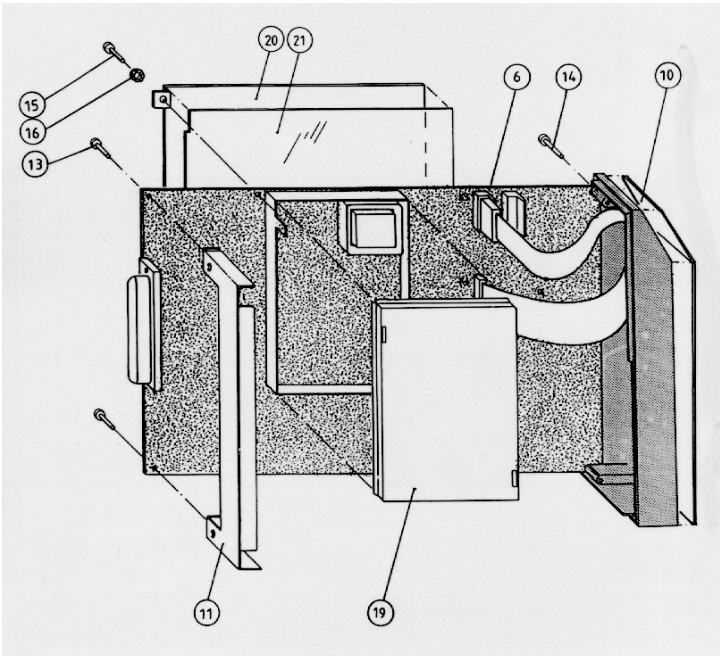
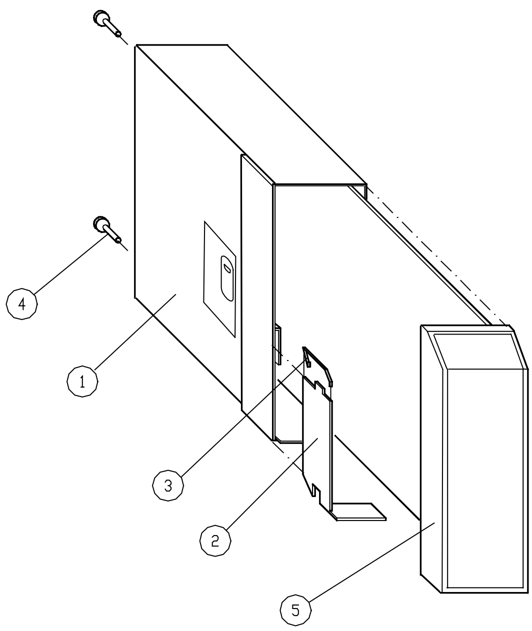




**Figure 9 Exploded view of the M-P module**

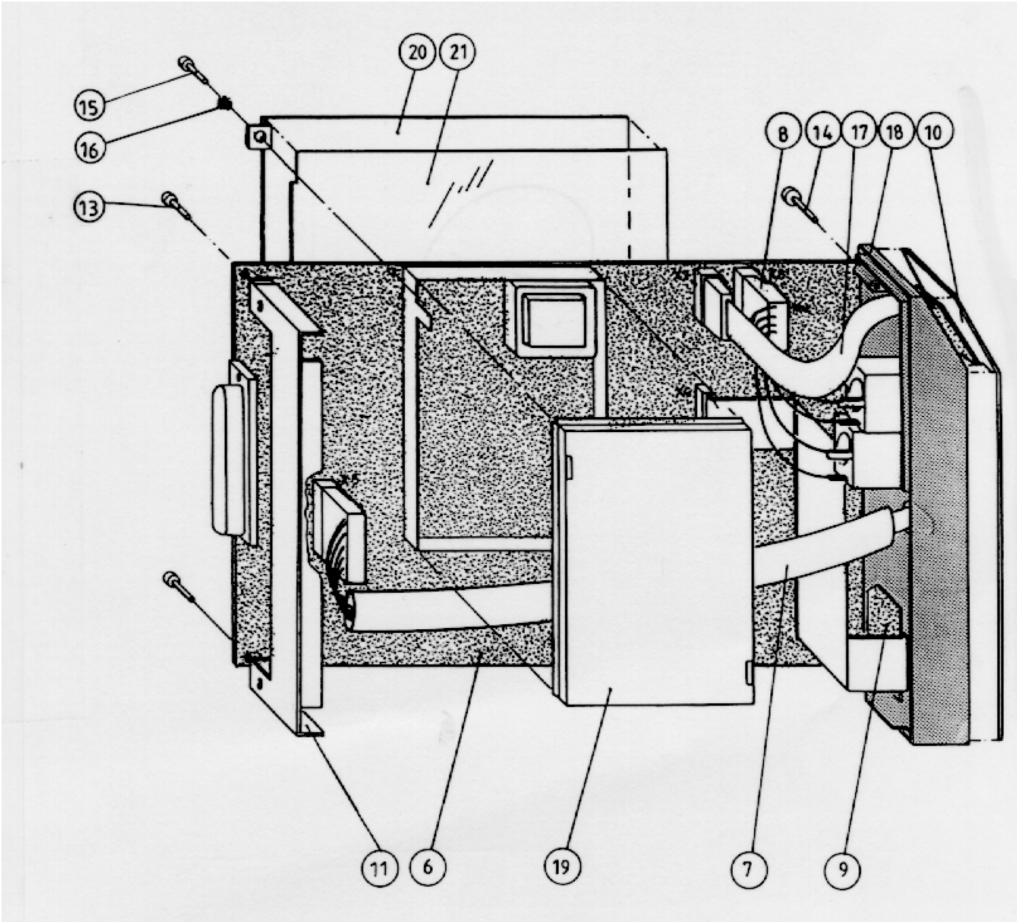
| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel unit (M-P) | 880044 | |
| 6 | PT board, M-PT, M-P | 885697 | 895047 |
| 6 | PT board, M-PT (rev.01), M-P (rev.03) | 895047 | |
| 6 | STP board, M-ESTP (rev.01), M-P (rev.00-01) | 880339 | |
| 6 | STP-board, M-ESTP (rev 03-05), M-P (rev .02) | 882627 | |
| 10 | Front Panel sticker, DA ; M-P (rev.00-03) | 892211 | 898744 |
| 10 | Front Panel sticker, DA ; M-P (rev.04) ; S/5 | 898744 | |
| 10 | Front Panel sticker, DE ; M-P (rev.00-03) | 880488 | 898735 |
| 10 | Front Panel sticker, DE ; M-P (rev.04) ; S/5 | 898735 | |
| 10 | Front Panel sticker, EN ; M-P (rev.00-03) | 880139 | 898734 |
| 10 | Front Panel sticker, EN, PT ; M-P (rev.04) ; S/5 | 898734 | |
| 10 | Front Panel sticker, EN, PT ; M-P (rev.04) ; S/5 | 898734 | |
| 10 | Front Panel sticker, ES ; M-P (rev.00-03) | 884201 | 898738 |
| 10 | Front Panel sticker, ES ; M-P (rev.04) ; S/5 | 898738 | |
| 10 | Front Panel sticker, FI ; M-P (rev.00-03) | 888863 | 898741 |
| 10 | Front Panel sticker, FI ; M-P (rev.04) ; S/5 | 898741 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 10 | Front Panel sticker, FR ; M-P (rev.00-03) | 880130 | 898736 |
| 10 | Front Panel sticker, FR ; M-P (rev.04) ; S/5 | 898736 | |
| 10 | Front Panel sticker, IT ; M-P (rev.00-03) | 886756 | 898739 |
| 10 | Front Panel sticker, IT ; M-P (rev.04) ; S/5 | 898739 | |
| 10 | Front Panel sticker, JA ; M-P (rev.00-03) | 888308 | 898745 |
| 10 | Front Panel sticker, JA ; M-P (rev.04) ; S/5 | 898745 | |
| 10 | Front Panel sticker, NL ; M-P (rev.00-03) | 886063 | 898737 |
| 10 | Front Panel sticker, NL ; M-P (rev.04) ; S/5 | 898737 | |
| 10 | Front Panel sticker, NO ; M-P (rev.00-03) | 893569 | 898743 |
| 10 | Front Panel sticker, NO ; M-P (rev.04) ; S/5 | 898743 | |
| 10 | Front Panel sticker, PT ; M-P (rev.04) ; S/5 | 898740 | 898734 |
| 10 | Front Panel sticker, SV ; M-P (rev.00-03) | 885847 | 898742 |
| 10 | Front Panel sticker, SV ; M-P (rev.04) ; S/5 | 898742 | |
| 11 | Metal frame | 879184 | |
| 13 | Cross cylinder-head screw M3x6 | 61721 | |
| 14 | Cross cylinder-head scerw M3x12 | 628700 | |
| 15 | Cross cylinder-head screw M3x16 | 628710 | |
| 16 | Shakeproof washer m3.2 | 63611 | |
| 19 | EMC cover | 884099 | |
| 20 | Protection plate | 883946 | |
| 21 | Insulating plate for 883946 | 884121 | |

## 6.2 Pressure Temp Module, M-PT, Rev. 00, 01, 02




| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel frame (M-PT) | 883801 | |




F

**igure 10 Exploded view of the M-PT module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 6 | PT board, M-PT, M-P | 885697 | 895047 |
| 6 | PT board, M-PT (rev.01), M-P (rev.03) | 895047 | |
| 6 | STP board, M-ESTP (rev.01), M-P (rev.00-01) | 880339 | |
| 6 | STP-board, M-ESTP (rev 03-05), M-P (rev .02) | 882627 | |
| 7 | Signal out connector, M-PT | 884316 | |
| 8 | T-Input connectors | 884315 | |
| 9 | P-Input connector | 884314 | |
| 10 | Front Panel sticker, DA ; M-PT (rev.00-01) | 892210 | 898768 |
| 10 | Front Panel sticker, DA ; M-PT (rev.02) ; S/5 | 898768 | |
| 10 | Front Panel sticker, DE ; M-PT (rev.00-01) | 885035 | 898759 |
| 10 | Front Panel sticker, DE ; M-PT (rev.02) ; S/5 | 898759 | |
| 10 | Front Panel sticker, EN ; M-PT (rev.00-01) | 884004 | 898758 |
| 10 | Front Panel sticker, EN ; M-PT (rev.02) ; S/5 | 898758 | |
| 10 | Front Panel sticker, ES ; M-PT (rev.00-01) | 886193 | 898762 |
| 10 | Front Panel sticker, ES ; M-PT (rev.02) ; S/5 | 898762 | |
| 10 | Front Panel sticker, FI ; M-PT (rev.00-01) | 888864 | 898765 |
| 10 | Front Panel sticker, FI ; M-PT (rev.02) ; S/5 | 898765 | |
| 10 | Front Panel sticker, FR ; M-PT (rev.00-01) | 885033 | 898760 |
| 10 | Front Panel sticker, FR ; M-PT (rev.02) ; S/5 | 898760 | |
| 10 | Front Panel sticker, IT ; M-PT (rev.00-01) | 886758 | 898763 |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 10 | Front Panel sticker, IT ; M-PT (rev.02) ; S/5 | 898763 | |
| 10 | Front Panel sticker, JA ; M-PT (rev.00-01) | 888307 | 898769 |
| 10 | Front Panel sticker, JA ; M-PT (rev.02) ; S/5 | 898769 | |
| 10 | Front Panel sticker, NL ; M-PT (rev.00-01) | 886330 | 898761 |
| 10 | Front Panel sticker, NL ; M-PT (rev.02) ; S/5 | 898761 | |
| 10 | Front Panel sticker, NO ; M-PT (rev.00-01) | 893571 | 898767 |
| 10 | Front Panel sticker, NO ; M-PT (rev.02) ; S/5 | 898767 | |
| 10 | Front Panel sticker, PT ; M-PT (rev.00-01) | 895237 | 898764 |
| 10 | Front Panel sticker, PT ; M-PT (rev.02) ; S/5 | 898764 | |
| 10 | Front Panel sticker, SV ; M-PT (rev.00-01) | 885845 | 898766 |
| 10 | Front Panel sticker, SV ; M-PT (rev.02) ; S/5 | 898766 | |
| 11 | Metal frame | 879184 | |
| 13 | Cross cylinder-head screw M3x6 | 61721 | |
| 14 | Cross cylinder-head scerw M3x12 | 628700 | |
| 15 | Cross cylinder-head screw M3x16 | 628710 | |
| 16 | Shakeproof washer m3.2 | 63611 | |
| 17 | Membrane keypad | 880101 | |
| 18 | Front panel frame, M-PT | 883801 | |
| 19 | EMC cover | 884099 | |
| 20 | Protection plate | 883946 | |
| 21 | Insulating plate for 883946 | 884121 | |

# 7 EARLIER REVISIONS

This manual also supports M-P revisions 02 and 03.

For service information on the earlier revisions, please refer to:

| | |
|---|---|
| P Module revision 00 | Service Manual p/n 880850 |
| P Module revision 01 | Service Manual p/n 882580 |

# APPENDIX A

# SERVICE CHECK FORM

## Pressure Modules, M-P, M-PT

Customer ______________________

Service ____________ Module type ____________ S/N ____________

Service engineer ______________________ Date ____________

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

**All modules**

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | | | | |

Notes ______________________

| | | |
|---|---|---|
| 4. Module software | P | |
| | PT | |

| | | | |
|---|---|---|---|
| 5. Communication and memories | ☐ | ☐ | ☐ |

Notes ______________________

**InvBP measurement**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6. Membrane keys | ☐ | ☐ | ☐ | 7. Cable and transducer detection | ☐ | ☐ | ☐ |
| 8. Calibration | ☐ | ☐ | ☐ | 9. Configuration BP/PT | ☐ | ☐ | ☐ |
| 10. Test with patient simulator | | | | | | | |

Notes ______________________

OK = Test OK          N.A. = Test not applicable          Fail = Test Failed

**TEMP measurement**

11. Temperature probe detection
12. Calibration check
13. Temp test -function

Notes

**Signal output**

14. ECG output
15. InvBP output

Notes

**All modules**

16. Electrical safety check
17. Functioning after electrical safety check
18. Final cleaning

Notes

**Notes**

**Used Spare Parts**

**Signature**

# Datex-Ohmeda

# S/5™ Dual Pressure Module, M-PP (Rev. 01)

# Technical Reference Manual


All specifications are subject to change without notice.

Document No. 8001014-4

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Dual Pressure Module, M-PP

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Dual Pressure Module, M-PP. The M-PP module is a single width plug-in module designed for use with the S/5 monitors. The Dual Pressure module provides invasive blood pressure (InvBP) measurement.

Later in this manual modules may be refered to without the S/5 system nomenclature for simplicity.

Please also refer to the *Technical Reference Manual* of the S/5 monitor for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.


**Figure 1 Dual Pressure Module, M-PP**

NOTE: The Dual Pressure Module, M-PP functions only with monitor software of level 97 and newer.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 37 × 180 × 112 mm / 1.5 × 7.1 × 4.4 in |
| Module weight | 0.35 kg / 0.8 lbs |
| Power consumption | approximately 3.5 W |

## 1.2 Typical performance

| | |
|---|---|
| Measurement range | -40...+320 mmHg |
| Accuracy | ±5 % or ±2 mmHg, whichever is greater |
| Zero adjustment range | ±150 mmHg |
| Calibration range | ±20 % |
| Scales | Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10 % of selected upper limit below zero. |
| Sweep speed | 12.5, 25, 50 mm/s |

DIGITAL DISPLAY

| | |
|---|---|
| Range | -40...+320 mmHg |
| Resolution | ±1 mmHg |

WAVEFORM DISPLAY

| | |
|---|---|
| Range | -30...+300 mmHg |

HEART RATE FROM ARTERIAL PRESSURE

| | |
|---|---|
| Measurement range | 30...250 bpm |
| Resolution | 1 bpm |
| Accuracy | ±5 bpm or ±5 %, whichever is greater |

## 1.3 Technical specifications

| | |
|---|---|
| Accuracy | ±5 % or ±2 mmHg, whichever is greater |
| Transducer and input sensitivity | 5 µV/V/mmHg, 5 VDC, 20 mA max current |
| Nonlinearity | < 1 %, 0...200 mmHg<br>< 2 %, -40...0 and 200...320 mmHg |
| Filter | 0...4 - 22 Hz adjustable |
| Zero set accuracy | ±1 mmHg |
| Calibration resolution | ±1 mmHg |
| Zero time | < 15 sec |
| Protection against electrical shock | Type CF defibrillation proof |

DIGITAL DISPLAY AVERAGING

Art and P1 digital displays are averaged over 5 seconds and updated at 5 second intervals. All other pressures have respiration artifact rejection.

NOTE: The accuracy of the measurement may be different from that specified, depending on the transducer/probe being used. Please check the transducer/probe specification.

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

## 2.2 Main components

The main components of the Dual Pressure Module, M-PP, are a PP circuit board, a front panel and a box. The front panel includes two Nicolay-type connectors, P5 and P6, and two direct function keys, Zero P5 and Zero P6 for pressure zeroing.

Communication between the Dual Pressure Module and the Central Unit is via an RS485 serial interface.

The power supply voltages to the Dual Pressure Module are generated in the power supply section of the Central Unit. All electrical connections between the Dual Pressure Module and the Central Unit are via a 25-pin D-connector at the back of the module.

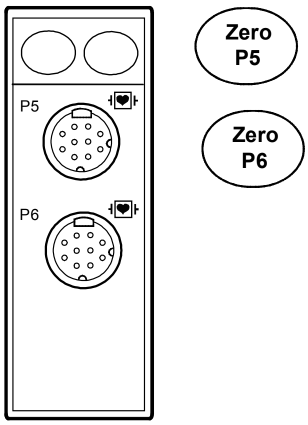



**Figure 2 Dual Pressure Module, M-PP, front panel**

### 2.2.1 PP board

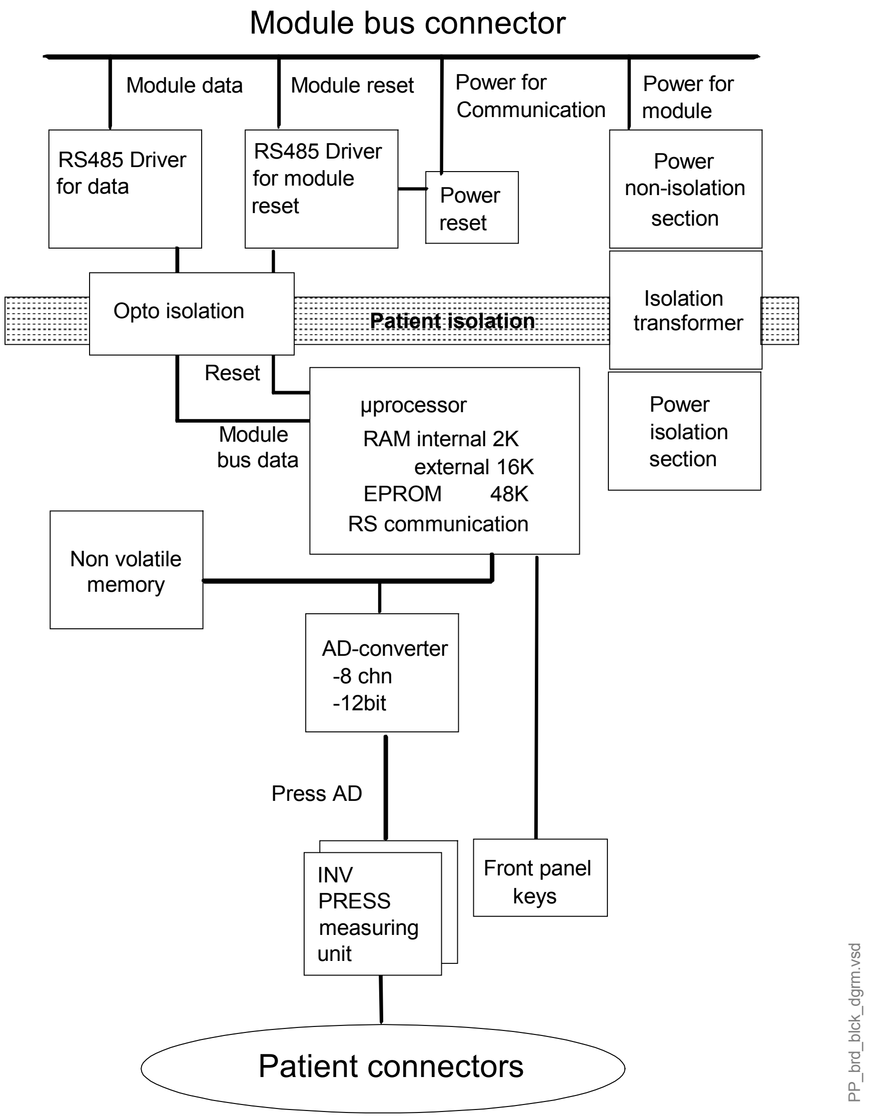



**Figure 3 PP board block diagram**

## Microprocessor unit

The microprocessor uses the Intel 80C196KC-16 CPU which includes three A/D converters and a UART. The microprocessor uses external memories, an 8-bit data bus, a 16 MHz oscillator, an open collector reset, and a watchdog timer. The three A/D-converters within the CPU convert the analog input signals to digital. The internal UART communicates and transfers data between the module and the CPU board in the monitor.High speed I/O is used to obtain the pulse control sequence necessary for pulse oximetry measurement. It receives its timing clock signal from the 16 MHz oscillator.

## Invasive blood pressure measurement unit

An isolated +5 V supply is connected to the input of the pressure transducer bridge circuit. From the bridge circuit output a differential voltage, which depends on blood pressure and input supply voltage, is calculated using the following formula:

Uout = Uin × Pressure × 5 V

where Uin = 5 V

Uout = 25 V × Pressure [mmHg]

Pressure amplification is performed by the instrumentation amplifier. The gain of the amplifier is set so that the level of the signal transferred to the A/D converter stays within the measurement range even when there are circumstantial offsets or offsets caused by the pressure transducer. The input filter before the amplifier attenuates high frequency disturbances.

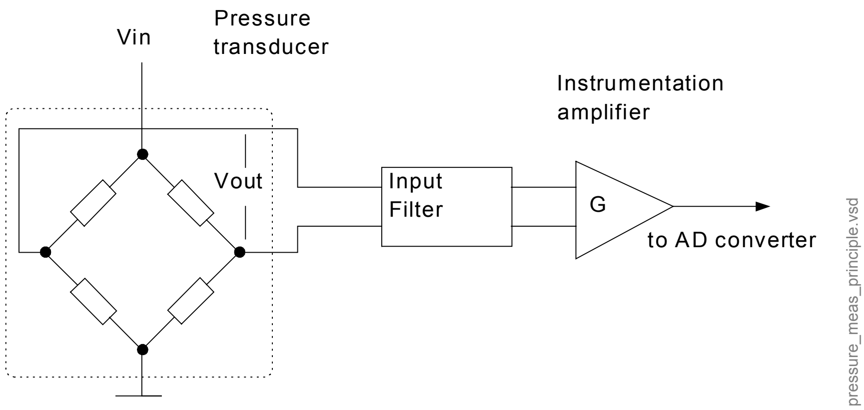



**Figure 4 Pressure transducer principle of operation**

## Serial communication

Serial communication between the Dual Pressure Module and the Central Unit is via an RS485 type bus. The communication bus drivers are powered from the Central Unit Module Bus. The module isolation section (+5 V) is powered from the isolated power supply.

The buffers of the serial communication drivers are controlled by a reset signal such that when the reset is active the drivers do not transfer data.

In addition to the RS485 reset there is a logic power-up reset, which holds for approximately 500 ms regardless of the state of the RS485 reset. A time constant determines the power-up reset time. The power-up reset also prevents the module from sending data to the Module Bus. The data transmission rate is 500 kbps.

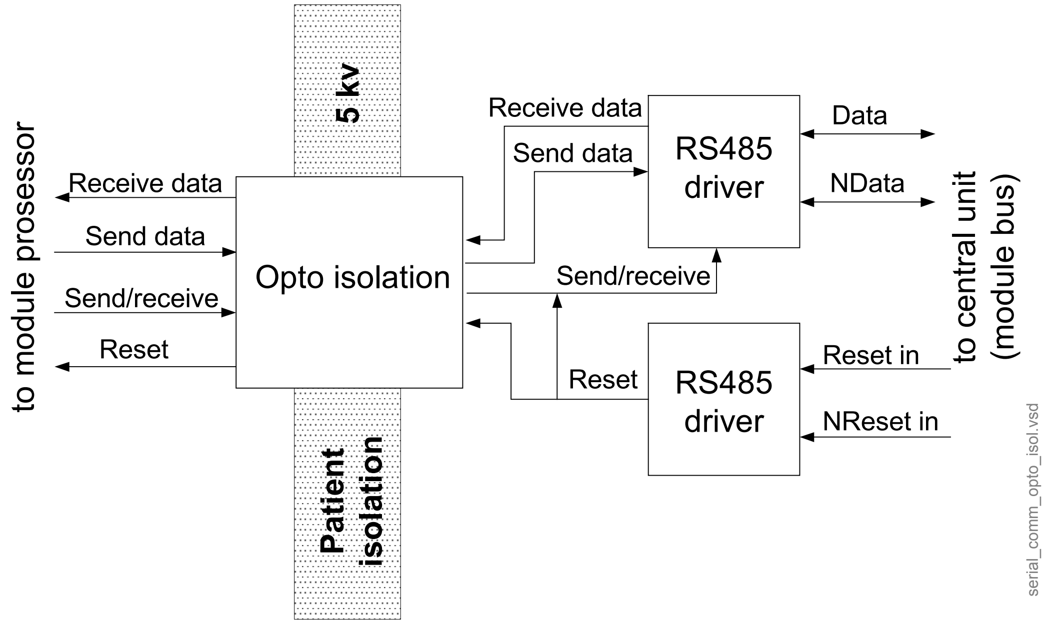



**Figure 5** **Serial communication and opto isolation sections**

## Isolated section

There are two opto isolators, one for data and one for the reset signal. Signals are processed on logical high-low levels even though the output of the opto isolators in the isolation section are analog signals.

The reset line is an open collector type with a pull-up resistor so that the microprocessor is able to use its internal watch-dog function.

### Power supply section

The module isolated supply voltage is developed from the +15 Vdirty (non-isolated) supply from the Central Unit power supply.

The isolated power supply is a switched-mode circuit, where an FET switch is controlled by an oscillator using a bipolar timer. The frequency of the oscillator is approximately 30 kHz with a pulse ratio of 50 %; switching of the FET switch is slow to suppress spurious interference.

A special isolation pulse transformer is used in the circuit. The transformer secondary circuit uses normal linear regulators except for +5 V which uses a low drop type linear regulator.

## 2.3 Connectors and signals

### 2.3.1 Module bus connector

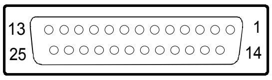
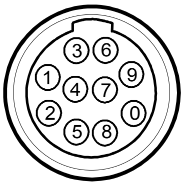



**Figure 6 Module bus connector (X1)**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485 |
| 2 | I | -15 VDC |
| 3 | I | +15 VDIRTY |
| 4 | I | +15 Vin |
| 5 | I/O | NDATA_RS485 |
| 6 | I/O | DATA_RS485 |
| 7 | | Ground |
| 8 | I | NRESET_RS485 |
| 9 | I | CTSB |
| 10 | O | RTSB |
| 11 | I | RXDB |
| 12 | O | TXDB |
| 13 | | Ground |
| 14 | I | +32 VDIRTY |
| 15 | I | GroundDIRTY |
| 16 | I | CTSC |
| 17 | O | RTSC |
| 18 | I | RXDC |
| 19 | O | TXDC |
| 20 | | ON/STANDBY |
| 21 | O | PWM_ECG |
| 22 | | RXDD_RS232 |
| 23 | | TXDD_RS232 |
| 24 | I | +5 VDCin |
| 25 | I | +5 VDC |

## 2.3.2 Front panel connectors

### Pressure connectors (P5, P6)

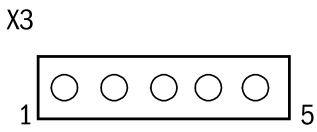



| Pin no. | Signal |
|---|---|
| 1 | Pressure 5/6 + |
| 2 | Pressure 5/6 - |
| 3 | Polarization - (ground) |
| 4 | Polarization + |
| 5 | Not connected |
| 6 | Not connected |
| 7 | Not connected |
| 8 | Not connected |
| 9 | Ground |
| 10 | Cable detection |

## 2.3.3 Other connectors

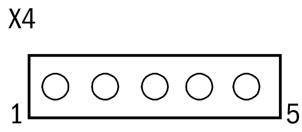
### Keyboard connector (X3)

| Pin no. | Signal | Notes |
|---|---|---|
| 1 | N/C | Not connected |
| 2 | PSWITCH | for zeroing of P5 |
| 3 | PSWITCH | for zeroing of P6 |
| 4 | fGND | Floating GND |
| 5 | fGND | Floating GND |




### Pressure sensor connector (X4)

| Pin no. Board | Pin no. fr.panel | Signal | Notes |
|---|---|---|---|
| 1 | 0 | PCABEL | 5V if cable not connected |
| 2 | 4 | PCURRENT | Pulsed supply to sensor |
| 3 | 3,9 | P- | Signal from the sensor |
| 4 | 1 | P+ | Signal from the sensor |
| 5 | 2 | fGND | Floating GND |



# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the Dual Pressure Module, M-PP, is limited to replacing faulty circuit boards or mechanical parts. Faulty circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a **service check**. The service should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a **check form** which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check list should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Patient simulator | | |
| Pressure manometer | | |
| InvBP transducer | | |
| Screwdriver | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring locking pin.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - all socket mounted IC's are inserted properly
   - EMC covers are attached properly
   - there are no loose objects inside the module

   ✍

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box, latch and spring locking pin are intact

   ✍

   - Reattach the module box and check that the latch is moving properly.

- Turn the monitor on and wait until the monitoring screen appears.
  Configure the monitor screen so that all the required parameters are shown, for example:

  **Monitor Setup** - ***Screen 1 Setup - Waveform Fields - Field 4 - P5***
  ***Field 5 - P6***

3. Plug in the module, M-PP. Check that it goes in smoothly and locks up properly.

- Preset the InvBP measurement settings:

  **Invasive Pressures** - ***P5 Setup - Label - P5***
  ***P6 Setup - Label - P6***

4. Enter the service menu:

   **Monitor Setup** ***- Install/Service (password 16-4-34) - Service View (password 26-23-8)***

   Take down the information regarding PP module software by selecting SCROLL VERS and turning the ComWheel.

5. Enter the PP module service menu (according to the module being tested):

   ***Modules - PP***

   Check that the “Timeouts”, “Bad checksums” and “Bad c-s by mod” values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. “RAM”, “ROM” and “EEPROM” all show OK.

6. Check the front panel membrane keys.
   Press each of the keys for at least one second. Check that the key being pressed is identified, i.e. the text on the service menu for “Button” changes from OFF to ON.

7. Check that “Cable” and “Probe” show OFF.

   Plug the cable from an invasive blood pressure transducer into front panel connector P5. Check that the corresponding “Cable” and “Probe” messages show ON and the correct pressure waveform field appears on the monitor screen.

8. Calibrate the InvBP channels according to the instructions in the Technical Reference Manual.

9. Check the InvBP channels with a patient simulator.

   The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

   SENSITIVITY switch position: 5 μV/V/mmHg

   ECG - BASE - BPM - 60

   BP - 2 - WAVE - ATM

   3 - WAVE - ATM

   Connect channel BP2 to connector P5 and channel BP3 to connector P6.
   Zero the InvBP channels by pressing the zeroing keys on the module front panel.

   BP - 2 - WAVE - CVP
   3 - WAVE - PA

   Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 15/10 mmHg (±2 mmHg) for channel P5 and 25/10 (±2 mmHg) for channel P6.

10. Perform an electrical safety check and a leakage current test.

11. Check that the module functions normally after performing the electrical safety check.

12. Clean the module with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the Dual Pressure Module, M-PP, in the following way. See the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly backwards and remove it from the main body. Be careful with the loose latch and spring locking pin.
3. To detach the PP board, remove the two screws, and disconnect the two ribbon cables from the front panel.

To reassemble the module, reverse the order of the disassembly steps.

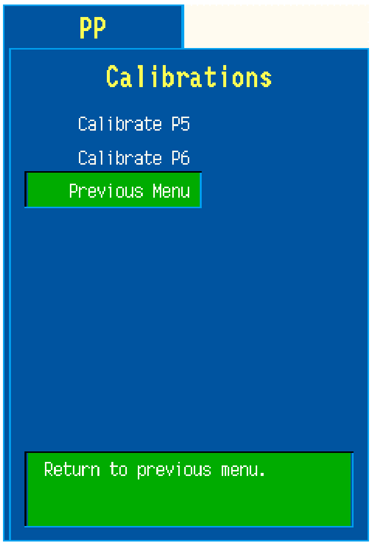
CAUTION When reassembling the module, make sure that all cables are connected properly.

# 3.4 Adjustments and calibrations

## 3.4.1 Invasive pressure calibration

Perform a pressure calibration whenever the pressure transducer (probe) is replaced with different type of transducer.

1. Enter the PP service menu (**Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***).
2. Enter the Calibrations menu.




3. Connect a pressure transducer with a pressure manometer to the P5/P6 connector. Select Calibrate P5 or Calibrate P6 from the menu. Leave the transducer at room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg...300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The text 'calibrated' will appear on the display.

# 4 TROUBLESHOOTING

See also the *User's Reference Manual* for more troubleshooting procedures.

## 4.1 Troubleshooting chart

| Trouble | Cause | Treatment |
|---|---|---|
| Abnormally low pressure | Transducer wrongly positioned. | Check mid-heart level and reposition transducer. |
| No pressure | Defective transducer. | Check the transducer. |
| | No pressure module plugged in. | Check the module. |
| | No selected waveform on screen. | Check selected pressure waveforms by pressing Monitor Setup key and selecting modify waveforms.<br>Check that pressure transducer open to patient. |
| "Not zeroed" message | Measurement on, channel not zeroed. | Zero the channel. |
| Zeroing failed-message | Unsuccessful zeroing of P5 /P6 (number field), possibly due to pulsating pressure waveform.<br>Offset is > 150 mmHg.<br>Defective transducer. | Open the transducer to air and zero the channel.<br>Open the transducer to air and zero the channel.<br>Replace the transducer and zero the channel. |
| Calibration failed-message | Unsuccessful calibration of P5/P6 (number field), possibly due to pulsating waveform<br>Gain is beyond the limits (± 20 % of the default gain). | Turn the transducer to sphygmomanometer and try again (zeroing takes place first).<br>Replace the transducer. |
| Out of range ≤ 40 mmHg | Pressure measurement is beyond measurement range. | Check the transducer level. Zero the channel. |
| Out of range > 320 mmHg | Pressure measurement is beyond measurement range. | Check the transducer level. Zero the channel. The patient may also have high blood pressure. |
| Zero adj. > 100 mmHg | Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain). The waveform may hit the top of the screen and the numeric display not shown. | Check the transducer. |
| Out of range | Measured pressure is beyond the internal measurement range of the module. The waveform may hit the top of the screen and the numeric display not shown. | Check the transducer and its level.<br>Zero the channel. |

## 4.2 Troubleshooting flowchart

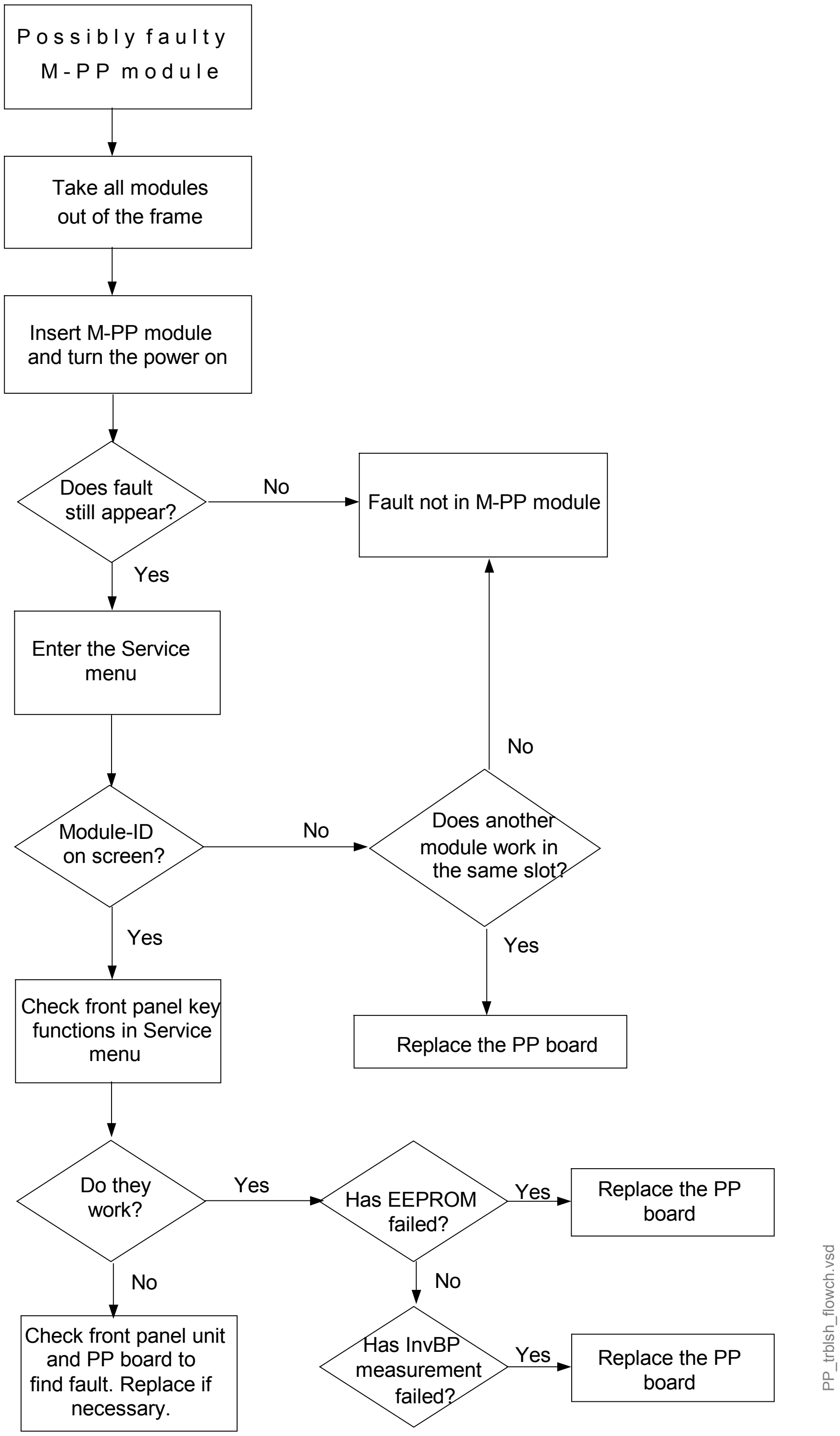
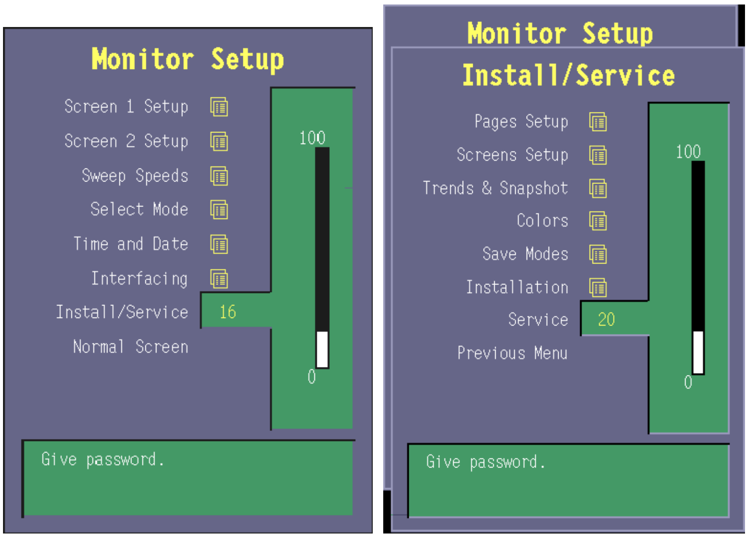
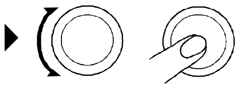



**Figure 7** **M-PP troubleshooting flowchart**

# 5 SERVICE MENU

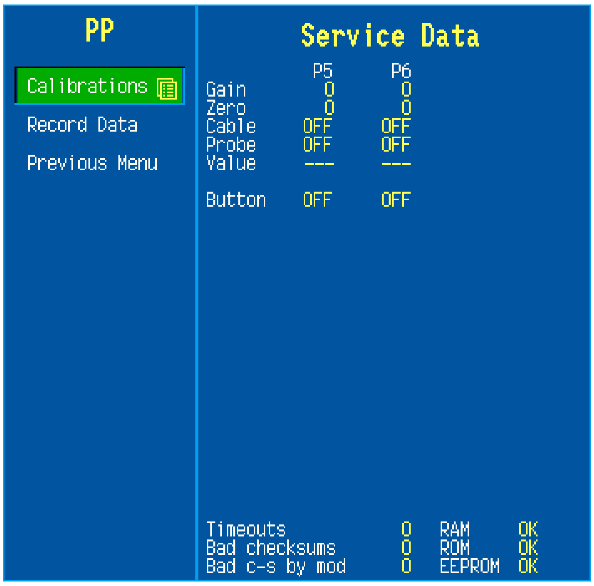
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters***.
5. Select ***PP module***.

## 5.1 PP menu




**Calibrations** See section 5.2 "PP Calibrations Menu."

**Record Data** **Record Data** prints out the service data and circuit board information (id., serial number, and software id.) on the Recorder Module, M-REC.

**Service Data** **Gain** is a coefficient to compensate for gain error. Usually the values for P5 and P6 are between 17000 and 25000.
**Zero** indicates the offset compensation value for each parameter in the A/D converter. Typically the values for P5 and P6 are within ±1000. Calibrate if the zero and/or gain value is outside the ranges.

**Cable** shows ON when the corresponding cable is connected to the front panel and **Probe** shows ON when the corresponding probe is connected to the cable.

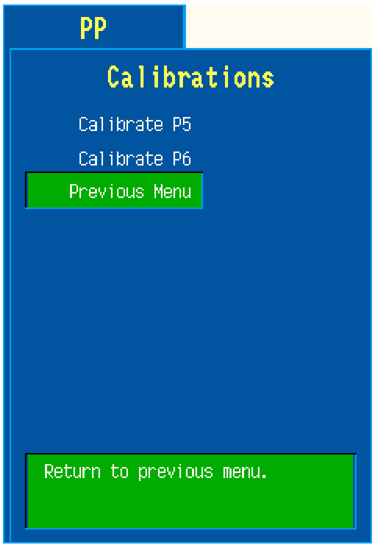
**Value displays** the measured numeric values simultaneously. Pressure value is a real time value and shown in mmHg.

**Button**; the front panel key function can be confirmed by pressing the key and checking that OFF turns to ON.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to the monitor has failed. **Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) during normal operation indicates either a serial communication failure or the module is not in place.

**RAM** indicates the state of the RAM memory. **ROM** indicates whether the checksum in the EPROM is in accordance with the software calculated value. **EEPROM** indicates whether the values stored in the permanent memory are valid. The state is either **OK, Fail** or **?** (module not in place or a communication error).

## 5.2 PP calibrations menu




**Calibrate P5 and Calibrate P6**

These functions are for calibrating invasive blood pressure channels P5 and P6. The calibrations require a pressure transducer (with an appropriate cable) and a pressure manometer.

Calibration:

1. Connect the pressure transducer with the pressure manometer to the P5 / P6 connector. Select Calibrate P5 / Calibrate P6. Leave the transducer at room air pressure.
2. Push the ComWheel to start zeroing.
3. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
4. Set the pressure on the display to match the pressure reading on the manometer and push the ComWheel.

# 6 SPARE PARTS

NOTE: Accessories are listed in the *Patient Monitor Supplies and Accessories*.

## 6.1 Dual Pressure Module, M-PP, Rev. 00, 01

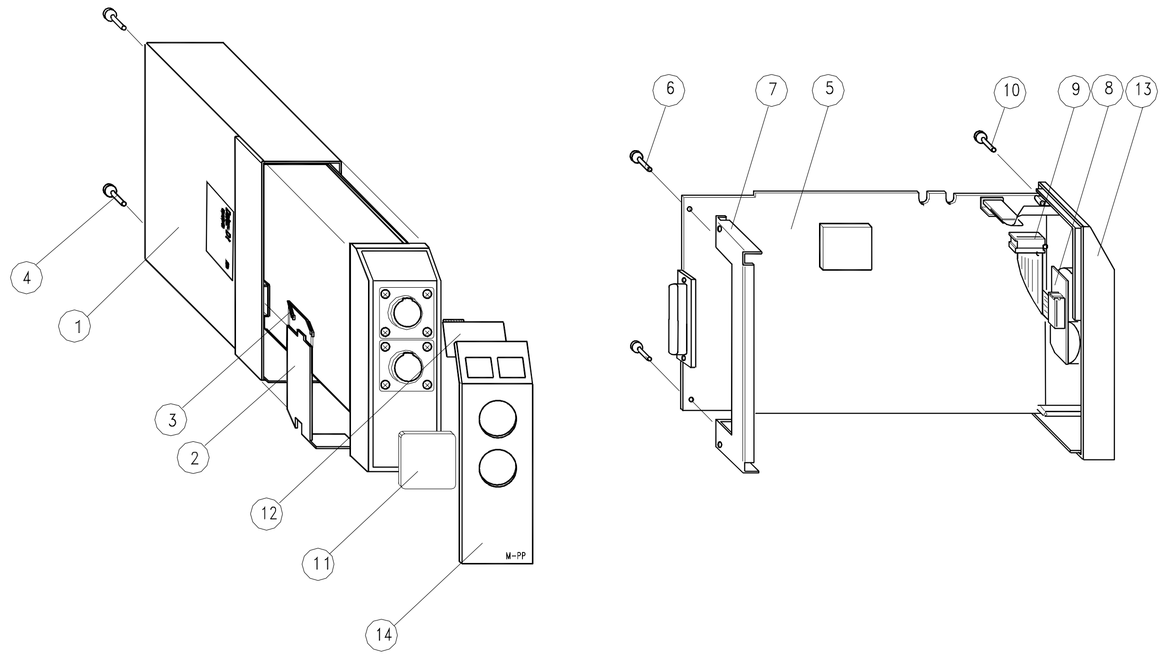



**Figure 8** **Exploded view of M-PP**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | PP board, M-PP (Rev.00-01) | 8000998 | |
| 6 | Cross cylinder-head screw M3x6 | 61721 | |
| 7 | Metal frame | 891034 | |
| 8 | PP input board, M-PP | 891308 | |
| 9 | Flat cable, M-PP | 891573 | |
| 10 | Cross cylinder-head scerw M3x12 | 628700 | |
| 11 | Fitting plate | 879510 | |
| 12 | Membrane keypad | 880101 | |
| 13 | SP-Front mask | 879094 | |
| 14 | Front Panel sticker, DA ; M-PP (rev.00) | 892212 | 898756 |
| 14 | Front Panel sticker, DA ; M-PP (rev.01) ; S/5 | 898756 | |
| 14 | Front Panel sticker, DE ; M-PP (rev.00) | 891293 | 898747 |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 14 | Front Panel sticker, DE ; M-PP (rev.01) ; S/5 | 898747 | |
| 14 | Front Panel sticker, EN ; M-PP (rev.00) | 889463 | 898746 |
| 14 | Front Panel sticker, EN / PT ; M-PP (rev.01) ; S/5 | 898746 | |
| 14 | Front Panel sticker, EN / PT ; M-PP (rev.01) ; S/5 | 898746 | |
| 14 | Front Panel sticker, ES ; M-PP (rev.00) | 891298 | 898750 |
| 14 | Front Panel sticker, ES ; M-PP (rev.01) ; S/5 | 898750 | |
| 14 | Front Panel sticker, FI ; M-PP (rev.00) | 891297 | 898753 |
| 14 | Front Panel sticker, FI ; M-PP (rev.01) ; S/5 | 898753 | |
| 14 | Front Panel sticker, FR ; M-PP (rev.00) | 891294 | 898748 |
| 14 | Front Panel sticker, FR ; M-PP (rev.01) ; S/5 | 898748 | |
| 14 | Front Panel sticker, IT ; M-PP (rev.00) | 891299 | 898751 |
| 14 | Front Panel sticker, IT ; M-PP (rev.01) ; S/5 | 898751 | |
| 14 | Front Panel sticker, JA ; M-PP (rev.00) | 894966 | 898757 |
| 14 | Front Panel sticker, JA ; M-PP (rev.01) ; S/5 | 898757 | |
| 14 | Front Panel sticker, NL ; M-PP (rev.00) | 891295 | 898749 |
| 14 | Front Panel sticker, NL ; M-PP (rev.01) ; S/5 | 898749 | |
| 14 | Front Panel sticker, NO ; M-PP (rev.00) | 893570 | 898755 |
| 14 | Front Panel sticker, NO ; M-PP (rev.01) ; S/5 | 898755 | |
| 14 | Front Panel sticker, PT ; M-PP (rev.00) | 895238 | 898746 |
| 14 | Front Panel sticker, SV ; M-PP (rev.00) | 891296 | 898754 |
| 14 | Front Panel sticker, SV ; M-PP (rev.01) ; S/5 | 898754 | |

# 7 EARLIER REVISIONS

This manual also supports the earlier revisions of the Dual Pressure Module, M-PP

# APPENDIX A

# SERVICE CHECK FORM

## Dual Pressure Module, M-PP

| | | | |
|---|---|---|---|
| Customer | | | |
| Service | | Module type | S/N |
| Service engineer | | | Date |

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | | | | |

| | | |
|---|---|---|
| 4. Module software | PP | |
| 5. Communication and memories | ☐ ☐ ☐ | |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 6. Membrane keys | ☐ | ☐ | ☐ | 7. Cable and transducer detection | ☐ | ☐ | ☐ |
| 8. Calibration | ☐ | ☐ | ☐ | 9. Test with patient simulator | ☐ | ☐ | ☐ |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 10. Electrical safety check | ☐ | ☐ | ☐ | 11. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 12. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes** ______________________________

**Used Spare Parts** __________ __________ __________

**Signature** ______________________________

# Datex-Ohmeda

# S/5™ NIBP Module, M-NIBP (Rev. 05)

# Technical Reference Manual Slot


All specifications are subject to change without notice.

Document No. 800 1015-5

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## NIBP Module, M-NIBP

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 NIBP module, M-NIBP. The Non-Invasive Blood Pressure parameter module, M-NIBP is a double width plug-in module designed for use with the S/5 monitors. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

Please also refer to the *Technical Reference Manual* of the S/5 monitor for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.


**Figure 1 Non-invasive blood pressure Module, M-NIBP**

NOTE: Do not use identical modules in the same monitor simultaneously. The M-NIBP and M-NE(12)STPR/-NESTR/-NETPR/M-MRI/M-MRIP are considered as identical modules.

NOTE: Non-invasive blood pressure Module, M-NIBP functions with all monitor software levels from 93 and newer.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 75 × 180 × 112 mm/3.0 × 7.1 × 4.4 in |
| Module weight | 0.7 kg/1.5 lbs |
| Power consumption | about 4 W |

## 1.2 Typical performance

Oscillometric measurement principle.

| | | |
|---|---|---|
| Measurement range | adult | 25...260 mmHg |
| | child | 25...195 mmHg |
| | infant | 15...145 mmHg |
| Accepted HR | 30...250 bpm | |
| Measurement interval | 1, 2.5, 3, 5, 10, 15, 30, 60 min (=1h), 2h, 4h | |
| Measurement time, typical | adult | 23 s |
| | infant | 20 s |
| Initial inflation pressure | adult | 185 ±10 mmHg |
| | child | 150 ±10 mmHg |
| | infant | 120 ±10 mmHg |
| Venous stasis | adult | 80 ±10 mmHg / 2 min |
| | child | 60 ±10 mmHg / 2 min |
| | infant | 40 ±10 mmHg / 1 min |
| Cuff widths | Please see *User's Guide* | |

## 1.3 Technical specifications

| | |
|---|---|
| Deflation rate, HR dep. | 5...13 mmHg/sec |
| Inflation rate, typical | 20...185 mmHg, 1...5 s |

Automatic software control, max. inflation pressure

| | |
|---|---|
| adult | 280 ±10 mmHg |
| child | 200 ±10 mmHg |
| infant | 150 ±10 mmHg |

Over pressure limit, stops measurement after 2 seconds

| | |
|---|---|
| adult | 320 mmHg |
| child | 220 mmHg |
| infant | 165 mmHg |

A safety valve limits the maximum cuff pressure to 320 mmHg in adult/child mode or 165 mmHg in infant mode. An independent timing circuit limits pressurizing (>15 mmHg) time to 2 minutes 10 seconds maximum in adult/child mode, and 1 minute 5 seconds in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, inflation pressure is increased typically 50 mmHg.

| | | |
|---|---|---|
| Max. measurement time | adult | 2 min. |
| | child | 2 min. |
| | infant | 1 min. |

Pressure transducer accuracy is better than ±3 mmHg or ±2 % (whichever is greater). Max. error ±4 mmHg.

| | |
|---|---|
| Protection against electrical shock | Type BF defibrillation proof |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for NIBP measurement:

- NIBP module
- Twin hose (adult or infant model)
- Blood pressure cuffs (different sizes)

## 2.2 Main components

The NIBP module consists the following parts:

- NIBP board
- Pneumatics and hosing
- NIBP air pump
- Zero valve
- Check valve
- Bleed valve
- Exhaust valves (2)
- Pressure transducers (2)
- Module keyboard and status indicator LEDs
- Front panel keys: Auto On/Off, Set Cycle Time, Stat On/Off, Start/Cancel

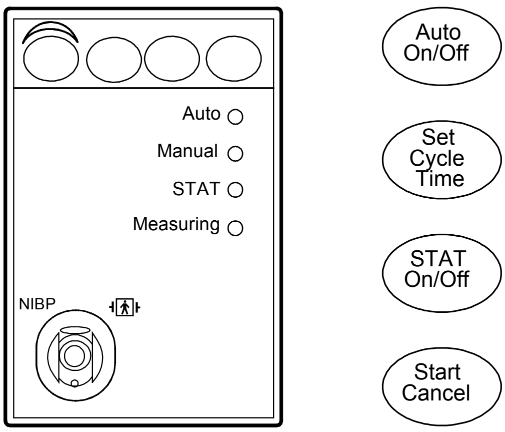



**Figure 2 Front panel of NIBP Module**

## 2.2.1 NIBP board

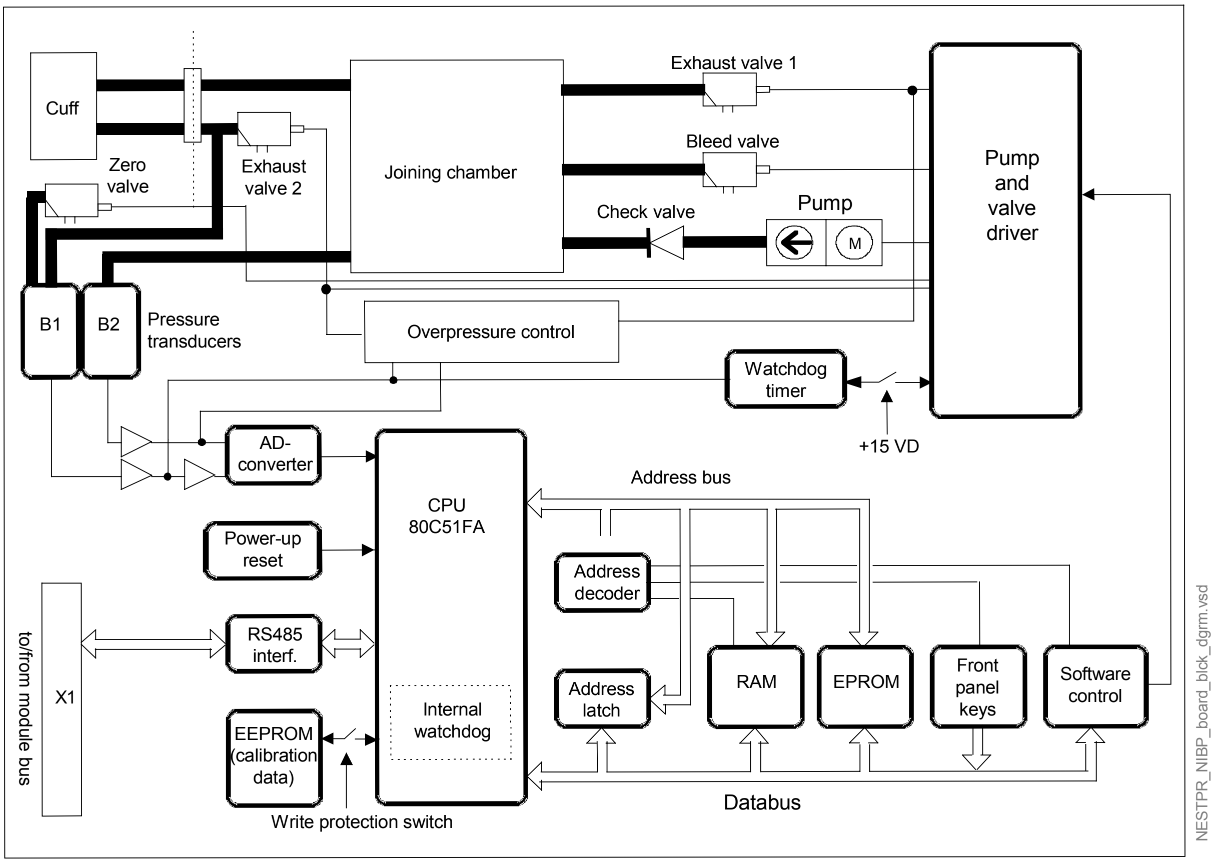



**Figure 3 NIBP board functional block diagram**

### Pressure transducers

The NIBP board contains two piezoresistive type pressure transducers. One is used for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement (B1). The other is used for detection of cuff hose type, cuff loose and cuff occlusion situations etc. (B2). The transducers are internally temperature compensated. They are supplied by a constant voltage and their output voltage changes up to 40 mV max. (50 kPa, 375 mmHg).

### Signal processing

Two signals from the pressure transducers are amplified and sent to A/D converter. Before the converter, one of the signals is used to adjust the offset of the pressure safety level. After the converter, digitized signals are sent to the microprocessor for data processing.

The NIBP board is controlled with 80C51FA microprocessor at 16 MHz oscillator frequency. Communication between the module and the monitor CPU board is established via an RS485 serial interface at 500 kbps data transfer rate.

## Memory

NIBP program memory (EPROM) size is 128k × 8. RAM size is 32k × 8 bit and it stores variable values in NIBP measurement. EEPROM is size 64 × 16 bit and is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and module serial number.

## Software control

Software controls the valves and pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used during pump/valve failures.

In addition to an external RS485 reset line the microprocessor system is equipped with its own power-up reset.

## Watchdog timer

The NIBP board is equipped with software independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than the preset time. As soon as the cuff pressure rises over a specified pressure limit, the timer starts counting. The timer is adjusted to stop the pump and open the valves in 2 minutes 10 seconds in adult/child mode and in 1 minute 5 seconds in infant mode.

## Valves

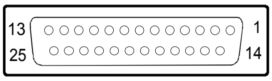
Exhaust valves are used for emptying the cuff and the joining chamber after the measurement.
Exhaust valve 1 is also used as a safety valve in infant mode. The valve opens at 165 mmHg.
Exhaust valve 2 is also used as a safety valve in adult mode and opens at 320 mmHg.
The bleed valve is used for emptying the cuff during the measurement. The zero valve is used for connecting the pressure transducer B1 to open air.

## Power supply section

All connections are established via a 25-pin connector (D-type, female). The module needs +5 V, ±15 V, and +15 VD (dirty) power supply to operate. The pump and the valves use a separate +15 VD power line. The supply voltages are generated in the power supply section of the S/5 monitor. The reference voltages ±5 $V_{ref}$ and +10 $V_{ref}$ are generated on the NIBP board.

# 2.3 Connectors and signals

## 2.3.1 Module bus connector




**Module Bus connector (X1)**

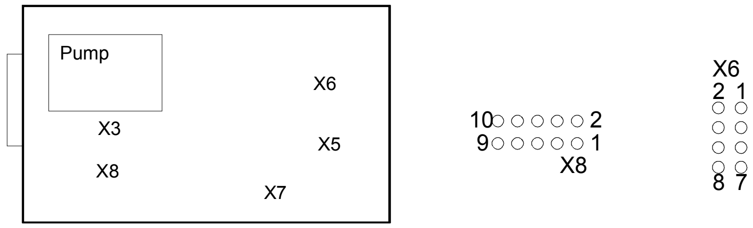
| Pin No | I/O | Signal | Not used |
|---|---|---|---|
| 1 | I | RESET_RS485 | |
| 2 | I | -15 VDC | |
| 3 | I | +15 VDIRTY | |
| 4 | I | +15 VDC | |
| 5 | I/O | -DATA_RS485 | |
| 6 | I/O | DATA_RS485 | |
| 7 | - | Ground & Shield | |
| 8 | I | -RESET_RS485 | |
| 9 | I | CTSB | * |
| 10 | O | RTSB | * |
| 11 | I | RXDB | * |
| 12 | O | TXDB | * |
| 13 | - | Ground & Shield | |
| 14 | I | +32 VDIRTY | * |
| 15 | I | GroundDIRTY | |
| 16 | I | CTSC | * |
| 17 | O | RTSC | * |
| 18 | I | RXDC | * |
| 19 | O | TXDC | * |
| 20 | - | ON/STANDBY | * |
| 21 | - | PWM_ECG | * |
| 22 | - | RXDD_RS232 | * |
| 23 | - | TXDD_RS232 | * |
| 24 | I | +5 VDC | |
| 25 | I | +5 VDC | |

***Not used in the M-NIBP module**

## 2.3.2 Test points

### NIBP board

There are test pad blocks on solder side.
X8 and X6 pads and voltages are:




**X8**

| Pin No | Signal |
|---|---|
| 1 | GND |
| 2 | WD out |
| 3 | reset |
| 4 | +5 V |
| 5 | +15 V dirty |
| 6 | +15 V |
| 7 | -15 V |
| 8 | - |
| 9 | - |
| 10 | GND |

**X6**

| Pin No | Signal |
|---|---|
| 1 | GND |
| 2 | A1 output |
| 3 | - 5 V |
| 4 | +5 V ref |
| 5 | B1 out - (A1 input) |
| 6 | B1 out + |
| 7 | B2 out + |
| 8 | B2 out - |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the M-NIBP module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with the appropriate tools and equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Pressure manometer | | |
| Adult cuff & hose | | |
| Infant cuff & hose | | |
| Screwdriver | | |

### 3.2.2 Recommended parts

| Part | Order No. | Notes |
|---|---|---|
| NIBP pump filter | 57142 | |

- Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - EMC covers are attached properly
   - the calibration protection switch on the NIBP board is intact
   - tubes are not pinched and there are no sharp bends on them

- tubes are connected properly
- the upper of the cuff connector tubes, as well as the related tube connector are marked
- there are no loose objects inside the module

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - the cuff connector is intact and is attached properly
   - the module box, the latch and the spring pin are intact

3. Replace the NIBP pump filter, if necessary.

- Reattach the module box and check that the latch is moving properly.
- Switch the monitor on and wait until the monitoring screen appears.
- Make sure that NIBP information is selected to be shown on the screen:

**Monitor Setup** ***- Screen 1 Setup - Digit Fields - Field 2 - NIBP***

4. Plug in the module. Check that it goes in smoothly and locks up properly

5. Check that the module is recognized, i.e. the NIBP headers appear on the selected digit field.

6. Enter the service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8)

   Take down the information regarding NIBP module software by selecting ***Scroll Vers*** and turning the ComWheel.

7. Enter the NIBP module service menu:

   ***Parameters - NIBP***

   Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' show all OK.

   ✍

8. Check the front panel LEDs and membrane keys.

   Select ***Buttons/Leds***

   Highlight the text ***Auto ON***. Check that the LED for the autocycle measurement is turning on and off on the module front panel when pressing the ComWheel. Check also the other LEDs by selecting ***Manual ON***, ***STAT ON*** and ***Measur. ON***.

   Press each of the module's membrane keys at least for one second. Check that the pressed key is identified, i.e. the text OFF changes to ON for the key in the menu.

   ✍

9. Check the pump and valves.

   Select ***Pneumatics*** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

   Highlight ***Start Pump*** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

   Highlight ***Open Exh1***. Press the ComWeel and check that the pressure inside the tubing system starts to drop then press the ComWheel again. Check the other exhaust valve by the same way by selecting ***Open Exh2*** from the menu.

   If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

   Highlight ***Open Zerovalve***. Press the ComWheel and check that the pressure B1 $\cong$ 0 mmHg. Close the zero valve by pressing the ComWheel again and check that the pressure B1 is equal with the pressure B2.

   Highlight ***Set Valve***. Press the ComWheel and set the value under the text 'Pulse Valve' to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting ***Previous Menu***.

   ✍

10. Check the NIBP tubing system for leakages.

    Select ***Calibrations*** from the NIBP service menu.

    Keep the pressure manometer connected to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 265 mmHg and then the pump stops.
    Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 6 mmHg per one minute. Release the pressure by pressing the ComWheel once more.

11. Calibration check.

    Recalibrate the NIBP measurement. Remember to set the calibration protection back on after the calibration.

    Disconnect the pressure manometer. Select ***Calibrations*** and then highlight ***Calibration Check***. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ±10 mmHg.

    Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

12. Check the watchdog timer activation pressure.

    Select ***Pneumatics*** from the NIBP service menu.

    Keep the pressure manometer connected to the cuff connector. Pump up the pressure very slowly and note the value on the manometer when your hear a signal from the loudspeaker. The pressure at where the watchdog timer should activate with an audible signal is

    13 mmHg (11...15 mmHg)

    Adjust the limit with the trimmer on the NIBP board, if necessary.

13. Check the watchdog timer.

    Select ***Watchdog*** from the NIBP service menu.

    Check the watchdog timer in the adult mode. Activate the timer by highlighting ***Test ADULT*** and then pressing the ComWheel. Check that the time beside the text 'Watchdog Interval' starts to run. Wait until you hear a signal from the loudspeaker and then check the time again. The time from the adult test should fall within 120...140 seconds.
    Check the watchdog timer also in the infant mode by first selecting ***Test INFANT*** from the menu. The time from the infant test should fall within 60...70 seconds.

    ✍

14. Check the safety valve.

    Select ***Safety Valve*** from the NIBP service menu.
    Keep the pressure manometer connected to the cuff connector.

    NOTE: Make sure your pressure manometer can be used to measure pressures over 300 mmHg. If such a pressure manometer is not available, perform the check with an adult cuff that is connected around some round object, for example calibration gas bottle.

    Highlight ***Start Test***. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated. Check the pressure values 'Max press' and '2 s after stop' for both transducers. All the values should be within 290...330 mmHg.

    Highlight ***Adult***. Press the ComWheel and check that the text changes now to ***Infant***. Select ***Start Test*** and wait until the pump stops and the pressure values on the screen have been updated. Check that the values 'Max press' and '2 s after stop' are all now within 154...165 mmHg.

    Return to the normal monitoring mode by pressing **Normal Screen**.

    ✍

15. Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses.
    Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message 'Cuff loose' appears on the screen within 30 seconds.

    Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message 'Cuff occlusion' appears on the screen within 30 seconds.

    ✍

16. Check that automatic inflation limits are in use:

    **NIBP** ***- NIBP Setup - Inflation Limits - Auto - Previous Menu***

    Connect the cuff onto your arm, highlight ***Start Ven.Stasis*** in the NIBP menu and press the ComWheel. Check the module identifies the cuff, i.e. the text 'Adult' appears into the NIBP digit field for a short moment.

    Keep the pressure inside the cuff for about half a minute in order to see that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.

17. Keep the cuff on your arm and perform one NIBP measurement. Check that the module gives a reasonable measuring result.

18. Connect an infant cuff to cuff connector and wrap it around your fingers.
    Start NIBP measurement and check that the module identifies the cuff, i.e. the text 'Infant' appears into the NIBP digit field. Cancel the measurement after the cuff identification.

19. Perform electrical safety check and leakage current test.

20. Check that the module functions normally after the performed electrical safety check.

21. Clean the module with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

**Rev. 01-03** Disassemble the M-NIBP module in the following way. See the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with loose latch and spring pin for locking.
3. To detach the NIBP board remove the four corner screws from the back of NIBP board. The NIBP board and the front panel can be detached.
4. To free the front panel and the NIBP board, disconnect tubes and connectors.
5. Remove the five screws and lift off the plastic pump cover. NIBP pump, safety (over pressure) valve, and valve unit which includes two valves, wires and a connector will be exposed. Remove them.
6. Pull out pulse valve from the bottom of the NIBP frame.

**Rev. 04 ->** Disassemble the M-NIBP module in the following way. See the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with loose latch and spring pin for locking.
3. To detach the NIBP board remove the support plate by 2 screws (item 25).
4. Remove the metal frame (item 26).
5. Detach the damping chamber with 3 screws.
6. Detach 2 screws (item 9).
7. To free the front panel and the NIBP board, disconnect tubes and connectors.
8. Remove the two screws and lift off the pump. NIBP pump, and valve unit which includes four valves, wires and a connector will be exposed. Remove them.

CAUTION Before reattaching the module box, make sure that the tubes are not pinched between the NIBP frame and the PC board.

NOTE: Take care that the connectors and especially the tubes are reconnected properly and to the correct ports.

# 3.4 Adjustments and calibrations

## 3.4.1 Pressure safety level detection “OFFSET”

Remove two screws at the rear of the module. Remove the module box. Connect first the service cable (e.g. a long Gas interface cable) to the module connector inside the monitor frame and then to the rear connector of the module. Switch the monitor on. Go to the NIBP service menu and select ***Pneumatics***. Pump reference pressure into the module:

13 mmHg (11...15 mmHg)

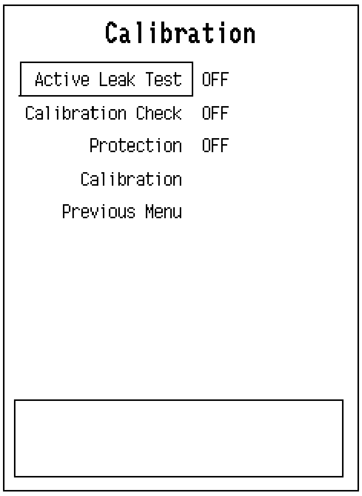
Adjust the trimmer until AD5 signal sign changes from negative to positive. Re-check the adjustement, then lock the trimmer with for example nail polish.

## 3.4.2 NIBP calibrations

The electronics of the NIBP pressure measurement is calibrated at the factory. Zeroing pressure is automatically maintained by the processor. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced. The calibration can be checked and recalibrated in the NIBP service menu.
The calibration of the primary pressure channel can also be checked from the NIBP setup menu (NIBP, NIBP Setup, Calibration Check). In this case the auto zeroing is performed at start - remove hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

## Calibration check

1. Enter Calibration menu.




2. Select ‘Calibration Check’ and press the ComWheel.
3. Connect an external precision manometer to the module.

4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display:

| Pressure | Max. error | Example |
|---|---|---|
| 0 mmHg | ±9 mmHg (=zero offset) | -2 |
| 100 mmHg | 100 + zero offset ±2 mmHg | 98 ±2 |
| 200 mmHg | 200 + zero offset ±3 mmHg | 198 ±2 |

I

f the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, we recommend recalibrating the module also when the error of B2 is larger than specified above to ensure best possible operation.

## Calibration

1. Enter Calibration menu.
2. Remove hoses from front panel connector to enable proper zeroing.
3. Select ***Calibration***. If it is not available, perform the steps A, B and C.

NOTE: Do not pull out the NIBP module from the monitor frame. The module must be in the frame during the entire procedure.

A) Turn the toggle switch at the bottom of the NIBP module to enable the calibration. Turn the switch to the right by, for example, a sharp pencil. This enables menu selection ‘Protection’. the message ‘Calibration switch ON!’ appears.

B) Select Protection OFF in the Calibration menu and press the ComWheel.

C) Return the toggle switch to the left. Menu selection ***Calibration*** is now enabled, and ***Protection*** is disabled. When the calibration is enabled, a message ‘Calibration not protected’ appears.

4. Start Calibration by pressing the ComWheel. Messages ‘ZEROING’ and ‘ZEROED’ will appear in the NIBP message field. After this a pressure bar will appear.
5. Connect an external mercury manometer with pump to module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure about 200 mmHg according to the manometer. Calibration is possible in the range 150 to 300 mmHg.
6. Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, press the ComWheel to confirm the calibration. The message ‘Calibrating’ will appear onto the NIBP digit field. After a few seconds it is followed by ‘Calibrated’, which means that the calibration has succeeded, and the new calibration data has been saved into EEPROM.

   NOTE! When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct (i.e. change the value for example one step higher and then back one step lower). “Calibrated” text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

**To set the protection on:**

Turn the toggle switch to the right. Select ***Protection*** ON and press the ComWheel. Then turn the toggle switch back to the left.

7. Remove the module from the frame and plug it back again. Then perform Calibration Check (see the preceding page) to verify the new calibration.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| Trouble | Cause | Treatment |
|---|---|---|
| No NIBP value displayed | NIBP not selected on screen. | Check monitor setup. |
| NIBP menu fading | No M-NIBP module, module not properly connected, or NIBP and NE(12)STPR/MRI module connected at the same time. | Plug in the module. |
| Artifacts-message | Unsuccessful measurement due to patient movements or shivering. | |
| Weak pulsation-message | Weak or unstable oscillation pulses due to:<br>– artifacts (accurate diastolic pressure difficult to measure)<br>– marked arrhythmia<br>– marked drop in diastolic pressure<br>– diastolic pressure difficult to measure<br>– improper cuff position or attachment<br>– too few pulses detected<br>– weak or unusual blood circulation<br>– may give systolic value | Check patient condition and retry.<br>Check any leaks and retry.<br>Use proper size of cuff. Check attachment. |
| Call service<br>Error X-message | NIBP hardware error.<br>X = error number. | See the description of the error message code, the causes and the solutions listed in the next chapter. |
| 'Cuff loose' message | 1. Hose and/or cuff not connected.<br>2. Hose and cuff connected.<br>Reason:<br>– cuff loosely wrapped<br>– leakage in cuff or hose<br>– leakage inside module<br>– pump does not work<br>– no pulses during the last three measurements | 1. Connect the hose and the cuff.<br>2.<br>– tighten the cuff<br>– replace cuff/hose<br>– check internal tubing and air chamber, and fix if necessary<br>– check pump connector; if OK, replace pump<br>– check cuff positioning |

| Trouble | Cause | Treatment |
|---|---|---|
| 'Air leakage' message | 1. Hose or cuff leaking.<br>Reason:<br>– cuff damaged<br>– cuff connector damaged<br>– O-ring damaged or missing<br>– hose double connector damaged<br>2. Hose and cuff OK.<br>Reason:<br>– leakage inside the module<br>– tube disconnected or damaged<br>– air chamber leaking<br>– tubes or valve(s) damaged | 1. Replace cuff<br>– replace cuff connector (if the fault is in hose connector, replace hose)<br>– replace O-ring<br>2. Connect or replace tube<br>– replace the whole tubing<br>– fix connections<br>– replace valve(s) |
| 'Unable to measure Sys' message | Systolic blood pressure probably higher than the maximum inflation pressure. | Automatic retrial with increased pressure. |
| 'Cuff occlusion' message | 1. Cuff and/or hose occluded.<br>Reason:<br>– cuff tube kinked<br>– tube inside module kinked<br>– occlusion inside/outside module<br>2. Cuff, hose, and tubes OK.<br>Reason:<br>– fault in pressure transducer<br>– fault in A/D converter<br>– faulty calibration<br>– missing voltages | 1.<br>– straighten tube<br>– remove occlusion<br>2.<br>– replace the NIBP board<br>– check calibration<br>– recalibrate |
| 'Calibration switch on' message | EEPROM protection switch at the bottom of the module is turned to right. | Enables setting the protection OFF in the Calibration menu. Turn switch to left if you are not going to calibrate. |
| 'Calibration not protected' message. | Calibration protection is set to OFF. | Set the protection ON in the NIBP Calibration menu. |

## 4.2 NIBP error code explanation

| Code | Explanation |
|---|---|
| 0 | RAM failure<br>Memory failure. Change NIBP board. |
| 1 | ROM checksum error<br>Memory failure. Change NIBP board. |
| 2 | +15V failure<br>Check short circuits. Change NIBP board. |
| 3 | -15V failure<br>Check short circuits. Change NIBP board. |
| 4 | EEPROM protection switch error. (only with S-STD93)<br>Turn the toggle switch to the left at the bottom of the module. |
| 5 | Calibration not protected. (only with S-STD93)<br>Protect calibration by selecting Protection ON in the NIBP calibration menu |
| 6 | ADC error<br>ADC circuit failure. Change NIBP board. |
| 7 | Watchdog time too short<br>Change NIBP board. |
| 8 | Watchdog time too long<br>Change NIBP board. |
| 9 | Watchdog activated<br>Change NIBP board. |
| 10 | EEPROM checksum error<br>Memory failure. Change NIBP board. |
| 11 | Auto zero range exceeded<br>Calibrate NIBP. |
| 12 | Communication break<br>Temporal break down of communication from monitor detected. Automatic recovery. |
| 14 | Too early Auto Start (needs 25 seconds without pressure). |

## 4.3 Troubleshooting flowchart

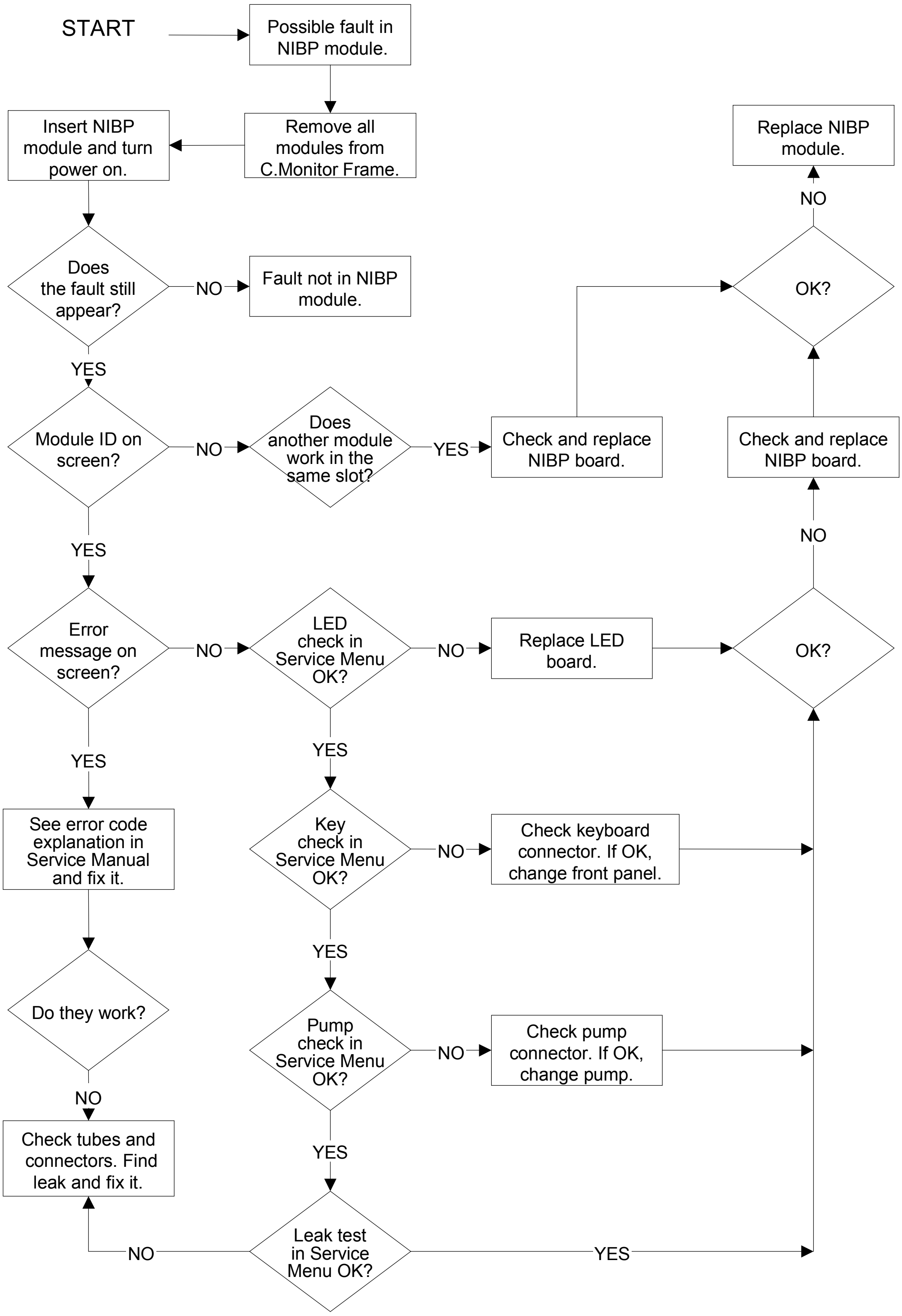
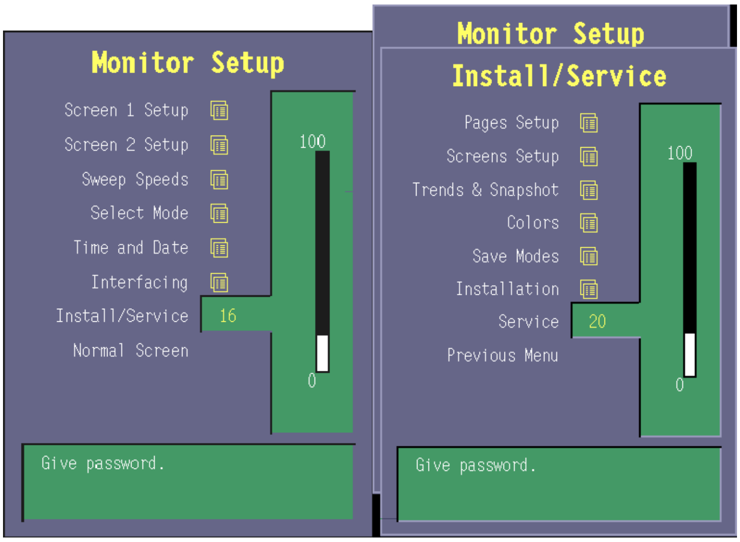
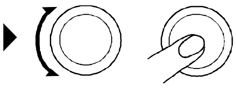



**Figure 4** **NIBP Module troubleshooting flowchart**

# 5 SERVICE MENU

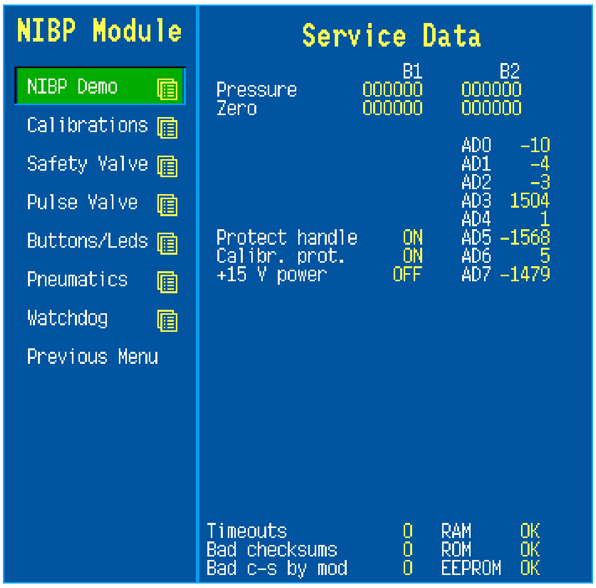
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters - NIBP***.

## 5.1 NIBP Service menu




**Service Data**

**Pressure** shows measured pressure multiplied by 10.
**Zero** shows pressure at auto zeroing multiplied by 10 and changes between +20 and -20 mmHg. Absolute pressure is the sum of **Pressure** and **Zero**.

**Protect handle** indicates hardware protection for EEPROM memory. It should be ON all the time in normal operation. If it is OFF data can not be read from or written to EEPROM, only the calibration protection can be set or reset by software. It can be turned to OFF by turning the toggle switch to the right at the bottom of the module, which also enables 'Protection ON/OFF' menu selection in the calibration menu.
**Calibr. prot.** shows software calibration protection and should be OFF to enable calibration.

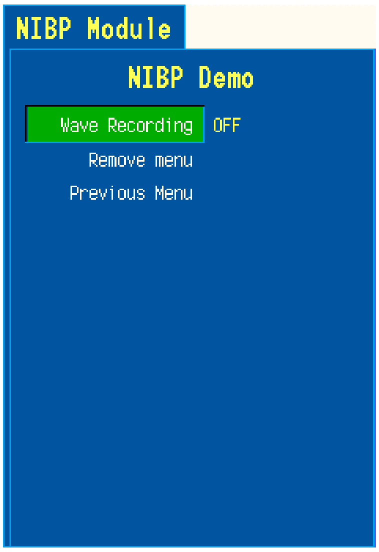
**+15 V power** indicates the condition of the supply voltage +15 Vdirty for the pump and valves. It exists (ON) or not (OFF) depending on service menu function. The supply voltage can be turned on by selecting the previous menu and then the desired menu again.

**AD0** to **AD7** show the values of each eight channels of A/D converter.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum in the EPROM is in accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.1.1 NIBP Demo menu



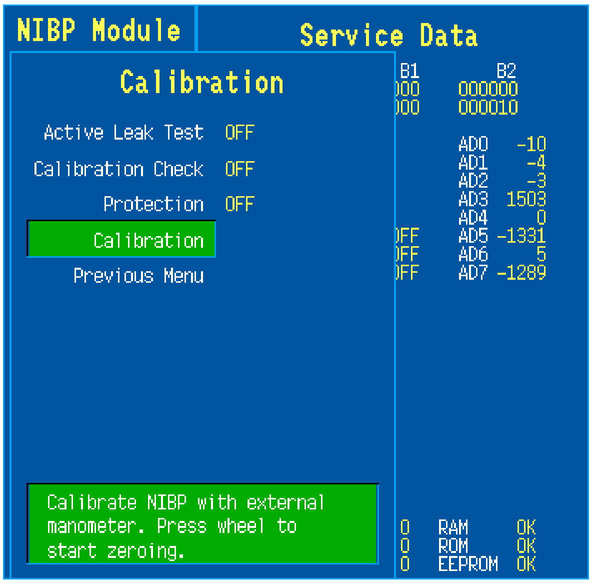

A service menu for demonstarting the oscillometric method of NIBP measurement. The menu shows the realtime pressure signals that are measured from the NIBP cuff. The measurement result is shown in the adjoining digit field.

**Wave Recording** **Wave Recording** is for selecting the recording option. If ON is selected, the pressure signals are recorded in realtime onto the M-REC paper.

**Remove menu** **Remove menu** widens the displayed waveform area.

**Previous Menu** The menu can be closed by selecting the **Previous Menu** or just by pressing the ComWheel if the **Remove menu** was selected.

## 5.1.2 NIBP Calibration menu




**Active Leak Test** Wrap an adult cuff around a pipe and connect the cuff to the module. Select the active leak test (ON). The module automatically pumps a pressure of 260 mmHg into the cuff. Wait for several seconds until the pressure stabilizes. Then check that the pressure reading does not drop more than 6 mmHg per minute. If it does, leaking point(s) should be detected and fixed. Cancel the test by selecting Active leak test OFF.

**Calibration Check**

Calibrate the NIBP measurement once a year. The checking and recalibrating can be done in the NIBP service menu.
Check the intake air filter as part of the calibration check. Change the filter if it is visibly dirty.
After the calibration check is selected (ON), manually pump pressure into the module and make sure that the same pressure values are shown both on the display and on manometer. Pressure of both pressure channels B1 and B2 are shown. Note that if the display shows +2 mmHg at zero pressure and if you pumped +200 mmHg into the module, the display should show +202 mmHg.

**Protection** Software calibration protection (ON/OFF). Select OFF when calibrating. Protection can be set to ON or OFF only when the toggle switch at the bottom of the module is set to the right.

**Calibration** Calibration selection is available only when protection is OFF.

NIBP calibration can be performed in the NIBP Service menu as follows:

NOTE: Both channels B1 and B2 must be calibrated simultaneously.

1. If **Protection** is ON change it to OFF by first turning the toggle switch to the right at the bottom of the module, which enables the **Protection** selection. Then turn the toggle switch to the left to enable **Calibration**.

NOTE : Do not disconnect the module from the frame when turning the switch. The module must be in the frame during the whole procedure.

NOTE: When the switch is at the right, the NIBP field shows an error message ‘Calibration switch on!’.

NOTE: When calibration is enabled, a message ‘Calibration not protected’ appears.

2. For proper zeroing to take place, remove the hose from the front panel connector. Select

**Calibration** and press the ComWheel. Messages 'ZEROING' and 'ZEROED' will appear in the NIBP message field. After this a pressure bar will appear beside the menu.

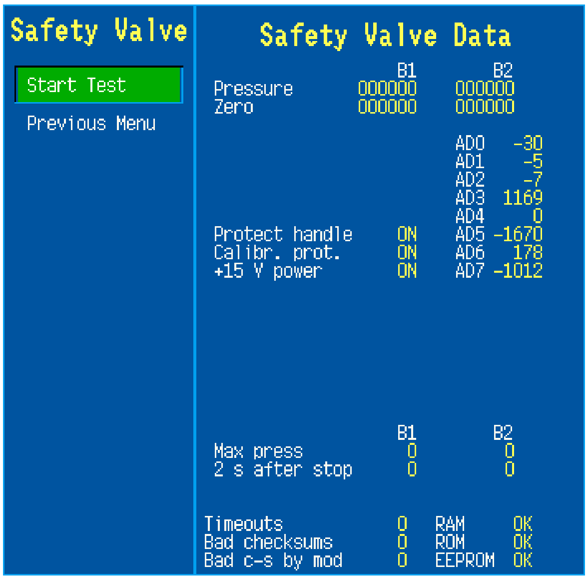
3. Connect an external mercury manometer with pump to module through the both tubes of the hose. Pump up to about 200 mmHg pressure (range of 150 to 300 mmHg allowed) according to the manometer. Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel.

4. When the values are equal, press the ComWheel to confirm the calibration. First the message 'Calibrating' will appear in the digit field for NIBP followed after a few seconds 'Calibrated', which means that the calibration data has now been saved.

   NOTE! When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct (i.e. change the value for example one step higher and then back one step lower). "Calibrated" text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

5. Use the bottom switch to enable **Protection** setting and set it ON, and finally disable **Protection** setting.

### 5.1.3 NIBP Safety Valve menu




**Start Test**

**Start test** is for starting and **Stop test** is for stopping the Safety Valve test.

**NOTE:** Parameter values in Service Data are for reference only.

### Safety Valve Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

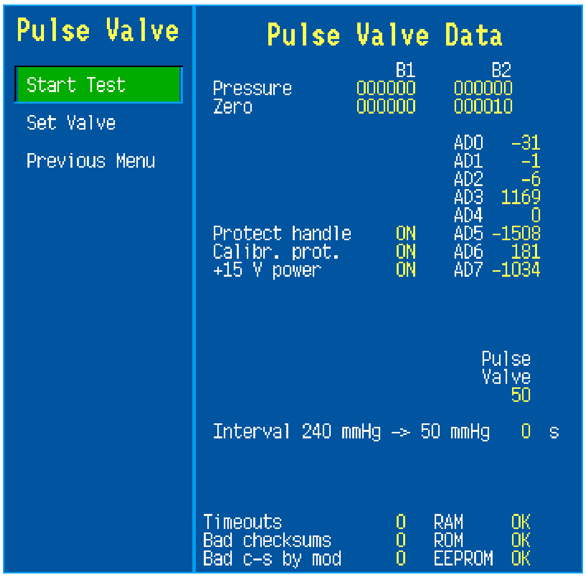
**Max. press** and **2 s after stop** show the measured values at Safety Valve test.

**Safety Valve Test Adult/Infant**
Wrap an adult cuff around a pipe and connect the cuff to the module. Highlight **Start test** and give the ComWheel a press. The test ends automatically or when **Stop test** (appears in place of **Start**

**test**) is pressed.

**Max. press** indicates the pressure at which the safety valve opens and is normally 310 ±15 mmHg for adult and 150 mmHg ±15 mmHg for infant. **2 s after stop** indicates the pressure at 2 seconds after the pump has stopped and is normally > 280 mmHg for adult and > 120 mmHg for infant. If the value is less, check leakage by the active leak test.

### 5.1.4 NIBP Pulse Valve menu




NOTE: Parameter values in Service Data are for reference only.

**Start Test** — **Start test** is for starting and **Stop test** is for stopping the test.

**Set Valve** — **Set Valve** lets you adjust the opening of the pulse valve.

## Pulse Valve Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts etc.**

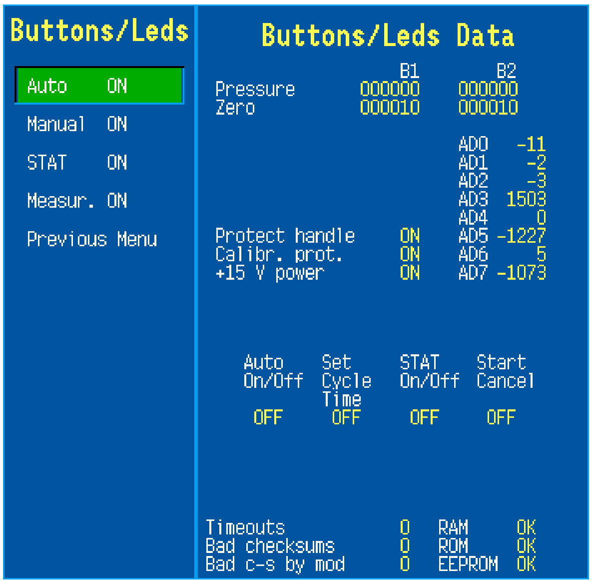
**Pulse Valve Checking**
Wrap an adult cuff around a pipe and connect the cuff to the module. Select the **Start test** and press the ComWheel. The pressure rises beyond 240 mmHg and stops. The pulse valve opens. The module counts the time it takes for the pressure to go down from 240 mmHg to 50 mmHg and displays it on the screen. The test can be manually stopped by selecting **Stop test**.

The valve can be adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First select Set Valve and press the ComWheel. See the pulse valve value and adjust it by turning the ComWheel. Then press the ComWheel to confirm the value.

The '**Interval 240 mmHg -> 50 mmHg**' time should be less than 60 seconds when the valve is '150' and less than 10 when fully opened (255). When fully closed (0), the system should be airtight and the pressure does not drop. Depending on an individual, the pulse valve may remain closed up to approx. value 45.

If the measured time deviates much from those above, then the pulse valve or its tubes are faulty.

### 5.1.5 NIBP Buttons/Leds menu




NOTE: Parameter values in Service Data are for reference only.

The front panel LEDs can be turned manually ON and OFF by selecting **Auto ON/OFF**, **Manual ON/OFF**, **STAT ON/OFF**, and **Measur. ON/OFF** from the menu.

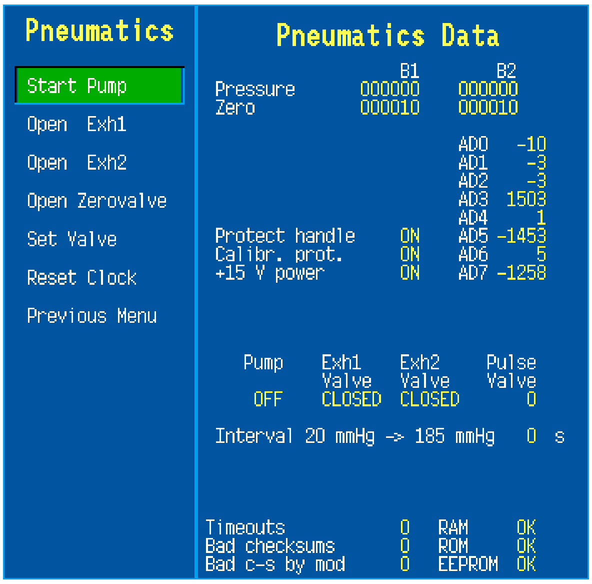
## Buttons/Leds Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

**Buttons Checking**

The front panel keys function is confirmed by pressing the key and observing OFF turns to ON at the corresponding text in the menu.

### 5.1.6 NIBP Pneumatics menu




NOTE: Parameter values in Service Data are for reference only.

**Start Pump/Stop Pump**

A manual control for the pump. The selection changes to **Stop Pump** when the pump turns on.

**Open Exh1/Close Exh1**

A manual control for the exhaust valve 1. The selection changes to **Close Exh1** when the valve is opened.

**Open Exh2/Close Exh2**

A manual control for the exhaust valve 2. The selection changes to **Close Exh2** when the valve is opened.

**Open Zerovalve/Close Zerovalve**

A manual control for the zero valve. The selection changes to **Close Zerovalve** when the valve is opened.

**Set Valve** With **Set Valve**, the opening of the pulse valve is adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First press the ComWheel, then turn it to adjust the value on screen and finally press to set the value.

**Reset Clock** **Reset Clock** will zero the time on the display.

## Pneumatics Data

See NIBP service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

**Pump, Exh1 Valve**, and **Exh2 Valve** show their states.

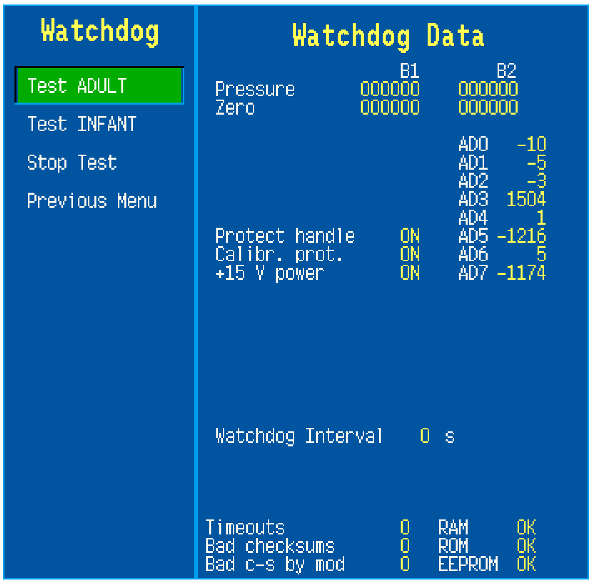
**Pulse Valve** shows how much the valve is opened (0 to 255) during Valve Setting.

**Interval 20 mmHg -> 185 mmHg Checking**

Select the **Start pump** at different combinations of the valves open/closed and press the ComWheel. The module counts the time it takes for the pressure to go up from 20 mmHg to 185 mmHg and displays it. When all the valves are closed, the pump should be able to pump the pressure in about 1 to 4 seconds into an adult cuff wrapped around a pipe. The pump does not stop without selecting the **Stop Pump** by pressing the ComWheel.

**Watchdog BEEP**
Connect manometer to the front panel and pump pressure into the module. When the AD5 value changes from negative to positive value (at about 5 mmHg) a beep is heard. This is the watchdog threshold pressure. Beyond this pressure the watchdog is active and cut pressures at about 2 min. (adult).

## 5.1.7 NIBP Watchdog menu




NOTE: Parameter values in Service Data are for reference only.

**Test ADULT** — **Test ADULT** is to test watchdog timer in adult mode (120 to 140 seconds).

**Test INFANT** — **Test INFANT** is to test watchdog timer in infant mode (about 60 to 70 seconds).

**Stop Test** — Stop Test is for stopping the test.

### Watchdog Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts etc.**

**Watchdog Interval** shows the time the +15 Vdirty stays on during the test.

**Adult watchdog time testing**
Select Test ADULT and press the ComWheel. Watchdog interval starts counting up seconds and keeps on counting as long as the +15 Vdirty is on. The time should be 120 to 140 seconds.

**Infant watchdog time testing**
Select Test INFANT and press the ComWheel. Watchdog interval starts counting up seconds and keeps on counting as long as the +15 Vdirty is on. The time should be 60 to 70 seconds.

# 6 SPARE PARTS

## 6.1 NIBP Module box

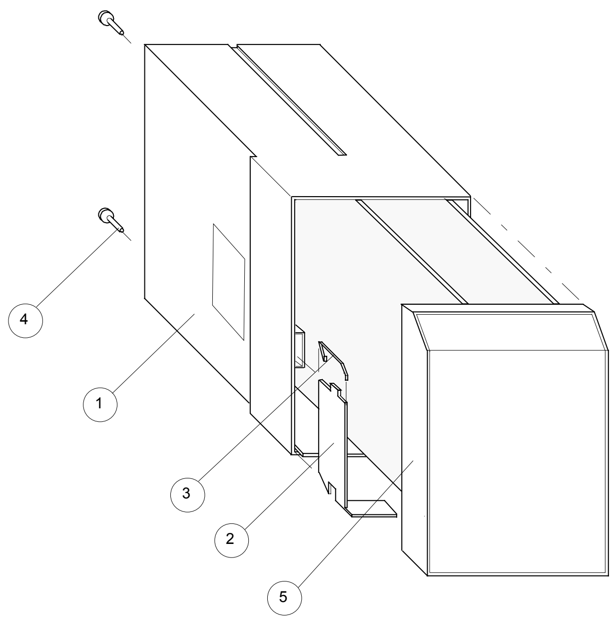



**Figure 5 Exploded view of the M-NIBP module box**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (wide) | 886168 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross reces screw 3 x 10 | 628706 | |
| 5 | Front mask unit, M-NIBP (includes all the connector and input boards) | 881335 | |

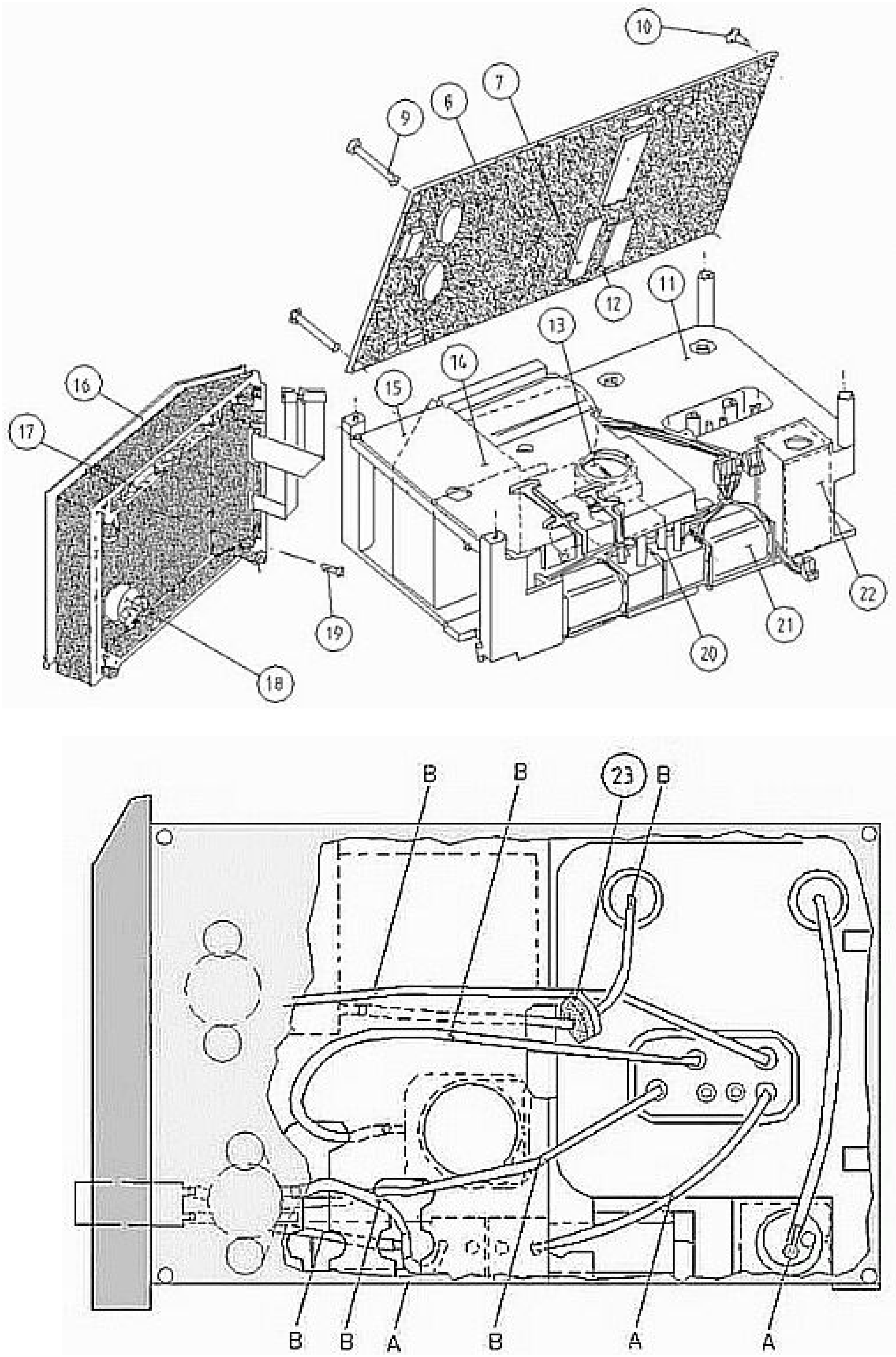



**Figure 6** **Exploded view of the M-NIBP module, rev. 00-03**

## 6.2 NIBP Module Rev. 00-03

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 7 | Software GAL for NIBP board | 880864 | |
| 8 | NIBP board, M-NIBP (rev.01) | 880359 | 883011 |
| 8 | NIBP board (rev.02) | 882418 | 883011 |
| 8 | NIBP board, M-NIBP (rev.03) | 883011 | |
| 9 | Cross cylinder head PT screw M3x20 | 628709 | |
| 10 | Cross cylinder-head PT screw M3x10 | 628703 | |
| 11 | NIBP frame, M-NIBP (rev.01-03) | 880427 | |
| 12 | Software GAL for NIBP board | 879866 | |
| 13 | NIBP Safety valve | 877109 | |
| 14 | NIBP pump, M-NIBP (rev.01-02) | 880363 | 883346 |
| 14 | NIBP pump, M-NIBP (rev.03) | 883346 | |
| 15 | Plastic pump cover, M-NIBP | 879176 | |
| 16 | Front Panel sticker, DA ; M-NIBP (rev.00-04) | 892215 | 898609 |
| 16 | Front Panel sticker, DA ; M-NIBP (rev.05) ; S/5 | 898609 | |
| 16 | Front Panel sticker, DE ; M-NIBP (rev.00-04) | 880476 | 898600 |
| 16 | Front Panel sticker, DE ; M-NIBP (rev.05) ; S/5 | 898600 | |
| 16 | Front panel sticker, EN ; M-NIBP (rev.00-04) | 879482 | 898599 |
| 16 | Front Panel sticker, EN ; M-NIBP (rev.05) ; S/5 | 898599 | |
| 16 | Front Panel sticker, ES ; M-NIBP (rev.00-04) | 884386 | 898603 |
| 16 | Front Panel sticker, ES ; M-NIBP (rev.05) ; S/5 | 898603 | |
| 16 | Front Panel sticker, FI ; M-NIBP (rev.00-04) | 888872 | 898606 |
| 16 | Front Panel sticker, FI ; M-NIBP (rev.05) ; S/5 | 898606 | |
| 16 | Front Panel sticker, FR ; M-NIBP (rev.00-04) | 880159 | 898601 |
| 16 | Front Panel sticker, FR ; M-NIBP (rev.05) ; S/5 | 898601 | |
| 16 | Front Panel sticker, IT ; M-NIBP (rev.00-04) | 886752 | 898604 |
| 16 | Front Panel sticker, IT ; M-NIBP (rev.05) ; S/5 | 898604 | |
| 16 | Front Panel sticker, JA ; M-NIBP (rev.00-04) | 888316 | 898610 |
| 16 | Front Panel sticker, JA ; M-NIBP (rev.05) ; S/5 | 898610 | |
| 16 | Front Panel sticker, NL ; M-NIBP (rev.00-04) | 886124 | 898602 |
| 16 | Front Panel sticker, NL ; M-NIBP (rev.05) ; S/5 | 898602 | |
| 16 | Front Panel sticker, NO ; M-NIBP (rev.00-04) | 893559 | 898608 |
| 16 | Front Panel sticker, NO ; M-NIBP (rev.05) ; S/5 | 898608 | |
| 16 | Front Panel sticker, PT ; M-NIBP (rev.00-04) | 895254 | 898605 |
| 16 | Front Panel sticker, PT ; M-NIBP (rev.05) ; S/5 | 898605 | |
| 16 | Front Panel sticker,SV ; M-NIBP (rev.00-04) | 885870 | 898607 |
| 16 | Front Panel sticker, SV ; M-NIBP (rev.05) ; S/5 | 898607 | |
| 17 | Led board, M-NIBP (rev.01-03) | 880361 | |
| 18 | NIBP Cuff connector | 64654 | |
| 19 | Cross cylinder-head scerw M3x12 | 628700 | |
| 20 | Port plug for 58534 | 58535 | |
| 21 | Magnetic valve, without port plug | 58534 | |
| 22 | Pulse valve (rev.03) | 880365 | |
| 23 | Check valve | 58542 | |

NOTE: The NIBP board 883011 replaces NIBP boards 880359 and 882418 only if used together with NIBP software 883902

## 6.3 NIBP Module Rev. 04

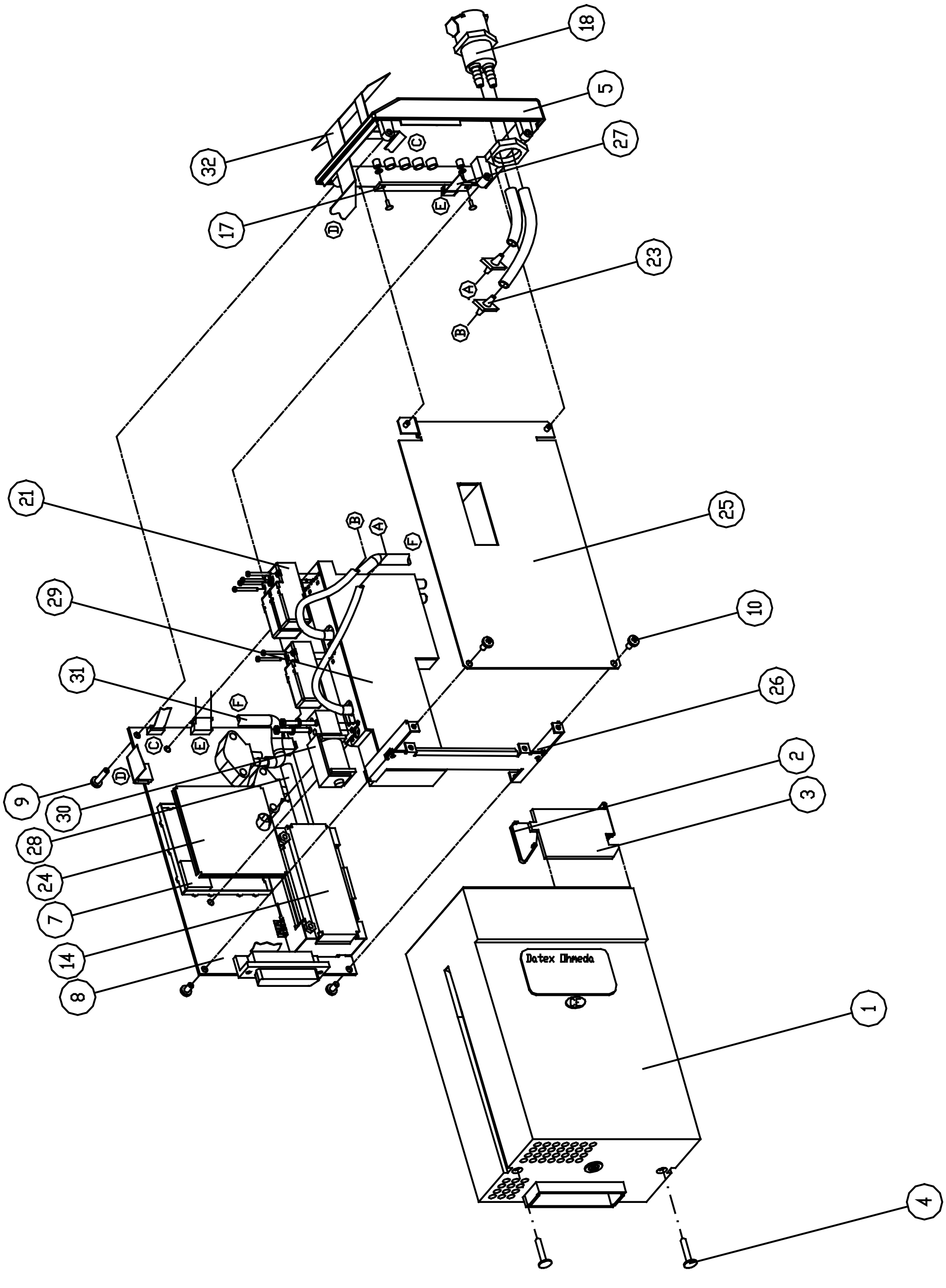



**Figure 7 Exploded view of the M-NIBP module, rev.04**

| Item | Description | Order No | Replaced by |
|---|---|---|---|
| 1 | Module box (wide) | 886168 | |
| 2 | Spring pin | 879182 | |
| 3 | Latch for module box | 879181 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front mask unit, M-NIBP (includes all the connector and input boards) | 881335 | |
| 8 | NIBP board, M-NIBP (rev. 04) | 894368 | |
| | NIBP board software (*) | 888237 | |
| 9 | Screw STZN 3.5x9.5 DIN 7981 | 62539 | |
| 10 | Cross cylinder-head screw M3x6 | 61721 | |
| 14 | NIPB pump, M-NESTPR, M-NIBP (rev.04) | 889993 | |
| 17 | Led board, M-NIBP (rev.04) | 893882 | |
| 18 | NIBP Cuff connector | 64654 | |
| 21 | Magnetic valve | 58562 | |
| 23 | Check valve | 58542 | |
| 24 | EMC cover | 888236 | |
| 25 | Support plate | 893881 | |
| 26 | Metal frame | 888230 | |
| 27 | Flat cable; LED | 894118 | |
| 28 | Air filter (NIBP) | 57142 | |
| 29 | Damping chamber, M-NESTPR, M-NIBP (rev.04) | 888240 | |
| 30 | Bleed valve, M-NESTPR, M-NIBP (rev.04) | 58566 | |
| 31 | Spring | 892676 | |
| 32 | Membrane keypad | 879374 | |

(*) NOTE! Do not install the NIBP board software 888237 into the NIBP modules M-NIBP rev. 00-03.

# 7 EARLIER REVISIONS

For service information on the earlier revisions, please refer to:

| | |
|---|---|
| NIBP Module revision 01 | Service Manual p/n 880850 |
| NIBP Module revision 02 | Service Manual p/n 882580 |
| NIBP Module revision 03 | Technical Reference Manual p/n 892953 |

# APPENDIX A

# SERVICE CHECK FORM

## Non-Invasive Blood Pressure Module, M-NIBP

| | | | | | |
|---|---|---|---|---|---|
| Customer | | | | | |
| Service | | Module type | | S/N | |
| Service engineer | | | | Date | |

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Pump's filter | ☐ | ☐ | ☐ | 4. Installation | ☐ | ☐ | ☐ |

Notes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. Recognition | ☐ | ☐ | ☐ | | | | |
| 6. Module software | NIBP | | | | | | |
| 7. Communication and memories | ☐ | ☐ | ☐ | 8. LEDs and membrane keys | ☐ | ☐ | ☐ |
| 9. Pump and valves | ☐ | ☐ | ☐ | | | | |

| | | |
|---|---|---|
| 10. Leak test | | ≤ 6 mmHg/min |

11. Calibration check

| | Measured B1 | Measured B2 | Allowed range |
|---|---|---|---|
| 0 mmHg | | | ±10 mmHg |
| 100 mmHg | | | 100 + z.o. ±2 mmHg |
| 200 mmHg | | | 200 + z.o. ±3 mmHg |
| 260 mmHg | | | 260 + z.o. ±4 mmHg |

z.o. = zero offset at 0 mmHg pressure

| | | |
|---|---|---|
| 12. Watchdog timer activation pressure | | 11...15 mmHg |

13. Watchdog timer

| | | Allowed range |
|---|---|---|
| Adult | | 120...140 s |
| Infant | | 60...70 s |

14. Safety valve

| | B1 | B2 | Allowed range |
|---|---|---|---|
| 'Max press' ADULT | | | 290...330 mmHg |
| '2 s after stop' ADULT | | | 290...330 mmHg |
| 'Max press' INFANT | | | 154...165 mmHg |
| '2 s after stop' INFANT | | | 154...165 mmHg |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 15. Cuff related messages | ☐ | ☐ | ☐ | 16. Adult cuff detection | ☐ | ☐ | ☐ |
| 17. Test measurement | ☐ | ☐ | ☐ | 18. Infant cuff detection | ☐ | ☐ | ☐ |

Notes ______________________________

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19. Electrical safety check | ☐ | ☐ | ☐ | 20. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 21. Final cleaning | ☐ | ☐ | ☐ | | | | |

Notes ______________________________

**Notes** ______________________________

______________________________

______________________________

______________________________

**Used Spare Parts** __________ __________ __________

**Signature** ______________________________

# Datex-Ohmeda

# S/5™ Recorder Module, M-REC (Rev. 03)

# Technical Reference Manual Slot


All specifications are subject to change without notice.

Document No. 8001016-3

January 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Recorder Module, M-REC



# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Recorder Module, M-REC. The REC module is a double width plug-in module designed for use with the S/5 monitors. Later in this manual may be refered to without the S/5 system nomenclature for simplicity..

Please also refer to the *Technical Reference Manual* of the S/5 monitor for information regarding system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The Recorder Module, M-REC provides real time printing of waveform and numerical data, and trend data.

The S/5 Compact Monitors may include a built-in recorder. The built-in recorder is technically the same as the Recorder Module.

NOTE: Printings on thermal paper may be destroyed when exposed to light, heat, alcohol etc. Take a photocopy for archive.


**Figure 1 Recorder Module, M-REC**

NOTE: The Recorder Module, M-REC, cannot be used in the Extension Frame, F-EXT4.
NOTE: The Recorder Module, M-REC functions with all monitor software versions.
NOTE: The Recorder Module, M-REC is not compatible with the Compact Monitor frames that contain the built-in recorder (F-CMREC, F-CMCREC, F-CMREC1 and F-CMCREC1).

# 1 SPECIFICATIONS

| | |
|---|---|
| Module size, W x D x H | 75 x 180 x 112 mm / 3.0 x 7.1 x 4.4 in |
| Module weight | 0.9 kg/ 2 lbs |
| Power consumption | 3 W |
| Principle | Thermal array |
| Print resolution | |
| Vertical | 8 dots/mm (200 dots/inch) |
| Horizontal | 32 dots/mm (800 dots/inch) at a speed of 25 mm/s and slower |
| Paper width | 50 mm, printing width 48 mm |
| Traces | Selectable 1, 2, or 3 traces |
| Print speed | 1, 6.25, 12.5, 25 mm/s |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Main components

### 2.1.1 Recorder board

The function of the recorder board is to establish an interface between the recorder unit and main CPU board in the monitor. The three front panel keys are connected to the recorder unit via the recorder board. The recorder unit and the recorder board are connected together with a small connector board and 12-pin flex-strip cable.

### External Communication

Communication with the main CPU board is via a +5 V CMOS level RS232 serial interface, with an RS485 reset.

**Reset** The differential RS485 reset from the module bus generates a Recorder Unit reset signal on the Recorder Board. The Recorder Board also generates a power-up-reset, whose time constant is approximately 0.1 second. The Recorder Unit reset signal is therefore active when either the Module Bus RS485-reset or the power-up-reset is active.

**+5 V priority** The recorder unit supply voltage, +15 VREC, is switched on after +5 V is present.

**Front panel keys** The recorder board can read the three front panel keys and pass their status on to the main CPU board.

To protect the keypad signals from static discharges, zener diodes and series resistors are used. Separate pull-up resistors are not needed because pull-up resistors connecting the keypad input signals to +5 V are inside the recorder.

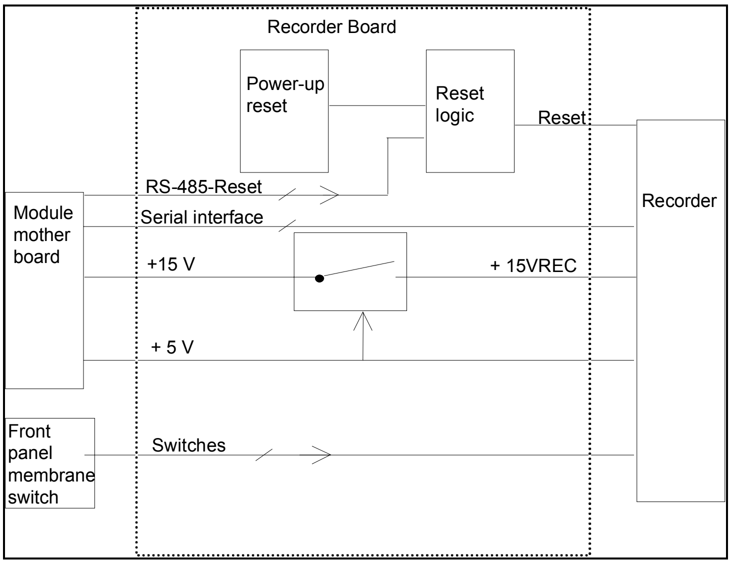



**Figure 2** **Recorder board block diagram**

## 2.2 Module bus connector

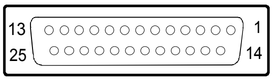



**Figure 3 Module Bus connector (X1) pin layout**

**Table 1 Module Bus connector (X1) pin description**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485 |
| 2 | - | Not connected |
| 3 | I | +15 VDIRTY |
| 4 | - | Not connected |
| 5 | - | Not connected |
| 6 | - | Not connected |
| 7 | - | Ground & Shield |
| 8 | I | -RESET_RS485 |
| 9 | O | CTSB |
| 10 | I | RTSB |
| 11 | O | RXDB |
| 12 | I | TXDB |
| 13 | - | Ground & Shield |
| 14 | - | Not connected |
| 15 | I | GroundDIRTY |
| 16 | - | Not connected |
| 17 | - | Not connected |
| 18 | - | Not connected |
| 19 | - | Not connected |
| 20 | - | Not connected |
| 21 | - | Not connected |
| 22 | - | Not connected |
| 23 | - | Not connected |
| 24 | I | +5 VDC |
| 25 | I | +5 VDC |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the Recorder Module, M-REC, is limited to replacing faulty circuit boards or mechanical parts. Faulty circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| M-NE(12)STPR/M-ESTPR/M-ESTP | | |
| Patient simulator | | |
| Screwdriver | | |

### 3.2.2 Recommended parts

| Part | Order No. | Notes |
|---|---|---|
| Recorder paper | 74205 | |

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring locking pin.

1. Check internal parts:
    - screws are tightened properly

- cables are connected properly
- EMC covers are attached properly (Rev. 02 ->)
- there are no loose objects inside the module

✍

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - the module box, latch and the spring locking pin are intact

   ✍

   - Reattach the module box and check that the latch moves properly.
3. Open the paper compartment hatch and take out the paper roll, if installed.

   Remove any paper chaff from the paper compartment.

   Clean the thermal printhead and the small glass window in front of the static brush with a cotton swab dipped in isopropyl alcohol. Avoid contact with the rubber paper roller.

   NOTE: Be careful to limit the application of alcohol to the thermal printhead and the window.

   Leave the paper compartment empty and close the hatch.

   ✍

   - Turn the monitor on and wait until the normal monitoring screen appears.
     Configure the monitor screen so that all required parameters are shown, for example:

   **Monitor Setup** ***- Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
   ***Field 2 - ECG2***
   ***Field 3 - P1***
   ***Field 4 - P2***
   ***Field 5 - PLETH***
   ***Field 6 - OFF***

   - Insert the Hemodynamic Moduleinto a module slot. Connect a patient simulator to the module and check that all connected parameters are shown on the screen.
   - Preset recording settings:

**Record/Print** - ***Record Waveforms - Waveform 1 - ECG1***
***Waveform 2 - P1***
***Waveform 3 - P2***
***Delay - Off***
***Paper Speed - 6.25 Mm/S***
***Length --> 30 S***

***Record Trends - Graphic Trend 1 - Hr***
***Graphic Trend 2 - P1***

**Monitor Setup** - ***Install/Service*** (password 16-4-34) ***- Installation - Printer & Recorder - Default Trend - Graph.***

***Display Trends - Time Scale - 2 h***

4. Plug in the Recorder Module. Check that the module goes in smoothly and locks up properly.

5. Press the RECORD WAVE key on the module front panel. Check that the message "Recorder: Out of paper" appears on the screen.

6. Open the paper compartment cover. Check that the previous message changes to "Recorder: Cover open".

   Install a paper roll and close the cover. Check that the message "Recorder: Cover open" disappears from the screen.

7. Press the RECORD WAVE key again and check that the module starts recording the selected waveforms. Press the STOP key on the module front panel to stop recording.

   NOTE: If no recording appears, check that the paper roll is installed correctly - only one side of the paper is printable.

   Press the PRINT TRENDS key and check that the module starts recording graphical trends. Wait until the recording stops.

8. Check that the quality of the recordings is acceptable.

9. Press the RECORD WAVE key again and this time wait until the recording stops. Check that the length of the recorded waveform scale is 18.7 cm (±1.5 cm).

   Change the paper speed setting to 1 mm/s:

**Record/Print** ***- Record Waveforms - Paper Speed - 1 mm/s***

Press the RECORD WAVE key and wait until the recording stops. Check that the length of the scale is now 3.0 cm (±0.5 cm).

✍

10. Perform an electrical safety check and a leakage current test.

✍

11. Check that the module functions normally after performing the electrical safety check.

✍

12. Clean the module with suitable detergent.

✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the Recorder Module, M-REC, in the following way. See figure 4.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with the loose latch and spring pin.
3. Open the recorder unit paper loading hatch. With a long blade screwdriver loosen the two screws at the bottom of the recorder unit housing.
4. Disconnect the 50-pin connector from the back of the recorder unit and 5-pin ribbon keypad connector from the recorder board.

The recorder unit and front panel frame can now be pulled out of the main body. The front panel frame is pulled out of the recorder by pulling rearward.

The recorder board is attached to the metal chassis with four screws.

CAUTION The recorder board is fixed to the metal chassis at the factory in a specific position. The recorder board and chassis must therefore not be separated.

To reassemble the module, reverse the order of the disassembly steps.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| Problem | Cause | Treatment |
|---|---|---|
| Module not responding to front panel keys, but operates through Recorder menu. | Membrane switch cable loose or broken. | Check the cable. Replace the front panel if necessary. |
| | M-REC: Flex-strip cable broken | Check the cable. Replace if necessary. |
| | M-REC: Bad contact on connector board. | Check contact. |
| Recorder will not start.<br>No error messages shown. | M-REC: Module not properly inserted. | Reinsert the module properly. |
| | M-REC: Flex-strip cable broken. | Check the cable. Replace if necessary. |
| | M-REC: Connector board loose. | Check connector board connections. |
| | Recorder board faulty. | Replace the recorder board. |
| | Recorder unit faulty. | Replace the recorder unit. |
| Recorder works but nothing appears on the paper. | Active side of the paper downwards. | Turn the paper roll over.<br>To test which side is active: Place the paper on a hard surface and draw a line with a fingernail - a dark line will appear on the active (thermal) side. |
| | Recorder unit faulty. | Replace the recorder unit. |

## 4.2 Messages

| Message | Explanation |
|---|---|
| Recorder: out of paper | Release paper jam or insert a roll of paper into the recorder. |
| Recorder: cover open | Close the recorder cover correctly. |
| Recorder: thermal array overheat | Recorder overheated. Stop using and allow it to cool down. |
| Recorder: input voltage low | +15 Vrec is too low. Check flex-strip cable and connector board. |
| Recorder: input voltage high | +15 Vrec is too high. Check flex-strip cable and connector board. |
| Recorder system error<br>1, 2, 3 | System error. Remove the recorder module and reinsert it.<br>If the problem persists, replace the recorder unit. |
| Recorder: module removed | The module not in place, or a communication error due to a fault in the module or in the main CPU board. |

# 5 SERVICE MENU

There is no service menu for the Recorder Module, M-REC.

# 6 SPARE PARTS

## 6.1 Spare parts list

NOTE: Spareparts for all revisions of a modude are in one spare part list. In case there are more than one sparepart order number for the same item: check the revision or possible adaptation of the part that correspond your device. In 'Replaced by' column you find the replacing order number for a sparepart that is not available anymore.

### 6.1.1 Recorder module, M-REC, Rev. 00

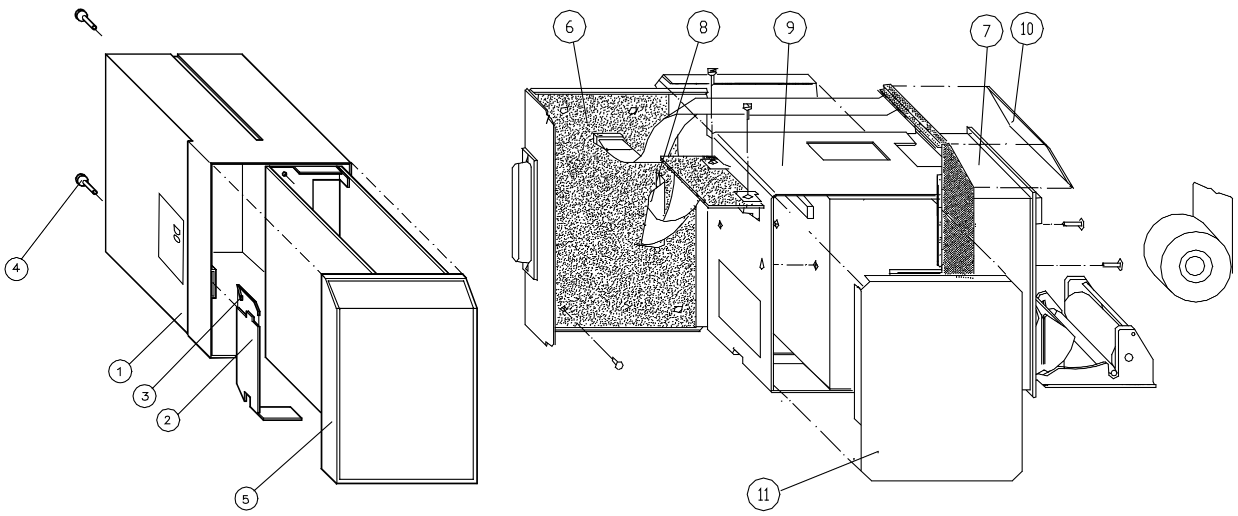



**Figure 4 Exploded view of Recorder Module box and Recorder Module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| - | Membrane keypad | 879372 | |
| 1 | Module box (wide) | 886168 | |
| 2 | Latch | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel unit, M-REC | 881328 | |
| 6 | Metal chassis with recorder board | 883384 | |
| 6 | Recorder board, M-REC (Rev.00) | 880313 | 883384 |
| 7 | Thermal plott.for REC,50,seril.76.8kB | 90350 | |
| 8 | 50-pin connector cable, M-REC | 879362 | |
| 9 | Metal chassis | 879179 | 883384 |
| 9 | Metal chassis with recorder board | 881964 | 883384 |
| 9 | Metal chassis with recorder board | 883384 | |
| 10 | Front panel sticker, DA ; M-REC (rev.00-02) | 892220 | 898857 |
| 10 | Front Panel sticker, DA ; M-REC (rev.03) ; S/5 | 898857 | |
| 10 | Front Panel sticker, DE ; M-REC (rev.00-02) | 880486 | 898848 |
| 10 | Front Panel sticker, DE ; M-REC (rev.03) ; S/5 | 898848 | |
| 10 | Front Panel sticker, EN ; M-REC (rev.00-02) | 879483 | 898847 |
| 10 | Front Panel sticker, EN ; M-REC (rev.03) ; S/5 | 898847 | |

| | | | |
|---|---|---|---|
| 10 | Front Panel sticker, ES ; M-REC (rev.00-02) | 884388 | 898851 |
| 10 | Front Panel sticker, ES ; M-REC (rev.03) ; S/5 | 898851 | |
| 10 | Front Panel sticker, FI ; M-REC (rev.00-02) | 888875 | 898854 |
| 10 | Front Panel sticker, FI ; M-REC (rev.03) ; S/5 | 898854 | |
| 10 | Front Panel sticker, FR ; M-REC (rev.00-02) | 880172 | 898849 |
| 10 | Front Panel sticker, FR ; M-REC (rev.03) ; S/5 | 898849 | |
| 10 | Front Panel sticker, IT ; M-REC (rev.00-02) | 886761 | 898852 |
| 10 | Front Panel sticker, IT ; M-REC (rev.03) ; S/5 | 898852 | |
| 10 | Front Panel sticker, JA ; M-REC (rev.00-02) | 888310 | 8000384 |
| 10 | Front Panel sticker, JA ; M-REC (rev.03) ; S/5 | 8000384 | |
| 10 | Front Panel sticker, NL ; M-REC (rev.00-02) | 886066 | 898850 |
| 10 | Front Panel sticker, NL ; M-REC (rev.03) ; S/5 | 898850 | |
| 10 | Front Panel sticker, NO ; M-REC (rev.00-02) | 893573 | 898856 |
| 10 | Front Panel sticker, NO ; M-REC (rev.03) ; S/5 | 898856 | |
| 10 | Front Panel sticker, PT ; M-REC (rev.00-02) | 895241 | 898853 |
| 10 | Front Panel sticker, PT ; M-REC (rev.03) ; S/5 | 898853 | |
| 10 | Front Panel sticker, SV ; M-REC (rev.00-02) | 885869 | 898855 |
| 10 | Front Panel sticker, SV ; M-REC (rev.03) ; S/5 | 898855 | |
| 11 | Metal cover plate, M-REC | 885292 | |

NOTE: When part 883384 is used, 50-pin connector cable 879362 is not needed.

Front panel stickers that are related to the Compact Module type and adaptation:

Adaptation codes:

DA=Danish,

DE=German,

EN=English,

ES=Spanish,

FI=Finnish,

FR=French,

IT=Italian,

JA=Japanese,

NL=Dutch,

NO=Norwegian,

PT=Portuguese,

SV=Swedish

# 7 EARLIER REVISIONS

For service information on the earlier revisions, please refer to:

| | |
|---|---|
| Recorder Module revision 00 | Service Manual p/n 880850 |
| Recorder Module revision 01 | Service Manual p/n 882580 |

# APPENDIX A

# SERVICE CHECK FORM

## Recorder Module, M-REC

Customer ______________________

Service __________ Module type __________ S/N __________

Service engineer ______________________ Date __________

OK = Test OK    N.A. = Test not applicable    Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Paper compartment cleaning | ☐ | ☐ | ☐ | 4. Installation | ☐ | ☐ | ☐ |

Notes ______________________

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. Paper recognition | ☐ | ☐ | ☐ | 6. Cover state recognition | ☐ | ☐ | ☐ |
| 7. Front panel membrane keys | ☐ | ☐ | ☐ | 8. Quality of recording | ☐ | ☐ | ☐ |

Notes ______________________

9. Recording speed

| | | |
|---|---|---|
| 6.25 mm/s | | 17.2 - 20.2 cm |
| 1.0 mm/s | | 2.5 - 3.5 cm |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10. Electrical safety check | ☐ | ☐ | ☐ | 11. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 12. Final cleaning | ☐ | ☐ | ☐ | | | | |

Notes ______________________

**Used Spare Parts** __________ __________ __________

**Signature** ______________________

# Datex-Ohmeda

# S/5™ Nellcor Compatible Saturation Module, M-NSAT (Rev. 04)
# S/5™ Datex-Ohmeda Oxygen Saturation Module, M-OSAT (Rev.01)

## Technical Reference Manual Slot


All specifications are subject to change without notice.


Document No. 8005426-1

October 2003



Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Nellcor Compatible Saturation Module, M-NSAT
## Datex-Ohmeda Oxygen Saturation Module, M-OSAT

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda Nellcor Compatible Saturation Module, M-NSAT and the Datex-Ohmeda Oxygen Saturation Module, M-OSAT. The M-NSAT and M-OSAT are single width plug-in modules designed for use with S/5 monitors. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

Please refer to the *Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The M-NSAT module utilizes Nellcor pulse oximetry algorithm and it should be used only with Nellcor pulse oximetry sensors specified in the *Instructions for use* sheet accompanying the module.

The M-OSAT module utilizes Datex-Ohmeda pulse oximetry algorithm and it should be used with Datex-Ohmeda OxyTip+ sensors and sensors specified in the *Instructions for use* sheet accompanying the module.

The monitors allow only one pulse oximetry source at a time. If M-NE(12)STPR/M-NE(12)STR/M-ESTPR/M-ESTR and M-NSAT or M-OSAT modules are plugged in the monitor simultaneously, then M-NSAT or M-OSAT overrides modules mentioned above as a pulse oximetry source.


**Figure 1 Nellcor Compatible Saturation Module, M-NSAT..04**


**Figure 2 Datex-Ohmeda Oxygen Saturation Module, M-OSAT**

NOTE: The M-NSAT and M-OSAT modules function only with monitor software versions 94 or later.

**WARNING** **To prevent erroneous readings, do not use physically damaged sensors, sensor cables or modules. Discard a damaged sensor or sensor cable immediately. Never repair a damaged sensor or cable; never use a sensor or cable repaired by others. A damaged sensor or a sensor soaked in liquid may cause burns during electrosurgery.**

**WARNING** **Inaccurate $SpO_2$ data can result if a sensor is past its useful life. Therefore, re-evaluate the measurement periodically by performing additional assessment of the patient and equipment, including consideration of use of alternate monitoring methods such as direct measurement of arterial oxyhemoglobin ($SaO_2$).**

**WARNING** **Allow sensor and cable to dry completely after cleaning. Moisture and dirt on the connector may affect the measurement accuracy.**

**WARNING** **Data validity. Conditions that may cause inaccurate readings and impact alarms include interfering substances, excessive ambient light, electrical interference, ventricular septal defects (VSD), excessive motion, low perfusion, low signal strength, incorrect sensor placement, poor sensor fit, and/or movement of the sensor on the patient.**

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, (W × D ×H) | 37 × 180 × 112 mm/1.5 × 7.1 × 4.4 in |
| Module weight | 0.4 kg/1 lbs |
| Power consumption | 3 W |

## 1.2 Typical performance of M-NSAT..04

| | |
|---|---|
| Measurement range and display range | 20 to 100 % |
| Calibration range | 70 to 100% |
| Accuracy (% ±1 SD)[1] | 100 to 70 %: ±2 digits to ±3.5 digits (depends on the sensor used)<br>20 to 69 %: unspecified |
| Resolution | 1 digit = 1 % |
| Display averaging | 5...7 s |
| Display update | 5 s |
| Pulse beep pitch | Varies with $SpO_2$ level |

The monitor is calibrated over the measurement range against functional saturation $SpO_2$ (func).

**ALARM**

| | |
|---|---|
| Alarm default limits | |
| high alarm | OFF |
| low alarm | 90% |

**HEART RATE FROM PLETH**

| | |
|---|---|
| Measurement range | 30 to 250 bpm |
| Accuracy | ±3 bpm |
| Resolution | 1 bpm |
| Display averaging | 5...7 s |
| Adjustable pulse beep volume | |

**PLETH WAVEFORM**

| | |
|---|---|
| Scales | Automatic scaling |
| Protection against electrical shock | Type BF |

[1] 1 SD (standard deviation) = 68 % of all readings in the specified range in stable conditions.

## 1.3 Typical performance of M-OSAT

| | | |
|---|---|---|
| Measurement range and display range | 20 to 100 % | |
| Calibration range | 70 to 100% | |
| Accuracy | 100 to 70 %: | ±2 digits<br>±3% digits<br>(during clinical motion condition) |
| (% ±1 SD)1 | 20 to 69 %: unspecified | |
| Resolution | 1 digit = 1 % | |
| Display averaging | 12 s typical | |
| Display update | 5 s | |
| Pulse beep pitch | Varies with SpO2 level | |

The monitor is calibrated over the measurement range against functional saturation SpO 2 (func).

**ALARM**

| | |
|---|---|
| Alarm default limits | |
| high alarm | OFF |
| low alarm | 90% |

**PULSE RATE FROM PLETH**

| | |
|---|---|
| Measurement range | 30 to 250 bpm |
| Accuracy | ±2 digits or ±2 bpm, whichever is greater |
| Resolution | 1 bpm |
| Display averaging | 12 s typical |
| Adjustable pulse beep volume | |

**PLETH WAVEFORM**

| | |
|---|---|
| Scales | Automatic scaling |
| Protection against electrical shock | Type BF |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Main components of M-NSAT..04

The M-NSAT module consists of the following parts

- $SpO_2$ pre-amplifier board
- Sensor connector cable
- Nellcor Pulse Oximeter Module MP-404
- NSAT interface board (NIO)

Sensors can be plugged into the M-NSAT module using the sensor extension cable MC-10 available from Nellcor. Sensors are plugged into a 9-pin female connector (D-type) on the end of the extension cable MC-10. The extension cable is plugged into a 14-pin connector on the front panel of the module. This connector is mounted on a small pre-amplifier board, which is connected by a flat cable to the MP-404.

The MP-404 is a surface mounted PC board manufactured by Nellcor Incorporated. It contains the signal processing electronics and software that are based on Nellcor's stand-alone pulse oximeters. The MP-404 is used with an external preamplifier.

The measured $SpO_2$ and pulse rate values, as well as status information, are transferred from the MP-404 to the NIO interface board. Communication between the MP-404 and NIO interface board is established through an RS232C serial interface. The NIO interface board, in turn, transmits the measurement information to the module bus of the monitor through RS485 serial interface.

## 2.2 Main components of M-OSAT

The M-OSAT module consists of the following parts

- $SpO_2$ sensor board and cable set
- Datex-Ohmeda Proloque module board
- OIO interface board

The sensor can be plugged into the M-OSAT module either directly or using sensor extension cables available from Datex-Ohmeda. Sensors are plugged into a 9-pin female connector (Datex-Ohmeda) on the front panel of the module. This connector is mounted on a small PC board, which is connected to the Proloque board by a cable. The EMC ferrite of this cable is mounted on the back of the front panel.

The Proloque board is a surface mounted PC board manufactured by Datex-Ohmeda. It contains the signal processing electronics and software. The Proloque board is used with an internal preamplifier.

The measured $SpO_2$ and pulse rate values, as well as status information, are transferred from the Proloque board to the OIO interface board. Communication between the Proloque board and OIO interface board is established through an RS232C serial interface. The OIO interface board, in turn, transmits the measurement information to the module bus of the monitor through an RS485 serial interface.

## 2.2.1 NIO and OIO Interface board

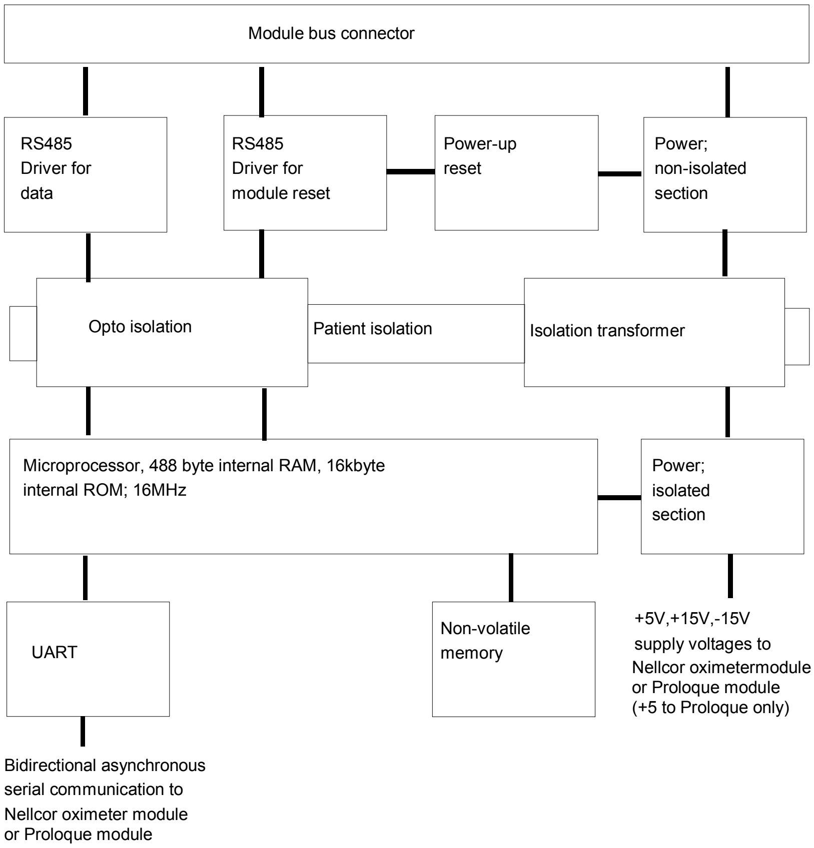



**Figure 3 NIO and OIO Interface board block diagram**

### RS485 drivers

There are drivers for data and for module reset functions.

These drivers are used for driving the RS485 type serial communication bus between the module and the Central Unit. Data transmission speed of the bus is 500 kbps.

In addition to RS485 bus RESET, there is a Power-up reset, which keeps the RESET pin of the CPU active during power up for about 500 ms despite of the state at the RS485 bus RESET. This is used to prevent the sending of RS485 data during the RESET of the module.

### Power supply, non-isolated section

The power supply is a half bridge type switched mode circuit, where the driver FETs are controlled by a quartz oscillator. The load of the half bridge is the primary of the isolation transformer. The voltage, +15 Vdirty from the Central Unit is used as the supply voltage of the switched mode circuit.

## Power supply, isolated section

The secondary voltages of the isolation transformer are rectified, filtered and +5V regulated . The voltages can be measured from the test connector X11. See Chapter *2.3.2 Other connectors.*

## Opto isolation

The signals of the serial communication bus between the NIO or OIO Interface board and the Central Unit are transferred through the patient isolation by high speed opto couplers.

## Microprocessor, UART, non-volatile memory

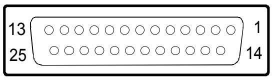
The microprocessor with on-chip memory has been used to convert and transfer data from Nellcor pulse oximeter module MP-404 or Proloque module to the monitor.

The communication between MP-404 or Proloque board and the CPU of NIO or OIO Interface board is realized with bi-directional asynchronous serial communication via the UART.

The non-volatile memory has been used to store identification information like serial number, control number, date etc.

# 2.3 Connectors and signals

## 2.3.1 Module bus connector




**Module bus connector (X1)**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485* |
| 2 | I | -15 VDC |
| 3 | I | +15 VDIRTY* |
| 4 | I | +15 VDC |
| 5 | I/O | -DATA_RS485* |
| 6 | I/O | DATA_RS485* |
| 7 | - | Ground & Shield* |
| 8 | I | -RESET_RS485* |
| 9 | I | CTSB |
| 10 | O | RTSB |
| 11 | I | RXDB |
| 12 | O | TXDB |
| 13 | - | Ground & Shield* |
| 14 | I | +32 VDIRTY |
| 15 | I | GroundDIRTY* |
| 16 | I | CTSC |
| 17 | O | RTSC |
| 18 | I | RXDC |
| 19 | O | TXDC |
| 20 | - | ON/STANDBY |
| 21 | - | BITOIN |
| 22 | - | RXDD_RS232 |
| 23 | - | TXDD_RS232 |
| 24 | I | +5 VDC |
| 25 | I | +5 VDC |

*Used in the M-NSAT and M-OSAT modules

## 2.3.2 Other connectors

**Test connector (X11)**

| Pin No | Voltage | Name | Note |
|---|---|---|---|
| 1 | +5V | +5VTEST | Supply voltage to the NSAT-board (NIO) |
| 2 | +5V | +5Vn | Supply voltage to the MP-404 board (Proloque module) |
| 3 | +14...17V | +15Vn | Supply voltage to the MP-404 board |
| 4 | - | GND | FGND |
| 5 | --14...-17V | -15V | -15Vn |
| 6 | - | - | N/C |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the M-NSAT or M-OSAT module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (Appendix A) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| M-NE(12)STPR/M-ESTPR/M-ESTP | | |
| Datex-Ohmeda $SpO_2$ finger probe | | |
| Nellcor $SpO_2$ finger probe with MC-10 cable or Datex-Ohmeda OxyTip+ finger probe | | |
| Screwdriver | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - EMC covers are attached properly
   - there are no loose objects inside the module
   - M-OSAT and M-NSAT ferrite of the cable sets are attached properly

   ✍

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - the probe connector and the cable lock (M-NSAT rev. 01 ->) are intact and are attached properly
   - the module box, the latch and the spring pin are intact

   ✍

- Reattach the module box and check that the latch is moving properly.
- Switch the monitor on and wait until normal monitoring screen appears.

- Configure the monitor screen so that all the needed parameters are shown, for example as follows:

**Monitor Setup** ***- Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
***Field 2 - ECG2***
***Field 3 - P1***
***Field 4 - P2***
***Field 5 - PLETH***
***Field 6 - OFF***

**Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Installation - Interfacing - SpO$_2$ - Module***

- Make sure that the other $SpO_2$ module M-NE(12)STPR/M-ESTPR/M-ESTP is connected, and therefore, the $SpO_2$ waveform field is shown on the screen.
- Connect the Datex-Ohmeda $SpO_2$ finger probe to the module and attach the probe onto your finger. Check that $SpO_2$ waveform appears onto the screen.

3. Plug in the M NSAT or M-OSAT module. Check that it goes in smoothly and locks up properly.

4. Check that the M-NSAT or M-OSAT module is recognized, i.e. the $SpO_2$ waveform with related values disappear from the screen within 30 seconds. The empty $SpO_2$ waveform field should remain with the message ‘No probe’.

5. Enter the service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8)

   Take down the information regarding NSAT or OSAT software by selecting SCROLL VERS and turning the ComWheel.

6. Enter the M-NSAT/M-OSAT service menu:

   ***Parameters - M-SAT***

   Check that the ‘Timeouts’, ‘Bad checksums’ and ‘Bad c-s by mod’ values are not increasing faster than by 5 per second. Check also that the module’s ROM memory has passed the internal memory test, i.e. the ‘ROM’ shows OK.

7. M-NSAT: Check that the $SpO_2$ probe related status information in the menu is correct. Only the 'NoProbe' should be active (1) when no probe is connected.

   M-OSAT and M-NSAT..04: The status information in the service menu is not valid for the M-OSAT/M-NSAT..04. Check that the message 'No Probe' is displayed on the screen when no probe is connected.

   ✍

8. M-NSAT: Check that all three error indicators, 'Preamp Error', 'QUART Error' and 'I/O Error' show NO.

   M-OSAT and M-NSAT..04: The error indicators in the service menu are not valid for the M-OSAT/M-NSAT..04.

   ✍

9. Connect a suitable $SpO_2$ finger probe to the module.

   Check that the message 'No Probe' changes to 'Check Probe' on the monitor screen.

   M-NSAT: Check that the corresponding status information is updated correctly in the service menu.

   ✍

10. Connect the $SpO_2$ probe onto your finger. Check that the reading of 95-100 and proper $SpO_2$ waveform appear.

    ✍

11. Perform electrical safety check and leakage current test.

    ✍

12. Check that the module functions normally after the performed electrical safety check.

    ✍

13. Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the M-NSAT or M-OSAT module in the following way. See also the exploded view of the module.

1. Remove the 2 screws from the rear of the module and detach the module box. Be careful with the loose latch and spring pin.
2. Bend the metal tabs that hold the EMC-cover to an upright position and lift the cover off.
3. Remove the 3 screws that secure the SpO2 measurement board to the Interface board.
4. Hold the SpO2 measurement board as near the module bus connector as possible and lift the board up carefully.
5. Disconnect the cable that comes from the front panel unit and the flat cable that comes from the Interface board.

Reassembling is essentially reversing the above described actions.

NOTE: When installing the SpO2 measurement board, make sure that the pin connector on the SpO2 measurement board connects properly with the connector on the Interface board underneath.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| **Problem** | **Cause** | **Treatment** |
|---|---|---|
| Message 'No probe' | 1. No probe connected to the module<br>2. Probe faulty<br>3. Wrong type of probe (not specified to be used with this module) | 1. Check probe connections<br>2. Change probe<br>3. Change probe (see possible probe types: User's Reference Manual) |
| Message 'Check probe' | 1. No probe attached to the patient<br>2. The extension cable not connected to the probe<br>3. Unsuitable site<br>4. Probe faulty<br>5. Wrong type of probe (not specified to be used with this module) | 1. See that the probe is properly attached to the patient<br>2. Check that the probe is connected to the cable<br>3. Try another place<br>4. Change probe<br>5. Change probe (see possible probe types from *User's Reference Manual*) |
| Finger probe falls off | 1. Probe is slippery<br>2. Finger is too thin or thick | 1. Follow Nellcor's or Datex-Ohmeda's instructions on this matter<br>2. Try other fingers or other probe types |
| Weak signal artifacts | 1. Poor perfusion<br>2. Movement artifacts<br>3. Shivering | Try another place |
| Message 'No pulse' | Acceptable pulses were present but have now ceased for 10 seconds | Try other fingers |

## 4.2 Troubleshooting flowchart

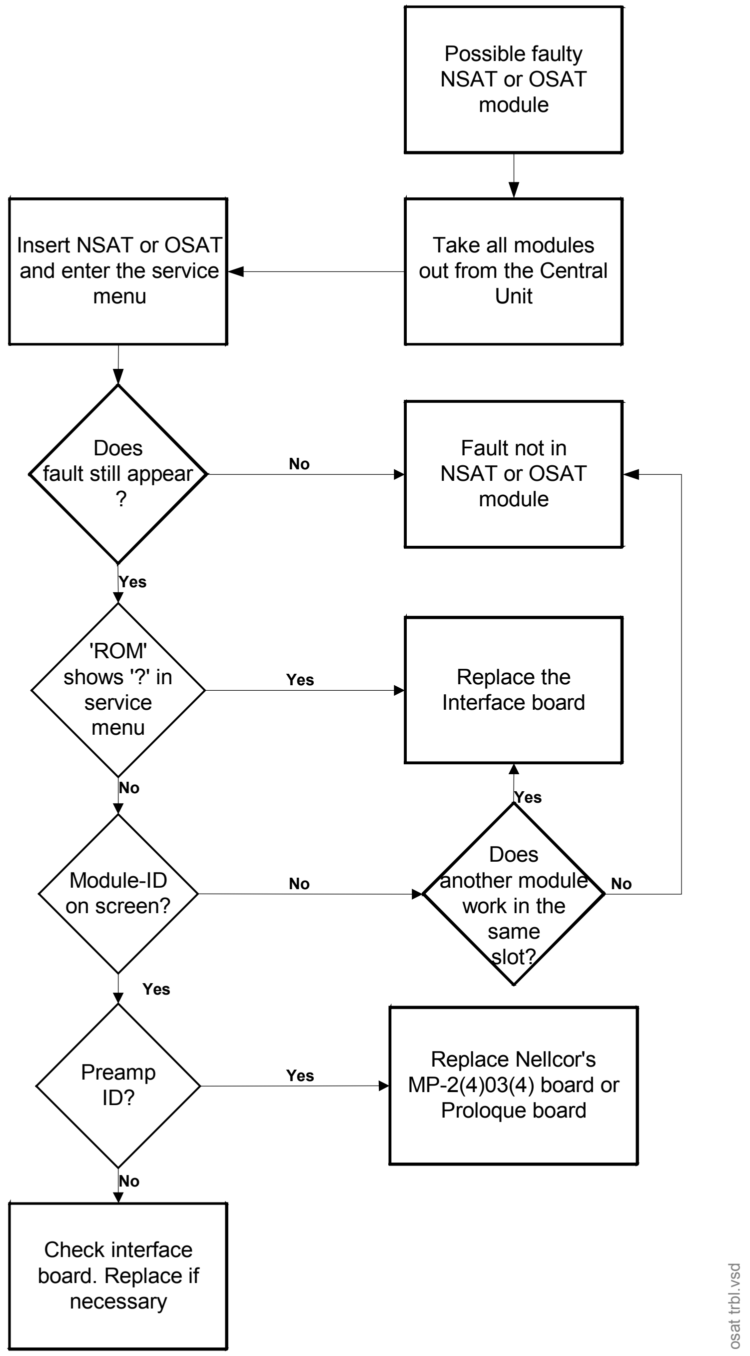
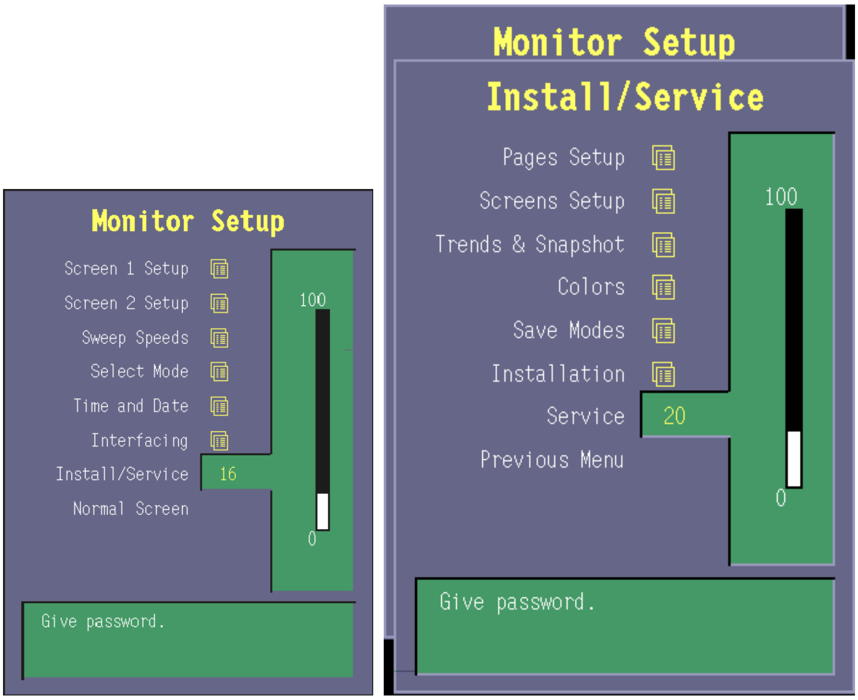
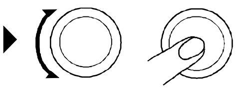



**Figure 4 Module troubleshooting flowchart**

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



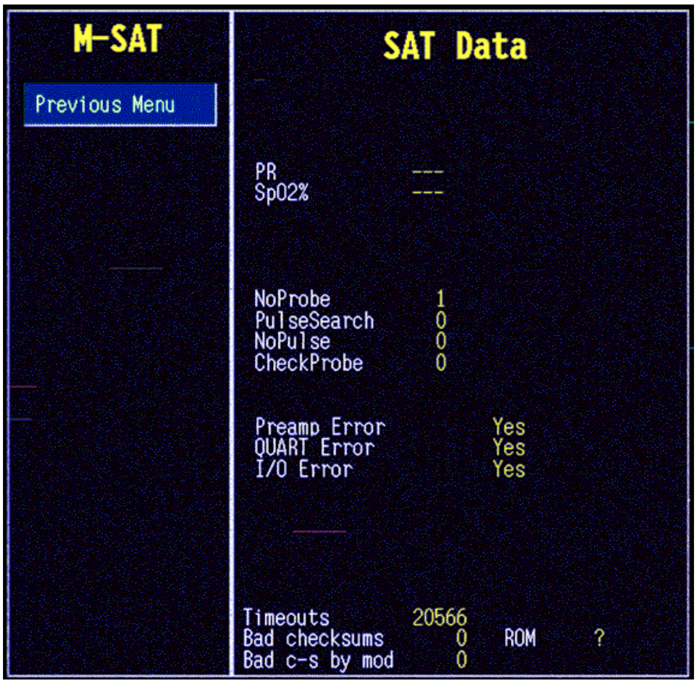
1. Press the **Monitor Setup** key

2. Select ***Install/Service*** (password 16-4-34)

3. Select ***Service*** (password 26-23-8)

4. Select ***Parameters - M-SAT*** (use for M-NSAT and M-OSAT )

## 5.1 M-NSAT menu




### NSAT Data

NOTE: Preamp Error is indicated on the service menu, even though module contains MP-204 board.

NOTE: The status and error indicators are not valid for the M-OSAT and the M-NSAT..04 revision.

**PR** shows the pulse rate value [bpm] calculated from pleth.
**$SpO_2$%** shows the oxygen saturation value multiplied by 100.
Next are listed the **messages** that are sent from the module to the monitor. Digit '0' means that the message is not active, '1' is for the active one.
**Preamp Error** indicates 'Yes' if the Preamp (MP-203(4)) board detects an error.

**QUART Error** indicates 'Yes' if an error is detected in the operation of QUART that is located in the Interface board.
**I/O Error** indicates 'Yes' if an error occurs in the communication between Preamp (MP-203(4)) and Interface board.
**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.
**ROM** indicates whether the checksum in the EPROM is in accordance with the one the software has calculated.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

# 6 SPARE PARTS

## 6.1 Nellcor Compatible Saturation Module, M-NSAT rev. 00, 01, 02, 03

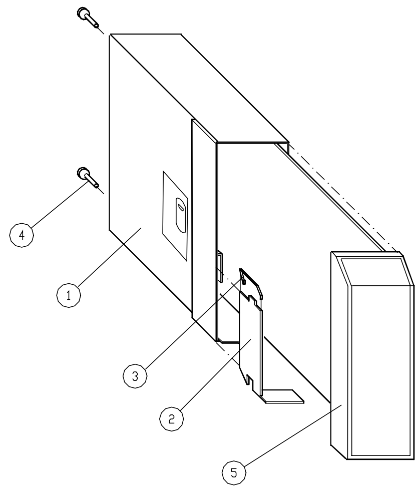



**Figure 5 Exploded view of M-NSAT single module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel frame, M-NSAT (rev.00) | 884012 | 887842 |
| 5 | Front panel frame, M-NSAT (Rev.01) | 887842 | |

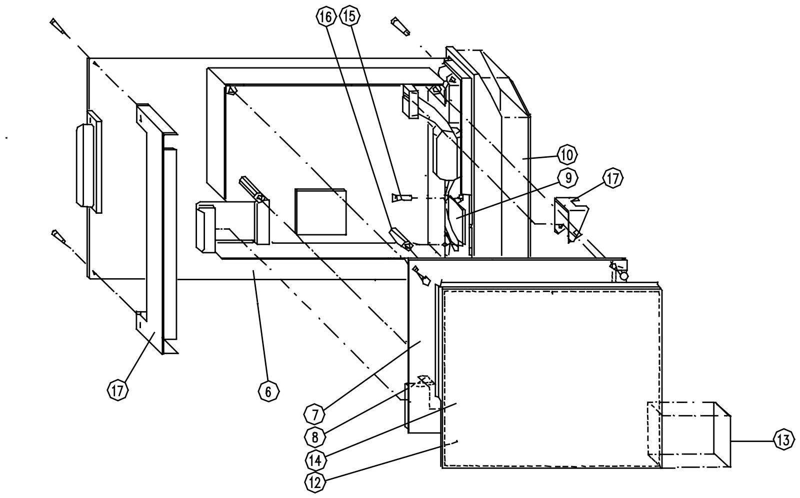



**Figure 6 Exploded view of M-NSAT Rev. 00, 01, 02, 03**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 6 | Cross cylinder-head screw M3x12 | 628700 | |
| 6 | Interface board, M-NSAT | 884383 | |
| 7 | SpO2 Measurement Board Spare Part Kit for M-NSAT | 898000 | |
| 7 | SpO2 measuring board (Kit), M-NSAT | 90310 | 898000 |
| 8 | Connector-access, jumper, pitch gr/bl/r | 54091 | |
| 9 | Connector board, M-NSAT | 884950 | |
| 10 | Front Panel sticker, DA ; M-NSAT (rev.01-02) | 892216 | 898920 |
| 10 | Front Panel sticker, DA ; M-NSAT (rev.03) ; S/5 | 898920 | |
| 10 | Front Panel sticker, DE ; M-NSAT (rev.00) | 885779 | |
| 10 | Front Panel sticker, DE ; M-NSAT (rev.01-02) | 888297 | 898911 |
| 10 | Front Panel sticker, DE ; M-NSAT (rev.03) ; S/5 | 898911 | |
| 10 | Front Panel sticker, EN ; M-NSAT (rev.00) | 884424 | |
| 10 | Front Panel sticker, EN ; M-NSAT (rev.01-02) | 888296 | 898910 |
| 10 | Front Panel sticker, EN ; M-NSAT (rev.03) ; S/5 | 898910 | |
| 10 | Front Panel sticker, ES ; M-NSAT (rev.00) | 886192 | |
| 10 | Front Panel sticker, ES ; M-NSAT (rev.01-02) | 888299 | 898914 |
| 10 | Front Panel sticker, ES ; M-NSAT (rev.03) ; S/5 | 898914 | |
| 10 | Front Panel sticker, FI ; M-NSAT (rev.01-02) | 888874 | 898917 |
| 10 | Front Panel sticker, FI ; M-NSAT (rev.03) ; S/5 | 898917 | |
| 10 | Front Panel sticker, FR ; M-NSAT (rev.00) | 885780 | |
| 10 | Front Panel sticker, FR ; M-NSAT (rev.01-02) | 888298 | 898912 |
| 10 | Front Panel sticker, FR ; M-NSAT (rev.03) ; S/5 | 898912 | |
| 10 | Front Panel sticker, IT ; M-NSAT (rev.00) | 886759 | |
| 10 | Front Panel sticker, IT ; M-NSAT (rev.01-02) | 888337 | 898915 |
| 10 | Front Panel sticker, IT ; M-NSAT (rev.03) ; S/5 | 898915 | |
| 10 | Front Panel sticker, JA ; M-NSAT (rev.01-02) | 888317 | 8000386 |
| 10 | Front Panel sticker, JA ; M-NSAT (rev.03) ; S/5 | 8000386 | |
| 10 | Front Panel sticker, NL ; M-NSAT (rev.00) | 886125 | |
| 10 | Front Panel sticker, NL ; M-NSAT (rev.01-02) | 888336 | 898913 |
| 10 | Front Panel sticker, NL ; M-NSAT (rev.03) ; S/5 | 898913 | |
| 10 | Front Panel sticker, NO ; M-NSAT (rev.01-02) | 893560 | 898919 |
| 10 | Front Panel sticker, NO ; M-NSAT (rev.03) ; S/5 | 898919 | |
| 10 | Front Panel sticker, PT ; M-NSAT (rev.01-02) | 895255 | 898916 |
| 10 | Front Panel sticker, PT ; M-NSAT (rev.03) ; S/5 | 898916 | |
| 10 | Front Panel sticker, SV ; M-NSAT (rev.00) | 886126 | |
| 10 | Front Panel sticker, SV ; M-NSAT (rev.01-02) | 888335 | 898918 |
| 10 | Front Panel sticker, SV ; M-NSAT (rev.03) ; S/5 | 898918 | |
| 11 | Cross cylinder-head screw M3x6 | 61721 | |
| 11 | Metal frame | 879184 | |
| 12 | Insulating plate 1, M-NSAT | 884700 | |
| 13 | Insulating plate 2, M-NSAT | 884705 | |
| 14 | EMC Cover, M-NSAT | 884701 | |
| 15 | Cross cylinder-head screw M3x8 | 628712 | |
| 16 | Bushing | 63392 | |
| 17 | Cable lock, M-NSAT | 887706 | |

## 6.2 Nellcor Compatible Saturation Module, M-NSAT rev. 04

NOTE: Check that the jumper J5 of the MP-404 board has been removed.

NOTE: Removed part 8, jumpers of the NIO interface board.

| Item | Item description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Spring pin | 879182 | |
| 3 | Latch | 879181 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel frame, M-NSAT (Rev. 04) | 8003170 | |
| 6 | Interface board, NIO/OIO spare part | 8003862 | |
| | Cross cylinder head PT-screw 3x12 | 628700 | |
| 7 | MP-404 measurement board spare part | 90313 | 8004263 |
| 8 | Jumper (removed from the board) | 54091 | |
| 9 | Pre-amplifier board, M-NSAT | 8002220 | |
| | Cross cylinder head PT-screw 2,2x8 | 628701 | |
| 10 | Front panel sticker, DA, M-NSAT (Rev. 04) | 8003115 | |
| 10 | Front panel sticker, DE, M-NSAT (Rev. 04) | 8003106 | |
| 10 | Front panel sticker, EN, M-NSAT (Rev. 04) | 8003105 | |
| 10 | Front panel sticker, ES, M-NSAT (Rev. 04) | 8003109 | |
| 10 | Front panel sticker, FI, M-NSAT (Rev. 04) | 8003112 | |
| 10 | Front panel sticker, FR, M-NSAT (Rev. 04) | 8003107 | |
| 10 | Front panel sticker, IT, M-NSAT (Rev. 04) | 8003110 | |
| 10 | Front panel sticker, JA, M-NSAT (Rev. 04) | 8003116 | |
| 10 | Front panel sticker, NL, M-NSAT (Rev. 04) | 8003108 | |
| 10 | Front panel sticker, NO, M-NSAT (Rev. 04) | 8003114 | |
| 10 | Front panel sticker, PT, M-NSAT (Rev. 04) | 8003111 | |
| 10 | Front panel sticker, SV, M-NSAT (Rev. 04) | 8003113 | |
| 11 | Metal frame | 879184 | |
| | Cross cylinder head screw M3x6 | 61721 | |
| 12 | Insulation plate 1., M-NSAT | 8001919 | |
| 13 | Insulation plate 2., M-NSAT | 8001920 | |
| 14 | EMC-cover, M-NSAT | 8001546 | |
| 15 | Cross cylinder-head screw M3x8 | - | |
| 16 | Bushing | 640430 | 63392 |
| 17 | Flat cable M-NSAT/M-OSAT | 8001925 | |
| 18 | M-NSAT pre-amp cable | 8003173 | |

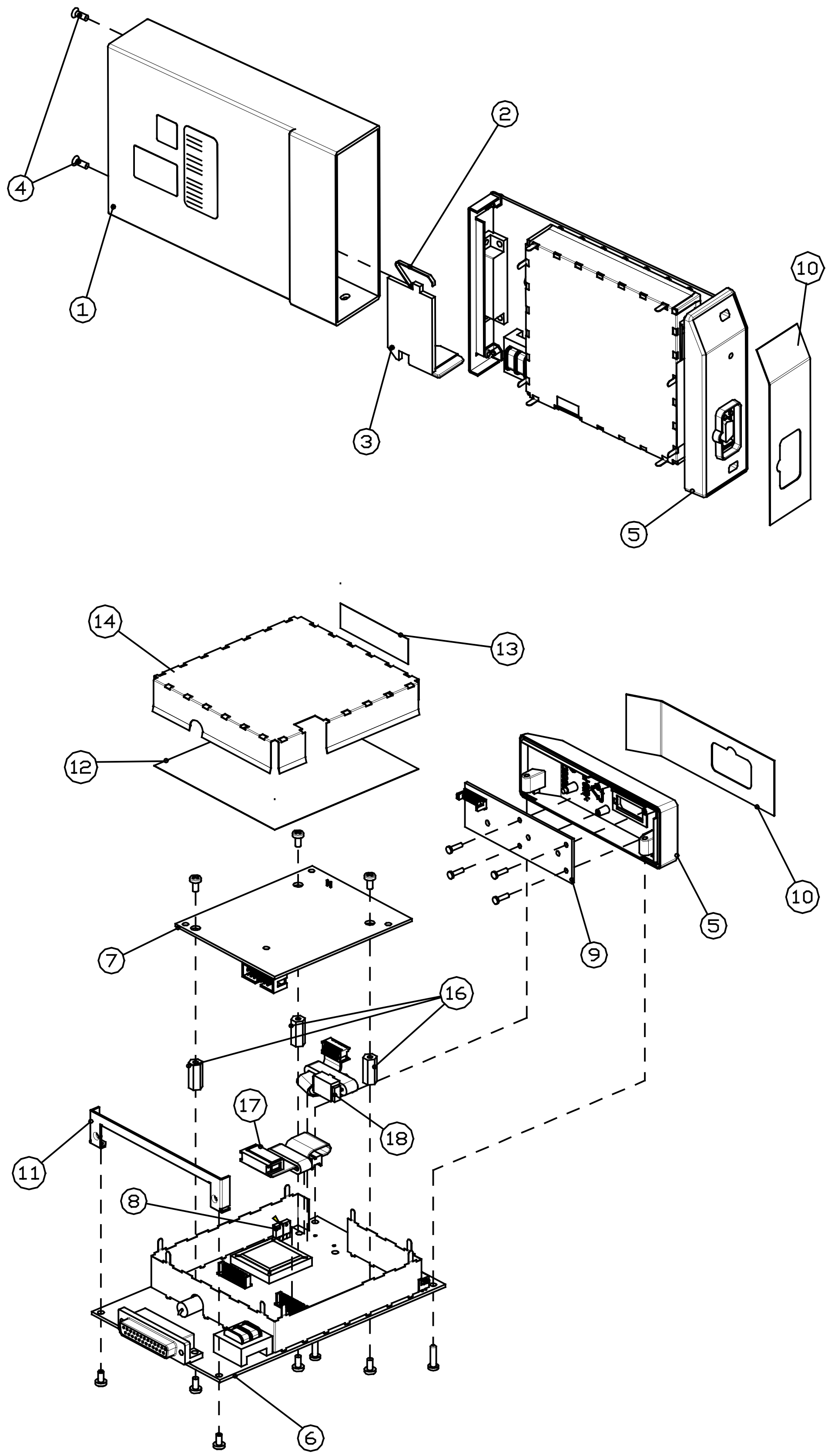



**Figure 7 Exploded view of M-NSAT Rev. 04**

# 6.3 Datex-Ohmeda Oxygen Saturation Module, M-OSAT rev. 00, 01

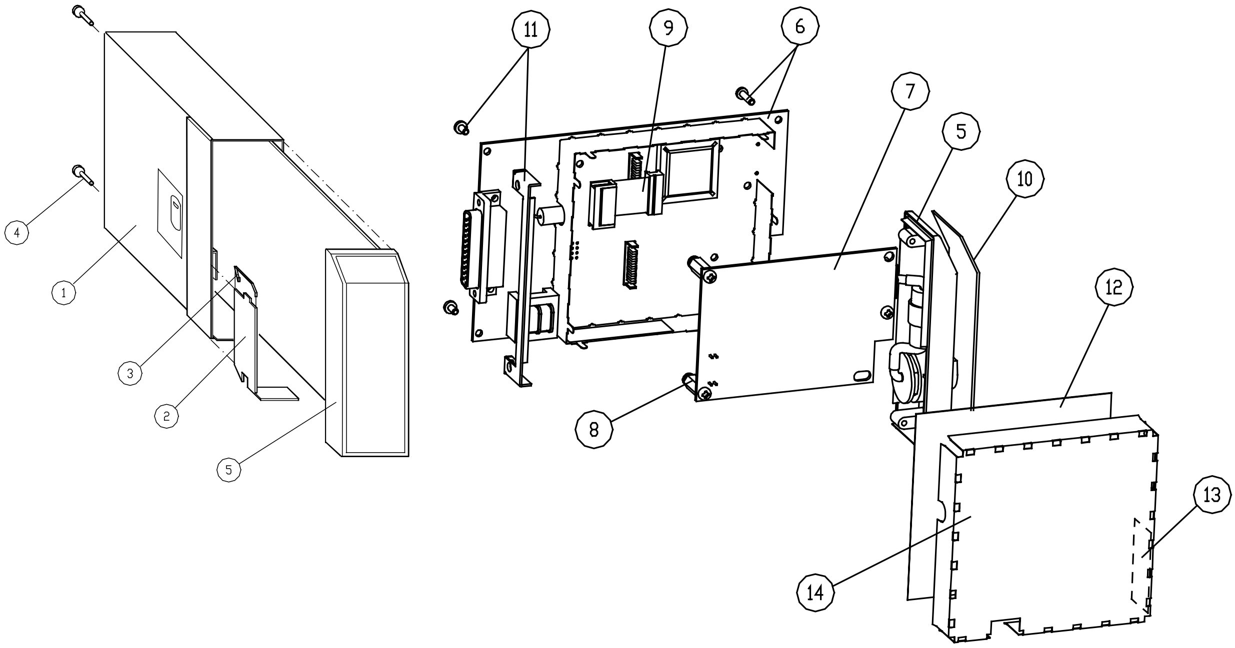



**Figure 8 Exploded view of M-OSAT module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| | Cable set for M-OSAT | 90503 | |
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front Panel Unit, M-OSAT : S/5 | 8001924 | |
| 6 | Cross cylinder-head screw M3x12 | 628700 | |
| 6 | Interface board, M-OSAT ; S/5 | 8001452 | |
| 7 | SpO2 measurement board ; S/5 | 90504 | |
| 8 | Bushing | 63392 | |
| 9 | Flat Cable, M-OSAT ; S/5 | 8001925 | |
| 10 | Front Panel sticker, DA ; M-OSAT ; S/5 | 8001823 | |
| 10 | Front Panel sticker, DE ; M-OSAT ; S/5 | 8001814 | |
| 10 | Front Panel sticker, EN ; M-OSAT ; S/5 | 8001813 | |
| 10 | Front Panel sticker, ES ; M-OSAT ;S/5 | 8001817 | |
| 10 | Front Panel sticker, FI ; M-OSAT ; S/5 | 8001820 | |
| 10 | Front Panel sticker, FR ; M-OSAT ; S/5 | 8001815 | |
| 10 | Front Panel sticker, IT ; M-OSAT ; S/5 | 8001818 | |
| 10 | Front Panel sticker, JA ; M-OSAT ; S/5 | 8001824 | |
| 10 | Front Panel sticker, NL ; M-OSAT ; S/5 | 8001816 | |
| 10 | Front Panel sticker, NO ; M-OSAT ; S/5 | 8001822 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 10 | Front Panel sticker, PT ; M-OSAT ; S/5 | 8001819 | |
| 10 | Front Panel sticker, SV ; M-OSAT ; S/5 | 8001821 | |
| 11 | Cross cylinder-head screw M3x6 | 61721 | |
| 11 | Metal frame | 879184 | |
| 12 | PCB-isolator plate, M-OSAT ; S/5 | 8001919 | |
| 13 | Connector isolator plate, M-OSAT : S/5 | 8001920 | |
| 14 | EMC cover, M-OSAT ; S/5 | 8001546 | |

# 7 EARLIER REVISIONS

This manual fully supports earlier revisions of M-NSAT and M-OSAT modules.

# *APPENDIX A*

# SERVICE CHECK FORM

## Nellcor Compatible Saturation Module, M-NSAT
## Datex-Ohmeda Oxygen Saturation Module, M-OSAT

Customer ______________________

Service ____________ Module type ____________ S/N ____________

Service engineer ______________________ Date ____________

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4. Recognition | ☐ | ☐ | ☐ | | | | |
| 5. Module software | NIO/OIO | | | | | | |
| | Nellcor / Proloque | | | | | | |
| 6. Communication and memories | ☐ | ☐ | ☐ | 7. $SpO_2$ probe status | ☐ | ☐ | ☐ |
| 8. Error status | ☐ | ☐ | ☐ | 9. $SpO_2$ probe detection | ☐ | ☐ | ☐ |
| 10. Test measurement | ☐ | ☐ | ☐ | | | | |
| 11. Electrical safety check | ☐ | ☐ | ☐ | 12. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 13. Final cleaning | ☐ | ☐ | ☐ | | | | |

Notes ______________________

**Notes** ______________________

**Used Spare Parts** ____________ ____________ ____________

**Signature** ______________________

# Datex-Ohmeda

# S/5™ NeuroMuscular Transmission Module, M-NMT (Rev. 02)

# Technical Reference Manual Slot


All specifications are subject to change without notice.

Document No. 800 1018-3

September 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
mailto:product.support.ussub@us.datex-ohmeda.com
www.us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## NeuroMuscular Transmission Module, M-NMT

# TABLE OF FIGURES

# INTRODUCTION

This section provides information for the maintenance and service of the NeuroMuscular Transmission Module, M-NMT. The M-NMT module is a single width plug-in module designed for use with the S/5 Anesthesia and Compact Anesthesia Monitors. Later in this manual modules can be called w/o system name Datex-Ohmeda S/5.

Please see also the*Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The module contains peripheral nerve stimulation and response measurement, which supports electromyography EMG. The module can also be used as a nerve locator for regional nerve blocking with a regional block cable. However, in this case there is no response measurement.


**Figure 1 NeuroMuscular Transmission Module, M-NMT**

The M-NMT requires monitor software S-xxx95 or greater.

From the M-NMT rev.01 onwards the module has contained a memory for storing stimulus current and reference response data. The memory function requires monitor software S-xxx97 or greater.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 37 × 180 × 112 mm / 1.5 × 7.1 × 4.4 in |
| Module weight | 0.37 kg /0.8 lbs |
| Power consumption | 3.3 W |

## 1.2 Technical specifications

### 1.2.1 NMT

| | |
|---|---|
| Stimulation modes | Train of four (TOF) |
| | Double burst (3.3) (DBS) |
| | Single twitch (ST) |
| | 50 Hz tetanus + post tetanic count (PTC) |
| Measurement intervals for TOF and DBS | |
| | Manual; 10 s, 12 s, 15 s, 20 s, 1 min, 5 min, 15 min |
| Measurement intervals for ST | Manual; 1 s, 10 s, 20 s |

### 1.2.2 Stimulator

| | |
|---|---|
| Stimulus pulse | Square wave, constant current |
| Pulse width | 100, 200 or 300 μs |
| Stimulus current range | 10...70 mA with 5 mA steps |
| Stimulus current accuracy | 10 % or ±3 mA whichever is the greater |
| Max. load | 3 kΩ |
| Max. voltage | 300 V |

### 1.2.3 Regional block mode

| | |
|---|---|
| Stimulation modes | Single twitch |
| Intervals | 1 s, 2 s, 3 s |
| Stimulus pulse | Square wave, constant current |
| Pulse width | 40 μs |
| Stimulus current range | 0...5.0 mA with 0.1 mA steps |
| Stimulus current accuracy | 20 % or 0.3 mA whichever is the greater |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 Nerve stimulation

There are three stimulus modes in the NeuroMuscular Transmission Module: Train of Four (TOF), Double Burst 3,3 (DBS) and Single Twitch (ST).

In the Train of Four stimulus mode, four stimulation pulses are generated at 0.5 second intervals. The response is measured after each stimulus and the ratio of the fourth and first response of the TOF sequence is calculated (TOF%).

NOTE: If the first response does not exceed a certain signal level, TOF% is not calculated due to poor accuracy.

Double burst (3,3) stimulation includes two bursts with a 750 ms interval. Both bursts consist of three pulses separated by 20 ms intervals. The responses of both bursts are measured, and the ratio of the second and first response is calculated (DBS%). EMG responses are measured immediately after the first stimulus pulse of both bursts.

In Single Twitch stimulation, one stimulation pulse is generated. The response is measured after the stimulus. In order to prevent decurarization of the stimulated area, the measurement is automatically stopped after 5 minutes stimulation in 1 sec cycle time.

### Tetanic/PTC

Tetanic/PTC (Post Tetanic Count) can measure deeper relaxation than TOF. The tetanic stimulation is produced when Start is chosen under Tetanic/PTC. The length of stimulation is 5 seconds. The stimulation generates pulses with a frequency of 50 Hz and with a selected pulse width and current. After tetanic stimulation and a three second delay, Single Twitch stimulation is produced to detect the post tetanic count (PTC). PTC describes the number of responses detected after tetanic stimulation. If there is no response, the measurement will be stopped. If responses will not fade away, a maximum of 20 responses will be calculated. If more can be detected, the PTC value is displayed only as '> 20' and measurement will be stopped. If the TOF, DBS or ST measurement cycle was on when tetanic stimulation started, the cycle will continue after the PTC. After completing the PTC measurement during 1 minute TOF, DBS or another PTC measurement is not possible. This is to avoid erroneous readings due to post tetanic potentiation.

### 2.1.2 Response

Before each stimulation, the sequence offset, noise and threshold for the response detection is measured. Offset is a baseline of the noise measurement. Noise is calculated by the same algorithm as the response signal itself. The response detection threshold is calculated based on the noise, and if the response is not greater than the threshold then it is interpreted as no response.

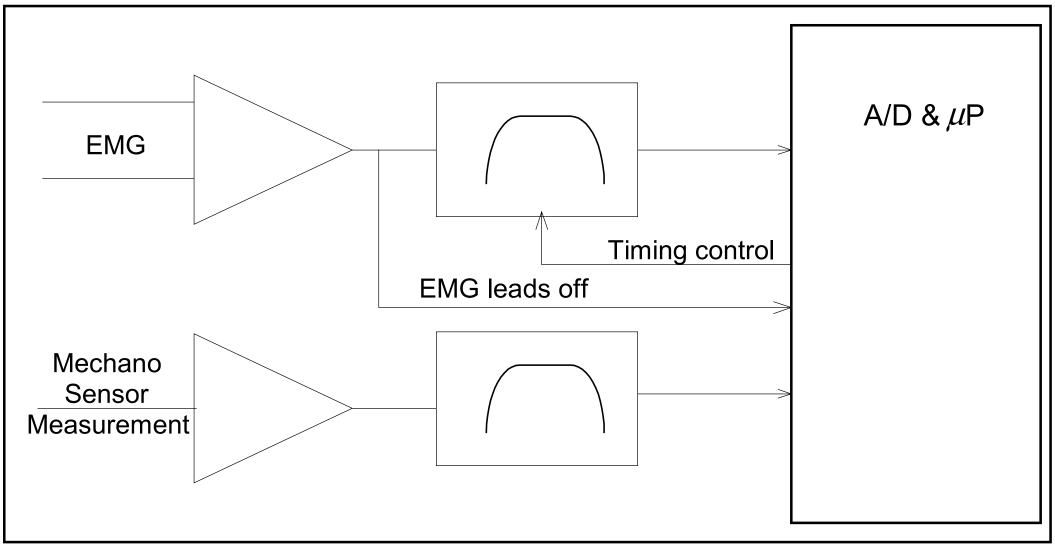



**Figure 2 Principle of response measurement**

#### EMG measurement

The EMG response is measured as integrated muscle activity. The EMG measurement starts 3 ms after the stimulation and lasts 15 ms. The 3 ms delay helps to prevent the effect of stimulation artifact.

#### Mechano sensor measurement

Response is measured as movement of the thumb, which is the area of positive signal.

### 2.1.3 Regional block

A regional block cable can be used as a nerve locator in local anesthesia. A maximum current of 5.0 mA is given every, every other or every 3rd second. The response measurement is ocular.

## 2.2 Main components

### 2.2.1 NMT board

The NMT Circuit Board consists of the following functional sections:

- constant current stimulator
- measuring electronics for the EMG signals
- microprocessor for the stimulation and measuring control, and for counting the measuring

results

- serial communication

The serial bus speed is 500 kbps and the bus itself is half duplex, i.e. data can be transferred in both directions but only one way at a time.

## Serial communication

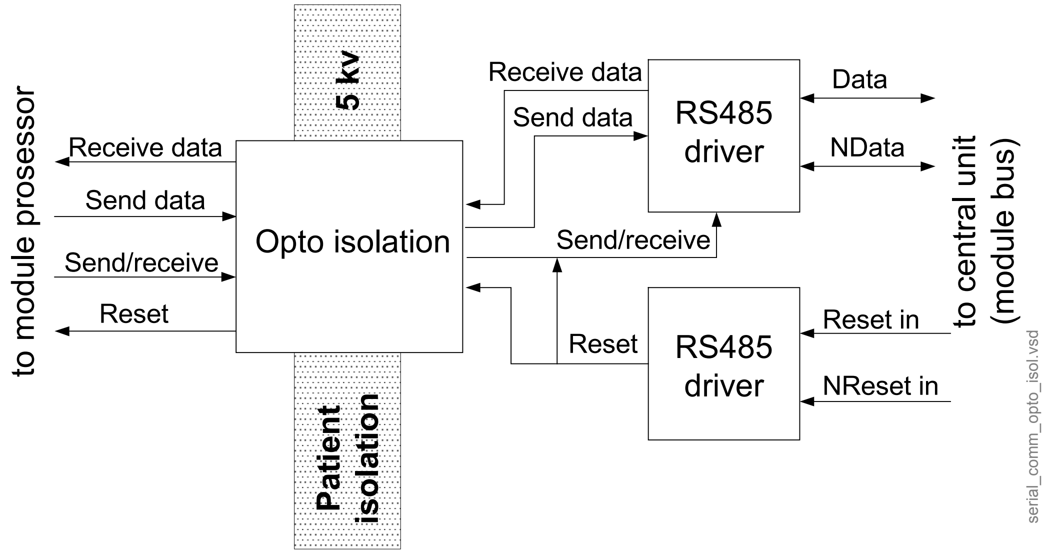



**Figure 3** **Serial communication and opto isolation**

## Stimulator

The constant current stimulator generates pulses whose amplitude is independent of the load. The main components of the stimulator are a transformer, a capacitor and a transistor. The transformer produces a high voltage which charges the capacitor and the transistor adjusts the pulse width and amplitude of the current.

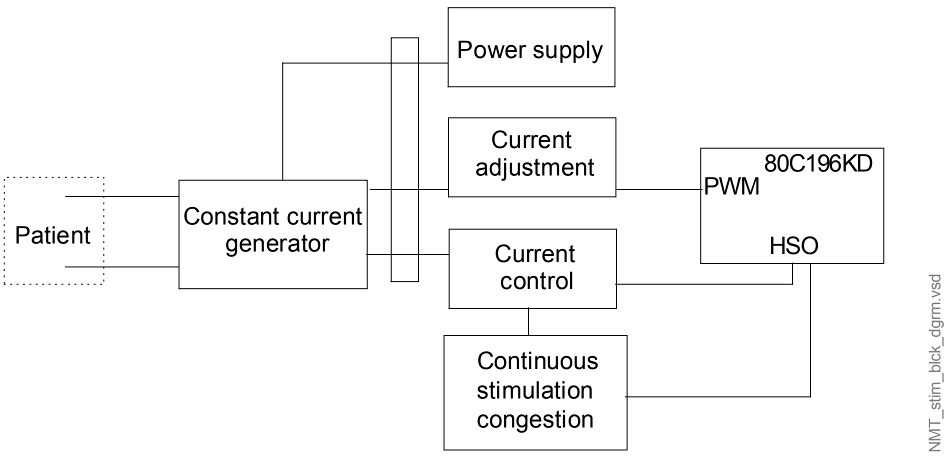



**Figure 4** **Stimulator block diagram**

## 2.3 Connectors and signals

### 2.3.1 Module bus connector

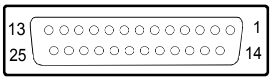
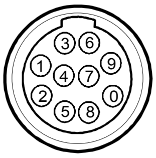



**Table 1 Module bus connector (X1)**

| Pin No. | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485 |
| 2 | I | -15 VDC |
| 3 | I | +15 VDIRTY |
| 4 | I | +15 VDC |
| 5 | I/O | -DATA_RS485 |
| 6 | I/O | DATA_RS485 |
| 7 | - | Ground & Shield |
| 8 | I | -RESET_RS485 |
| 9 | I | CTSB |
| 10 | O | RTSB |
| 11 | I | RXDB |
| 12 | O | TXDB |
| 13 | - | Ground & Shield |
| 14 | I | +32 VDIRTY |
| 15 | I | GroundDIRTY |
| 16 | I | CTSC |
| 17 | O | RTSC |
| 18 | I | RXDC |
| 19 | O | TXDC |
| 20 | - | ON/STANDBY |
| 21 | - | PWM_ECG |
| 22 | - | RXDD_RS232 |
| 23 | - | TXDD_RS232 |
| 24 | I | +5 VDC |
| 25 | I | +5 VDC |

## 2.3.2 Front panel connector

### NMT connector (NMT)




| Pin No. | Signal |
|---|---|
| 1 | EMG Signal + |
| 2 | EMG Signal - |
| 3 | Not Used |
| 4 | Stimulus + |
| 5 | Stimulus - |
| 6 | Ground |
| 7 | Not Connected |
| 8 | Sensor Identification |
| 9 | +5 V |
| 10 | Mechanical Signal |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the NeuroMuscular Transmission Module, M-NMT, is limited to replacing faulty circuit boards or mechanical parts. Faulty circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

The Datex-Ohmeda NMT Stimulator (order code 871251) is recommended for functional checks.

CAUTION Only trained personnel with the appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (Appendix A), which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| NMT simulator | 871251 | |
| M-NMT ElectroSensor | | |
| M-NMT MechanoSensor | | |
| M-NMT Sensor Cable | | |
| 3 kΩ resistor | | |
| Screwdriver | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring locking pin.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - the EMC cover is attached properly
   - there are no loose objects inside the module

   ✍

2. Check external parts:
   - the front cover and the front panel sticker are intact
   - connectors are intact and are attached properly
   - the module box, latch and spring locking pin are intact

   ✍

- Refit the module box and check that the latch moves properly.
- Turn the monitor on and wait until the normal monitoring screen appears.

- Configure the monitor screen so that information regarding the NMT measurement is shown, for example:

  **Monitor Setup** ***- Screen 1 Setup - Digit Fields - Field 4 - Nmt***

- Preset the NMT measurement settings:

  **Others** ***- NMT - Stimulus Mode - TOF***
  ***Set Cycle Time - 10 sec***
  ***NMT Setup - Current - S(70 mA)***
  ***Pulse Width - 200 $\mu$S***
  ***Stim. Beep Volume - 2***

3. Plug in the module. Check that it goes in smoothly and locks up properly

4. Check that the module is recognized, i.e. the NMT header with related information appear in the chosen digit field.

5. Enter the service menu:

   **Monitor Setup** ***- Install/Service (password 16-4-34) - Service (password 26-23-8***)

   Take down the information regarding NMT software by selecting SCROLL VERS and turning the ComWheel.

6. Enter the NMT module service menu:

   ***Parameters - NMT***

   Check that the “Timeouts”, “Bad checksums” and “Bad c-s by mod” values are not increasing faster than by 5 per second. Check that the module’s memories have passed the internal memory test, i.e. “RAM”, “ROM” and “EEPROM” all state OK.

7. Check the front panel START-UP and STOP/CONTINUE membrane keys.
   Press each key for at least one second and check that the key being pressed is identified, i.e. the color under the corresponding text on the menu turns blue.

8. Check that the message “Cable off” is shown in the digit field and that “Cable” in the service menu states OFF.

   Plug the M-NMT Sensor Cable with the M-NMT ElectroSensor into front panel connector NMT. Check that the message in the digit field changes to “Measurement OFF” and “Cable” on the service menu states EMG and ELECTR. OFF.

9. Perform the stimulus current test.

   Connect a 3 kΩ resistor between the ElectroSensor’s stimulus electrode leads (brown and white).

   Start the test by highlighting START CURR. TEST on the service menu and pressing the ComWheel. Check that the test was successful with all three test currents, i.e. the “Current test (mA):” on the menu states 30 OK, 50 OK and 70 OK.

- Connect the M-NMT ElectroSensor leads to the NMT simulator. Set the switch on the simulator to “Fade off” and turn the knob to “max”. Check “Cable” on the service menu now states only EMG.

10. Start NMT measurement (TOF) by pressing the START-UP key on the module.

    When the message “Supramax search” changes to “Setting reference” in the digit field, check that the supramaximal current detected is less than 70 mA, i.e. the “Current set” value on the service menu is less than 700.

11. Check that the module gives four successive stimulus pulses with 10 second intervals. A small asterisk (✻) should be shown in the digit field during each of the stimulus pulses and simultaneous sound signals should be heard from the loudspeaker.

    Check that on the service menu the values for “T1%”, “T2%”, “T3%”, “T4%” and “Ratio%” are all within 950-1059.

    Check also that in the digit field the “TOF%” value is within 95-105, “Count” is 4 and “T1%” is within 95-105.

12. Check that the “Noise” value on the service menu stays under 100.

13. Change the stimulus pulse width to 100 µs through the NMT service menu:

    ***NMT Setup - Pulse Width - 100 µS***

Check that the “TOF%” value is still within 95-105, “Count” is 4 and “T1%” is within 95-105 in the digit field.

Check the same parameters with a stimulus pulse width of 300 µs.

14. Turn the knob on the NMT simulator to “0”.

    Check that on the service menu the values for “T1%”, “T2%”, “T3%”, “T4%” turn to 0 and the “Ratio%” states - - -. In the digit field “TOF%” should also state - - - , and “Count” and “T1%” should show 0.

    Turn the NMT simulator knob back to “max”.

15. Change the stimulus mode to Double Burst Stimulation (DBS) through the service menu:

    ***NMT Setup - Stimulus Mode - DBS***

    Check that the module now gives only two stimulus pulses with a 10 seconds interval.

    Check that on the service menu the values for “T1%”, “T2%”, and “Ratio%” are still within 950-1059. In the digit field the “DBS%” value should be within 95-105, “Count” is 2 and “T1%” is within 95-105.

16. Change the stimulus mode to Single Twitch Stimulation (ST):

    ***NMT Setup - Stimulus Mode - ST***

    Check that the module starts to give only one stimulus pulse with a 1 second interval. Note the time when the ST stimulation started.

    Check that on the service menu the value for “T1%” is within 950-1059. In the digit field the “Count” value should be 1 and “T1%” within 95-105.
    Let the monitor continue to give single twitch stimulation.

17. Check that the NMT measurement stops and the message “Measurement OFF” appears in the digit field for NMT five minutes after the start of the ST stimulation.

18. Replace the M-NMT ElectroSensor with the M-NMT MechanoSensor and check that “Cable” on the service menu states PIEZO.

19. Perform an electrical safety check and a leakage current test.

20. Check that the module functions normally after performing the electrical safety check.

21. Clean the module with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the NeuroMuscular Transmission Module, M-NMT, in the following way. See the *Exploded view of NMT Module*.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with the loose latch and spring locking pin.
3. Detach the NMT board by removing the two screws located near the front panel frame, disconnect the cables and pull out the front panel frame.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| Trouble | Cause | Treatment |
|---|---|---|
| Check the stimulus electrodes.<br>EMG electrode off. | Loose electrodes or loose stimulus clip. | Change or attach the electrodes or clip. |
| Supramax. not found. | Loose electrodes or loose stimulus clip.<br>Stimulus electrodes attached to wrong place.<br>Patient is relaxated. | Change or attach the electrodes or clip.<br>Change the place of the stimulus electrode. |
| Response too weak. | Loose stimulus electrodes.<br>Measuring electrodes attached to wrong place.<br>Patient is relaxated. | Change or attach the electrodes.<br>Change the place of the meas. electrodes. |
| Ref. not stable. | Patient is relaxated.<br>Movement artifact. | |

# 4.2 Troubleshooting flowchart

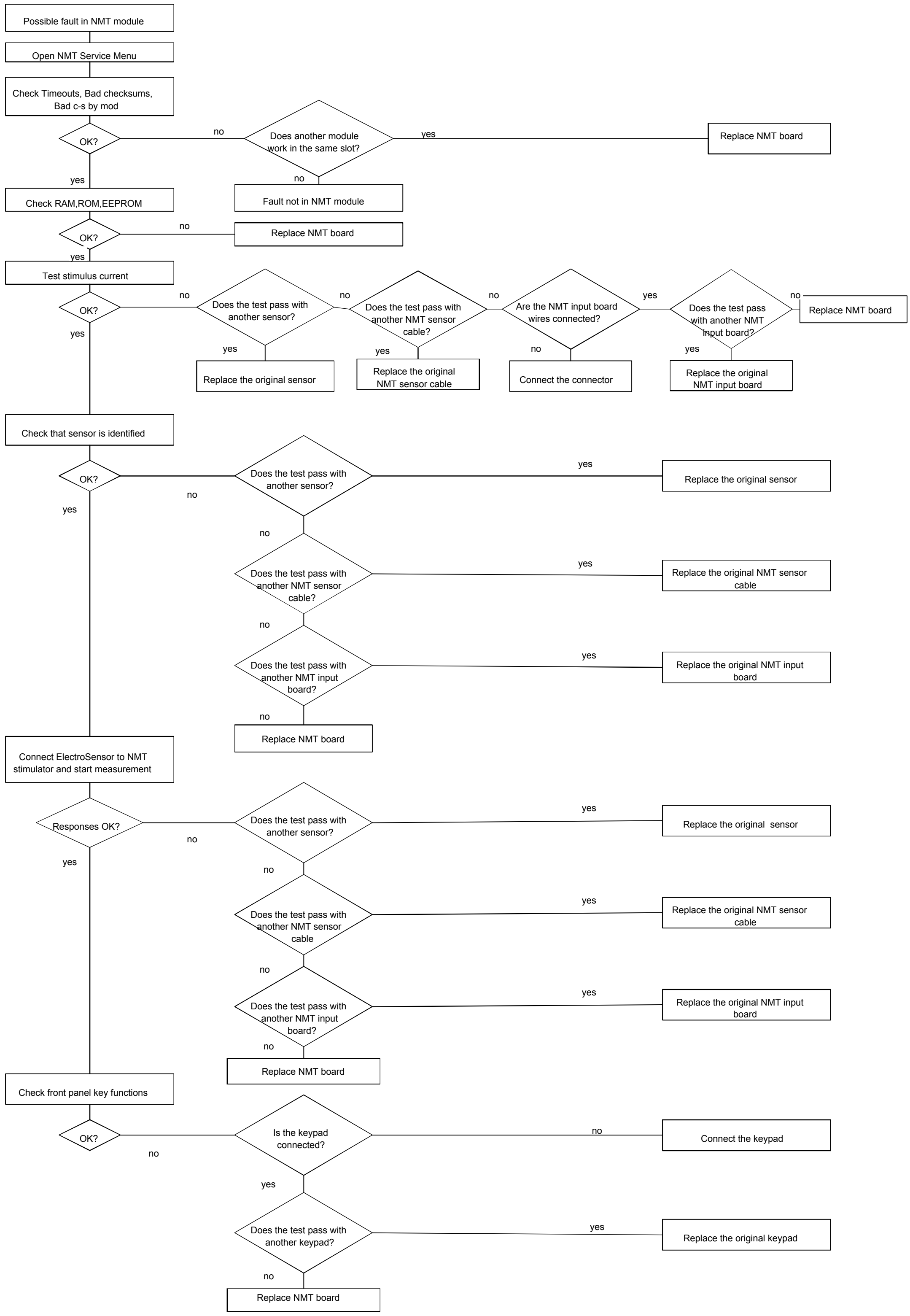
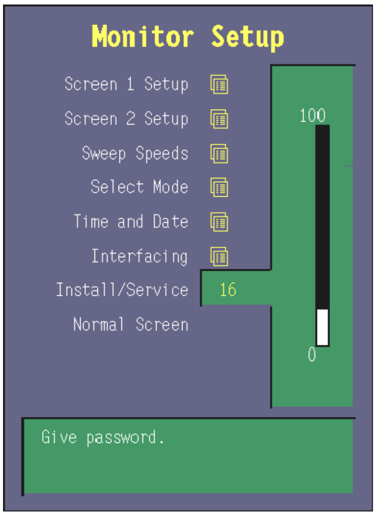
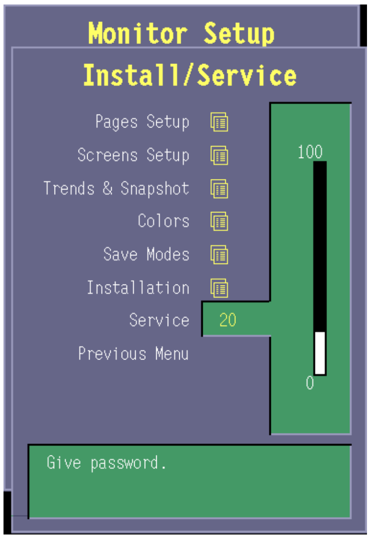


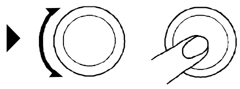

**Figure 5** **Module troubleshooting flowchart**

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.

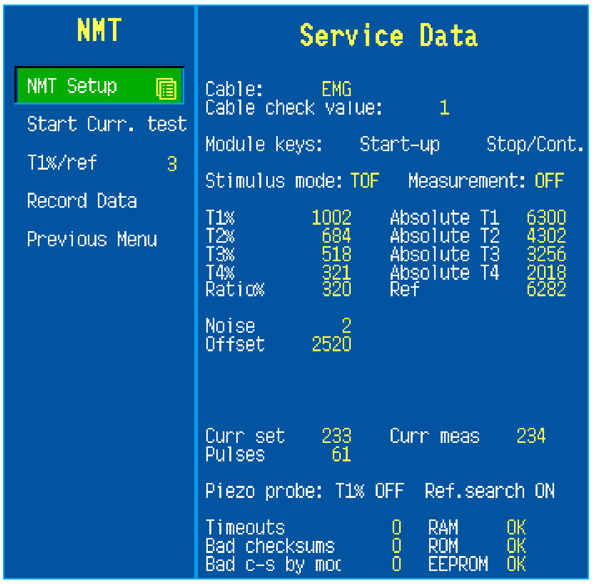


1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters***.
5. Select ***NMT***.

## 5.1 NMT menu




**Start Curr. test** **Start Curr. test** is a test where the module itself checks the difference between a given current and the measured current. A 3 kΩ resistance should be connected between the stimulus electrodes before starting the test. All the currents checked will be displayed on the service data screen. After the current value, the status of the test is shown. If the test is not passed, send the module back to the factory for calibration.

**T1%/ref** **T1% / ref** gives a selection for changing settings related to the M-NMT MechanoSensor. A setting of **3** should always be used for normal monitoring. The settings **1** and **2** are for research purposes only.

**Record Data** **Record Data** prints out the displayed service data and circuit board information (id., serial number, and software id.) onto the Recorder Module, M-REC.

### Service Data

**Cable** shows the type of cable being used.

**Cable check value** shows the bit amount. From the following chart you can check the value for each cable:

| | |
|---|---|
| EMG | -100...+100 |
| Cable OFF | >1950 |
| Piezo | 900...1100 |
| Regional block | 600....800 |

**Module Keys** checks the function of the module keys. A blue background appears at the back of the text when a key is pressed for more than one second.

**Stimulus mode** shows the selected stimulus. Stimulus mode can be changed using the NMT Setup menu.

**Measurement** indicates ON/OFF.

**T1%, T2%** shows the measured response. A value of 1000 corresponds to 100%.

**Absolute T1, T2** shows the voltage measured from the A/D converter.

**Noise** indicates the interference just before the measurement. A typical value is <10.

**Offset** is an average of the noise measurement. A typical value is 510.

**Curr set** is the selected current, a value of 700 corresponds to 70 mA.

**Curr meas** is the measured current, a value of 700 corresponds to 70 mA.

**Pulses** indicates pulses the module has produced.

**Piezo probe T1% and ref. search** shows information related to the MechanoSensor settings.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.

**Bad checksums** is a cumulative number that indicates how many times communication from the module to the monitor has failed.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The non-zero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also, other modules can cause communication errors that cause these numbers to rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum in the EPROM is in accordance with the software calculated value.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

# 6 SPARE PARTS

## 6.1 Spare part list

NOTE: Accessories are listed in the *Patient Monitor Supplies and Accessories*.

### 6.1.1 NMT Module, M-NMT rev. 00, 01, 02

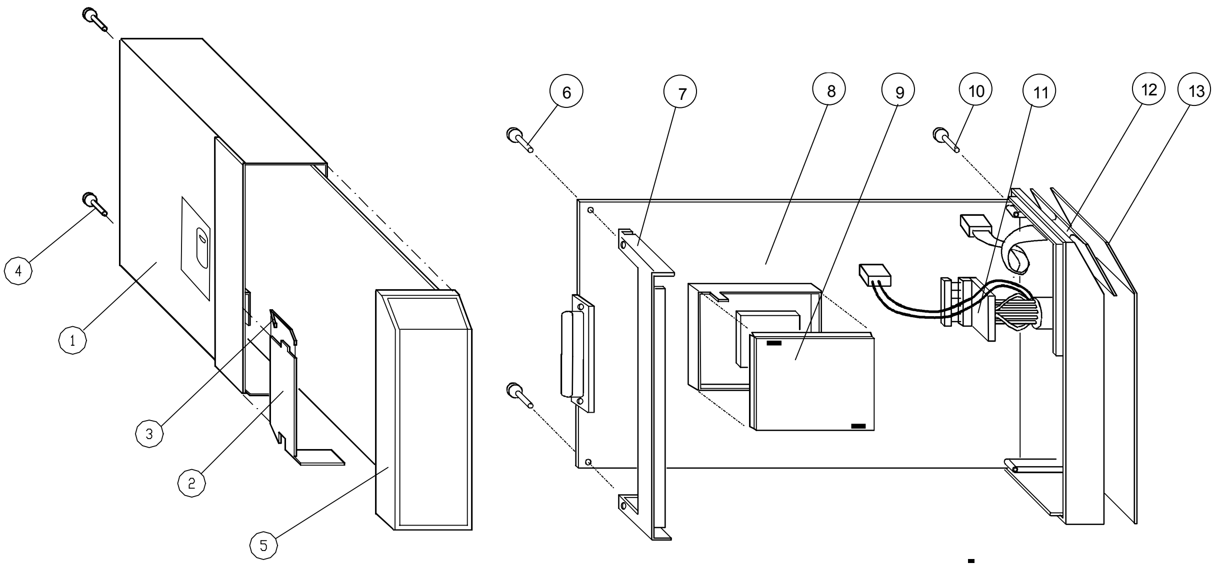



**Figure 6 Exploded view of NMT Module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel unit, M-NMT | 887186 | |
| 6 | Cross cylinder-head screw M3x6 | 61721 | |
| 7 | Metal frame | 879184 | |
| 8 | NMT board, M-NMT (rev.00-01) | 887487 | |
| 9 | EMC cover, M-NMT | 886320 | |
| 10 | Cross cylinder-head scerw M3x12 | 628700 | |
| 11 | NMT input board | 887184 | |
| 12 | Membrane keypad | 880101 | |
| 13 | Front Panel sticker, DA ; M-NMT (rev.00-01) | 892217 | 898846 |
| 13 | Front Panel sticker, DA ; M-NMT (rev.02) ; S/5 | 898846 | |
| 13 | Front Panel sticker, DE ; M-NMT (rev.00-01) | 886003 | 898837 |
| 13 | Front Panel sticker, DE ; M-NMT (rev.02) ; S/5 | 898837 | |
| 13 | Front Panel sticker, EN ; M-NMT (rev.00-01) | 886002 | 898836 |
| 13 | Front Panel sticker, EN ; M-NMT (rev.02) ; S/5 | 898836 | |
| 13 | Front Panel sticker, ES ; M-NMT (rev.00-01) | 887498 | 898840 |
| 13 | Front Panel sticker, ES ; M-NMT (rev.02) ; S/5 | 898840 | |
| 13 | Front Panel sticker, FI ; M-NMT (rev.00-01) | 888873 | 898843 |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 13 | Front Panel sticker, FI ; M-NMT (rev.02) ; S/5 | 898843 | |
| 13 | Front Panel sticker, FR ; M-NMT (rev.00-01) | 886004 | 898838 |
| 13 | Front Panel sticker, FR ; M-NMT (rev.02) ; S/5 | 898838 | |
| 13 | Front Panel sticker, IT ; M-NMT (rev.00-01) | 887542 | 898841 |
| 13 | Front Panel sticker, IT ; M-NMT (rev.02) ; S/5 | 898841 | |
| 13 | Front Panel sticker, JA ; M-NMT (rev.00-01) | 888318 | 8000383 |
| 13 | Front Panel sticker, JA ; M-NMT (rev.02) ; S/5 | 8000383 | |
| 13 | Front Panel sticker, NL ; M-NMT (rev.00-01) | 887370 | 898839 |
| 13 | Front Panel sticker, NL ; M-NMT (rev.02) ; S/5 | 898839 | |
| 13 | Front Panel sticker, NO ; M-NMT (rev.00-01) | 893572 | 898845 |
| 13 | Front Panel sticker, NO ; M-NMT (rev.02) ; S/5 | 898845 | |
| 13 | Front Panel sticker, PT ; M-NMT (rev.00-01) | 895240 | 898842 |
| 13 | Front Panel sticker, PT ; M-NMT (rev.02) ; S/5 | 898842 | |
| 13 | Front Panel sticker, SV ; M-NMT (rev.00-01) | 887369 | 898844 |
| 13 | Front Panel sticker, SV ; M-NMT (rev.02) ; S/5 | 898844 | |

# 7 EARLIER REVISIONS

This manual also supports earlier module revision 00.

# APPENDIX A

# SERVICE CHECK FORM

## NeuroMuscular Transmission Module, M-NMT

Customer ____________________

Service ____________ Module type ____________ S/N ____________

Service engineer ____________________ Date ____________

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | 4. Recognition | ☐ | ☐ | ☐ |
| 5. Module software | NMT | | | | | | |
| 6. Communication and memories | ☐ | ☐ | ☐ | 7. Membrane keys | ☐ | ☐ | ☐ |
| 8. ElectroSensor recognition | ☐ | ☐ | ☐ | 9. Stimulus current test | ☐ | ☐ | ☐ |

| | | |
|---|---|---|
| 10. Supramaximal current | | < 70 mA |

11. TOF measurement with NMT simulator

| | | |
|---|---|---|
| T1% | | 950-1059 |
| T2% | | 950-1059 |
| T3% | | 950-1059 |
| T4% | | 950-1059 |
| Ratio% | | 950-1059 |
| TOF% | | 95-105 |
| Count | | 4 |
| T1% | | 95-105 |
| 12. Noise | | < 100 |

13. Stimulus pulse width

| | 100 µs | 300 µs | Allowed range |
|---|---|---|---|
| TOF% | | | 95-105 |
| Count | | | 4 |
| T1% | | | 95-105 |

| | OK | N.A. | Fail |
|---|---|---|---|
| 14. No response | ☐ | ☐ | ☐ |

15. DBS measurement with NMT simulator

| | | |
|---|---|---|
| T1% | | 950-1059 |
| T2% | | 950-1059 |
| Ratio% | | 950-1059 |
| DBS% | | 95-105 |
| Count | | 2 |
| T1% | | 95-105 |

16. ST measurement with NMT simulator

| | | |
|---|---|---|
| T1% | | 950-1059 |
| Count | | 1 |
| T1% | | 95-105 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17. Automatic measurement off | ☐ | ☐ | ☐ | 18. MechanoSensor recognition | ☐ | ☐ | ☐ |
| 19. Electrical safety check | ☐ | ☐ | ☐ | 20. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 21. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes** ______________________________

______________________________

**Used Spare Parts** __________ __________ __________

**Signature** ______________________________

# Datex-Ohmeda

# Anesthesia record keeping keyboard, K-ARKB (rev. 00)

# S/5™ Keyboard Interface Board, B-ARK (rev. 00)

# Barcode reader, N-SCAN (rev. 00)

# Technical Reference Manual Slot

All specifications are subject to change without notice.

Document No. 8003840-1

April 2002

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
mailto:product.support.ussub@us.datex-ohmeda.com
www.us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Anesthesia record keeping keyboard, K-ARKB, S/5 Keyboard Interface Board, B-ARK and Barcode reader, N-SCAN

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the anesthesia record keeping keyboard, K-ARKB, the S/5 Keyboard Interface Board, B-ARK and the barcode reader, N-SCAN. The information is applicable for the current production revisions of the devices. Later in this manual modules may be refered to without the S/5 system nomenclature for simplicity..

Please refer to the*Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

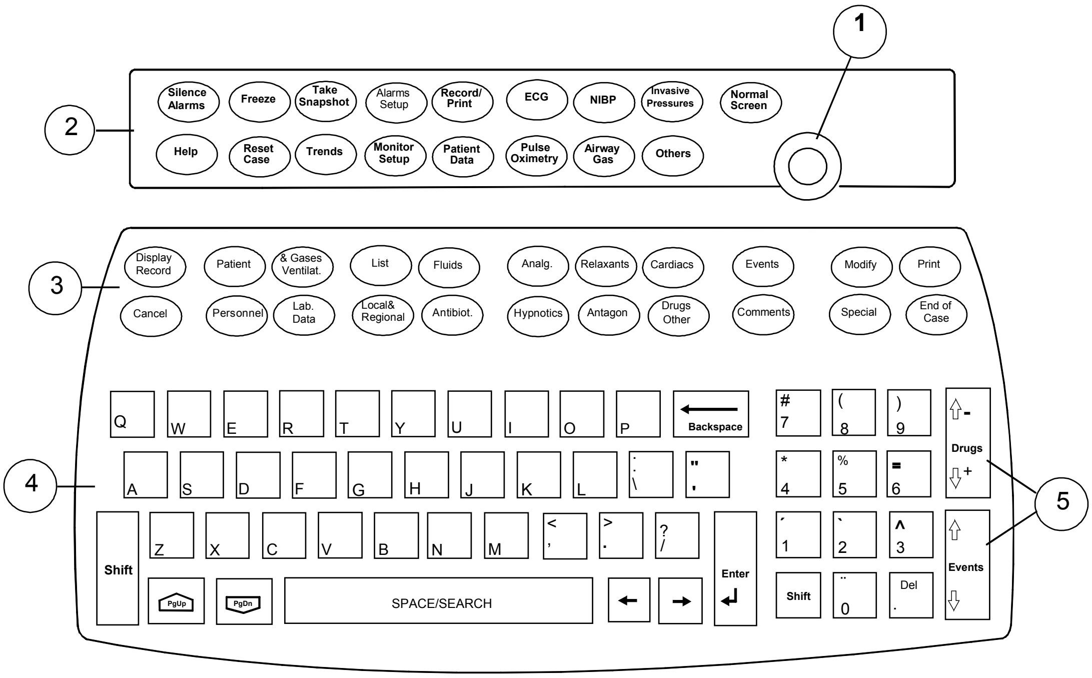



**Figure 1** **Anesthesia record keeping keyboard, K-ARKB (English version)**

(1) The ComWheel

(2) Keys that function as the S/5 monitor's command bar. The power switch is in the monitor's Command Bar.

(3) Keys for record keeping control.

(4) Letter and number keys for typing in information that is not listed in the menus.

(5) Arrow keys (Drugs, Events) for moving up or down the Event list and Event trend when the record is on the display.

NOTE: The S/5 Keyboard Interface Board, B-ARK can only be used with S/5 Anesthesia Monitor and AS/3 Anesthesia Monitor.

NOTE: The K-ARK and K-ARKB keyboards are compatible with monitor software versions: S-ARK94 and later, L-ARK99(A), L-00A03/04, L-00A07/08 and L-ANE01(A) and later

# Related documents

| For more information about... | See |
|---|---|
| Technical issues | Technical Reference Manual of the Monitor, Part I |
| Configuration | Anesthesia Record Keeping Solution, user documentation |
| Contents of the menus in your hospital | Contact the personnel responsible for the menu configurations in the hospital |
| Monitor, parameters, physiological trends, general messages and symbols on the display | Datex-Ohmeda S/5 Anesthesia Monitor, User's Guide and User's Reference Manual |
| Printer | The printer manual |
| Barcode reader | The barcode reader manual |

# 1 SPECIFICATIONS

## 1.1 General specifications

### 1.1.1 Keyboard, K-ARKB

| | |
|---|---|
| Dimensions (W × D × H) | 328 × 232 × 61 mm/12.9 × 9.1 × 2.4 in |
| Weight | 1.3 kg/3.8 lbs. |
| Power | +5 V DC ±10 %, 70 mA max, supplied from S/5 AM or S/5 CM |
| Character set | ASCII |
| Communication interface | PC compatible serial line plus S/5 type serial line |
| Environmental requirements: | |
| Operating temperature | +10...+35 °C/+50...+95 °F |
| Storage temperature | -10...+45 °C/+14...+113 °F |
| Humidity | 10...90 % non-condensing |

### 1.1.2 Barcode reader, N-SCAN

| | |
|---|---|
| Dimensions (W × L × H) | 7.1 × 12.7 × 16 cm/2.8 × 5 ×6.3 in |
| Weight approx. | 170 g/5.98 oz. (w/o cable) |
| Power | supplied from S/5 monitor or AS/3 AM or AS/3 CM |
| Light source | 675 nm laser diode |
| Laser classifications | CDRH Class II, IEC Class 1, IEC 825 Class 2 |
| Environmental requirements: | |
| Operating temperature | 0...+40 °C/+32...+104 °F |
| Storage temperature | -40...+60 °C/-40...+140 °F |
| Humidity | 5...95 % non-condensing |
| Durability | withstands 1.2 m drop to concrete |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Introduction

Anesthesia Record Keeping Solution is an automated anesthesia documentation system. For the Anesthesia Record Keeping Solution, the record keeping configurations from the network and a memory module, and optionally the keyboard, K-ARKB is needed.

The anesthesia Record Keeping Solution is connected to the network, and runs in the S/5 AM or S/5 CM. Memory Module, M-MEM (N-CMMEM) is needed for backup data storage.

The anesthesia Record Keeping Solution combines the physiological data measured by the monitor, information automatically integrated from external devices such as the S/5 ADU, and the information entered manually using the menus into a printable anesthesia record. The record can be stored in electronic format for later review/printing and for statistical analysis.

## 2.2 Anesthesia record keeping keyboard, K-ARKB

The anesthesia record keeping keyboard, K-ARKB, consists of the controller board, alphanumeric keyboard and membrane keyboard.

### 2.2.1 Controller Board

The controller board reads the status of the keyboard keys and the ComWheel, and forwards the information to the CPU board, in the monitor through an RS232 serial interface.

Additionally, the board controls the LEDs on the K-ARKB front panel.

#### External communication

Communication with the CPU board, takes place in the RS232 serial communication channel which is available on the CPU bus. There are also two bidirectional signals (Data and Clock) for PCKB format communication.

For serial communication, the anesthesia record keeping keyboard is connected to the S/5 Anesthesia Monitor 8-Module Frame by 9-pin-26-pin interface cable. The cable is connected to Keyboard Interface Board, B-ARK or to Display Controller board, B-DISP (or B-DHIGH), in the F-CU8.

In case of PCKB type communication, the Keyboard can be connected to the S/5 LCD Display, D-LCC10A or to the S/5 CM.

#### CPU

The CPU on the controller board is of a type 80C51FA and the oscillator frequency is 11.059 Mhz. There is a power-up-reset whose time constant is about 1 second.

#### Serial communication

The RS232 serial communication IC needs only +5 V supply voltage because it chops the necessary RS-level supply voltages to its external capacitors. A diode allows the use of two keyboards, and a pull-down resistor on the CPU board is used for pulling the corresponding line to the negative RS-level. The speed rate of the serial communication is 19.2 kbps.

#### LEDs

The CPU on the controller board controls the alarm LEDs according to commands received from the main CPU board.

### 2.2.2 Alpha-numeric keyboard

The controller board reads the status of the keys on the alphanumeric keyboard. The boards are connected together with a 26-pin ribbon cable.

### 2.2.3 Membrane keyboard

The controller board reads the status of the keys on the membrane keyboards. The membrane keyboard and the controller board are connected together with a ribbon cable.

## 2.3 Keyboard Interface Board, B-ARK

The Keyboard Interface Board, B-ARK is installed in the 8-Module Frame of the S/5 Anesthesia Monitor. It has a 26-pin D-connector to which the anesthesia record keeping keyboard, K-ARKB is connected. The board passes the keyboard signals to the F-CU8.

## 2.4 Barcode reader, N-SCAN

The barcode reader, N-SCAN is an optional device to make record keeping faster by using bar codes. With the barcode reader the user has direct access to a menu item by reading a bar code mapped to the menu item. Barcodes can also be used for pushing and turning the ComWheel and opening the main menus (L-ARK99(A) or later).

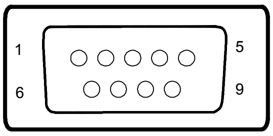
**WARNING** **When using the barcode reader, N-SCAN, do not stare into beam. The barcode reader, N-SCAN is a Class 2 laser product.**

## 2.5 Connectors and signals

**Bar Code Reader 5-pin connector on the anesthesia record keeping keyboard, K-ARKB**

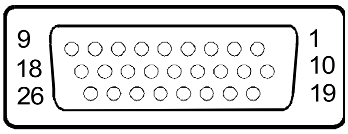
| Pin No | Signal |
|---|---|
| 1 | PC-CLOCK |
| 2 | PC-DATA |
| 3 | N.C. |
| 4 | GND |
| 5 | +5 V |

**Anesthesia record keeping keyboard 9-pin connector on the anesthesia record keeping keyboard, K-ARKB**




| Pin No | I/O | Signal |
|---|---|---|
| 1 | I/O | PC-DATA |
| 2 | I | RX |
| 3 | O | TX |
| 4 | I | +5 V |
| 5 | | GND |
| 6 | I | RESET |
| 7 | - | GND |
| 8 | - | N.C. |
| 9 | I/O | PC-CLOCK |

**The connector located on the Keyboard Interface Board, B-ARK**




| Pin No | I/O | Signal |
|---|---|---|
| 1 | | N/C |
| 2 | | N/C |
| 3 | | N/C |
| 4 | | N/C |
| 5 | | N/C |
| 6 | O | Ground |
| 7 | | N/C |
| 8 | | N/C |
| 9 | | N/C |
| 10 | | N/C |
| 11 | | N/C |
| 12 | | N/C |
| 13 | | N/C |
| 14 | | N/C |

| Pin No | I/O | Signal |
|---|---|---|
| 15 | O | + 5 V |
| 16 | | N/C |
| 17 | | N/C |
| 18 | | N/C |
| 19 | I | RxD RS232 |
| 20 | O | TxD RS232 |
| 21 | | N/C |
| 22 | | N/C |
| 23 | | N/C |
| 24 | | N/C |
| 25 | | N/C |
| 26 | | N/C |

**The CPU bus connector (X1)**

| Pin No | a | b | c |
|---|---|---|---|
| 1 | +15 V | AGND | DGND |
| 2 | -15 V | BALE | DGND |
| 3 | SA0 | SA1 | DGND |
| 4 | SA2 | SA3 | RESET_RS485 |
| 5 | SA4 | SA5 | -RESET_RS485 |
| 6 | SA6 | SA7 | DATA_RS485 |
| 7 | SA8 | SA9 | -DATA_RS485 |
| 8 | SA10 | SA11 | TXDD_RS232 |
| 9 | SA12 | SA13 | RXDD_RS232 |
| 10 | SA14 | SA15 | BIT0IN |
| 11 | SA16 | SA17 | BIT1IN |
| 12 | SA18 | SA19 | TXDC |
| 13 | SA20 | SA21 | RXDC |
| 14 | SA22 | SA23 | RTSC |
| 15 | -SMEMR | -SMEMW | CTSC |
| 16 | -IOR | -IOW | TXDB |
| 17 | CLK | -RESET | RXDB |
| 18 | -IOCHRDY | IRQ10 | RTSB |
| 19 | N/C_1 | IRQ11 | CTSB |
| 20 | N/C_2 | IRQ12 | TXDA |
| 21 | -SBHE | IRQ15 | RXDA |
| 22 | SD0 | SD1 | RTSA |
| 23 | SD2 | SD3 | CTSA |
| 24 | SD4 | SD5 | LOUDSPEAKER |
| 25 | SD6 | SD7 | +5 V |
| 26 | SD8 | SD9 | +5 V |
| 27 | SD10 | SD11 | +5 V |
| 28 | SD12 | SD13 | +5 V |
| 29 | SD14 | SD15 | ON/STBY |
| 30 | +15 VD | -RESET_CPU | +5 V_CPU |
| 31 | +15 VD | +32 VD | REFRESH_WD |
| 32 | GNDD | GNDD | POWER_FAIL |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the K-ARKB Keyboard is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be then returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| **Tool** | **Order No.** | **Notes** |
|---|---|---|
| B-ARK | | with AM |
| Screwdriver | | |

1. Disconnect the interface cable from the anesthesia record keeping keyboard, K-ARKB and check the cable:
   - the connector pins are clean and straight and at about the same height
   - the locking screws are intact
   - the cable is intact

   Leave the cable disconnected.

   ✍

2. Detach the bottom cover and check internal parts:
   - all screws are tightened properly
   - the block screws for the interface cable are in place and are tightened properly
   - the block screw threads are intact
   - the interface cable connector is clean and intact
   - all internal cables are connected properly
   - all IC's that are on sockets are attached properly
   - there are no loose objects inside

   Reattach the bottom cover, reconnect and lock the interface cable to the anesthesia record keeping keyboard, K-ARKB.

   ✍

3. Check external parts:
   - the anesthesia record keeping keyboard, K-ARKB plastic frame is intact
   - the front panel stickers are intact
   - the ComWheel cover is intact and is attached properly
   - all four rubber pads are in place on the bottom cover

   ✍

- Install the B-ARK into the Central Unit. Connect and lock the interface cable to the B-ARK rear panel connector.

4. Switch the monitor on. Check that the LED on the upper right hand corner of the anesthesia record keeping keyboard, K-ARKB is lit up.

   ✍

5. Enter the service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8)

   Take down the information regarding anesthesia record keeping keyboard, K-ARKB software.

   ✍

6. Select the menu ***Keyboard*** with the ComWheel.
   Highlight the text ***Upper Led***. Check that the red alarm LED is turning on and off on the anesthesia record keeping keyboardwhen pressing the ComWheel. Check also the yellow alarm LED by selecting ***Lower Led*** from the menu.

   ✍

7. Check the ComWheel.

   Turn the ComWheel clockwise and counterclockwise and check that each step generates a sound from the loudspeaker and the corresponding values at the bottom of the menu increase.

   Select ***Dummy Press***. Press the ComWheel and check that the press generates a sound and the corresponding value in the menu increases.

   ✍

8. Check the anesthesia record keeping keyboard, K-ARKB membrane keys.

   Press the keys on the upper part of the anesthesia record keeping keyboard one by one. Check that each key generates a sound from the loudspeaker and the corresponding text in the menu changes from yellow to red.

Press the keys on the lower part, all except the keys **Modify** and **Print**. Check that each key generates a sound from the loudspeaker, or at least the 'Message count' value increases in the service menu.

Press the keys **Modify** and **Print** and check that the corresponding menus open onto the screen.

9. Perform electrical safety check and leakage current test.

10. Check that the anesthesia record keeping keyboard functions normally after the performed electrical safety check.

11. Clean the anesthesia record keeping keyboard with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

The anesthesia record keeping keyboard, K-ARKB is disassembled in the following way. See the *Exploded view of the K-ARKB keyboard.*

1. Disconnect the anesthesia record keeping keyboard - monitor cable ( keyboard - LCD display cable).
2. Remove four screws from the bottom of the keyboard, and detach the cover plate from the bottom plate.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting charts

### 4.1.1 Anesthesia record keeping keyboard, K-ARKB

| **Problem** | **Cause** | **Treatment** |
|---|---|---|
| Keys have not effect on the display. | Cable is not connected or broken.<br>Wrong type of cable is connected. | Connect right type of cable properly (see above). |
| | Loose connector inside.<br>Component failure inside. | Detach the bottom plate and check connectors and components. |
| Membrane key not working. | Ribbon cable loose or broken. Keyboard cable loose or broken. D-connector pin failure. IC failure on the Controller board. RS232 communication failure on the main CPU board.<br>NOTE: The cancel key does not respond if the menu is closed.<br>The modify key may not work if there is no selection. | Check the items. Replace them if necessary. |
| Led does not light at alarm or stays lit after alarm is over. | Cable loose or broken. LED broken.<br>Component failure on the Controller board. | Check the items. Replace them if necessary. |

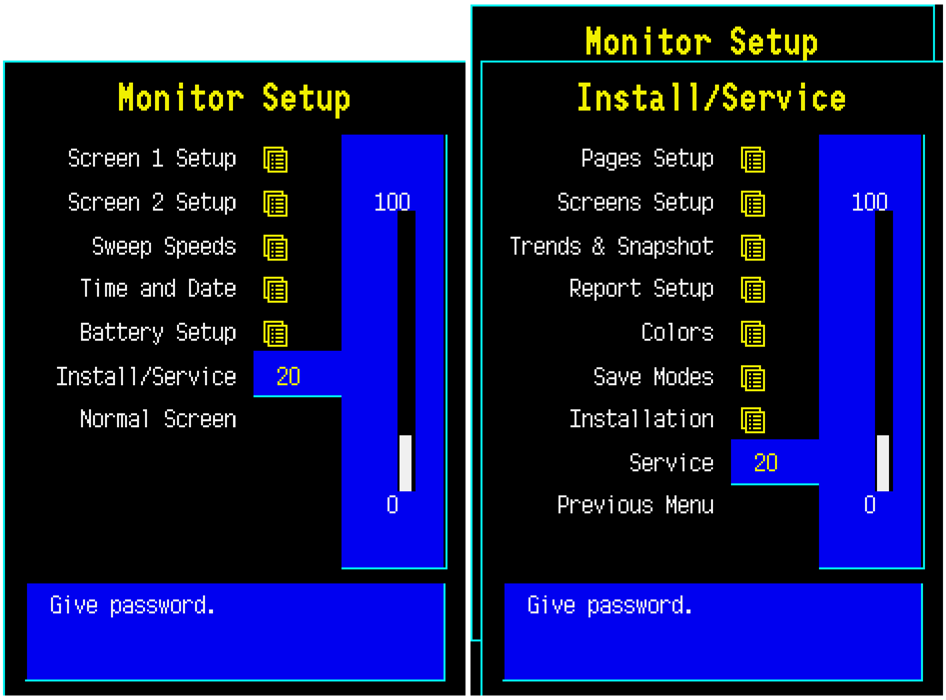
See more troubleshooting items on *User's Reference Manual*.

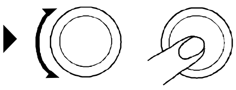
## 4.1.2 Barcode reader

| Problem | Cause | Treatment |
|---|---|---|
| Barcode reader does not give a beep sound | Beep sound is OFF. | Contact personnel responsible for installing and configuring the monitors. ***Bar Code Beep*** should be ***ON*** in **Monitor Setup** - ***Install/Service*** - ***Installation*** - ***Monitor Settings*** menu. Password is required for the selection. |
| Nothing happens when trying to use the barcode reader. | Cable connections are not properly connected. | Confirm that the cables are properly connected. |
| Barcode reader opens a ***Search*** menu but nothing else happens. | Menu directory does not have a barcode reader file. | Contact personnel responsible for installing and configuring the monitors. |
| Barcode reader led flashes and you may hear a beep sound, but nothing else happens. | 1. Barcodes are not included in the configuration.<br>2. Barcode reader is not correctly programmed.<br>3. Monitor is not connected to the network and the memory module does not have a menu card inside.<br>4. Monitor has an old configuration which is not updated.<br>5. Old software version on monitor. | 1. Contact personnel responsible for installing and configuring the monitors.<br>2. Contact personnel responsible for installing and configuring the monitors. The barcode reader should be reprogrammed. See the instructions following the barcode reader.<br>3. Connect the monitor to the network or insert a menu card into the memory module.<br>4. Contact personnel responsible for installing and configuring the monitors.<br>5. Please upgrade your monitor.<br>NOTE: Possible connecting cables are 881152 and Y-piece or 8001117. |
| Search result seems to mix different menu items. | Menu files have been modified after which they have not been recompiled with the map files. | Contact personnel responsible for installing and configuring the monitors. The menu files have to be recompiled together with the map files. |

See more troubleshooting items on *Barcode reader manual*.

# 5 SERVICE MENU



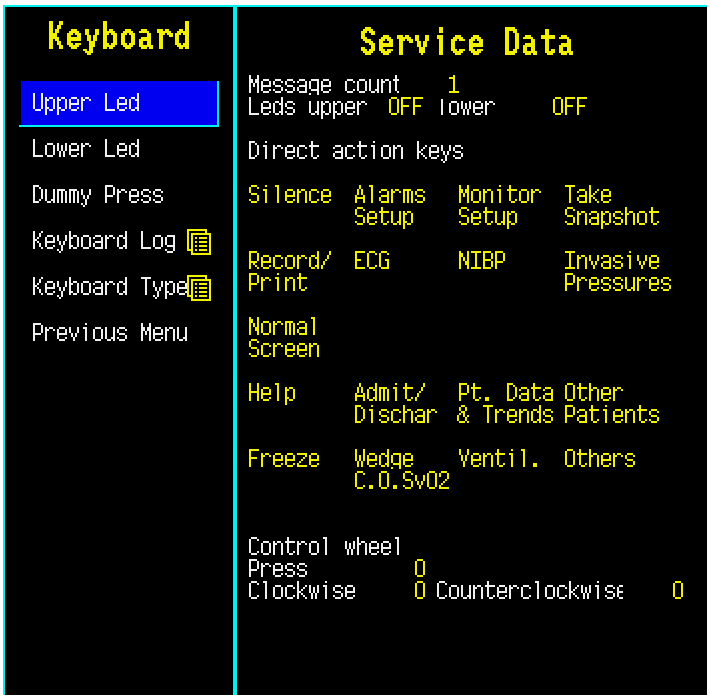



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Keyboard***.

## 5.1 Keyboard menu

A service menu for testing the command board functions and for setting the K-ARKB type.

NOTE: All counters are automatically zeroed on returning to the previous menu.



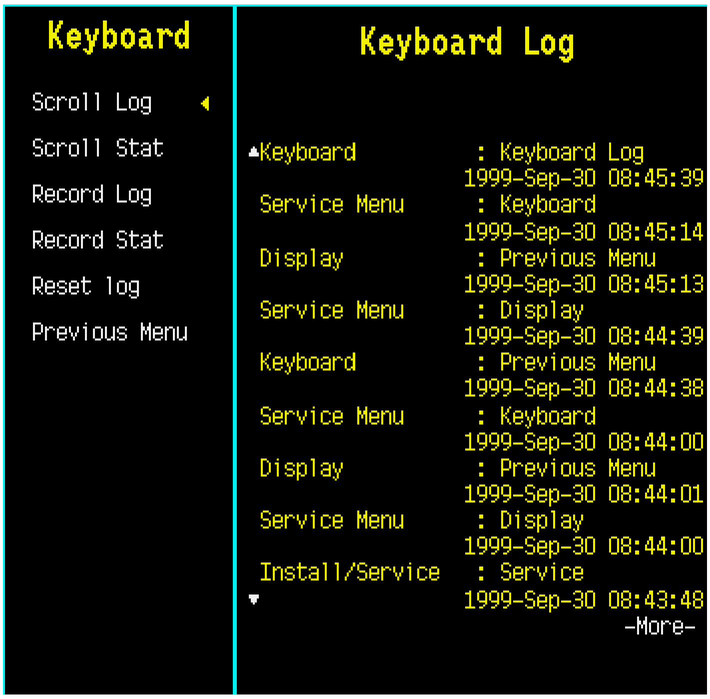

***Upper Led*** is for testing the upper alarm LED (red) on the command board. When the text is highlighted, the upper alarm LED can be turned on and off by pressing the ComWheel.
***Lower Led*** is for testing the lower alarm LED (yellow) on the command board. When the text is highlighted, the lower alarm LED can be turned on and off by pressing the ComWheel.
***Dummy Press*** is for testing the ComWheel. When the text is highlighted, pressing of the ComWheel create a sound from the loudspeaker and the corresponding number on the service data field increase.

**Service Data**

**Message count** counts the number of messages that are sent out to the main CPU board.
**Leds upper** and **lower** indicate the states of the alarm LEDs on the command board.
**Direct action keys** texts are indications to the command board membrane keys. When a key on the command board is pressed, the corresponding text in the menu changes its colour.
**Control wheel, Press** counts the ComWheel pressings.
**Control wheel, Clockwise** and **Counterclockwise** the ComWheel turnings.
**Since** shows the date and the time of the last run time reset.

### 5.1.1 Keyboard Log

All the keyboard presses and the commands given by the ComWheel are recorded in the Keyboard Log. The keyboard log is saved in the permanent memory of the monitor. The length of the log is 1150 events. The log is FIFO type.




### 5.1.2 Keyboard Type

***Store Mask*** A selection for setting the anesthesia record keeping keyboard's language. The selected language determines the outcome of the lower keypad.

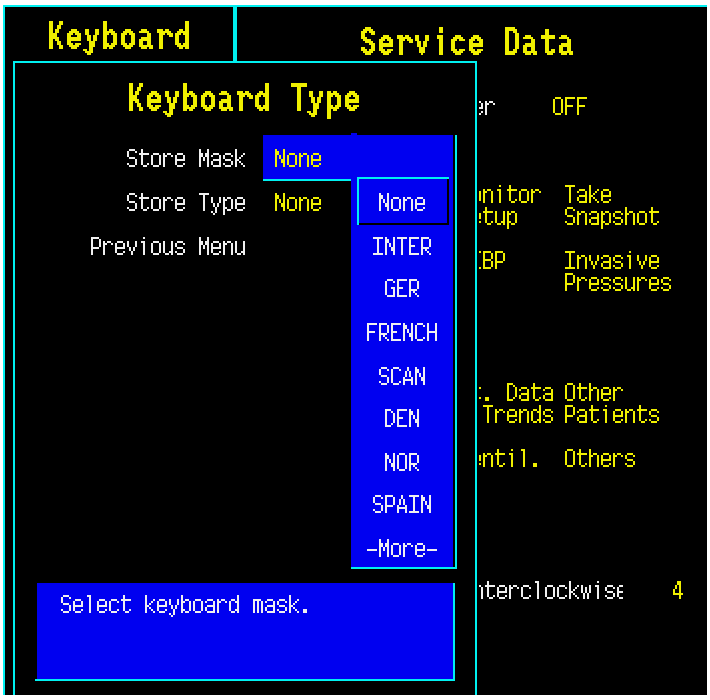
***Store Type*** is for setting the keyboard's type;

COM = Command Board

ARK = Anesthesia record keeping keyboard

IC = Information Center Keyboard

NOTE: The settings should be checked if the controller board is replaced. If settings are changed, the new settings will not be valid until the next start-up.



# 6 SPARE PARTS LIST

## 6.1 Spare parts list

### 6.1.1 Anesthesia Keyboard, K-ARK rev. 00, 01, 02

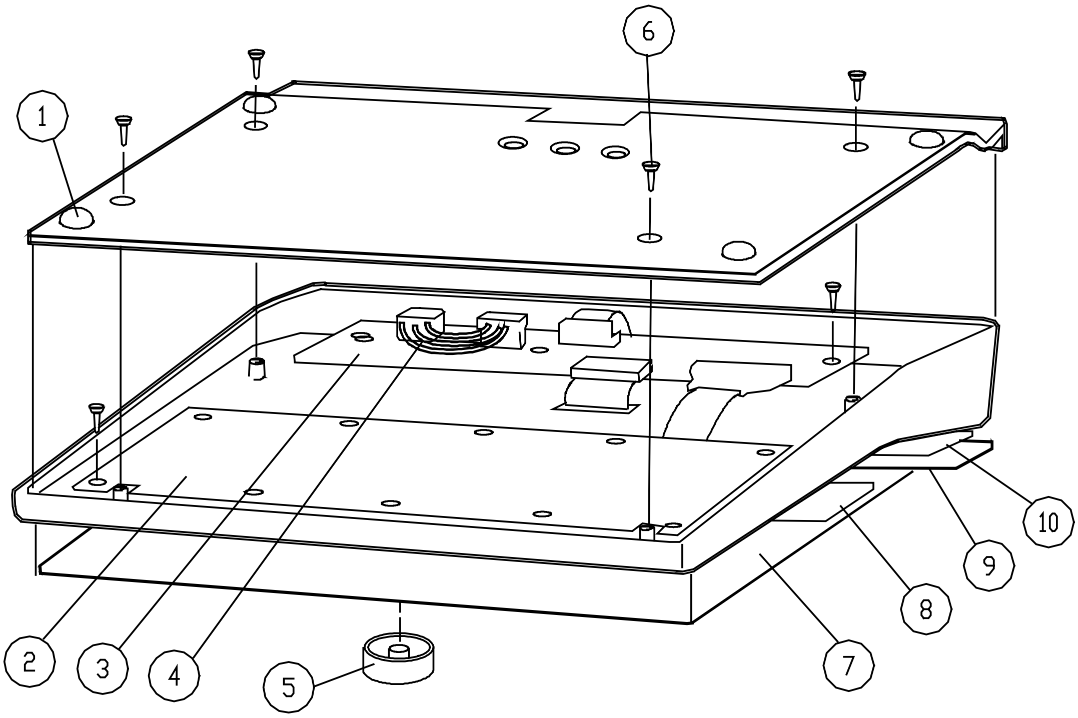



**Figure 2 Exploded view of the K-ARK keyboard**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Sticker-pad,diam 16,height 8 | 65142 | |
| 2 | Alpha-numeric Keyboard PC-board, K-ARK (rev.00-01), K-CENTRALB | 884178 | |
| 3 | Command board PCB, K-ARK (rev.01-02) | 893944 | |
| 3 | Controller board, K-ARK (rev.00), K-CENTRALB | 884177 | |
| 4 | Rotary wheel | 879872 | |
| 5 | ComWheel cover and spring | 879191 | |
| 6 | Cross cylinder-head screw M3x6 | 61721 | |
| 7 | Lower Front Panel sticker, IT ; K-ARK (rev.02) | 893608 | |
| 7 | Lower Front Panel sticker, SCA ; K-ARK (rev.00-01) | 884632 | 893807 |
| 7 | Lower Front Panel sticker, DA ; K-ARK (rev.02) | 893611 | |
| 7 | Lower Front Panel sticker, DE ; K-ARK (rev.00-01) | 885133 | 893604 |
| 7 | Lower Front Panel sticker, DE ; K-ARK (rev.02) | 893604 | |
| 7 | Lower Front Panel sticker, EN ; K-ARK (rev.00-01) | 884017 | 893603 |
| 7 | Lower Front Panel sticker, EN ; K-ARK (rev.02) | 893603 | |
| 7 | Lower Front Panel sticker, ES ; K-ARK (rev.00-01) | 886198 | 893607 |
| 7 | Lower Front Panel sticker, ES ; K-ARK (rev.02) | 893607 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 7 | Lower Front Panel sticker, FI ; K-ARK (rev.00-01) | 888862 | 893609 |
| 7 | Lower Front Panel sticker, FI ; K-ARK (rev.02) | 893609 | |
| 7 | Lower Front Panel sticker, FLE ; K-ARK (rev.00-01) | 886161 | 893114 |
| 7 | Lower Front Panel sticker, FLE ; K-ARK (rev.02) | 893114 | |
| 7 | Lower Front Panel sticker, FR ; K-ARK (rev.00-01) | 884406 | 893605 |
| 7 | Lower Front Panel sticker, FR ; K-ARK (rev.02) | 893605 | |
| 7 | Lower Front Panel sticker, IT ; K-ARK (rev.00-01) | 886911 | 893608 |
| 7 | Lower Front Panel sticker, NL ; K-ARK (rev.00-01) | 886282 | 893606 |
| 7 | Lower Front Panel sticker, NL ; K-ARK (rev.00-01) | 892200 | 893611 |
| 7 | Lower Front Panel sticker, NL ; K-ARK (rev.02) | 893606 | |
| 7 | Lower Front Panel sticker, NO ; K-ARK (rev.02) | 893552 | |
| 7 | Lower Front Panel sticker, PT ; K-ARK (rev02) | 895261 | |
| 7 | Lower Front Panel sticker, SCA ; K-ARK (rev.02) | 893807 | |
| 7 | Lower Front Panel sticker, SV ; K-ARK (rev.00-01) | 885916 | 893610 |
| 7 | Lower Front Panel sticker, SV ; K-ARK (rev.02) | 893610 | |
| 8 | Membrane keypad, lower, K-ARK | 879964 | |
| 9 | Upper Fron Panel sticker, ES ; K-ARK (rev.01) | 892329 | 893598 |
| 9 | Upper Fron Panel sticker, FI ; K-ARK (rev.01) | 892331 | 893600 |
| 9 | Upper Front Panel sticker, DE ; K-ARK (rev.01) | 892326 | 893595 |
| 9 | Upper Front Panel sticker, , ES ; K-ARK (rev.00) | 886200 | |
| 9 | Upper Front Panel sticker, FR ; K-ARK (rev.00) | 884731 | |
| 9 | Upper Front Panel sticker, FR ; K-ARK (rev.01) | 892327 | 893596 |
| 9 | Upper Front Panel sticker, DA ; K-ARK (rev.01) | 892199 | 893602 |
| 9 | Upper Front Panel sticker, DA ; K-ARK (rev.01) | 892199 | 893602 |
| 9 | Upper Front Panel sticker, DA ; K-ARK (rev.02) | 893602 | |
| 9 | Upper Front Panel sticker, DE ; K-ARK (rev.00) | 885140 | |
| 9 | Upper Front Panel sticker, DE ; K-ARK (rev.02) | 893595 | |
| 9 | Upper Front Panel sticker, EN, SCA ; K-ARK (rev.00) | 881648 | |
| 9 | Upper Front Panel sticker, EN, SCA ; K-ARK (rev.01) | 892350 | 893594 |
| 9 | Upper Front Panel sticker, EN, SCA ; K-ARK (rev.02) | 893594 | |
| 9 | Upper Front Panel sticker, ES ; K-ARK (rev.02) | 893598 | |
| 9 | Upper Front Panel sticker, FI ; K-ARK (rev.00) | 888861 | |
| 9 | Upper Front Panel sticker, FI ; K-ARK (rev.02) | 893600 | |
| 9 | Upper Front Panel sticker, FR ; K-ARK (rev.02) | 893596 | |
| 9 | Upper Front Panel sticker, IT ; K-ARK (rev.00) | 886910 | |
| 9 | Upper Front Panel sticker, IT ; K-ARK (rev.01) | 892330 | 893599 |
| 9 | Upper Front Panel sticker, IT ; K-ARK (rev.02) | 893599 | |
| 9 | Upper Front Panel sticker, NL, FLE ; K-ARK (rev.00) | 886162 | |
| 9 | Upper Front Panel sticker, NL, FLE ; K-ARK (rev.00) | 886162 | |
| 9 | Upper Front Panel sticker, NL, FLE ; K-ARK (rev.01) | 892328 | 893597 |
| 9 | Upper Front Panel sticker, NL, FLE ; K-ARK (rev.01) | 892328 | 893597 |
| 9 | Upper Front Panel sticker, NL, FLE ; K-ARK (rev.02) | 893597 | |
| 9 | Upper Front Panel sticker, NO ; K-ARK (rev.02) | 893551 | |
| 9 | Upper Front Panel sticker, PT ; K-ARK (rev.02) | 895260 | |
| 9 | Upper Front Panel sticker, SV ; K-ARK (rev.00) | 885915 | |
| 9 | Upper Front Panel sticker, SV ; K-ARK (rev.01) | 892332 | 893601 |
| 9 | Upper Front Panel sticker, SV ; K-ARK (rev.02) | 893601 | |
| 10 | Membrane keypad, K-VHC14 | 879373 | |

## 6.1.2 Anesthesia record keeping keyboard, K-ARKB rev. 00

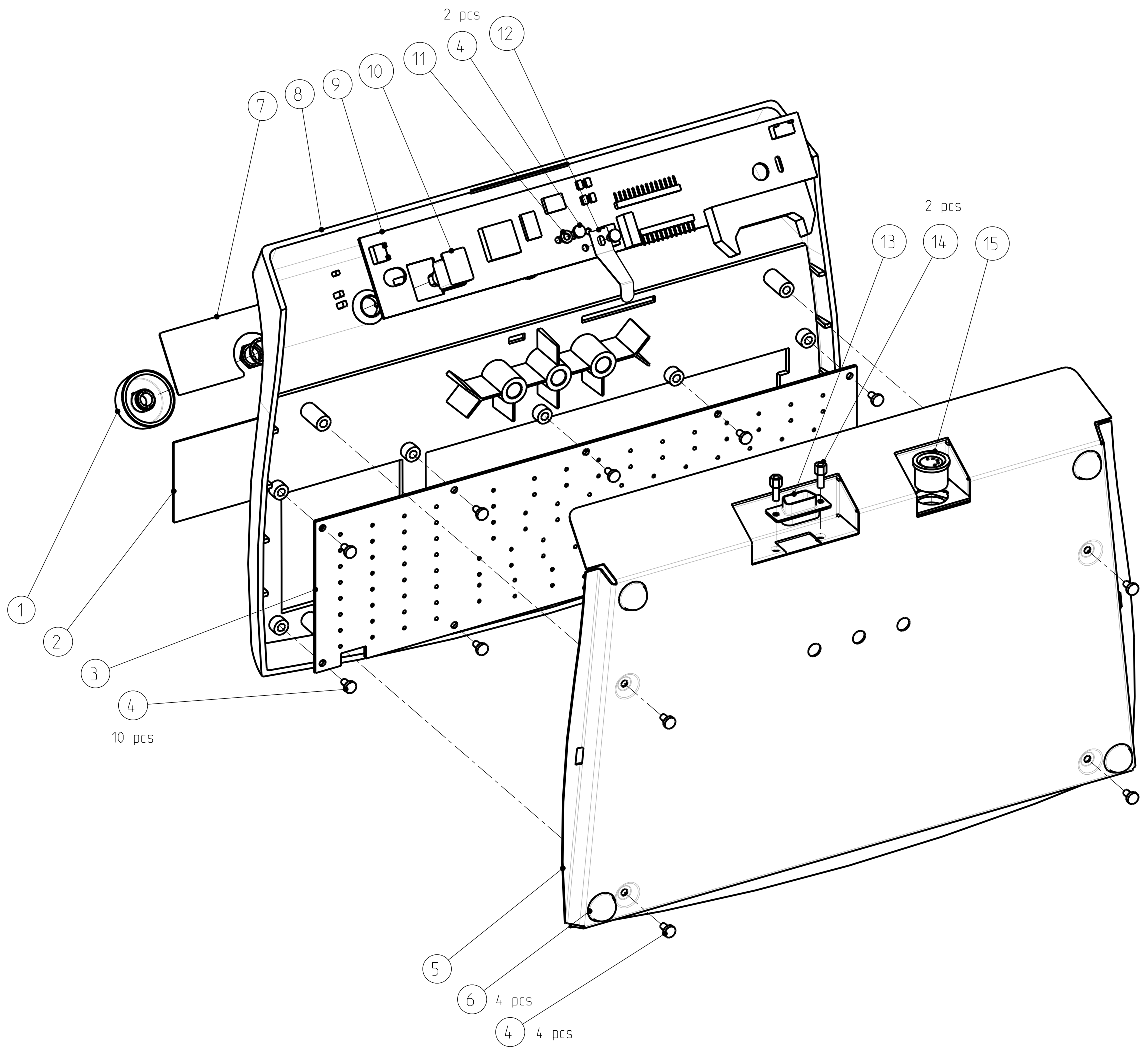



**Figure 3 Exploded view of the K-ARKB keyboard**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | ComWheel ; S/5 | 898794 | |
| 2 | Membrane keypad, lower, K-ARKB ; S/5 | 8000006 | |
| 3 | Alpha-numeric Keyboard PC-board, K-ARK (rev.00-01), K-CENTRALB | 884178 | |
| 4 | Cross cylinder-head screw M3x6 | 61721 | |
| 4 | Cross cylinder-head screw M3x6 | 61721 | |
| 4 | Cross cylinder-head screw M3x6 | 61721 | |
| 5 | Bottom plate, K-ARKB ; S/5 | 898392 | |
| 6 | Sticker-pad,diam 16,height 8 | 65142 | |
| 7 | Membrane keypad, K-ARKB ; S/5 | 8000050 | |
| 8 | Keyboard casing, K-ARKB ; S/5 | 898391 | |
| 9 | Command bar board, K-ARKB ; S/5 | 8000054 | |
| 10 | Opto-encoder, rotary switch,16-positions,push button, metall shaft, 4inch ribbon cable and | 113291 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| | connector | | |
| 11 | Shakeproof washer m3.2 | 63611 | |
| 12 | Emc plate, K-ARKB ; S/5 | 8000960 | |
| 13 | Output connector cable, K-ARKB ; S/5 | 8000098 | |
| 14 | D-female screwlock | 640624 | |
| 15 | Connection cable PC-KB, K-ARKB ;S/5 | 8000097 | |

### 6.1.3 Front panel stickers for K-ARKB

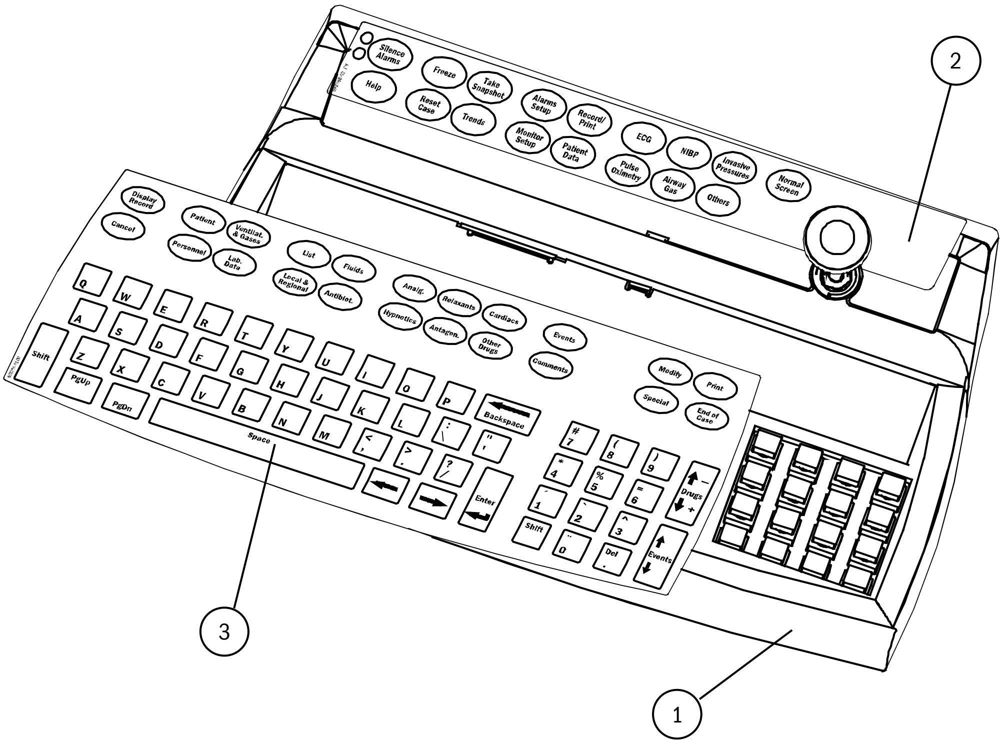



**Figure 4 K-ARKB S/5 front panel stickers**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Keyboard casing, K-ARKB ; S/5 | 898391 | |
| 2 | Upper Front Panel sticker, DA ; K-ARKB (rev.00) ; S/5 | 898369 | |
| 2 | Upper Front Panel sticker, DE ; K-ARKB (rev.00) ; S/5 | 898378 | |
| 2 | Upper Front Panel sticker, EN ; K-ARKB (rev.00) ; S/5 | 898368 | |
| 2 | Upper Front Panel sticker, EN ; K-ARKB (rev.00) ; S/5 | 898368 | |
| 2 | Upper Front Panel sticker, ES ; K-ARKB (rev.00) ; S/5 | 898372 | |
| 2 | Upper Front Panel sticker, FI ; K-ARKB (rev.00) ; S/5 | 898375 | |
| 2 | Upper Front Panel sticker, FR ; K-ARKB (rev.00) ; S/5 | 898370 | |
| 2 | Upper Front Panel sticker, IT ; K-ARKB (rev.00) ; S/5 | 898373 | |
| 2 | Upper Front Panel sticker, JA ; K-ARKB (rev.00) ; S/5 | 8000373 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 2 | Upper Front Panel sticker, NL ; K-ARKB (rev.00) ; S/5 | 898371 | |
| 2 | Upper Front Panel sticker, NL ; K-ARKB (rev.00) ; S/5 | 898371 | |
| 2 | Upper Front Panel sticker, NO ; K-ARKB (rev.00) ; S/5 | 898377 | |
| 2 | Upper Front Panel sticker, PT ; K-ARKB (rev.00) ; S/5 | 898374 | |
| 2 | Upper Front Panel sticker, SV ; K-ARKB (rev.00) ; S/5 | 898376 | |
| 3 | Front Panel sticker, lower, BE, NL ; K-ARKB ; S/5 | 898797 | |
| 3 | Front Panel sticker, lower, DA ; K-ARKB (rev.00) ; S/5 | 898390 | |
| 3 | Front Panel sticker, lower, DE ; K-ARKB (rev.00) ; S/5 | 898381 | |
| 3 | Front Panel sticker, lower, EN ; K-ARKB (rev.00) ; S/5 | 898380 | |
| 3 | Front Panel sticker, lower, ES ; K-ARKB (rev.00) ; S/5 | 898384 | |
| 3 | Front Panel sticker, lower, FI ; K-ARKB (rev.00) ; S/5 | 898387 | |
| 3 | Front Panel sticker, lower, FR ; K-ARKB (rev.00) ; S/5 | 898382 | |
| 3 | Front Panel sticker, lower, IT ; K-ARKB (rev.00) ; S/5 | 898385 | |
| 3 | Front Panel sticker, lower, JA ; K-ARKB (00) ; S/5 | 8000374 | |
| 3 | Front Panel sticker, lower, NL ; K-ARKB (rev.00) ; S/5 | 898383 | |
| 3 | Front Panel sticker, lower, NO ; K-ARKB (rev.00) ; S/5 | 898389 | |
| 3 | Front Panel sticker, lower, PT ; K-ARKB (rev.00) ; S/5 | 898386 | |
| 3 | Front Panel sticker, lower, SKAND ; K-ARKB ; S/5 | 898796 | |
| 3 | Front Panel sticker, lower, SV ; K-ARKB (rev.00) ; S/5 | 898388 | |

### 6.1.4 Keyboard Interface Board, B-ARK

| Item | Item description | Order No. |
|---|---|---|
| | Grounding plate, blank/narrow | 885198 |
| | Block screw for cables | 546096 |

# 7 EARLIER REVISIONS

Information of Anesthesia Keyboard , K-ARK rev. 00 see service manual 885 941.

Information of Anesthesia Keyboard, K-ARK rev. 02 see tech. reference manual 896 624.

Previous Bar Code Reader (by HP) rev. 00 see Technical Reference Manual 895 585.

# APPENDIX A

# SERVICE CHECK FORM

## Anesthesia record keeping keyboard, K-ARKB

| | | | | | |
|---|---|---|---|---|---|
| Customer | | | | | |
| Service | | Keyboard type | | S/N | |
| Service engineer | | | | Date | |

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Cable | ☐ | ☐ | ☐ | 2. Internal parts | ☐ | ☐ | ☐ |
| 3. External parts | ☐ | ☐ | ☐ | 4. ON -LED | ☐ | ☐ | ☐ |
| 5. Software | KB | | | | | | |
| 6. Alarm LEDs | ☐ | ☐ | ☐ | 7. ComWheel | ☐ | ☐ | ☐ |
| 8. Membrane keys | ☐ | ☐ | ☐ | | | | |

Notes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9. Electrical safety check | ☐ | ☐ | ☐ | 10. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 11. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes**

**Used Spare Parts**

**Signature**

# Datex-Ohmeda

# S/5™ Memory Module, M-MEM (Rev. 06)

# Technical Reference Manual


All specifications are subject to change without notice.

Document No. 8001020-5

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
mailto:product.support.ussub@us.datex-ohmeda.com
www.us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Memory Module, M-MEM (Rev. 04)

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 MEM Module, M-MEM. The Memory Module, M-MEM is an optional data storage single width module designed for S/5 monitors. Later in this manual modules may be refered to without the S/5 system nomenclature for simplicity.

Please also refer to the*Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The Memory Module is used for storing patient related physiological data, discrete record keeping events, menu configurations and user defined monitor configurations in removable PCMCIA[1] compatible memory cards.

The memory module can be utilized in the following applications:

- As a backup media for patient related physiological and record keeping data.
- As a local menu server for the monitor it is attached to.
- A memory card with its previously recorded patient data can be transported to a new monitor location with the patient, enabling continuous data collection.
- To save and load user defined monitor configurations.

The memory module is available in one version:

- Single width external plug-in Memory Module, M-MEM for S/5 Critical Care and Anesthesia monitors.

The memory module has two card slots, which use rewritable PCMCIA-ATA specification compatible memory cards: Data and Menu Cards.

The data card is used for storing patient related data and record keeping events, and the menu card is used as a storage media for pre-recorded menu configurations and user defined monitor configurations. If the module is used only for data backup and transportation, the Menu card is not necessarily required. Similarly, if only record keeping configurations are needed, The data card does not have to be present. In the latter case, however, no physiological or event data can be stored in a memory card.

Module software runs under MS-DOS[2] compatible operating system provided by Datalight[3]. The files created in Data and Menu MemCards are MS-DOS compatible.

[1] PCMCIA = Personal Computer Memory Card International Association
[2] MS-DOS is a trademark of Microsoft Corporation
[3] Datalight is a trademark of Datalight, Inc.

The communication between the monitor CPU and the memory module is performed with a high-speed internal TTL level RS-232 serial interface. Data transfer rate is 76.8 kbps.

## Compatibility

NOTE: Memory Module,M-MEM, cannot be used in the **Extension Frame,F-EXT4** and in the **S/5 Compact Monitors**.

# 1 SPECIFICATIONS

## 1.1 General specifications

### 1.1.1 M-MEM

| | |
|---|---|
| Module size (W × D × H) | 37 × 180 × 112 mm/1.5 × 7.1 × 4.4 in |
| Module weight | 0.4 kg/1.0 lbs |
| Total power consumption | 2 W maximum |

## 1.2 Technical specifications

| | |
|---|---|
| MemCard capacity | 32 MB |
| Data storage capacity | 2 days of continuous physiological data trends |

| | |
|---|---|
| Operating system | Datalight ROM-DOS |
| File system | MS-DOS compatible |
| MemCards | PCMCIA-ATA compatible memory cards |

# 2 FUNCTIONAL DESCRIPTION

The Memory Module, M-MEM contains a memory board and a LED (Light Emitting Diode) board attached to the front panel.

The front panel has a dual PCMCIA card connector for two MemCards. Above the card slots there are two push buttons for removing the MemCards from the module, and two memory card specific LEDs. The LEDs are on during memory card read and write operations to notify the user not to remove them until the operation is complete.

## 2.1 Memory Module, M-MEM

### 2.1.1 Memory board

#### Processor section

Basically, the memory module is a single board PC with any unnecessary I/O functions removed. The processor is Intel 80C186 compatible and the software runs under the DOS operating system. Operating frequency is 16 MHz. The board has 512 kB RAM, 448 KB ROM, 128 kB EEPROM and associated buffer circuits for memory operations.

The Intel 82365SL compatible PC Card Interface Controller (PCIC) provides all the functions needed in MemCard operations. Serial communication, EEPROM read and write operations and LED control is accomplished through a QUART circuit. In addition, the processor board contains circuitry to control reset signals and MemCard programming voltages.

The memory module board block diagram is shown in figure 1.

#### PCMCIA card interface

M-MEM has PCMCIA compatible card sockets for two MemCards. Both sockets consist of 60 signal and 8 power connections. MemCards are PCMCIA-ATA compatible, and their memory capacity is 6 MB.

All MemCard read and write operations as well as card power management are controlled by a PCIC interface controller.
Card removals and insertions are also detected by the interface controller.
MemCard files are MS-DOS compatible and they can be copied for archiving with any MS-DOS compatible computer equipped with any PCMCIA-ATA specification compatible card drive.

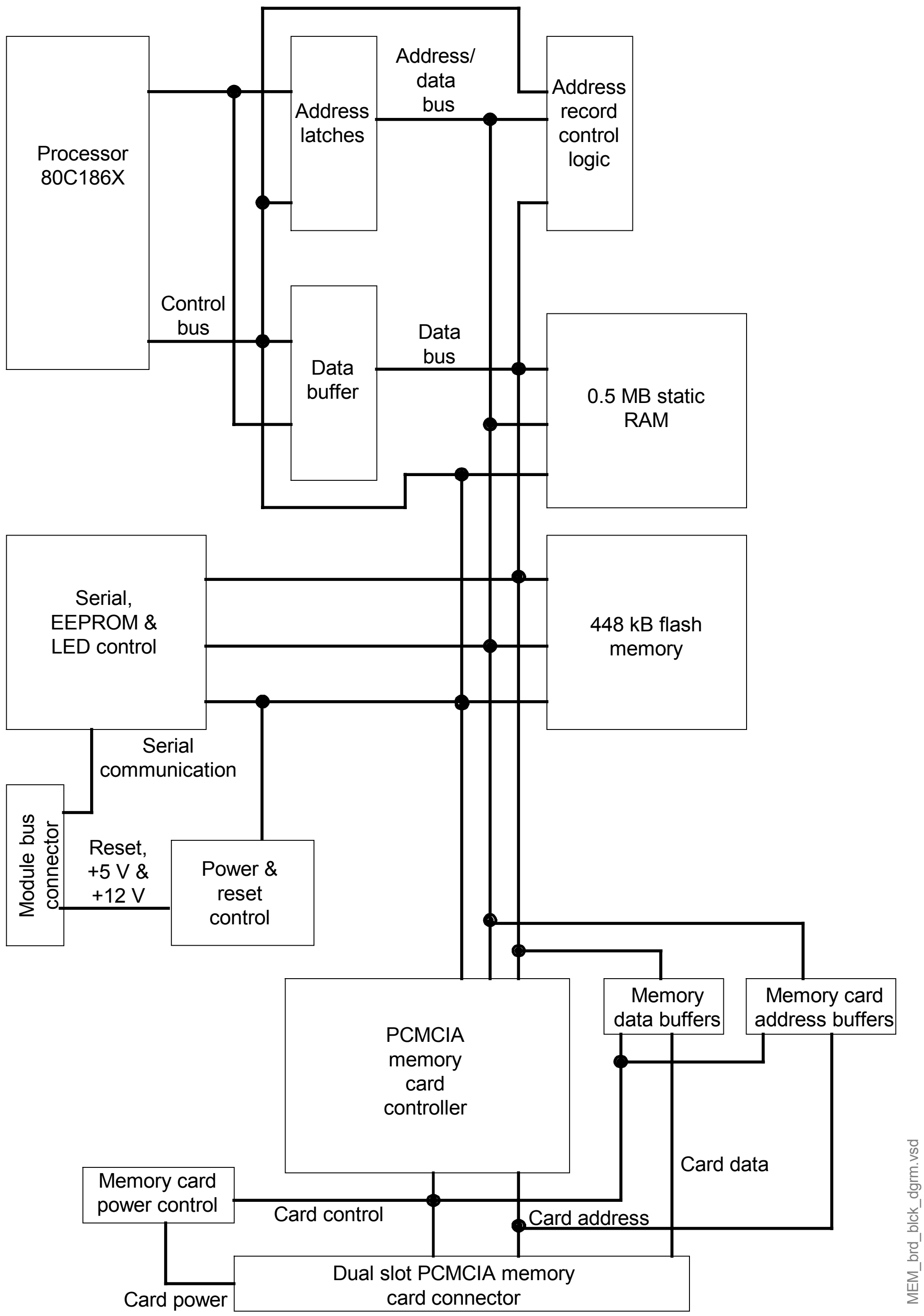



**Figure 1** **Memory board block diagram**

### Serial communication

Serial communication between the module and main CPU board is performed through a module bus TTL-level RS-232 interface. The data transfer rate is 76.8 kbps.

An RS485 type monitor reset signal is converted to module reset by an interface transceiver, and power reset is generated by a reset circuit.

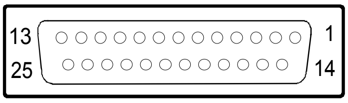
### Power supply

The module receives its power (+5 V, +15 V) from the monitor. The PCMCIA card programming voltage +12 V is generated from +15 V by voltage regulators. Card programming voltage is controlled by an interface controller. Otherwise, only +5 V power is used in the module. Maximum power consumption is 2 W.

## 2.1.2 LED board

The LED board contains only two yellow light emitting diodes and a three-lead cable to the memory board.

Connectors and signals




**Module bus connector (X1)**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET_RS485* |
| 2 | I | -15 VDC |
| 3 | I | +15 VDIRTY |
| 4 | I | +15 VDC* |
| 5 | - | -DATA_RS485 |
| 6 | - | DATA_RS485 |
| 7 | - | Ground & Shield* |
| 8 | I | -RESET_RS485* |
| 9 | I | CTSB |
| 10 | O | RTSB |
| 11 | I | RXDB |
| 12 | O | TXDB |
| 13 | - | Ground & Shield* |
| 14 | I | +32 VDIRTY |
| 15 | I | GroundDIRTY |
| 16 | O | CTSC* |
| 17 | I | RTSC* |
| 18 | O | RXDC* |
| 19 | I | TXDC* |
| 20 | - | ON/STANDBY |
| 21 | - | BIT0IN |
| 22 | - | RXDD_RS232 |
| 23 | - | TXDD_RS232 |
| 24 | I | +5 VDC* |
| 25 | I | +5 VDC* |

* Used in MEM module

**LED board connector (X5)**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | O | +5 V |
| 2 | O | LED1 control |
| 3 | O | LED2 control |

### Connector board connector (X1)

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | Ground & Shield* |
| 2 | I | Ground & Shield* |
| 3 | I | -RESET_RS485* |
| 4 | I | +15 VDC* |
| 5 | I | RESET_RS485* |
| 6 | O | CTSC* |
| 7 | I | RTSC* |
| 8 | O | RXDC* |
| 9 | I | TXDC* |
| 10 | - | N/C |
| 11 | - | N/C |
| 12 | - | N/C |
| 13 | I | +5 VDC* |
| 14 | I | +5 VDC* |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the memory module is limited to replacing faulty PC boards, MemCards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with the appropriate tools and equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. However, the service check procedures can also be used for determining possible failures. The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| MemCard - Menu (PCMCIA-ATA) | | |
| MemCard - Data (PCMCIA-ATA) | | |
| M-NE(12)STPR/M-ESTPR/M-ESTP | | |
| Patient simulator | | |
| Screwdriver | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - EMC covers are attached properly
   - there are no loose objects inside the module

✍

2. Check external parts:

– the front cover and the front panel sticker are intact

– the memory card housing frame is intact

– the module box, the latch and the spring pin are intact

✍

- Reattach the module box and check that the latch is moving properly.
- Switch the monitor on and wait until the monitoring screen appears.
- Configure the monitor screen so that all the needed parameters are shown, for example as follows:

**Monitor Setup** - ***Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
***Field 2 - ECG2***
***Field 3 - P1***
***Field 4 - P2***
***Field 5 - PLETH***
***Field 6 - OFF***

- Insert the M-NE(12)STPR/M-ESTPR/M-ESTP. Connect a patient simulator to the module and check that all connected parameters are shown on the screen.

3. Plug in the Memory Module without memory cards. Check that the module goes in smoothly and locks up properly.

✍

4. Check that both LEDs on the module’s front panel light up briefly when the module is connected.

✍

5. Enter the service menu:

**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

Take down the information regarding MEM software by selecting ***Scroll Vers*** and turning the ComWheel.

✍

6. Enter the memory module service menu:

...***Frame - MemCards***

Check that the module is recognized properly, i.e. “Module present” and “Module active” state YES.

✍

7. Check that the Memory board memories and the PCMCIA controller have passed their tests. The status for each should be OK.

   ✍

- Select ***...Frame - Communication***.

8. Check that “Interface status” states ACTIVE continuously and the error counter values on the bottom part of the menu are stable.

   ✍

- Select ***...Frame - MemCards***

9. Insert a Memory card labelled “Menu” in the left hand side memory card slot. Check that the message “Menu Card inserted” appears onto the message field and the white menu card symbol onto the upper right hand corner of the screen within 1 minute.

   NOTE: The battery symbol overrides the memory card symbols in the Compact Monitor.

   Wait until the information regarding SLOT1 is fully updated in the service menu then check that the “Card type” states MENU and the “File system” ATA.

   Check that the rest of the information for SLOT1 is reliable and no errors have been detected.

   ✍

10. Insert a Memory card labelled “Data” in the right hand side memory card slot. Check that the message “Data Card inserted” appears onto the message field and the green menu card symbol onto the upper right hand corner of the screen within 1 minute.

    Wait until the information regarding SLOT2 is fully updated in the service menu then check that the “Card type” states DATA and the “File system” ATA.

    Check that the rest of the information for SLOT2 is reliable and no errors have been detected.

    ✍

- Enter the ***Save Modes*** -menu:
  **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Save Modes*** (password 13-20-31)

  Save the current modes into the Menu card by selecting LOAD MODES and then TO MEMORY CARD --> SAVE. Wait until the text “Saved” appears then return to the previous menu.
- Change the name for the mode number 1:

  Highlight the mode number 1, press the ComWheel and select NAME. Select suitable characters from the list by turning and pressing the ComWheel, then confirm the new name by selecting END.

11. Load the original modes from the Menu card by selecting LOAD MODES and then FROM MEMORY CARD --> LOAD. Wait until the text “Loading” changes to “Loaded”, then return to the previous menu.

    Check that the mode number 1 has got back its original name.

    ✍

- Press the membrane key **Display Trends**. Check that there are enough trend information available for the monitored parameters.

- Erase the trends:

    **Reset Case** ***- Reset All - Yes***

    Check that the trends have been erased by pressing the key **Display Trends** again

12. Reload the trends from the Data card by pressing the key **Patient Data**, selecting ***Patient From Card***, pressing the ComWheel on the last saved file (the file information is shown at the bottom of the menu) and selecting ***Load***.

    Wait until the message “Loading from Mem. Module” disappears then check that the original trends are available again by pressing the key **Display Trends**.

    ✍

13. Perform electrical safety check and leakage current test.

    ✍

14. Check that the module functions normally after the performed electrical safety check.

    ✍

15. Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

The memory module is disassembled in the following way. See the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly to detach it from main body. Be careful with loose latch and spring pin for locking.
3. Remove the two screws that are located on the module bus connector and the screws that connect the front panel frame to the Memory board.
4. Disconnect the LED board cable and remove the front panel frame.
5. Remove the EMC cover carefully from around the Memory board.

CAUTION When reassembling the module, make sure that the cables, especially the LED board cable, are reconnected properly.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting charts

### 4.1.1 Memory Module

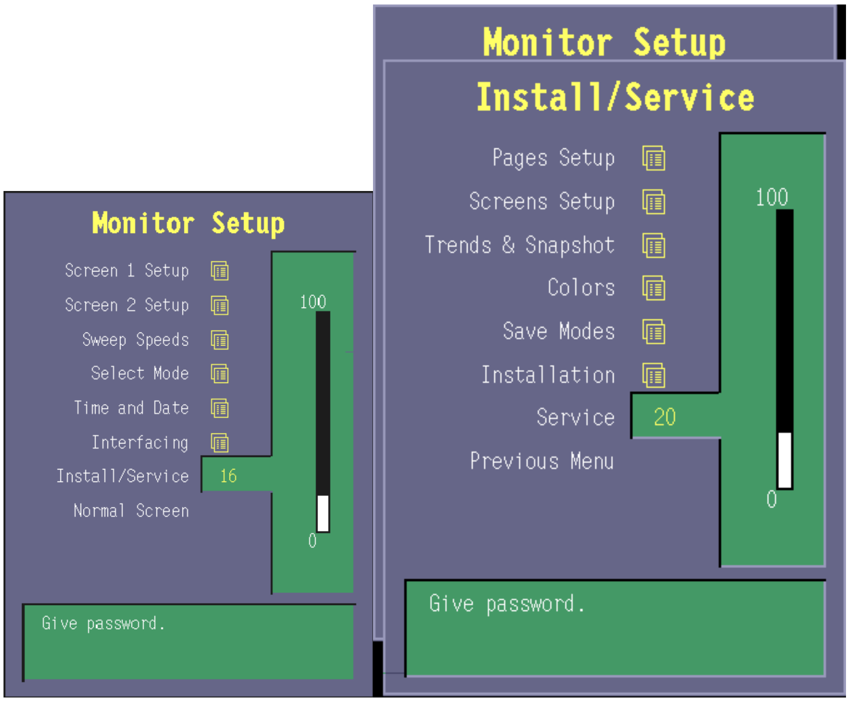
| Trouble | Cause | Treatment |
|---|---|---|
| 'Memory module removed' message | Module removed from monitor frame.<br>Possible error in data communication between the module and the monitor. | Insert module in the module frame.<br>Remove module briefly from the monitor. Insert module back to monitor frame. If the message persists replace the memory board or the main CPU board. |
| 'Memory module error' message | Module has detected an error condition. | If message persists, remove module for repair. |
| 'Memory module comm. error' message | Module not properly attached to monitor frame. | Check module attachment. |

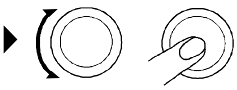
### 4.1.2 Memory cards

| Trouble | Cause | Treatment |
|---|---|---|
| 'Two Data Cards in mem. module' message | Two Data cards detected. | Remove MemCard from the left hand side slot of the module. |
| 'Two Menu Cards in mem. module' message | Two Menu cards detected. | Remove MemCard from the right hand side slot of the module. |
| 'No menus in Menu Card' message | There are no menus in the Menu card. | Insert a Menu card with valid menu configuration files in the module. |
| 'Faulty Data Card - change card' | An error has occurred during Data card read/write operation | Change Data card. |
| 'Faulty Menu Card - change card' | An error has occurred during Menu card read/write operation | Change Menu card. |

# 5 SERVICE MENU

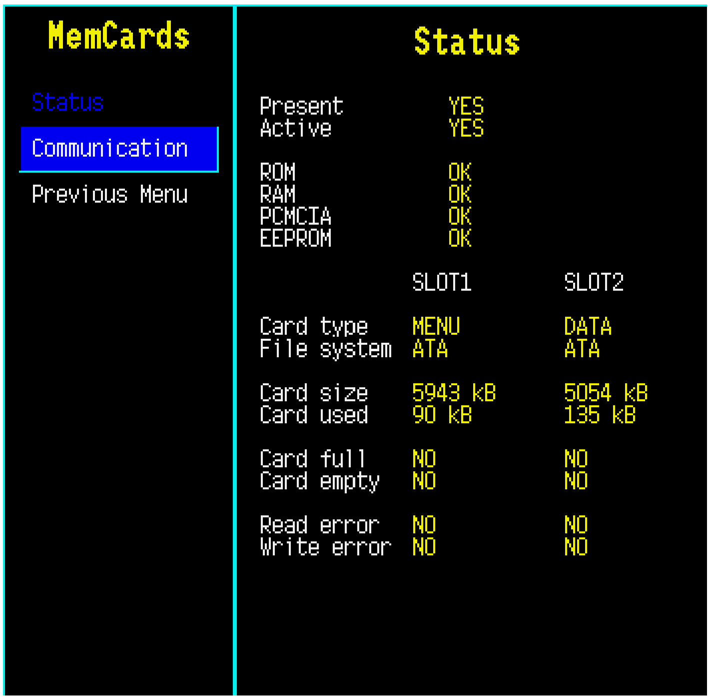
NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Frame - MemCards***.

## 5.1 MemCards Status menu




Module **Present** indicates whether the module is firmly attached to the monitor. Possible values are YES and NO. Module **Active** indicates whether the module services are available. Possible values are YES and NO.

**ROM** indicates the status of the ROM memory of the module. Possible values are OK and ERR.
**RAM** indicates the status of the RAM memory of the module. Possible values are OK and ERR.
**PCMCIA** indicates the status of the PCMCIA controller of the module. Possible values are OK and ERR.
**EEPROM** indicates the status of the EEPROM memory of the module. Possible values are OK and ERR.

**SLOT1** and **SLOT2** indicates the left hand slot and the right hand slot , respectively.
**Card type** indicates whether the card is MENU or DATA card. If duplicated card is inserted, type DUPL.
**File system** indicates the type of the used memory card. The only supported file system is ATA. If a memory card using another file system is used, the message UNKNOWN is shown. If the card is poorly attached, the message LOOSE is shown.

**Card size** indicates the total amount of the disk space in the card in kilobytes.
**Card used** indicates the total amount of the used disk space in the card in kilobytes.

**Card full** indicates whether the all disc space in the card is used. Possible values are YES and NO.
**Card empty** indicates the lack of menu files in the MENU card or no files in the DATA card. Possible values are YES and NO.

**Read error** indicates whether the reading from the card has failed. Possible values are YES and NO.
**Write error** indicates whether the writing to the card has failed. Possible values are YES and NO.

All values can be '- - -' to indicate 'No data available'.

## 5.2 Communication

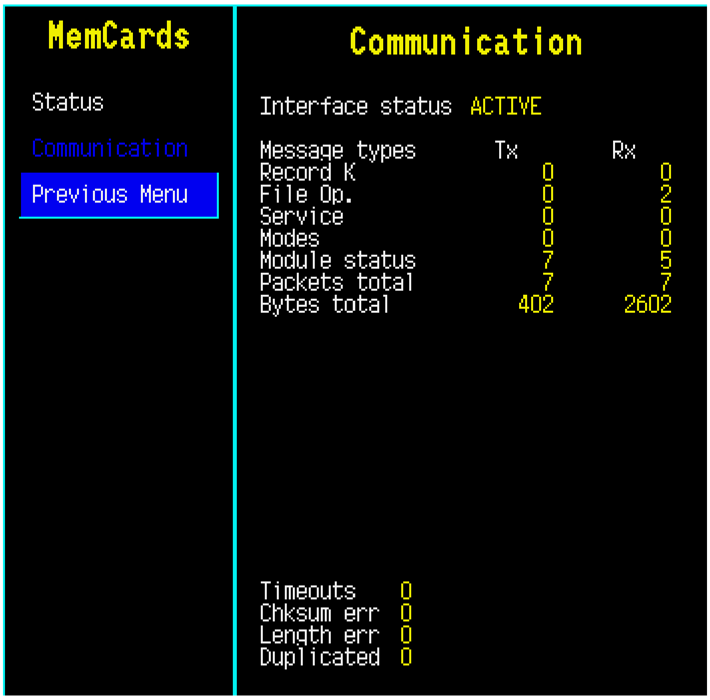
**Interface status** indicates the status of data link between the monitor and memory module. If memory module is properly attached, the status should always be on ACTIVE. If status blinks between ACTIVE and CLOSED, a communications error has occurred: remove module briefly, and insert it back to the monitor frame to check if error disappears.

**Message types** indicates the type of data packets that have been sent (**Tx**) and received (**Rx**) since last monitor start. Data types are listed on the lines below **Message types** text.

**Record K** indicates the communication between the Monitor and Record Keeper.
**File Operation** indicates the operations of Patient data.
**Service** indicates the Memory Module operations.
**Modes** indicates the User Mode operations.
**Module status** indicates the numberof sent/received data packets that relate to the memory module status.
**Packets total** indicates the total amount of data packets that have been sent/received since last monitor start.
**Bytes total** indicates the total amount of data bytes that have been sent/received since last monitor start.

The last four lines indicates transmission errors:

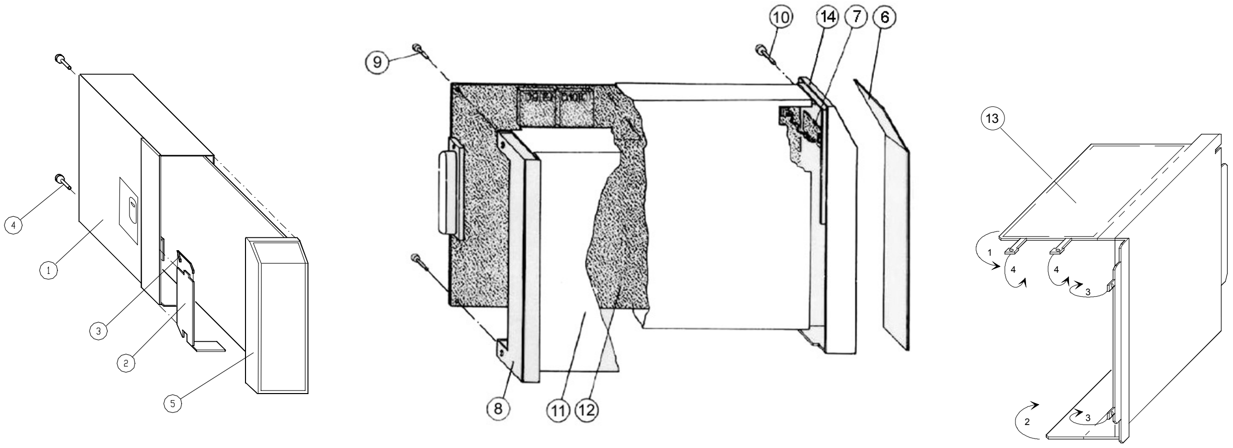
**Timeouts** indicates the number of time-outs that have occurred in memory module data transmission since last monitor start.
**Chksum err** indicates the number of checksum errors in data packets from memory module since last monitor start.
**Lenght err** indicates the number of data packets with erroneous length from the memory module since last monitor start.
**Duplicated** indicates the number of duplicate data packets from the memory module since last monitor start.



# 6 SPARE PARTS

## 6.1 Spare parts list

### 6.1.1 Memory Module, M-MEM




| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Front panel frame, M-MEM | 883838 | |
| 6 | Front Panel sticker ; M-MEM (rev.04->) ; S/5 | 898860 | |
| 6 | Front Panel sticker, EN ; M-MEM (rev.02-03) | 884597 | 898860 |
| 6 | Front Panel sticker, JA ; M-MEM ; S/5 | 8000387 | |
| 6 | Front Panel sticker, JA ; M-MEM (rev.02-03) | 888319 | 8000387 |
| 7 | LED board, M-MEM | 885252 | |
| 8 | Metal frame | 879184 | |
| 9 | Cross cylinder-head screw M3x6 | 61721 | |
| 10 | Cross cylinder-head scerw M3x12 | 628700 | |
| 11 | EMC cover, M-MEM | 885860 | |
| 12 | Memory board, M-MEM | 883509 | |
| 13 | Insulation plate, M-MEM | 886656 | |
| 14 | Cross cylinder-head screw M3x8 | 628712 | |
| | MEM Software for M-MEM rev.01-06 | Use<br>MEM Software<br>Upgrade Kit<br>8002917 | |

### 6.1.2 Memory Cards

| Item | Item description | Order No. |
|---|---|---|
| | Memory Card, Menu (Eng) | 893860 |
| | Memory Card, Data (Eng) | 887045 |
| | Memory Card, Menu (Fre) | 893861 |
| | Memory Card, Data (Fre) | 887047 |
| | Memory Card, Menu (Jpn) | 893862 |
| | Memory Card, Data (Jpn) | 890349 |
| - | Memory Card, Menu (Ger) | 895880 |

# 7 EARLIER REVISIONS

All main differences of Memory Module, M-MEM (rev. 00 – 04).

# *APPENDIX A*

# SERVICE CHECK FORM

## Memory Module, M-MEM

Customer ______

Service ______ Module type ______ S/N ______

Service engineer ______ Date ______

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | | | | |

Notes ______

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4. Front panel LEDs | ☐ | ☐ | ☐ | | | | |
| 5. Module software | MEM | | | | | | |
| 6. Module recognition | ☐ | ☐ | ☐ | 7. Memories and PCMCIA controller | ☐ | ☐ | ☐ |
| 8. Communication | ☐ | ☐ | ☐ | 9. Menu -card recognition | ☐ | ☐ | ☐ |
| 10. Data -card recognition | ☐ | ☐ | ☐ | 11. Menu -card functions | ☐ | ☐ | ☐ |
| 12. Data -card functions | ☐ | ☐ | ☐ | | | | |

Notes ______

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13. Electrical safety check | ☐ | ☐ | ☐ | 14. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 15. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes** ______

**Used Spare Parts** ______ ______ ______

**Signature** ______

# Datex-Ohmeda

# S/5™ Interface Module, M-INT (Rev. 01)

# Technical Reference Manual


All specifications are subject to change without notice.


Document No. 8001021-4

January 2003



Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
mailto:product.support.ussub@us.datex-ohmeda.com
www.us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Interface Module, M-INT (Rev. 01)



# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Interface Module, M-INT. The Interface module is a single width plug-in module designed for use with the S/5 Monitors. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

Please refer to the*Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The Interface Module, M-INT, provides an interface between the S/5 Monitors and other external monitors such as, Datex-Ohmeda Cardiocap and Capnomac Ultima, Criticon Dinamap 1846 SX, and Abbott Oximetrix 3.


**Figure 1 Interface Module, M-INT**

NOTE: The Interface Board, B-INT, and Interface Module, M-INT, cannot be used simultaneously in the same monitor.

# 1 SPECIFICATIONS

## 1.1 Serial I/O Definitions

- RS-232 buffered (channels 1-2)
- All standard baud rates are possible from 300 to 115200
- Each interfaced device has a fixed baud rate.

## 1.2 Analog definitions

- There are four analog inputs available on channel 1 and four on channel 2.
- All analog inputs are Op-Amp buffered, with an input impedance of 1 MΩ. Each analog input is also equipped with a 1 MΩ pull-down resistor to -12 V for NC detection.
- Sampling rate: 10 ms/sample/channel
- Input range: -10 V...+10 V
- Resolution: 10 bits → 1024 voltage levels in input range

# 2 FUNCTIONAL DESCRIPTION

The Interface Module, M-INT, detects and identifies the external monitors connected to the module. The identification is made by a serial string, sent by the external monitor.

When an external monitor is connected to the Interface Module, numeric data is always displayed on the monitor screen. Also, analog real time waveforms are displayed, if the external monitor is able to send them.

Connections from the Interface Module to external monitors are isolated from the S/5 monitor.

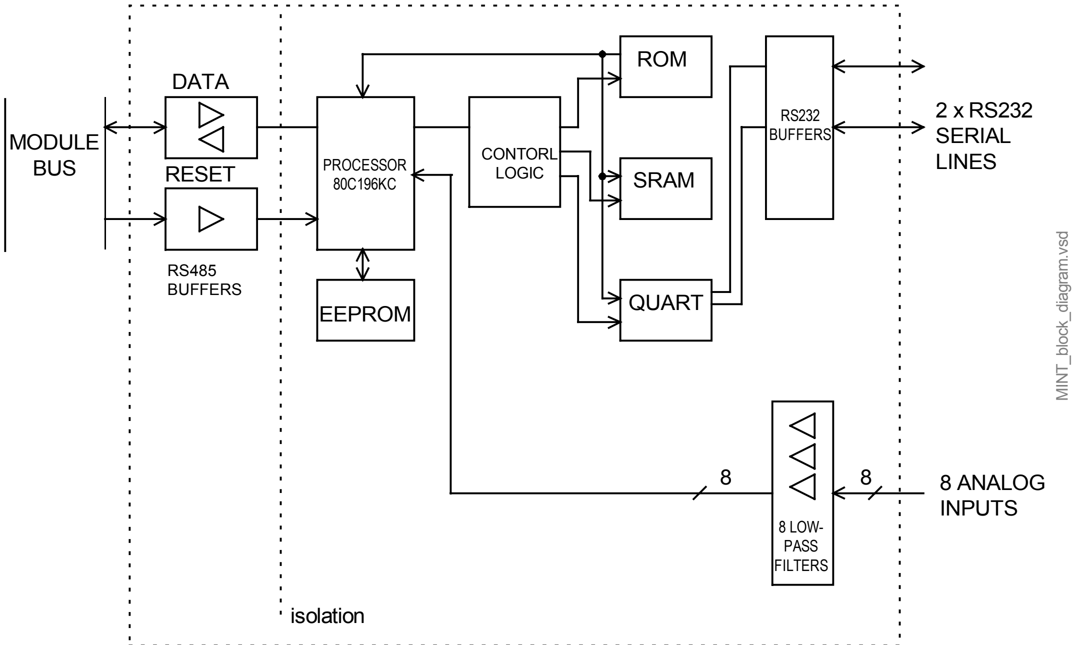



**Figure 2** **Interface Module, M-INT, block diagram**

## 2.1 Main components

The Interface Module contains an 80C196KC16 microprocessor.

### External Connections

The connectors on the Interface Module are:

- One 25-pin D-connector X1 for the module bus.
- Two 9-pin connectors, X2 and X3, for external monitors. These are internally connected to two 9-pin female D-connectors via ribbon cables.

Each X2 and X3 connector has an RS-232 serial communication channel and four analog inputs.

### RS-485 Serial Communication

The Interface Module uses RS485 signal levels when communicating with the external monitor. The RS485 signals are transformed to digital signal levels and fed via an opto-isolator to the microprocessor. The communication signals for transmitting (TxD) and receiving (RxD) data are sent to the microprocessor ports. The direction of the communication is controlled by REC/SND signals, generated by the microprocessor, via the opto-isolator. When the module bus is reset, the communication is always set to the receiving state.

### Reset

The interface board resets when module bus is reset. The RESET signal is converted from an RS-485 signal level to a digital signal level and then fed to an opto-isolator. The RESET signal is renamed to POWEROK signal. The POWEROK signal resets the microprocessor and the GAL circuit.

### RS-232 Serial Communication

A QUART is used to provide four serial communication channels with external monitors. However, only two channels are used. The microprocessor controls resetting of the QUART during normal operation. When the microprocessor is reset the QUART is also reset.

### Memories

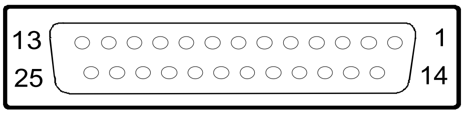
There are static RAM, ROM, EEPROM memories in the Interface Module. The memory decoding is done with the GAL circuit. The microprocessor communicates with the EEPROM in serial mode.

### Analog Inputs

Eight analog inputs from the serial/analog connectors are connected to eight low pass filters. The frequency limit (-3 dB) is set to 35 Hz. The input signal levels are between -10 V and +10 V, and the output signals are scaled between 0 V and 5 V. The output signals are then fed to the microprocessor A/D inputs.

## 2.2 Connectors and signals

### 2.2.1 Module bus connector




**Module Bus Connector (X1)**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | O | RESET_RS485 |
| 2 | O | -15 VDC |
| 3 | O | +15 VDIRTY |
| 4 | O | +15 VDC |
| 5 | I/O | -DATA_RS485 |
| 6 | I/O | DATA_RS485 |
| 7 | | Ground & Shield |
| 8 | O | -RESET_RS485 |
| 9 | O | CTSB |
| 10 | I | RTSB |
| 11 | O | RXDB |
| 12 | I | TXDB |
| 13 | | Ground & Shield |
| 14 | O | +32 VDIRTY |
| 15 | O | GroundDIRTY |
| 16 | O | CTSC |
| 17 | I | RTSC |
| 18 | O | RXDC |
| 19 | I | TXDC |
| 20 | | ON/STANDBY |
| 21 | | BITOIN |
| 22 | | RXDD_RS232 |
| 23 | | TXDD_RS232 |
| 24 | O | +5 VDC |
| 25 | O | +5 VDC |

### 2.2.2 Interface board connectors

**Power test connector (X11)**

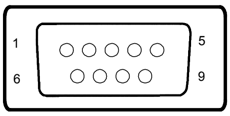
| Pin No | Signal |
|---|---|
| 1 | +5 V TEST |
| 2 | +5 V ref |
| 3 | +12 V |
| 4 | GND |
| 5 | -12 V |
| 6 | NC |

**Analog test connector (X5)**

This connector is for factory tests only.

| Pin No | Signal |
|---|---|
| 1 | ACH0 |
| 2 | ACH1 |
| 3 | ACH2 |
| 4 | ACH3 |
| 5 | ACH4 |
| 6 | ACH5 |
| 7 | ACH6 |
| 8 | ACH7 |
| 9 | GND |

### 2.2.3 Front panel connectors




**Serial/Analog connector(X2) CH 1 (floating, off-board)**

| Pin No | Definition |
|---|---|
| 1 | A0 analog input |
| 2 | RXD |
| 3 | TXD |
| 4 | A1 analog input |
| 5 | GND |
| 6 | A2 analog input |
| 7 | RTS |
| 8 | CTS |
| 9 | A3 analog input |

**Serial/Analog Connector (X3) CH 2 (floating)**

| Pin No | Definition |
|---|---|
| 1 | A4 analog input |
| 2 | RXD |
| 3 | TXD |
| 4 | A5 analog input |
| 5 | GND |
| 6 | A6 analog input |
| 7 | RTS |
| 8 | CTS |
| 9 | A7 analog input |

# 3 SERVICE PROCEDURES

## 3.1 General Service Information

Field service of the Interface Module, M-INT, is limited to replacing faulty circuit boards. A faulty circuit board should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Datex-Ohmeda gas monitor with the $SpO_2$ measurement | | e.g. ULT-S |
| INT Interface cable | 892377 | |
| Calibration gas | | |
| $SpO_2$ probe | | |
| Screwdriver | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring locking pin.

1. Check internal parts:

- screws are tightened properly
- cables are connected properly
- all socket mounted IC's are inserted properly
- the EMC cover is attached properly
- there are no loose objects inside the module

2. Check external parts:

- the front cover and the front panel sticker are intact
- the block screws for cables are in place and are tightened properly
- the block screw threads are intact
- all connectors are intact and are attached properly
- the module box, latch and spring locking pin are intact

Reattach the module box and check that the latch moves properly.

3. Plug the Interface Module into the monitor Central Unit. Check that it goes in smoothly and locks up properly.

- Connect the Datex-Ohmeda gas monitor with the interface cable (order code 892377) to Interface Module, M-INT, connector 1. Lock the cable properly.

- Turn both monitors on.

- Make sure the serial output mode of the Datex-Ohmeda gas monitor being used is set to NUMERIC.

- Configure the S/5 monitor screen so that all required parameters are shown, for example:

**Monitor Setup** ***- Screen 1 Setup - Waveform Fields - Field 5 - Pleth***
***Field 6 - Co$_2$***

4. Set the interface for the Datex-Ohmeda gas monitor being used:

**Monitor Setup** ***- Install/Service (password 16-4-34) - Installation - Interfacing - Gases/Spiro - XXX***
***SpO$_2$ - XXX***

***XXX*** = the gas monitor being used

Check that the menus NIBP and SvO$_2$/C.O. are selectable from the menu.

✍

5. Enter the service menu:

   **Monitor Setup** ***- Install/Service (password 16-4-34) - Service (password 26-23-8)***

   Take down the information regarding Interface Module, M-INT, software by selecting SCROLL VERS and turning the ComWheel.

   ✍

6. Enter the M-INT service menu:

   ***Parameters - More - Interface***

   Check that the “Timeouts”, “Bad checksums” and “Bad c-s by mod” values are not increasing faster than by 5 per second. Check that the Interface Module M-INT memories have passed the internal memory test, i.e. “RAM” and “ROM” state OK.

   ✍

7. Check that the interfaced gas monitor is identified, i.e. the required waveform fields are shown on the screen and the gas monitor type in shown correctly on the service menu.

   Check that the communication state is “online”.

   ✍

8. Select GASES from the M-INT service menu.

   Check that “id:” states the correct monitor and interface type, “Active” states YES and “Timeout” NO.

   Check that the numeric values on the service menu are reasonable.

   Simulate breathing by feeding calibration gas into the Datex-Ohmeda gas monitor sampling line and check that the values on the service menu correspond with the values on the gas monitor screen.

   Check that the values in the S/5 monitor gas waveform field are correct and a proper $CO_2$ waveform is shown.

   Stop feeding the calibration gas. Check that the message “Apnea” appears in the S/5 monitor waveform field, and in the message field, if the selected interface type is ULT/al.

   ✍

9. Select $SpO_2$ from the M-INT service menu.

   Check that “id” states the correct monitor and interface type, “Active” states YES and “Timeout” NO.

Check that “ProbeOff” shows 1 when no $SpO_2$ probe is connected to the interfaced gas monitor. Connect the $SpO_2$ probe and check that the “NoProbe” shows 1.

Attach the $SpO_2$ probe to your finger and check that the values on the menu correspond with the values on the gas monitor screen.

Check that the values in the S/5 monitor pleth waveform field are correct and a proper pleth waveform is shown.

Disconnect the $SpO_2$ probe. Check that the message “Probe off “ appears in the S/5 monitor waveform field, and “$SpO_2$ probe off” appears in the message field, if the interface type is ULT/al.

10. Turn the gas monitor off. Check that the messages “Interfaced Gas monitor removed” and “Interfaced $SpO_2$ monitor removed” appear on the S/5 monitor screen.

11. Turn the S/5 monitor off. Connect the gas monitor with interface cable to Interface Module, M-INT connector 2.

    Turn the monitors on and check that the necessary numerics and waveforms are still interfaced, together with the alarms, if the interface type is ULT/al.

12. Disconnect the Interface Module, M-INT, for a moment, then plug the module back into the monitor.
    Check that interfacing with the gas monitor is restored.

13. Perform an electrical safety check and a leakage current test.

14. Check that the Interface Module, M-INT, functions normally after performing the electrical safety check.

- Set the interface back for modules:

  **Monitor Setup** ***- Install/Service (password 16-4-34) - Installation - Interfacing - Gases/Spiro - Module***
  ***$SpO_2$ - Module***

15. Clean the module with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

Disassemble the Interface Module, M-INT, in the following way (see *Figure 3 Exploded view of module box and M-INT*).

1. Remove the two screws from the back of the module.
2. Pull the module box slowly backwards and remove it from the main body.
3. To detach the circuit board, remove four screws and disconnect the two ribbon cables from the front panel.

To reassemble the module, reverse the order of the disassembly steps.

# 4 TROUBLESHOOTING

Enter the Service Menu (see chapter 5). Select Scroll Vers and scroll down the SW version/Unit id list. Make sure that the software code and level, control and serial numbers of the Interface Module, M-INT, are displayed under B-INT/M-INT.

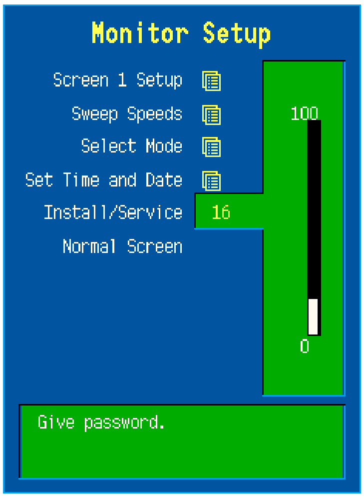
If they are not displayed, the Interface Module, M-INT, is faulty.

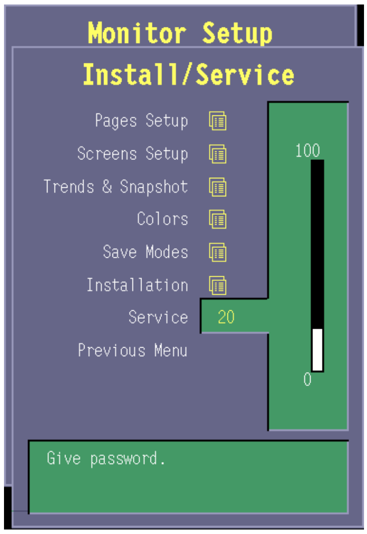
## 4.1 Troubleshooting chart

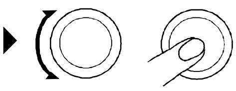
| Trouble | Cause | Treatment |
|---|---|---|
| M-INT not active in the Service Menu. Software version and ID data are not available in the Service Data field. | Module is not connected properly.<br>M-INT is faulty | Check that the module is firmly pushed into the module slot.<br>Replace M-INT Interface board. |
| Measured values from the interfaced monitor do not appear on the display after approximately one minute. | Monitor not selected for interface.<br>Poor contact in the interface cables.<br>Wrong interface cable. | Select the right monitor from the Interfacing menu.<br>Check the cables and connections. Change the cable to another connector.<br>Check cable type and change if necessary. |

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.

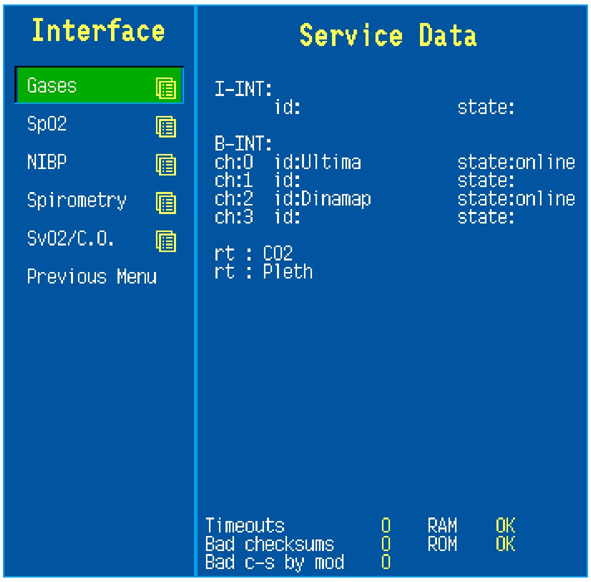


1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters - More - Interface***.

## 5.1 Interface menu




### Interface

**Gases, SpO$_2$, NIBP, Spirometry, SvO$_2$/C.O.** indicate the parameters for which service data is available. The data which can be seen on those pages is raw data from the interfaced monitors, which will be processed for the normal screen.

### Service Data

**I-INT:** Indicates the status of the interface via the UPI4(NET) Board.

**B-INT:** Indicates the status of the interface via the 4 interface channels of B-INT or two channels of M-INT module.

**id:** The name of the interfaced monitor, e.g. Ultima.

**state:** describes the state of the connection, alternatives are:
'init' - the channel is initialized
'wait' - the monitor is waiting for the external monitor
'online' - the connection is ready
'search' - the external monitor is being searched

**rt:** real time values that are available via the interface.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.

**Bad checksums** is a cumulative number that indicates how many times communication from the module to the monitor has failed.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors which cause these numbers rise.

**RAM** indicates the state of the RAM memory.

**ROM** indicates whether the checksum in the ROM is in accordance with the software calculated value.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

# 6 SPARE PARTS

## 6.1 Spare Parts List

NOTE: Accessories are listed in the *Patient Monitor Supplies and Accessories*.

### 6.1.1 Interface Module, M-INT, Rev. 00, 01

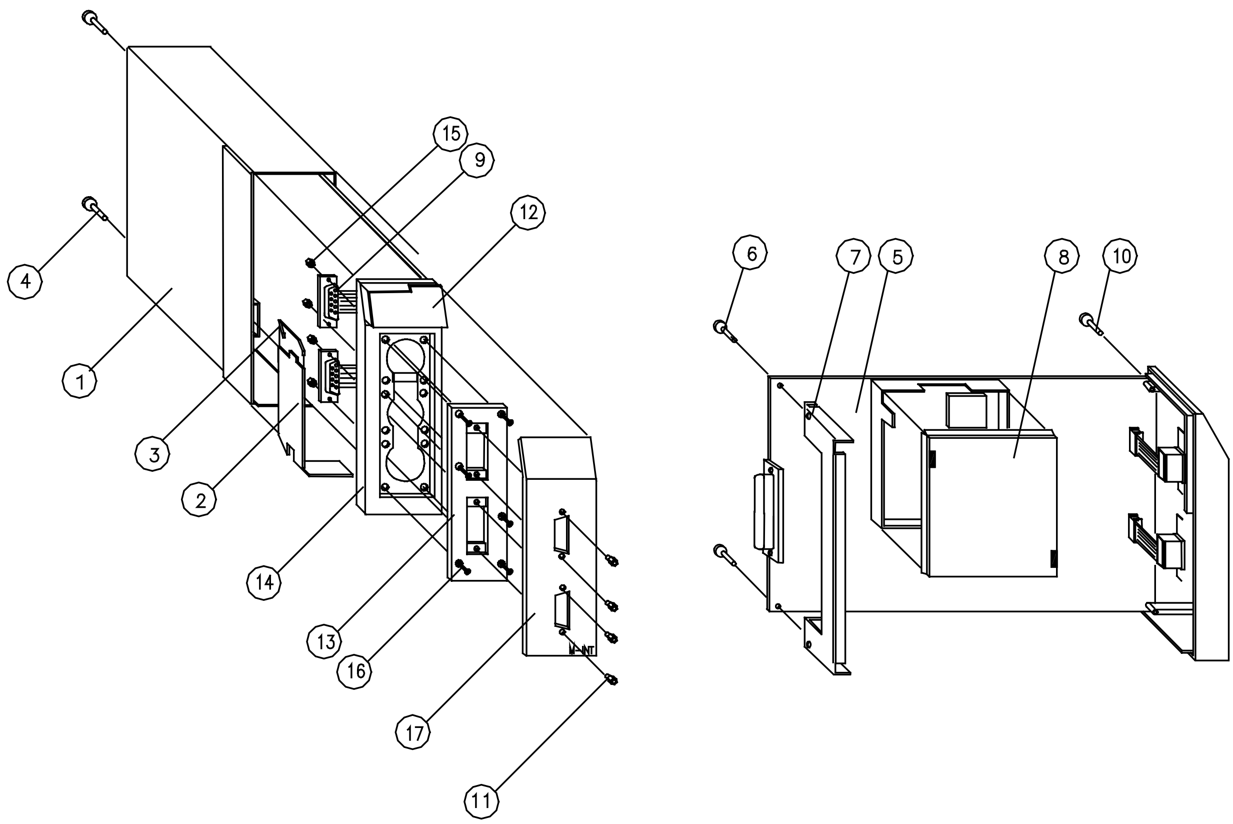



**Figure 3 Exploded view of module box and M-INT**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (single width) | 886167 | |
| 2 | Latch for module box | 879181 | |
| 3 | Spring pin | 879182 | |
| 4 | Cross recess screw M3x8 black | 616215 | |
| 5 | Interface board, M-INT (rev.00) | 890843 | |
| 6 | Cross cylinder-head screw M3x6 | 61721 | |
| 7 | Metal frame | 879184 | |
| 8 | EMC cover | 884099 | |
| 9 | D-connector with flat cable, M-INT | 891432 | |
| 10 | Cross cylinder-head scerw M3x12 | 628700 | |
| 11 | Block screw for cables, M-INT | 891033 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 12 | Fitting plate, M-INT | 890869 | |
| 13 | Connector plate, M-INT | 890357 | |
| 14 | SP-Front mask | 879094 | |
| 15 | Nut-hex,stzn, M3 | 63116 | |
| 16 | Cross cylinder head screw M2.5x10 | 628708 | |
| 17 | Front Panel sticker, EN ; M-INT (rev.01) ; S/5 | 8000214 | |
| 17 | Front Panel sticker, M-INT (rev.00) | 890896 | 8000214 |

# 7 EARLIER REVISIONS

All main differences of Interface Module, M-INT (rev. 00), are noted in this manual.

# APPENDIX A

# SERVICE CHECK FORM

## Interface Module, M-INT

Customer ______

Service ______ Module type ______ S/N ______

Service engineer ______ Date ______

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | | | | |

Notes ______

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4. Interface selection | ☐ | ☐ | ☐ | | | | |
| 5. Module software | M-INT | | | | | | |
| 6. Communication and memories | ☐ | ☐ | ☐ | 7. Recognition of connection | ☐ | ☐ | ☐ |
| 8. Gas interface (1) | ☐ | ☐ | ☐ | 9. $SpO_2$ interface (1) | ☐ | ☐ | ☐ |
| 10. Recognition of disconnection | ☐ | ☐ | ☐ | 11. Interface (2) | ☐ | ☐ | ☐ |
| 12. Restarting | ☐ | ☐ | ☐ | | | | |

Notes ______

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13. Electrical safety check | ☐ | ☐ | ☐ | 14. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 15. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes** ______

**Used Spare Parts** ______ ______ ______

**Signature** ______

**Datex-Ohmeda**

# S/5™ Device Interfacing Solution, N-DISxxx (Rev. 00)

## Technical Reference Manual Slot


Document No. 8005676

October 2003

Datex-Ohmeda, Inc.
P.O. Box 7550,
Madison, WI 53707-7550
U.S.A.
Tel. +1-608-221 1551
Fax +1-608-222 9147

mailto:product.support.ussub@us.datex-ohmeda.com
www.us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

# S/5™ Device Interfacing Solution, N-DISxxx (rev. 00)

# TABLE OF FIGURES

# INTRODUCTION

This *Technical Reference Manual Slot* provides information for the maintenance and service of the Datex-Ohmeda S/5 Device Interfacing Solution, N-DISxxx. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

Please refer to the*Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

Please also refer to the *Installation Guide* accompanying each module.

The purpose of the Device Interfacing Solution is to produce a data connection between an external bedside device and an S/5 monitor.

The N-DISxxx is a new interfacing solution and works beside the previous interface solutions, B-INT and M-INT that are still available.

Up to 10 devices can be connected simultaneously via device specific N-DISxxx modules. No Device Interfacing Solution is called N-DISxxx the xxx are replaced with a device specific ending like N-DISAEST and N-DISRGM.

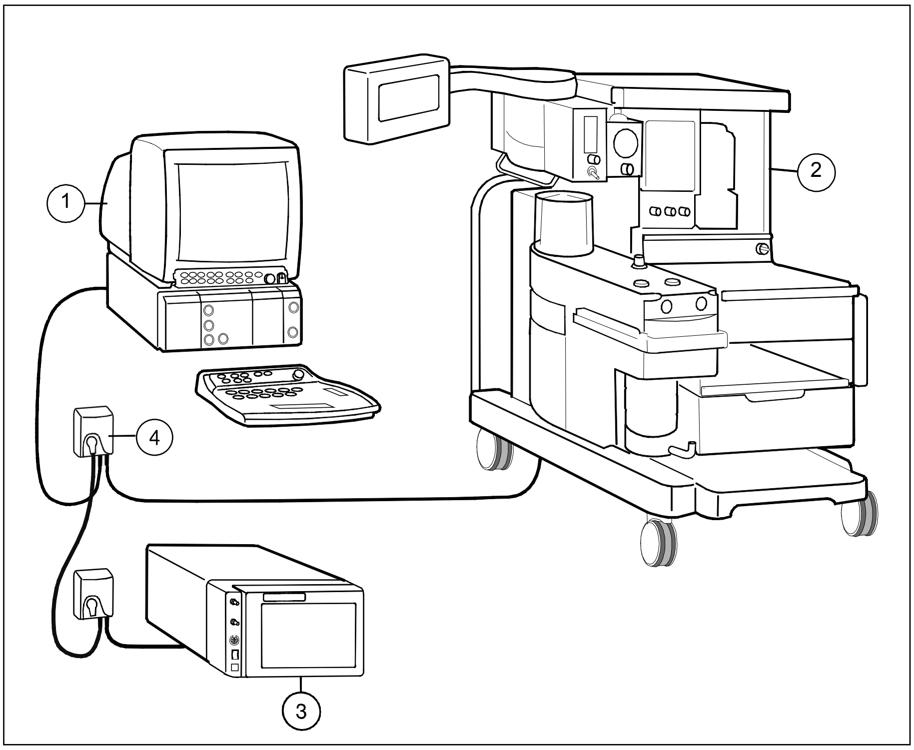



**Figure 1 Example of interfacing via the Device Interfacing Solution, N-DISAEST and N-DISRGM**

(1) Datex-Ohmeda S/5 Anesthesia Monitor (with software L-ANE01(A) or greater)

(2) Aestiva3000 anesthesia machine

(3) RGM monitor

(4) DIS module (max. 10 pcs)

NOTE: The Device Interfacing Solution requires S/5 monitor software version 01 or greater.

NOTE: The Device Interfacing Solution requires B-UPI4(NET).

# 1 SPECIFICATIONS

## 1.1 Environmental specification

| | |
|---|---|
| Operating temperature | +10...+35 °C (50...95 °F) |
| Storage and transport temperature | -10...+50 °C (14...122 °F) |
| Relative humidity | 10...90 % (non condensing) |
| Atmospheric pressure | 660...1060 hPa<br>(66...106 kPa/660...1060 mbar/500...800 mmHg) |

### 1.1.1 Protection against ingress of liquids

According to IEC/EN 60592 class IPX 1.
The DIS module must always be used in a vertical position to prevent water from entering the module.

## 1.2 Technical specifications

### 1.2.1 General

Max 10 DIS modules or 10 m (33 ft) cable length.

**Module**

| | |
|---|---|
| Size (W × D × H) | 60 × 27 × 85 mm/2.4 × 1.1 × 3.4 in |
| Weight | 0.1 kg/0.2 lbs |

**Bus cables**

8 pin Hirose HR12/HR212 connector

| | |
|---|---|
| Material | black PVC |
| Lenght/Weight | 1 m/47 g (39 in/3.3 ft./0.104 lbs.)<br>2 m/85 g (79 in/6.6 ft./0.187 lbs.)<br>6 m/220 g (236 in/19.7 ft./0.485 lbs.) |

**Device cables**

Depends on device.

| | |
|---|---|
| Material | elastollan |
| Lenght | 0.5...1 m (19...39 in/1.6...3.3 ft.) |
| Weight | 40...70 g (0.088...0.154 lbs.) |

## 1.3 Electrical specification

There is no isolation in the DIS module. The interfaced device, DIS module and monitor must be situated in the same patient environment (as defined in IEC 60601-1-1).

**WARNING** **Connecting electrical equipment together, or using the same extension cord for more than one device, may cause their leakage currents to exceed the limit specified in relevant safety standards. Always make sure that the entire combination complies with the international safety standard IEC 60601-1-1 for medical electrical systems and with the requirements of local authorities.**

## 1.4 Maximum power consumption

600 mW (75 mA @ 8 V)

## 1.5 Module communication

Bus communication speed is 500 kbps. RS422 implementation.

Device communication speed depends on the interfaced external device. RS232 implementation.

# 2 FUNCTIONAL DESCRIPTION

The S/5™ Device Interfacing Solution provides a seamless link between external patient care devices and the Datex-Ohmeda S/5 monitoring system. You can interface simultaneously up to ten external devices: monitors, ventilators, blood gas analyzers, etc.

The Device Interfacing Solution is designed for use with the S/5 Anesthesia Monitor and Compact Anesthesia Monitor, and S/5 Critical Care Monitor and Compact Critical Care Monitor. The Device Interfacing Solution (DIS) is only compatible with the S/5 Anesthesia and S/5 Critical Care Monitor when the monitor has B-UPI4(NET) and B-CPU4 or B-CPU5 boards installed. Also, DIS is only compatible with the S/5 version (i.e. F-CM(REC)1 frame) of the Compact Anesthesia and Compact Critical Care monitor. In addition, the S/5 Monitors must be equipped with DIS compatible main software. The Device Interfacing Solution, N-DISxxx can not be used with AS/3 and CS/3 Compact Monitors.

**WARNING** **The manufacturer guarantees a reliable functioning of the devices with tested software versions only. Always refer to the Installation guide accompanying the DIS module and verify the compatibility before use.**

## 2.1 Main components

The implementation of Device Interfacing Solution can be divided into five parts:

- Device specific software
- Device specific module
- Device specific cable
- Bus cables
- Software in Datex-Ohmeda monitor

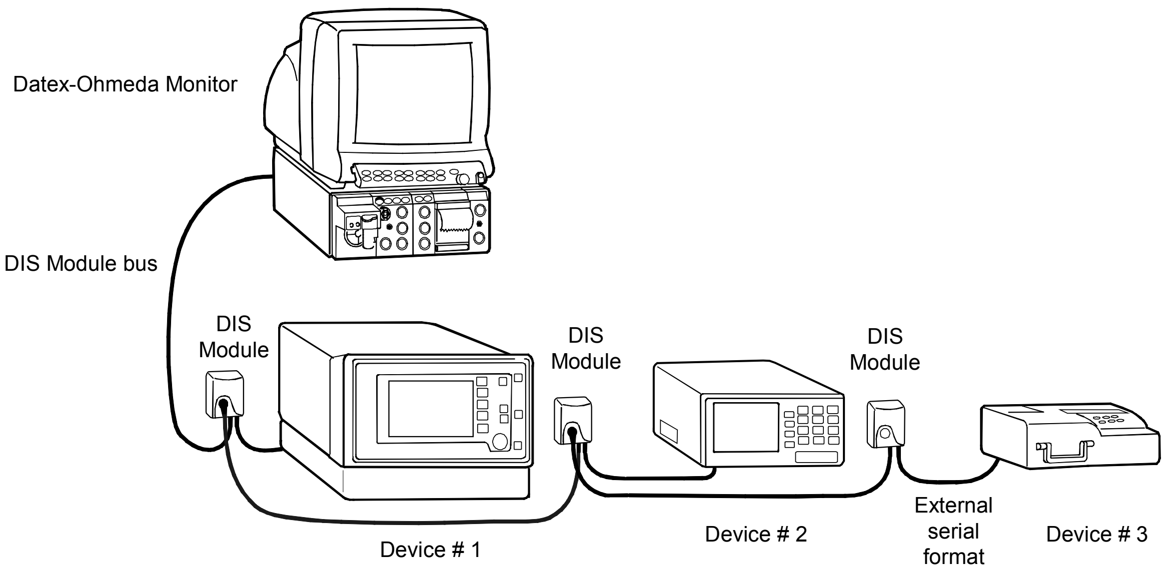



**Figure 2 Implementation of Device Interfacing Solution**

# 2.2 DIS module

A DIS module receives data from an external device, converts the data to a suitable format for the monitor and then sends the data to the monitor. The main board contains the power supply with current limiter, microcontroller, reset circuits, memory and serial communication buffers. The board communicates with the Datex-Ohmeda monitor through the DIS bus.

A DIS module consists of:

- Power supply with current limiter and reset circuit parts
- Microcontroller H8, internal and external RAM, non volatile memory etc.
- Programming connection
- Device communication connection and RS232 driver
- Bus communication connection and RS422 driver
- LEDs, that indicate the status of the communication
- Device specific software

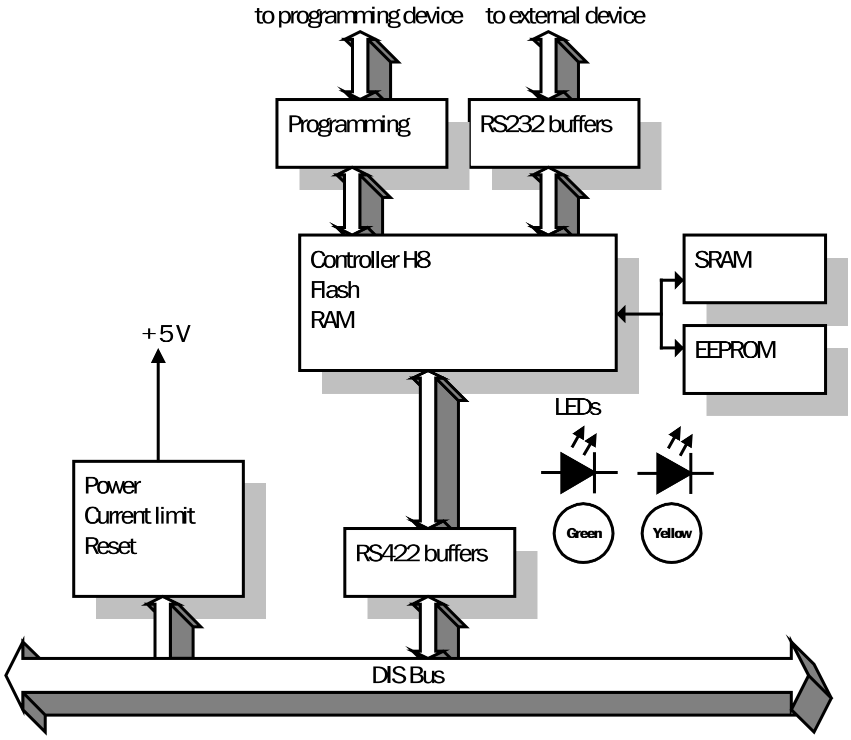
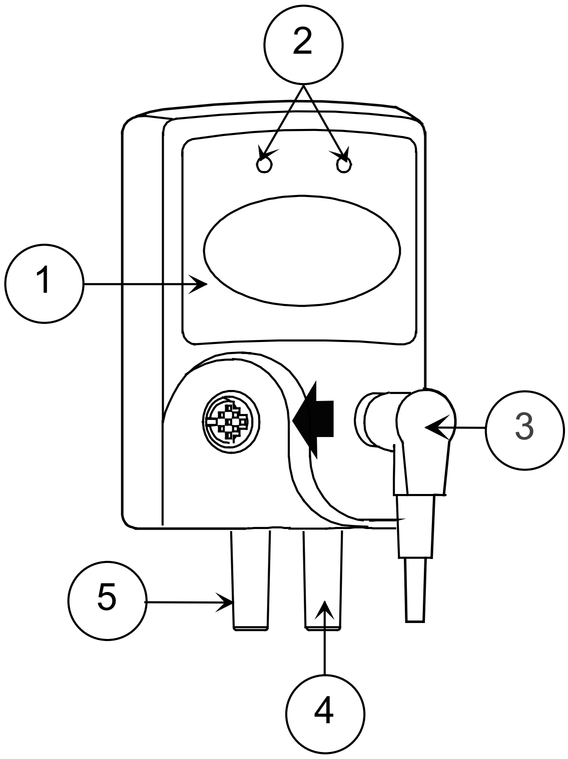



**Figure 3 DIS module**

## 2.3 Connections

Connect the device specific cable to the external device and the bus cable to the D-O monitor's B-UPI4(NET) board, or to another DIS module.




(1) Label specifying the external device

(2) LED indicators

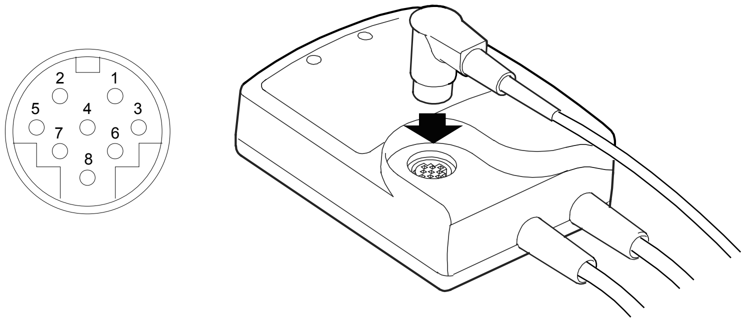
(3) Bus cable from another DIS module (if used)

(4) Device specific cable to the external device

(5) Bus cable to the D-O monitor's B-UPI4(NET) board (or to another DIS module)

## 2.4 Connectors and signals

Male bus cable connector




| Pin no | Signal | Color |
|---|---|---|
| 1 | Data from UPI + | brown |
| 2 | Data from UPI - | red |
| 3 | VDD 9 V to 18 V (max 1 A) | orange |
| 4 | GND | yellow |
| 5 | VCC 7 V to 8 V (max 1 A) | blue |
| 6 | GND | grey |
| 7 | Data to UPI + | white |
| 8 | Data to UPI - | black |

## 2.5 Interfaced devices, parameters and communication

### Ventilator interfaces

| Device | Device set values for trends | Measured numeric values | Waveforms | Module name | Supported versions |
|---|---|---|---|---|---|
| Datex-Ohmeda SmartVent 7900 | Vent. mode, I:E ratio, RR, TV, PEEP, Pinsp, InspPause | $FiO_2$, TVexp, MV, RR, Pmean, Ppeak, Pplat | Paw, Flow, Vol | N-DIS7900 For ventilator 7900 except when used with Aestiva. | Software version 3.3 |
| Datex-Ohmeda Aestiva /5<br>Aestiva /5 Compact | Vent. mode, I:E ratio, RR, TV, PEEP, Pinsp, InspPause | $FiO_2$, TVexp, MV, RR, Pmean, Ppeak, Pplat | Paw, Flow, Vol | N-DISAEST For all Aestiva anesthesia machines. | Software version 1.0 |
| Dräger Evita 4 | $FiO_2$, Vent. mode, I:E ratio, RR, TV, PEEP, Pinsp | $FiO_2$, $EtCO_2$, TVexp, MV, MVspont, RR, Ppeak, Pplat, Pmean, Raw, Compl, PEEPi | Paw, Flow, Vol | N-DISEV4 | Medibus version 4.00 Evita 4 version 1.00 |
| Nellcor Puritan Bennett 7200 | Vent. mode, RR, TV, PEEP, $O_2$ setting | expTV, expMV, expMVspont, RR, Ppeak, Pplat, Pmean, Dyn. Raw, Dyn. Compl,<br>I:E ratio | | N-DIS7200 | Versions 7200ae, 7200e, 7200spe |
| Nellcor Puritan Bennett 840 | Vent. mode, I:E ratio, RR, TV, PEEP, $O_2$ setting. | expTV, expMV, expMVspont, RR, Ppeak, Pplat, Pmean,<br>I:E ratio | | N-DIS840 | F |
| Siemens Servo 300 | CMV freq set, SIMV freq set, Insp. Time,<br>Pause time, MV, PEEP, Pinsp, Plimit,<br>Vent mode, $O_2$ concentr | $O_2$ insp, TV exp, TV insp, MV exp, MV insp, RR, Ppeak, Pplat, Pmean, PEEP, PAmbient | Paw, Flow, Vol | N-DISS300 | Firmware version 2.x |
| Dräger Primus | FiO2, vent.mode, I:E ratio, RR, TV, PEEP, Pinsp | FiO2, EtCO2, TVexp, MV, MVspont, RR, Pmean, Ppeak, Pplat, Raw, Compl, PEEPi | Paw, Flow, Vol | N-DISPRIM | Medibus 4.03<br>Primus 1.05. |

## Monitor interfaces

| Device | Numeric values | Module name | Supported versions |
|---|---|---|---|
| Abbott Qvue/Q2 | CO, CCO, Tblood, and $SvO_2$ (Q2 only) | N-DISQVUE | QVue: 2.03<br>Q2: 4.00 |
| Abbott Oximetrix 3 | CO, $SvO_2$ | N-DISOXIM3 | Software versions 104 and 105 |
| Aspect A-2000 BIS Monitor | BIS, SQI, EMG | N-DISA2000 | Firmware version 1.03 or 1.06 |
| Baxter Vigilance | CO, CCO, $SvO_2$, TBLOOD | N-DISVIGIL | Software version 5.02 E |
| Datex-Ohmeda RGM Monitor | $CO_2$, $O_2$, $N_2O$, AA, RR, $SpO_2$, HR, Paw, TV, MV | N-DISRGM | Signal version: 8.007<br>ACX version: 4.20 |
| Datex-Ohmeda Tonocap | $PgCO_2$ | N-DISTONO | 2.1 or later |
| Datex-Ohmeda<br>Capnomac, Capnomac II, | $EtCO_2$, $FiCO_2$, $EtO_2$, $FiO_2$, $EtN_2O$, $FiN_2O$, EtAA, FiAA, AA selection, RR, PAmbient | N-DISWHITE | All versions |
| Satlite, Satlite trans and Satlite Plus | Pulse, $SpO_2$ | | All versions |
| Oscar oxy, Cardiocap 1GS and Cardiocap 2GS | $EtCO_2$, $FiCO_2$, $EtO_2$, $FiO_2$, $EtN_2O$, $FiN_2O$, RR, Pulse, $SpO_2$% | | All versions |
| Capnomac Ultima | $EtCO_2$, $FiCO_2$, $EtO_2$, $FiO_2$, $EtN_2O$, $FiN_2O$, EtAA, FiAA, AA selection, RR, PAmbient, Auto id AA, Pulse, $SpO_2$%, MV exp, MV insp, TV exp, TV insp, Compl, Ppeak, Pplat, PEEP, I:E | | All versions |
| Normocap CD-200 | $EtCO_2$, $FiCO_2$, $EtN_2O$, $FiN_2O$, RR, PAmbient | | All versions |
| Multicap, Normocap CD2-02, | $EtCO_2$, $FiCO_2$, $EtO_2$, $FiO_2$, $EtN_2O$, $FiN_2O$, RR, PAmbient | | All versions |

## Heart-lung machines

| Device | Device set values for trends | Measured numeric values in trends | Monitor name | Supported versions |
|---|---|---|---|---|
| Jostra HL20 | bypass on, bypass off, aorta closed, aorta open | speed, flow rate, systolic pressure, diastolic pressure, mean arterial pressure, $FiO_2$, $FiCO_2$, cardioplegia amount | N-DISHL20 | R11 |

## Bloodgas analyzers

| Device | Numeric values | Monitor name | Supported versions |
|---|---|---|---|
| AVL Opti CCA | pH, $PCO_2$, $PO_2$, ctHb, $SO_2$, barometric pressure, $HCO_3$, BE, Temp, Kalium (Potassium), Natrium (Sodium), $O_2Ct$ | N-DISOPT | 2.2 |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the Device Interfacing Solution is limited to replacing faulty mechanical parts that are listed as spare parts. Faulty DIS modules should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check for Datex-Ohmeda Device Interfacing Solution. The service check should be performed after any service repair, however, the service check procedures can be used also for determine possible failures.

The instructions include an *Appendix A: Service Check form*, to be filled in when performing the corresponding procedures.

The symbol ✍ in the instructions means that the performed procedure should be signed in the check form.

### Recommended tools

| **Tool** | **Order No.** | **Notes** |
|---|---|---|
| Screwdrivers | | |

### Recommended parts

No recommended parts.

### 3.2.1 Visual inspection

- Disconnect the DIS module from the DIS bus and from the interfaced external device.

1. Internal inspection
   - Disassemble the DIS module.
   - Make sure there are no loose parts inside the DIS module.
   - Check the screws holding the PC board are tightened properly.
   - Check that the cables are attached properly and the connectors are intact.

2. External inspection
   - Check that the DIS module case and label are clean and intact.
   - Reassemble the DIS module.
   - Check that the screws for the DIS module case are secured properly.
   - Check that the bus cable connector is intact.
   - Check that the DIS bus and device specific cables are intact.

### 3.2.2 Functional inspection

3. DIS module interface status
   - Connect the DIS module to the DIS bus and to the external device that is specified in the DIS module label, if possible. Turn on the interfaced external device.
   - Check that no error messages are displayed on the monitor screen.
   - Check via the Interfacing menu that the connected DIS module status is correct:

     **Monitor Setup** ***- Interfacing - Status Page***
   - Check that the waveforms and numeric fields are transferred to the monitor according to the configuration.

4. Recognition of interface
   - Disconnect the DIS bus cable and check that the '[device name] module removed' message appears onto the monitor screen. Reconnect the cable.
   - Turn off the external device (if possible) and check that the '[device name] disconnected from module' message appears onto the screen. Turn the external device back on again.

5. DIS module service menu

   – Enter the service menu

     **Monitor Setup** – ***Install/Service*** (password 16-4-34) –
     ***Service*** (password 26-23-8) –
     ***Parameters – More – DIS Interfacing***

   – Check that the menu displays submenus for all connected DIS modules.

   – Enter the corresponding DIS module service menu and check that the displayed information corresponds with the information on the DIS module labels.

   – Check that the DIS bus voltage is between 6.00...8.00 V.

   – Check that the DIS module timeout and checksum error values do not increase more than by 5 per second.

   – Check that the status of each DIS module memory indicates OK.

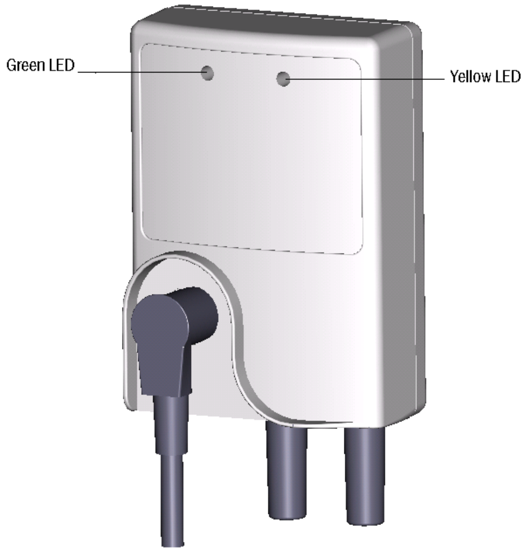
6. Perform the electrical safety test and leakage current test. Check that the DIS module functions normally after the tests.

7. Clean the DIS module, the bus cable and the device specific cable with a suitable detergent.

8. Fill up all the necessary documents.

# 4 TROUBLESHOOTING

## 4.1 LED indicators




### 4.1.1 Green LED

The meaning of the green LED is to indicate that communication between the monitor and DIS module and communication between the DIS module and external device is working properly. When all cables are connected and the connected devices are on, the green LED should be lit continuously.

### 4.1.2 Yellow LED

The meaning of the yellow LED is to alert the user. The yellow LED is lit when any of the following conditions becomes true:

1. The DIS module is connected to the DIS bus but the external device is not connected.
2. The external device is in power off state.
3. The external device is not selected from the interfacing menu as an active source of data.

NOTE: The meaning of the yellow LED varies with some external devices. See the *Installation Guide* delivered with the DIS module.

## 4.2 Quick functional check

You have two ways for checking the function of the Device Interfacing Solution:

- Press the **Monitor Setup** key and select ***Interfacing*** and open the ***Status Page*** menu. The status page shows you the current communication status of the interfacing modules connected to the bus (1...10 pcs).

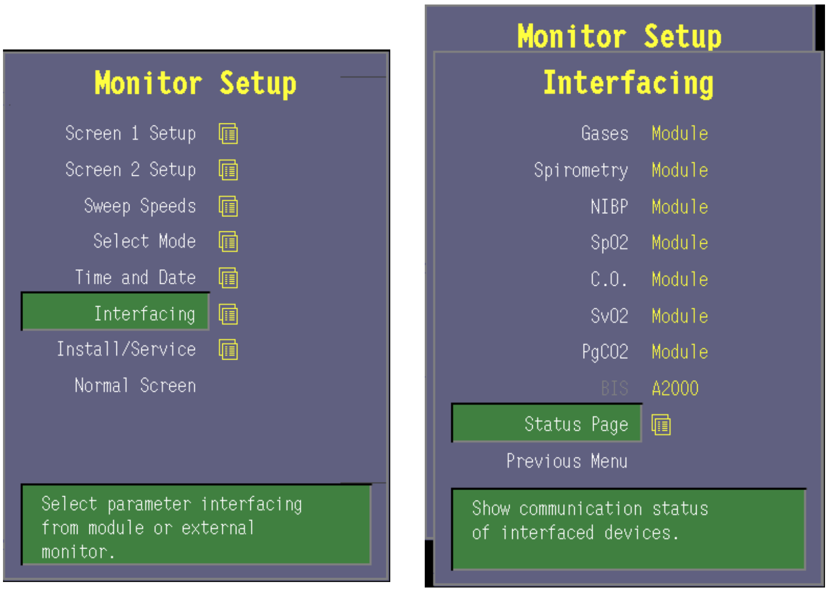
NOTE: The status message 'Connected' appears on the monitor screen after you have connected the external device to the DIS module and turned it on, if the monitor and DIS module have already been initialized.

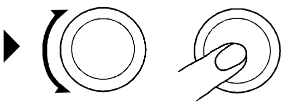
- Check the LED indicators on the DIS module (the green LED indicates the physical connections, the yellow LED software selections):

| GREEN | YELLOW | INDICATION |
|---|---|---|
| lit ☼ | dark ● | physical connections between the monitor, DIS module and external device are in order and the device has been selected in the menu |
| dark ● | lit ☼ | physical connections between the monitor, DIS module and external device are not in order; the external device has not been selected in the menu (see the *User's Reference Manual* of the monitor) |
| lit ☼ | lit ☼ | physical connections between the monitor, DIS module and external device are in order but the external device has not been selected in the menu (see the *User's Reference Manual* of the monitor) |
| dark ● | dark ● | the DIS module is not connected to the monitor |

# 5 DEVICE INTERFACING SOLUTION MENUS

## 5.1 DIS Status menu



**Monitor Setup** - ***Interfacing*** - ***Status Page***

### 5.1.1 Interfacing

For selecting the parameter data source:

- Select the desired measurement parameter (e.g., ***Gases***).
- Select the desired source by name (e.g., ***Aest***).

NOTE: The name of the device is visible on the list only if the device is correctly connected to the module.

### 5.1.2 Status Page

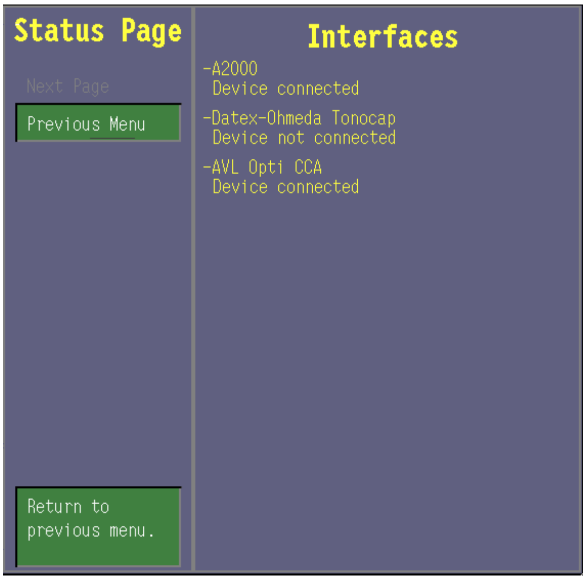
**Status Page**

The selection **Next page** is available, if more than 8 DIS modules are connected to the DIS bus simultaneously.

**Interfaces**

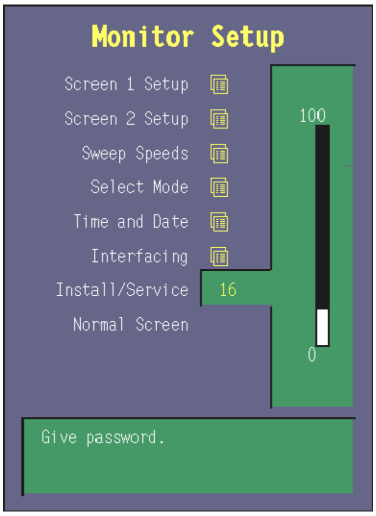
The menu displays a list of all connected DIS modules and the statuses of the corresponding external devices.

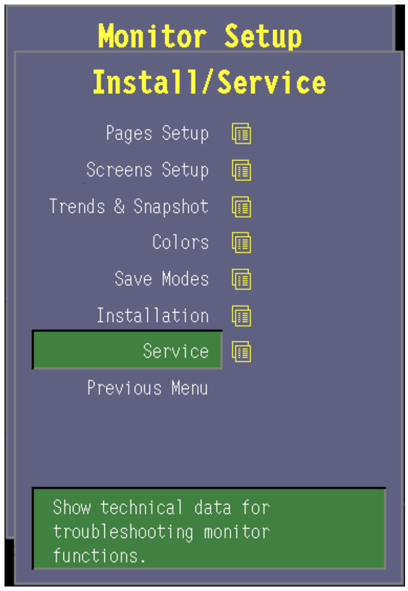
If the bus voltage is too low you can not add more devices. ‘DIS module bus voltage low. Do not add more devices or reduce cable length’ message appears.

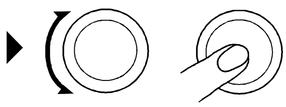


## 5.2 Service Menu

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



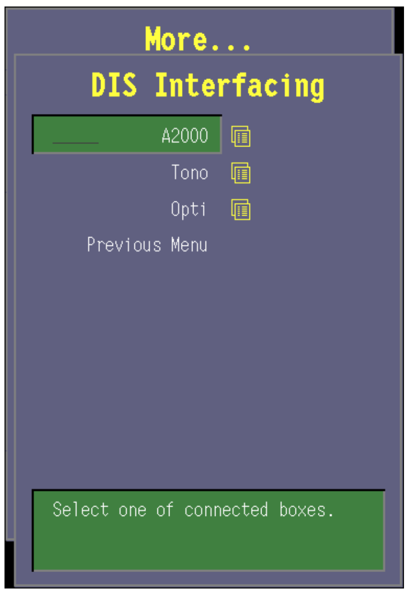



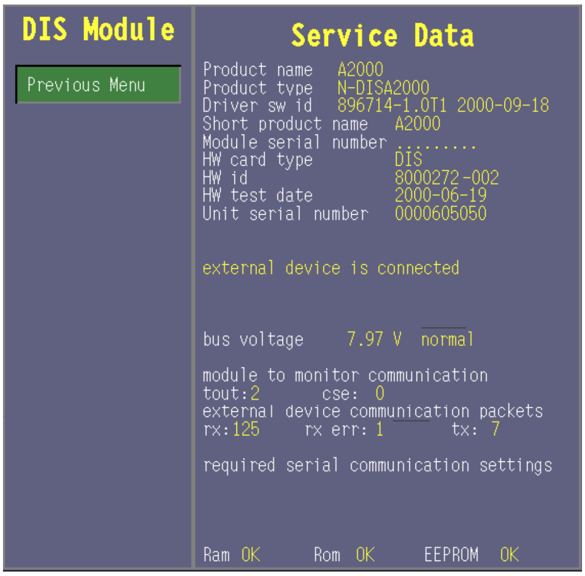
**Monitor Setup** - ***Install/Service*** (password 16-4-34*)* - ***Service*** (password 26-23-8) - ***Parameters – More – DIS Interfacing***

### 5.2.1 DIS Interfacing

The menu displays submenus for all connected DIS modules.



## 5.2.2 DIS Module specific page



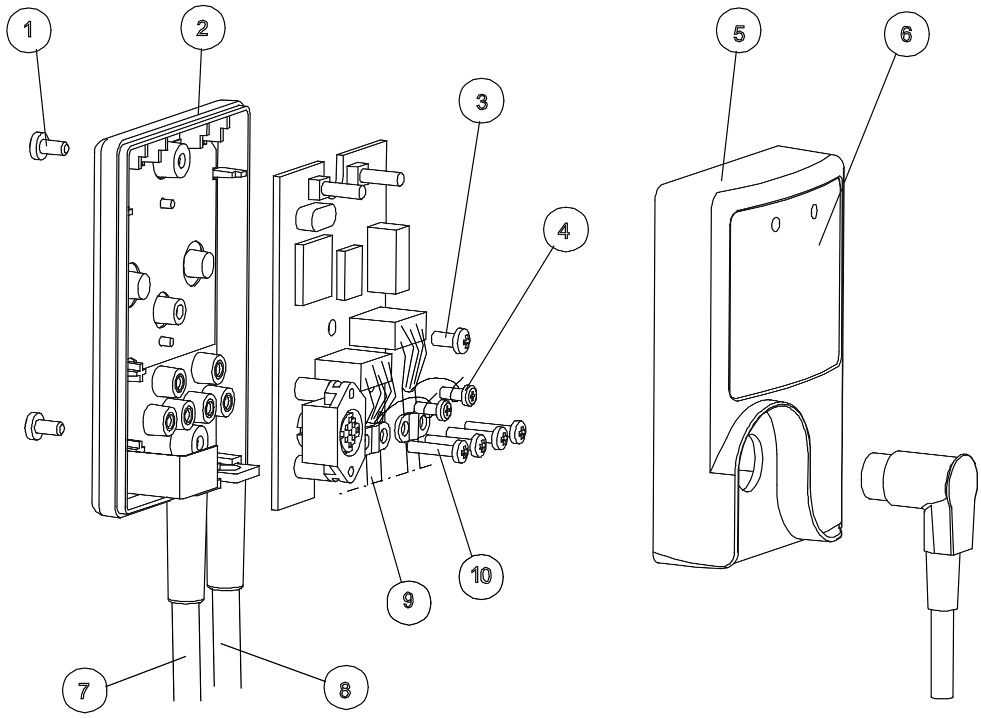

**Service Data**

**Product name:** DIS module name.
**Product type:** DIS module type.
**Driver sw id:** DIS module software and its release date.
**Short product name:** DIS module name.
**Module serial number:** DIS module serial number.
**HW card type:** PCB type.
**HW id:** DIS module PCB identification number.
**HW test date:** DIS module PCB testing date.
**Unit serial number:** DIS module PCB serial number.

**Comment field:** Indicates the status of the external device.

**bus voltage**: DIS bus voltage, measured by the UPI4(NET) board or the Central Processing Board in S/5 Compact Monitor. The value should normally be within 6...8 V.
**tout**: DIS module timeouts, seen by the monitor. The value should not increase more than by 5 per second.
**cse**: DIS module checksum errors, seen by the monitor. The value should not increase more than by 5 per second.
**rx:** The number of data packets from the external device received by the DIS module.
**rx err:** The number of data errors from the external device received by the DIS module.
**tx:** The number of data packets to the external device sent by the DIS module.
**Ram:** Status of DIS module RAM memory.
**Rom:** Status of DIS module ROM memory.
**EEPROM:** Status of DIS module EEPROM memory.

# 6 SPARE PARTS




| Item | Description | | Order no. |
|---|---|---|---|
| 1 | Screw for the DIS module case | | 617210 |
| 2 | DIS module case, rear | | 896930 |
| 3 | Screw for the PC board | | 61209 |
| 4 | Screw for cable | | 617120 |
| 5 | DIS module case, front | | 896929 |
| 7 | Bus cable, 1 m | | 900501 |
| 7 | Bus cable, 2 m | | 900502 |
| 7 | Bus cable, 6 m | | 900503 |
| | **Labels for module case:** | | |
| 6 | Label for Dräger Evita 4 Ventilator | N-DISEV4 | 897193 |
| 6 | Label for Aspect A-2000 EEG Monitor | N-DISA2000 | 897194 |
| 6 | Label for Datex-Ohmeda 5250 RGM Monitor | N-DISRGM | 897195 |
| 6 | Label for Jostra HL-20 Perfusion Machine | N-DISHL20 | 897196 |

| Item | Description | | Order no. |
|---|---|---|---|
| 6 | Label for Nellcor P-B 7200 | N-DIS7200 | 897207 |
| 6 | Label for Nellcor P-B 840 | N-DIS840 | 8002435 |
| 6 | Label for Datex-Ohmeda Aestiva/5 | N-DISAEST | 8002595 |
| 6 | Label for Abbot Q-Vue/Q2 | N-DISQVUE | 897210 |
| 6 | Label for Datex-Ohmeda Tonocap | N-DISTONO | 897209 |
| 6 | Label for Datex-Ohmeda Smartvent 7900 | N-DIS7900 | 8002598 |
| 6 | Label for AVL Opticca | N-DISOPT | 897543 |
| 6 | Label for Abbot Oximetrix 3 | N-DISOXIM3 | 8000983 |
| 6 | Label for Siemens Servo | N-DISS300 | 8000392 |
| 6 | Label for Baxter Vigilance | N-DISVIGIL | 8002434 |
| 6 | Label for Datex-Ohmeda Whiteline monitors | N-DISWHITE | 8000405 |
| 6 | Label for Dräger Primus | N-DISPRIM | M1008264 |
| | **Device specific cables:** | | |
| 8 | Cable for Dräger Evita 4 Ventilator | N-DISEV4 | 897213 |
| 8 | Cable for Aspect A-2000 EEG Monitor | N-DISA2000 | 897214 |
| 8 | Cable for Datex-Ohmeda 5250 RGM Monitor | N-DISRGM | 897215 |
| 8 | Cable for Jostra HL20 Perfusion Machine | N-DISHL20 | 897216 |
| 8 | Cable for Nellcor P-B 7200 | N-DIS7200 | 897227 |
| 8 | Cable for Nellcor P-B 840 | N-DIS840 | 8002481 |
| 8 | Cable for Datex-Ohmeda Aestiva/5 | N-DISAEST | 897228 |
| 8 | Cable for Abbot Q-Vue/Q2 | N-DISQVUE | 897230 |
| 8 | Cable for AVL Opticca | N-DISOPT | 897544 |
| 8 | Cable for Datex-Ohmeda Tonocap | N-DISTONO | 897229 |
| 8 | Cable for Datex-Ohmeda Smartvent 7900 | N-DIS7900 | 8002597 |
| 8 | Cable for Abbot Oximetrix 3 | N-DISOXIM3 | 8002839 |
| 8 | Cable for Siemens Servo | N-DISS300 | 8002838 |
| 8 | Cable for Baxter Vigilance | N-DISVIGIL | 8002841 |
| 8 | Cable for Datex-Ohmeda Whiteline monitors | N-DISWHITE | 8002840 |
| 8 | Cable for Dräger Primus | N-DISPRIM | M1011570 |
| 9 | Strain relief | N-DISxxx | 897443 |
| 10 | Screw M2.5×10 | | 61615 |

# 7 EARLIER REVISIONS

No earlier revisions.

# APPENDIX A

# APPENDIX A: SERVICE CHECK FORM

## S/5™ Device Interfacing Solution, N-DISxxx (Rev. 00)

| | | | | | |
|---|---|---|---|---|---|
| Customer | | | | | |
| Service | | DIS module label | N-DIS________ | S/N | |
| Service engineer | | | | Date | |

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| **Visual inspection** | | | | | | | |
| 1. Internal inspection | ☐ | ☐ | ☐ | 2. External inspection | ☐ | ☐ | ☐ |
| **Functional inspection** | | | | | | | |
| 3. DIS module interface status | ☐ | ☐ | ☐ | 4. Recognition of interface | ☐ | ☐ | ☐ |
| 5. DIS module service menu | ☐ | ☐ | ☐ | 6. Electrical safety check and leakage current test | ☐ | ☐ | ☐ |
| 7. Final cleaning | ☐ | ☐ | ☐ | | | | |

Notes:

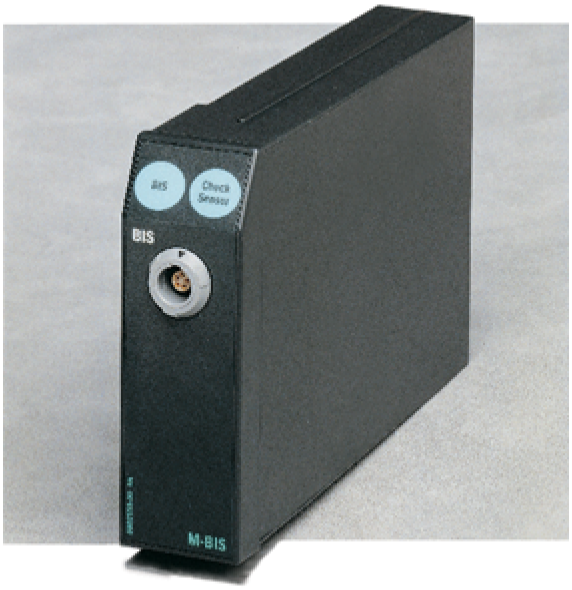
**Used Spare Parts**

**Signature**

# Datex-Ohmeda

# S/5™ BIS Module

# Technical Reference Manual Slot




All specifications are subject to change without notice.

Document No. 800 3476-2

January 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## BIS Module, M-BIS

# TABLE OF FIGURES



# TABLE OF TABLES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 BIS Module, M-BIS. The BIS module is a single width plug-in module designed for use with the S/5 monitors. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

BIS, and the BIS logo are trademarks of Aspect Medical Systems Inc., and are registered in the USA, EU and other countries. Later in this manual Aspect Medical Systems Inc. will be refered to as Aspect.

Please refer to the *Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The BIS module is indicated for monitoring the state of the brain by data acquisition of EEG signals. BIS may be used as an aid in monitoring the effects of certain anesthetic agents. The raw EEG signals are processed to produce a single number, ranging from 100 for a patient being wide awake to 0 in the absence of brain activity.

Calculated parameters are:

- Bispectral Index, BIS
- Suppression Ratio, SR
- Electromyograph EMG
- Signal Quality Index, SQI

The calculated parameters can be selected on the display, and trended, (excluding SQI).
The module has two user keys, BIS for BIS menu and Check Sensor for impedance check.

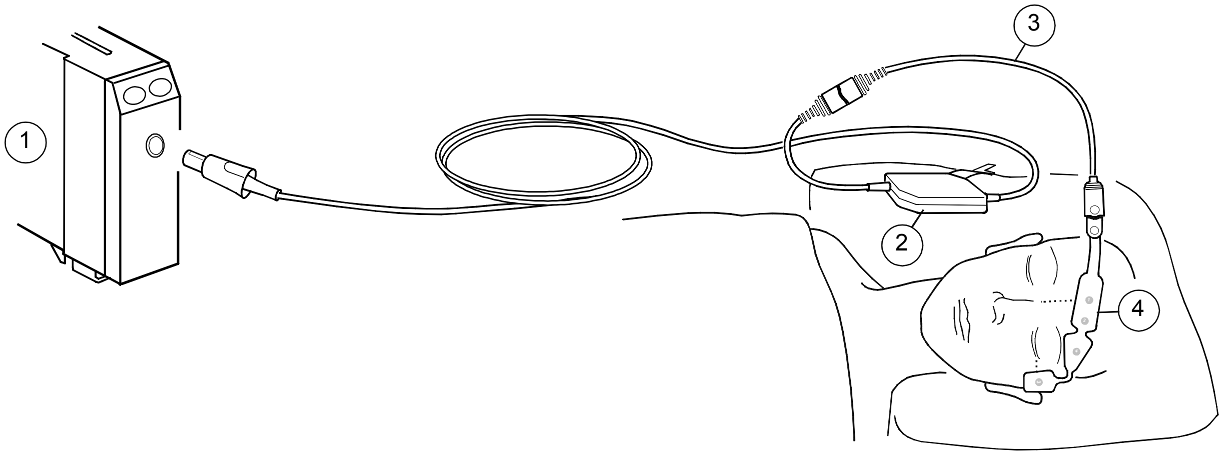



**Figure 1** **Measurement setup**

(1) Module with BIS measurement capability, M-BIS

(2) Digital Signal Converter

(3) Patient Interface Cable

(4) BIS Sensor

NOTE: M-BIS module requires monitor software version 02 or greater.

## Accessories

The BIS measurement is based on Aspect Medical Systems Inc. technology, and all accessories are developed and manufactured by Aspect.
NOTE: Only Aspect accessories can be used with the M-BIS module.

# 1 SPECIFICATIONS

## 1.1 General specifications

### 1.1.1 BIS Module

| | |
|---|---|
| Module size, W × D × H | 37 × 180 × 112 mm/1.5 × 7.1 × 4.4 in |
| Module weight | 0.3 kg/0.7 lbs |
| Power consumption | 2.2 W |

### 1.1.2 Digital Signal Converter, DSC

| | |
|---|---|
| DSC size, W × D × H | 66 × 108 × 25 mm/2.6 × 4.3 × 1.0 in |
| DSC weight | 0.134 kg/0.3 lbs |
| Integral DSC Cable length | 3.6m / 12.5 ft |
| Patient Interface Cable (PIC Plus) length | 1.2m / 4 ft |

### 1.1.3 Environmental specifications

| | |
|---|---|
| Operating temperature | +10 ... +40°C |
| storage temperature | -25 ... +70°C |
| relative humidity | 10 ... 95%, non -condensing |
| atmospheric pressure | 700 ... 1060 mbar |
| Protection against electrical shock | Type BF |

## 1.2 Technical specifications

### Parameter specifications

**BIS EEG**

| | |
|---|---|
| Epoch duration | 2 seconds |
| Artifact rejection | automatic |
| EEG scales | 25 to 400 µV |
| EEG sweep speeds | 12.5 / 25 / 50 mm /sec |
| Bispectral index (BIS) | 0 to 100 |
| Signal quality index (SQI) | 0 to 100 |
| EMG | 30 to 80 db (70 to 110 Hz) |
| Suppression ratio (SR) | 0 to 100 % |
| Update rate | 1 second for BIS index |
| Filters | 2 - 70 Hz bandpass (default) / 0.25Hz highpass |
| Smoothing rate | 15 seconds, default in S/5 AM and CAM<br>30 seconds, default in S/5 CCM and CCCM |

**DSC**

| | |
|---|---|
| Analog to digital converter | noise-shaped sigma-delta |
| Sampling rate | 16384 samples/second |
| Resolution | 16 bits at 256 samples/second |
| Input impedance | >50 Mohms |
| Noise | < 0,3µV RMS (2.0µV peak-to-peak) 0.25 to 50 Hz |
| Common mode rejection | 110 dB at 50/60 Hz to earth ground (Isolation mode) |
| Bandwith | 0.16 to 450 Hz |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

The BIS measurement is based on EEG signals, these are processed as the BIS index. The BIS sensor is placed on the patient's forehead to acquire the high-resolution signals required. These EEG signals are transferred to the digital signal converter DSC that amplifies and digitizes the EEG signal and sends it to the module. The module calculates the BIS index and sends them to the monitor via MBUS.

### BIS measurement on the monitor screen

The waveform field shows the BIS EEG waveform. The following BIS related data appears in digit fields and graphical trends (except SQI):

**BIS** number indicates the patient's level of hypnosis, ranging from 100 for wide awake to 0 in the absence of brain activity.

**Signal Quality Index (SQI )** bar graph indicates the quality of the EEG signal in the range of 0 to 100.

**Electromyograph (EMG)** bar graph represents the absolute power in the 70 to 110 Hz frequency band and ranges from 30 to 55 dB. This frequency band contains power from muscle activity (electromyograph) as well as power from high frequency artifacts.

**Suppression ratio (SR)** number indicates the percentage of suppressed (flatline) EEG detected over the last 63 seconds. It ranges from 0 to 100%.

## 2.2 Sensor Check

Sensor check is performed automatically at the beginning of each case when the sensor is attached to the patient interface cable (monitor). An initial checking sensor message is shown in digit field together with an appropriate sensor picture. The information of the passed or failed sensor check is printed to this picture at each electrode's location. The BIS measurement can't continue if the first sensor check fails. In such a case a message "Sensor check failed" is shown in the digit and waveform field.

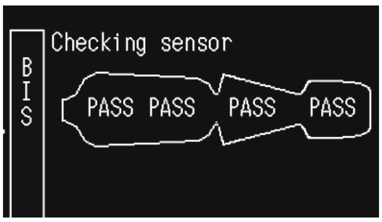



**Figure 2 BIS sensor check**

Continuous checking of the reference and signal electrodes and periodic checking of the ground electrode is performed by default. It can be switched off by selecting the appropriate comand from the  message "Automatic check off" will appear. Sensor check can be started manually by pushing a module key or selecting the appropriate command from the menu. Manual sensor check can be useful e.g. when AEP's are being monitored at the same time, as the continuous sensor check might disturb the AEP measurement.

During periodic ground checks, the signal disappears momentarily and the message “Checking sensor” display  in the digit and waveform fields. Also, all BIS calculation stops during this check, and no measurement values are shown.

CAUTION Continuous impedance check may need to be disabled if the 1 nA 128 Hz impedance check signal interferes with other equipment such as evoked potential.

**WARNING** **Make sure that the electrodes, sensor and connectors do not touch any electrically conductive material, including earth.**

## 2.3 Main components

The BIS measurement chain is composed of Aspect BIS Sensor, Aspect digital signal converter, M-BIS module containing Aspect BIS Engine board and Datex-Ohmeda's interfacing board, and host monitor. A block diagram of the system is shown below.

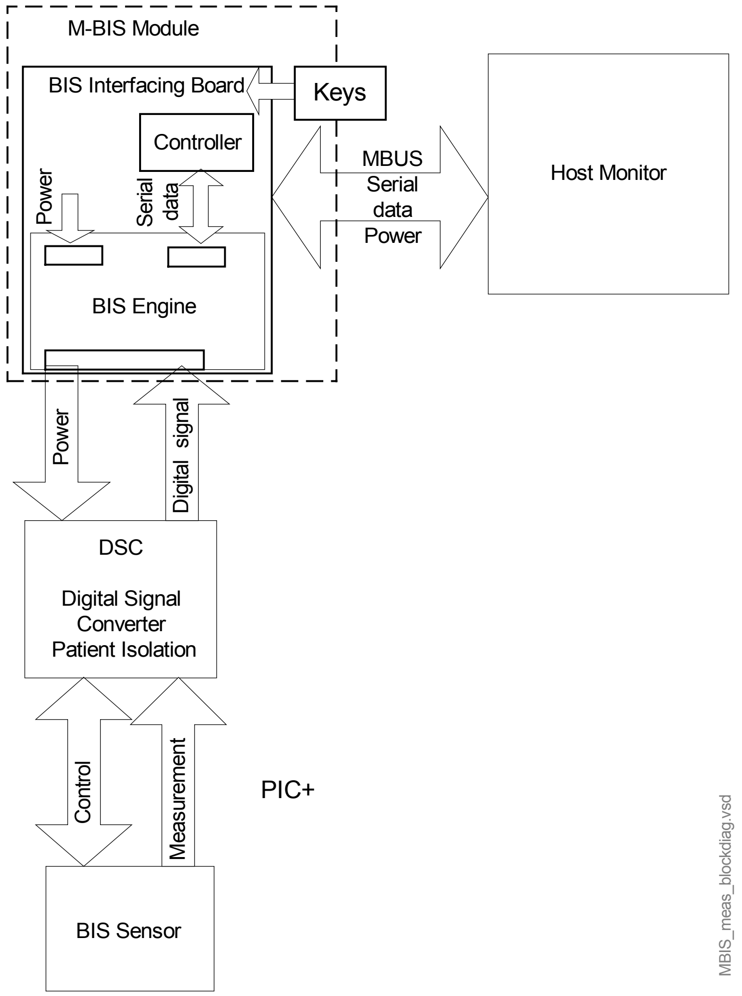



**Figure 3 BIS measurement system block diagram**

### 2.3.1 Digital Signal Converter, DSC

The digital signal converter, DSC, receives, amplifies and digitizes patient EEG signals. It is placed close to the patient's head where the EEG signal is less subject to interference from other medical equipment. The digital signal converter is connected to the module with a 3.6m long shielded cable and to the BIS sensor with 1.2m long patient interface cable, see Figure 1. For BIS Sensor related documentation refer to BIS documentation by Aspect, Inc.

CAUTION Do not autoclave the DSC. Do not open it for any reason.

**WARNING** **When using the electrosurgery unit, ensure proper contact of the ESU return electrode to the patient to avoid burns at monitor measurement sites. Also ensure that the ESU return electrode is near the operating area.**

**WARNING** **Radiated field strengths above 1V/m may cause erroneous measurements at various frequencies. Do not use electrical radiating equipment close to the DSC.**

## 2.3.2 BIS Module

### Aspect BIS Engine

The BIS Module provides Bispectral index values to the monitor. The BIS Engine processes the digital signal from DSC and outputs the BIS index and other supporting parameters through an asynchronous serial connection. The BIS Engine outputs the BIS Index, raw EEG, EMG, Signal Quality Index (SQI), Suppression Ratio (SR) and electrode impedance's. The BIS Engine software includes Aspects' proprietary algorithm for BIS calculation.

### BIS interfacing board

The BIS interfacing board supplies the data from BIS Engine to the monitor via the module bus. In addition, the module accepts commands from the monitor via the module bus. The module also provides supply voltages and all the required control signals to the BIS Engine and DSC.

The controller H8 has on-chip RAM and FLASH ROM, external SRAM and EEPROM.

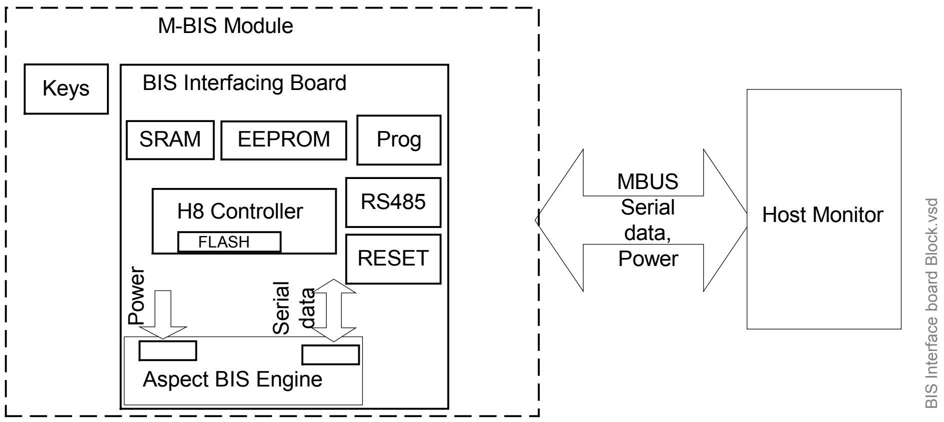



**Figure 4** **Block diagram of setup**

# 2.4 Connectors and signals

## 2.4.1 Module bus connector

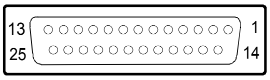



**Table 1 Module bus connector (X1) pin description**

| PIN | Name | Description |
|---|---|---|
| 1 | Reset_ RS485 | Module Bus Reset + |
| 8 | Nreset_ RS485 | Module Bus Reset - |
| 6 | Data_ RS485 | Module Bus Data + |
| 5 | Ndata_ RS485 | Module Bus Data - |
| 3 | +15VD | +15V Supply voltage |
| 7 | GND | Ground |
| 13 | GND | Ground |
| 15 | GND | Ground |
| 22 | RS232_TXD | BIS-Engine SW update, data out, no monitor use |
| 23 | RS232_RXD | BIS-Engine SW update, data in, no monitor use |
| 24 | +5,1V | +5V Supply voltage |
| 25 | +5,1V | +5V Supply voltage |
| Other | NC | Not Connected |

## 2.4.2 H8 programming connectors pin order

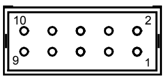
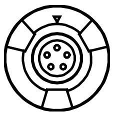



**Table 2 Connector pinning for H8 programming connector**

| PIN | Name | Description |
|---|---|---|
| 1 | GND | Ground |
| 2 | PRG_FB | Program feedback |
| 3 | TxD | Data output to programmer |
| 4 | RxD | Data input from programmer |
| 5 | /RESET | RESET input from programmer |
| 6 | VDD | Power input from programmer |
| 7 | PRG_VCC | Programming voltage from programmer |
| 8 | MODE.2/BOOT | Control input from programmer |
| 9 | PCFB | Programmer Connector feedback / GND |
| 10 | CODE_RES | Coding resistor output to programmer |

### 2.4.3 BIS Engine connectors pin order

**Table 3 Connector pinning for DSC and BIS Engine connectors**



| PIN Redel | Name | PIN Samtec | Description |
|---|---|---|---|
| 1 | DSC_OUTA | 2 | Power out A |
| 2 | DSC_OUTB | 4 | Power out B |
| 3 | DSC_IN | 6 | Data input |
| 4 | DGND | 7,8,9,10 | Ground |
| 5 | Chassis Ground | 1,3,5, | Ground |

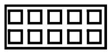


**Table 4 Connector pinning BIS Engine power connector**

| PIN | Name | Description |
|---|---|---|
| 1, 2 | +12V | +12V Power output for BE |
| 5,6,7,8 | +5V | +5V Power output for BE |
| 3,4,9,10 | GND | Ground |

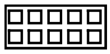
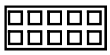


**Table 5 Connector pinning for BIS Engine serial data connector**

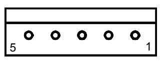
| PIN | Name | Description |
|---|---|---|
| 1 | RS232_RXD | Data input to BE |
| 2 | TTL_RXD | Data input to BE |
| 3 | RS232_TXD | Data output from BE |
| 4 | TTL_TXD | Data output from BE |
| 5 | NC | Not Connected |
| 6 | NC | Not Connected |
| 7 | RS232_RESET | Reset input to BE |
| 8 | /TTL_RESET | /RESET input to BE |
| 9 | GND | Ground |
| 10 | /USE_TTL | TTL/RS232 selection input to BE |



### 2.4.4 Keys

**Table 6 Key connector pin assignments**

| PIN | Name | Description |
|---|---|---|
| 1 | GND | Ground /NC |
| 2 | Key 1 | Key 1, right |
| 3 | Key 2 | Key 2 left |
| 4 | GND | Ground |
| 5 | GND | Ground / Shield |



# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the M-BIS is limited to replacing faulty circuit boards or mechanical parts. Faulty circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

The Datex-Ohmeda BIS Simulator (order No. 900509) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form, *Service check form*, which should be filled in when performing the procedures.

The mark in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| BIS Simulator or<br>BIS Sensor simulator | 900509<br>900508 | |
| Screwdriver | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring pin for locking.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - there are no loose objects inside the module

   ✍

2. Check external parts of the module:
   - the front cover and the front panel sticker are intact
   - connectors are intact and are attached properly
   - the module box, latch and spring pin for locking are intact

   Reattach the module box

   ✍

3. Check the external parts of the Digital Signal Converter
   - - the cover and the panel stickers are intact
   - - cables and their connections are intact

   Do not connect DSC to the module yet

   ✍

Turn the monitor on and wait until the normal monitoring screen appears.

- Configure the monitor screen so that information regarding the BIS measurement is shown:

**Monitor Setup** - ***Screen 1 Setup – Waveform Fields – Field1 – BIS EEG***

**Others** – ***BIS – Scale - 100uV***
**Others** – ***BIS – Smoothing Rate 15s***

4. Installation

   Plug in the module. Check that it goes in smoothly and engages properly

   ✍

5. Recognition of module

   Check that the module is recognized, i.e. the BIS header with related information appears in the chosen waveform field and 'Cable off' message is shown on field.

   ✍

6. Enter the service menu:

   **Monitor Setup - *Install/Service*** (password 16-4-34) **- *Service*** (password 26-23-8)

   Record the information regarding the module software of M-BIS by selecting SCROLL VERS and turning the ComWheel.

   Note! DSC related data will appear only when the DSC is connected for the first time after start-up.

   ✍

7. Recognition of DSC

   Connect the PIC+ cable to the DSC.

   Connect the DSC to the module.

   - Check that the DSC is recognized (DSC related data appears to the page)

   - Check that ‘No sensor’ appears to the selected waveform field.

   ✍

8. Enter the BIS module service menu:

   ***Parameters - More... - BIS***

   Check that the ‘Mod Mon Timeouts’, ‘ Mon Mod Bad checksums’ , ‘ Mod Mon Bad Checksums’, ‘ Bad Checksums from BIS’ values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. ‘RAM’, ‘ROM’ and ‘EEPROM’ all state OK.

   ✍

9. Check the **BIS** and **Sensor Check** membrane keys of the module. Stay in the module view and press each key for at least one second and check that the key being pressed is identified, i.e. the corresponding PRESSED text appears in the service menu.

   ✍

10. Check that ‘ Messages from BE ’ are increasing steadily.

    ✍

11. Go to the Sensor page.

    Check that

    - no sensor is identified

    - mains frequency is set correctly

    - check that ‘ BE powerup test’, ‘DSC selftest Ch1’ and ‘DSC selftest Ch2’ all show PASs

    (if not, go to BIS Setup page, perform DSC Test and check the results again)

    ✍

12. Sensor check

    Connect the BIS simulator to the PIC+ cable. See that ‘Checking sensor’ text and image appear. Wait for a while seconds and check that all sensors show PASS. Check that the ‘Sensor type’ shows Demo Sensor.

    ✍

13. Check that the ‘BIS’, ‘SQI’ and ‘SR’ values are between 0..1000, and the ‘EMG’ value between 0..10000. Note! If Sensor simulator 900508 is used, the values can be out of the given range.

    ✍

14. Go to the Module page

    Check that no BIS Engine errors appear.

    ✍

15. Perform sensor check by pressing ‘Check Sensor’ and verify sensor passes.

    ✍

16. Perform an electrical safety check and a leakage current test.

    ✍

17. Check that the module functions normally after performing the electrical safety check.

    ✍

18. Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

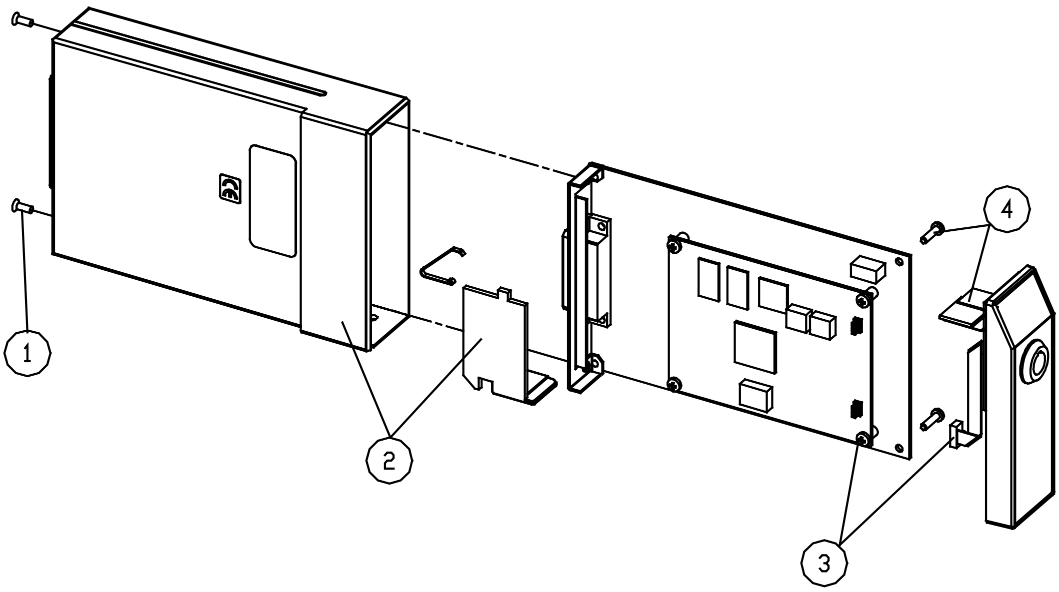



**Figure 5 BIS module disassembly and reassembly**

Disassemble the M-BIS in the following way.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with the loose latch and spring locking pin.
3. Detach the BIS Engine board by removing the four screws located at the corners of the board and disconnecting the front panel connector cable.
4. Detach the interface board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| Trouble | Cause | Treatment |
|---|---|---|
| No BIS waveforms on screen. | BIS waveforms not selected on screen. | Press Monitor Setup key and select BIS waveforms on the screen. |
| Sensor impedance check is not available on menus. | Sensor is not connected to the DSC or DSC is not connected to the module | Connect the sensor and the DSC |
| Sensor impedance check fails | Sensor poorly attached | Attach the sensor by following the sensor instructions |

## 4.2 Messages

The messages below will appear in the BIS digit field (DF), BIS waveform field (WF) or at the message field (MF) at the upper section of the Datex-Ohmeda S/5 patient monitor display.

| Message | Location | Cause | Treatment |
|---|---|---|---|
| Cable off<br>BIS cable off | DF<br>MF | DSC cable is not connected to the module. | Connect the DSC to the module |
| No Sensor<br>No BIS Sensor | DF<br>MF | Sensor is not connected to PIC+ cable or<br>PIC+ cable is not connected to the DSC | Connect the Sensor to the PIC+ cable<br>Connect the PIC+ cable to the DSC<br>Replace sensor and then PIC+ cable. |
| Incompatible sensor | DF | Sensor is not recognized.<br>Sensor is not a BIS sensor. | Connect correct type of sensor<br>Make sure PIC connector is clean and dry |
| Incompatible DSC | DF | Current module hw/sw is incompatible with this DSC<br>E.g. DSC-2 | Connect correct type of DSC |
| Sensor check failed<br>BIS sensor check failed | DF<br>MF | Sensor check failed, one or more of the electrode impedances exceeds the threshold. | Reattach the sensor to the patient by following the sensor instructions<br>Replace the sensor<br>Check PIC+ cable and then DSC |
| Poor signal | DF | Artifacts, or the amount of EMG activity prevents calculating BIS, data excluded.<br>SQI < 50 | Check the sensor then the PIC cable. Reattach the sensor to the patient by following the sensor instructions |
| Checking sensor | DF | Sensor check in progress. Can be either the initial sensor check, manual check or the periodic check. | Wait until the check has been performed |
| Checking Sensor – message stays more than 2 min. | DF | Sensor check fails, the sensor is not attached to the patient while connected to the PIC+ cable | Attach the sensor to the patient and press the Check Sensor button on the module front panel |
| Automatic check off | DF | Continuous sensor checking has been turned off | Turn the check on from the BIS menu |
| Replace Sensor | DF | The sensor has passed its use by date<br>The sensor has been used for 24h | Replace with a new sensor |
| High BIS impedance | DF | Sensor is not attached properly to the patient | Check the cable connections<br>Reattach the sensor to the patient by following the sensor instructions |
| Artifact | DF | Non-EEG data such as EMG, eyeblinks or shivering present. | Wait for good data |
| Module error | DF | BIS Engine failure<br>for more information see service page description | Replace the BIS Engine |
| DSC Error | DF<br>MF | The DSC is not communicating or operating properly. This may occur during the use of electrocautery device.<br>For more information see service page description | Replace the DSC<br>If the message persists, the BIS Engine may require service. |
| Demo data | MF | BIS simulator is connected | Disconnect the BIS simulator |

# 4.3 Troubleshooting flowchart

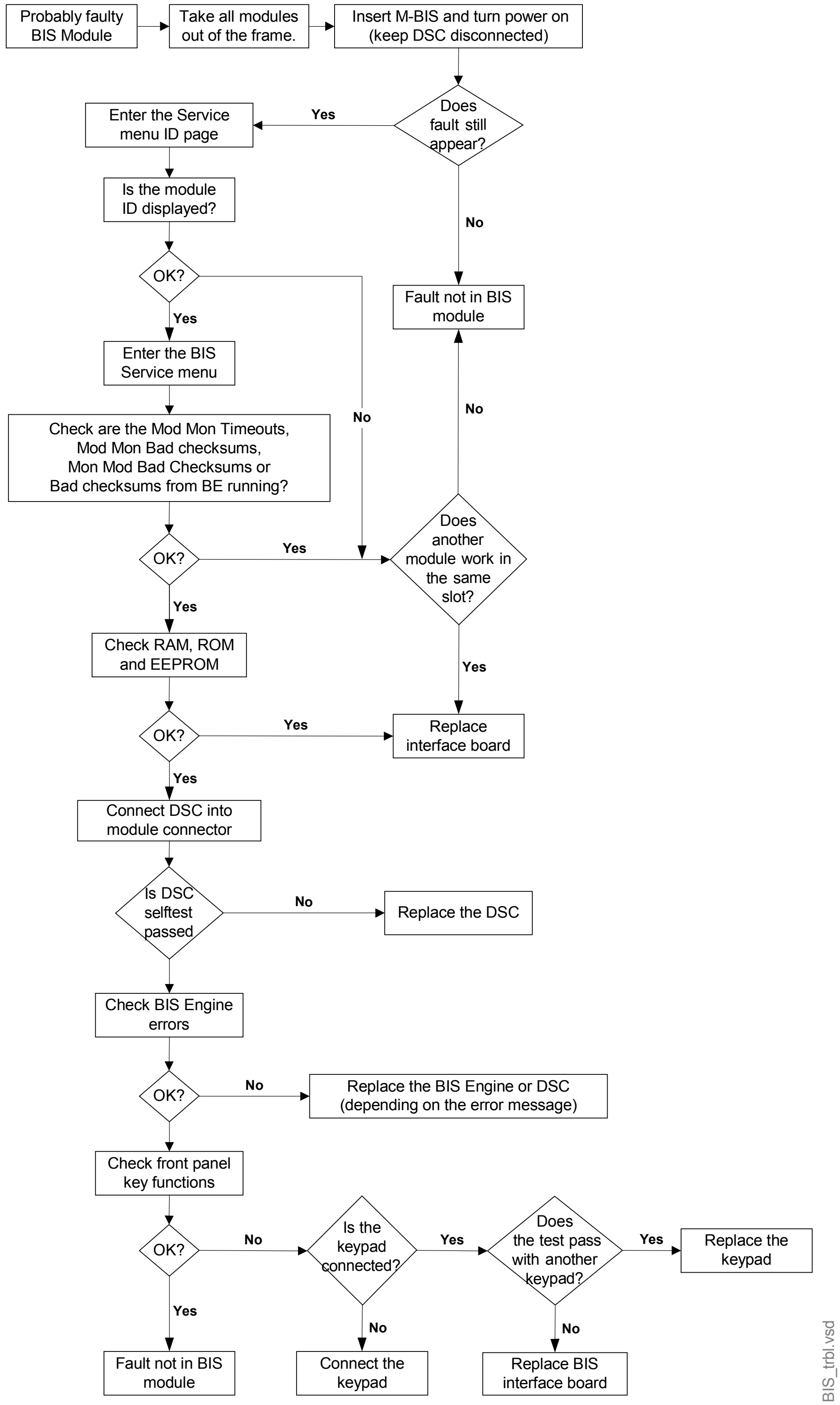
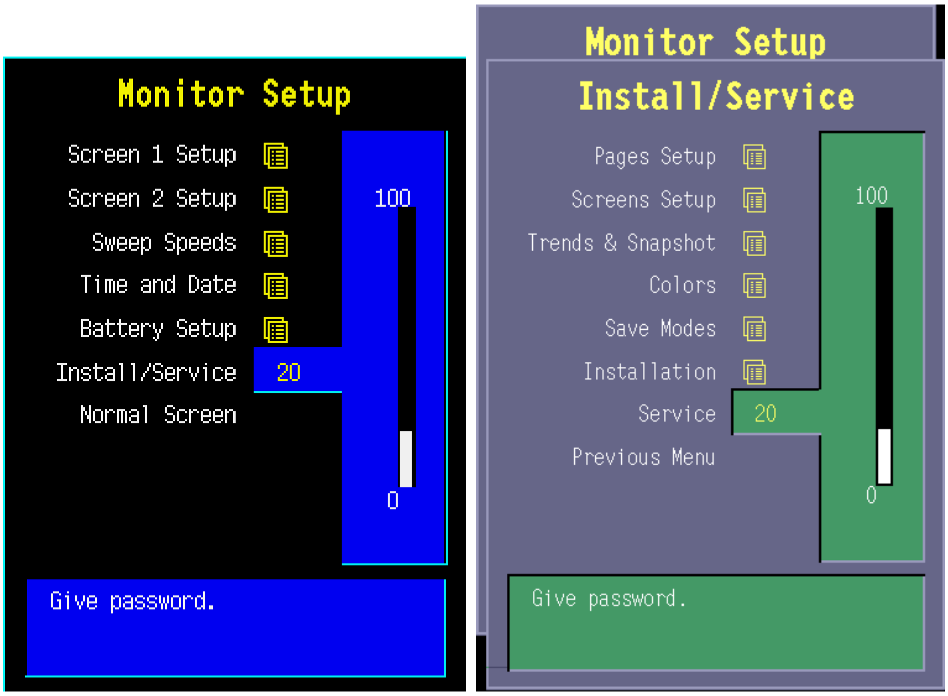
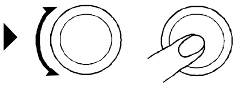



**Figure 6** **BIS module troubleshooting flowchart**

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.

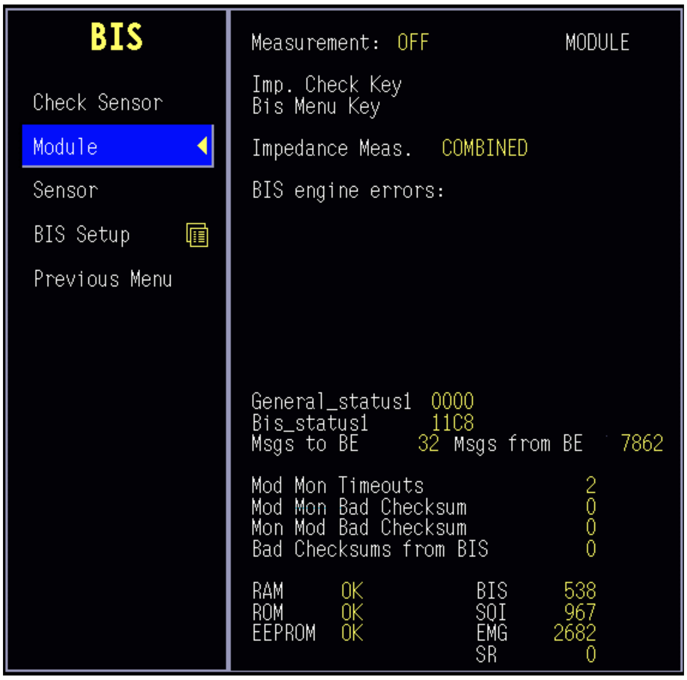


Press the **Monitor Setup** key - select ***Install/Service*** (password: 16-4-34) - select ***Service*** (password: 26-23-8) - select ***Parameters - More... - BIS***.

# 5.1 BIS service menu

## 5.1.1 Module service page




**Check Sensor** activates the sensor impedance check.

**Module**

**Measurement** indicates if BIS Engine is on: ON/OFF
**Imp.Check Key** indicates that the key in the module front panel works properly.
**Bis Menu Key** indicates that the key in the module front panel works properly.
**Impedance Meas** indicates the impedance measurement mode. The modes are CYCLIC/COMBINED/GROUND/OFF
**BIS Engine errors:** error messages created by DSC or BIS Engine. See "*Table 9*" below for detailed description of the error message
**Statuses (HEX):** See appendix B; How to read HEX numbers.
**General Status1** indicates the general status of the module. See "*Table 7*" to see the detailed description of the message
**Bis_status1** indicates the BIS Engine status. See "*Table 8*" to see the detailed description of the message
**Msgs to BE** number of data packages sent from interface board to BIS Engine
**Msgs from BE** number of data packages sent from BIS Engine to interface board
**Mod Mon Timeouts** is a cumulative number that indicates how many times the module (interface board) has not responded to monitor's inquiry.
**Mod Mon Bad Checksum** is a cumulative number that indicates how many times there has been an error in the message from module (interface board) to monitor.
**Mon Mod Bad Checksum** is a cumulative number that indicates how many times there has been an error in the message from monitor to module (interface board).
**Bad Checksums from BIS** is a cumulative number that indicates how many times there has been an error in the message from the BIS Engine to module interface board.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum at the EPROM is accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in permanent memory are valid.
The states in memory checks are **OK, Fail** or **?** (module not in place or a communication error).
**Measured parameters indicated:**
**BIS** indicates BIS index ; range 0..1000 (corresponds 0..100)
**SQI** indicates signal quality index; range 0..1000 (corresponds 0..100)
**EMG** indicates EMG activity level; range 0..10000 (corresponds 0..100dB NOTE! On the display EMG will be shown between 30..55dB on the bar graph or 30..80dB on the trend)
**SR** indicates supression ratio; range 0...100 (corresponds 0..100%)

**General_Status1** **Module general status.**

**Table 7** **Module general status**

| | |
|---|---|
| bit 0-5 | Not used |
| bit 6 | State error |
| bit 7 | Communication failure |
| bit 8 | Power failure |
| bit 9 | Clock failure |
| bit 10 | EEPROM checksum failure |
| bit 11 | EEPROM writing failure |
| bit 12 | ROM failure |
| bit 13 | RAM failure |
| bit 14 | Test mode |
| bit 15 | Init mode |

**BIS_Status1** **BIS Engine status**

**Table 8** **BIS Engine status**

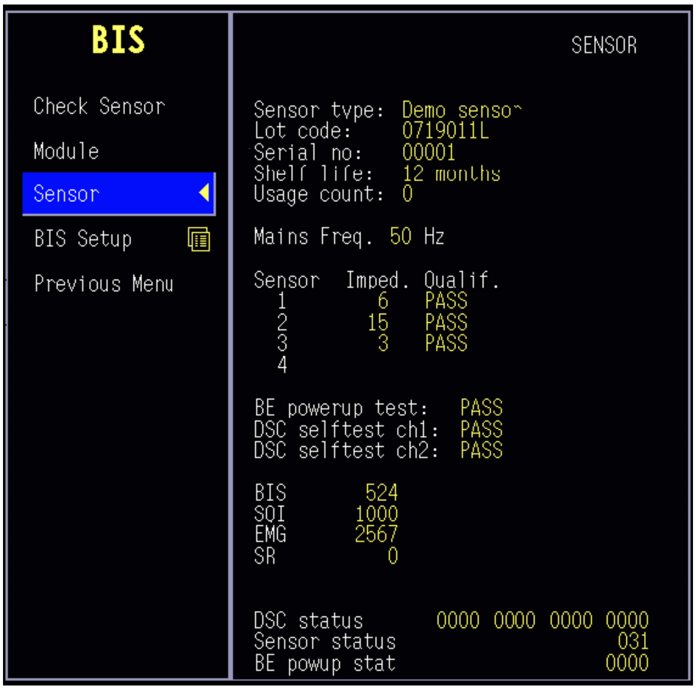
| | |
|---|---|
| bit 0 | Check Sensor key pressed |
| bit 1 | BIS key pressed |
| bit 2 | Inpedance check mode cyclic |
| bit 3 | Impedance check mode combined |
| bit 4 | Impedance check mode ground |
| bit 5 | Impedance check off |
| bit 6 | Measurement on |
| bit 7 | EEG measurement on |
| bit 8 | Impedance check on DSC channel 1 passed |
| bit 9 | Impedance check on DSC channel 2 passed |
| bit 10 | BIS Engine powerup failure |
| bit 11 | DSC selftest failure |
| bit 12 | DSC quick test failure |
| bit 13 | DSC selftest on |
| bit 14 | No data from BIS Engine |
| bit 15 | Not used |

**Table 9 BIS Engine and DSC error messages**

| Message | Errors of type 1 |
|---|---|
| DSC buffer overrun | |
| Out of dynamic memory | |
| Execution time exceeded in main | |
| Error in algorithm processing | |
| Invalid state in UART receive state machine | UART related errors |
| UART initalization error | |
| Transmit queue full | |
| Illegal number of data bytes for packet to be transmitted to the Host | |
| Illegal number of channels for EEG data | Misc. errors |
| Illegal EEG data type | |
| Illegal EEG data rate | |
| Illegal EEG filter coefficients | |
| No updates from Host | Communication related errors |
| Bad CRC - TI_SELFTEST_CODE | EEPROM CRC checks |
| Bad CRC - TI_RUN_CODE | |
| Bad CRC - FPGA_CONFIG | |
| Bad CRC - REV_INFO | |
| Illegal serial number | Serial number check |
| DSC failed to power up | DSC related errors |
| Serious DSC overcurrent error | |
| DSC receiver data overrun | |
| DSC failed repeatedly in responding to commands | |
| DSC update failed | |
| Serious DSC power regulation fault | |
| General DSC failure | |
| Sensor Negative Ground Fault | Smart sensor errors |
| Serious Sensor Positive Ground Fault | |
| Serious Sensor Overcurrent Fault | |

| **Message** | **Errors of type 2** |
|---|---|
| Illegal message ID | Errors for layer 3 packets |
| Illegal command parameter | |
| Illegal length for layer 2 data | |
| Disabled interrupt received - UART transmitter empty interrupt | UART related errors |
| Disabled interrupt received - UART modem interrupt | |
| No status nibble received | DSC related errors |
| DSC not connected | |
| DSC disconnected after test failure | |
| Illegal DSC ID | |
| DSC power regulation fault | |
| DSC interface fault | |
| DSC did not respond to command | |
| Illegal PIC ID | |
| DSC overcurrent | |
| DSC overrun | |
| EEPROM Bad packet length | Software update related errors |
| EEPROM Bad checksum | |
| EEPROM Bad code length | |
| EEPROM Illegal packet subtype | |
| EEPROM physical write error | |
| EEPROM NOT_DATA_TIMEOUT | |

### 5.1.2 Sensor




**Sensor type:** indicates the type of the sensor connected
**Lot code:** indicates the manufacturing lot code of the sensor. The lot code contains the manufacturing date and shift
**Serial no:** indicates the serial number of the sensor.
**Shelf life:** indicates max storage duration
**Usage count:** indicates how many times the sensor has been attached/detached. Not Active!!
**Mains Freq.:** indicates the set mains frequency; 50Hz/60 Hz
**Sensor Impedances:** indicates the last measured impedances
**Imped.** indicates the measured impedance value in Kohms.
**Qualif.** indicates the quality of the measured impedance; PASS/FAIL
**BE powerup test:** indicates the status of BIS Engine power up test: PASS/FAIL
**DSC selftest ch1:** indicates the DSC selftest status for channel 1: PASS/FAIL
**DSC selftest ch2:** indicates the DSC selftest status for channel 2: PASS/FAIL

**Measured parameters indicated:**
**BIS** indicates BIS index ; range 0..1000 (corresponds 0..100)
**SQI** indicates signal quality index; range 0..1000 (corresponds 0..100)
**EMG** indicates EMG activity level; range 0..10000 (corresponds 0..100dB
(NOTE! On the trend display EMG will be shown between 30..80dB)
**SR** indicates supression ratio; range 0...100 (corresponds 0..100%)

**Statuses (HEX):** See "*APPENDIX B*" How to read HEX numbers.
**DSC status:** indicates the DSC status for the four channels. See "*Table 10*" to see the detailed description of the message.
**Sensor status:** indicates the Sensor status. See "*Table 11*" to see the detailed description of the message.
**BE powup stat:** indicates the BE power up status. See "*Table 12*" to see the detailed description of the message.

**Table 10 DSC status**

| | |
|---|---|
| bit 0 | Noise test |
| bit 1 | BIS key pressed |
| bit 2 | Blocked droop test |
| bit 3 | Unblocked gain test |
| bit 4 | Impedance wait time out test |
| bit 5 | Noise timeout test |
| bit 6 | Blocked timeout test |
| bit 7 | Unblocked timeout test |
| bit 8 | DSC not connected test |
| bit 9 | Not used test |
| bit 10 | Not used test |
| bits 11 - 15 | Not used |

**Table 11 Sensor status**

| | |
|---|---|
| bit 0 | Quick selftest pass |
| bit 1 | Quick selftest gain |
| bit 2 | Quick selftest noise |
| bit 3 | Quick selftest fail |
| bit 4 | Quick selftest valid |
| bit 5 | Sensor valid |
| bit 6 | Sensor invalid |
| bit 7 | Sensor too many uses |
| bit 8 | Sensor expired |
| bit 9 | Sensor validity unknown |
| bits 10 -15 | Not used |

**Table 12 BE powup stat**

| | |
|---|---|
| bit 0 | XRAM test |
| bit 1 | Dma test |
| bit 2 | Timer test |
| bit 3 | Fpga test |
| bits 4 -15 | Not used |

### 5.1.3 Setup


**Automatic Check:** A selection to define whether automatic sensor check is used ON/OFF

**Test DSC** indicates the status of the DSC self test; PASS/FAIL

**Filters:** A selection to define if filters are used
ON; disturbances are filtered from the raw EEG signal
OFF; raw EEG signal is shown

# 6 SPARE PARTS

## 6.1 Spare part list

### 6.1.1 M-BIS

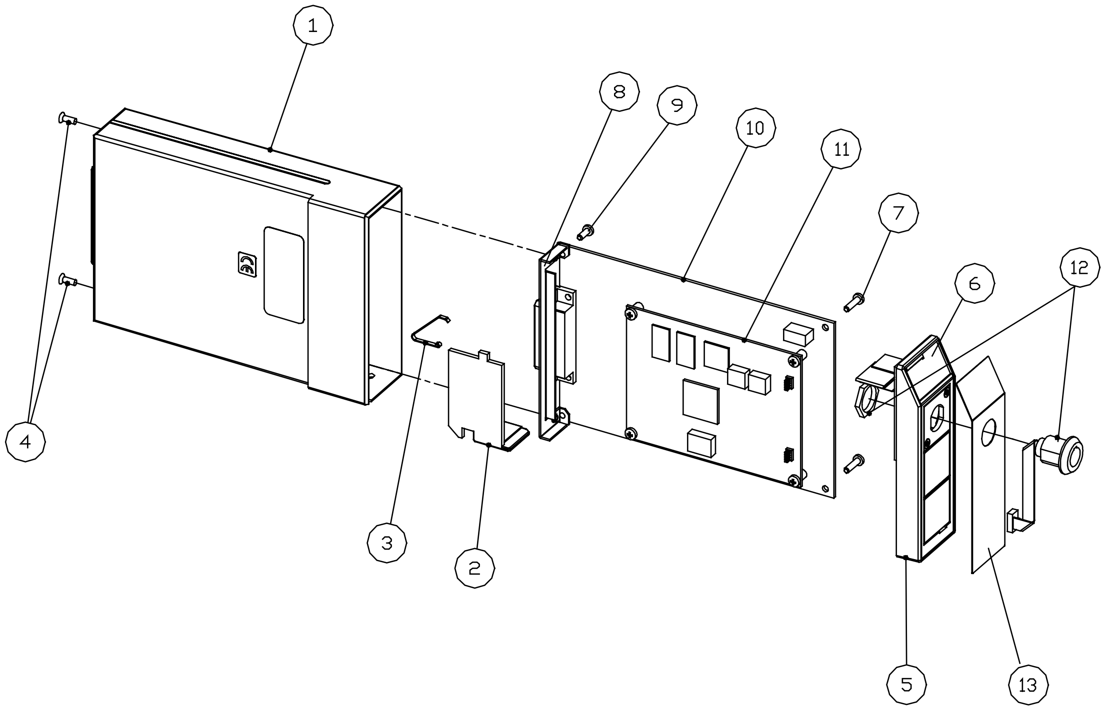



**Figure 7 Exploded view of module box and BIS module**

| Item | Description | Order code |
|---|---|---|
| 1 | Module box (single width) | 886167 |
| 2 | Latch | 879181 |
| 3 | Spring pin | 879182 |
| 4 | Cross recess screw, M3×8 black | 616215 |
| 5 | Front panel unit | 8002476 |
| 6 | Membrane keypad | 880101 |
| 7 | Cross cylinder head screw, M3×12 | 628700 |
| 8 | Metal frame | 879184 |
| 9 | Cross cylinder head screw, M3×6 | 61721 |
| 10 | BIS interface board | 8002285 |
| 11 | Aspect BIS engine board | 900505 |
| 12 | BIS connector unit, M-BIS | 8002480 |

| Item | Description | Order code |
|---|---|---|
| 13 | Front panel sticker, M-BIS, DA | 8002855 |
| 13 | Front panel sticker, M-BIS, DE | 8002848 |
| 13 | Front panel sticker, M-BIS, EN | 8002555 |
| 13 | Front panel sticker, M-BIS, ES | 8002853 |
| 13 | Front panel sticker, M-BIS, FI | 8002847 |
| 13 | Front panel sticker, M-BIS, FR | 8002852 |
| 13 | Front panel sticker, M-BIS, IT | 8002850 |
| 13 | Front panel sticker, M-BIS, JA | 8003001 |
| 13 | Front panel sticker, M-BIS, NO | 8002849 |
| 13 | Front panel sticker, M-BIS, NL | 8002856 |
| 13 | Front panel sticker, M-BIS, PT | 8002854 |
| 13 | Front panel sticker, M-BIS, SV | 8002851 |

# 7 EARLIER REVISIONS

| Revision | Manual slot/main manual | Note |
|---|---|---|

No previous revisions

# APPENDICES A, B

This page intentionally left blank.

# SERVICE CHECK FORM

## BIS Module, M-BIS

| | | | |
|---|---|---|---|
| Customer | | | |
| Service | | Module type | S/N |
| Service engineer | | | Date |

☐ OK = Test OK

☐ N.A. = Test not applicable

☐ Fail = Test Failed

**Service check**

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Check internal parts: | ☐ | ☐ | ☐ | 2. Check external parts of the module: | ☐ | ☐ | ☐ |
| 3. Check the external parts of DSC | ☐ | ☐ | ☐ | 4. Installation | ☐ | ☐ | ☐ |
| 5. Recognition of module | ☐ | ☐ | ☐ | | | | |
| 6. module software | M-BIS | | | | | | |
| 7. Recognition of DSC | ☐ | ☐ | ☐ | 8. Communication and memories of module | ☐ | ☐ | ☐ |
| 9. membrane keys | ☐ | ☐ | ☐ | 10. Messages from BE | ☐ | ☐ | ☐ |
| 11. Sensor IDSensor | ☐ | ☐ | ☐ | 12. Sensor check | ☐ | ☐ | ☐ |

13. Checks with simulator

| | | Allowed range |
|---|---|---|
| BIS | | 0...1000 |
| SQI | | 0...1000 |
| SR | | 0...100 |
| EMG | | 0...10000 |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 14. BIS Engine errors | ☐ | ☐ | ☐ | 15. check | ☐ | ☐ | ☐ |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 16. Electrical safety check | ☐ | ☐ | ☐ | 17. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 18. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes**

**Used Spare Parts**

**Signature**

# APPENDIX B, HOW TO READ HEX NUMBERS

Some status information on the BIS Module service pages are given as HEX (hexadecimal) numbers. To understand them, please read the following:

A HEX number has a base of 16 instead of 10. This means that every character in a number can have a value between 0 and 15. Numbers from 0 to 9 are displayed as if they were normal 10-based numbers. Numbers from 10 to 15 are displayed with letters from a to f or A to F respectively.

Every character of a HEX number expands into a binary code of four 0:s (zeroes) and 1:s (ones) as given in table 13. Four successive characters thus expand into four times four binary numbers. Here's an example:

We have a HEX number F3A1. We expand the number into binary code so that we first take the four binary digits that correspond to F, which are 1111. Then we write the four binaries that correspond to 3 (0011) after the first four. We now have 11110011. And so on.

Eventually, we have a string of 16 binary numbers, so called bits. HEX number F3A1 corresponds to a binary code of 1111 0011 1010 0001. Spaces are added here for legibility and to visualize the fact that every group of four bits corresponds to one HEX character.

The bits in a binary number are numbered from right to left always starting from 0 as follows:

| bit 15 | bit 14 | bit 13 | bit 12 | bit 11 | bit 10 | bit 9 | bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |

With this information and a table of status fields from section 5 "*Service Menu*" we can translate a HEX status code into actual status messages. If a bit is 1 this means that the corresponding status/error condition is valid, whereas a 0 means that it is not.

**Table 13 HEX to binary conversion**

| HEX | binary | HEX | binary |
|---|---|---|---|
| 0 | 0000 | 8 | 1000 |
| 1 | 0001 | 9 | 1001 |
| 2 | 0010 | A | 1010 |
| 3 | 0011 | B | 1011 |
| 4 | 0100 | C | 1100 |
| 5 | 0101 | D | 1101 |
| 6 | 0110 | E | 1110 |
| 7 | 0111 | F | 1111 |

# Datex-Ohmeda

# S/5$^{TM}$ Remote Controller, K-REMCO (Rev. 01)

# S/5$^{TM}$ Remote Controller, K-CREMCO

# Technical Reference Manual Slot

All specifications are subject to change without notice.

Document No. 8003934-1

January 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Remote Controller

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Remote Controllers, K-REMCO and K-CREMCO. Remote Controllers are designed for use with the S/5 monitors. Later in this manual the remote controllers may be refered to without the S/5 system nomenclature for simplicity.

Please also refer to the *Technical Reference Manual* of the S/5 monitor for information regarding system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The Remote Controller, K-REMCO/K-CREMCO, brings the Command Bar functions near to the user and allows access to the same menus as the Command Bar.

- Remote Controller, K-REMCO for Anesthesia Monitor and Critical Care Monitor
- Remote Controller, K-CREMCO for Compact Monitors.

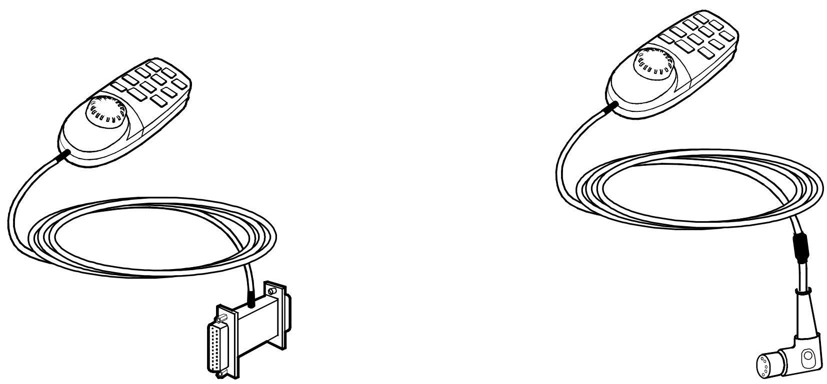


**Figure 1 K-REMCO, K-CREMCO**

NOTE: K-REMCO and K-CREMCO requires monitor software version 97 or greater.

# 1 SPECIFICATIONS

## 1.1 Remote Controller, K-REMCO, K-CREMCO

| | |
|---|---|
| Dimensions (without cable) | 150 × 60 × 50 mm |
| Weight (incl. cable) | 0.5 kg |
| Cable length | 6 m |
| Input voltage | 5 V |
| Power consumption | 180 mW |
| Communication protocol | RS-232 |

NOTE: Power supply from the display controller board only.

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Remote Controller, K-REMCO/ K-CREMCO

The Remote Controller consists of 12 direct function keys and the ComWheel.

**K-REMCO/ K-CREMCO PCBs**

The K-REMCO/ K-CREMCO has two PCBs located inside the Remote Controller. One board has only the pushbutton switches of the keys. The other board reads the status of the keys and the ComWheel and forwards the information to the CPU board.

**External communication**

**K-REMCO Rev.00-01:**
Two signals, TXD and RXD in RS232 format are in use. No handshaking is used. Serial communication speed is 19.2 kbps.The 26-pin subminiature D-connector of the Remote Controller is connected to the Display Controller Board, B-DISP.

**K-REMCO Rev.00 with optional Remote Controller - Compact Monitor cable or K-CREMCO Rev.00:**

Two signals, TXD and RXD in RS232 format are in use. No handshaking is used. Serial communication speed is 19.2 kbps. The DIN 5 connector is connected to keyboard connector X9.

**ComWheel**

The ComWheel is used for menu selection.

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service is limited to replacing faulty PC boards or mechanical parts. The PC boards are then returned to Datex-Ohmeda for repair.

Datex-Ohmeda Technical Services is always available for service advice. Please provide the unit serial number, full type designation and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a *check form* (*Appendix A*) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| • Central Unit | • | • |
| • Screwdriver | • | • |

### 3.2.2 Remote Controller, K-REMCO / K-CREMCO

- Turn the monitor to STBY.
- Disconnect the remote controller cable from the display controller board.
- Detach the remote controller upper cover and the keypad cover by removing the screws (7 pcs) from the bottom.

1. Check internal parts:
   – cables are connected properly
   – the remote controller cable is fastened to the bottom cover with screws
   – the keypad switches are intact
   – the software EPROM under the keypad is attached properly

✍

2. Check external parts:
   – the upper and bottom covers are intact
   – the keypad cover is intact
   – the ComWheel cover is intact and is attached properly

✍

- Reassemble the remote controller.

3. Check the remote controller cable:
   – the cable is intact
   – the cable connector is intact
   – the connector pins are clean, straight and at about the same height
   – the locking screws inside the connector case are intact

   ✍

- Reconnect the cable to the display controller board and on the monitor.

4. Wait until normal monitoring screen appears, then check that the picture on the screen is displayed with correct resolution.

   If the resolution is not correct, replace the remote controller cable.

   ✍

5. Enter the service menu:
   **Menu** (on the remote controller keypad) **- Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8)

   Take down the information regarding remote controller software.

   ✍

- Select the menu KEYBOARD:

  ***Service - Keyboard***

6. Check the remote controller keys.
   Press the keys one by one. Check that each key generates a sound from the loudspeaker.

   ✍

7. Check the ComWheel.

   Turn the ComWheel clockwise and counterclockwise and check that each step generates a sound and the corresponding values at the bottom of the menu increase.

   Select DUMMY PRESS. Press the ComWheel and check that the press generates a sound and the corresponding value in the menu increases.

   ✍

8. Perform electrical safety check and leakage current test.

   ✍

9. Check that the remote controller functions normally after the performed electrical safety check.

   ✍

10. Clean the remote controller and the cable.

    ✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

### 3.3.1 Remote Controller K-REMCO / K-CREMCO

The Remote Controller is disassembled according to the following procedure.

1. Disconnect the K-REMCO/ K-CREMCO cable from the monitor.
2. Pull out the knob of the ComWheel.
3. Open the nut on the shaft of the ComWheel.
4. Open the three cross head screws on the bottom of the K-REMCO/ K-CREMCO.
5. Remove the top cover.
6. Open the four screws on the bottom of the K-REMCO/ K-CREMCO.
7. Remove the keyboard cover.
8. Disconnect the K-REMCO/ K-CREMCO cable and the wire set from the Comwheel.
9. Remove the PCBs.

The Remote Controller is reassembled by reversing the disassembly procedure. In reassembly remember to put the reinforcing cord of the cable around the screw on the metal bridge before tightening the screw.

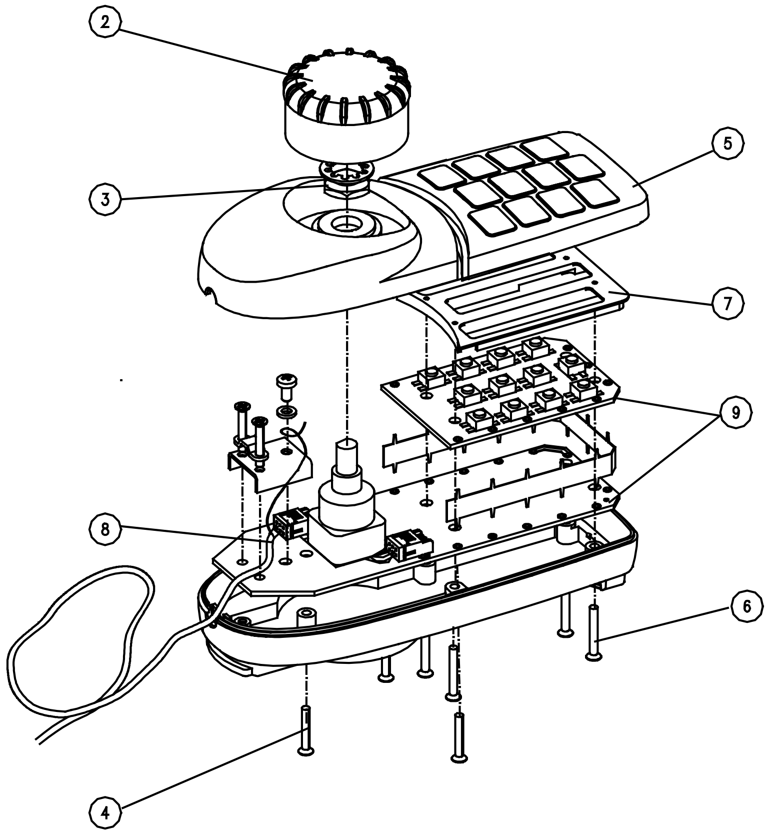



**Figure 2 K-REMCO, K-CREMCO disassembly and reassembly**

# 4 TROUBLESHOOTING

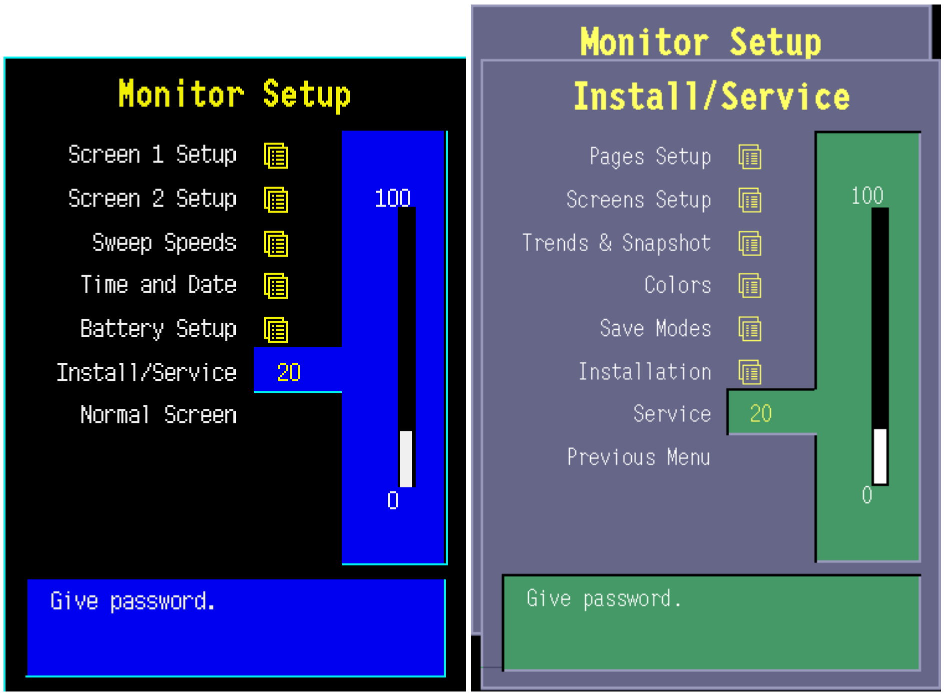
## 4.1 K-REMCO, K-CREMCO

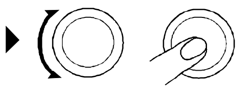
See Keyboard Service Menu in chapter 5, and perform tests available. If any of the tests fail, see explanation below.

| **Problem** | **Cause** | **Treatment** |
|---|---|---|
| ON/STBY switch not working | Keyboard cable loose or broken. D-26 connector pin failure. Switch leads broken. Switch connector loose. Switch faulty | Check the items. Replace them if necessary |
| ComWheel not working | ComWheel leads broken or connector loose. ComWheel faulty. | Check the items. Replace the ComWheel if necessary |
| Membrane key not working | Switch cable loose or broken. Keyboard cable loose or broken. D-26 connector pin failure. RS232 communication failure on CPU board | Check the items. Replace them if necessary. |

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8) **- *Keyboard***.

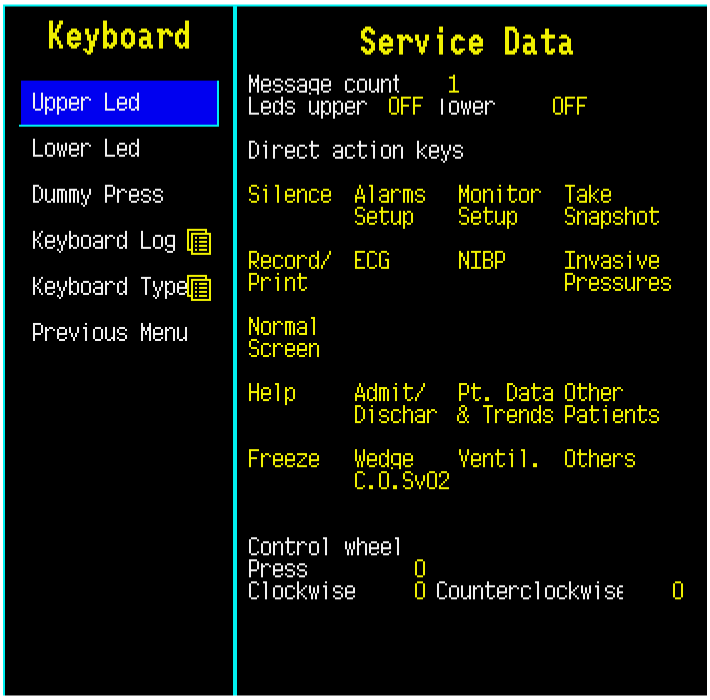
## 5.1 Keyboard menu

The service menu for testing the command board functions.

***Upper Led*** is for testing the upper alarm LED (red) on the command board. When the text is highlighted, the upper alarm LED can be turned on and off by pressing the ComWheel.

***Lower Led*** is for testing the lower alarm LED (yellow) on the command board. When the text is highlighted, the lower alarm LED can be turned on and off by pressing the ComWheel.

***Dummy Press*** is for testing the ComWheel. When the text is highlighted, pressing of the ComWheel create a sound from the loudspeaker and the corresponding number on the service data field increase.




**Service Data**

**Message count** counts the number of messages that are sent out to the main CPU board.

**Leds upper** and **lower** indicate the states of the alarm LEDs on the command board.

**Direct action keys** texts are indications to the command board membrane keys. When a key on the command board is pressed, the corresponding text in the menu changes its colour.

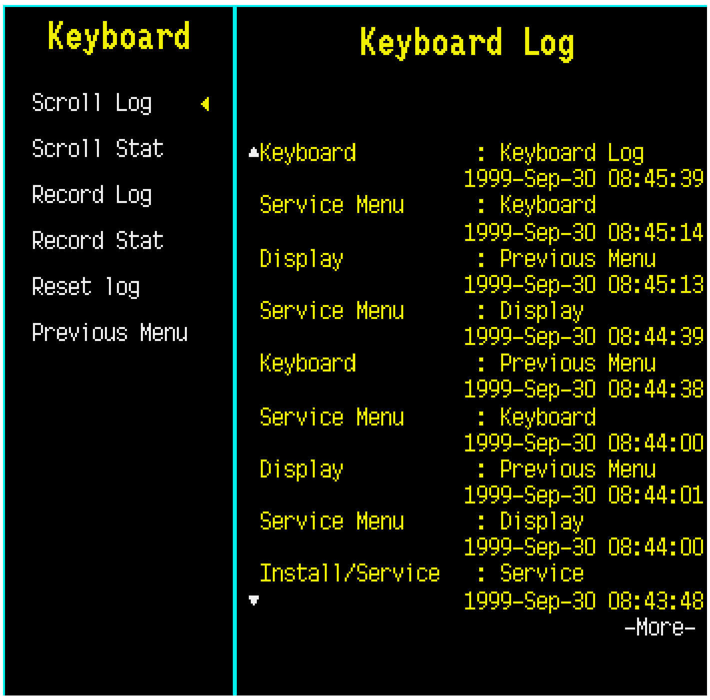
**Control wheel, Press** counts the ComWheel pressings.

**Control wheel, Clockwise** and **Counterclockwise** the ComWheel turnings.

**Since** shows the date and the time of the last run time reset.

### 5.1.1 Keyboard Log

All the keyboard presses and the commands given by the ComWheel are recorded in the Keyboard Log. The keyboard log is saved in the permanent memory of the monitor. The length of the log is 1150 events. The log is FIFO type.



## 5.1.2 Keyboard Type

***Store Mask*** A selection for setting the anaesthesia keyboard's language. The selected language determines the outcome of the lower keypad.

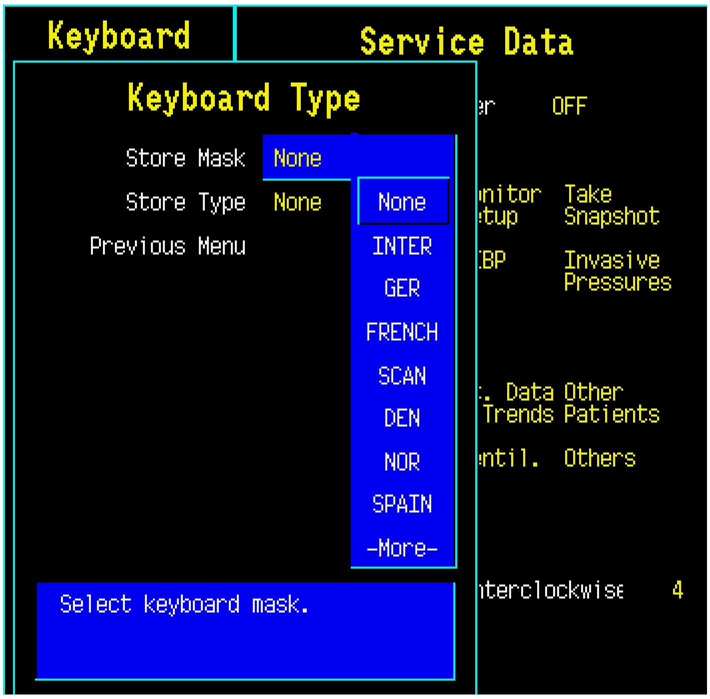
***Store Type*** is for setting the keyboard's type;

COM = Command Board

ARK = Anaesthesia Keyboard

AIC = Information Center Keyboard

NOTE: The settings should be checked if the controller board is replaced. If settings are changed, the new settings will not be valid until the next start-up.



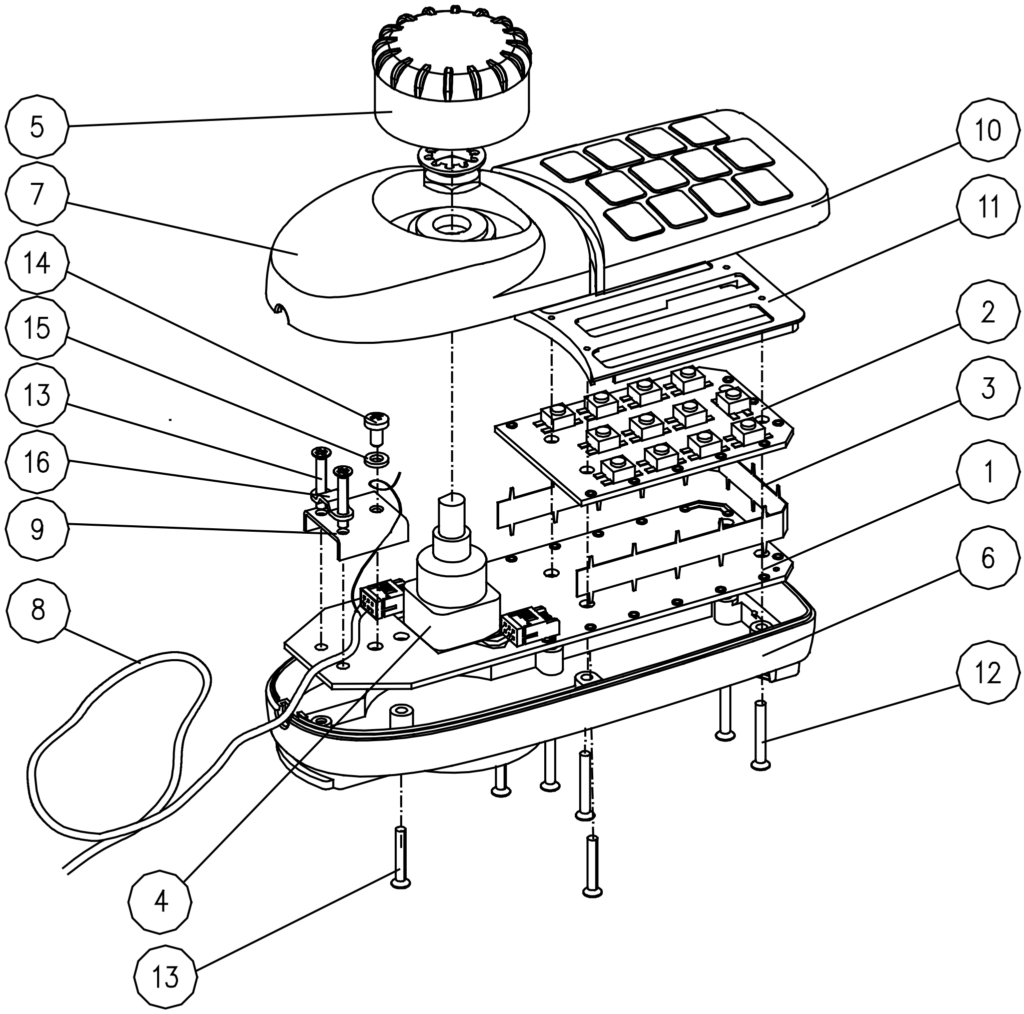
# 6 SPARE PARTS

NOTE: Only changed part numbers are listed under later revisions. To find the desired part: check first the list of the revision that corresponds your device. If the part is not listed there, check the previous revision, etc. until you find the right number.

* this part is recommended for stock

Item numbers refer to the exploded view.

## 6.1 Remote Controller, K-REMCO

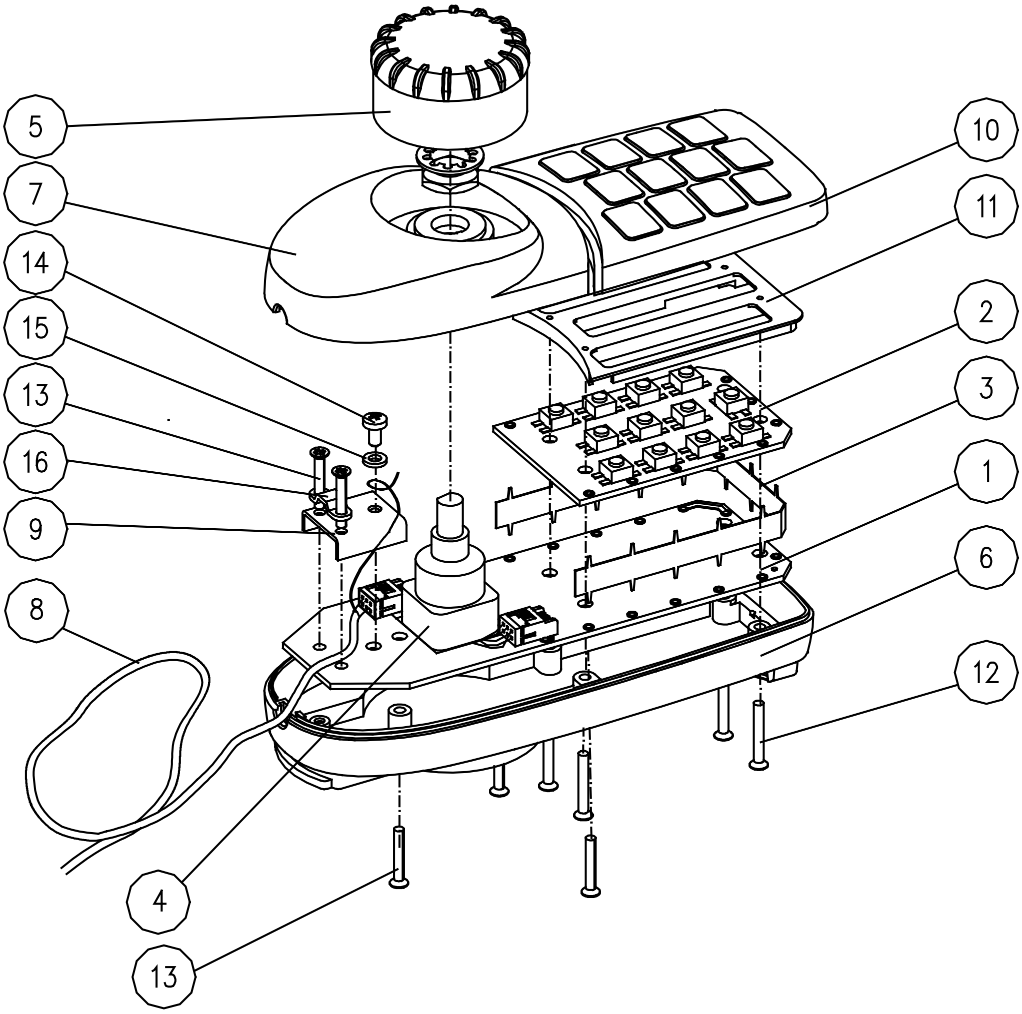



### 6.1.1 Remote Controller, K-REMCO Rev. 00, 01

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | CPU board, K-REMCO | 890368 | |
| 2 | Keyboard PCB, K-REMCO | 890371 | |
| 3 | Connecting plate | 891427 | |
| 4 | Rotary wheel | 891036 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 5 | ComWheel cover | 891423 | 898940 |
| 5 | ComWheel (green) ; K-REMCO ; S/5 | 898940 | |
| 6 | Cover (Munsell N9) ; K-REMCO ; S/5 | 898939 | |
| 6 | Plastic rear cover, K-REMCO | 891421 | 898939 |
| 7 | Bottom (Munsell N9) ; K-REMCO ; S/5 | 898938 | |
| 7 | Plastic front cover, K-REMCO | 891422 | 898938 |
| 8 | Remote controller cable, K-REMCO | 891813 | |
| 9 | Bridge for cable | 893235 | |
| 10 | Front Panel sticker, DA ; K-REMCO (rev.00), (rev.01 ; S/5) | 892203 | |
| 10 | Front Panel sticker, DE ; K-REMCO (rev.00), (rev.01 ; S/5) | 892312 | |
| 10 | Front Panel sticker, EN ; K-REMCO (rev.00), (rev.01 ; S/5) | 891425 | |
| 10 | Front Panel sticker, ES ; K-REMCO | 892315 | |
| 10 | Front Panel sticker, FI ; K-REMCO (rev.00), (rev.01 ; S/5) | 892317 | |
| 10 | Front Panel sticker, FR ; K-REMCO (rev.00), (rev.01 ; S/5) | 892313 | |
| 10 | Front Panel sticker, IT ; K-REMCO (rev.00), (rev.01 ; S/5) | 892316 | |
| 10 | Front Panel sticker, JA ; K-REMCO (rev.01) S/5 | 894962 | |
| 10 | Front Panel sticker, NL ; K-REMCO (rev.00), (rev.01 ; S/5) | 892314 | |
| 10 | Front Panel sticker, NO ; K-REMCO (rev.00), (rev.01 ; S/5) | 893553 | |
| 10 | Front Panel sticker, PT ; K-REMCO (rev.01) ; S/5 | 895233 | |
| 10 | Front Panel sticker; SV ; K-REMCO (rev.00), (rev.01 ; S/5) | 892318 | |
| 11 | Front panel framework | 891426 | |
| 12 | Slotted recess screw M2.5x22 | 61218 | |
| 13 | Cross recess PT-screw M2.5x16 | 628719 | |
| 13 | Cross recess PT-screw M2.5x16 | 628719 | |
| 14 | Cross cylinder-head screw M3x6 | 61721 | |
| 15 | Shakeproof washer m3.2 | 63611 | |
| 16 | Cable binder | 546454 | |

## 6.2 Remote Controller, K-CREMCO




### 6.2.1 Remote Controller, K-CREMCO

| No. | Description | Item | Replaced by |
|---|---|---|---|
| 1 | CPU board, K-REMCO | 890368 | |
| 2 | Keyboard PCB, K-REMCO | 890371 | |
| 3 | Connecting plate | 891427 | |
| 4 | Rotary wheel | 891036 | |
| 5 | ComWheel (green) ; K-REMCO ; S/5 | 898940 | |
| 6 | Cover (Munsell N9) ; K-REMCO ; S/5 | 898939 | |
| 7 | Bottom (Munsell N9) ; K-REMCO ; S/5 | 898938 | |
| 8 | K-Remco - CM cable | 891965 | |
| 9 | Bridge for cable | 893235 | |
| 10 | Front Panel sticker, DA ; K-REMCO (rev.00), (rev.01 ; S/5) | 892203 | |
| 10 | Front Panel sticker, DE ; K-REMCO (rev.00), (rev.01 ; S/5) | 892312 | |
| 10 | Front Panel sticker, EN ; K-REMCO (rev.00), (rev.01 ; S/5) | 891425 | |
| 10 | Front Panel sticker, ES ; K-REMCO | 892315 | |
| 10 | Front Panel sticker, FI ; K-REMCO (rev.00), (rev.01 ; S/5) | 892317 | |

| No. | Description | Item | Replaced by |
|---|---|---|---|
| 10 | Front Panel sticker, FR ; K-REMCO (rev.00), (rev.01 ; S/5) | 892313 | |
| 10 | Front Panel sticker, IT ; K-REMCO (rev.00), (rev.01 ; S/5) | 892316 | |
| 10 | Front Panel sticker, JA ; K-REMCO (rev.01) S/5 | 894962 | |
| 10 | Front Panel sticker, NL ; K-REMCO (rev.00), (rev.01 ; S/5) | 892314 | |
| 10 | Front Panel sticker, NO ; K-REMCO (rev.00), (rev.01 ; S/5) | 893553 | |
| 10 | Front Panel sticker, PT ; K-REMCO (rev.01) ; S/5 | 895233 | |
| 10 | Front Panel sticker; SV ; K-REMCO (rev.00), (rev.01 ; S/5) | 892318 | |
| 11 | Front panel framework | 891426 | |
| 12 | Slotted recess screw M2.5x22 | 61218 | |
| 13 | Cross recess PT-screw M2.5x16 | 628719 | |
| 13 | Cross recess PT-screw M2.5x16 | 628719 | |
| 14 | Cross cylinder-head screw M3x6 | 61721 | |
| 15 | Shakeproof washer m3.2 | 63611 | |
| 16 | Cable binder | 546454 | |

# 7 EARLIER REVISIONS

No earlier versions

# *APPENDIX A*

# Service check form
# Remote Controller, K-REMCO, K-CREMCO

Customer ______________________

Service ____________ Keyboard type ____________ S/N ____________

Service engineer ______________________ Date ____________

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. Cable | ☐ | ☐ | ☐ | 4. Monitor picture | ☐ | ☐ | ☐ |

Notes ______________________

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. Stand by -LED | ☐ | ☐ | ☐ | | | | |
| 6. Command board software | KB | | | | | | |
| 7. Alarm LEDs | ☐ | ☐ | ☐ | 8. Membrane keys | ☐ | ☐ | ☐ |
| 9. ComWheel | ☐ | ☐ | ☐ | | | | |

Notes ______________________

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10. Electrical safety check | ☐ | ☐ | ☐ | 11. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 12. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes** ______________________

**Used Spare Parts** ____________ ____________ ____________

**Signature** ______________________

# Datex-Ohmeda

# S/5™ Single-width Airway Module

# Technical Reference Manual Slot


All specifications are subject to change without notice.

Document No. 8003487-3

October 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551  Fax 1-608-222-9147

www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## S/5 Single-width Airway Modules

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Single-width Airway Module, M-miniC. The Single-width Airway Module is a single-width plug-in module designed for use with the S/5 monitors. Later in this manual the module can be called w/o the system name Datex-Ohmeda S/5.

Please also refer to the*Technical Reference Manual* of the S/5 monitor for information regarding system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

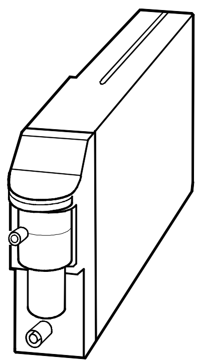
The Single-width Airway Module provides airway and respiratory measurements.

Letters in the module name stand for:
M = plug-in module, C = $CO_2$

NOTE: Do not use identical modules in the same monitor simultaneously. The M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, M-CAiOVX , M-CAiOVX/SERVICE and M-miniC are considered identical modules.

NOTE: The Single-width Airway Module or Compact Airway Module and Airway Module, G-XXXX, cannot be used simultaneously in the same monitor.

NOTE: M-miniC is intended for patients weighing over 5kg (11lb).



NOTE: The Single-width Airway Module, M-miniC is designed for use with L-ANE02(A), L-ICU02(A), L-CANE02(A), L-CICU02(A) or later versions respectively.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 37 × 208 × 111 mm, 1.5 × 8.2 × 4.4 in |
| Module weight | 400 g/1,1 lbs |
| Power consumption | 1.5 W Prms, 2.3 W momentary |

**Environmental specifications**

| | |
|---|---|
| Operating temperature | +10...+40 °C |
| Storage temperature | -25...+70 °C |
| Atmospheric pressure | 666...1060 hPa /<br>(67...106 kPa)<br>(500...800 mmHg)<br>(666...1060 mbar) |
| Humidity | 10...95 % non-condensing (in airway 0...100 %, condensing) |
| Protection against electrical shock | Type BF |

## 1.2 Typical performance

### 1.2.1 $CO_2$

| | |
|---|---|
| Measurement range | 0...20 vol% (0...20 kPa, 0...150 mmHg) |
| Measurement rise time | < 300 ms with nominal flow |
| Accuracy ( 0...15 vol%) | ±(0.2 vol% +2 % of reading) |
| (15...20 vol%) | ±(0.7 vol% +2 % of reading) |

If CO2 concentration is below 0.1%, 0.0% is displayed.

## 1.3 Gas specifications

| | |
|---|---|
| Airway humidity | 0...100 %, condensing |
| Sampling rate | 150 ±25 ml/min. (sampling line 2 to 3 m, normal conditions) |
| Sampling delay | 2.1 seconds typical with a 3-m sampling line |
| Total system response time | 2.4 seconds typical with a 3-m sampling line, including sampling delay and rise time (typically 3.7 seconds with a 6-m sampling line) |
| Display update rate | breath-by-breath |

Automatic compensation for pressure, $CO_2$-$N_2O$ and $CO_2$-$O_2$ collision broadening effect compensation selectable from menu.

| | |
|---|---|
| Warm up time | 1 min for operation with $CO_2$<br>30 min for full specifications |
| Autozeroing interval | Immediately after 'calibrating gas sensor' and 2, 7, 12, 17, 32, 47, 62 minutes after start-up, then every 60 minutes |

### 1.3.1 Normal conditions

Accuracy specifications apply in normal conditions (after 30 minutes warm-up period):

| | |
|---|---|
| Ambient temperature | 18...28 °C, within ±5 °C of calibration |
| Ambient pressure | 500...800 mmHg, ±50 mmHg of cal. |
| Ambient humidity | 20...80 % RH, ±20 % RH of cal. |

Non-disturbing gases are those with a maximum effect on the $CO_2$ reading < 0.2 vol %. The effect is valid for specific concentrations shown in parentheses of the non-disturbing gas:

- Ethanol $C_2H_5OH$ (< 0.3 %)
- Acetone (< 0.1 %)
- Methane $CH_4$ (< 0.2 % )
- Nitrogen $N_2$
- water vapor
- Trichloromonofluoromethane (<1 %)
- Dichlorotetrafluoroethane (<1 % )
- Dichloroflurомethane (<1 % )

Disturbing gases and their effect on the $CO_2$-reading at 5.0 vol% $CO_2$ are shown below. Errors listed reflect the effect of specific concentrations (shown in parentheses) of an individual disturbing gas and should becombined when estimating the effect of gas mixtures:

- Halotane (4%) increases < 0.3 vol%
- Isoflurane (5%) increases < 0.4 vol%
- Enflurane (5%) increases < 0.4 vol%
- Desflurane (24%) increases < 1.2 vol%
- Sevoflurane (6%) increases < 0.4 vol%
- Helium (50%) decreases < 0.3 vol%

| | |
|---|---|
| If $O_2$ compensation is not activated: | Oxygen (40 ... 95%) decreases < 0.3 vol% |
| If $O_2$ compensation is activated: | Oxygen (40 ... 95%) error < 0.15 vol% |
| If $N_2O$ compensation is not activated: | $N_2O$ (40%) increases < 0.4 vol% |
| | $N_2O$ (40 to 80%) increases < 0.8 vol% |
| If $N_2O$ compensation is activated: | $N_2O$ (40 to 80%) error < 0.3 vol% |

### 1.3.2 Conditions exceeding normal

Accuracy specifications under the following conditions ❶❷❸:

| | |
|---|---|
| ❶ Ambient temperature | 10...40 °C, within ±5 °C of calibration |
| Ambient pressure | 500...800 mmHg, ±50 mmHg of calibration |
| Ambient humidity | 10...98 % RH, ±20 % RH of calibration |

❷ During warm-up 1 to 10 minutes, under normal conditions

❸ During warm-up 10 to 30 minutes, under normal conditions

| | **Accuracy under different conditions (see above)** | |
|---|---|---|
| | Conditions ❶ and ❸ | Condition ❷ |
| **$CO_2$ ( 0 ... 15 vol%)** | ±(0.3 vol% + 4 % of reading)<br>(at 5 vol% error ±0.5 vol%) | ±(0.4 vol% + 7 % of reading)<br>(at 5 vol% error ±0.75 vol%) |
| **$CO_2$ (15 ... 20 vol%)** | ±(0.8 vol% + 4 % of reading)<br>(at 5 vol% error ±0.5 vol%) | ±(0.9 vol% + 7 % of reading)<br>(at 5 vol% error ±0.75 vol%) |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 $CO_2$ measurement

Mini$CO_2$ is a side stream gas analyzer, measuring real time concentrations of $CO_2$. It is a nondispersive infrared analyzer, measuring absorption of the gas sample using optical narrow band filter.

The infrared radiation detector is thermopile.

Concentration of $CO_2$ is calculated from absorption measured at 4.2 ... 4.3 µm.

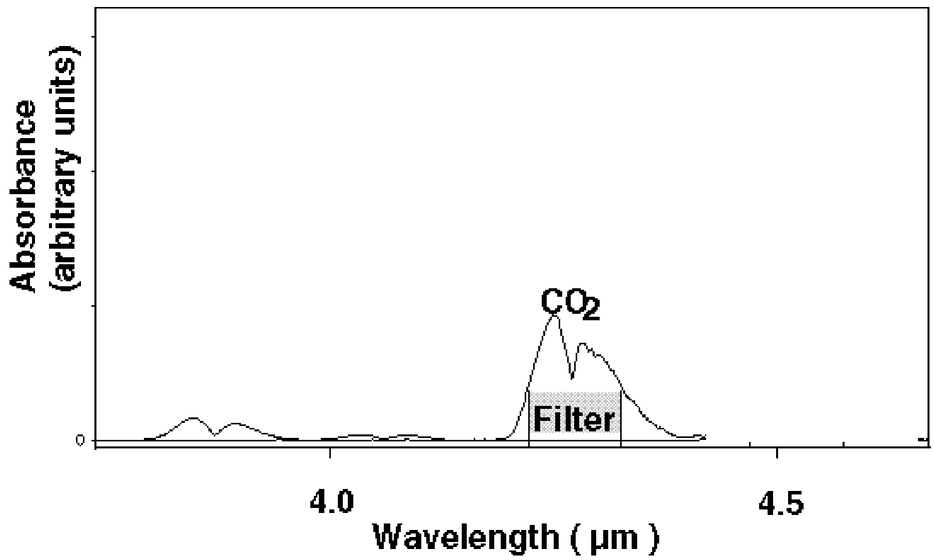



**Figure 1** **Absorbance of $CO_2$**

## 2.2 Main components

The Single-width Airway Module consists of:

- Gas sampling system
- mini$CO_2$ measuring unit
- CPU board

### 2.2.1 Gas sampling system

The sampling system draws a gas sample to the analyzer at a fixed rate.

The gas sampling system samples the measured air to the module, and removes water and impurities from it. A sampling line is connected to the water trap. The pump draws gas through the sampling line to the gas measuring unit. After the measurement, the gas is exhausted from the sample gas out connector.

The sample flow is nominally 150 ml/min.

#### Mini D-fend™

The sample is drawn through the sampling line. The gas then enters the module through the water trap, where it is divided into two flows, a main flow and a side flow. The main flow goes into the analyzer. This flow is separated from the patient side by a hydrophobic filter. The side flow creates a slight subatmospheric pressure within the Mini D-fend water trap which causes fluid removed by the hydrophobic filter to collect in the bottle.

#### Zero valve

The main flow passes through a magnetic valve before proceeding to the analyzer. This valve is activated to establish the zero point for the mini$CO_2$ measuring unit. When the valve is activated, room air is drawn through a filter into the internal system and the gas sensor.

#### Nafion™ tube [1)]

A nafion tube is used between the water trap and the zero valve to balance the sample gas humidity with that of ambient air. The tube  prevents errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases.

#### Gas analyzers

After the zero valve and nafion tube the gas passes through mini$CO_2$ measuring unit.

#### Sample flow differential pressure transducer

The sample flow differential pressure transducer measures pressure drop across a restrictor and calculates the sample flow from the pressure difference.

---

[1)] Nafion is a trademark of Perma Pure Inc.

## Working pressure transducer

The working pressure transducer measures absolute working pressure near the mini$CO_2$ measuring unit. The following messages are based on the obtained pressure values: ‘sample line blocked’, ‘check D-fend’, ‘replace D-fend’ and ‘check sample gas outlet’.

## Sampling pump and damping chamber

The gas sampling pump is a membrane pump run by a DC-motor. Sample flow is measured with a differential pressure transducer across a known restriction. The motor is automatically controlled to maintain a constant flow even when the D-fend water trap ages and starts to get occluded. It also enables use of sample tubes with varying lengths and diameters.

NOTE: In no occasion is the flow reversed towards patient.

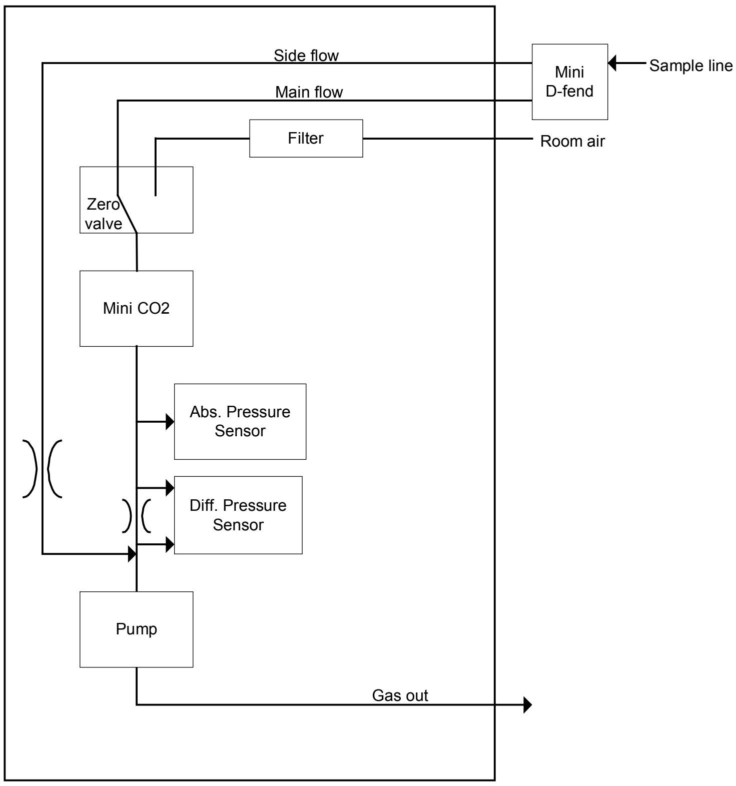



**Figure 2 Gas tubing layout**

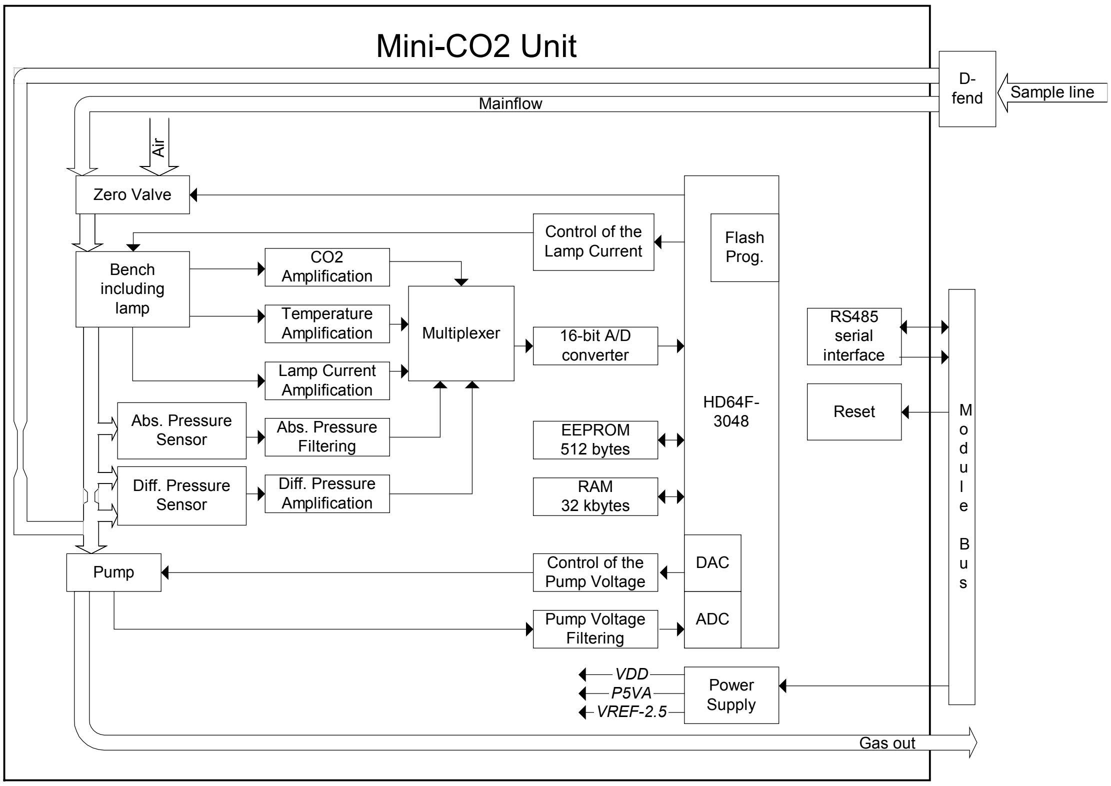



**Figure 3 MiniCO$_2$ block diagram**

## 2.2.2 MiniCO$_2$ measuring unit

The miniCO$_2$ measuring unit is a non-dispersive infrared analyzer measuring absorption of the gas sample at 4.2 ... 4.3 $\mu$m infrared wavelength, which is selected using an optical narrow band filter. The IR lamp is a filament surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 3 mm length. From the sample chamber, the radiation goes into a thermopile detector with an optical filter in front of it.

The temperature sensor measures miniCO$_2$ measuring unit's temperature and it is used for temperature compensation.

The miniCO$_2$ measuring unit includes miniCO$_2$ flexible board which connects the thermopile signal and the temperature sensor signal to the CPU board.

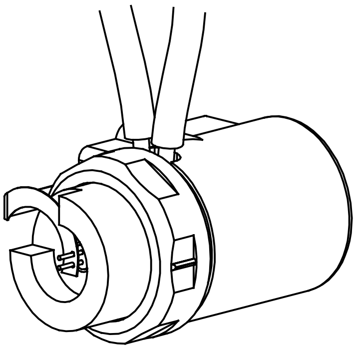


**Figure 4 MiniCO$_2$ measuring unit**

### 2.2.3 CPU board

CPU board contains the processor, memories and all the analog signal processing needed. Mini$CO_2$ measuring unit is attached to the board with a flexible PCB. Also supply voltage and RS485 serial channel are connected to the CPU board using another flexible PCB.

Analog signals ($CO_2$, temperature, absolute and differential pressure and lamp current signals) are fed through a multiplexer to the 16-bit A/D-converter. The processor controls the A/D-converter and calculates the $CO_2$ percentage and respiration rate from this data.

The processor controls sample flow by adjusting pump voltage based on the differential pressure signal. The processor also controls the current of the IR source and keeps it constant.

Calibration data is stored on the eeprom.

## 2.3 Connectors and signals

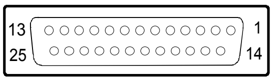



**Figure 5** **Module bus connector pin layout**

**Table 1** **Module bus connector pin description**

| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET RS485 |
| 2 | I | -15 VDC (not used) |
| 3 | I | +15 VDIRTY |
| 4 | I | +15VDC (not used) |
| 5 | I/O | -DATA RS485 |
| 6 | I/O | DATA RS485 |
| 7 | | Ground and Shield |
| 8 | I | -RESET RS485 |
| 9 | | n/c |
| 10 | | n/c |
| 11 | | n/c |
| 12 | | n/c |
| 13 | | Ground and Shield |
| 14 | I | +24/+32 VDIRTY depends on power supply (not used) |
| 15 | I | Ground DIRTY |
| 16 | | n/c |
| 17 | | n/c |
| 18 | | n/c |
| 19 | | n/c |
| 20 | I | GASFR (not used) |
| 21 | I | CTSD (not used) |
| 22 | I | TXDD (not used) |
| 23 | O | RXDD (not used) |
| 24 | I | +5 VDC (not used) |
| 25 | I | +5 VDC DIRTY (not used) |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the Single-width Airway Module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please, provide the unit serial number, full type designation and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

CAUTION The module electronics can only be repaired and calibrated at the factory.

### 3.1.1 Mini$CO_2$ measuring unit

CAUTION The mini$CO_2$ measuring unit and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. The information provided is for reference only.

### 3.1.2 Serviceable or exchangeable parts

- Mini D-fend
- Mini D-fend O-rings
- Nafion tube
- Zero valve
- Modflex board
- Air filter
- Pump

NOTE: After any component replacement see chapter *Adjustments and calibrations*.

Calibration interval 6 months. Preventive maintenance once a year including change of Nafion tube and O-rings of water separator, pump check and calibration, leak test, absolute pressure sensor check.

# 3.2 Service check

These instructions include complete procedures for a service check. The service check is recommended to be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form, *Appendix A*, which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

## 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Screwdriver | | Pozidrive, medium size |
| Ambient pressure manometer | | Amb. Press. can be checked from local meteorological station |
| Flowmeter | | TSI model 4140 recommended |
| Flow cassette 50/1.1 | 873812 | |
| Extra silicon tubing | 73375 | |
| Calibration gas and the regulator | 755580 (gas)<br>755534* | Contains 5% CO2 and air |
| Gas Interface Cable 2.5 m | 884299 | |

*NOTE: Ensure that the calibration gas and regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required. For more information see *Adjustments and calibrations* chapter of Compact Airway modules slot.

## 3.2.2 Recommended parts

| Part | Order No. | Notes |
|---|---|---|
| Mini D-fend | 8002174 | Pkg of 10 pieces |
| Sampling line 3 m/10 ft | 73319 | Pkg of 10 pieces |
| Mini D-fend O-ring (2 pcs) | 656565 | |
| Nafion tube | 733382 | |

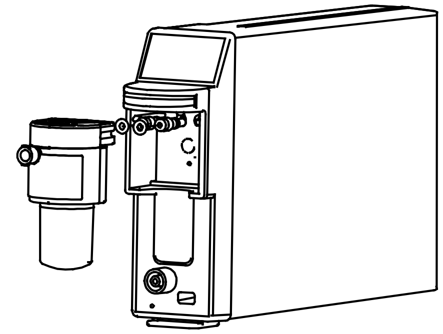
Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly
   - there are no loose objects inside the module

   ✍

2. Check external parts:
   - the front cover and the front panel stickers are intact
   - all connectors are intact and are attached properly
   - the Mini D-fend latch is moving properly
   - the module box, the latch and the spring pin are intact

3. Detach the Mini D-fend. Check the condition of the rubber O-rings on the metal Mini D-fend connectors, located in the module front cover.
   If necessary, detach the connectors by first disconnecting the tubes, then removing the locking rings from the back of the front cover.
   NOTE: The O-rings should be replaced annually.



- Replace the Mini D-fend and sampling line with new ones.

  NOTE: Use only Datex-Ohmeda sampling lines in order to ensure proper functioning.

Connect the Single-width Airway Module to the Central Unit's Module motherboard using the Gas interface cable (the grounding plates of the cable should be removed).
Turn on the monitor.
Configure the monitor screen so that $CO_2$ curve is shown, for example as follows:

**Monitor Setup** - ***Screen 1 Setup - Waveform fields -***
***Field 6 - CO2***
***Digit Fields***
***Lower Field 1 - Gases***

4. Wait until the message 'Calibrating gas sensor' disappears from the screen, then enter the Service menu.
   **Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8).
   Write down the information regarding the Single-width Airway Module software.

5. Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second.
   If one of the values is increasing faster, it indicates a failure in module bus communication.

6. Enter the service menu ***Gases***:

   ***Gas Unit - Gases***

   Check that the flow measurement offset, i.e. the shown sample 'Zero' value is within ±10 ml/min.

7. Check that the shown 'Ambient' value corresponds with the current ambient pressure (±20 mmHg).

8. Check the zero valve.
   Feed calibration gas and check that the gas readings in the service menu correspond with the values on the gas bottle sticker. Keep feeding gas, then activate the zero valve from the menu. The $CO_2$ reading should drop back to near 0 %.

9. Perform the steam test for the Nafion tube, or replace it by a new one.
   NOTE: The Nafion tube should be replaced annually.

10. Perform sampling system leak test.

    Connect a flow cassette with high flow resistance value (50/1.1) to the end of the sampling line and start following the 'Amb-Work' value in the service menu. When the value exceeds 130 mmHg connect the other port of the flow cassette to the sample gas out connector and switch off the pump.
    Wait until the pressure inside the sampling system is stabilized, then observe the shown 'Amb-Work' value. The value, i.e. the pressure inside the sampling system should not drop more than 6 mmHg in 20 seconds.

    If the pressure drops more, first check connections and repeat the test.

11. Check the flow rates.

    Wait until the 'Sample Flow' value returns close to 150 ml /min.
    Connect a flowmeter to the 3 meter sampling line and check that the flow (the flowmeter reading) is within the following range:

    | | |
    |---|---|
    | Sampling flow (ml/min) | –135...165 |

    If necessary, readjust the sampling flow:
    Select 'Sample gain adj' from the menu.
    To increase the sampling flow, turn the ComWheel counterclockwise,
    to decrease the flow, turn the ComWheel clockwise.
    A change of 0.050 in the 'Gain' value changes the flow approximately 7.5 ml/min.

After you have changed the gain, wait until the ‘Sample Flow’ value on the screen returns near to the original, then check the flowmeter reading again.

12. Check that the ‘Amb-Work’ value in the service menu is within the following range:

| | |
|---|---|
| Amb-Work (mmHg) | 20...50 |

13. Perform the gas calibration.

**Airway Gas** ***- Gas Calibration***

NOTE: The calibration should not be performed before 30 minutes warm-up time.
Use calibration gas 755580 (5 % $CO_2$, about 20 % $O_2$) for calibrating the M-miniC.

Turn off the monitor, disconnect the Gas interface cable and reassemble the module.

NOTE: When reassembling the module, make sure that the tubes are not pinched between the module box and internal parts.

Install the Single-width Airway Module into the Central Unit, turn on the monitor and wait until the message ‘Calibrating gas sensor’ disappears from the screen.

14. Block the tip of the sampling line with your finger and check that the message ‘Sample line blocked’ appears on the monitor screen within 60 seconds.

15. Detach the mini D-fend and check that the message ‘Check D-fend’ appears on the monitor screen within 30 seconds.

16. Reattach the mini D-fend. Simulate at least 5 breaths by feeding calibration gas into the sampling line. Check that the shown gas information is correct.
Check that the monitor shows the message ‘Apnea’ within 30 seconds after you have stopped feeding the gas.

17. Turn off the monitor, disconnect and clean the module.

- Fill in all necessary documents.
- It is recommended to fill in the PM sticker since the service check includes all the Planned Maintenance actions. Attach it to a suitable place on the module box.

## 3.3 Disassembly and reassembly

Disassemble the airway module in the following way. See also the exploded view of the module.

1. Remove two screws from the back of the module.
2. Pull the module box slowly backwards and detach it from the main body.

Reassembling is essentially reversing what was described above.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

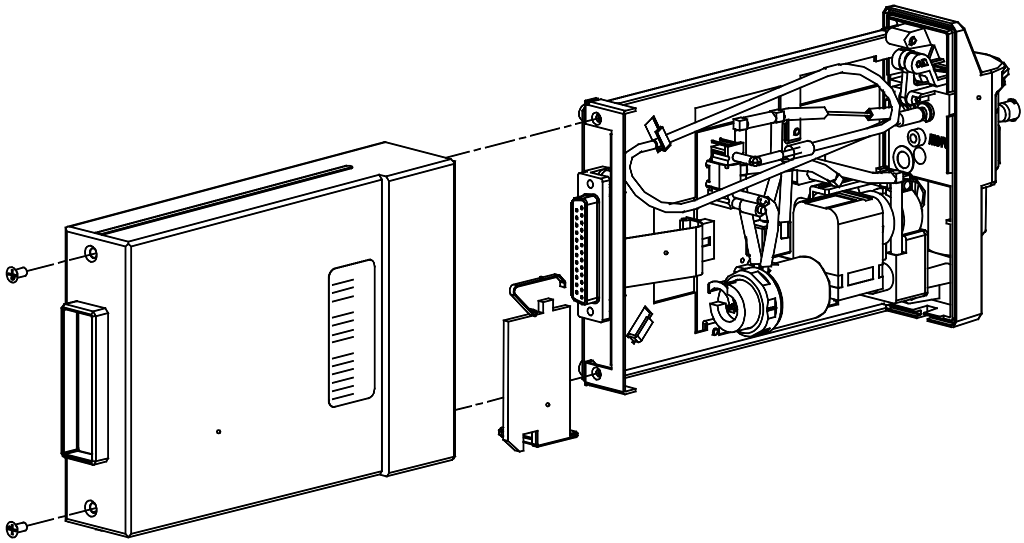


**Figure 6 Disassembling the M-miniC module**

### 3.3.1 Pump unit

1. Remove the module cover.
2. Remove the mask.
3. Unplug the hose of the pump.
4. Disconnect the pump’s cable from the CPU board.
5. Remove the three screws that connect the pump unit to the board.
6. Reassembling is essentially reversing what was described above.

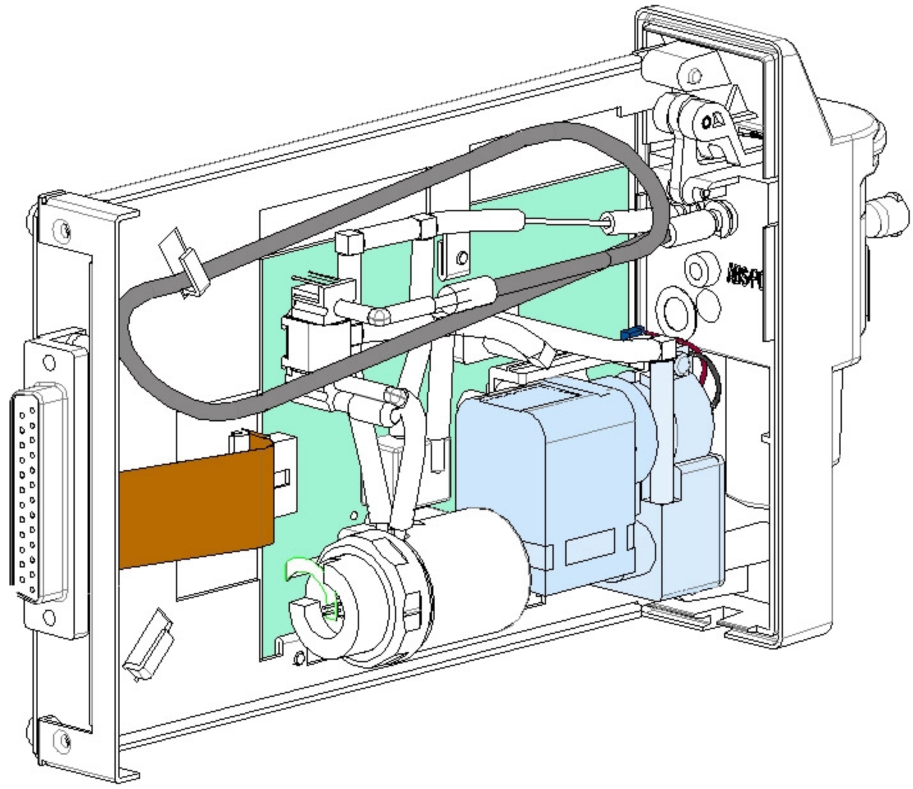


**Figure 7 Uncovered M-miniC module**

### 3.3.2 MiniCO$_2$ assy

1. Remove the module cover.
2. Unplug two tubes from the back of the mask.
3. Remove mask.
4. Detach the miniCO$_2$ assy from the frame plate by removing three screws.
5. Disconnect the flexible board from the miniCO$_2$ assy.
6. Reassembling is essentially reversing what was described above.

### 3.3.3 Instructions after replacing MiniCO$_2$ assy

After replacing the MiniCO$_2$ assy:

- perform the sampling system leak test
- perform the occlusion test
- perform the gas calibration

## 3.4 Adjustments and calibrations

See the *User's Reference Manual* for normal gas calibration instructions.

### 3.4.1 Gas sampling system adjustment

For the flow rate measurements a flowmeter with a low flow resistance and capability to measure low flow rates is required. A normal length of sampling line has to be connected to the monitor as it has a considerable effect on the flow.

### 3.4.2 Flow rate measurement

**If any flow rates are not correct, first replace the Mini D-Fend water trap. Then recheck the flows.**

Sampling flow rate is measured by a rotameter at the sampling line. The flow rate should be between 135 and 165 ml/min. The flow rate is adjusted in the Gas Service Menu with 'Sample Gain Adj.'.

### 3.4.3 Flow rate adjustment

NOTE: Before adjusting the sampling flow make sure there is no leakage in the sampling system.

Refer to chapter *3.2 Service check,* step 11:
Wait until the 'Sample Flow' value is back to near 150 ml /min.
Connect a flowmeter to the 3 meter sampling line and check that the flow (the flowmeter reading) is within the following range:

| | |
|---|---|
| Sampling flow (ml/min) | 135...165 |

If necessary, readjust the sampling flow:

Select 'Sample gain adj' from the menu.
To increase the sampling flow, turn the ComWheel counterclockwise,
to decrease the flow, turn the ComWheel clockwise.
A change of 0.050 in the 'Gain' value changes the flow approximately 7.5 ml/min.
After you have changed the gain, wait until the 'Sample Flow' value on the screen returns near to the original, then check the flowmeter reading again.

### 3.4.4 Gas calibration

Gas calibration is performed in the ***Airway Gas*** menu. Please refer to the *User's Reference Manual.*

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting charts

| Trouble | Possible cause/treatment |
|---|---|
| No response to breathing | Sampling line or water trap blocked or loose, or improperly attached.<br>Water trap container full.<br>See the gas sampling system troubleshooting. |
| SENSOR INOP. -message | The temperature is too low or high, check temperature in the service menu.<br>Supply voltage is too low or high, IR source current or voltage is too low or high, check current in the service menu.<br>Pump is not working properly, check sample flow and pump voltage in the service menu.<br>Ambient pressure too low or high, check the ambient pressure in the service menu.<br>Zero valve not working properly, check the functionality by switching zero valve on and off in the service menu. |
| ZEROING ERROR -message | Gas zeroing failed. Condensation or residual gases are affecting the zero measurement. Allow module to run drawing room air for a half an hour and calibrate again. |
| CHECK D-FEND -message | Amb – Work pressure difference too small.<br>Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage. |
| REPLACE D-FEND -message | Amb – Work pressure difference too big.<br>Indicates residue build-up on the water trap membrane. This decreases air flow. Replace the D-fend. |
| SAMPLE LINE BLOCKED -message | Amb – Work pressure difference too big.<br>Sampling line or water trap is occluded. Water trap container is full. If occlusion persists, check internal tubing for blockages. |
| No response to any gas | Sampling line, water trap, or internal tubing blocked or loose, or improperly attached.<br>Zero valve malfunction. Pump failure. Supply voltage missing. Serial communication error. |

| Trouble | Possible cause/treatment |
|---|---|
| Sudden increase in gas display | Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates. |
| Abnormally high (or abnormally low) response to $CO_2$<br>or sudden occlusion warning | Pressure transducer failure. Check the Ambient and Amb – Work pressures in 'Gases' service menu. |
| Strong drift in all gases | Leak in sampling line or internal tubing (especially in conjunction with too low readings). |

### 4.1.1 $CO_2$ measurement

| Trouble | Possible clinical cause | Possible technical cause | Action |
|---|---|---|---|
| too low $ETCO_2$ value | • sudden decrease in circulation<br>• pulmonary embolism<br>• hyperventilation<br>• very large dead-space<br>• large shunting | • leak in sampling system<br>• calibration error<br>• high by-pass flow from ventilator | • check all connections<br>• check calibration |
| too high $ETCO_2$ | • hypoventilation<br>• increased metabolism | • D-fend contaminated<br>• calibration error | • change D-fend<br>• check calibration |
| waveform clipped | • - | • incorrect scaling | • change scale |
| no response to breathing | • apnea<br>• (disconnection)[1)] | • sampling line or water trap loose or blocked (air leak)[1)]<br>• sample gas outlet blocked | • check all connections<br>• check that outlet is open |
| $ETCO_2$ overscale >20%<br>Shown until 32 %, specified range 0...20 % | • abnormally high $ETCO_2$ (permissive hypercapnia) | • $CO_2$ sensor contaminated<br>• D-fend malfunction | • let the module run without a sampling line until $CO_2$ sensor has dried out<br>• change D-fend |
| $ETCO_2$>$PaCO_2$ | • unit is mmHg or kPa and $ETCO_2$ is close to arterial $PCO_2$ | • "dry gas" as default | • change to "wet gas" by using install/service menu |

## 4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of dirt accumulating in the internal tubing.

The following checks should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system check and if necessary adjust the flow rate.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: D-fend water trap should be replaced when the REPLACE D-FEND message appears during the monitor startup.

NOTE: If any liquid has entered the mini$CO_2$ measuring unit due to water trap filter failure, leave the module running without a sampling line for several hours and check the functions after it has dried out.

### 4.2.1 Sampling system leak test

1. Connect a flow cassette with high flow resistance value (50/1.1) to the end of the sampling line and start following the 'Amb-Work' value in the service menu. When the value exceeds 130 mmHg connect the other port of the flow cassette to the sample gas out connector and switch off the pump.
2. Wait until pressure inside the sampling system is stabilized, then observe the shown 'Amb-Work' value. The value, i.e. the pressure inside the sampling system, should not drop more than 6 mmHg in 20 seconds.
3. If the pressure drops more, first ensure the connections you have made and repeat the test.

## 4.3 Mini$CO_2$ measuring unit troubleshooting

CAUTION The mini$CO_2$ measuring unit can only be repaired and calibrated at the factory. In case of failure, the complete miniCO2 assy should be sent to Datex-Ohmeda for factory exchange.

## 4.4 CPU board troubleshooting

The CPU board can not be repaired in the field.

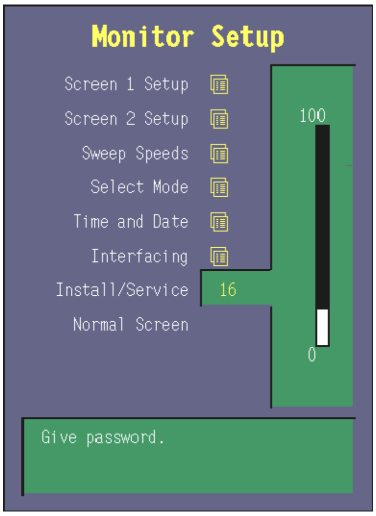
Check only that all connectors are properly attached.

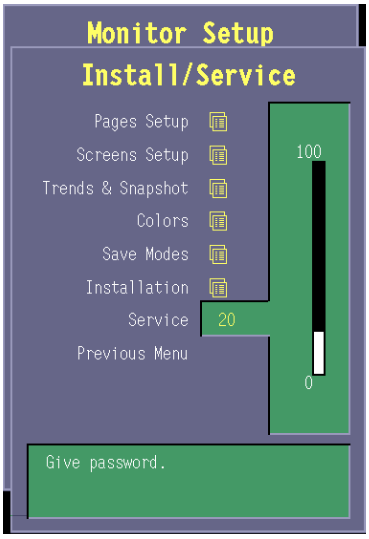
## 4.5 Error messages

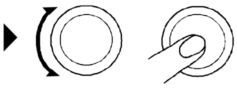
| Message | Explanation |
|---|---|
| Occlusion or Sample Line Blocked | The sample tube inside or outside the monitor is blocked or water trap is occluded. If occlusion persists, measured gas values disappear. |
| Continuous occlusion. Check sample line and D-fend. | Occlusion over 40 seconds. |
| Check D-fend | -the water trap is not connected<br>-there is a leak in the sampling line inside the module. If air leak persists, measured gas values disappear.<br>Check sample gas out. |
| (Air leak detected.) Check water trap and sample gas out-flow. Press normal screen to continue. | Air leak over 40 seconds. |
| Replace D-fend (replace water trap) | Indicates residue build-up on the water trap membrane. This decreases air flow. |
| Gas calibration is not available during first 5 minutes/during occlusion/during air leak | Entering calibration is not allowed during 5 minutes after power up and during occlusion or air leak. |
| Gas out blocked | - Gas out connector on the front panel, or the exhaust line connected to it, is blocked.<br>- If the sample gas is returned to patient circuit the filter in the return kit may be occluded.<br>- Make sure the sample gas outlet is connected to an open scavenging system only where gas is removed in room pressure. |
| Recalibration | Time out, fluctuating gases, gain adjusted “over”. |
| Zero error | Unsuccessful zeroing. |
| Unstable, Calibr error | Unsuccessful calibration. |
| **Menu messages during calibration**: | |
| Zero error | Unsuccessful zeroing |
| Adjust | Calibration gas accepted and monitor is ready for adjusting the gas values to match the calibration gas concentration |
| Unstable | Unsuccessful calibration |

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.

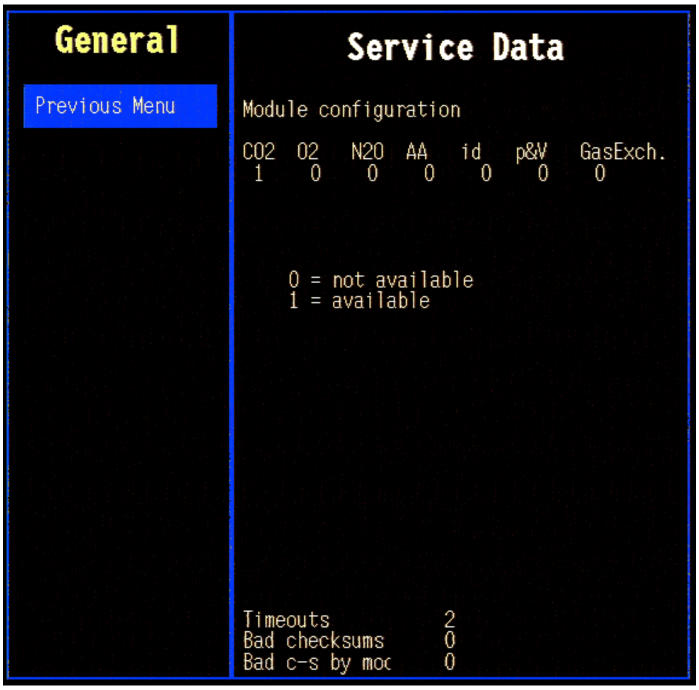


Press the **Monitor Setup** key - select ***Install/Service*** (password: 16-4-34) - select ***Service*** (password: 26-23-8) - select ***Parameters*** - select ***Gas Unit***.

## 5.1 General menu




**Service Data field**

**Module configuration** shows which measurement options are available, i.e. are detected by the module.

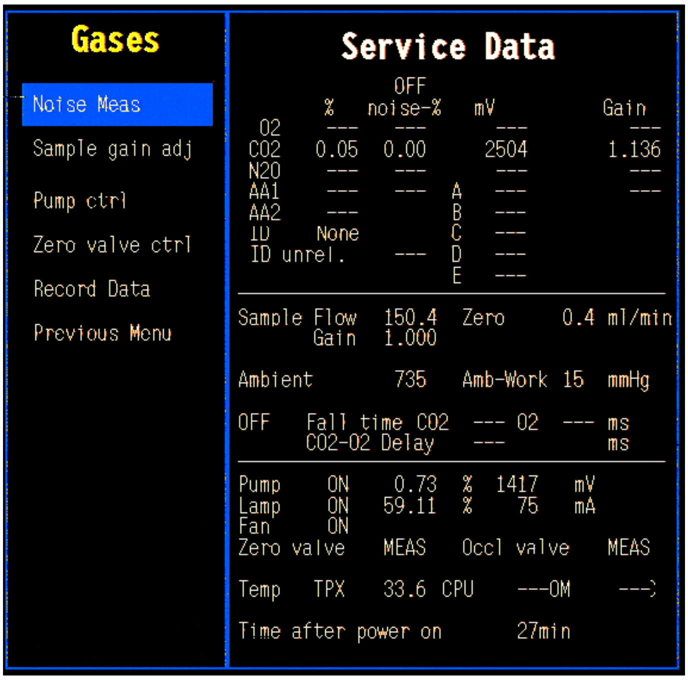
**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.

**Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.

**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.

The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure or module not in place. Also other modules can cause these numbers to rise.

## 5.2 Gases service menu




**Noise Meas** A selection for activating the noise measurement.

**Sample gain adj** A selection for adjusting the sampling pump gain, i.e. for for adjusting the sample flow measurement.

**Pump ctrl** A manual control for the sampling pump.

**Zero valve ctrl** A manual control for the zero valve.

**Record Data** Record Data prints out the shown service data and board information (id. serial number and software id.) onto the recorder module (if installed).

### Service Data field

**$O_2$, $CO_2$, $N_2O$, AA** **%** -field shows realtime concentrations, **noise-%** is standard deviation of concentration.

**$O_2$, $CO_2$, $N_2O$, AA channels A-E**

**mV** -field: signal is scaled to mV, **Gain**: User gain. It is scaled as (User gain)/(Factory gain).

**ID** Shows the identified agent. Not used in M-miniC.

**ID unrel.** The shown value tells how **unreliable** the identification is. With pure agent, the value is normally < 50. Not used in M-miniC.

**Sample Flow** **Sample Flow** is calculated from differential pressure and is adjusted by the module. **Zero** value as measured during initialization when the pump is off. **Gain**: sample flow measurement can be calibrated by adjusting the gain.

**Ambient** **Ambient** pressure is measured during initialization and every auto-zeroing. **Amb-Work**: ambient pressure - sampling system internal pressure.

**$CO_2$-$O_2$ Delay** In ms. No delay between $CO_2$, $N_2O$, and agents. Not used in M-miniC.

**Pump** Can be toggled ON/OFF.
DHC output 0-1.78% is shown. Pump voltage is also shown.

**Lamp** The state, PWM control, and current of the lamp are shown.

**Zero and Occl valve**

Can be toggled between measurement state (MEAS) and zeroing/occlusion states (ZERO/OCCL).

**Temp** Temperatures measured by the module from mini$CO_2$ measuring unit (in the display: TPX).

**Time after power on**

In minutes after power on.

# 6 SPARE PARTS

## 6.1 Spare parts list

### 6.1.1 M-miniC

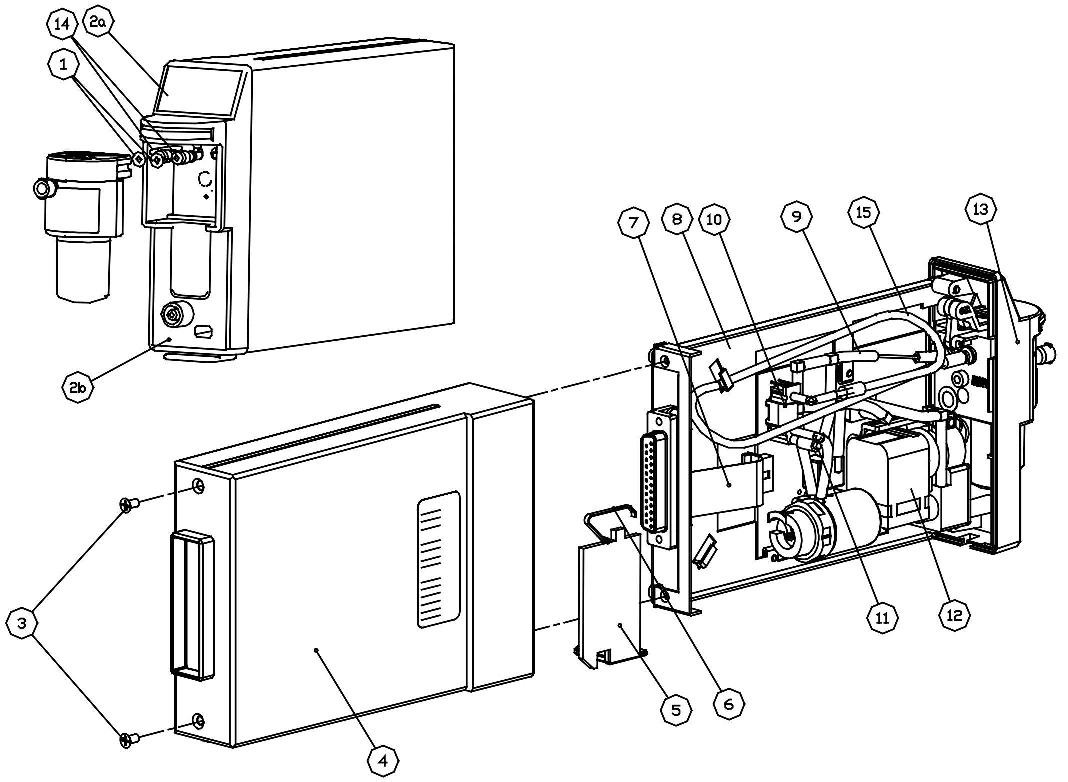



**Figure 8 Exploded view of M-miniC**

| Item | Description | Order No. | Item | Description | Order No. |
|---|---|---|---|---|---|
| | Mini-CO2 unit | 8001645 | 8 | Frame for MiniCO2 | 8002145 |
| 1 | O-ring | 656565 | 9 | Tube unit | 8000574 |
| 2 a,b | Front panel stickers | 8003140 | 10 | Magnetic valve | 585714 |
| 2 a,b | Front panel stickers USA | M1006287 | 11 | Air filter | 571421 |
| 3 | Screw (for module box) | 61621 | 12 | Pump unit | 8000573 |
| 4 | Module box | 886167 | 13 | Front plate unit | 8001647 |
| 5 | Latch for module box | 879181 | 14 | Connector (Mini D-fend tube connector) | 8002173 |
| 6 | Spring pin for module box | 879182 | 15 | Nafion tube | 733382 |
| 7 | Modflex board | 8002231 | | | |

# 7 EARLIER REVISIONS

| Revision | Manual slot/main manual | Note |
|---|---|---|
| No earlier revisions | | |

# APPENDIX A

# SERVICE CHECK FORM

## Single-width Airway Module M-miniC

Customer ______________________________

Service ____________ Module type ____________ S/N ____________

Service engineer ______________________ Date ____________

☐ OK = Test OK

☐ N.A. = Test not applicable

☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. D-fend O-rings | ☐ | ☐ | ☐ | | | | |

Notes ______________________________

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 4. Module software | GAS | | | | | | |
| 5. Module bus communication | ☐ | ☐ | ☐ | | ☐ | ☐ | ☐ |
| 6. Flow measurement offset | | | | | ±10 ml/min | | |
| 7. Ambient pressure | ☐ | ☐ | ☐ | 8. Zero valve | ☐ | ☐ | ☐ |
| 9. Special tube, (Nafion) | ☐ | ☐ | ☐ | | | | |
| 10. Leak test | | | | | ≤ 6 mmHg/20 sec | | |
| 11. Flow rates | | | | | | | |
| Sampling flow | | | | | 135...165 ml/min | | |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 12. Working pressure | | | | | | | |
| Amb-Work | | | | | 20...50 mmHg | | |
| 13. Gas calibration | ☐ | ☐ | ☐ | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14. Occlusion detection | ☐ | ☐ | ☐ | 15. 'Check D-fend' | ☐ | ☐ | ☐ |
| 16. Apnea detection | ☐ | ☐ | ☐ | 17. Final cleaning | ☐ | ☐ | ☐ |

**Notes** ______________________________

______________________________

______________________________

______________________________

______________________________

**Used Spare Parts** __________ __________ __________

__________ __________ __________

**Signature** ______________________________

# Datex-Ohmeda

# S/5$^{TM}$ Entropy Module, M-ENTROPY (Rev. 00)

# Technical Reference Manual Slot


All specifications are subject to change without notice.


Document No. 8004390

January 2003



Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147
www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## Entropy Module, M-ENTROPY

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Entropy Module, M-ENTROPY. The Entropy module is a single width plug-in module designed for use with the S/5 Anesthesia monitors. Later in this manual modules can be called w/o system name S/5.

Please see also related *Technical Reference Manual* for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description,system installation, interfacing, functional check and planned maintenance.

The Datex-Ohmeda S/5 Entropy Module, M-ENTROPY and accessories are indicated for monitoring the state of the central nervous system (CNS) by data acquisition of electroencephalograph (EEG) and frontal electromyograph (FEMG) signals in the anesthesia environment. The spectral entropies, State Entropy (SE) and Response Entropy (RE), are processed EEG and FEMG variables, and may be used as an aid in monitoring the effects of certain anesthetic agents.

The Entropy module uses:

- Electroencephalography (EEG) signal, together with
- spontaneous facial muscular activity with frontal electromyography (FEMG) signal to measure:
    - Response Entropy (RE)
    - State Entropy (SE)
    - Burst suppression ratio (BSR)

The Entropy module is responsible for EEG and FEMG signal acquisition, amplification, filtering and digitization and electrode impedance measurement. All the calculated parameters can be selected on the display, and trended.

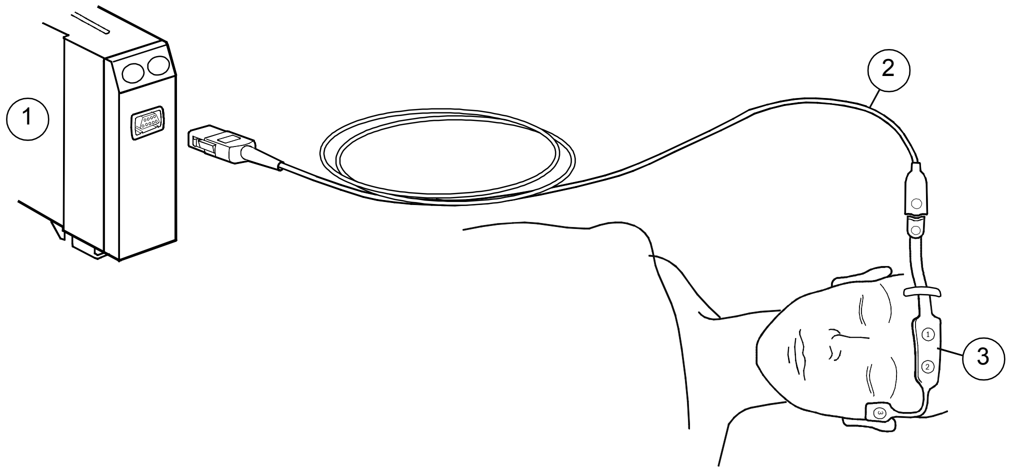



**Figure 1 Measurement setup**

(1) Entropy module
(2) Entropy sensor cable
(3) Entropy sensor

NOTE: The Entropy Module, M-ENTROPY requires monitor software version 03 or greater.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size (WxDxH) | 37 x 180 x 112 mm/1.5 x 7.1 x 4.4 in |
| Module weight | 0.3 kg/0.7 lbs |
| Power consumption | 2.6 W W |

## 1.2 Technical specifications

### 1.2.1 EntrEEG

| | |
|---|---|
| Amplification | 10 000 |
| Resolution | 60 nV |
| Max amplitude | 800 $\mu V_{pp}$ |
| Sampling frequency | 400 Hz |
| Range | ±400 μV |
| Frequency range | 0.5...118 Hz |
| Input impedance | 1 MΩ @ 10 Hz |
| Noise level | <0.5 μV rms from 0.5 Hz to 118 Hz |
| CMRR | >100 dB @ 50 Hz |
| Parameters from EEG | RE, SE, BSR |
| Defibrillation protection | 3000V, 218 J |
| Allowable Input Offset | ±300 mV |

### 1.2.2 Impedance measurement

| | |
|---|---|
| Measurement frequency | 75 Hz |
| Current | 10 μA |
| Range | 0...30 kΩ |
| Resolution | 100 Ω |
| Accuracy | ±1kΩ or ±10 % whichever is greater |
| Measurement time, all leads 5 s | |
| Start of measurement manual/automatic | |
| Leads off detection | >3 MΩ, continuous |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurements principle

Hypnotic component of anesthesia is most reliably monitored by measuring cortical electrical activity. Electroencephalography (EEG) changes from irregular to more regular patterns when anesthesia deepens. Similarly, frontalis EMG (FEMG) quiets down as the deeper parts of the brain are increasingly saturated with anesthetics. Entropy measures irregularity of EEG and FEMG.

Entropy parameters and BSR are calculated from EEG and FEMG signals acquired with a sensor which is attached to the patient's forehead. The sensor consists of three electrodes. This referential measurement yields one channel of raw EntrEEG.

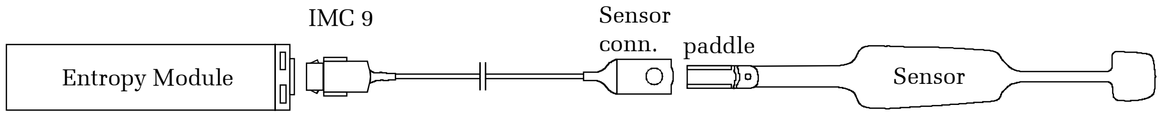



**Figure 2 A general view of the cable connections**

### 2.1.1 EntrEEG

EEG is differential voltage signal measured from electrodes attached to the patient’s skin. EEG measures the spontaneous electrical activity of the brain. This electrical activity reflects the state of the brain. In referential measurement the referential electrode delivers its potential to every channel’s minus-input. The signal is the potential difference between this common reference electrode (electrode #3) and the electrode connected to plus input (electrode #1). Purpose of the ground electrode (electrode #2) is to reduce common mode noise.

The EntrEEG signal is amplified, antialias filtered, digitised and software filtered. After that the EntrEEG signal is shown on the screen and the RE, SE and BSR characteristics are calculated out of it.

### 2.1.2 FEMG

FEMG is electrical signal originating from facial muscles. FEMG signal has much broader spectrum than EEG and it overlaps with EEG at low frequencies. FEMG signal gives its contribution to the RE values (see chapter 2.1.3). Mains power frequency and its harmonics are digitally filtered away to reject interference noise from power lines.

### 2.1.3 RE and SE

Entropy numbers range from 100 to zero (RE 0-100, SE 0 – 91), correlating to the patient's anesthetic state. High values of Entropy indicate high irregularity of the signal signifying that the patient is awake. There are two Entropy parameters: the fast-reacting **Response Entropy** and the more steady and robust **State Entropy**. State Entropy consists of the entropy of EEG signal calculated up to 32 Hz. Response Entropy includes additional high frequencies up to 47 Hz and, consequently the fast frontalis EMG (FEMG) signals enable a fast response time.

| | |
|---|---|
| Response Entropy, RE | 0 < f < 47 Hz |
| State Entropy, SE | 0 < f < 32 Hz |

**Table 1 Frequency ranges for Entropy calculation.**

### 2.1.4 Impedance measurement

The impedance measurement is done for all leads at the same time and the EntrEEG is stopped for no longer than 5 seconds during the impedance measurement.
Differences in electrode impedance of the electrodes causes common mode noise coupling to measured signal. To minimise this the electrode impedance is measured and a warning of unsatisfactory impedance level is generated when necessary. The impedance of an electrode is measured by applying a known current through the electrode and measuring the voltage drop over the electrode. This way the impedance of a single electrode can be resolved.

## 2.2 Main components

The Entropy board consists of the following functional sections:

- Microprosessor for measurement control, and for processing the measurement signal
- Digital I/O circuit for smart chip communication (the chip is located in the entropy sensor)
- Serial communication driver for module bus communication

The serial bus speed to monitor is 500 kbps and the bus itself is half duplex, i.e. data can be transferred to both directions but only one way at a time.

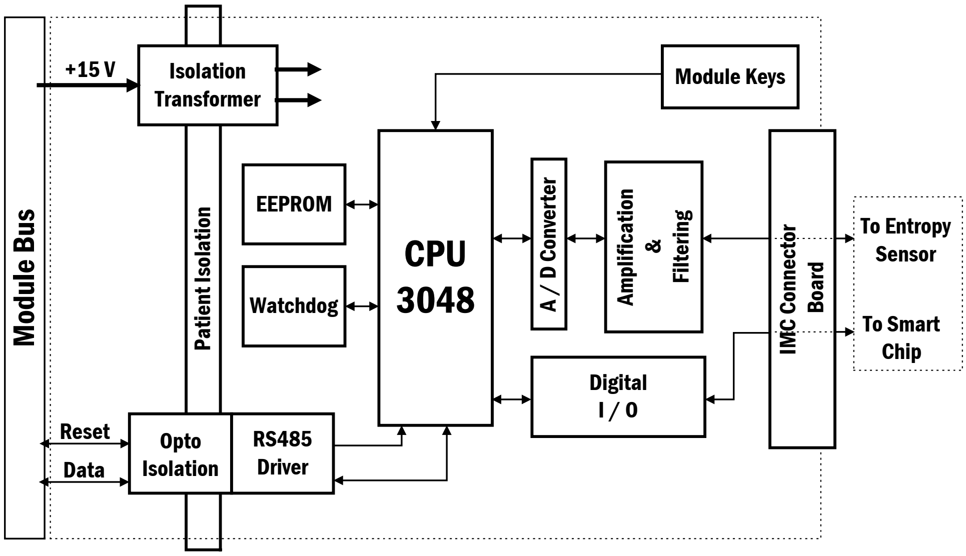
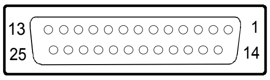



**Figure 3 Entropy measurement system block diagram**

# 2.3 Connectors and signals

## 2.3.1 Module bus connector




Female D25

**Table 2 Module bus connector (X1) pin description**

| PIN | Name | Description |
|---|---|---|
| 1 | Reset_ RS485 | Module Bus Reset + |
| 3 | +15VD | +15V Supply voltage |
| 5 | Ndata_ RS485 | Module Bus Data - |
| 6 | Data_ RS485 | Module Bus Data + |
| 7 | GND | Ground |
| 8 | Nreset_ RS485 | Module Bus Reset - |
| 13 | GND | Ground |
| Other | NC | Not Connected |

## 2.3.2 Module front panel connector

Front view

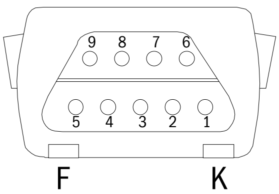



**Table 3 Module front panel connector pin description**

| PIN | Name | Color | Description |
|---|---|---|---|
| 1 | VCC | PURPLE | Supply voltage |
| 2 | I/O | WHITE | Bi-directional data line (open drain) |
| 3 | CLOCK | BLUE | Clock input |
| 4 | RESET | YELLOW | Control input (reset) |
| 5 | GND | GREY | Smartchip ground |
| 6 | Screen | - | Cable screen |
| 7 | Electrode 2 (N) | GREEN | EEG channel neutral |
| 8 | Electrode 3 (-) | RED | EEG channel - |
| 9 | Electrode 1 (+) | BROWN | EEG channel + |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the M-ENTROPY is limited to replacing faulty circuit boards or mechanical parts. Faulty circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

The Datex-Ohmeda simulator for M-ENTROPY (order code N-ES ) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form, *Appendix A*, which should be filled in when performing the procedures.

The mark in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| simulator for M-ENTROPY | N-ES | |
| Screwdriver | | |

- Detach the module box by removing the two screws from the back of the module. Be careful with the loose latch and spring pin for locking.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - the EMC cover is attached properly in the module
   - there are no loose objects inside the module

✍

2. Check external parts of the module:
   – the front cover and the front panel sticker are intact
   – connectors are intact and are attached properly
   – the module box, latch and spring pin for locking are intact

✍

- Reattach the module box.
- Turn the monitor on and wait until the normal monitoring screen appears.
- Configure the monitor screen so that information regarding the Entropy measurement is shown:

**Monitor Setup** - ***Screen 1 Setup - Waveform Fields - Field 1 - EntrEG***

**Others** - ***Entropy - Entr.EEG - 250 µV***
**Others** - ***Entropy - Display format - All***
**Others** - ***Entropy - Automatic check - OFF***

3. Plug in the module. Check that it goes in smoothly and locks up properly

✍

4. Check that the module is recognized, i.e. the EntrEEG header with related information appears in the chosen waveform fields and 'Cable off' message is shown on the field.

✍

5. Connect the cable to the module. Check that the cable is recognized i.e. message 'No sensorf' is shown on the waveform field. If the Entropy sensor is connected 'Sensor off' message appears.

✍

6. Enter the service menu:

   **Monitor Setup** - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

   Record the information regarding the software of M-ENTROPY by selecting SCROLL VERS and turning the ComWheel.

✍

7. Enter the Entropy module service menu:

   ***Parameters - More... - Entropy***

   Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. 'RAM', 'ROM' and 'EEPROM' all state OK.

8. Check the **Entropy** and **Check Sensor** membrane keys both of the module. Go to module view and press each key for at least one second and check that the key being pressed is identified, i.e. the Check Sensor text is highlighted in the service menu and that press Entropy key brings up the Entropy menu.

9. Connect the Entropy simulator (N-ES) to the cable. Go to ***Entropy*** service menu and select ***Check Sensor*.** From the Sensor view check that the impedances in all three leads are 0 k$\Omega$.

10. Keep the Entropy simulator connected and check that the EntrEEG waveform and RE and SE values appear on the monitor screen. The RE and SE values start to decrease after a couple of minutes.

11. Perform an electrical safety check and a leakage current test.

12. Check that the module functions normally after performing the electrical safety check.

13. Clean the module with suitable detergent.

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

### 3.3.1 M-ENTROPY

Disassemble the M-ENTROPY in the following way.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with the loose latch and spring locking pin.
3. Detach the Entropy board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

# 4 TROUBLESHOOTING

## 4.1.1 Troubleshooting chart

| Trouble | Cause | Treatment |
|---|---|---|
| No EntrEEG waveform on screen. | EntrEEG waveform not selected on screen. | Press Monitor Setup key and select EntrEEG waveform on the screen. |
| No EntrEEG waveform on screen and 'Sensor off' message shown in the number field. | Entropy sensor not attached to skin. | Attach sensor to patient. |
| Number field shows '- - -' and message 'Sensor check failed' is displayed in number field. | Module could not accomplish a successful sensor check. | Check the sensor connection to skin and initiate a new check by pressing 'Check sensor' module key or from Entropy menu. |
| EntrEEG signal looks noisy and 'Noise' message is displayed in the number field and waveform field | High frequency electrical interference (i.e., electrocautery) is coupling to the sensor. | Remove noise sources if possible. Check the sensor and electrode impedances. |
| Sensor check measurement is not available on menus. | Measurement is off because sensor is not connected to cable and to patient. | Sensor check starts immediately when sensor is connected to the patient and first Entropy values should appear 15 seconds after successful sensor check. |
| Electrode impedances show 'Fail' and 'Press electrodes' message is displayed on number fields after impedance measurement. | One or more of sensor electrodes is poorly connected to patient. | Check the sensor contact and cable. If the sensor electrodes have too high impedance (>7.5k) the measurement fails even if the sensor seems properly attached. Cure for this is to prepare the skin better, check that the sensor is not dried out or outdated and try again. |

## 4.1.2 Troubleshooting flowcharts

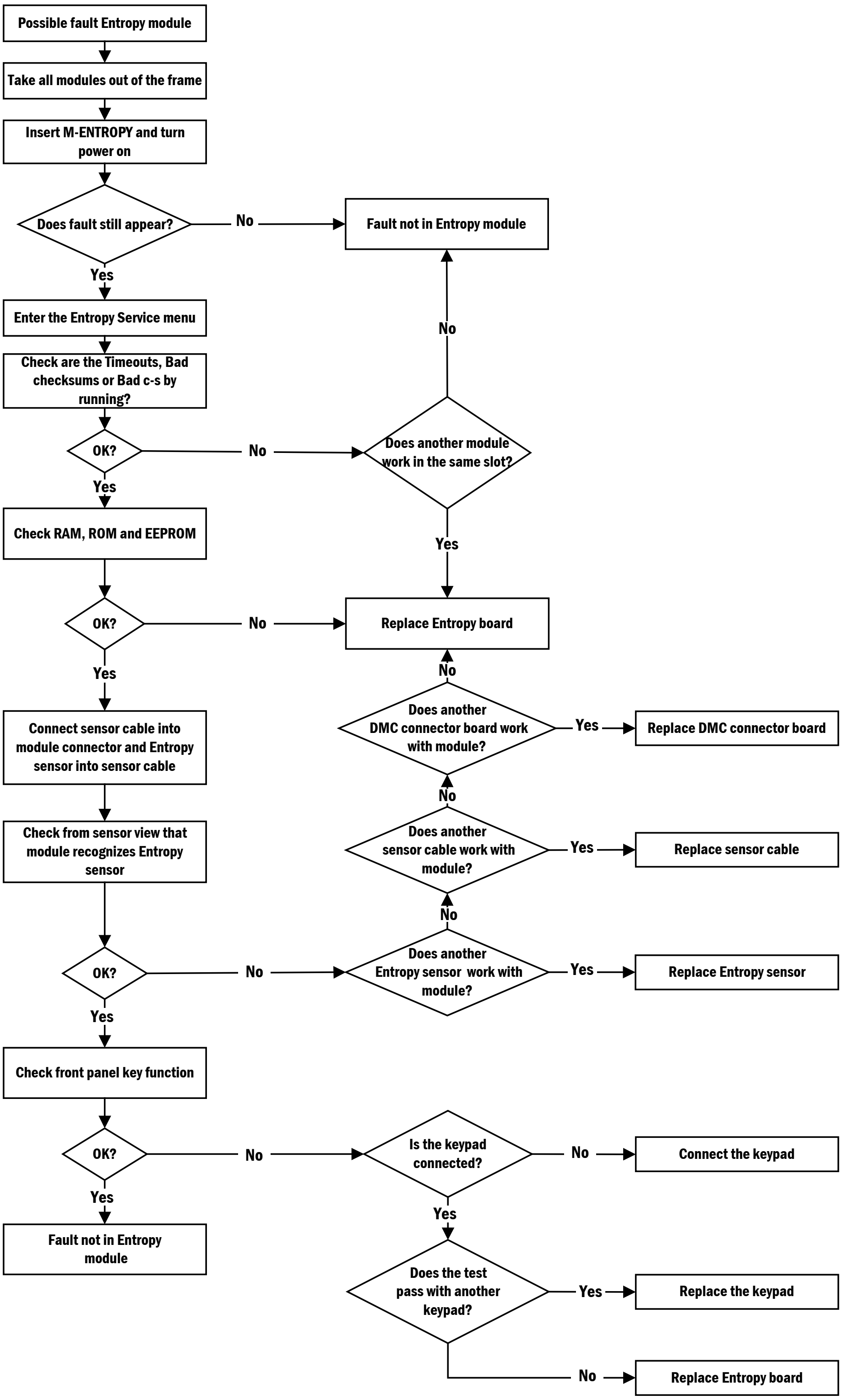
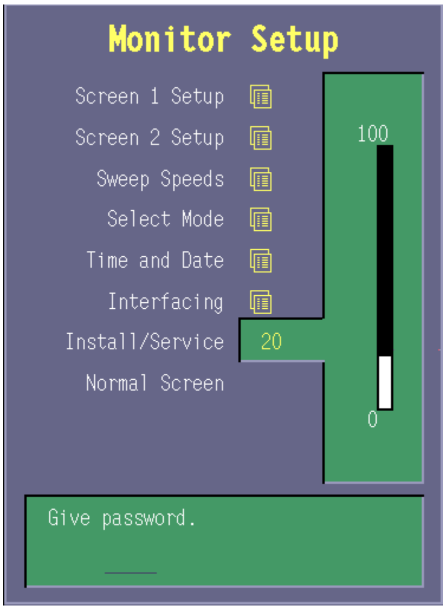
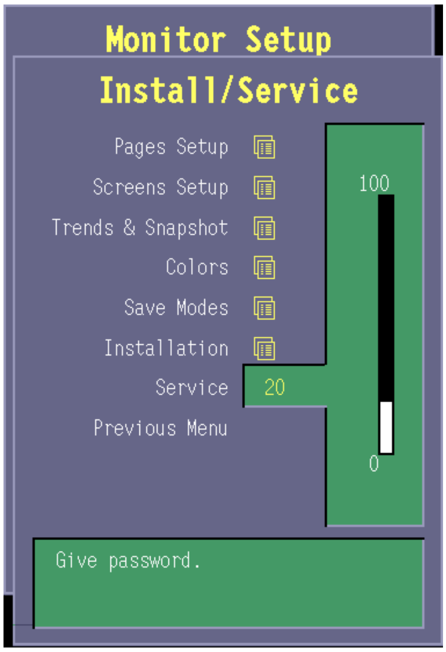


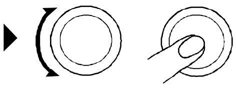

**Figure 4 Entropy module troubleshooting flowchart**

# 5 SERVICE MENU

NOTE: The Service Menu pictures are for reference only. Details on the menu page can vary depending on the software version.



Press the **Monitor Setup** key - select ***Install/Service*** (password: 16-4-34) - select ***Service*** (password: 26-23-8) - select ***Parameters - More... - Entropy***.

# 5.1 Entropy service menu

**Check Sensor** Module measures impedance of sensor electrodes. Works same way as from Entropy menu or module key.

**Module** Service data is changed to module view.

**Measurement** shows whether the Entropy measurement is ON or OFF. Measurement should start by itself when the sensor is attached to the patient

**Last service** shows the date of last maintenance**.**

**Entropy** refers to the respective module key. Is highlighted when Entropy key is pressed on module. (Opens the Entropy menu.)

**Check Sensor** is highlighted when the Check Sensor key is pressed on module. Activates the sensor check

**Mains** shows the currently used mains frequency, 50 or 60 Hz**:**

**BSR Status** shows Burst if the module is not currently detecting suppressed EEG. Shows Suppression if the module is detecting suppressed EEG periods.

**Artefact** shows Off if there is no high-frequency noise present, On if the module detects noise.

**Diathermy** shows On if the module is detecting diathermy (i.e., electrocautery)

**AD clipped** shows On if the signal is getting clipped at the A/D converter.

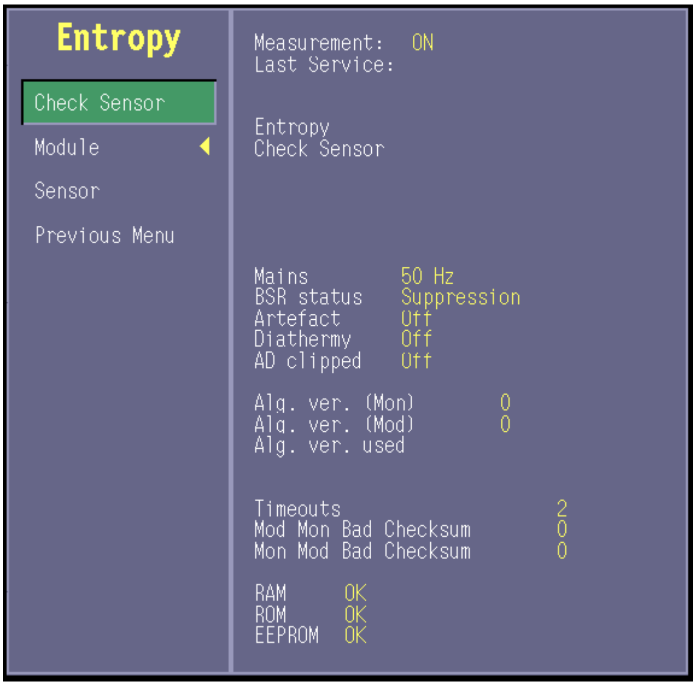
**Alg. ver. (Mon)** shows monitor algorithm version number.

**Alg. ver. (Mod)** shows module algorithm version number.

**Alg. ver. used** shows the currently used algorithm version.

**Mod Mon Timeouts** is a cumulative number that indicates how many times the module has not responded to monitor's inquiry.
**Mod Mon Bad Checksum** is a cumulative number that indicates how many times there has been an error in the message from module to monitor.
**Mon Mod Bad Checksum** is a cumulative number that indicates how many times there has been an error in the message from monitor to module.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum at the EPROM is accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in permanent memory are valid.The states in memory checks are **OK, Fail** or **?** (module not in place or a communication error).



**Sensor** Service data is changed to sensor view.

**Entropy** refers to the respective module key. Is highlighted when Entropy key is pressed on module. (Opens the Entropy menu.)

**Check Sensor** is highlighted when the Check Sensor key is pressed on module. Activates the sensor check.

**Cable** indicates whether the Entropy sensor cable is connected to the module or not.

**Sensor** indicates whether the Entropy sensor is connected to the cable or not.

**Sensor S/N** module reads manufacturing serial number form the sensor chip

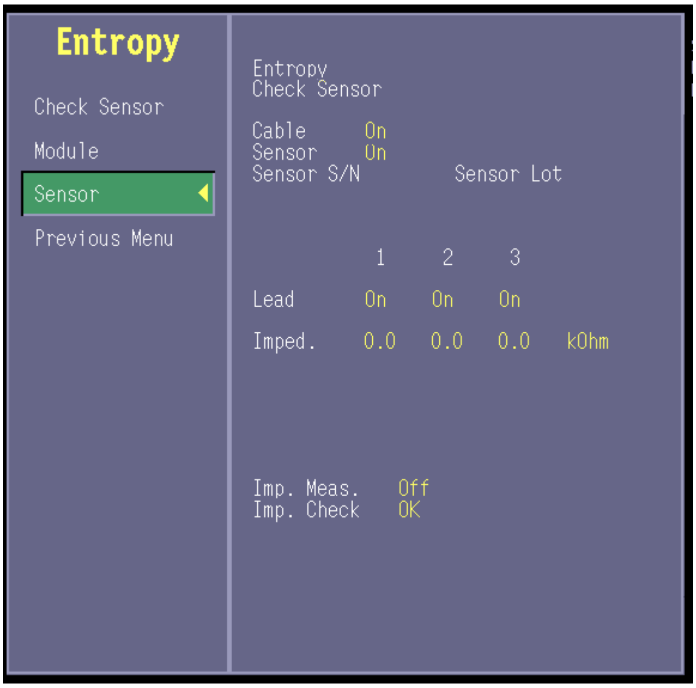
**Sensor Lot** module reads manufacturing lot number form the sensor chip

**Lead 1/2/3** shows the lead on/off status of all sensor electrodes.

**Imped. 1/2/3** shows the respective impedance value of each sensor electrode of last impedance check.

**Imp. Meas.** shows On if the Automatic check (sensor impedance measurement) is on in the module.

**Imp. Check** shows OK if the last impedance check has been succesful.



# 6 SPARE PARTS

## 6.1 Spare part list

NOTE: Accessories are listed in the *Patient monitor and supplies catalogue*.

### 6.1.1 M-ENTROPY

| Item | Description | Order code | Item | Description | Order code |
|---|---|---|---|---|---|
| 1 | Entropy board, M-ENTROPY | 8004787 | 7 | Membrane keypad | 880101 |
| 2 | IMC Connector board | 8004791 | 8 | Ferrite holder | 8005304 |
| 3 | Cross cylinder screw M3x8 | 628712 | 9 | Latch | 879181 |
| 4 | Metal frame | 879184 | 10 | Spring pin | 879182 |
| 5 | Screw M3x4 | 61719 | 11 | Module box<br>(single width) | 886167 |
| 6 | Front mask | 8004742 | 12 | Cross recess screw M3x8 | 616215 |
| 14 | Cross cylinder screw M3x12 | 628700 | 13 | Connector cable | 8005305 |

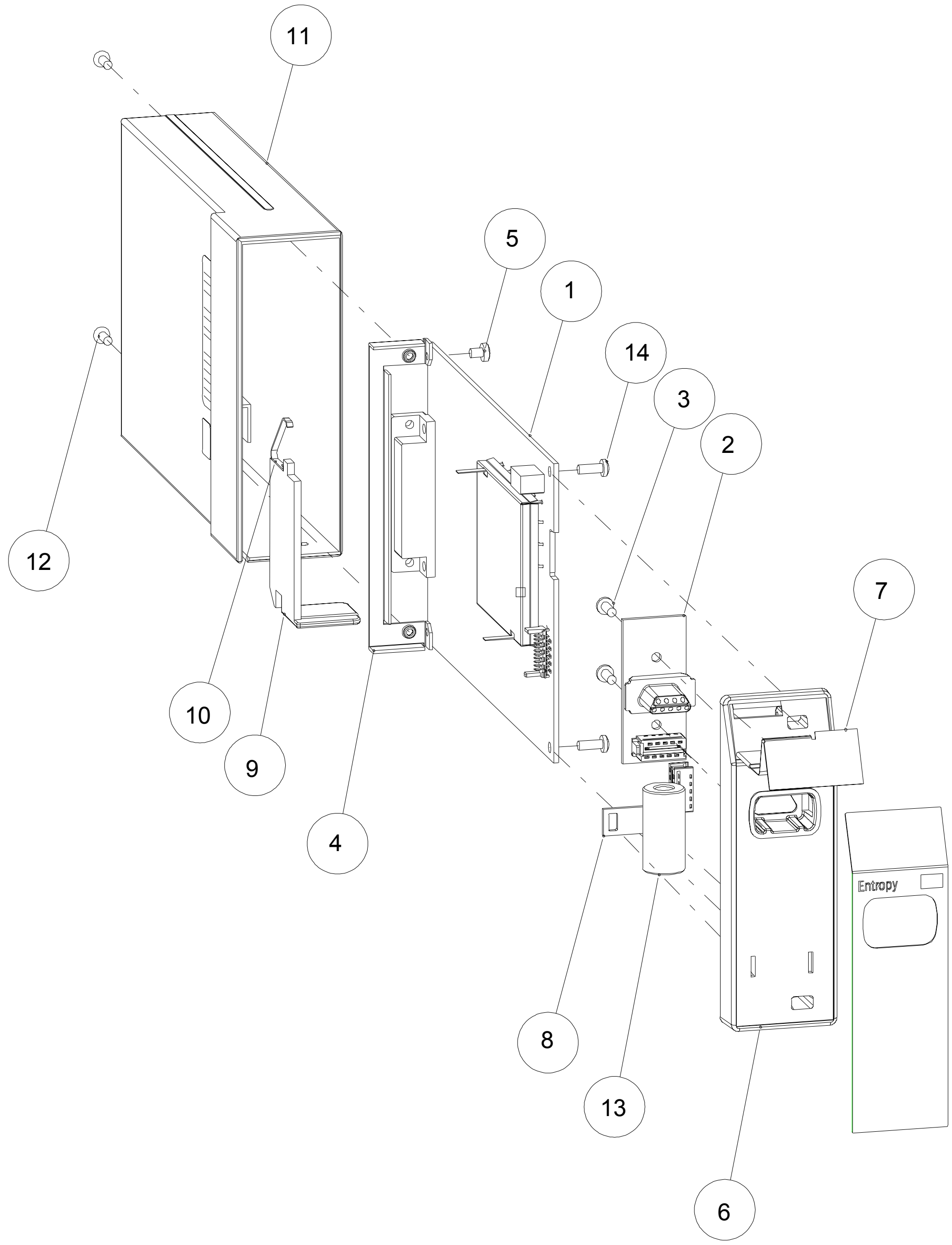



**Figure 5** **Exploded view of Entropy module**

### 6.1.2 Front panel stickers

| Adaptation | S/5 M-ENTROPY |
|---|---|
| DA | 8004757 |
| DE | 8004748 |
| EN | 8004747 |
| ES | 8004751 |
| FI | 8004754 |
| FR | 8004749 |
| IT | 8004752 |
| JA | 8004758 |
| NL | 8004750 |
| NO | 8004756 |
| PL | 8004759 |
| PT | 8004753 |
| SV | 8004755 |

# 7 EARLIER REVISIONS

| Revision | Manual slot/main manual | Note |
|---|---|---|

No previous revisions

# APPENDIX A

This page intentionally left blank.

# SERVICE CHECK FORM

## Entropy Module, M-ENTROPY

Customer ____________________

Service ____________ Module type ____________ S/N ____________

Service engineer ____________________ Date ____________

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts of module | ☐ | ☐ | ☐ |
| 3. Installation | ☐ | ☐ | ☐ | 4. Recognition of module | ☐ | ☐ | ☐ |
| 5. Recognition of sensor | ☐ | ☐ | ☐ | | | | |
| 7. Communication and memories of module | ☐ | ☐ | ☐ | | | | |
| 8. Membrane keys | ☐ | ☐ | ☐ | | | | |

6. Module software

| | |
|---|---|
| M-ENTROPY | |
| | |

9. Impedances

| | + | - | |
|---|---|---|---|
| Lead1 | | | 1...3 kΩ |
| Lead 2 | | | 1...3 kΩ |
| Lead 3 | | | 1...3 kΩ |

10. Checks with simulator

| | | Allowed range |
|---|---|---|
| EntrEEG waveforms | | 245...255 $\mu V_{pp}$ |
| RF value | | 8...12 |
| SE value | | 8...10 |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 11. Electrical safety check | ☐ | ☐ | ☐ | 12. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 13. Final cleaning | ☐ | ☐ | ☐ | | | | |

**Notes**

**Used Spare Parts**

**Signature**

# Datex-Ohmeda
# Hemodynamic Modules
# S/5™ PRESTN Module, M-PRESTN (Rev. 01)
# S/5™ RESTN Module, M-RESTN (Rev. 01)
# S/5™ PRETN Module, M-PRETN (Rev. 01)

## Technical Reference Manual Slot


All specifications are subject to change without notice.

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licenced practitioner. Outside the USA, check local laws for any restriction that may apply.


Document No. 8005571-1

April 2004



Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel: 1-608-221-1551 Fax: 1-608-222-9147

www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel: +358 10 394 11 Fax: +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## S/5 Hemodynamic Modules

# TABLE OF FIGURES

# INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the hemodynamic modules S/5 M-PRESTN/-RESTN/-PRETN. The modules are double width modules designed for use with S/5 monitors. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

Please also refer to *Technical Reference Manual* of the S/5 monitor for information regarding system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The M-PRESTN/-RESTN/-PRETN modules provide general hemodynamic parameters.

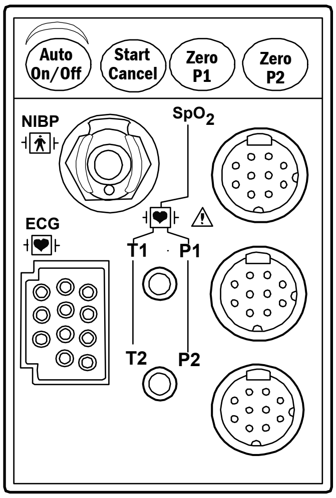



**Figure 1 S/5 PRESTN Module, M-PRESTN**

NOTE: Do not use identical modules in the same monitor simultaneously.
The following modules are considered identical:
M-ESTP/-EST/-ETP,
M-ESTPR/-ESTR/-ETPR,
M-NESTPR/-NESTR/-NETPR,
M-NE12STPR/-NE12STR/-NE12TPR
M-PRESTN/M-RESTN/M-PRETN

**Table 1 Options of S/5 hemodynamic modules**

| | Parameter | PRESTN | RESTN | PRETN |
|---|---|---|---|---|
| **P** | Two invasive blood pressures | • | | • |
| **R** | Impedance respiration | • | • | • |
| **E** | ECG | • | • | • |
| **S** | Pulse oximetry | • | • | |
| **T** | Two temperatures | • | • | • |
| **N** | NIBP | • | • | • |

NOTE: 12-lead ECG measurement requires Display Controller, B-DISP or B-DISPX.

Intended purpose (Indications for use)

The Datex-Ohmeda PRESTN module (model family M-PRESTN) and accessories are indicated for monitoring of hemodynamic parameters of all hospital patients. The hemodynamic parameters of the module comprise ECG including ST-segment and arrhythmia, Impedance respiration, NIBP, Temperature,SpO2 (including monitoring during conditions of clinical patient motion),and invasive blood pressure.

Impedance respiration measurement is indicated for patients aged 3 and up. The NIBP measurement is indicated for patients who weigh 5kg (11 lb.) and up. This device is indicated for use by qualified medical personnel only.

Monitor software compatibility

Datex-Ohmeda PRESTN rev. 01 module is designed for use with Datex-Ohmeda monitors using software as follows:
AM: L-ANE01(A) or later versions;
CCM: S-00C01 rev. 10.5, S-00C02 rev. 10.5 or newer versions;
CAM: S-00A05 rev. 10.9, S-00A06 rev. 10.9, L-00A07 rev. 10.9, L-00A08 rev. 10.9 or newer versions and
CCCM: S-00C03 rev. 10.9, S-00C04 rev. 10.9 or newer versions.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size | 75 × 180 × 112 mm |
| W × D × H | 3.0 × 7.1 × 4.4 in |
| Module weight | 0.7 kg / 1.5 lbs |
| Power consumption | about 6 W |
| Operation temperature | 10 to 40 °C / 50 to 104 °F |

## 1.2 Typical performance

### 1.2.1 NIBP

NOTE: Non-invasive blood pressure measurement is intended for patients weighing over 5 kg (11 lb.)

Oscillometric measurement principle.

| | | |
|---|---|---|
| Measurement range | adult | 25 to 260 mmHg |
| | child | 25 to 195 mmHg |
| | infant | 15 to 145 mmHg |
| Pulse rate range accepted | 30 to 250 bpm | |
| Measurement interval | STAT (continuous 5 min), 1, 2.5, 3, 5, 10, 15, 30 and 60 min (1 h), 2 and 4 h | |
| Typical measuring time | adult | 23 s |
| | infant | 20 s |
| Initial inflation pressure | adult | 170 ±10 mmHg |
| | child | 150 ±10 mmHg |
| | infant | 120 ±10 mmHg |
| Venous stasis | adult | 40 ±5 mmHg / 2 min |
| | child | 40 ±5 mmHg / 2 min |
| | infant | 30 ±5 mmHg / 1 min |
| Cuff widths | please see *User's Guide* | |

### 1.2.2 ECG

| | |
|---|---|
| Lead selection, 12-lead ECG | I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6 |
| Lead selection, other modules | I, II, III, aVR, aVL, aVF, V |
| Sweep speeds | 12.5, 25, 50 mm/sec |

**DISPLAY FILTER**

| | |
|---|---|
| Diagnostic, 12-lead ECG | 0.05 to 150 Hz |
| Diagnostic, other modules | 0.05 to 100 Hz |
| Monitoring | 0.5 to 30 Hz (-3 dB, with 50 Hz reject filter) |
| | 0.5 to 40 Hz (-3 dB, with 60 Hz reject filter) |

| | |
|---|---|
| ST filter | 0.05 to 30 Hz (-3 dB, with 50 Hz reject filter)<br>0.05 to 40 Hz (-3 dB, with 60 Hz reject filter) |

**HEART RATE FROM ECG**

| | |
|---|---|
| Range | 30 to 250 bpm |
| Accuracy | ±5 bpm or ±5 %, whichever is greater |
| Resolution | 1 bpm |
| Update interval | 5 s |
| Averaging time | 10 s |

**ST LEVELS (in main software)**

| | |
|---|---|
| ST level range | -9 to +9 mm (-0.9 to +0.9 mV) |
| Resolution | 0.1 mm (0.01 mV) |
| Averaging | calculated from 8 QRS |

**SYNCHRONIZATION**

| | |
|---|---|
| Direct ECG | analog output of ECG, 1 V/1 mV |
| Pacer | 5 V and 0.5 to 2.5 ms pulse, < 30 ms after pacer peak |
| Defibrillator | 5 V and 10 ms pulse, < 35 ms after R-point synchronization |

### 1.2.3 Pulse oximetry

| | |
|---|---|
| Measurement range | 0 to 100 % |
| Calibration range | 70 to 100 % |
| Accuracy[1] | 100 to 70 %, ±2 digits<br>±3 digits during clinical patient motion<br>69 to 0 %, unspecified |
| Display resolution | 1 digit = 1 % of $SpO_2$ |
| Display averaging time | 20, 10 sec, beat-to-beat |
| Pulse beep pitch | varies with $SpO_2$ level |

The monitor is calibrated against functional oxygen saturation $SpO_2$ func.

**PULSE RATE FROM PLETH**

| | |
|---|---|
| Measurement range | 30 to 250 bpm |
| Accuracy | 30 to 100, ±5 bpm,<br>100 to 250, ±5 % |
| Resolution | 1 bpm |
| Display averaging | 10 s |

Adjustable pulse beep volume.

**PLETH WAVEFORM**

| | |
|---|---|
| Scales | 2, 5, 10, 20, 50 mod%, Auto |

Start up scale is 20 mod% if AUTO is not selected to be the default setting.

### 1.2.4 Temperature

| | |
|---|---|
| Measurement range | 10 to 45 °C (50 to 113 °F) |
| Measurement accuracy | ±0.1 °C (25 to 45.0 °C) |

1 Accuracy is based on deep hypoxia studies with volunteered subjects during motion and non-motion conditions over a wide range of arterial blood oxygen saturations as compared to arterial blood CO-Oximetry.

| | |
|---|---|
| | ±0.2 °C (10 to 24.9 °C) |
| Display resolution | 0.1 °C (0.1 °F) |
| Temperature test | automatic (every 10 min) |
| Probe type | compatible with YSI 400 series |
| Single use sensors | ±0.2 °C (25 to 45.0 °C)<br>±0.3 °C (10 to 24.9 °C) |

### 1.2.5 Invasive blood pressure

| | |
|---|---|
| Measurement range | -40 to 320 mmHg |
| Measurement accuracy | ±2 mmHg or ±5 % |
| Zero adjustment range | ±150 mmHg |
| Calibration range | ±20 % |
| Scales | upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10 % of selected upper limit below zero. |
| Sweep speed | 12.5, 25, 50 mm/s |

**DIGITAL DISPLAY**

| | |
|---|---|
| Range | -40 to 320 mmHg |
| Resolution | ±1 mmHg |

**WAVEFORM DISPLAY**

| | |
|---|---|
| Range | -30 to 300 mmHg |

**PULSE RATE FROM ARTERIAL PRESSURE**

| | |
|---|---|
| Measurement range | 30 to 250 bpm |
| Resolution | 1 bpm |
| Accuracy | ±5 bpm or ±5 % whichever is greater |

### 1.2.6 Respiration

NOTE: The respiration measurement is intended for patients over three years old

| | |
|---|---|
| Measurement range | 4 to 120 bpm |
| Accuracy | ±5 bpm or ±5 % |
| Resolution | 1 bpm |
| Averaging time | 30 s |
| Update interval | 10 s |

**RESPIRATION WAVEFORM**

| | |
|---|---|
| Sweep Speeds | 6.25 mm/s and 0.625 mm/s |

# 1.3 Technical specifications

## 1.3.1 NIBP

| | | |
|---|---|---|
| Deflation rate, PR dep. | 3 to 8 mmHg/s | |
| Inflation time | 20 to 185 mmHg, 1 to 5 s | |

Automatic software control, max. inflation pressure

| | | |
|---|---|---|
| | adult | 280 ±10 mmHg |
| | child | 200 ±10 mmHg |
| | infant | 145 ±5 mmHg |

Over pressure limit, stops measurement after 2 seconds

| | | |
|---|---|---|
| | adult | 320 mmHg |
| | child | 220 mmHg |
| | infant | 160 mmHg |

The safety circuit limits the maximum cuff pressure to 320 mmHg in adult/child mode or 160 mmHg in infant mode. Independent timing circuit limits pressurizing (>15 mmHg) time to 3 minutes maximum in adult/child mode, and 90 seconds at (>5mmHg ) in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, inflation pressure is increased typically 50 mmHg.

| | | |
|---|---|---|
| Max. measurement time | adult | 120 s |
| | child | 120 s |
| | infant | 75 s |

Pressure transducer accuracy is better than ±3 mmHg or ±2 % whichever is greater.
Max. error ±4 mmHg.

| | |
|---|---|
| Protection against electrical shock | Type BF defibrillation proof |

## 1.3.2 ECG

| | |
|---|---|
| Defibrillation protection | 5000 V, 360 J |
| Recovery time | 5 s |
| Input impedance | >2.5 MΩ (10 Hz) |
| CMRR | ≥95 dB (ST) |
| System noise | <30 µV (p-p, RTI) |
| Allowable offset | ±800 mVDC |
| Gain range | 0.2 to 5.0 cm/mV |
| Pacemaker pulse detection | 2 to 700 mV, 0.5 to 2 ms pulses |
| Protection against electrical shock | Type CF defibrillator proof |

## 1.3.3 Pulse oximetry

| | |
|---|---|
| Protection against electrical shock | Type BF defibrillation proof |

### 1.3.4 Temperature

| | |
|---|---|
| Measurement accuracy | ±0.1 °C (25.0 to 45.0 °C)<br>±0.2 °C (10.0 to 24.9 °C) |
| Protection against electrical shock | Type CF defibrillation proof |

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please refer to the transducer/probe specification.

### 1.3.5 Invasive blood pressure

**DIGITAL DISPLAY AVERAGING**
Digital displays Art and P1 are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

| | |
|---|---|
| Accuracy | ±5 % or ±2 mmHg, whichever is greater |
| Transducer and input sensitivity | 5 μV/V/mmHg, 5 VDC, 20 mA max current |
| Filter | 0 to 4 - 22 Hz adjustable |
| Zero set accuracy | ±1 mmHg |
| Calibration resolution | ±1 mmHg |
| Zero time | less than 15 s |
| Protection against electrical shock | Type CF defibrillation proof |

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please refer to the transducer/probe specification.

### 1.3.6 Respiration

| | |
|---|---|
| Excitation frequency, 12-lead ECG | 31.25 kHz |
| Breath detection | automatic, range 0.3 to 6 Ω manually adjustable minimum detection: 0.2, 0.4, 0.6, 0.8, 1.0 |
| Input dynamic range | 0.2 to 32 Ω |
| Input impedance range | 100 to 5000 Ω |
| Respiration Rate | min. 4 bpm<br>max. 120 bpm |
| Lead off detection | >3 MΩ |

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 NIBP

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for the NIBP measurement:

- M-PRESTN/-RESTN/-PRETN module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

### 2.1.2 ECG

Electrocardiography analyzes the electrical activity of the heart by measuring the electrical potential produced with electrodes placed on the surface of the body.

ECG reflects:

- electrical activity of the heart
- normal/abnormal function of the heart
- effects of anesthesia on heart function
- effects of surgery on heart function

See the *User's Guide* or the *User's Reference Manual* for electrodes positions and other information.

### 2.1.3 Pulse oximetry

A pulse oximeter measures the light absorption of blood at two wavelengths, one in the near infrared (about 900 nm) and the other in the red region (about 660 nm) of the light spectrum. These wavelengths are emitted by LEDs in the $SpO_2$ probe, the light is transmitted through peripheral tissue and is finally detected by a PIN-diode opposite the LEDs in the probe. The pulse oximeter derives the oxygen saturation ($SpO_2$) using an empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation $SaO_2$.

In order to measure the arterial saturation accurately, pulse oximeters use the component of light absorption giving variations synchronous with heart beat as primary information on the arterial saturation.

A general limitation of pulse oximetry is that due to the use of only two wavelengths only two hemoglobin species can be discriminated by the measurement.

The modern pulse oximeters are empirically calibrated either against fractional saturation $SaO_2$frac;

$$SaO_2frac = \frac{HbO_2}{HbO_2 + Hb + Dyshemoglobin}$$ Formula 1

or against functional saturation $SaO_2$func;

$$SaO_2func = \frac{HbO_2}{HbO_2 + Hb}$$ Formula 2

Functional saturation is more insensitive to changes of carboxyhemoglobin and methemoglobin concentrations in blood.

The oxygen saturation percentage $SpO_2$ measured by the Datex-Ohmeda module is calibrated against functional saturation $SaO_2$func. The advantage of this method is that the accuracy of $SpO_2$ measurement relative to $SaO_2$func can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method, pulse oximeters are not able to correctly measure oxygen content of the arterial blood at elevated carboxyhemoglobin or methemoglobin levels.

## Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

## Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

## Probe

The standard probe is a finger clamp probe which contains the light source LEDs in one half and the photodiode detector in the other half. Different kinds of probes are available from Datex-Ohmeda.

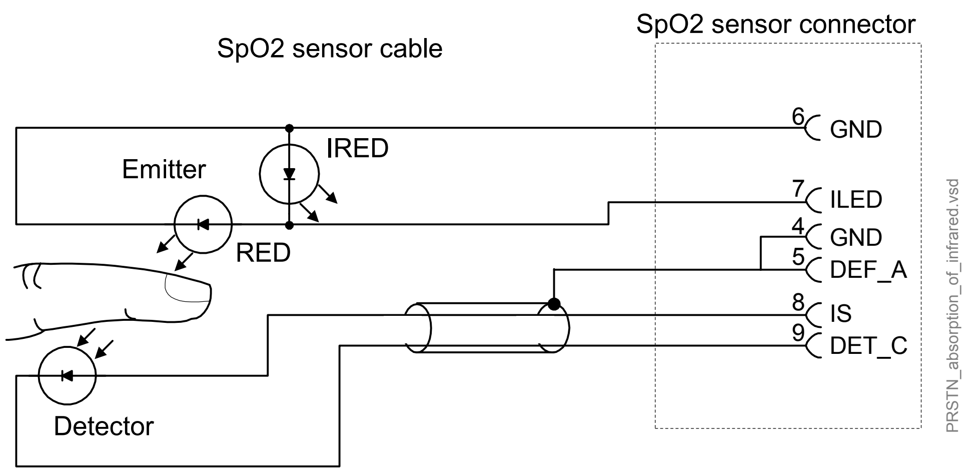



**Figure 2** **Absorption of infrared light in the finger probe, parts layout and schematic diagram**

### 2.1.4 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called NTC (Negative Temperature Coefficient) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it
- Applying a constant current through the resistor and measuring the voltage that is generated across it.

In Datex-Ohmeda modules the two methods are combined in the form of a voltage divider. The NTC-resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

### 2.1.5 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

### 2.1.6 Respiration

Impedance respiration is measured across the thorax between ECG electrodes. The respiration signal is made by supplying current between the electrodes and by measuring the differential current from the electrodes. The signal measured is the impedance change caused by breathing. From these impedance changes, respiration rate is calculated, and the respiration waveform is displayed on the screen.

## 2.2 Main components

### 2.2.1 M-PRESTN/-RESTN/-PRETN modules

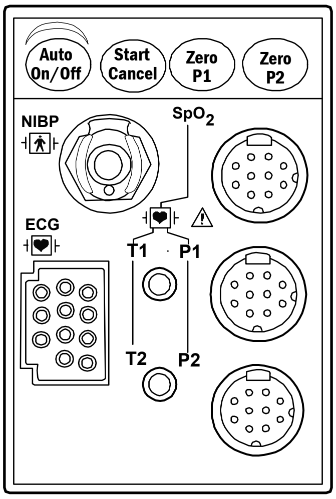



**Figure 3** **Front panel of M-PRESTN**

The **M-PRESTN, M-RESTN, and M-PRETN modules** contain three main PC boards, the STP board, the ECG board, and the NIBP board. They work independently. Each of these has their own processor and software in the processor flash memory.

There are two small boards, the SP input and the ECG input board attached to the front panel of the module. The front panel has seven connectors and four keys. The connectors are two for temperature measurement, two for invasive blood pressure measurement, one for ECG, one for NIBP, and one for $SpO_2$ measurement. The keys are for NIBP Auto On/Off, NIBP Start/Cancel, P1 zero, and P2 zero.

## 2.2.2 NIBP board

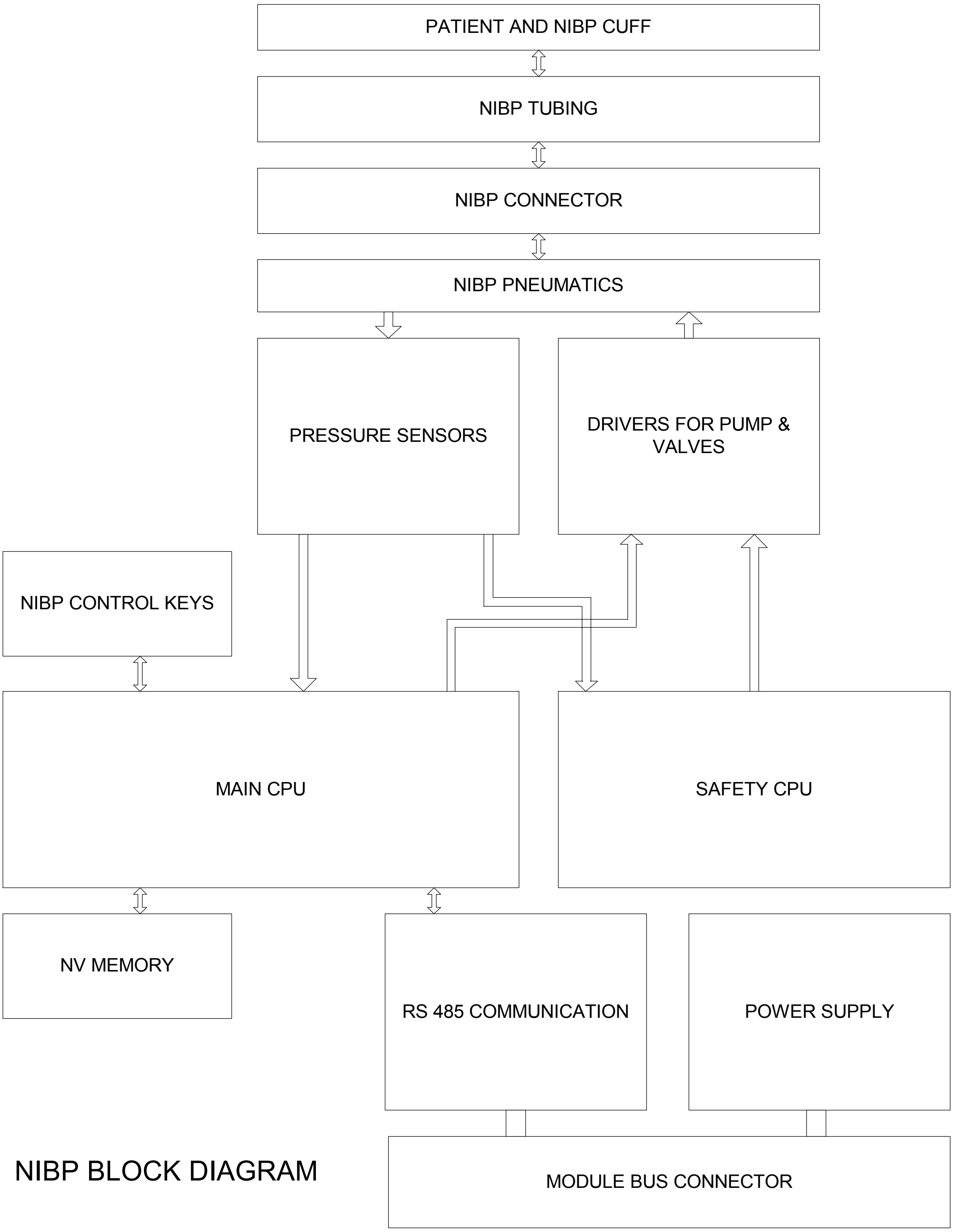



**Figure 4 NIBP board functional block diagram**

## Signal processing

Two signals from the pressure transducers are amplified and sent to the A/D converter. After the converter, digitized signals are sent to the microprocessor for data processing.

The NIBP board is controlled with a H8/3052 microprocessor at 16 MHz oscillator frequency.

## Memory

NIBP program memory (processor flash memory) size is 512k × 8. The processor has 4 kBytes RAM and there is also an external RAM memory the size of which is 128k x 8. Variable values of the NIBP measurement are stored into the external RAM. The EEPROM size is 512 x 8 and it is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and module serial number.

## Software control

Software controls valves and pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used at pump/valve failures.

In addition to external RS485 reset line the microprocessor system is equipped with its own power-up reset. See the section in the ECG board's description: *"RS485 communication"*

## Safety circuit

The NIBP board is equipped with an independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than the preset maximum measurement time, or if the pressure of the cuff is inflated over the specified pressure limit. The maximum measurement time values and pressure limits for different measurement modes have been specified in the technical specification section of this manual.

## Pneumatics

Pneumatics of PRESTN module has the following parts:

- **Intake air filter**; for preventing dust and other parts to enter the air pump and the valves.
- **Air pump**: for pumping the measuring pressure of the cuff.
- (**Pulse) Valve**; for producing a linear pressure fall (bleeding) in order to measure the blood pressure of the patient.
  Note that there has been used also two other names **Valve** and **Set valve** to designate pulse valve in service menu.
- **Safety valve**; The safety valve has been intended to be used for deflating the cuff in single fault case, i.e. to prevent too long measurement time or too high inflation pressure of the cuff.
  Note that there has been used also **Exh2 valve** to designate the **Safety valve** in service menu.
- **Main pressure sensor**; for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement.
- **Safety pressure sensor** for detection of cuff hose type, cuff loose, cuff occlusion situations etc.and recognising the pressure sensor fault.
- **Cuff connector**; for connecting the cuff.

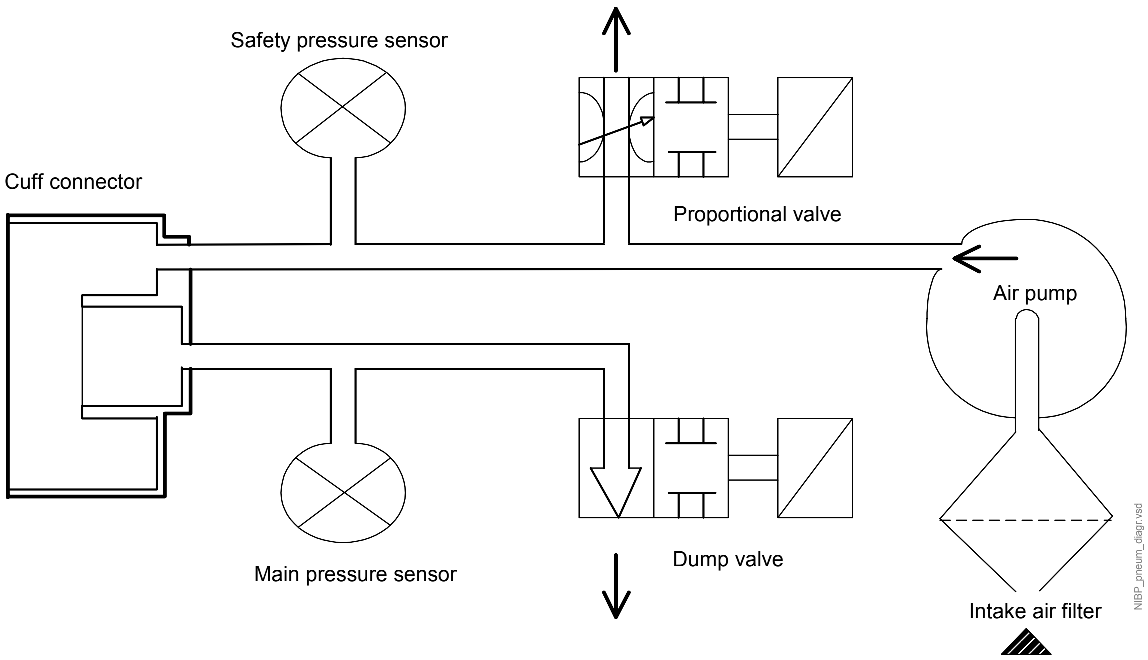



**Figure 5 NIBP pneumatics diagram**

## Power supply section of the NIBP board

All connections are established via 25-pin connector (D-type, female). The module needs +15 V (dirty) power supply to operate. The supply voltage (+15V) is generated in the power supply section of the S/5 monitor. The other voltages needed for the operation of the NIBP measurement are made on the NIBP board.

### 2.2.3 ECG board in 12-lead measurement

The 12-lead ECG measurement consists of the elements shown in Figure 6. All functions are located in the ECG board except the ECG input unit .

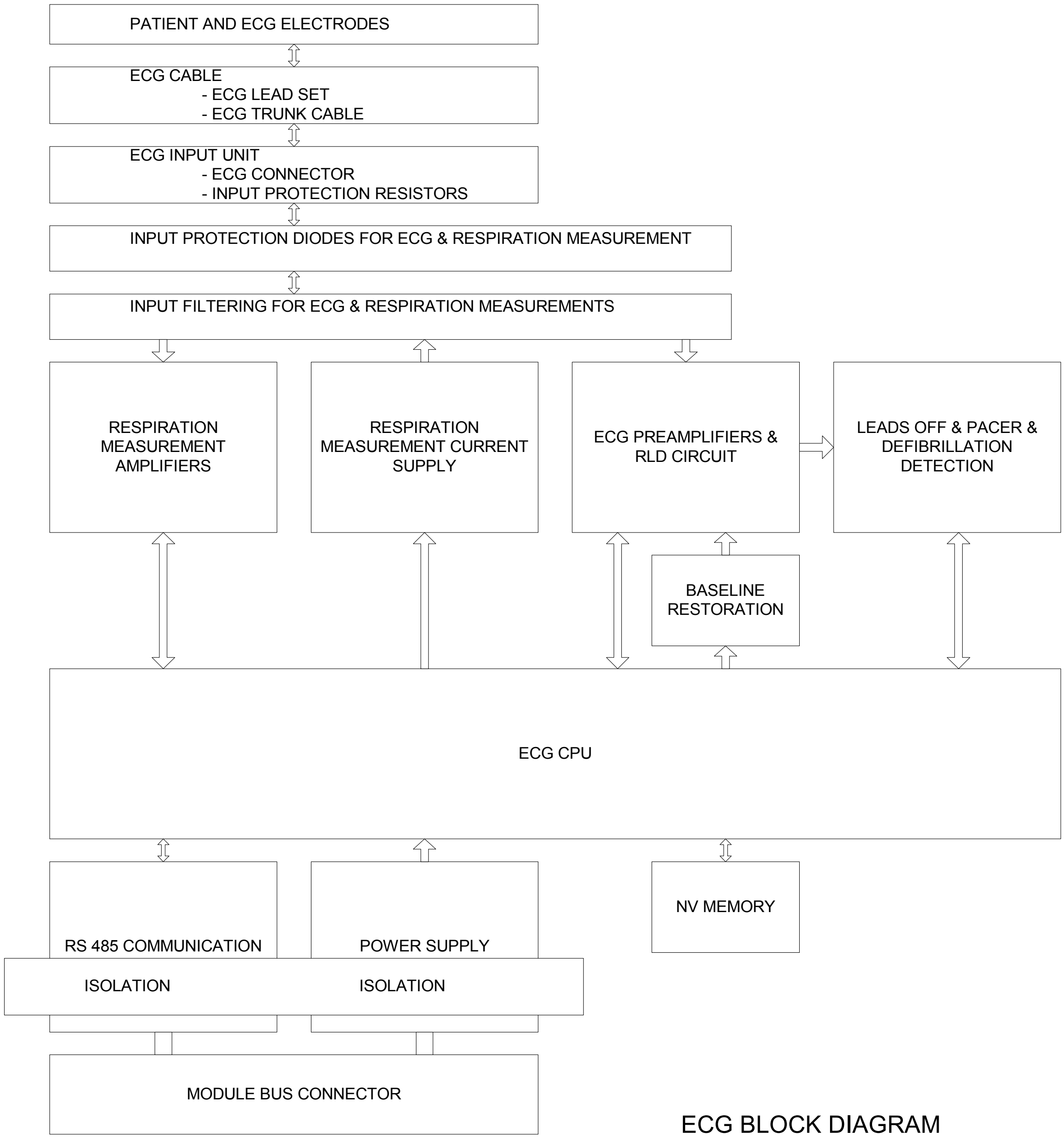



**Figure 6 12-lead ECG measurement block diagram**

## ECG input unit

The ECG input unit consists of the front panel connector and the ECG input connector board with the high voltage protection resistors. The connector for the 12-lead ECG cable is a green 11-pin rectangle shaped connector.

## Input protection and filtering

The input protection is implemented with high voltage protection resistors in the ECG input unit and with protection diodes in the ECG board. The input filtering for ECG measurement is done with passive RC filtering.

## ECG preamplifiers

The buffer amplifiers are used for each lead. The “Leads off” detection is implemented by measuring the output level of the input buffer amplifiers with A/D converter of CPU. The ECG signals are measured using differential amplifiers.

## ECG amplifiers and baseline restoration

The function of the ECG amplifiers and baseline restoration is to amplify the signal and to restore the baseline of the signal in the middle of the display after the change of the signal level e.g. after the change of the DC offset voltage.

## Pacer detection

Pacer detection has been made by using three slew rate detector circuits. The pacer detection amplifiers have been realized at the front of the slew rate detectors independently from the ECG measuring channels.

## Respiration impedance supply

The 31.25 kHz sine wave generator is used as the respiration measurement signal supply. Analog switches are used for connecting the sine wave to the ECG leads to be measured.

## Respiration impedance amplifiers

Buffer amplifiers are used in respiration measurement. Analog switches are used for selecting the measurement leads. There are also additional amplifiers for increasing the respiration signal gain. When ECG measurement is 5/12-lead, the respiration measurement is always done between R and F, independently on the ECG lead selection. When ECG measurement is 3-lead, then the respiration measurement is done at the same lead as the ECG measurement (I, II or III).

## ECG CPU

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

### RS485 communication

The communication to the CPU board of the monitor uses RS485 protocol. The RS485 driver circuits are optically isolated from the processor of the module. PWM signal is used for direct ECG signal. Direct ECG signal is available from the X2 connector of the UPI board or from the PT module.

### Power supply

The ECG board has a driver controlled half bridge switching power supply with 5 kV isolation. The supply voltages have been regulated with linear regulators.

## 2.2.4 ECG filtering

The S/5 monitors have three ECG filtering modes:

| | |
|---|---|
| MONITORING | 0.5 to 30 Hz (with 50 Hz reject filter)<br>0.5 to 40 Hz (with 60 Hz reject filter) |
| DIAGNOSTIC 12-lead ECG | 0.05 to 150 Hz |
| ST FILTER | 0.05 to 30 Hz (with 50 Hz reject filter)<br>0.05 to 40 Hz (with 60 Hz reject filter) |

The purpose of filtering is to reduce high frequency noise and low frequency (e.g. respiratory) movement artifacts.

Monitor filter is used in normal monitoring. Diagnostic filter is used if more accurate diagnostic information is needed. ST filter gives more accurate information of ST segment, but reduces high frequency noise.

The high-pass filters 0.5 Hz and 0.05 Hz are done with software. The monitor sends a command to the hemodynamic module determining which of the corner frequencies 0.5 Hz or 0.05 Hz is to be used.

The 50 Hz and 60 Hz reject filters are both low-pass filters with zero at 50 Hz or 60 Hz correspondingly. They are software based filters used for the mains supply filtering. With these filters the 3 dB value for low-pass filter is 30 Hz or 40 Hz.

In diagnostic mode the upper frequency is 150 Hz and it is limited by software.

## 2.2.5 STP board

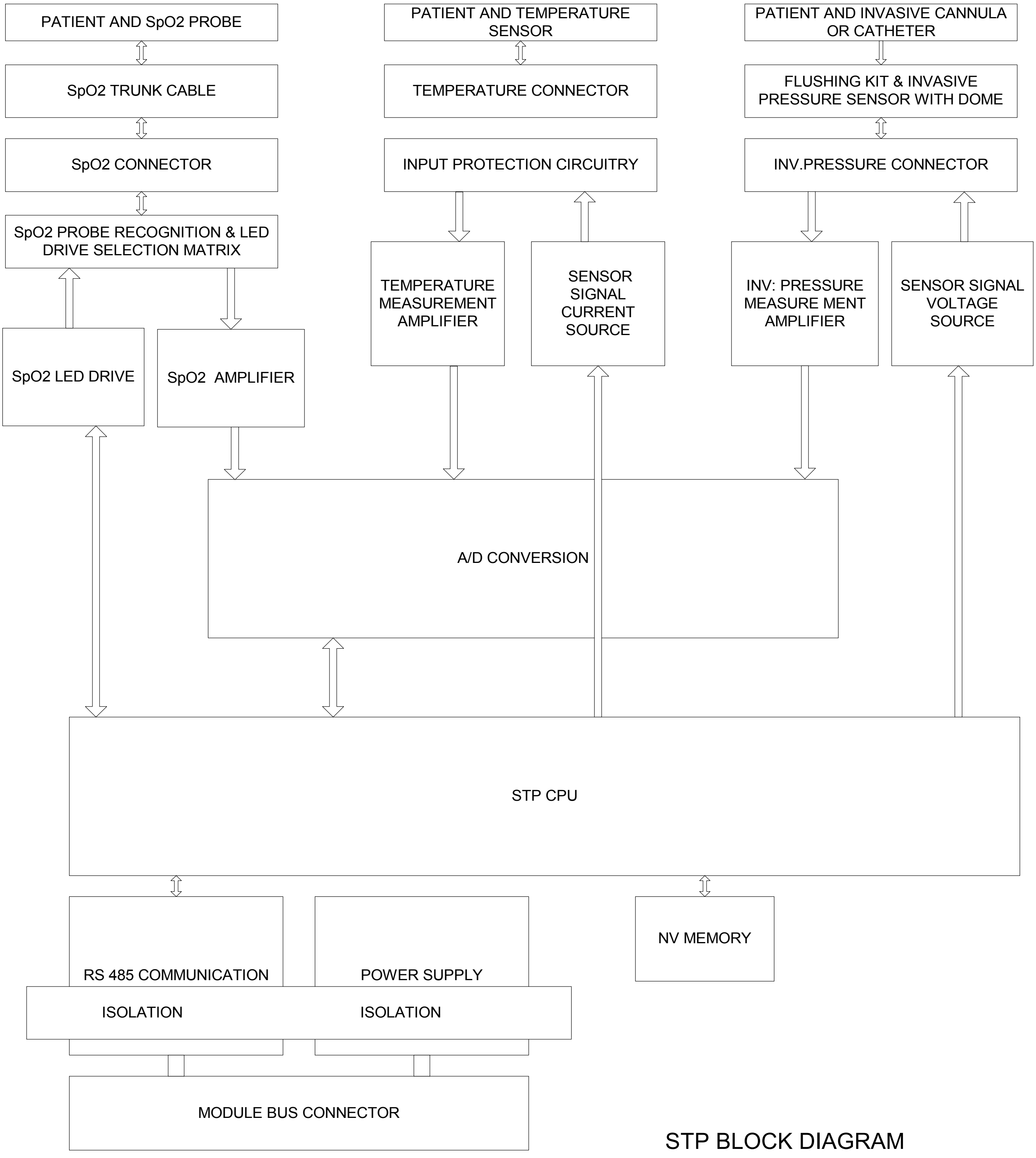



**Figure 7 STP board block diagram**

## Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

## Temperature measurement unit

The NTC-resistor value in the probe depends on the patient's temperature. It is measured with the following principle described below.

The constant current source is supplied about 7μA current through the temperature sensor (YSI 400-series NTC resistor). The constant current is caused a voltage over the temperature sensor (NTC resistor). The voltage over the temperature sensor is amplified in a differential amplifier stage. The amplified voltage is transferred to a controller of the STP board through an A/D converter.

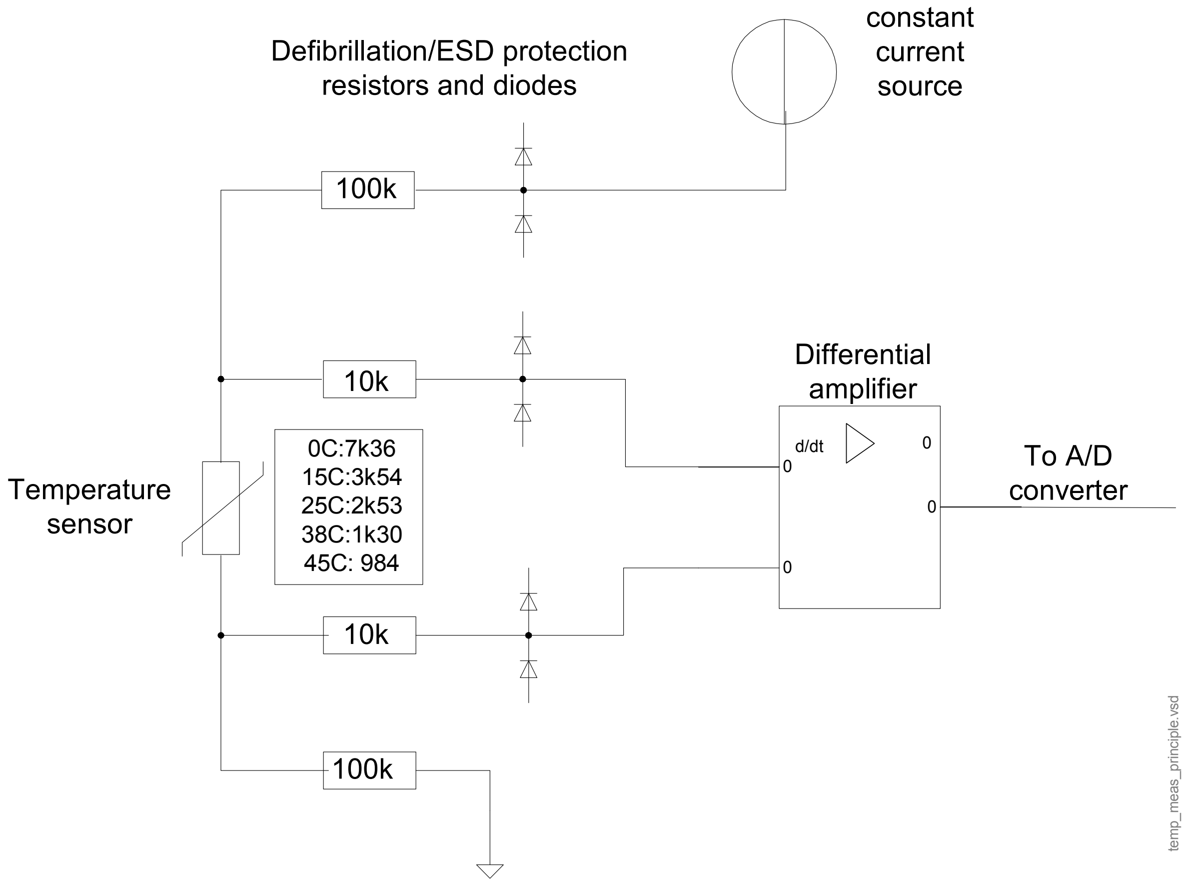



**Figure 8** **Temperature measurement principle**

## Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\text{ V}$, where $U_{in}$ is 5 V

$\Rightarrow U_{out} = 25\text{ V} \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

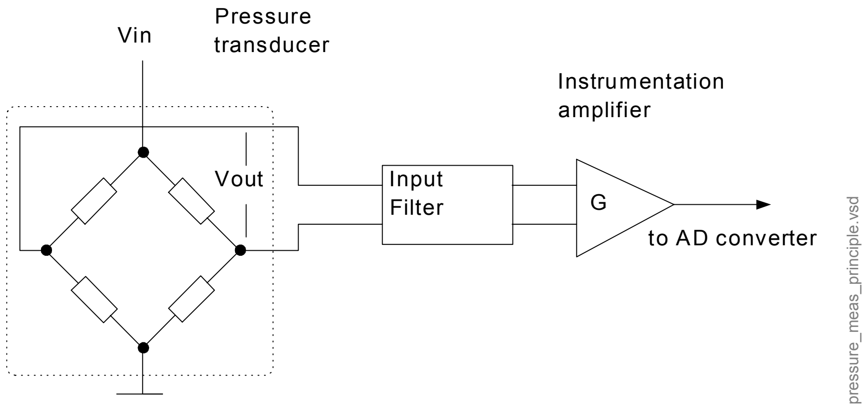



**Figure 9 Pressure measurement principle**

## Pulse oximetry measurement section

### LED control signals

The D/A converters of the microcontroller on STP board set the LED intensity adjustment values for the infrared- and red LEDs of SpO2 probe. The microcontroller on the STP board switches ON ( to the adjusted intensity ) and OFF the SpO2 probe LEDs according to the predetermined sequence.

### LED driving circuit

Differential amplifiers measure the LED currents (LED current indication) of SpO2 probe over the shunt resistors placed in the LED current paths. The LED driving voltages (LED voltage indication) are measured from the driver circuitry. The LED driving circuits also have MOSFET transistor matrix to enable the use of different probe configurations.

### Measured signal preamplification

The preamplifier is bipolar/single-ended current-to-voltage converter with adjustable gain. A higher gain is used for measuring thin tissue. The preamplification stage has also ambient light reduction and second amplifier stage.

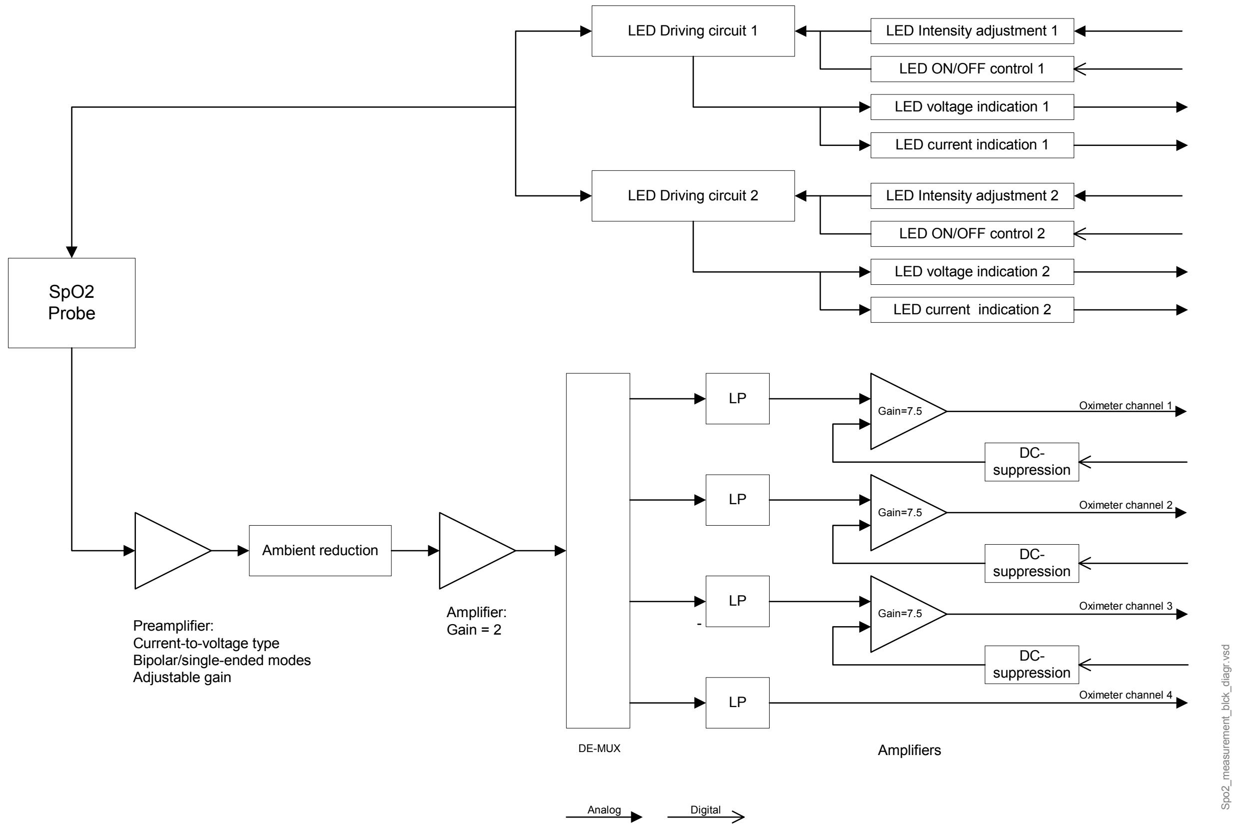



**Figure 10 Pulse oximetry measurement block diagram**

## Red and infrared channel separation

The detector signal is possible to multiplex to four different channels depending on the content of the signal. The detector signal must at least multiplex into infrared- and Red signals. Other channels are for e.g. diagnostic purposes.

## Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. Data transmission rate is 500kbps.

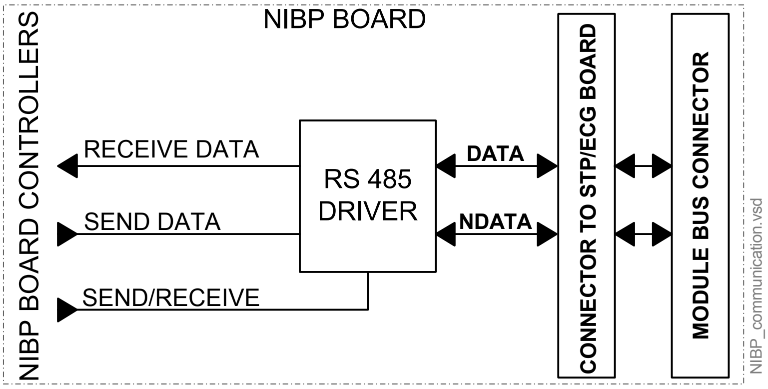



**Figure 11 Serial communication of NIBP board**

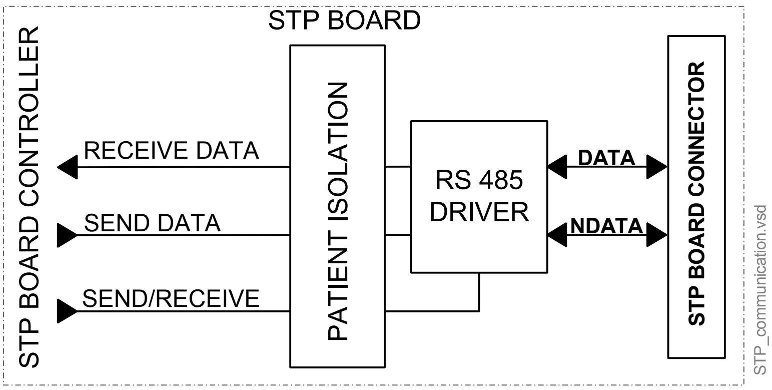



**Figure 12 Serial Communication and Isolation of STP board**

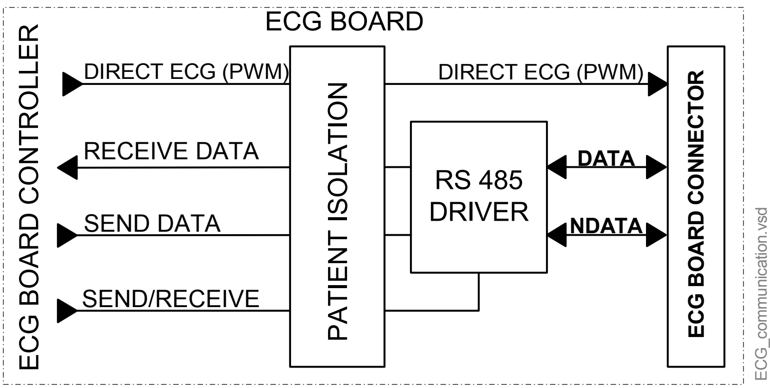



**Figure 13 Serial Communication and Isolation of ECG board**

#### Signals and isolation barrier

The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

#### Power supply section

The power for the electronics on the floating part of the STP and the ECG boards is made on each board with the switching power supplies connected to a high voltage isolated transformer. The switching power supplies on the STP and ECG boards are synchronized to the frequency, about 340kHz of the switching power supply on the NIBP board. The PRESTN module uses only +15VD voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. Each measuring board is protected against overloading with PTC type automatic fuses.

## 2.3 Connectors and signals

### 2.3.1 Module bus connector (on the NIBP board)

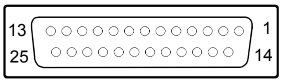



**Figure 14 Module bus connector (X1) pin layout**

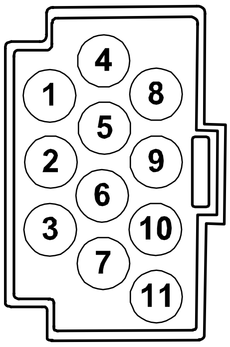
**Table 2 Module bus connector description**

Only the shaded signals of the table below are valid for the PRESTN module

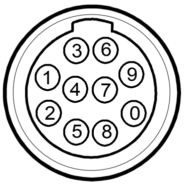
| Pin No | I/O | Signal | Note |
|---|---|---|---|
| 1 | I | RESET_RS485 | |
| 2 | I | -15 VDC | |
| 3 | I | +15 VDIRTY | |
| 4 | I | +15 VDC | |
| 5 | I/O | NDATA_RS485 | |
| 6 | I/O | DATA_RS485 | |
| 7 | | Ground & Shield | |
| 8 | I | -RESET_RS485 | |
| 9 | I | CTSB | |
| 10 | O | RTSB | |
| 11 | I | RXDB | |
| 12 | O | TXDB | |
| 13 | | Ground & Shield | |
| 14 | I | +32 VDIRTY | |
| 15 | I | GroundDIRTY | |
| 16 | I | CTSC | |
| 17 | O | RTSC | |
| 18 | I | RXDC | |
| 19 | O | TXDC | |
| 20 | | ON/STANDBY | |
| 21 | O | PWM_ECG | |
| 22 | | RXDD_RS232 | |
| 23 | | TXDD_RS232 | |
| 24 | I | +5 VDC | |
| 25 | I | +5 VDC | |

## 2.3.2 Front panel connectors

**Table 3 Front panel connectors**

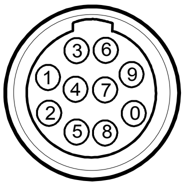
| ECG Connector | Pin No | Signal Name |
|---|---|---|
|  | 1<br>2<br>3<br>4<br>5<br>6<br>7<br>8<br>9<br>10<br>11 | R/RA; Right arm electrode<br>C2/V2; Chest electrode<br>C3/V3; Chest electrode<br>L/LA; Left arm electrode<br>N/RL; Neutral/ Right Leg Drive electrode<br>C1/V1; Chest electrode<br>C4/V4; Chest electrode<br>F/LL; Left Leg electrode<br>C6/V6; Chest electrode<br>C5/V5; Chest electrode<br>Cable Shield |

### $SpO_2$ connector ($SpO_2$)



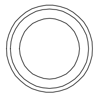
| Pin No | Signal |
|---|---|
| 1 | Feedback resistor |
| 2 | Ground |
| 3 | Not Connected |
| 4 | Cable shield + probe identification ground |
| 5 | Probe identification |
| 6 | LED drive ground |
| 7 | LED drive current |
| 8 | Input signal current |
| 9 | Ground |
| 10 | Ground |

### Invasive blood pressure connectors (P1, P2)



| Pin No | Signal |
|---|---|
| 1 | Pressure + |
| 2 | Pressure - |
| 3 | Polarisation - (ground) |
| 4 | Polarisation + |
| 5 | Not connected |
| 6 | Not connected |
| 7 | Not connected |
| 8 | Not connected |
| 9 | Ground |
| 10 | Cable detection |

### Temp connector (T1, T2)



| Pin No | Signal |
|---|---|
| 1 | Temperature probe |
| 2 | Temperature probe |

### 2.3.3 Test points on boards

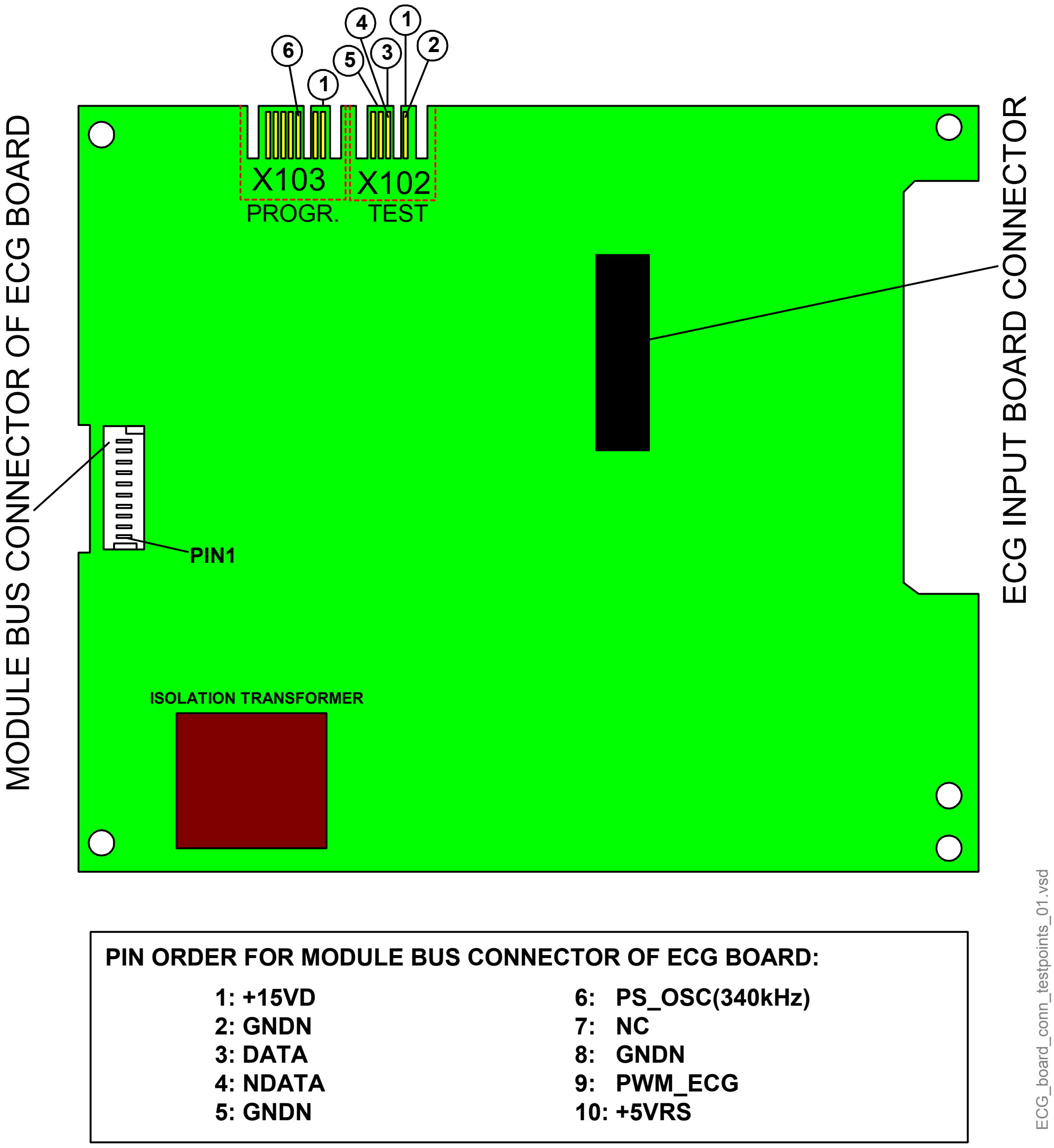
#### 12-lead ECG board

**Test pins (strips) of X103:**

| | |
|---|---|
| Component side: | 6: +5VD |
| Solder side: | 1: GNDF |

**Test pins (strips) of X102:**

| | |
|---|---|
| Component side: | 2: 2.5V<br>4: 2.5Vref |
| Solder side: | 1:+5VA<br>3: +2.5V_R<br>5: GNDF |




**PIN ORDER FOR MODULE BUS CONNECTOR OF ECG BOARD:**

| | |
|---|---|
| 1: +15VD | 6: PS_OSC(340kHz) |
| 2: GNDN | 7: NC |
| 3: DATA | 8: GNDN |
| 4: NDATA | 9: PWM_ECG |
| 5: GNDN | 10: +5VRS |

**Figure 15 ECG board connectors and test points**

## NIBP board

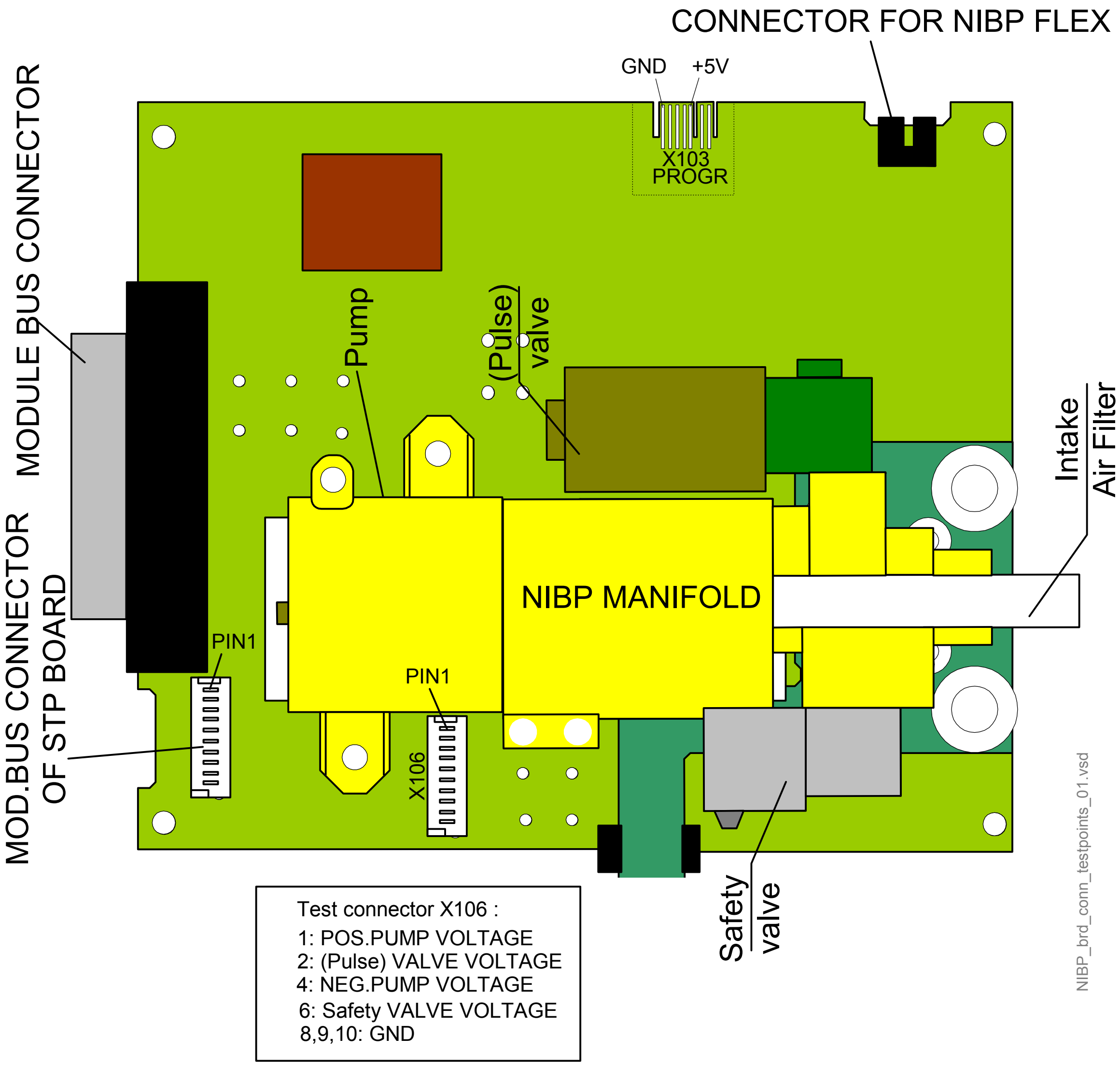
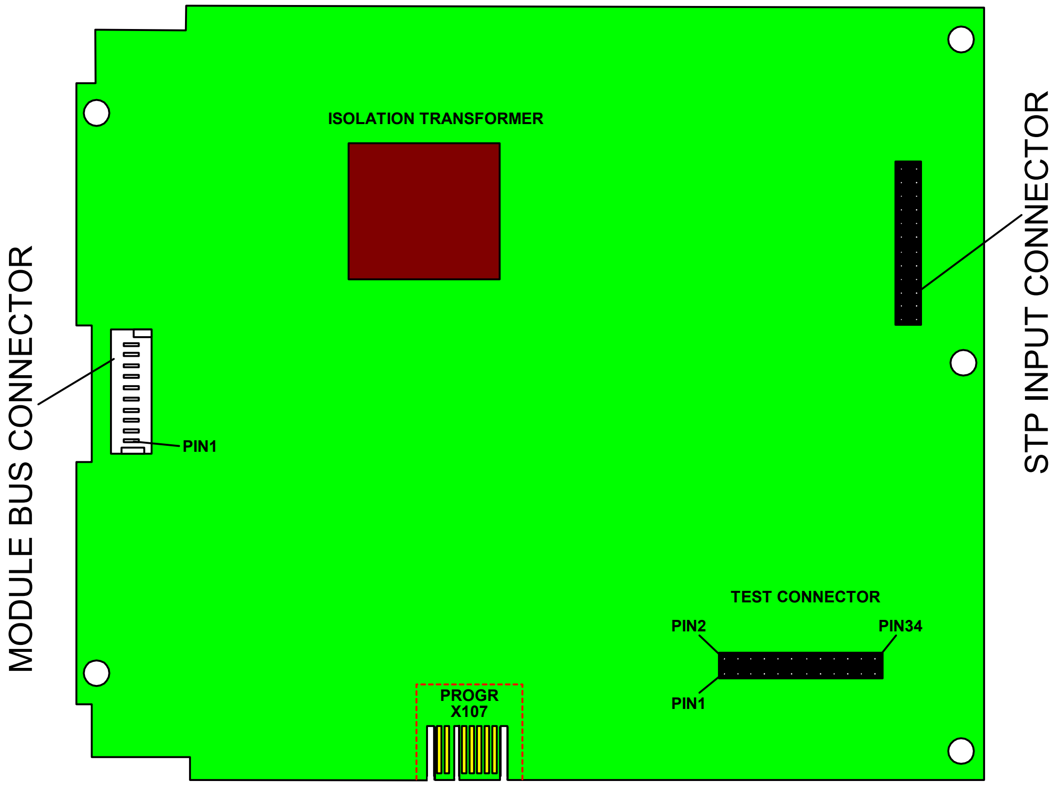



**Figure 16** **NIBP board connectors and test points**

## STP board




**TEST CONNECTOR PIN ODER:**

19: +2.3V(ref.voltage)
20: GNDF
21: +6V(non regulated)
22: GNDF
23: +4.5V(ADC ref. voltage)
24: GNDF
25: +5V
26: GNDF
27: +5V(analog)
28: GNDF
29: +5VLED
30: GNDF

STP_brd_conn_testpoints_01.vsd

**Figure 17 STP board connectors and test points**

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the hemodynamic modules is limited to replacing faulty printed circuit boards or mechanical parts. Faulty printed circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair; however, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form , which should be filled in when performing the procedures.

The mark in the instructions means that the performed procedure should be signed in the check form.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Patient simulator | - | |
| Pressure manometer | - | |
| Temperature test set | 884515 | |
| Multi-link 3-leadwire set | | |
| Multi-Link 5-leadwire set V2-V6 | | |
| Multi-Link 5-leadwire set C2-C6 | | |
| Multi-Link 12-lead ECG trunk cable | | |
| $SpO_2$ finger probe | OXY-F4-N or SAS-F4 | |
| InvBP transducer | | |
| Adult NIBP cuff & hose | | |
| Infant NIBP cuff & hose | | |
| Screwdriver | | |

### 3.2.2 Recommended parts

| Part | Order No. | Notes |
|---|---|---|
| NIBP pump filter | 57142 | |

## All modules

Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.

1. Check internal parts:

– screws are tightened properly

– cables are connected properly

– all IC's that are on sockets are attached properly

– EMC covers are attached properly

– there are no loose objects inside the module

2. Check external parts:

– the front cover and the front panel sticker are intact

– all connectors are intact and are attached properly

– the module box, the latch and the spring pin are intact

3. Replace the NIBP pump filter in PRESTN/RESTN/PRETN modules, if necessary.

- Reattach the module box and check that the latch is moving properly.
- Switch the monitor on and wait until the monitoring screen appears. Configure the monitor screen so that all the needed parameters are shown, for example as follows:

**Monitor Setup** - ***Waveform Fields -***

***Field 1 - ECG1***
***Field 2 - ECG2***
***Field 3 - P1***
***Field 4 - P2***
***Field 5 - Pleth***
***Field 6 - Resp***
***Digit Fields - Lower Field 2 - NIBP***
***Lower Field 3 - T1+T2***

4. Plug in the module. Check that it goes in smoothly and locks up properly

   ✍

5. Check that the module is recognized, i.e. all needed parameter information, except invasive blood pressure, starts to show on the screen.

   ✍

   Preset ECG, Respiration, InvBP and $SpO_2$ measurement settings:

   **ECG** ***- ECG Setup - Hr Source - Auto***
   ***Pacemaker - Show***

   **Others** ***- Resp Setup - Size - 1.0***
   ***Resp Rate Source - Auto***
   ***Measurement - On***
   ***Detection Limit - Auto***

   **Invasive Pressures** ***- P1 'Art' Setup - Label - Art***
   ***P2 'Cvp' Setup - Label - Cvp***

   **Pulse Oximetry** ***- Pleth Scale - Auto***

## ECG measurement

6. Enter the service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***-***
   ***Service*** (password 26-23-8) ***- Parameters***

   Take down the information regarding module software by selecting ***Scroll Vers*** and turning the ComWheel.

   ✍

7. Enter the ESTP: ECG service menu:

   Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second. Check also that the ECG/RESP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' state all OK.

   ✍

8. Check that the power frequency value is set according to the current mains power frequency. Change the setting by selecting ***Power Freq***, if necessary.

   ✍

9. Connect a 12-lead ECG trunk cable without a lead set to the module. Check that the message "Leads off" is displayed on the screen.

   ✍

10. Connect both 5-leadwire sets to the trunk cable. Connect limb lead electrodes and one electrode from the chest lead set to the same potential. Check that the ‘Cable type’ shows 10 lead.

    ✍

11. Change the 3-leadwire set to the trunk cable. Check that all the electrodes show OFF in the service menu and the message ‘Leads Off’ is shown on the screen.

    Connect all the leads together, for example to a suitable screwdriver. Check that all the electrodes show ON and the message ‘Asystole’ appears.

    Disconnect one of the leads and check that the corresponding electrode in the service menu shows OFF within 10 seconds from the disconnection, and then reconnect the lead. Check the rest of the leads using the same method.

    NOTE: When the ground lead (black) is disconnected all the electrodes should show OFF.

    NOTE: The ‘Asystole’ and ‘Different leads off’ messages are shown using certain priority, so even when one of the leads is disconnected, the lead related ‘Leads off’ message may not appear onto the screen.

    NOTE: When RA, LA or LL electrode is disconnected, all six V electrodes show OFF.

    NOTE: With PRESTN/RESTN/PRETN modules and 5 lead cable the state of V2, V3, V4, V5 and V6 electrodes follow the state of the V electrode.

    Connect the leads to a patient simulator.
    Perform the settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    ECG - BASE - BPM - 160
    PACE - WAVE - NSR

    Check that normal ECG waveform is shown, the HR -value is 160 (±5) and the ‘Pacer count’ -value is not increasing in the service menu.

    ECG - PACE - WAVE - ASNC

    Check that pacemaker spikes are shown on the ECG waveform, the ‘HR’ -value changes to 75 (±5) and the ‘Pacer count’ -value is increasing according to shown pacemaker spikes.

    Set the pacemaker option off:

    ECG - PACE - WAVE - NSR

    ✍

## Respiration measurement

12. Check that the 'Resp Available' and 'RESP Measurement' show both ON in the ESTP: ECG service menu.

13. Check the respiration measurement with a patient simulator.

The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

BASELINE IMPEDANCE -<u>switch</u> - 500
LEAD SELECT-<u>switch</u> - II/RL-LL

RESP - WAVE - NORM
RATE - 20
OHMS - 1.0
RATIO - 1/1
APNEA - OFF
SHIFT - OFF

Check that the RESP waveform is shown and the 'RR' -value is 20 (±5). Change the position of the BASELINE IMPEDANCE -switch and check that appropriate RESP waveform and 'RR' -value are shown again within 30 seconds.

RESP - APNEA - 32 S

Check that the monitor activates the APNEA -alarm.

NOTE: Make sure that only the ECG leads are connected to the simulator during the apnea -test. If other cables are connected at the same time, the respiration signal from the simulator may be disturbed, and therefore, the APNEA -alarm may not be activated.

NOTE: When you have ECG service menu open, spikes will appear on the respiration waveform. These spikes represent the threshold level for detecting inspiration and expiration.

## Temperature measurement

14. Enter the ESTP: STP service menu:

***Parameters - ESTP : STP***

Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values do not increase faster than by 5 per second. Check also that the STP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' show all OK.

15. Check that the 'Cable' and 'Probe' show OFF for both channels, T1 and T2, when no probes are connected.

Connect a temperature test plug into the connector T1. Check that the 'Cable' and 'Probe' for

T1 show ON and the corresponding temperature value appears onto the monitor screen. Perform the same check also for the channel T2.

16. Check the temperature calibrations using temperature test plugs.
    If the deviation on a temperature reading on the screen is more than 0.1 °C, calibrate the temperature channels according to the instructions in the chapter 3.4.2 *Temperature calibration*.

17. Activate the temperature test by selecting ***Temp Test*** from the menu and pressing the ComWheel twice. When the message 'Performing temp test' disappears from the digit field, check that no error messages appear and 'Temp error' shows OFF for both channels in the service menu.

18. Check that the module configuration has been set correctly. The configuration in use is shown beside the text 'Configuration' in the service menu and it can be either STP, ST or TP. Change the configuration in the ***Calibrations*** menu, if necessary.

## Invasive blood pressure measurement

19. Check the front panel membrane keys that are related to the InvBP measurement.
    Press each of the keys at least for one second. Check that the pressed key is identified, i.e. one of the texts for 'Buttons' changes from OFF to ON in the service menu.

20. Check that the 'Cable' and 'Probe' for P1 show OFF. Plug a cable with an invasive blood pressure transducer into the front panel connector P1 and check that the 'Cable' and 'Probe' show ON and the corresponding pressure waveform appears onto the screen.

    Perform the same check also for the InvBP channel P2.

21. Calibrate the InvBP channels P1 and P2 according to the instructions in the chapter. *Invasive pressure calibration*

22. Check the InvBP channels with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    SENSITIVITY -switch - 5 µV/V/mmHg

    ECG - BASE - BPM - 60 - BP - 1 - WAVE - ATM
    2 - WAVE - ATM

Restore the normal monitoring screen by pressing the key **Normal Screen**.

Connect cables from the channels BP1 and BP2 to the module connectors P1 and P2. Zero the InvBP channels by pressing the keys ZERO P1 and ZERO P2 on the module front panel.

BP - 1 - WAVE - ART
2 - WAVE - CVP

Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 120/80 (±3 mmHg) for the channel P1 and 15/10 (±2 mmHg) for the channel P2.

Check that HR- value is calculated from P1 when ECG is not measured (ECG cable disconnected).

✍

## $SpO_2$ measurement

23. Check that the message 'No probe' is shown when no $SpO_2$ sensor is connected to the module. Connect a $SpO_2$ finger probe to the module. Check that the message 'Probe off' is shown when the probe is not connected to a finger.

    ✍

24. Connect the $SpO_2$ probe onto your finger. Check that the reading of 95-99 and $SpO_2$ waveform appears. Check that HR- value is calculated from $SpO_2$ when ECG and InvBP (P1) are not measured.

    ✍

## Non Invasive Blood Pressure measurement

25. Enter the NIBP module service menu:
    ***Parameters - NIBP***

    Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 5 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' show all OK.

    ✍

26. Check the front panel membrane keys.

    Select ***Buttons/Leds***.

    Press each of the two NIBP related membrane keys at least for one second. Check that the pressed key is identified, i.e. the corresponding text changes from OFF to ON in the menu when the key is released back up again.

    ✍

27. Check the pump and valves.

    Highlight ***Pneumatics*** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

Select ***Start Pump*** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

Highlight ***Open Exh2***. Press the ComWheel and check that the pressure inside the tubing system starts to drop then press the ComWheel again. If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

Highlight ***Set Valve***. Press the ComWheel and set the value under the text 'Pulse Valve' to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting ***Previous Menu***.

28. Check the NIBP tubing system for leakages.

    Select ***Calibrations*** from the NIBP service menu.

    Connect the pressure manometer to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 265 mmHg and then the pump stops.
    Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 6 mmHg per one minute. Release the pressure by pressing the ComWheel once more.

29. Calibration check.

    Recalibrate the NIBP measurement. Remember to set the calibration protection back on after the calibration.

    Disconnect the pressure manometer. Select ***Calibrations*** and then highlight ***Calibration Check***. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ±20 mmHg.

    Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

30. Check the safety valve.

    Select ***Safety Valve*** from the NIBP service menu.
    Keep the pressure manometer connected to the cuff connector.

    NOTE: Make sure your pressure manometer can be used to measure pressures over 300 mmHg. If such a pressure manometer is not available, perform the check with an adult cuff that is connected around some round object, for example a calibration gas bottle.

    Highlight ***Start Test***. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated. Check the pressure values ‘Max press’ and ‘2 s after stop’ for both transducers. All the values should be within 270 - 330 mmHg.

Highlight ***ADULT***. Press the ComWheel and check that the text changes now to ***INFANT***. Select ***Start Test*** and wait until the pump stops and the pressure values on the screen have been updated. Check that the values ‘Max press’ and ‘2 s after stop’ are all now within 135 to 165 mmHg.

Return to the normal monitoring mode by pressing **Normal Screen**.

31. Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses.
    Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message ‘Cuff loose’ appears on the screen within 70 seconds.
    Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message ‘Cuff occlusion’ appears on the screen within 70 seconds.

32. Check that automatic inflation limits are in use:

    **NIBP** - ***NIBP Setup - Inflation Limits - Auto - Previous Menu***

    Connect the cuff onto your arm, highlight ***Start Ven.Stasis*** in the NIBP menu and press the ComWheel. Check the module identifies the cuff, i.e. the text ‘Adult’ appears into the NIBP digit field for a short moment.

    Keep the pressure inside the cuff for about half a minute in order to find out that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.

33. Keep the cuff on your arm and perform one NIBP measurement. Check that the module gives a reasonable measuring result.

34. Connect an infant cuff to cuff connector and wrap it around your fingers.
    Start NIBP measurement and check that the module identifies the cuff, i.e. the text ‘Infant’ appears into the NIBP digit field. Cancel the measurement after the cuff identification.

## All modules

35. Perform electrical safety check and leakage current test.

36. Check that the module functions normally after the performed electrical safety check.

37. Clean the module with suitable detergent.

✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

CAUTION When reassembling the module, make sure that all cables are reconnected properly.

### 3.3.1 M-PRESTN/-RESTN/-PRETN modules

Disassemble the M-PRESTN/-RESTN/-PRETN module in the following way. See the exploded view of the module in chapter 6.1.1.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearwards and detach it from the main body. Be careful with loose latch and spring pin for locking.
3. To detach the ECG board, detach four screws, disconnect ribbon cable from the STP board (supply voltage), and ribbon cable from the ECG input board.
4. When the ECG board is removed, the STP board can be detached by removing four screws, disconnecting the cable from the membrane keypad, the cable from the temperature connectors, and cables from the SP input board. Also disconnect the NIBP hoses and the ribbon cable from the NIBP board.
5. When the ECG board and the STP board are removed, the NIBP board can be detached by removing four screws. Disconnect the hoses from the pressure transducers and the pump. If the filter for the air inlet of the pump is removed, it must be replaced.

# 3.4 Adjustments and calibrations

## 3.4.1 NIBP calibrations

The electronics of the NIBP pressure measurement is calibrated at the factory. The processor automatically maintains the zeroing pressure. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced.

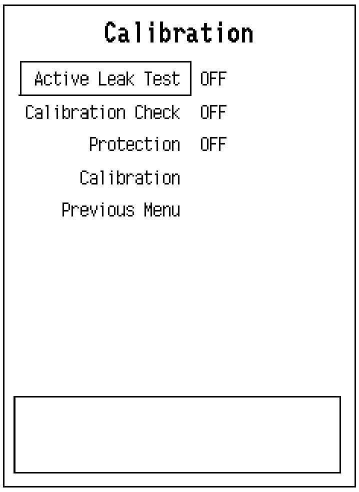
Recalibrate the NIBP measurement once a year. The checking and recalibrating can be done in the NIBP service menu.

The calibration of the primary pressure channel can also be checked from the NIBP setup menu (***NIBP - NIBP Setup - Calibration Check***). In this case the auto zeroing is performed at start - remove hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

Check the intake air filter as part of the calibration check. Change the filter if it is visibly dirty.

### Calibration check

1. Enter ***Calibration*** menu.




2. Select ***Calibration Check*** and press the ComWheel.
3. Connect an external precision manometer to the module.

4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display (The zeroing offset is automatically subtracted from the pressure readings).

**Table 4 NIBP calibration check pressures**

| Pressure | Max. error | Example |
|---|---|---|
| 0 mmHg | ±5 mmHg (=zero offset) | -1 |
| 100 mmHg | 100 ±2 mmHg | 100 ±2 |
| 200 mmHg | 200 ±3 mmHg | 200 ±3 |

If the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, we recommend recalibrating the module when the error of B2 is larger than specified above to ensure best possible operation.

## Calibration

1. Enter ***Calibration*** menu.
2. Remove hoses from front panel connector to enable proper zeroing.
3. Select ***Calibration***. If it is not available, perform the steps A, B, and C.

NOTE: Do not pull out the NIBP module from the monitor frame. The module must be in the frame during the whole procedure.

A. Press NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds to enable the calibration. This enables menu selection ***Protection***. The message 'Calibration switch ON!' appears.

B. Select ***Protection OFF*** in the Calibration menu and press the ComWheel.

C. Press the buttons again for 3 seconds. Menu selection ***Calibration*** is now enabled, and ***Protection*** is disabled. When the calibration is enabled, a message 'Calibration not protected' appears.

- Start Calibration by pressing the ComWheel. Messages 'Zeroing' and 'Zeroed' will appear in the NIBP message field. After this a pressure bar and text 'Calibrating' will appear.
- Connect an external mercury manometer with pump to module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure about 200 mmHg according to the manometer. Calibration is possible in the range 150 to 250 mmHg.
- Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, press the ComWheel to confirm the calibration. The message 'Calibrated' will appear onto the NIBP digit field after a few seconds, which means that the calibration succeeded, and the new calibration data is saved in EEPROM.

NOTE: When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct. For example change the value one step higher and then back one step lower. "Calibrated" text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

- To set the protection on:
  Press NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds. Select ***Protection ON*** and push the ComWheel. Then press the buttons again for three seconds.
- Remove the module from the frame and plug it back again. Then perform *Calibration check* (see the preceding page) to verify the new calibration.

## 3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate, accurate test plugs (25 °C and 45 °C) are needed. A test set of two plugs is available from Datex-Ohmeda, order code 884515.

Calibrate the temperature when measured test values differ for more than ±0.1 °C, and always after STP board replacement.

1. Enter ESTPR: STP service menu.
2. Enter ***Calibrations*** menu.
3. Choose ***Protection OFF*** in protect mode.
4. Select ***Calibrate T1/Calibrate T2***.
5. Insert calibration plug (25 °C) into T1/T2 connector.
6. Press the ComWheel.
7. Insert calibration plug (45 °C) into T1/T2 connector.
8. Press the ComWheel.
9. Choose ***Protection ON*** in protect mode.

## 3.4.3 Invasive pressure calibration

Calibrate invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer, and when STP board is replaced.

1. Enter ESTPR: the STP service menu.
   (**Monitor Setup**, ***Install/Service*** (password 16-4-34), ***Service*** (password 26-23-8), ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Connect a pressure transducer with a pressure manometer to the P1/P2 connector. Choose ***Calibrate P1*** or ***Calibrate P2***. Leave the transducer to room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The message 'Calibrated' will appear on the display.

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting charts

See also the *User's Reference Manual* for more troubleshooting procedures.

### 4.1.1 NIBP

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| No NIBP value displayed | NIBP not selected on screen. | Check monitor setup. |
| NIBP menu fading | No M-PRESTN module, module not properly connected, or NIBP and PRESTN module connected at the same time. | Plug in the module. |
| Artifacts-message | Unsuccessful measurement due to patient movement, shivering, external artifact or weak signal. | |
| Weak pulsation-message | Weak or unstable oscillation pulses due to:<br>• artifacts<br>• weak pulse pressure due to arrhythmias<br>• improper cuff position or attachment<br>• too few pulses detected<br>• weak or unusual blood circulation<br>• obese subject | Check patient condition and retry.<br>Check any leaks and retry.<br>Use proper size of cuff. Check attachment. |
| Call service<br>Error X-message | NIBP hardware error.<br>X = error number. | See the description of the error message code in 4.1.2, the causes and the solutions listed in the next chapter. |

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Cuff loose-message | 1. Hose and/or cuff not connected. | 1. Connect the hose and the cuff. |
| | 2. Hose and cuff connected. Reasons: | |
| | – cuff loosely wrapped | – tighten the cuff |
| | – leakage in cuff or hose | – replace cuff/hose |
| | – leakage inside module | – check internal tubing and air chamber, and fix if necessary |
| | – pump does not work | – check pump connector; if OK, replace pump |
| Air leakage-message | 1. Hose or cuff leaking. Reasons: | 1. Replace cuff |
| | – cuff damaged | – replace cuff |
| | – cuff connector damaged | – replace cuff connector (if the fault is in hose connector,) |
| | – O-ring damaged or missing | – replace O-ring |
| | – hose double connector damaged | – replace hose |
| | 2. Hose and cuff OK. Reasons: | 2. Connect or replace tube |
| | – leakage inside the module | – replace the whole tubing |
| | – tube disconnected or damaged | – fix connections |
| | – tubes or valve(s) damaged | – replace tubes/valve(s) |
| Unable to measure Sys-message | Systolic blood pressure probably higher than the inflation pressure or artifacts. | Automatic retrial with increased pressure. |

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Cuff occlusion-message | 1. Cuff and/or hose occluded. Reason: | |
| | – cuff tube kinked | – straighten tube |
| | – tube inside module kinked | – straighten tube |
| | – occlusion inside/outside module | – remove occlusion |
| | 2. Cuff, hose, and tubes OK. Reason: | |
| | – fault in pressure transducer | – replace the NIBP board |
| | – fault in A/D converter | – replace the NIBP board |
| | – faulty calibration | – check calibration |
| Calibration switch on – message | EEPROM protection has been handled by pressing module buttons **Auto ON/OFF** and Start **Cancel** simultaneously for 3 seconds. | Enables setting the protection OFF in the Calibration menu. Press the buttons again if you are not going to calibrate. |
| Calibration not protected - message. | Calibration protection is set to OFF. | Set the protection ON in the NIBP Calibration menu. |

### 4.1.2 NIBP error code explanation

| Code | Explanation | Treatment |
|---|---|---|
| 0 | RAM failure; memory failure | Change the NIBP board. |
| 1 | ROM checksum error; memory failure | Change the NIBP board. |
| 2 | Pump current failure | Check short circuits. Change the NIBP board. |
| 3 | Safety CPU internal test failure or pressure sensor reference voltage failure | Change the NIBP board. |
| 4 | EEPROM protection error | Press module buttons **Auto ON/OFF** and Start **Cancel** simultaneously for 3 seconds. |
| 5 | Calibration not protected | Protect calibration by selecting Protection ON in the NIBP calibration menu. |
| 6 | Pressure sensors give different readings | Try to remeasure, if the problem persists recalibrate. If the problem still persists change the NIPB board. |
| 7 | Calibration failure | Reset module and recalibrate. If this does not help, change the NIBP board. |
| 8 | Exhaust Valve occlusion | Check tubing. If this does not help, change the NIBP board. |
| 9 | Measurement related SW error | Automatic recovery. |
| 10 | EEPROM checksum error; memory failure | Change the NIBP board. |
| 11 | Auto zero range exceeded | Calibrate the NIBP. |
| 12 | Communication break; temporal break down of communication from monitor detected | Automatic recovery. |
| 13 | Illegal neonate cuff with identifying magnet connected | Remove the cuff. |
| 14 | - | |
| 15 | Safety CPU pressure calibration error | Recalibrate. If this does not help, change NIBP board. |
| 16 | Communication error between CPUs | Change NIBP board. |
| 17 | Safety CPU has cut down power from pneumatics due to repeating safety limit violations | Reset module. If problem persists change NIBP board. |

### 4.1.3 ECG

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| HR numerical display shows '---' | No heart rate available. | If no ECG waveform, check LEADS OFF message and connect the leads. |
| | | If ECG waveform exists, check heart rate source e.g. in the ECG Setup menu behind ECG key. |
| Unacceptable ECG waveform | Poor electrode or poor electrode skin contact. | Electrodes from different manufacturers are used. /Too much/little gel is used. |
| | Poor electrode condition. | Electrodes are dried out. |
| | Improper site of electrodes. | Check that electrodes are not placed over bones, active muscles, or layers of fat. |
| | Improper skin preparation. | Remove body hair. Clean attachment site carefully with alcohol. |
| | Improper bandwidth filter. | Check filter. |
| No ECG trace | Waveform not selected on screen. | Press the **Monitor Setup** key and make adjustments. |
| | Module not plugged in correctly. | Plug in. |
| Noise-message | High frequency or 50/60 Hz noise. | Isolate noise source. |

### 4.1.4 Pulse oximetry ($SpO_2$)

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Message 'NO PROBE' | No probe connected to the monitor. | Check probe connections. |
| | Probe faulty. | Change the probe. |
| Message 'PROBE OFF' though probe properly attached to the patient | Unsuitable site. | Try another site. |
| | Probe faulty. | Try another probe. |
| | Probe connection cable not connected to probe. | Connect the cable to probe. |
| Finger probe falls off | 1. Probe is slippery. | 1. Wipe with 70 % isopropyl alcohol and allow drying. |
| | 2. Finger is too thin or thick. | 2. Try other fingers, or other probe types. |
| Weak signal artifacts | Poor perfusion. | Try another place. |

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| | Movement artifacts. | |
| | Shivering. | |
| Message 'NO PULSE' | Pulse search > 20 sec. and low $SpO_2$ or low pulse rate. | Try other fingers. |
| Message 'ARTIFACT' | Pulse modulation exceeds the present scale. | Try another place or another probe. |
| Message 'CHECK PROBE' | DC value not in balance. | Try another probe. |
| Message 'POOR SIGNAL' | Poor perfusion.<br>Modulation (Red or Ired) < 0.25 % | Check that the sensor is positioned correctly to the patient. |
| Message 'FAULTY PROBE' | Probe is faulty. | Change the probe. |
| No $SpO_2$ | No waveform selected on screen. | Check selected $SpO_2$ waveforms by pressing **Monitor Setup** key and selecting ***Modify waveforms***. |
| | Wrong configuration setting. | Check the configuration settings from the ESTPR:STP/Calibrations menu (**Monitor Setup** ***- Install/Service - Service - Parameters***) |

### 4.1.5 Temperature

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Message 'TEMPERATURE ERROR' | Faulty calibration. | Perform calibration. If it does not help, check that front panel connector is properly connected to STP board. |
| No temperature displayed | Wrong type of probe. | Use correct probe. |
| | Temperature out of measurable range. | The range is between 10 and 45 °C. |
| | Temperature calibration not protected. | Set the protection ON in the Service Menu. |

### 4.1.6 Invasive blood pressure

| TROUBLE | CAUSE | TREATMENT |
|---|---|---|
| Abnormally low pressure | Transducer wrongly positioned. | Check mid-heart level and reposition transducer. |
| No pressure | Defective transducer. | Check transducer. |
| | No pressure module plugged in. | Check the module. |
| | No waveform selected on screen. | Check selected pressure waveforms by pressing Monitor Setup key and selecting modify waveforms. |
| | | Check that pressure transducer is open to patient. |
| | Wrong configuration setting | Check the configuration setting from the ESTP:STP/Calibrations menu (**Monitor Setup** ***- Install/Service - Service - Parameters***) |
| Not zeroed -message | Measurement on, channel not zeroed. | Zero the channel. |
| Zeroing failed -message | Unsuccessful zeroing of P1 /P2 (number field). | Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel. |
| | | Offset is > 150 mmHg. Open the transducer to air and zero the channel. |
| | | Defective transducer. Replace it and zero the channel. |
| Calibration failed -message | Unsuccessful calibrating of P1/P2 (number field), possibly due to pulsating waveform | Turn the transducer to sphygmomanometer and try again (zeroing takes place first). |
| | | Gain is beyond the limits (± 20 % of the default gain). Replace the transducer. |
| Out of range < 40 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. |
| Out of range > 320 mmHg | Measurement pressure is beyond measurement range. | Check transducer level. Zero the channel. The patient may also have high pressure. |
| Zero adj. > 100 mmHg | Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain). | Check transducer. The waveform may hit the top and the numeric display not shown. |

| **TROUBLE** | **CAUSE** | **TREATMENT** |
|---|---|---|
| Out of range | Measured pressure is beyond the internal measurement range of the module. | The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel. |

### 4.1.7 Impedance respiration

| **TROUBLE** | **CAUSE** | **TREATMENT** |
|---|---|---|
| No resp trace | Waveform not selected on the screen | Press the Monitor Setup key and make adjustments. |
| | Module not plugged in correctly | Re-plug the module. |
| Unacceptable resp waveform | Poor electrode or poor electrode skin contact | Electrodes from different manufacturers are used. Too much/little gel is used. |
| | Poor electrode condition | Electrodes are dried out. |
| | Improper site of electrodes | Check that electrodes are not placed over bones, active muscles, or layers of fat. |
| | Improper skin preparation | Remove body hair. Clean attachment site carefully with alcohol. |
| Message: ‘SMALL RESP CURVE’ | Respiration signal is very small | With 3-lead cable in ESTPR/NESTPR try another lead connection I, II, III or try 5-lead cable. |
| Message: ‘APNEA ALARM’, and respiration waveform normal | Respiration source is $CO_2$ | Check respiration source and change it to correct one. |

## 4.2 Troubleshooting flowcharts

### 4.2.1 M-PRESTN module troubleshooting for NIBP parameter

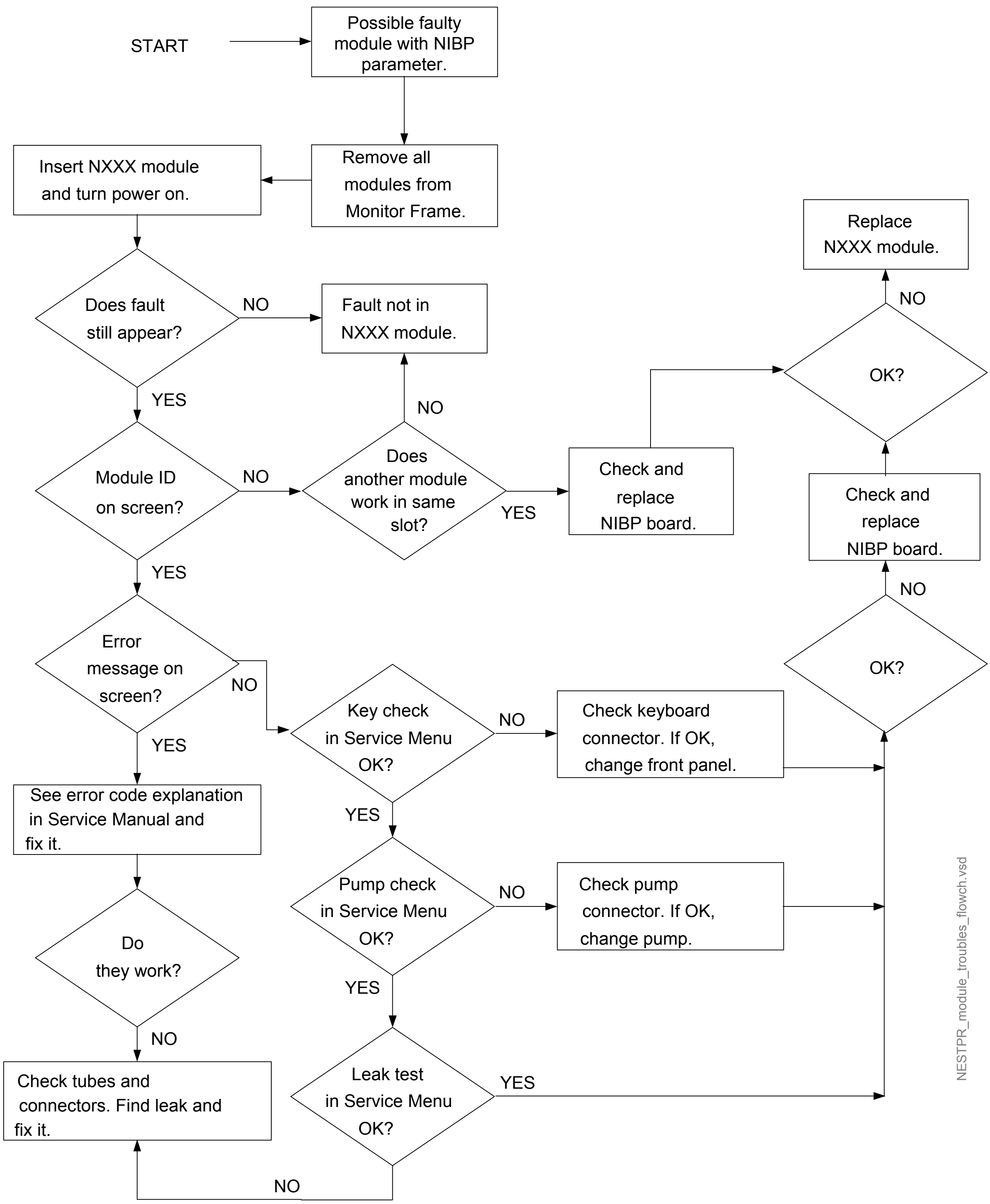



**Figure 18** **M-PRESTN module troubleshooting flowchart for NIBP Parameter**

## 4.2.2 M-PRESTN module troubleshooting for parameters ESTPR

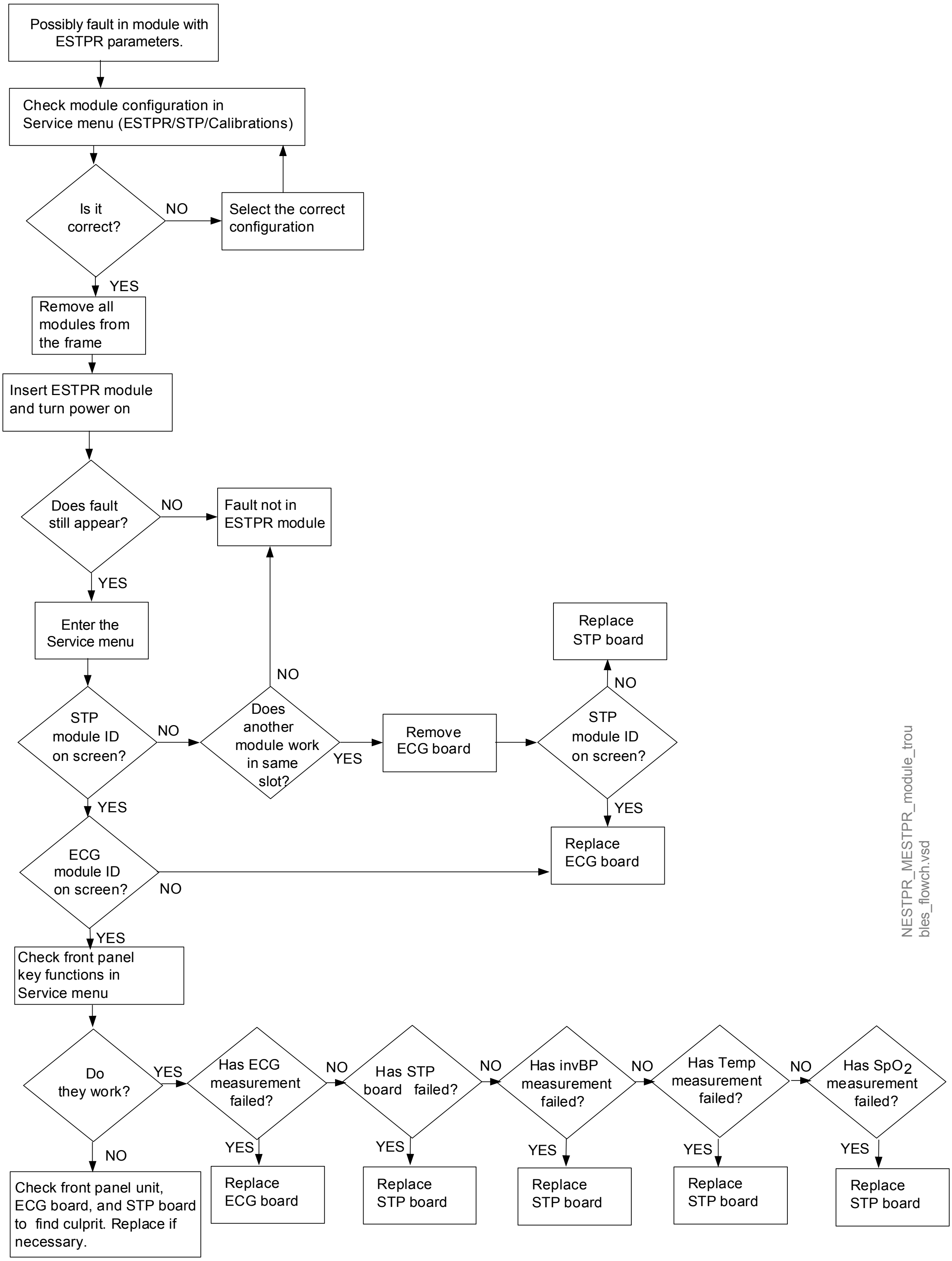
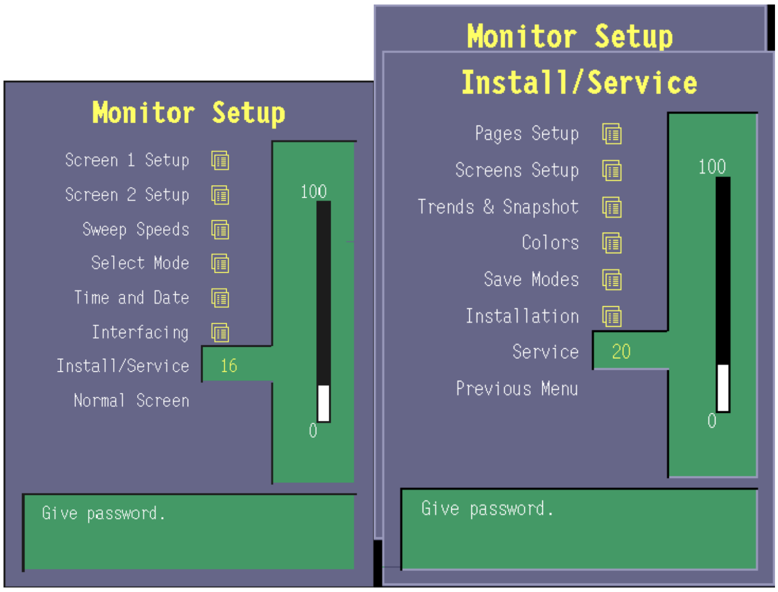
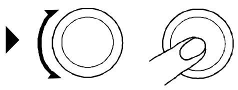



**Figure 19 M-PRESTN Module Troubleshooting Flowchart for Parameters ESTPR**

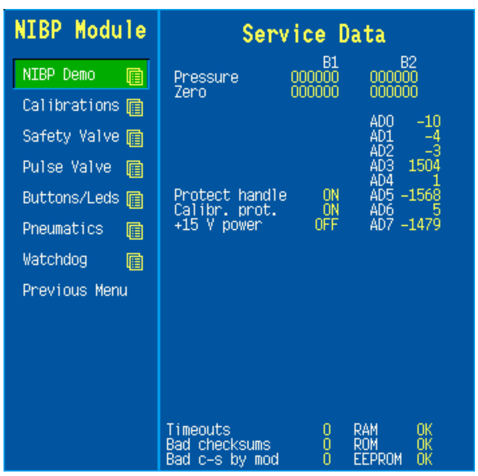
# 5 SERVICE MENU



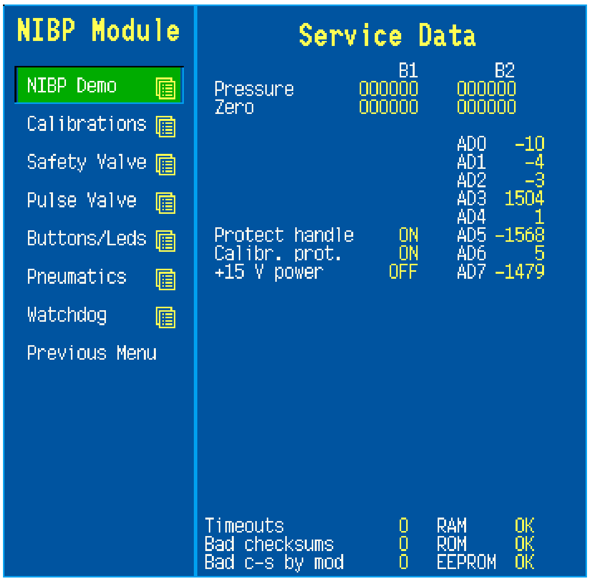



1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters - NIBP***.

NOTE: Parameter values in Service Data fields are for reference only on this chapter.



## 5.1 NIBP service menu




### Service Data

**Pressure** shows measured pressure multiplied by 10. This value is automatically zero-drift compensated.
**Zero** shows difference between zeroing value in the permanent memory (stored when module is calibrated) and the current automatic zero-drift compensation multiplied by 10. The value can change between +20 and -20 mmHg. If the zero drift exceeds ± 10 mmHg, the module should be recalibrated.

**Protect handle** indicates hardware protection for EEPROM memory. It should be ON all the time in normal operation. If it is OFF data can not be read from or written to EEPROM, only the calibration protection can be set or reset by software. It can be turned to OFF by pressing NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds, which also enables ***Protection ON/OFF*** menu selection in the calibration menu.
**Calibr. prot.** shows software calibration protection and it should be OFF to enable calibration.

**+15 V power** refers to legacy NIBP modules. Not used in M-PRESTN/M-RESTN/M-PRETN.

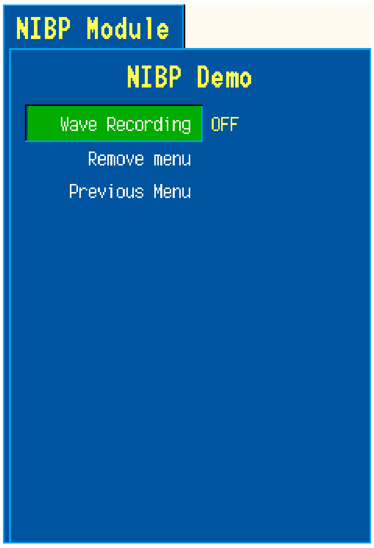
**AD0** to **AD7** show the values of each eight channels of A/D converter. AD7 is not used in M-PRESTN/M-RESTN/M-PRETN.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum in the EPROM is in accordance with the one the software has

calculated.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.1.2 NIBP demo menu



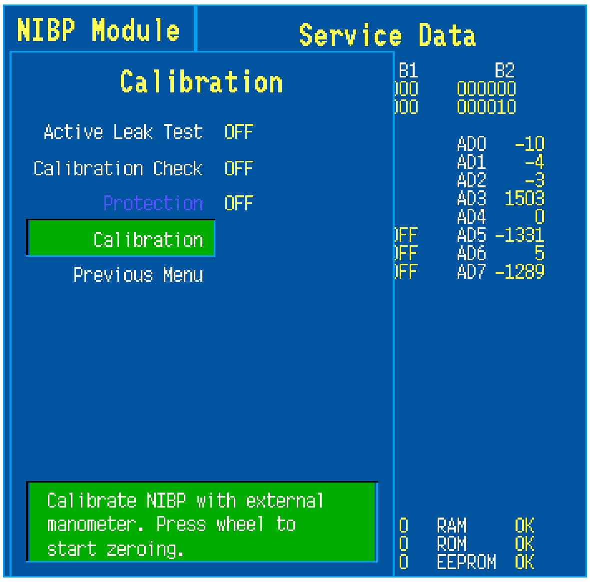

A service menu for demonstrating the oscillometric method of NIBP measurement. The menu shows the real-time pressure signals that are measured from the NIBP cuff. The measurement result is shown in the adjoining digit field.

**Wave Recording** — **Wave Recording** is for selecting the recording option. If ON is selected, the pressure signals are recorded in real-time onto the M-REC paper.

**Remove menu** — **Remove menu** widens the displayed waveform area.

**Previous Menu** — The menu can be closed by selecting the **Previous Menu** or just by pressing the ComWheel if the **Remove menu** was selected.

### 5.1.3 NIBP calibration menu




**Active Leak Test** Wrap an adult cuff around a pipe and connect the cuff to the module. Select the active leak test (ON). The module automatically pumps a pressure of 260 mmHg into the cuff. Wait for several seconds until the pressure stabilizes. Then check that the pressure reading does not drop more than 6 mmHg per minute. If it does, leaking point(s) should be detected and fixed. Cancel the test by selecting Active leak test OFF.

**Calibration Check**

After the calibration check is selected (ON), the module zeroes the pressure transducers at the beginning of the calibration check. Do not pump pressure until the text 'Calibrating' appears to the NIBP digit field or the zeroing will fail. After zeroing is done, manually pump pressure into the module and make sure that the same pressure values are shown both on the display and on the manometer. Pressure of both pressure channels B1 and B2 are shown. Note difference to the legacy modules with NIBP. The pressure values are automatically zero-compensated, so the readings of B1 and B2 should be the same as the manometer readings.

**Protection** Software calibration protection (ON/OFF). Select OFF when calibrating. **Protection** selection becomes available in the menu after pressing NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds.

**Calibration** Calibration selection is available only when protection is OFF and module buttons **Auto ON/OFF** and **Start Cancel** are pressed simultaneously for 3 seconds.

NIBP calibration can be performed in the NIBP Service menu as follows:

NOTE: Both channels B1 and B2 must be calibrated simultaneously.

1. If **Protection** is ON change it to OFF by pressing NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds, which enables the **Protection** selection. Then press the buttons again for 3 seconds to enable **Calibration**.

NOTE: The module must be in the frame during the whole procedure.

NOTE: When the buttons have been pressed, the NIBP field shows an error message 'Calibration switch on!'.

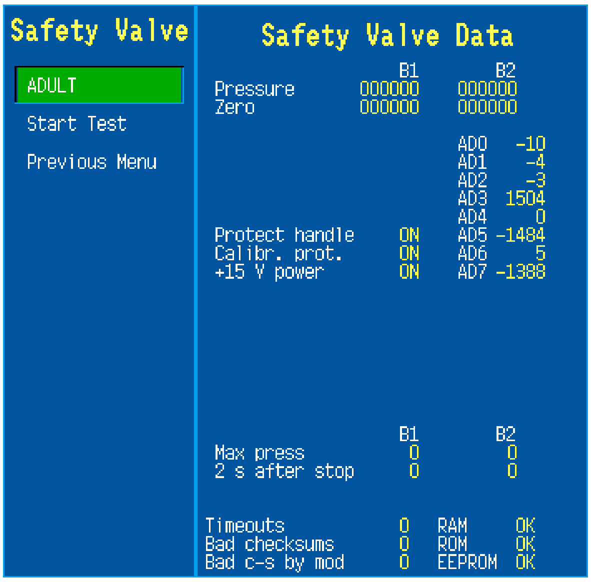
NOTE: When calibration is enabled, a message 'Calibration not protected' appears.

2. For proper zeroing to take place, remove the hose from the front panel connector. Select ***Calibration*** and push the ComWheel. Messages 'Zeroing' and 'Zeroed' will appear in the NIBP message field. After this a pressure bar will appear beside the menu and the text 'Calibrating' will appear to NIBP digit field.
3. Connect an external mercury manometer with pump to module through the both tubes of the hose. Pump up to about 200 mmHg pressure (range of 150 to 300 mmHg allowed) according to the manometer. Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel.
4. When the values are equal, push the ComWheel to confirm the calibration. After a few seconds 'Calibrated' message will appear to the NIBP digit field, which means that the calibration data has now been saved.

NOTE: When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct. For example change the value one step higher and then back one step lower. "Calibrated" text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

5. Use the module buttons again to enable **Protection** setting and set it ON, and finally disable **Protection** setting.

### 5.1.4 NIBP safety valve menu




**Start Test** **Start test** is for starting and **Stop test** is for stopping the Safety Valve test.

### Safety Valve Data

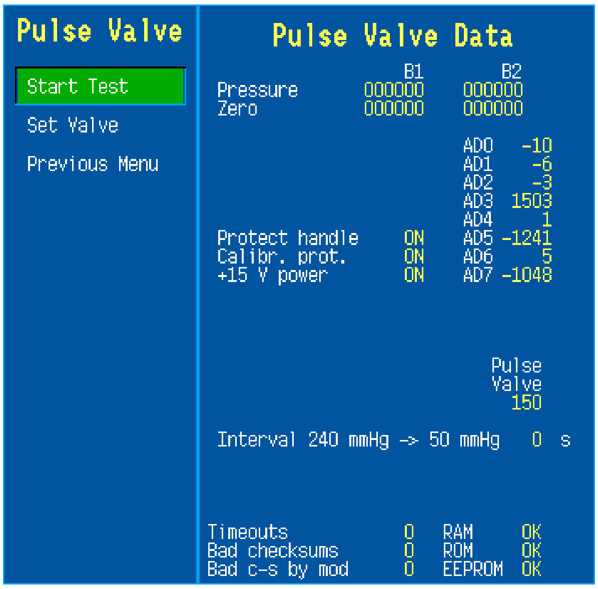
See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

**Max. press** and **2 s after stop** show the measured values at Safety Valve test.

**Safety Valve Test Adult/Infant**
Wrap an adult cuff around a pipe and connect the cuff to the module. Highlight **Start test** and give the ComWheel a push. The test ends automatically or when **Stop test** (appears in place of **Start test**) is pushed.

**Max. press** indicates the pressure at which the safety valve opens and is normally 300 ±15 mmHg for adult and 150 mmHg ±15 mmHg for infant. **2 s after stop** indicates the pressure at 2 seconds after the pump has stopped and is normally > 270 mmHg for adult and > 130 mmHg for infant. If the value is less, check leakage by the active leak test.

### 5.1.5 NIBP pulse valve menu




**Start Test** — **Start test** is for starting and **Stop test** is for stopping the test.

**Set Valve** — **Set Valve** lets you adjust the opening of the pulse valve.

## Pulse Valve Data

See NIBP Service menu in chapter 5.1 for information on general items Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0 to **AD7** as well as **Timeouts etc.**

#### Pulse Valve Checking

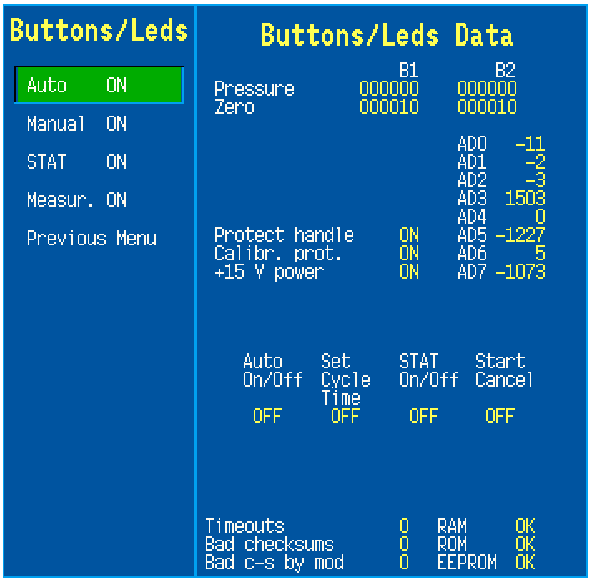
Wrap an adult cuff around a pipe and connect the cuff to the module. Select the **Start test** and push the ComWheel. The pressure rises beyond 240 mmHg and stops. The pulse valve opens. The module counts the time it takes for the pressure to go down from 240 mmHg to 50 mmHg and displays it on the screen. The test can be manually stopped by selecting **Stop test**.

The valve can be adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First select Set Valve and push the ComWheel. See the pulse valve value and adjust it by turning the ComWheel. Then push the ComWheel to confirm the value.

The '**Interval 240 mmHg -> 50 mmHg**' time should be less than 60 seconds when the valve is '150' and less than 10 when fully opened (255). When fully closed (0), the system should be airtight and the pressure does not drop. Depending on an individual, the pulse valve may remain closed up to approx. value 100.

If the measured time deviates much from those above, then the pulse valve or its tubes are faulty.

### 5.1.6 NIBP buttons/leds menu




The selections ***Auto ON/OFF***, ***Manual ON/OFF***, ***STAT ON/OFF***, and ***Measur. ON/OFF*** have no effect on the module.

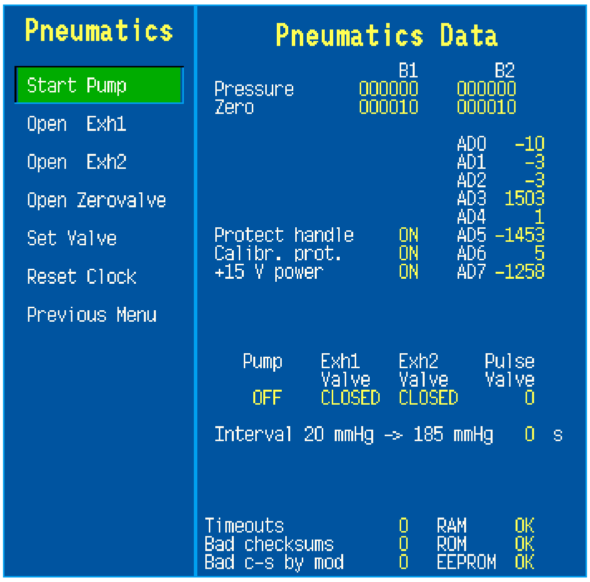
## Buttons/Leds Data

See NIBP Service menu in chapter 5.1 for information on general items Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0 to AD7 as well as Timeouts etc.

**Buttons Checking**

The front panel keys function is confirmed by pressing and releasing the key and observing OFF turns to ON at Auto On/Off, and Start Cancel.

### 5.1.7 NIBP pneumatics menu




**Start Pump/Stop Pump**
A manual control for the pump. The selection changes to **Stop Pump** when the pump turns on.

**Open Exh1/Close Exh1**
No effect on the module.

**Open Exh2/Close Exh2**
A manual control for the exhaust valve 2. The selection changes to **Close Exh2** when the valve is opened.

**Open Zero valve**
No effect on the module.

**Set Valve** With **Set Valve**, the opening of the pulse valve is adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First push the ComWheel, then turn it to adjust the value on screen and finally push to set the value.

**Reset Clock** **Reset Clock** will zero the time on the display.

### Pneumatics Data field

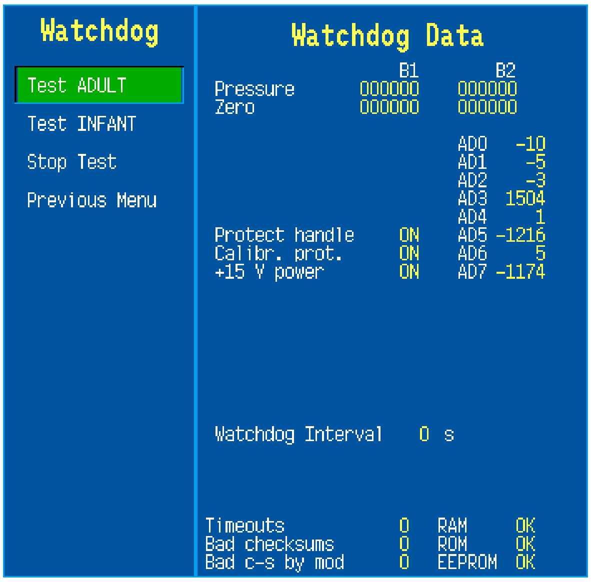
See NIBP service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts** etc.

**Pump, Exh1 Valve**, and **Exh2 Valve** show their states. Note that **Exh1 Valve** has no effect to the module.

**Pulse Valve** shows how much the valve is opened (0 to 255) during Valve Setting.

**Interval 20 mmHg -> 185 mmHg Checking**
Select the **Start pump** at different combinations of the valves open/closed and push the ComWheel. The module counts the time it takes for the pressure to go up from 20 mmHg to 185 mmHg and displays it. When all the valves are closed, the pump should be able to pump the pressure in about 1 to 4 seconds into an adult cuff wrapped around a pipe. The pump does not stop without selecting the **Stop Pump** by pushing the ComWheel.

### 5.1.8 NIBP watchdog menu




**Test ADULT** No effect on the module.

**Test INFANT** No effect on the module.

**Stop Test** No effect on the module.

## Watchdog Data field

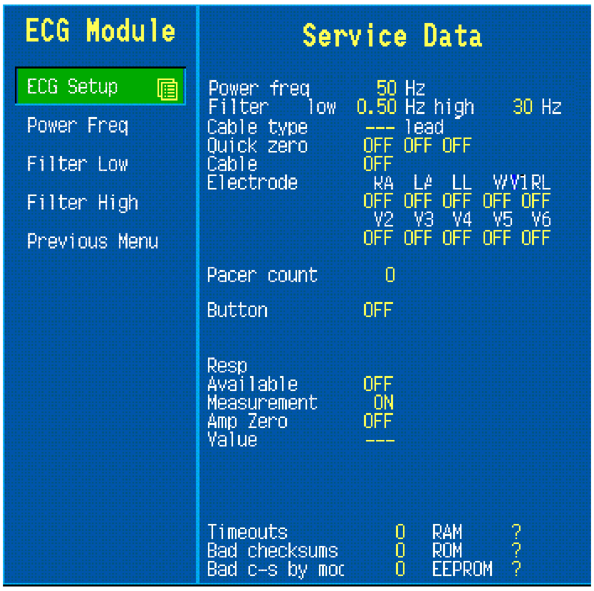
See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0** to **AD7** as well as **Timeouts etc.**

**Watchdog Interval** no effect on the module.

**Adult watchdog time testing**
No effect on the module.

**Infant watchdog time testing**
No effect on the module.

### 5.1.9 ECG service menu




**Power freq** Set power frequency; 50 Hz/60 Hz.

**Filter low** Set filter low frequency; 0.05 Hz/0.5 Hz.

**Filter high** Set filter high frequency; 30 Hz (40 Hz if power freq is 60 Hz) / 100 Hz or 150 Hz @ NE12STPR.

## Service Data field

**Power freq, and Cable type** show the values chosen or detected, **Filter low and high** defines the selected filter (Monitor/Diagnostic/ST).

**Quick zero** at PRESTN module is ON when the ECG signal is beyond scale, and therefore, is quickly returned to optimal range using fast signal processing methods. All the **Quick zero** bits are ON at the same time.

**Cable** shows ON when ECG cable is connected.

**Electrode** shows ON when each of these electrodes are connected.
**Pacer count** is a running number for pacemaker users.

**Button** No effect on the module.

**Resp Available** indicates that ECG hardware is capable of measuring impedance respiration.

**Measurement** shows ON when the respiration measurement is on.

**Amp zero** shows ON when zeroing of the respiration amplifier takes place.

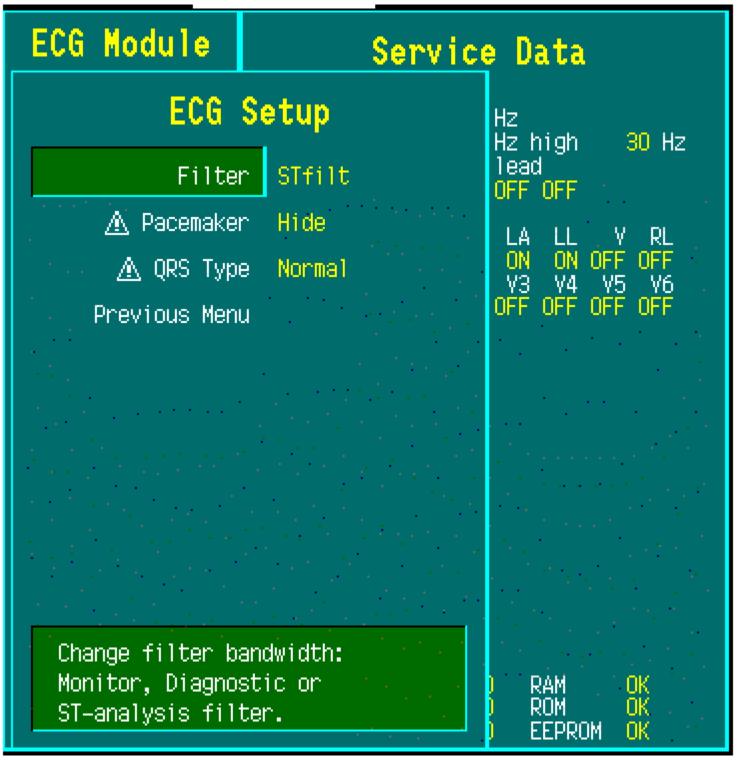
Waveform **VALUE** will be updated in one second interval.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.

The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum at the EPROM is in accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.1.10 ECG setup menu




**Filter** Filters the ECG signal high frequency noise and slow respiratory artefacts.

**Monit** (monitor) filter is used in routine monitoring. It effectively filters the artefacts caused by the electrosurgery unit and respiration.

**Diagn** (diagnostic) filter is used if more accurate information of the waveform is needed (e.g., of P-wave or AV block). The diagnostic filter is more susceptible to both high frequencies and baseline wander than monitor filter.

**STfilt** (ST filter) permits more accurate information of ST segment. It filters the high frequency artefacts caused by electrosurgery unit but catches the slow changes in ST segment. The ST filter is more susceptible to baseline wander than the monitor filter.

**Pacemaker** Selects how to display the pacing pulse of cardiac pacemaker. The selections are **Show, Hide**, **ON R** and **Sensit**.

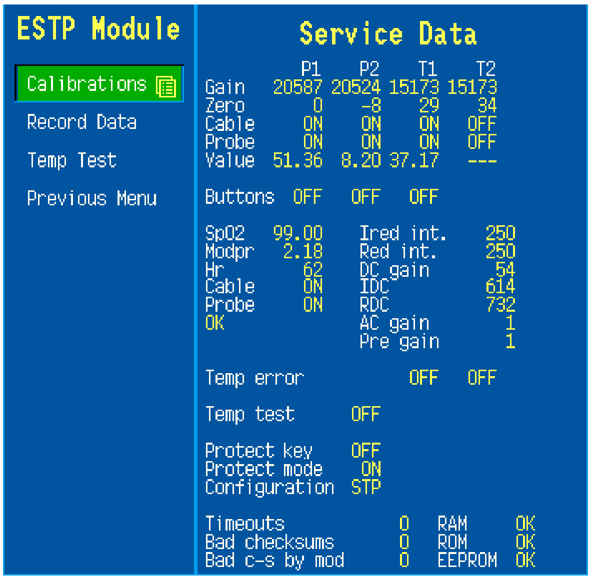
**Hide**, the pacing pulse is filtered away from ECG data.

**Show**, the pacer pulse is filtered away from ECG data but the pulse is displayed as a constant height marker.

**ON R,** pacing pulses are not filtered away from ECG data. This improves ECG monitoring with A-V pacemaker patients, as QRS complexes are counted even if the pacing pulse hits the QRS complex. However, during asystole the monitor may count pacing pulses as heart beats.

**Sensit** selection uses a more sensitive pacemaker detection. Pacemaker spike is displayed on ECG.

## 5.2 STP service menu




**Record Data** Record Data prints out the shown service data and board information (id, serial number and sw id) onto the recorder module, M-REC.

**Temp Test** **Temp Test** activates the automatic temperature test for the temperature channels T1 and T2. The result from the test is shown in the service data field.

NOTE: The Temp Test needs to be selected twice before the test starts.

### Service Data field

**Gain** is a coefficient to compensate gain error. Usually the values for P1 and P2 are between 17000 and 25000 and for T1 and T2 between 13000 and 14300. **Zero** indicates offset compensation value of each parameter in A/D converter. Typically the values for P1 and P2 are within ±1000 and for T1 and T2 between -150 and +300. Calibrate if zero and/or gain value is outside the ranges.

**Cable** shows ON when a corresponding cable is connected to the front panel and **Probe** shows ON when a corresponding probe is connected to the cable.

Under **Value** the measured numeric values are displayed simultaneously. Pressure values are real time values and shown in mmHg. Temperature values are shown in degrees Celsius.

The front panel STP keys functions are confirmed by pressing each key and observing OFF turns to ON at **Button**.

**$SpO_2$** shows measured beat-to-beat $SpO_2$ value. **Modpr** is a modulation % that indicates AC/DC ratio in the measured signal. **Hr** is a pulse rate calculated from every beat.

**Cable** and **Probe** can be either OFF or ON, and these indicate the state PROBE OFF.
Under them there is a message field for $SpO_2$. It can be OK, PULSE SEARCH, NO PROBE, PROBE OFF, NO PULSE, ARTEFACT, POOR SIGNAL, or CHECK PROBE.

Balance between leds is adjusted by changing the intensity of red/infrared. Intensity of infrared (**Ired int.**) is in the range of 40 to 255 and red intensity (**red int.**)is in the range of 40 to 255.

**DC gain** shows the gain of DC signal adjusted by the module.

**IDC** is the value of infrared signal.

**RDC** is the dc value of red signal.

**AC gain** is the gain of infrared and red ac signals. AC gain values can be 1 or 0. Value 1 means high ac gain and 0 means low gain.

**Pre gain** is a preamplifier gain for infrared and red signals. Pre gain values can be 1 or 0. Value 1 means normal operation. Value 0 means that signal levels are very low and extra gain is taken into use.

**Temp error** shows the status of the temperature test. No errors found show the status (OFF) and errors found (ON).

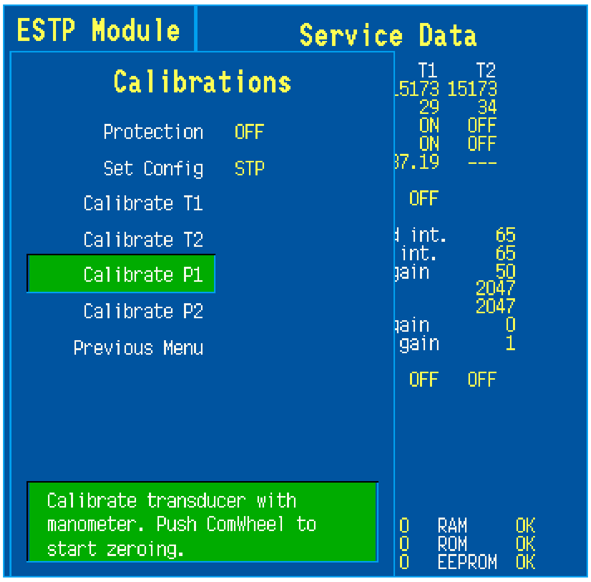
**Protect key** shows normally OFF but turns to ON when the button at the bottom of the module is pressed.

**Protect mode** is normally ON. It turns to OFF when Protect is switched to OFF for the temperature calibration in Calibration Menu.
**Configuration** shows the chosen module configuration: TP, ST, or STP.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 5 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.

**RAM** indicates the state of the RAM memory.
**ROM** indicates whether the checksum at the EPROM is in accordance with the one the software has calculated.
**EEPROM** indicates if the values stored in the permanent memory are valid.
The state is either **OK, Fail** or **?** (module not in place or a communication error).

### 5.2.2 STP calibration menu




**Protection** Protection for the configuration and temperature calibrations can be set ON and OFF .

**Set Config** The module configuration should be set according to the module type. The setting is possible only when the protection is set OFF. The available selections are TP, ST or STP. The configuration setting should be checked if the STP board is replaced.

**Calibrate T1 / Calibrate T2**

The functions are for calibrating the temperature channels T1 and T2. The calibrations are possible only when the protection is set OFF. The temperature calibration requires accurate test plugs of value 25 °C and 45 °C.

Calibration:

1. Select ***Calibrate T1/Calibrate T2***
2. Insert the test plug 25 °C into the T1/T2 connector
3. Press the ComWheel
4. Insert the test plug 45 °C into the T1/T2 connector
5. Press the ComWheel

**Calibrate P1/Calibrate P2**

The functions are for calibrating the invasive blood pressure channels P1 and P2. The calibrations require a pressure transducer (with an appropriate cable) and a pressure manometer.

1. Connect the pressure transducer with the pressure manometer to the P1/P2 connector. Select ***Calibrate P1/Calibrate P2***. Leave the transducer to room air pressure.
2. Press the ComWheel to start zeroing.
3. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
4. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel.

# 6 SPARE PARTS

## 6.1 Spare parts list

### 6.1.1 M-PRESTN rev. 01, M-RESTN rev. 01, M-PRETN rev. 01

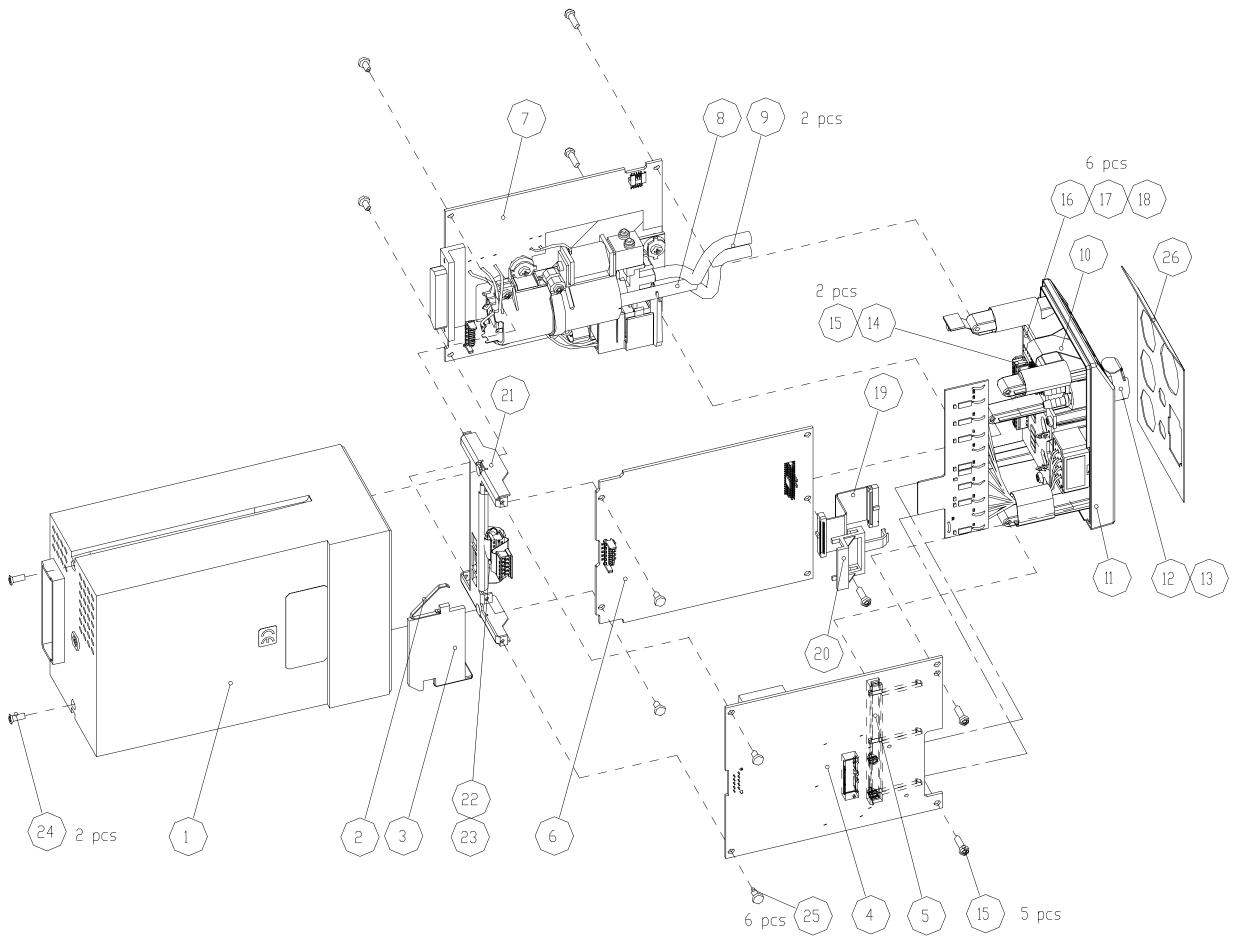



**Figure 20 Exploded view of M-PRESTN Module**

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 1 | Module box (wide) | 886168 | |
| 2 | Spring pin | 879182 | |
| 3 | Latch for module box | 879181 | |
| 4 | ECG_120 board | M1008909 | |
| 5 | ECG Input board holder | M1021216 | |
| 6 | STP_120 board | M1006153 | |
| 7 | NIBP unit | M1012677 | |
| 8 | Air filter (NIBP) | 57142 | |
| 9 | Silicon tube NIBP (2pcs, 100mm) | 73375 | |
| 10 | Membrane keypad | 8005215 | |
| 11 | Mask including NIBP flex board and ECG connector unit | M1018978 | |
| 12 | NIBP Cuff connector | 64654 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 13 | NIBP Mounting nut | 8004036 | |
| 14 | TEMPERATURE input board | 8005216 | |
| 15 | Screw; pan-head, TORX PT 3x10mm (7 pcs) | 628728 | |
| 16 | PRESS / SpO2 input board, M-PRESTN | 8005219 | |
| 16 | PRESS input board, M-PRETN | 8005492 | |
| 16 | SpO2 input board, M-RESTN | 8005490 | |
| 17 | Screw; Cross head recess PT 2.5x10 (6kpl) | M1021234 | |
| 18 | Fitting plate (only M-RESTN, M-PRETN) | 879510 | |
| 19 | STP cable (34 contacts, female) | M1001763 | |
| 20 | Cable holder | M1008749 | |
| 21 | Board holder | M1021283 | |
| 22 | Module bus cable | 8004009 | |
| 23 | Cable tie | 64001 | |
| 24 | Screw; cross head recess M3x8 black (2 pcs) | 616215 | |
| 25 | Screw; cross head cylinder M3x6 ( 6 pcs) | 61721 | |
| 26 | Front panel, DA, M-PRESTN | M1021293 | |
| 26 | Front panel, DE, M-PRESTN | M1021294 | |
| 26 | Front panel, EN, M-PRESTN | M1021440 | |
| 26 | Front panel, ES, M-PRESTN | M1021295 | |
| 26 | Front panel, FI, M-PRESTN | M1021296 | |
| 26 | Front panel, FR, M-PRESTN | M1021297 | |
| 26 | Front panel, IT, M-PRESTN | M1021298 | |
| 26 | Front panel, JA, M-PRESTN | M1021299 | |
| 26 | Front panel, NL, M-PRESTN | M1021300 | |
| 26 | Front panel, NO, M-PRESTN | M1021301 | |
| 26 | Front panel, PL, M-PRESTN | M1021302 | |
| 26 | Front panel, PT, M-PRESTN | M1021303 | |
| 26 | Front panel, SV, M-PRESTN | M1021305 | |
| 26 | Front panel, DA, M-PRETN | M1021423 | |
| 26 | Front panel, DE, M-PRETN | M1021424 | |
| 26 | Front panel, EN, M-PRETN | M1021422 | |
| 26 | Front panel, ES, M-PRETN | M1021425 | |
| 26 | Front panel, FI, M-PRETN | M1021426 | |
| 26 | Front panel, FR, M-PRETN | M1021427 | |
| 26 | Front panel, IT, M-PRETN | M1021428 | |
| 26 | Front panel, JA, M-PRETN | M1021429 | |
| 26 | Front panel, NL, M-PRETN | M1021430 | |
| 26 | Front panel, NO, M-PRETN | M1021431 | |
| 26 | Front panel, PL, M-PRETN | M1021432 | |
| 26 | Front panel, PT, M-PRETN | M1021433 | |
| 26 | Front panel, SV, M-PRETN | M1021434 | |
| 26 | Front panel, DA, M-RESTN | M1021441 | |
| 26 | Front panel, DE, M-RESTN | M1021443 | |
| 26 | Front panel, EN, M-RESTN | M1021440 | |
| 26 | Front panel, ES, M-RESTN | M1021444 | |
| 26 | Front panel, FI, M-RESTN | M1021445 | |
| 26 | Front panel, FR, M-RESTN | M1021446 | |
| 26 | Front panel, IT, M-RESTN | M1021447 | |
| 26 | Front panel, JA, M-RESTN | M1021448 | |
| 26 | Front panel, NL, M-RESTN | M1021449 | |
| 26 | Front panel, NO, M-RESTN | M1041450 | |

| Item | Description | Order No. | Replaced by |
|---|---|---|---|
| 26 | Front panel, PL, M-RESTN | M1021451 | |
| 26 | Front panel, PT, M-RESTN | M1021452 | |
| 26 | Front panel, SV, M-RESTN | M1021453 | |

# 7 EARLIER REVISIONS

No earlier revisions.

**For your notes:**

# APPENDIX A

# SERVICE CHECK FORM

## DATEX-OHMEDA M-PRESTN, M-RESTN, M-PRETN MODULES

Customer ____________________

Service ____________ Module type ____________ S/N ____________

Service engineer ____________________ Date ____________

☐ OK = Test OK ☐ N.A. = Test not applicable ☐ Fail = Test Failed

| All modules | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | ☐ | ☐ | ☐ | 2. External parts | ☐ | ☐ | ☐ |
| 3. NIBP pump filter | ☐ | ☐ | ☐ | 4. Installation | ☐ | ☐ | ☐ |
| 5. Recognition | ☐ | ☐ | ☐ | | | | |

Notes ____________________

ECG measurement S/N ____________

6. Module software (serial numbers)

| | |
|---|---|
| ECG/RESP | |
| STP | |
| NIBP | |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 7. Communication and memories | ☐ | ☐ | ☐ | 8. Power frequency | ☐ | ☐ | ☐ |
| 9. Cable recognition | ☐ | ☐ | ☐ | 10. Lead detection | ☐ | ☐ | ☐ |
| 11. Test with patient simulator | ☐ | ☐ | ☐ | | | | |

Notes ____________________

RESP measurement

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 12. RESP measurement recognition | ☐ | ☐ | ☐ | 13. Test with patient simulator | ☐ | ☐ | ☐ |

Notes

TEMP measurement

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 14. Communication and memories | ☐ | ☐ | ☐ | 15. Temperature probe detection | ☐ | ☐ | ☐ |
| 16. Calibration check | ☐ | ☐ | ☐ | 17. Temp test -function | ☐ | ☐ | ☐ |
| 18. Configuration STP/ST/TP | ☐ | ☐ | ☐ | | | | |

Notes

InvBP measurement

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 19. Membrane keys | ☐ | ☐ | ☐ | 20. Cable and transducer detection | ☐ | ☐ | ☐ |
| 21. Calibration | ☐ | ☐ | ☐ | 22. Test with patient simulator | ☐ | ☐ | ☐ |

Notes

$SpO_2$ measurement

S/N

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 23. $SpO_2$ probe detection | ☐ | ☐ | ☐ | 24. Test measurement | ☐ | ☐ | ☐ |

Notes

NIBP measurement

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| S/N | | | | | | | |
| | OK | N.A. | Fail | | OK | N.A. | Fail |
| 25. Communication and memories | ☐ | ☐ | ☐ | 26. Membrane keys | ☐ | ☐ | ☐ |
| 27. Pump and valves | ☐ | ☐ | ☐ | | | | |

| | | |
|---|---|---|
| 28. Leak test | | 28. $\leq 6$ mmHg/min |

| 29. Calibration check | Measured B1 | Measured B2 | Allowed range |
|---|---|---|---|
| 0 mmHg | | | $\pm 9$ mmHg |
| 100 mmHg | | | $100 \pm 2$ mmHg |
| 200 mmHg | | | $200 \pm 3$ mmHg |
| 260 mmHg | | | $260 \pm 4$ mmHg |

30. Safety valve functions

| | B1 | B2 | Allowed range |
|---|---|---|---|
| 'Max press' ADULT | | | 270 to 330 mmHg |
| '2 s after stop' ADULT | | | 270 to 330 mmHg |
| 'Max press' INFANT | | | 130 to 165 mmHg |
| '2 s after stop' INFANT | | | 130 to 165 mmHg |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 31. Cuff related messages | ☐ | ☐ | ☐ | 32. Adult cuff detection | ☐ | ☐ | ☐ |
| 33. Test measurement | ☐ | ☐ | ☐ | 34. Infant cuff detection | ☐ | ☐ | ☐ |

Notes

All modules

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 35. Electrical safety check | ☐ | ☐ | ☐ | 36. Functioning after electrical safety check | ☐ | ☐ | ☐ |
| 37. Final cleaning | ☐ | ☐ | ☐ | | | | |

Notes

Notes

Used Spare Parts

Signature

# Datex-Ohmeda

# S/5™ Airway Module, G-AO (rev. 06)
# S/5™ Airway Module, G-AiO (rev. 05)
# S/5™ Airway Module, G-AiOV (rev. 04)
# S/5™ Airway Module, G-AOV (rev. 04)

# S/5™ Gas Interface Board, B-GAS (rev. 01)

## Technical Reference Manual Slot

All specifications are subject to change without notice.

Document No. 8001005-5

September 2003

Datex-Ohmeda, Inc.

P.O. Box 7550, Madison
WI 53707-7550, USA
Tel. 1-608-221-1551 Fax 1-608-222-9147

www.us.datex-ohmeda.com

mailto:product.support.ussub@us.datex-ohmeda.com

Datex-Ohmeda Division, Instrumentarium Corp.
P.O. Box 900, FIN-00031
DATEX-OHMEDA, FINLAND
Tel. +358 10 394 11 Fax +358 9 146 3310
www.datex-ohmeda.com

# TABLE OF CONTENTS

## S/5 Airway modules and S/5 Gas Interface Board, B-GAS

# TABLE OF FIGURES

# INTRODUCTION

The S/5 Airway Modules, G-AO, G-AiO, G-AOV and G-AiOV are designed for use with the S/5 Anesthesia Monitor and provide airway and respiratory parameters. Later in this manual modules can be called w/o system name S/5.

This Technical Reference Manual Slot provides information for the maintenance and service of the airway modules. Please see also the *Technical Reference Manual* for information regarding to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

Letters in the name stand for:
G = Side mountable gas module
O = $CO_2$, Patient $O_2$, and $N_2O$
V = Patient Spirometry
A = Anesthetic agents
i = Agent identification

**Table 1 Options of Parameter Modules**

| | $CO_2$ | $N_2O$ | Patient $O_2$ | Agents | Agent id | Spirometry |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| **G-AO** | • | • | • | • | | |
| **G-AiO** | • | • | • | • | • | |
| **G-AOV** | • | • | • | • | | • |
| **G-AiOV** | • | • | • | • | • | • |

NOTE: The Airway Modules and Compact Airway Modules cannot be used simultaneously in the same monitor.

### Gas Interface Board

Gas Interface Board, B-GAS is used for connecting the airway module to the central unit. The connection can also be made through the Interface Board, B-INT.

# 1 SPECIFICATIONS

## 1.1 General specifications

| | |
|---|---|
| Module size, W × D × H | 135 × 410 × 135 mm/5.3 × 15.0 × 5.3 in |
| Module weight | 6 kg/13 lbs. |

## 1.2 Typical performance

| | |
|---|---|
| Sampling rate | 200 ml/min nominal (180...220 ml/min) |
| Display update rate | breath-by-breath |

Automatic compensation for pressure, $CO_2$-$N_2O$, and $CO_2$-$O_2$ collision broadening effect. Warm-up time 3 min for operation, 30 min for full specifications.

Auto-zeroing is performed at start-up, after 5 min + 5 min + 5 min + 15 min + 15 min + 15 min, and after that every 60 min at regular intervals.

### 1.2.1 $CO_2$

| | |
|---|---|
| Measurement range | 0 to 10 %, (0 to 10 kPa), (0 to 76 mmHg) |
| Extended range | 10 to 15 %, (10 to 15 kPa), (76 to 114 mmHg) (unspecified) |

If $CO_2$ concentration is below 0.1 %, 0.0 % is displayed.

### 1.2.2 Respiration rate

| | |
|---|---|
| Breath detection | 1 % change in $CO_2$ level |
| Measurement range | 4 to 60 breaths/min |

### 1.2.3 $O_2$

| | |
|---|---|
| Measurement range | 0 to 100 % $O_2$ |

### 1.2.4 $N_2O$

| | |
|---|---|
| Measurement range | 0 to 100 % $N_2O$ |

### 1.2.5 Hal, Iso, Enf

| | |
|---|---|
| Measurement range | 0 to 5 % |
| Extended range | 5 to 15 % (unspecified) |

### 1.2.6 Sev

| | |
|---|---|
| Measurement range | 0 to 8 % |
| Extended range | 8 to 15 % (unspecified) |

### 1.2.7 Des

| | |
|---|---|
| Measurement range | 0 to 18 % |
| Extended range | 18 to 30 % (unspecified) |
| Resolution | two decimals when the AA concentration below 1.0 % |

If AA concentration is below 0.10 %, 0.00 % is displayed.

### 1.2.8 Agent identification

| | |
|---|---|
| Identified agents | HAL, ENF, ISO, SEV, DES |
| Identification time | 30 seconds (typical value with pure agents) |
| Identification threshold | 0.15 vol% (typical) |

Mixture warning when minor component concentration > 0.3 vol% and > 15 %of total agent concentration

### 1.2.9 Patient Spirometry

Values are valid when:

| | | |
|---|---|---|
| Respiratory rate | adult 4...30 | pedi 4...50 breaths/min |
| I:E ratio | 1:3 - 1:0.5 | |

Inner diameter of ET tube is ≥ 5.5 mm (adult) or 3 to 6 mm (pediatric).

### 1.2.10 Airway Pressure (Paw)

| | |
|---|---|
| Accuracy | ±1.5 $cmH_2O$ |
| Resolution | 1 $cmH_2O$ |
| Measuring range | -20 to +80 $cmH_2O$ |

### 1.2.11 Tidal Volume (TV)

| | |
|---|---|
| Accuracy | ±6 % or 30 ml (adult); ±6 % or 4 ml (ped) |
| Resolution | 1 ml |
| Measurement range | 150 to 2000 ml (adult)<br>15 to 300 ml (pediatric) |

### 1.2.12 Minute Volume (MV)

| | |
|---|---|
| Resolution | 0.1 l/min |
| Measurement range | 2 to 15 l/min (adult)<br>0.5 to 5 l/min (pediatric) |

### 1.2.13 Airway flow

| | |
|---|---|
| Measurement range | 1.5 to 100 l/min for both directions (adult)<br>0.25 to 25 l/min for both directions (pediatric) |

# 1.3 Technical specification

## 1.3.1 $CO_2$

| | |
|---|---|
| Measurement rise time | <360 ms (from 10 to 90 %) |
| Gain stability | ≤0.2 %$CO_2$/24 h (0 to 8 %) |
| | ≤0.4 %$CO_2$/24 h (8 to 10 %) |
| Gain temperature drift | ≤0.2 %$CO_2$/10 °C (0 to 8 %) |
| | ≤0.4 %$CO_2$/10 °C (8 to 10 %) |
| Nonlinearity error | ≤0.2 %$CO_2$ (0 to 8 %) |
| | ≤0.4 %$CO_2$ (8 to 10 %) |

## 1.3.2 $O_2$

| | |
|---|---|
| Measurement rise time | <480 ms (from 10 to 90 %) |
| Gain drift | ≤2 % $O_2$/24 h |
| Gain temperature drift | ≤3 % $O_2$/10 °C |
| Nonlinearity error | ≤2 % $O_2$ |

## 1.3.3 $N_2O$

| | |
|---|---|
| Measurement rise time | <360 ms (from 10 to 90 %) |
| Gain drift | ≤2 % $N_2O$/24 h |
| Gain temperature drift | ≤3 % $N_2O$/10 °C |
| Nonlinearity error | ≤2 % $N_2O$ |

## 1.3.4 AA

| | |
|---|---|
| Measurement rise time | <520 ms (from 10 to 90 %) |
| Gain drift | ≤0.4 % AA/24 h |
| Gain temperature drift | ≤0.4 % AA/10 °C |
| Nonlinearity error | ≤0.2 % AA |

Protection against electrical shock
Type BF

# 2 FUNCTIONAL DESCRIPTION

## 2.1 Measurement principle

### 2.1.1 $CO_2$, $N_2O$ and Agent measurement

The $CO_2$, $N_2O$, and anesthetic agent the gas measurements are based on absorption of infrared light as it passes through the gas sample in measuring chamber of the photometer. The light absorption is measured at three wavelengths using an infrared detector. One of the wavelengths is that of the $CO_2$ absorption peak at 4.3 micrometers, the second is that of the $N_2O$ absorption peak at 3.9 micrometers, and the third is that of the anesthetic agent absorption peak at 3.3 micrometers. The signal processing electronics receive the signals from the IR detector and demodulate it to get DC components out of these signals which correspond to the content of each gas in the sample.

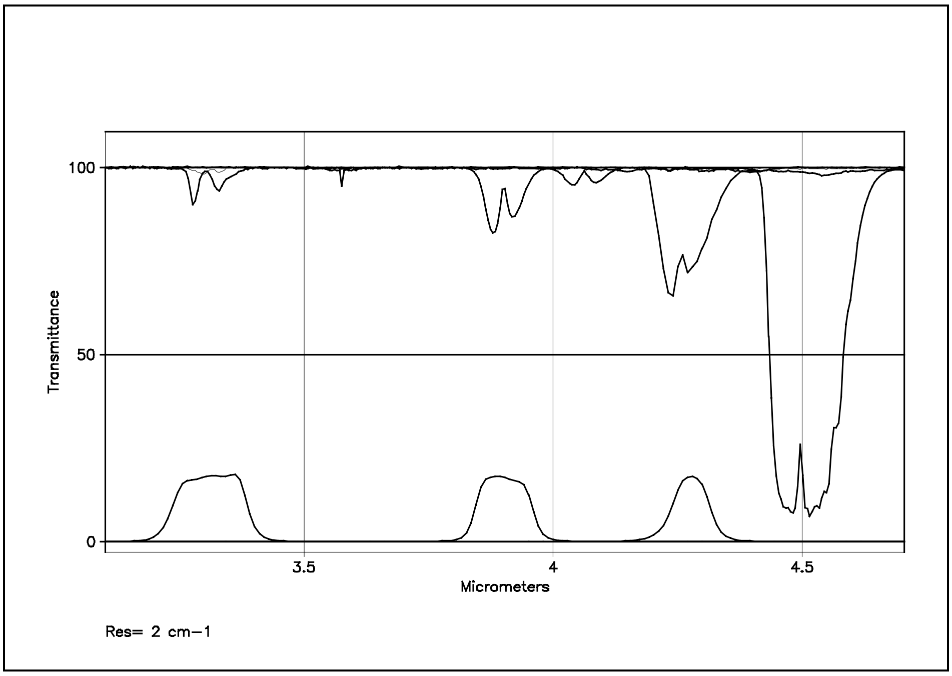



**Figure 1 $CO_2$/$N_2O$/AA gas absorption spectra**

## 2.1.2 $O_2$ measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer is generated in a measuring cell with a strong magnetic field that is switched on and off at a frequency of 110 Hz. The output signal is a DC voltage proportional to the $O_2$ concentration difference between the two gases to be measured.

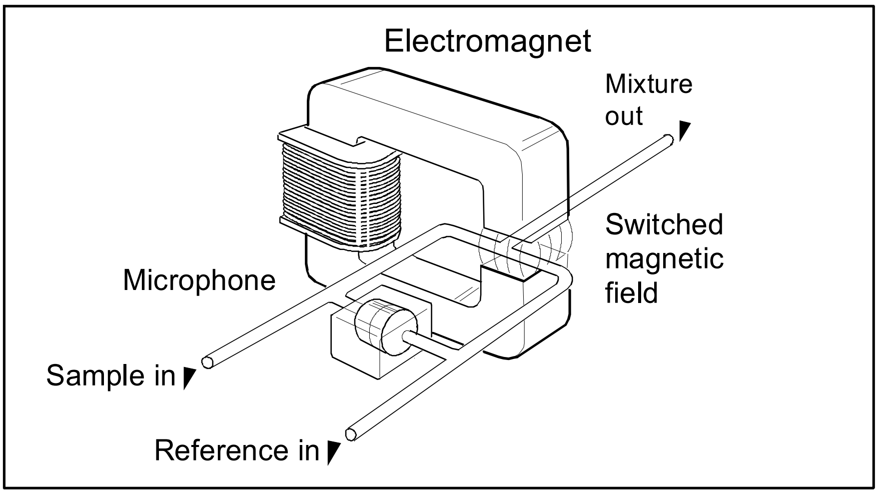



**Figure 2 $O_2$ measurement principle**

### 2.1.3 Agent identification

The anesthetic agent identification bench identifies Halothane, Enflurane, Isoflurane, Desflurane and Sevoflurane.

The bench measures the spectrum of the gas between 3.24 µm and 3.39 µm. Because the spectrum of each of the anaesthetic agents is different it is possible to identify them.

The bench consists of an infrared source, a measuring chamber, a rotating filter and a detector. The peak wavelength of the narrow bandpass filter changes when the angle between the light path and the filter is changed. When the filter rotates the required spectrum is scanned through. The agent or a mixture of agents is identified by comparing the measured spectrum with stored reference spectra.

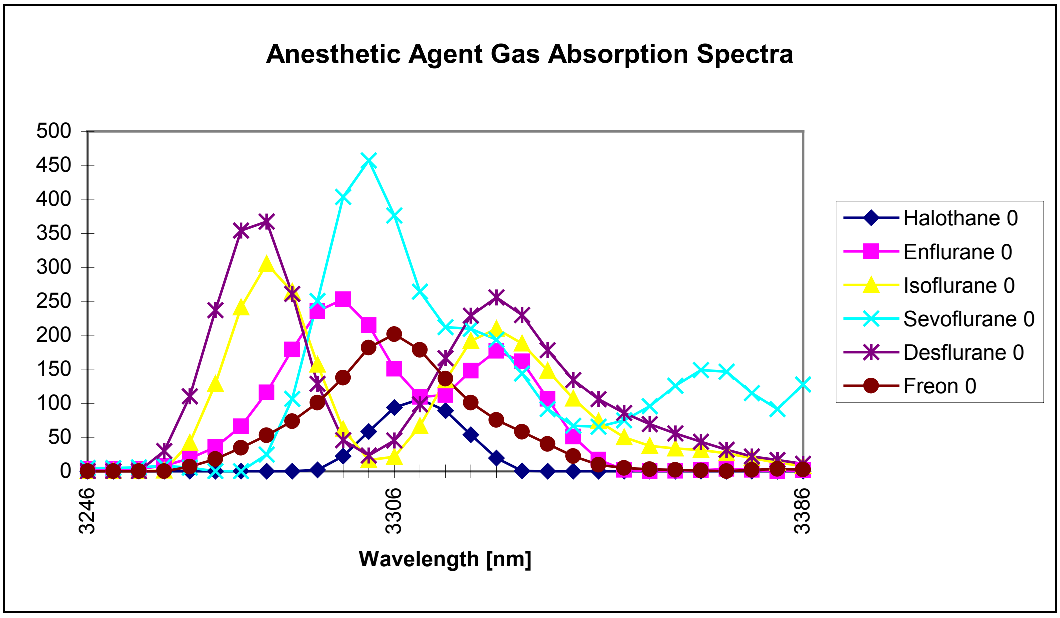



**Figure 3** **Anaesthetic Agents gas absorption spectra**

### 2.1.4 Patient Spirometry

In anesthesia, CMV (Controlled Mechanical Ventilation) is the mostly used ventilation mode. In this mode, mechanical breaths are delivered to the patient by a ventilator with a proper tidal volume (TV), respiration rate (RR), and inspiration/expiration ratio in time (I:E) determined by the settings of the ventilator.

Delivery of life support gases is based on pressure. However, without knowing the measured volume of exhalation, one cannot be sure that a breath occurred. The ultimate goal of ventilation is to use the least amount of pressure to generate the most appropriate volume for each breath.

Patient Spirometry monitors ventilation in anesthesia. Both patient breathing circuit and the function of the ventilator are monitored. The following parameters are displayed:

Expiratory and inspiratory tidal volume (TV) in ml.
Expiratory and inspiratory minute volume (MV) in l/min.
Expiratory volume in first second (V1.0) in per cent for adults and in 0.5 seconds for children.
Inspiration/expiration ratio in time (I:E)
Airway pressures: Peak pressure ($P_{peak}$), End inspiratory pressure ($P_{plat}$), Positive end expiratory pressure (PEEP), Real time airway pressure waveform ($P_{aw}$)
Flow: Real time flow waveform (V')
Compliance (C)
Pressure volume loop
Flow volume loop

#### Airway pressure

PEEP, $P_{peak}$, and $P_{plat}$ are measured by pressure transducer on the PVX board. Atmospheric pressure is used as a reference in measurement. The pressure measurement is made from the airway part that is closest to the patient between patient circuit and intubation tube.

#### Airway flow

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The obtained pressure signal is linearized and corrected according to the density of the gas. Speed of the flow is calculated from these pressure values and TV value is then integrated. MV value is further calculated and averaged using TV and RR (respiratory rate) values.

### Patient Spirometry sensor, D-lite

Patient Spirometry is measured with a specific sensor,D-Lite+/ D-lite or Pedi-Lite+/ Pedi-lite.

D-lite and Pedi-lite sensors are designed to measure kinetic pressure by two-sided Pitot tube. The pressure reduction caused by measuring cross is taken into account, too, especially in small flows.

Velocity is calculated from pressure difference according to Bernoulli's equation. Flow is then determined using the calculated velocity.

$$\boxed{v = \sqrt{\frac{2 \times dP}{\rho}}}$$ (from Bernoulli's equation)

$\boxed{F = v \times A}$,

where,

F=flow (l/min)

v=velocity (m/s)

A=cross area ($m^2$)

dP=pressure difference ($cmH_2O$)

$\rho$=density ($kg/m^3$)

Finally the volume information is obtained by integrating the flow signal.

## 2.2 Main components

The airway modules consist of ACX-200 and OM-101 gas measuring units, ASX-200 agent identification unit (G-AiO/AiOV), PVX board (G-OV/AiOV/AOV), gas sampling system, ACX measuring board and gas mother board.

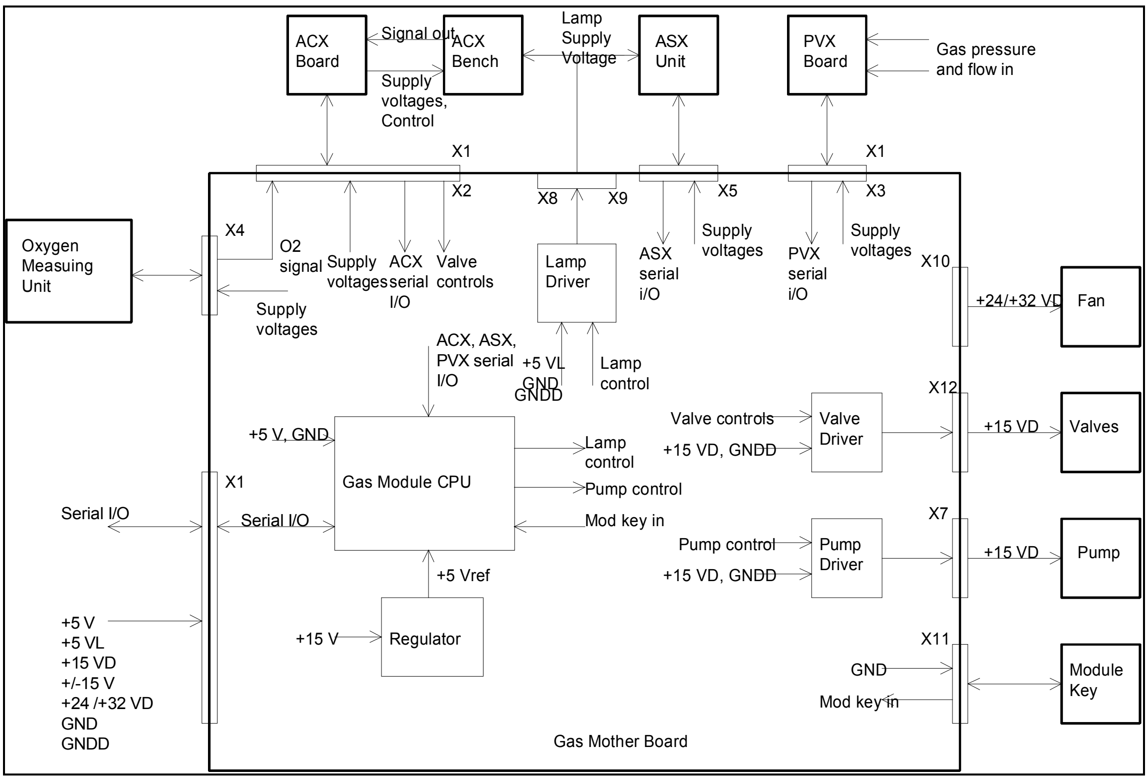



**Figure 4 Airway module block diagram**

### 2.2.1 Gas sampling system

The gas sampling system samples the gas arriving at the module, and removes water and impurities from it. A sampling line is connected to the water trap on the front panel. The pump draws gas through the sampling line to gas measuring units. After the measurements, the gas is exhausted from the sample gas out connector on the rear panel of the module.

### Water trap, D-fend

The gas sample enters the monitor through the water trap, where it is divided into two flows, main flow and side flow (see Gas sampling system block diagram). The main flow goes into the measuring system through a hydrophobic filter.

The side flow creates a slight sub-atmospheric pressure within the water trap container. This facilitates gathering the fluid removed by the hydrophobic filter.

#### Sampling line

The sampling line is an integral part of the total sampling system. The resistance established by the sampling line is significant when the software determines the occlusion and air-leak alarm limits during the turn-on sequence.

The small inner diameter causes fluids such as blood or mucus not to propagate within the tube, so that when the line is clogged, it is replaced.

#### The Nafion™ tube [1)]

A nafion tube (tubes A or B, and C: see figure 5) is used to balance the sample gas humidity with that of ambient air. The tube will prevent errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases. It is inserted between the water trap and the zero valve (G-AiO/AiOV) or between the zero valve and ACX-200 measuring unit (G-O/OV/AO/AOV). The tube is also inserted between the $CO_2$ absorber and the zero valve.

#### Zero valve

The main flow passes through a solenoid valve before proceeding to the ACX-200 measuring unit. This valve is activated to establish the zero points for the ACX-200 and $O_2$ measuring units at start-up, at 5 minutes, and after that at regular intervals. After 1-hour of monitoring, the auto-zeroing is performed once an hour. When the valve is activated, room air is drawn through the $CO_2$ absorber into the internal system and the gas sensors.

[1)] Nafion is a trademark of Du Pont

## Gas measuring units, ACX-200 and $O_2$ unit

After the zero valve, the gas passes through the ACX-200 and $O_2$ measuring units. In the ACX-200 measuring unit, infrared light is passed through chambers containing the main flow gas (measurement) and a chamber containing reference gas. The measurement is made by determining the ratio between the two light intensities.

The oxygen sensor has two inputs. One input accepts the main flow and the other draws in room air for reference. The sensor uses a differential pressure transducer to compare the pressure gradient produced when both gases are exposed to an oscillating magnetic field. Both gas flows exit from a single port.

In i model, the ASX agent identification unit is installed in parallel with the oxygen sensor. The task of the ASX unit is to identify anesthesia agents using the same infrared light method used in the ACX-200 unit.

## Pressure valve

The pressure valve is used to measure the pressure gradient between the $O_2$ measurement flow and the $O_2$ reference flow. This pressure gradient reflects the condition of the D-fend water trap filter.

Normally the pressure gradient between the $O_2$ measurement flow and the reference flow is approximately +8 mmHg. If the software detects the gradient to be between 0 and -5 mmHg, the pressure valve will initiate pressure measurement of the reference flow. If the gradient is greater than -5 mmHg, the software triggers the message 'Replace Trap'.

## Flow cassettes

The internal flow rates are set using flow cassettes. These cassettes are used to set the side flow rate and the $O_2$ reference flow rate, the flow rates through the measuring units and the total flow rate of the sampling system.

## Sampling pump and damping chamber

The sampling pump is a vibrating membrane pump driven by a 50 Hz/12 V/0.4 A square wave current.

The damping chamber is used to even out the pulsating flow and silence the exhaust flow.

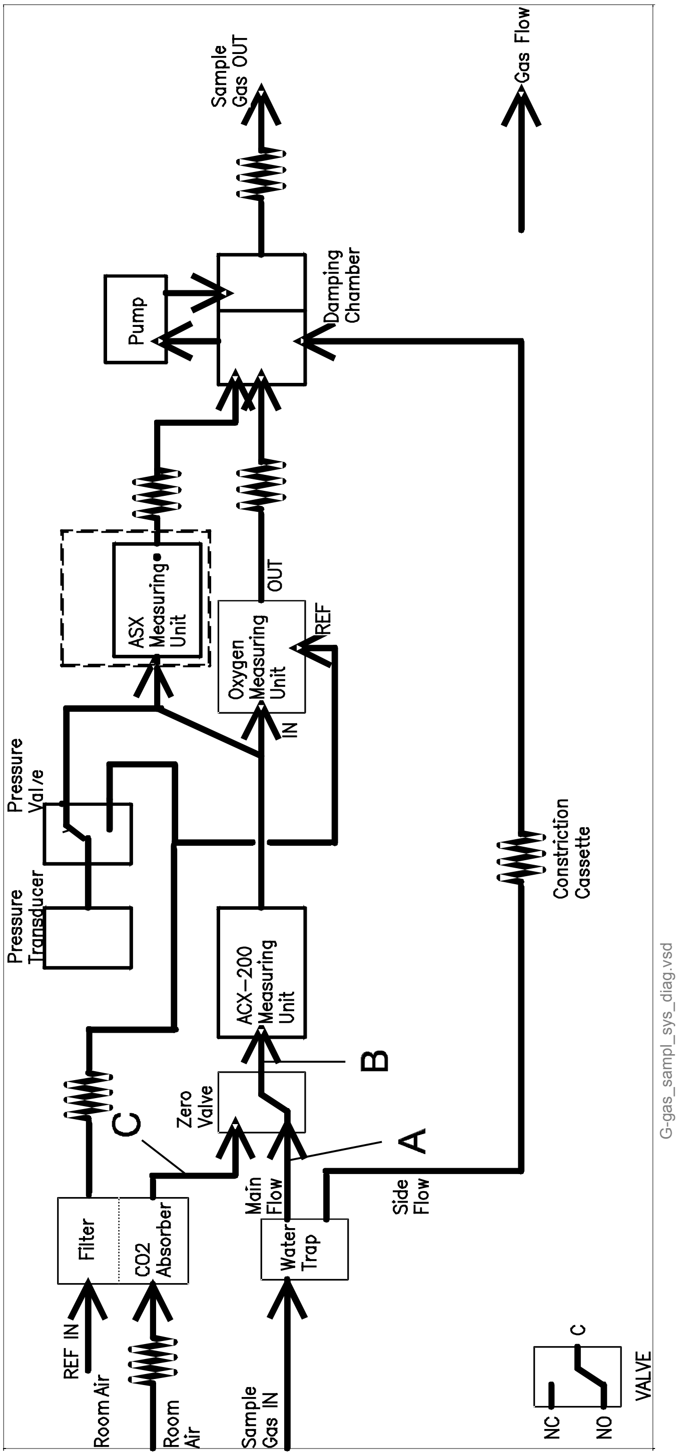


**Figure 5 Gas sampling system block diagram**

In G-AO, -AOV models, tube A is Teflon, B and C Nafion. In G-AiO, -AiOV models, tubes A and C are Nafion, B is Teflon.

See new tubing since autumn 1998 in figure 7.

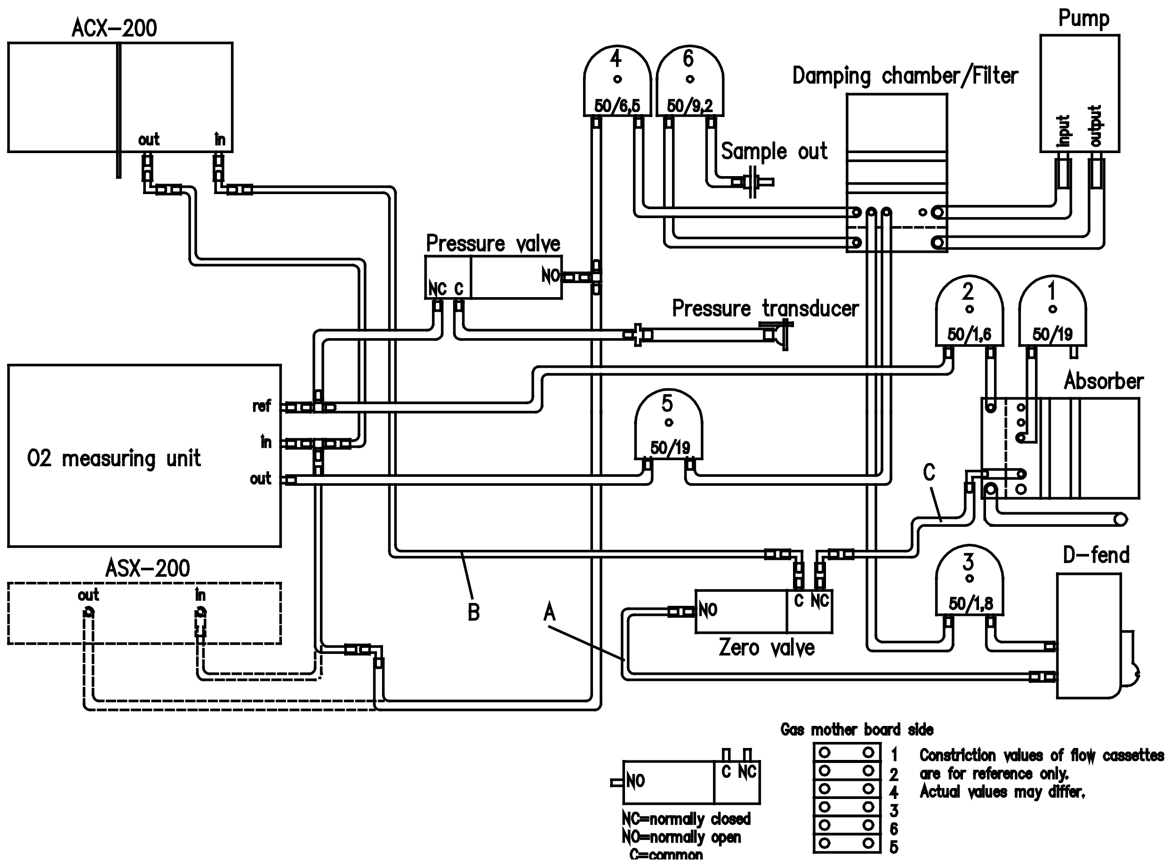



**Figure 6** **Gas sampling system layout**

See new sampling system layout since autumn 1998 in figure 8.

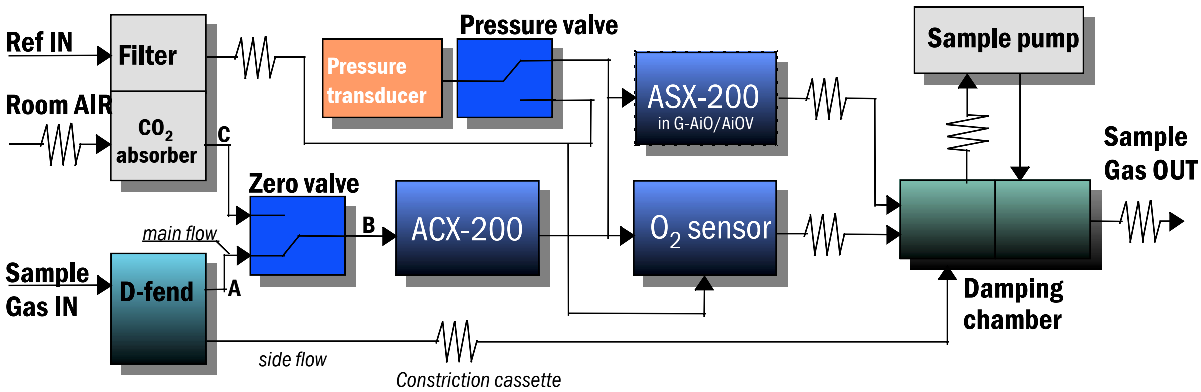



**Figure 7** **Gas sampling system block diagram**

In G-AO, -AOV models, tube A is Teflon, B and C Nafion. In G-AiO, -AiOV models, tubes A and C are Nafion, B is Teflon. Figure 7 is valid for modules manufactured since autumn 1998.

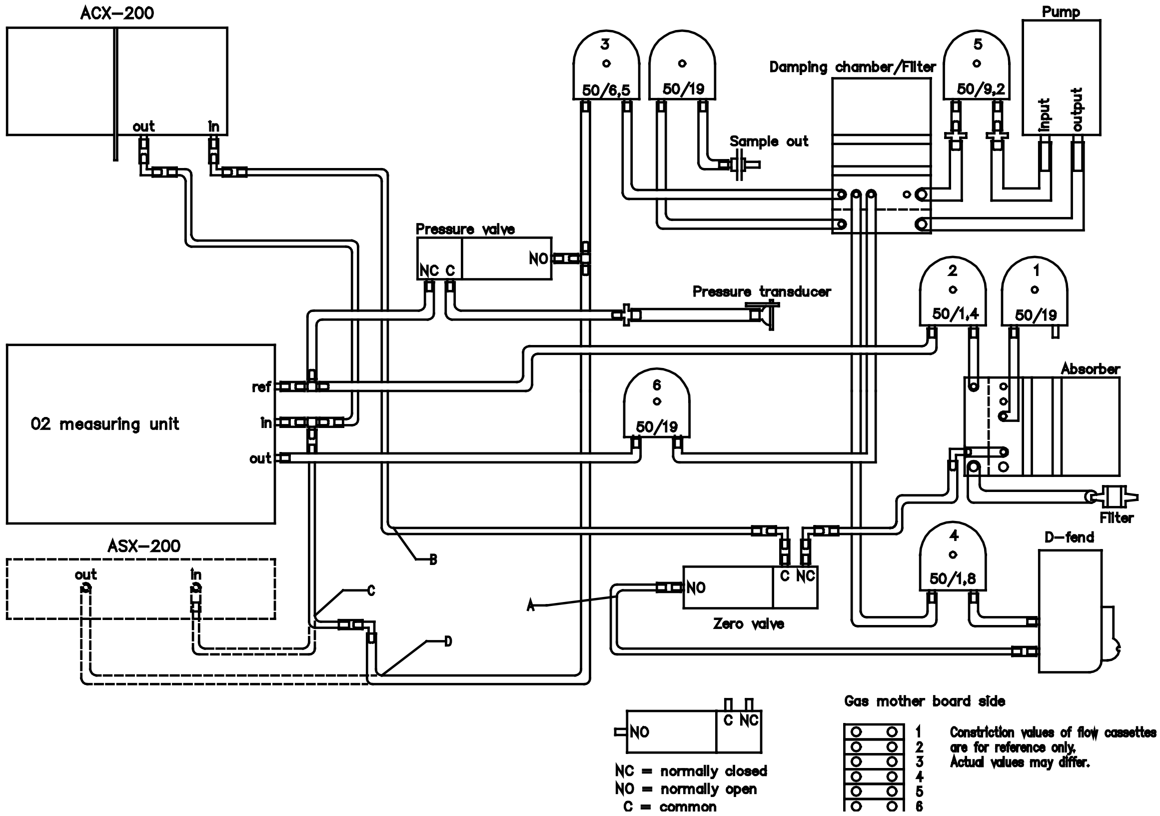



**Figure 8** **Gas sampling system layout**

Figure 8 is valid for modules manufactured since autumn 1998.

**Table 2 Flow cassettes**

| Flow cassette | Code |
|---|---|
| 50/26.0 | 878048 |
| 50/19.0 | 873800 |
| 50/16.3 | 878047 |
| 50/15.3 | 873801 |
| 50/14.1 | 878046 |
| 50/13.1 | 873802 |
| 50/12.4 | 878045 |
| 50/11.2 | 874770 |
| 50/10.4 | 873803 |
| 50/9.2 | 874509 |
| 50/8.7 | 873804 |
| 50/7.4 | 873805 |
| 50/6.5 | 878044 |
| 50/5.8 | 873806 |
| 50/5.1 | 878043 |
| 50/4.4 | 873807 |
| 50/3.8 | 878042 |
| 50/3.2 | 873808 |
| 50/3.0 | 878040 |
| 50/2.8 | 878039 |
| 50/2.5 | 878038 |
| 50/2.3 | 873809 |
| 50/2.0 | 878037 |
| 50/1.8 | 873810 |
| 50/1.6 | 878036 |
| 50/1.4 | 873811 |
| 50/1.1 | 873812 |

NOTE: The number on the cassette represents relative flow when a specific pressure is applied. Therefore 50/26.0 presents the least resistance and 50/1.1 the most.

### 2.2.2 ACX-200 measuring unit

The ACX photometer is of dual path type. The infrared light beam passes through a measuring chamber containing the gas to be analyzed, and a reference chamber, which is free of $CO_2$, $N_2O$, and AA. The measurement is made by determining the ratio between the two light intensities.

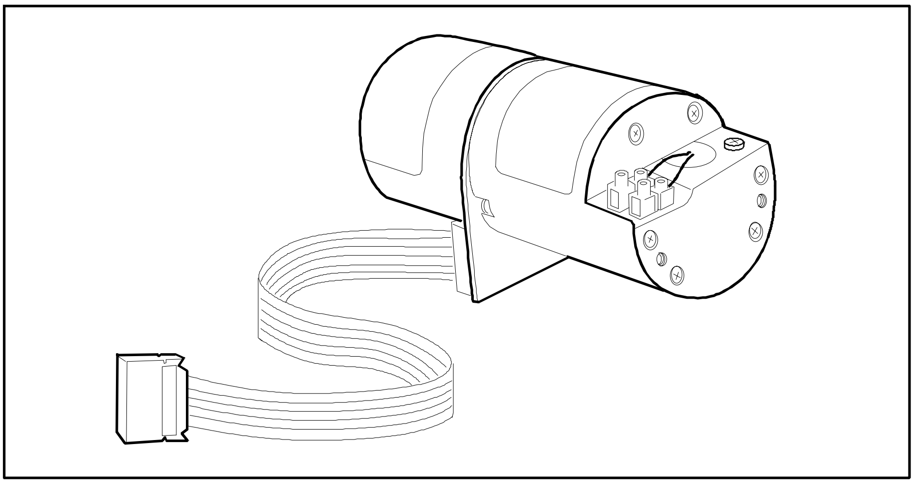


**Figure 9 ACX photometer (ACX-200 measuring unit)**

A filter wheel is used to control the light from an incandescent lamp that passes through the photometer. The filters are arranged so that the light is passed sequentially:

- first at the $CO_2$ absorption wavelength through the reference chamber
- then through the measuring chamber
- finally it is blocked completely

The same sequence is repeated at the $N_2O$ and anesthetic agent gas absorption wavelengths.

After passing through the filters the light is reflected and focused by a mirror onto the infrared detector. This detector measures the three light levels for each gas described above.

There is an optical sensor incorporated in the photometer which detects light from a reflective surface on the filter wheel once every revolution. The pulses from this sensor are used to synchronize the electronics to the signal from the infrared detector. A stabilizing diode measures the temperature, which is needed to compensate for thermal drifts. The infrared detector, the optical sensor and the stabilizing diode are mounted on the preamplifier board.

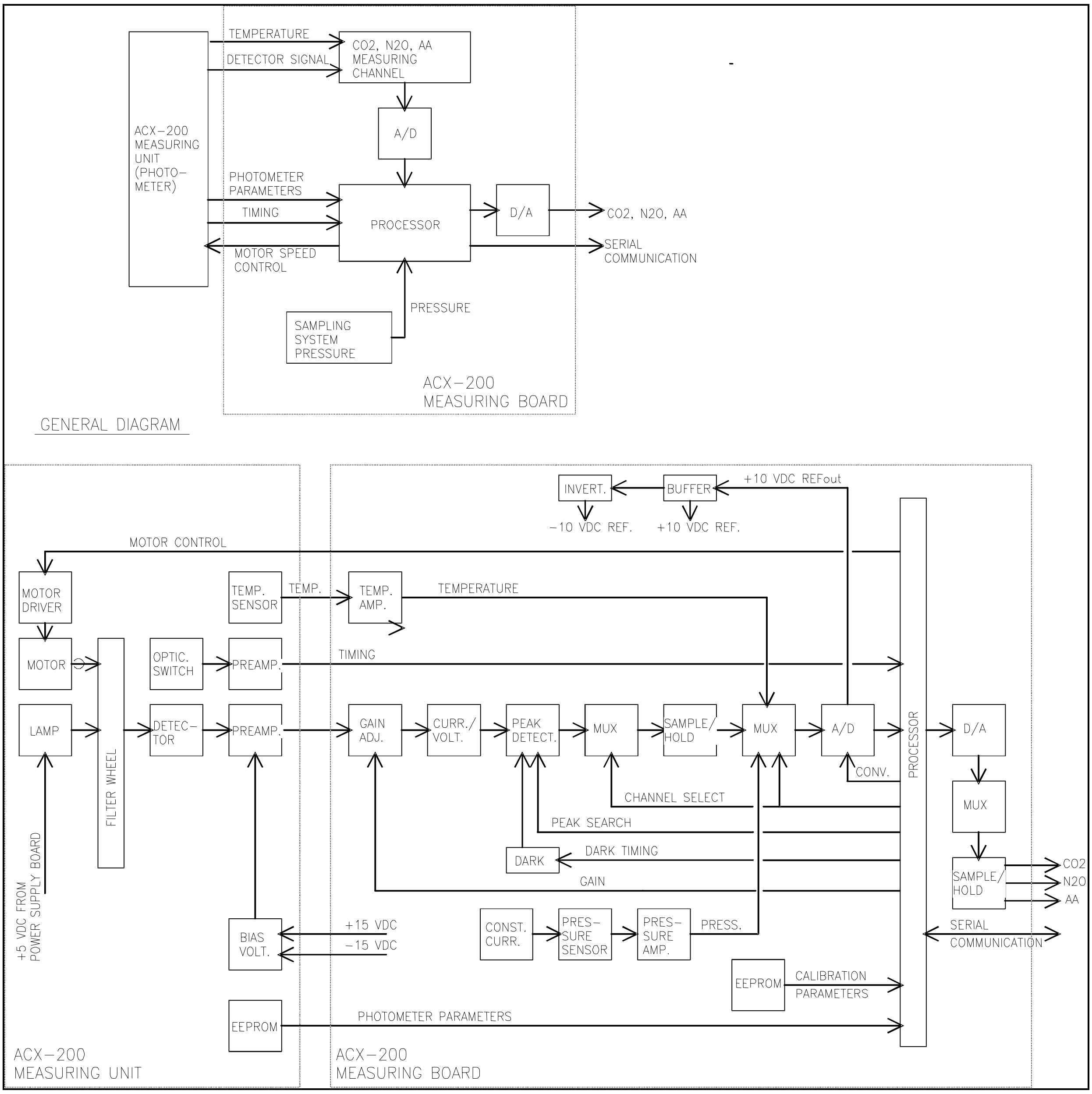



**Figure 10** **$CO_2$/$N_2O$/AA measurement block diagram**

### 2.2.3 OM measuring unit

The oxygen measurement is based on the paramagnetic susceptibility, which is a unique property of oxygen among all gases generally present in a breathing gas mixture. The gas to be measured and the reference gas, which usually is room air, are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 110 Hz.

An alternating differential pressure is generated between the sample and reference inputs due to forces acting on the oxygen molecules in a magnetic field gradient.

The pressure is measured with a sensitive differential transducer, rectified with a synchronous detector and amplified to produce a DC voltage proportional to the oxygen partial pressure difference of the two gases.

### 2.2.4 ACX measuring board

The measuring electronics can be divided into a few functional blocks, which are described below (see the block diagram in figure 11).

The ACX Measuring board controls gas measurements. It converts the photometer signal into digital data, calculates results and transmits it to Gas mother board. The board contains, in addition to the 80C51FA processor, EPROM, RAM, and EEPROM, several analog and digital I/O functions.

#### Internal and external bus

The processor has access to the Measuring board peripherals (memory, A/D converter, D/A converters, etc) via an internal bus. For communication between the Gas mother board and the Measuring board, there is an external bus in connector X1.

#### Memory

Memory components include 64k $\times$ 8 bit EPROM program memory, 32k $\times$ 8 bit low current CMOS RAM, and EEPROM for permanent calibration values and setup memory.

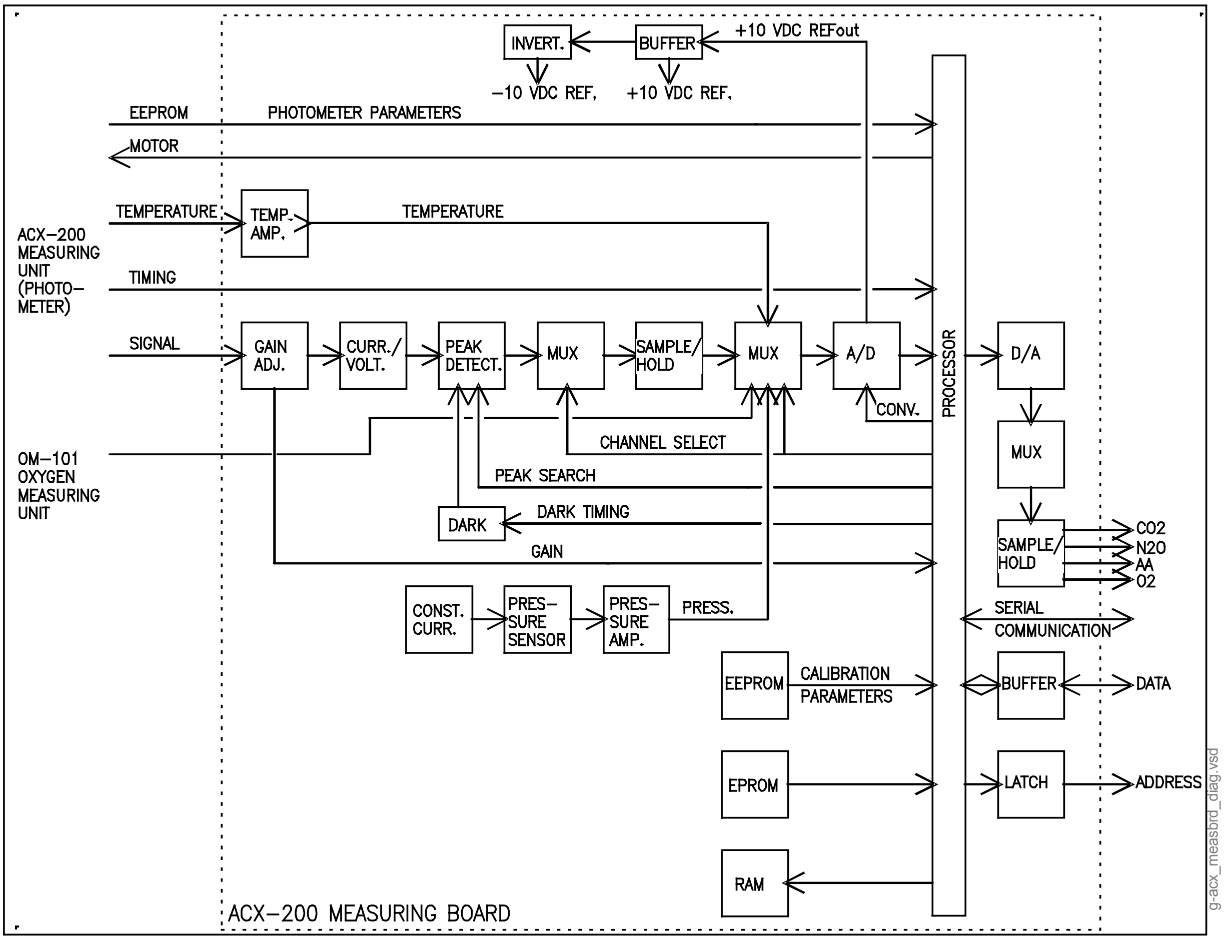



**Figure 11** **ACX measuring board block diagram**

## 2.2.5 ASX agent identification bench

The ASX-200 agent identification bench has one measuring chamber. Background compensation is done by subtracting the background spectrum from the measured signal. The background spectrum is measured simultaneously with the zeroing of the ACX-200 unit. The resulting spectrum is analyzed to identify the agent.

The ASX unit requires two calibrations. One is the time between synchronization pulse and measured spectrum (time offset) of the ASX-200 and the other is the peak wavelength of the narrow bandpass filter. The former is calibrated automatically together with the gas calibration of the ACX and the latter is calibrated at the factory.

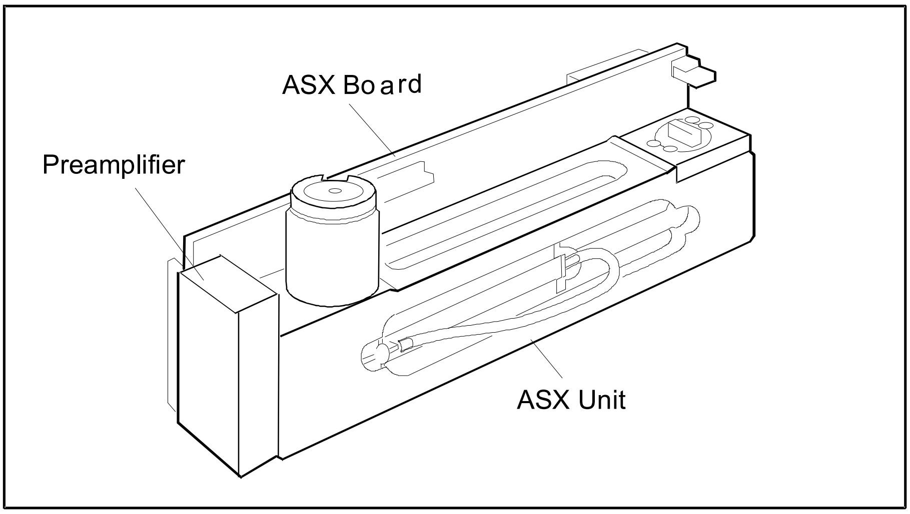



**Figure 12 ASX measuring unit**

### ASX preamplifier board

The absorption of infrared light is measured with a lead selenide detector. The signal is amplified and then sent to the measuring board.

## 2.2.6 ASX measuring board

The measuring electronics can be divided into a few functional blocks, which are described below (See the block diagram in figure 13).

The ASX measuring board controls the measurement. It converts the ASX photometer signal to digital data, calculates results and communicates with the main CPU through a serial channel. The board contains, in addition to the 80C196 processor, EPROM, RAM, and EEPROM, several analog and digital I/O functions.

**Processor section**

Processor is a 80C196 and works at 12 MHz. It has an internal A/D-converter with a multiplexer. One channel is used for converting temperature signal. Two others are for the measurement signal from preamplifier board.

The processor uses an internal bus to access EPROM (64k x 8 bit), SRAM (8k x 8 bit) and two D/A-converters. It communicates with the Gas mother board through a serial channel (RXD, TXDB).

EEPROM is a 64 x 16 bit serial chip. It is partly protected so that if jumper X1 is installed the processor can erase or write the protected registers by serial communication commands. The protected section contains permanent factory calibrations.

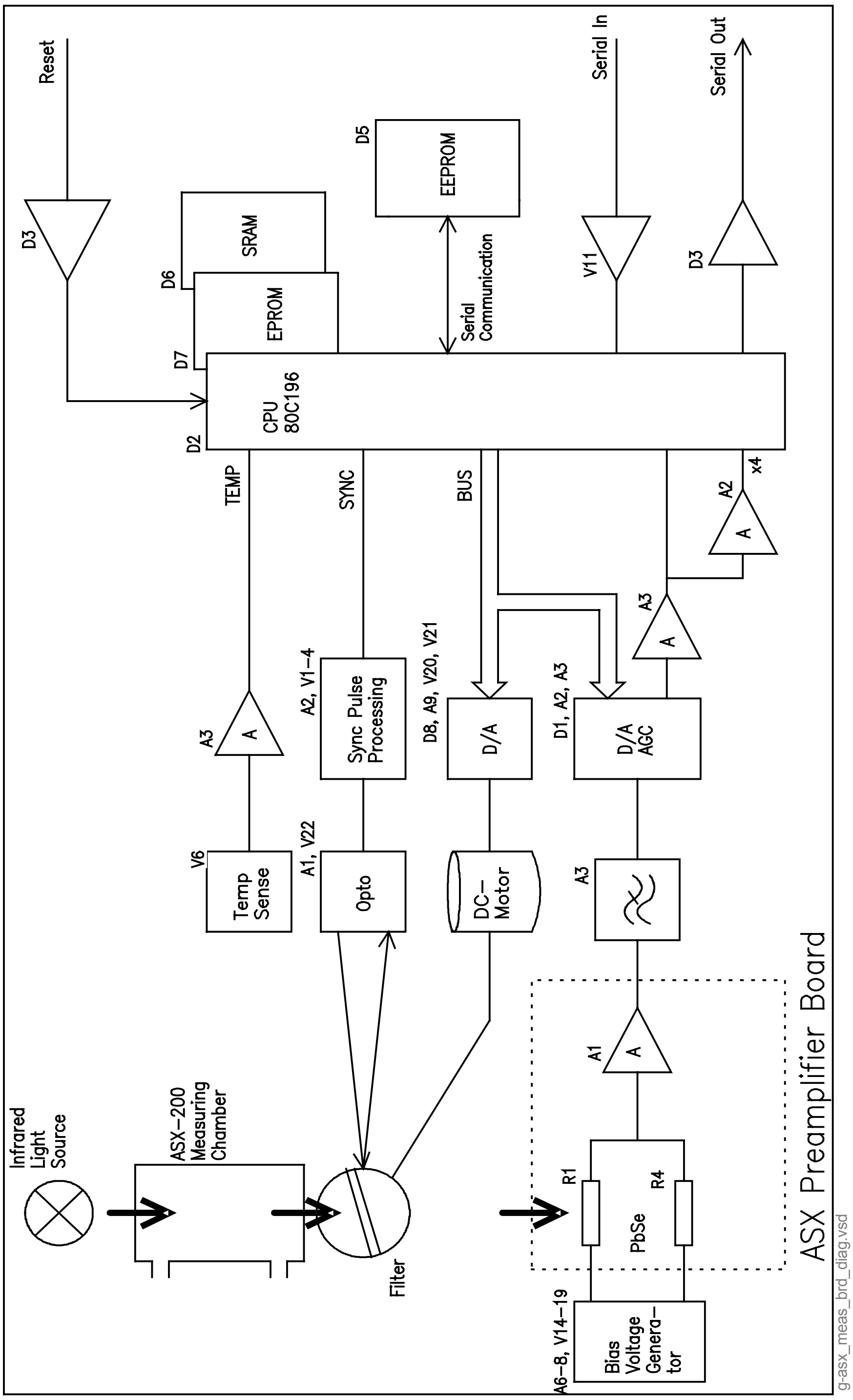



**Figure 13** **ASX measuring board block diagram**

### 2.2.7 PVX board

When Patient Spirometry is used, special sensors, D-Lite+ / D-lite or Pedi-Lite+ / Pedi-lite, replaces the normal airway adapter in the patient circuit. The spirometry tubing is attached to the two connectors on the sensor and on the module front panel.

NOTE: Overpressure or negative pressure of more than 300 $cmH_2O$ to the flow and volume tubing should never be applied.

The board is intended to perform the following tasks

- Measure the pressures in airways and the speed of breathing flow.
- Calculate tidal volume, minute volume, compliance and other useful information on patient lungs.

#### Pressure transducers

There are two pressure transducers on the PVX board for airway pressure measuring purposes.

The breathing flow of a patient passing through D-lite adapter creates pressure difference. This pressure difference is measured by pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer B2.

NOTE: Never apply DIFFERENTIAL pressure higher than 25 $cmH_2O$ to the spirometry tubing. Make sure that both spirometry tubes are always connected.

#### Temperature compensation

Temperature is measured by B1. This signal is used only for temperature compensation of the pressure transducer B1 on the PVX board.

#### Data processing

After the multiplexer, the signals, PRESS, FLOW0, FLOW1, and TEMP are A/D converted for data processing.

#### External communication

Communication between the PVX board and the Gas mother board is established in serial form, using the serial channel (pins 10 and 11) of CPU on the PVX board.

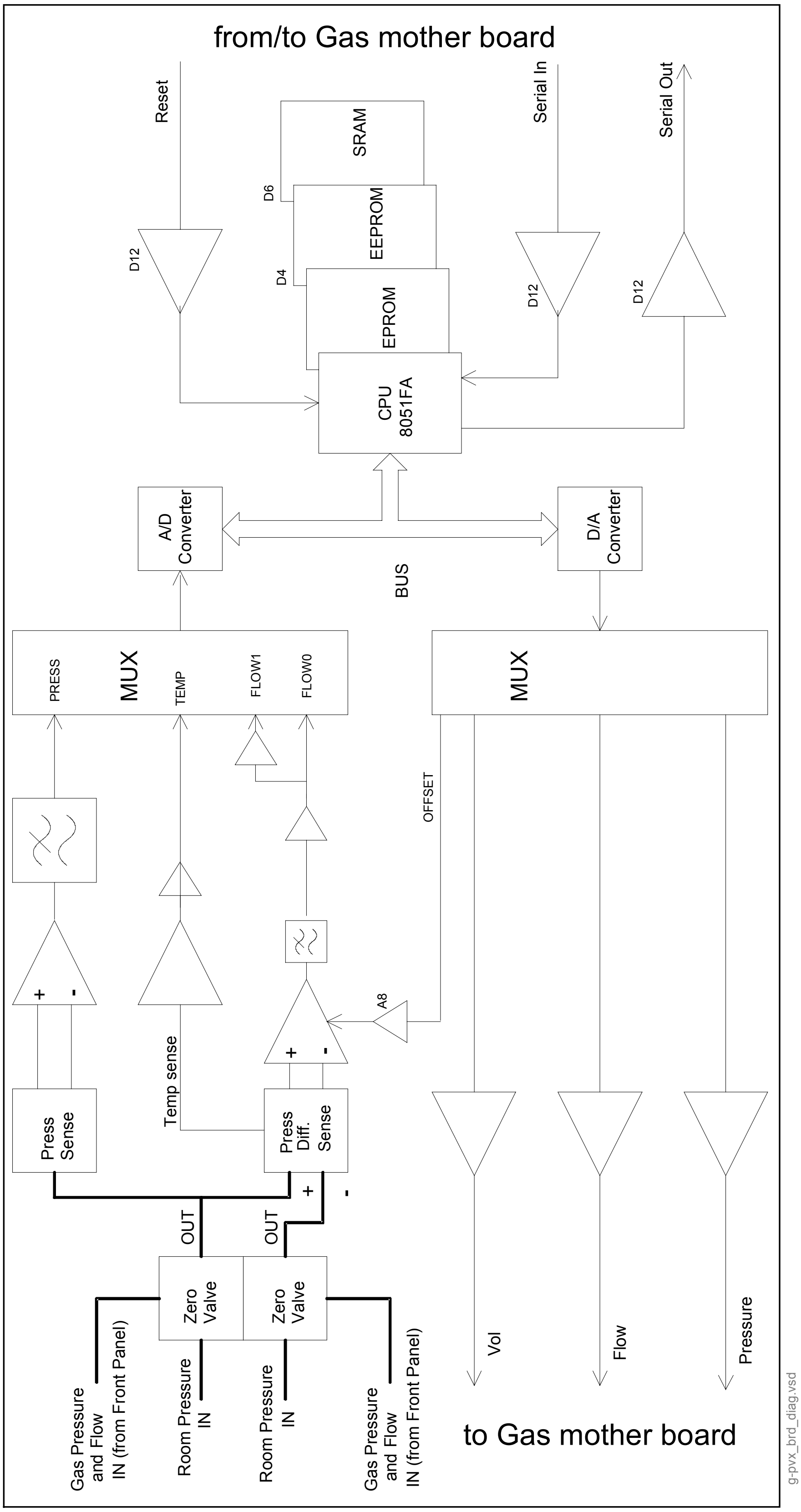



**Figure 14** **PVX board block diagram**

## 2.2.8 Gas mother board

The Gas mother board controls power supply to each measuring unit, as well as the serial communication between the units and the module processor. There are connectors for the pump, valves and gas measuring units on the board. The board contains a processor which controls the functions within the module.

The tasks of the module processor are:

- to receive commands from the main CPU board and pass them on to Measuring boards.
- to gather measurement results from the Measuring boards, analyze them, and transmits data to the main CPU board.
- to control the valves and pump based on the data which ACX Measuring board transmits.

### Main parts

- Module processor 80C196KC/16 MHz
- 16 MHz oscillator
- EPROM program memory
- External RAM memory
- EEPROM
- Address and data bus latch
- Address decoding GAL-circuit
- 4-channel serial communication IC (QUART, D4)

### External communication

Serial communication bus inside the module processor is used. The bus is connected to module bus via RS-485 buffer. Transmit and reception controls of buffer are controlled by the processor.

### Connections to measuring boards

Data collection from the measuring units takes place in serial communication bus. Serial communication lines of the measuring units are connected to QUART IC on the Gas mother board; Channel 1 - ACX, channel 2 - ASX, channels 3 - PVX, channel 4 - not in use). The transmit side of QUART has a buffer IC and the receipt side has a pull-up resistor.

## Valves, pump and infrared lamps control

Valves are controlled by the ACX Measuring board from which the control signals are run through buffer IC to the valve connector. OCCLUS signal controls the pressure (occlusion) valve and ZERO signal controls the zero valve.
The control signal for the pump comes from the module processor. The signal is 50 Hz pulse-width modulated square wave. The control command is received from ACX Measuring board in serial communication.
The control command (LAMP) of the infrared lamps of the chambers comes from the module processor.

## Key push reading

CPU reads the front panel key pushes.

## Reset

Voltage supervising circuit performs power-on reset. Reset from the module bus is connected via RS-485 buffer.

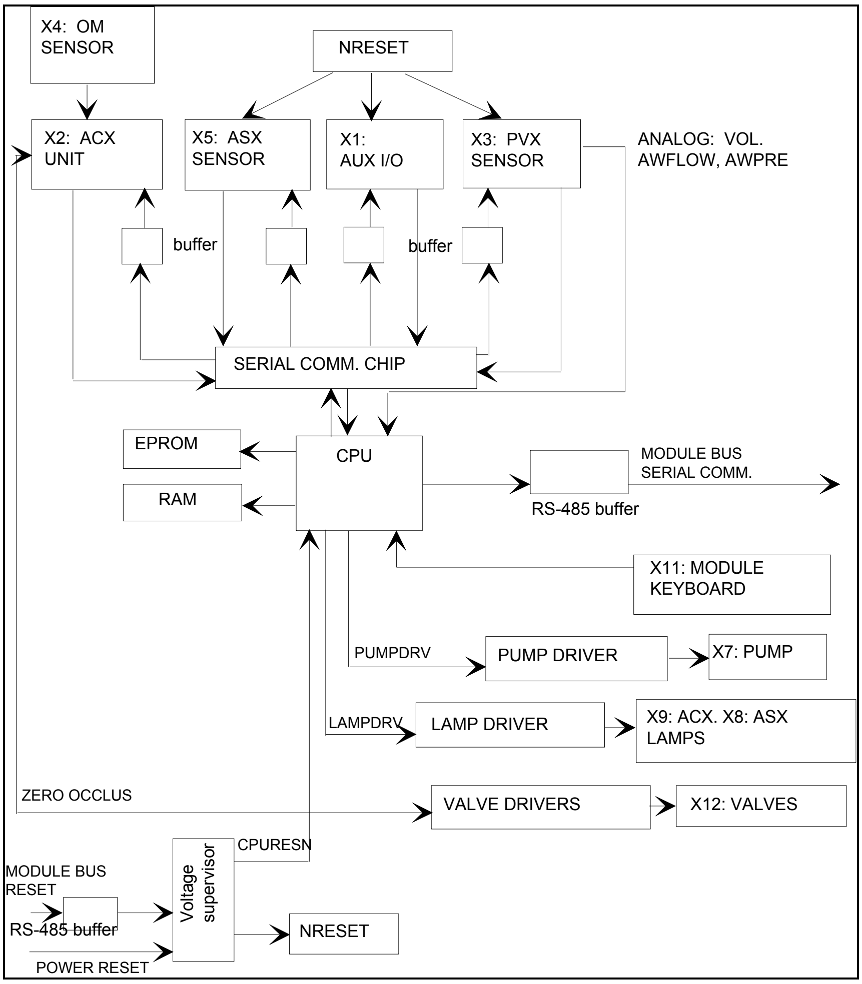



**Figure 15** **Gas mother board block diagram**

### 2.2.9 Gas interface board

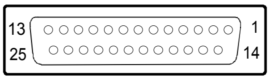
The Gas interface board, B-GAS is used for connecting an Airway Module to the Central Unit.

The board connects Airway Module signals to the module bus and supplies voltages from the module bus to the Airway Module.

On the board there is a fuse (T4A) and some capacitors to regulate the power supply.

## 2.3 Connectors and signals

### 2.3.1 Module bus connector




| Pin No | I/O | Signal |
|---|---|---|
| 1 | I | RESET RS485 |
| 2 | I | -15 VDC |
| 3 | I | +15 VDIRTY |
| 4 | I | +15VDC |
| 5 | I/O | -DATA RS485 |
| 6 | I/O | DATA RS485 |
| 7 | | Ground and Shield |
| 8 | I | -RESET RS485 |
| 9 | | n/c |
| 10 | | n/c |
| 11 | | n/c |
| 12 | | n/c |
| 13 | | Ground and Shield |
| 14 | I | +24/+32 VDIRTY Depends on power supply |
| 15 | I | Ground DIRTY |
| 16 | | n/c |
| 17 | | n/c |
| 18 | | n/c |
| 19 | | n/c |
| 20 | I | GASFR (not used) |
| 21 | I | CTSD (not used) |
| 22 | I | TXDD (not used) |
| 23 | O | RXDD (not used) |
| 24 | I | +5 VDC |
| 25 | I | +5 VDC DIRTY, for infrared lamps |

For B-GAS CPU Mother Board connector, see CPU Bus Connector in the Central Unit Section.

### 2.3.2 Gas mother board connectors

| | |
|---|---|
| X1 | Module connector. Serial communication bus to the main CPU board. Supply voltages. |
| X2 | ACX Measuring board |
| X3 | PVX board |
| X4 | Oxygen measuring unit |
| X5 | ASX Measuring board |
| X7 | Sampling pump |
| X8, X9 | Power supply for infrared lamps (ACX, ASX) |
| X10 | Fan |
| X11 | Module front panel keys |
| X12 | Valves |

**ACX measuring board (X1) - Gas mother board (X2)**

| Pin No. | a | b | c |
|---|---|---|---|
| 1 | +15 V | NC | AGND |
| 2 | -15 V | NC | +10 VREF |
| 3 | AOUT6 | NC | AOUT5 AA |
| 4 | AOUT4 VL | NC | AOUT3 $CO_2$ |
| 5 | AOUT2 $O_2$ | NC | AOUT1 $N_2O$ |
| 6 | DAC1 FLOW | NC | DAC0 PRES |
| 7 | AIN7 SAL | NC | ADC6 VOUT R |
| 8 | ADC5 AWL | NC | ADC4 VOUT IR |
| 9 | ADC3 $O_2$ | NC | ADC2 |
| 10 | ADC1 AWP | NC | AIN4 SSIGN |
| 11 | NC | AGND | NC |
| 12 | NC | AGND | NC |
| 13 | NC | LAMP | NC |
| 14 | NC | PB5 | NC |
| 15 | NC | SSYNC | NC |
| 16 | RBD2 | SMOTOR | NC |
| 17 | -RESET | -PC0 | TO RTSO |
| 18 | SEROUT 0 | NC | SERIN 0 |
| 19 | P1.1 | PC2 FGAIN 1 | P1.0 |
| 20 | OP0 RTSA | PC3 FGAIN 2 | INT0 |
| 21 | SEROUT 1 | PC4 OCCLUS | SERIN 1 |
| 22 | OP1 RTSB | PC5 PUMPON | IP2 TIMERIN 0 |
| 23 | SEROUT 2 | PC6 ZERO | SERIN 2 |
| 24 | NC | PC7 RTS0 | NC |
| 25 | NC | PA0 | NC |
| 26 | NC | PA1 | NC |
| 27 | NC | PA2 | NC |
| 28 | INT1 | PA3 | INT3 |
| 29 | +5 V DRV | PA4 | +5 V |
| 30 | +15 VDIRTY | PA5 | +5 V |
| 31 | +12 V | PA6 | 21 VAC |
| 32 | GND DIRTY | PA7 ALR CALL | DGND |

NC = not connected
AIN is an AD-converter and AOUT is a DA-converter in ACX board.
ADC is an AD-converter and DAC is a DA-converter in the Gas mother board.

**ASX board (X5) - Gas mother board (X5)**

| Pin No. | Signal |
|---|---|
| 1 | Analog ground |
| 2 | N/C |
| 3 | N/C |
| 4 | N/C |
| 5 | +15 V |
| 6 | -15 V |
| 7 | DIRB (not used) |
| 8 | RXD |
| 9 | TXDB |
| 10 | N/C |
| 11 | -RESET |
| 12 | +5 V |
| 13 | +15 VDIRTY |
| 14 | Digital ground |

**PVX board (X1) - Gas mother board (X3)**

| Pin No. | a | b | c |
|---|---|---|---|
| 1 | +15 V | NC | AGND |
| 2 | -15 V | NC | +10 VREF |
| 3 | NC | NC | NC |
| 4 | NC | NC | NC |
| 5 | NC | NC | NC |
| 6 | DAC1 FLOWY | NC | DAC0 PRES |
| 7 | VOL | NC | NC |
| 8 | FLOW | NC | NC |
| 9 | NC | NC | NC |
| 10 | PRESS | NC | NC |
| 11 | NC | NC | NC |
| 12 | NC | NC | NC |
| 13 | NC | NC | NC |
| 14 | NC | NC | NC |
| 15 | NC | NC | NC |
| 16 | NC | NC | NC |
| 17 | -RESET | NC | NC |
| 18 | NC | DIR | NC |
| 19 | NC | NC | NC |
| 20 | NC | NC | NC |
| 21 | RxD | NC | TxDP |
| 22 | NC | NC | NC |
| 23 | NC | NC | NC |
| 24 | NC | NC | NC |
| 25 | NC | NC | NC |
| 26 | NC | NC | NC |
| 27 | NC | NC | NC |
| 28 | NC | NC | NC |
| 29 | NC | NC | +5 V |
| 30 | +15 VDIRTY | NC | +5 V |
| 31 | NC | NC | NC |
| 32 | GND DIRTY | NC | DGND |

# 3 SERVICE PROCEDURES

## 3.1 General service information

Field service of the airway modules is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

NOTE: After any component replacement see chapter *Adjustments and calibrations*

CAUTION The ACX-200 photometer and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. Datex-Ohmeda supplies spare ACX-200 photometers. The information provided for the ACX-200 is for reference only.

CAUTION Due to the complicated and sensitive mechanical construction of the $O_2$ measuring unit, no repairs should be attempted inside the unit.

CAUTION The ACX-200 Measuring board can be repaired and calibrated only at the factory.

CAUTION The PVX-100 measuring unit can be repaired only at the factory.

## 3.2 Service check

These instructions include complete procedures for a service check. The service check is recommended after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark ✍ in the instructions means that the check form should be signed after performing the procedure.

### 3.2.1 Recommended tools

| Tool | Order No. | Notes |
|---|---|---|
| Screwdrivers | | |
| Tools for blocking internal tubes | | |
| A glass of water | | |
| Flowmeter | | |
| Multimeter | | |
| Gas Interface Cable 2.5 m | 884299 | |
| Sampling line 3.0 m | 73319 | |
| Spirometry tube | 884101 | |
| D-lite | 733950 | |
| Calibration gas | 755582 | |

### 3.2.2 Recommended parts

| Part | Order No. | Notes |
|---|---|---|
| Special tube | 733383 | |
| Special tube | 733382 | |
| OM ref. filter | 86901 | |
| Fan filter | 871558 | |
| Cable tie | 64001 | |
| D-fend O-ring (2 pcs) | 65312 | |
| D-fend (black) | 876446 | |
| Sampling line 3.0 m | 73319 | |
| Extra silicon tubing | | |
| Spare constriction cassettes | | |

## All modules

- Remove the airway module case, the top protection cover and the bronze plate from the side of the $O_2$ sensor, if installed.
- Detach the ACX measuring board and the PVX board with the support plate, if installed.

NOTE: Wear a static control wrist strap when handling PC boards. Electrostatic discharge may damage components on the board.

1. Check internal parts:
   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - tubes are not pinched and there are no sharp bends on them
   - tubes are connected properly
   - there are no loose objects inside the module

   NOTE: Make sure that none of the tubes is in contact with the sampling pump or the $O_2$ sensor.

2. Check external parts:
   - the module case is intact
   - the four rubber pads under the frame are all in place
   - the metal rear panel is intact
   - the equipotential tap and the sample gas out connector are tightened properly
   - the block screws for the gas interface cable are in place and are tightened properly
   - the D-fend latch is functioning properly

- Install the ACX measuring board.
- Detach the D-fend.

3. Check the condition of the rubber O-rings on the metal D-fend connectors, located inside the module front cover.

   If necessary, detach the connectors by first disconnecting the tubes, then removing the locking rings from the back of the front cover.

   NOTE: The O-rings are recommended to be replaced annually.

4. Check the OM ref. filter (order code 86901) visually, if installed.

   NOTE: The OM ref. filter is recommended to be replaced annually.

   If the module does not contain the OM ref. filter, install it to prevent dirt entering the $O_2$ sensor reference channel:

a) shorten the thick $O_2$ reference channel tube by 4 centimeters (the tube that is connected to the upper part of the $CO_2$ absorber)
b) connect the OM ref. filter to the loose end of the tube
c) fasten the filter to the outermost hole in the tubing plate (at the PVX board side) with a cable tie (order code 64001)

- Replace the D-fend and the sampling line.

  NOTE: Use only Datex-Ohmeda sampling lines in order to ensure proper functioning.

- Connect the module to the Central Unit with a long gas interface cable and switch the monitor on.

- Configure the monitor screen so that all the necessary parameters are shown, for example as follows:
  **Monitor Setup** ***- Screen 1 Setup - Waveform Fields - Field 1 - Paw***
  ***Field 2 - Flow***
  ***Field 3 - Off***
  ***Field 4 - O2***
  ***Field 5 - AA***
  ***Field 6 - CO2***
  ***Digit Fields - Field 1 - Gases***

5. Check that the module fan is running.

6. Wait until the message ‘Calibrating gas sensor’ disappears from the screen, then enter the Service menu:

   **Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8)

   Take down the information regarding Airway module software.

   NOTE: The PVX software string does not appear on the ‘Sw version/Unit id’ -list. Check PVX software from the sticker that is located on the PVX software EPROM (if the PVX board was installed originally).

7. Enter the ACX service menu:

   ***Parameters - Gas Unit - ACX***

   Check that the ‘Timeouts’, ‘Bad checksums’ and ‘Bad c-s by mod’ -values are not increasing faster than by 50 per second. If one of the values is increasing faster, it indicates a failure in module bus communication.

8. If the module contains a membrane key on the front panel, press the key at least for one second and check that it is identified, i.e. the text for Button changes from OFF to ON in the menu.

- Select Halothane as the anesthetic agent by first selecting AGENTS from the ACX service menu:

  ***Agents - Select Agent - Hal - Previous Menu***

9. Check that the Calib zero -value for $N_2O$ is less than 61000.

   If the value exceeds the limit, it indicates bad contamination in the ACX measuring chamber. The measuring chamber can be cleaned according to the special cleaning instructions found in the chapter Cleaning the measuring chamber of ACX measuring unit. However, if cleaning does not help, the whole ACX measuring unit should be exchanged.

   NOTE: If the ACX measuring chamber was cleaned or the unit was replaced, then also the tubing between the D-fend and the ACX measuring unit, including the zero valve, should be replaced. The mentioned parts should not be cleaned.

   NOTE: With monitor software S-___95 and S-___96 the Calib zero -value for $N_2O$ is always shown as a negative value. The correct value can be calculated by adding the value shown to the value 65536.

10. Check that the Ambient -value corresponds with the current ambient pressure (±20 mmHg).

11. Perform the steam test for the special tubes (Nafion), or replace the tubes.

    NOTE: The special tubes are recommended to be replaced annually.

12. Check the $CO_2$ absorber.

    Keep the tip of the sampling line away from you and let the monitor draw in room air. Check the “Insp $CO_2$” -value from the ACX service menu. If the value is less than 4, replace the $CO_2$ absorber.

13. Check the zero valve.
    Feed calibration gas into the sampling line and check that the gas readings in the service menu correspond with the gas values on the calibration gas bottle. Keep feeding gas and activate the zero valve from the menu. The $O_2$ reading should drop back near 21 %, the other gas readings near 0 %. If the readings did not drop, replace the zero valve.

14. Perform the sampling system leak test.

15. Block the tip of the sampling line with your finger until the 'Amb-Work' -value becomes stable. If the value does not reach 110, replace the sampling pump and repeat the leak test.

16. Check the flow rates, adjust if necessary.

    NOTE: If any of the constriction cassettes is replaced, the leak test should be repeated.

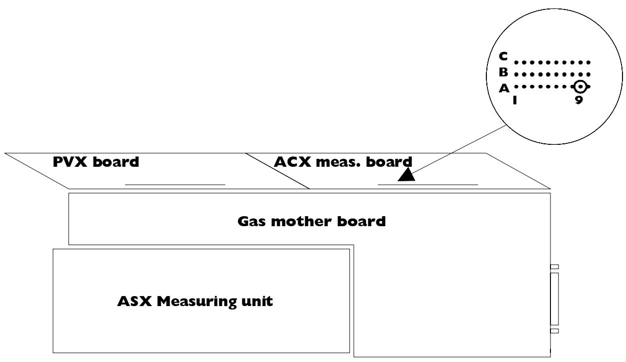
17. Check that the 'Amb-Work' -value is within 50... 75 and the OM (in-ref) -value is equal or higher than 0. If the values differ, readjust the flows.

18. Check the $O_2$ sensor output voltage.

    Feed calibration gas and check that the value OM volt: mV in the menu rises at least to 2800 (3500 nominal). Adjust the $O_2$ sensor output, if necessary.

    NOTE: The voltage measurement requires module software 884295 or 885388.

    If the value is not updated, measure the $O_2$ sensor output voltage from the ACX measuring board connector X1, pin A9.




The output voltage should rise at least to 2.8 V (3.5 V nominal).

19. Perform gas calibration:
AIRWAY GAS - GAS CALIBRATION
NOTE: For maximum accuracy, a warm-up time of 30 minutes is recommended.

NOTE: If the module contains the agent identification unit, the ASX-100 or ASX-200, keep feeding gas at least 15 seconds after the message 'Adjust' appears in the menu. This way the agent identification unit has enough time for calibration.

- Enter the ACX service menu:

**Monitor Setup** ***- Install/Service*** (password 16-4-34) ***- Service*** (password 26-23-8) - ***Parameters - Gas Unit - ACX***

- Select Halothane as the  anesthetic agent:

***Agents - Select Agent - Hal - Previous Menu***

20. Perform the fall time measurement in the ACX service menu.

Check that the measured fall times are within the ranges that are given in the Technical Reference Manual.

NOTE: The fall time measurement can be performed only with module software 884295 or 885388.

21. Perform the noise measurement.

Check that the measured noise values are within the ranges that are given in the Technical Reference Manual.

NOTE: The noise measurement can be performed only with module software 884295 or 885388.

## Agent identification option

22. Check that the 'ACX_ASX Delay' -value in the ACX service menu is within 400-800.

    If the value is not within the range, readjust the flows and repeat the fall time measurement.

    ✍

- Enter the ASX service menu:

  ***Gas Unit - ASX***

  NOTE: The ASX service menu values are not updated with the anesthetic identification unit ASX-100.

23. Feed calibration gas. When the proper absorption spectrum is shown in the menu check that the Peak normal value is close to 10.50 (±0.20). Check also that the difference between the "Peak normal" and "Peak mirror" values is not higher than 0.30.

    If the values do not meet the range, repeat the gas calibration.

    ✍

- Set the AA identification to the automatic mode:

  ***Agents - Select Agent - Auto - Previous Menu***

24. Feed calibration gas (order code 755583) and check that the message 'Desflurane' appears into the digit field for gases.

    NOTE: The ASX-100 is not capable of identifying Desflurane.

    NOTE: The ASX-100 with software 878364-1.1, or lower, is not capable of identifying calibration gas R23 (order code 755582). Therefore, the message 'Agent mixture' should appear instead.

    ✍

## Patient spirometry option

- Switch the monitor off and install the PVX board, then switch the monitor back on.
- Preset gas measurement settings:

***Airway Gas - Spirometry Setup - Paw Scale - 20***
***Flow Scale - 15***

1. Check that the patient spirometry connectors on the front panel are clean and intact.

2. Connect a clean spirometry tube to the module and a clean D-lite to the other end of the tube. Block the D-lite's sampling line port, for example with a luer stopper.
   Take the D-lite in your hand and occlude both ends tightly with your fingers (or with both hands). Pressing firmly with the fingers creates a pressure inside the D-lite. Check that a pressure of at least 5 $cmH_2O$ is generated.

   NOTE: If the module has the male and female patient spirometry connectors (pediatric option), make sure that the date marking on the D-lite is 10/94 or newer.

   If the system leaks heavily, no pressure will be generated.
   If there is a small leak in the connections, the monitor will measure a pressure difference which is then interpreted as flow and seen on the monitor screen. The pressure waveform decreases slowly and the flow waveform either goes above, or below the zero line, depending on which of the connectors leak.

   In case of leakage, check all connections and try again.

3. Remove the blockage from the sampling line port and connect the sampling line. Breath through the wider side of the D-lite. Check that the flow waveform moves downwards when you breath in, and upwards when you breath out.
   If the flow waveform moves in opposite manner, check the order of the PVX tubes inside the module.

4. If possible, also check the patient spirometry measurement with the spirometry tester (order code 884202). Follow the instructions that are supplied with the tester.

## All Airway modules

- Switch the monitor off, disconnect the gas interface cable and reassemble the module.

  NOTE: When reassembling the module, make sure that the tubes and cables are not pinched between the PC boards and covers.

29. Clean, or replace the airway module fan filter.

    ✍

30. Perform electrical safety check and leakage current test.

    ✍

- Reconnect the gas interface cable and sampling line, switch the monitor on and wait until the message ‘Calibrating gas sensor’ disappears from the screen.

31. Block the tip of the sampling line with your finger and check that the message ‘Sample line blocked’ appears onto the monitor screen within 30 seconds.

    ✍

32. Detach the D-fend and check that the message ‘Check D-fend’ appears onto the screen within 30 seconds.

    Reattach the D-fend.

    ✍

- Simulate at least 5 breaths by feeding calibration gas into the sampling line.
  Check that the shown gas information is correct.

33. Check that the monitor activates the APNEA -alarm within 30 seconds after you have stopped feeding gas.

    ✍

34. Switch the monitor off, disconnect the gas interface cable and clean the module.

    ✍

- Fill in all necessary documents.

## 3.3 Disassembly and reassembly

The airway module (G-AiOV) is disassembled in the following way. See the exploded view.

1. Remove three screws from the rear panel.
2. Remove one thumb screw and one 5 mm cross recess screw from the bottom of the airway module case.
3. Slide the case rearward and detach it from the module.
4. Lift off the top protection cover.

The PVX board can be detached by pulling sideways after two tubes are disconnected from two valves.

The ACX measuring board can be detached by pulling sideways after a ribbon cable connector is disconnected and a tube is pulled off from pressure transducer.

5. Remove the bronze plate from the right side of the module by pulling it up.
6. To remove the gas mother board cover, remove two front panel screws from the side of the module, and the D-connector screws.
7. The front panel can be detached by removing three screws.
8. Tubing system plate with tubes and flow cassettes can be lifted off.
9. Fan can be lifted off after plastic pc board rail is detached.

The gas mother board is attached to the side of the module with screws.

The ASX unit, the ACX measuring unit, and the $O_2$ measuring unit are attached to the chassis with two screws each.

The pump and its magnetic shield can be removed from the chassis by unscrewing the two screws beneath two springs at the port side of the pump.

Damping chamber/filter case can be slid out of hooks.

Reassembling is essentially reversing what was described above.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

## 3.4 Adjustments and calibrations

### 3.4.1 Gas sampling system adjustment

Flow rates should be measured and possibly adjusted under the following conditions:

- After any part within the sampling system has been replaced
- Gas response is slow

NOTE: Adjust the flows with a new, clean D-fend water trap and original Datex-Ohmeda sampling line.

NOTE: Before adjusting the flows, make sure that there is no leakage in the sampling system.

NOTE: Let the monitor warm up for 30 minutes before measuring flow rates.

For the flow rate measurements a flowmeter with a low flow resistance and capability to measure low flow rates is required. A normal length of sampling line has to be connected to the monitor as it has a considerable effect on the flow.

The flow rates are adjusted by changing the flow resistance cassettes (constriction cassettes) in the sampling system. See Table 2 in chapter "*Gas sampling system*" for the alternative cassettes.

The adjustments and the respective constrictions to be adjusted are shown in the next figure, see also chapter *"Gas sampling system"* to see gas sampling system block diagrams for modules manufactured since autumn 1998.

### 3.4.2 Flow rate measurement

**If any flow rates are not correct, first replace the D-fend water trap. Then recheck the incorrect flows before adjusting the flow rates.**

The sampling flow rate is measured by a flowmeter at the sampling line. The rate should be between 180 and 220 ml/min.

The sampling flow rate is adjusted by changing the flow cassette which is located between the pump and the damping chamber.

Due to two different tubing layouts, if the described location does not contain a flow cassette, the sampling flow rate is adjusted by changing the flow cassette that is located between the pump and the sample gas out connector.

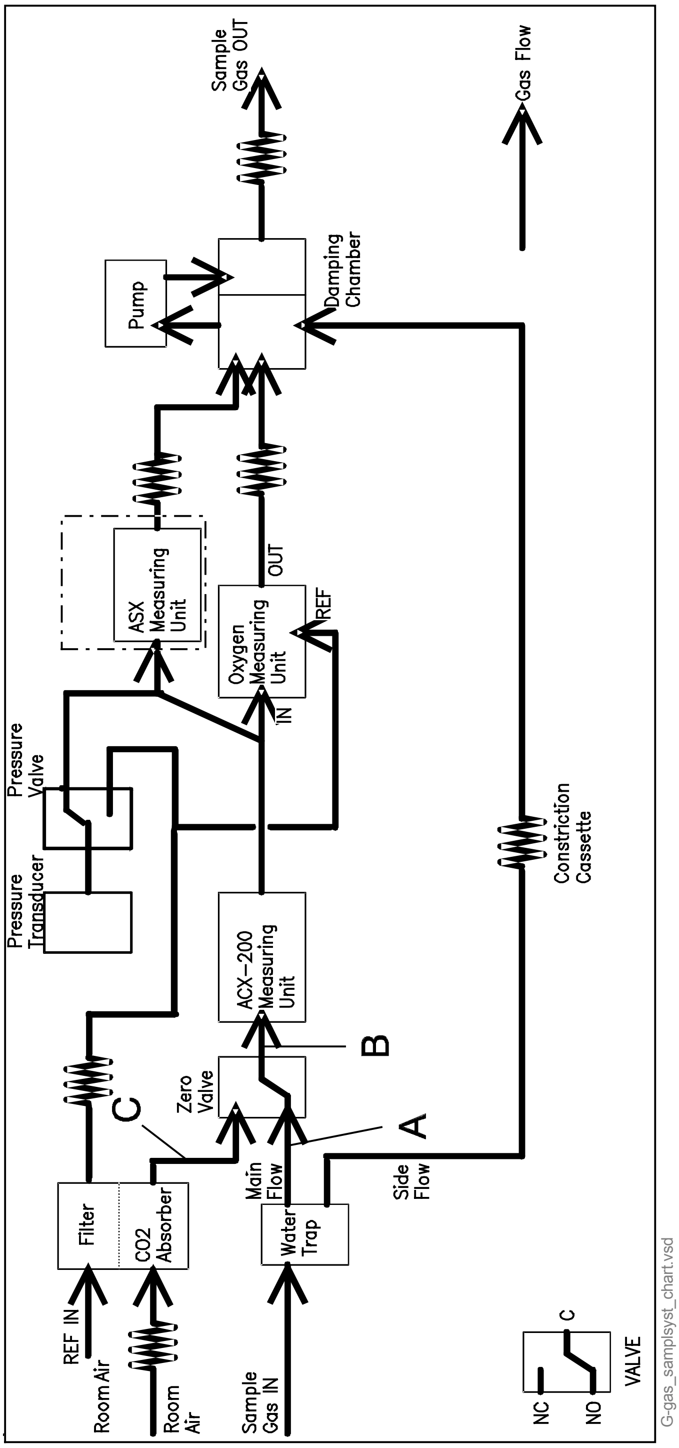



**Figure 16 Gas sampling system adjustment chart**

See also chapter *"Gas sampling system"* to see gas sampling system block diagrams for modules manufactured since autumn 1998.

The rate of the side flow is checked by blocking the side flow after the water trap and measuring the flow rate as above. The rate should decrease by 10 to 27 ml/min.

Measurement flow and reference flow of the oxygen measuring unit are checked as follows:

1. Connect the flowmeter behind the flow cassette (no. 2) ahead of the oxygen measuring unit REF inlet. The flowmeter should show between 25 and 42 ml/min. The flow rate is adjusted by changing the cassette.
2. Connect the flowmeter between the oxygen measuring unit IN inlet and the tube which is connected to it. The flow rate should be between 18 and 25 ml/min **larger** than the REF flow. This is adjusted by changing the flow cassettes (no. 4 and 5) which are located between the IN and OUT inlets.
3. Flow rate of $CO_2$ absorber is measured by connecting the flowmeter to the unoccupied connector of the flow cassette (no. 1). Make sure that the monitor is in normal situation (APNEA text on the screen). The flow rate should be zero. When the gas zeroing takes place, the rate should be between 180 and 220 ml/min. The gas zeroing can be simulated in the ACX Service Menu manually (pump start, zero valve on). The flow rate is adjusted by changing the cassette (no. 1).

CAUTION When changing cassettes make sure that the tubes are reconnected properly.

| **Flow to be adjusted** | **Constr. No. (see figure 16)** | **Nominal value (tolerance) ml/min** |
|---|---|---|
| sampling flow | 6 | 200 (180 to 220) |
| side flow | 3 | 10 to 27 |
| $O_2$ measurement in | 4 and 5 | 45 to 60 |
| $O_2$ reference in | 2 | 25 to 42 |
| $CO_2$ absorber flow | 1 | 180 to 220 when zeroing |

NOTE: Changing any of the cassettes will have some effect on the other flow rates. After any adjustments check the other flow rates as well.

### $O_2$ measurement flow pressure

Gradual decrease of main flow rate due to the water trap filter clogging can be checked by measuring pressure difference between the $O_2$ measurement flow and the $O_2$ reference flow. Remember that the sampling line should be attached to the water trap before starting the test.

The pressure difference is automatically checked after every gas zeroing.

See ACX Service menu chapter later in this manual for further information.

## 3.4.3 Oxygen measurement unit adjustments

The only field service procedures for the $O_2$ measuring unit are the offset (zero), gain, and frequency adjustments. In case of any other trouble, the measuring unit should be replaced and the faulty one sent to Datex-Ohmeda for repair.

## Offset (zero) adjustment

Because the oxygen measuring unit is a differential sensor, which actually measures the difference between the $O_2$ concentrations in the sample and reference gases, its output must be adjusted to equal zero when atmospheric air is present at both inputs.

1. Connect a digital voltmeter to the output of the $O_2$ measuring unit at pin 7 of connector X4 on the Gas mother board.
2. Let the monitor draw in room air and adjust the voltage to zero with the $O_2$ measuring unit trim resistor designated 'ZERO' (see figure 17) in the $O_2$ module PC board. The potentiometers are located at the same side of the measuring unit as the tubing connectors.
3. Perform gas calibration (see *User's Reference Manual*).

## Gain adjustment

1. Adjust the $O_2$ measuring unit offset as described in the previous section.
2. Sample 100 % oxygen and adjust the measuring unit output to between 7.7 V and 8.3 V with the trim resistor designated 'GAIN' (see figure 17). If the output will not exceed 7.7 V, it is acceptable that the output exceeds at least 5 V. At that level software is still able to compensate the output.
3. Check and if necessary readjust the offset and gain until the readings remain stable.
4. Perform gas calibration (see *User's Reference Manual*).

## Temperature compensation adjustment

Factory calibrated.

## Frequency adjustment

The switching frequency of the electromagnet of the $O_2$ measuring unit has been selected to be 110 Hz to avoid interference from harmonics of both 50 Hz and 60 Hz mains frequency.

Fine adjustment is seldom necessary. However, if you wish to reduce the effects of mechanical resonance peaks of the cabinet which appears as high noise level of the $O_2$ measuring unit analog output (above 20 mV peak to peak) it is worth of trying the fine frequency adjustment. One turn of trimmer 'FREQUENCY' will change the frequency by 1.5 Hz. Try to find minimum noise but do not deviate more than $\pm$5 Hz.

## Gas calibration

The gas calibration is performed in the Airway Gas -menu. Calibrating

The airway module should be calibrated once every six months or whenever there are indications of errors in the gas readings.

Calibrate the gas measurement with the Datex-Ohmeda calibration gas. Do not use any other calibration gases.

– When you calibrate the modules M-C, M-CO or M-COV, use the gas 755581 and the regulator 755534.

– When you calibrate the modules M-CAiO, M-CAiOV or M-CAiOVX, use the gas 755583 and the regulator 755534.

If you do not use the recommended calibration gases, the calibration does not succeed.

During gas calibration,% units are always used for $CO_2$ regardless of selected measuring units.

Anesthetic agent is always calibrated with Desflurane selected. If some other agent is selected for monitoring, the selection is stored in the memory and returned when the calibration is over.

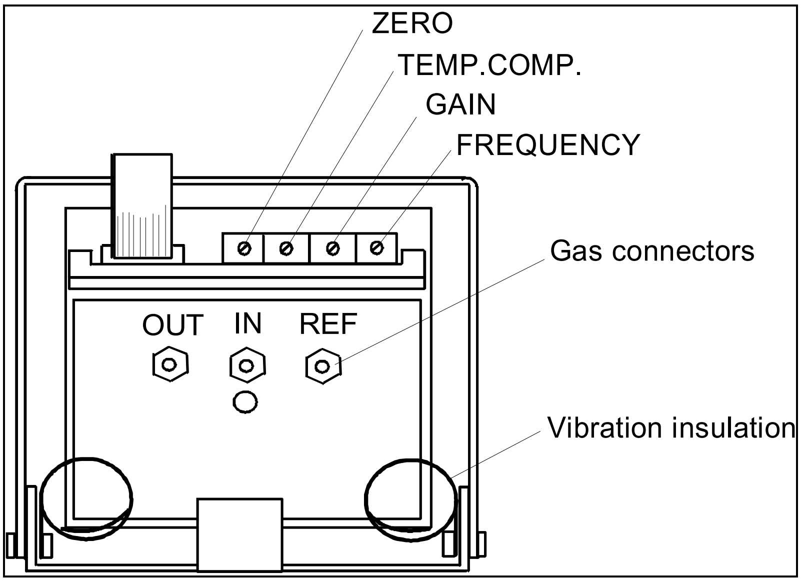



**Figure 17 $O_2$ measuring unit adjustments**

## 3.4.4 Flow calibration

PVX board is calibrated at the factory and due to the board's design calibration is not regularly needed. The calibration data is saved into the board's EEPROM memory and if the software EPROM of the board is changed the calibration must be performed. It is recommended to perform the calibration both with adult values using the D-lite, and with pediatric values using Pedi-lite.

1. Connect a spirometry tube with the D-lite sensor to the airway module. To improve the accuracy, the endotracheal tube and all accessories which are in normally use should be attached also during the calibration.
2. Enter service menu (Monitor Setup/Install Service/Service View/Modules).
3. Enter the PVX menu. After the flow is zeroed ('Zero OK' message displayed) attach calibration pump or spirometry tester to the flow sensor (D-lite or Pedi-lite). Select the sensor type.
4. Set the calibration volume for adult to 1000 ml and for pediatric to 300 ml.
5. Work on the calibration pump slowly, approximately 1 pump in 5 seconds, pump until 'adjust'-message appears. If you use the spirometry tester, perform the calibration according to the tester instructions.
6. Adjust the reading to match the calibration volume (1000 ml for the D-lite and 300 ml for the Pedi-lite).

# 4 TROUBLESHOOTING

## 4.1 Troubleshooting chart

| Trouble | Possible Cause/Treatment |
|---|---|
| No response to breathing | Sampling line or water trap blocked or loose, or improperly attached.<br>Water trap container full.<br>Interface cable to monitor disconnected.<br>See chapter "*Gas sampling system troubleshooting*." |
| SENSOR INOP. message | The temperature is too high, check fan and filter at the rear panel.<br>Communication error, check timeout and bad checksum values at the service menu.<br>Check Airway Module connection cable and supply voltages.<br>Check ACX measuring board. |
| xx ZEROING ERROR-message | Gas zeroing failed. Condensation or residual gases are affecting zero measurement. Allow module to run drawing room air for half an hour and calibrate again. |
| AIR LEAK-message | Air leak in sampling system. Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage. Supply voltage missing |
| REPLACE TRAP-message | Flow resistance increased due to residue built-up on water trap membrane. Replace the water trap. |
| REBREATHING-message | $CO_2$ concentration in inspiratory air is too high. Possibly $CO_2$ absorber in ventilator is saturated. Change the absorber. |
| OCCLUSION-message | Sampling line or water trap is occluded. Water trap container is full. If occlusion persists check internal tubing for blockages. Check the power supply voltages. |
| SELECT AGENT-message | No anesthetic agent is selected though delivery is started. Vaporizer valve is broken. Traces of cleaning or disinfecting agent in the water trap container affecting the readouts. Replace the water trap. |
| No response to any gas | Sampling line, water trap, or internal tubing blocked or loose, or improperly attached.<br>Pressure valve malfunction. Pump failure. Supply voltage missing. Serial communication error. Check those items. |
| Sudden increase in gas display | Measuring chamber contamination.<br>±15 V supply voltages missing.<br>Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap.<br>Check flow rates. |
| Abnormally high response to all gases (or abnormally low) or sudden occlusion warning | Pressure transducer failure. Exchange the ACX Measuring board. |
| Random output (resembling noise) | Chopper motor timing pulses out of sync.<br>Chopper motor not running, motor faulty or connection loose.<br>Chopper motor driver transistor C-E open circuit or current limiter short circuit.<br>Exchange the ACX measuring board. |
| Strong drift in all gases | Leakage in the sampling line or internal tubing (especially in conjunction with too low readings).<br>Exchange the ACX measuring board. |
| No gas waveforms intermittently. | Gas waveforms are not shown during automatic zeroing, occlusion, or air leak. Check the monitor screen for possible messages and proceed accordingly. |

### 4.1.1 Supply voltage troubleshooting

| Trouble | Possible Cause | Treatment |
|---|---|---|
| "Gas module removed"<br>No Gas module exists after turning the monitor on. | +5V lost | Gas module CPU not running. Check Gas Interface cable.<br>Check +5V from module mother board and timeout value from module service page. |
| Random $CO_2$ value.<br>No $CO_2$ or AA response.<br>Abnormal AA mixture messages and AA selections.<br>"Unknown Agent"<br>"Zero error" after zeroing<br>"Calibrate Agent ID"<br>"Sensor Inop" | +5 Vdirty lost | Check the IR lamp resistance (approximately 4 Ohm)and the lamp voltage (module mother board connectors X8 and X9)<br>X8 = ASX lamp(i-models)<br>X9 = ACX lamp |
| "Continuous Occlusion"<br>"Sensor Inop"<br>Random curve trace and gas digit values(resembling noise).<br>Pressure and flow curves extremely low. | +15 V lost | Check voltage from module mother board X1 pin 4, X2 pin 1a, X3 pin 1a, X4 pin 9 and X5 pin 5. |
| $CO_2$ value high.<br>"Air leak"<br>"Sensor Inop"<br>Paw and Flow curves extremely high. | -15 V lost | Check voltage from module mother board X1 pin 2, X2 pin 2a, X3 pin 2a, X4 pin 6 and X5 pin 6. |
| "Air Leak"-message remains on the screen. | +15 V dirty lost | Check voltage from module mother board X1 pin 3, X2 pin30a , X3 pin 30a, X4 pin 1 and X5 pin 13. |
| Fan stopped. | +32 V lost | Check the fuse on Gas interface board.<br>Check the fan and regulated fan supply voltage from module mother board connector X10. |
| "Calibrating gas sensor" remains on the screen. | One or more of the voltages lost: +5 Vdirty, +15 V,-15 V, +15 Vdirty<br><br>ACX measuring board not communicating with the Gas mother board.<br>ACX measuring unit badly contaminated. | Check those voltages as above.<br><br>Check whether the ACX software version is available in the service menu. If not, replace the ACX measuring board.<br>Replace the ACX measuring unit. |

## 4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of pump aging or dirt accumulating in the internal tubing.

The following checks should help in localizing the fault. Whenever suspecting the sampling system and always after working on the sampling system check and if necessary adjust the flow rates.

The sampling system details are illustrated in figures 5, 6, 7 and 8.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: D-fend water trap should be replaced when the OCCLUSION message appears during the monitor startup.

NOTE: If any liquid has entered the ACX-200 measuring unit due to water trap filter failure, contact Datex-Ohmeda technical services.

### 4.2.1 Sampling system leak test

Connect power cord and sampling line. Turn the power on and wait until the initialization is over.

1. Choose ACX service data page in the Gas unit service menu.
2. Connect a tube to the sample out connector and drop its other end into a glass of water.
3. Block the sample inlet, reference flow of the oxygen measuring unit, and the $CO_2$ absorber port that draws room air in. Wait for one minute.
   There should be less than 1 bubble per 10 seconds coming out of the tube. Bubble should not move upwards more than 11 mm per 30 seconds inside the tube. If it does, there is a leak between the pump and the sample out connector.
4. Perform leak test to the $CO_2$ absorber by opening zero valve. The maximum permitted leakage is the same as above.

CAUTION Do not turn the pump off while performing the leak test. Negative pressure in the sampling system will suck water into the module.

### 4.2.2 Water separation

1. Dip the patient end of the sampling line into water quickly (about a half second) three times at 45 seconds' interval. After that drop the end into water and lift it up when the sampling line is totally filled with water.
2. Check that all the water goes into the trap container and not into the monitor.

### 4.2.3 Steam test for the special tubes

Choose Halothane as anesthetic agent and let the monitor sample room air. Then quickly feed air of 100 % relative humidity (for instance from a kettle in which you are boiling water) to the monitor. If the digital reading jumps as much as 0.1 % replace the special (Nafion) tubes.

## 4.3 OM measuring unit troubleshooting

Because of the complex and very sensitive construction of the oxygen measuring unit no repairs should be attempted inside the unit. Instead, if the fault has been found in the measuring unit itself, it should be replaced and the faulty unit be sent to Datex-Ohmeda for repair.

In cases of no response to $O_2$ or strong drift, check the tubing for loose connections, blockages and leaks.

CAUTION Never apply overpressure to the $O_2$ measuring unit as the pressure transducer may be permanently damaged.

If the message ‘$O_2$ zero error’ is displayed check the $O_2$ measuring unit output voltage on Gas mother board (see Section Offset adjustment).

If the adjustment range of the (software) calibration is insufficient check the $O_2$ measuring unit output voltage and adjust the gain if necessary (see Section Gain adjustment).

If there are problems with $O_2$ response time check the $O_2$ measurement flow rate and adjust it if necessary (see Section Gas Sampling System Adjustments).

If the $O_2$ signal is noisy, check the measurement unit suspension. Frequency adjustment may help in some cases (see Section Frequency adjustment).

## 4.4 ACX troubleshooting

CAUTION The measuring unit ACX-200 can be repaired and calibrated only at the factory.

The ACX troubleshooting is carried out in the General Troubleshooting scheme. The ACX testing is explained at the ACX service information section, please refer to it.

### 4.4.1 Cleaning the measuring chamber of ACX measuring unit

In case the $N_2O$ “zero calibration constant” in Gas Service (ULT) or $N_2O$ “calib zero” in ACX Service (AM/CCM) indicates contamination of the measuring chamber (value 61000 or more), or if the software will stuck to the “calibrating gas sensor” state due to contamination, it is possible to attempt the measuring chamber cleaning. However, Datex-Ohmeda recommend exchanging the measuring unit rather than cleaning.

The measuring chamber should first try to be cleaned by rinsing it with distilled water only. If rinsing alone is not sufficient the cleaning can be tried with Datex-Ohmeda Cleaning Fluid (85969).

NOTE: Do not use other cleaning agents such as blood gas electrode cleaners. These may damage the unit.

## Cleaning procedure

Tools needed

- 10 ml syringe
- water glass
- 2 pcs 30 cm silicon tubes with inner diameter of 3 mm
- screwdriver

1. Detach the measuring unit from the monitor or gas module.
2. Attach the silicon tubes to the tube connector on the unit.
3. Attach the 10 ml syringe to one of the tubes.
4. Place the tip of the other tube into the water glass.
5. Pour some distilled water into the glass.
6. Suck the water into the tubing with the syringe.
7. Leave for 15 minutes.
8. Move the syringe piston in and out 10 times.
9. Detach the tubes from the unit and empty the water from the measuring chamber.
10. Attach one silicon tube to the unit and connect the other end of the tube to the gas outlet of the monitor or gas module.
11. Switch the monitor on and let the sample out flow dry out the unit at least for 15 minutes.
12. Attach the unit back to the monitor or gas module and switch the monitor on.
13. Let the monitor run at least 30 minutes before checking the calib zero in the service mode.
14. If the zero value is still more than 61000, repeat the procedure with the cleaning fluid.

NOTE: After cleaning with the cleaning fluid the measuring chamber must be well rinsed with distilled water.

NOTE: The monitor will stay in “Calibrating gas sensor” state until the measuring chamber is completely dry.

## 4.5 ASX agent identification unit troubleshooting

NOTE: Please read also the troubleshooting section in *User's Reference Manual*.

CAUTION The agent identification bench ASX-200 can be repaired and calibrated only at the factory.

| Trouble | Possible Cause/Treatment |
|---|---|
| AGENT MIXTURE-message when calibration gas (Freon) is fed. | Repeat calibration.<br>If the module contains ASX-100, it is not capable to identify calibration gas R23, therefore the message. However, the ASX-100 will still calibrate with R23. |
| No response from ASX. | Communication between ASX unit and Central Unit is lost. ASX bench disconnected or faulty.<br>Check that the motor is running. |

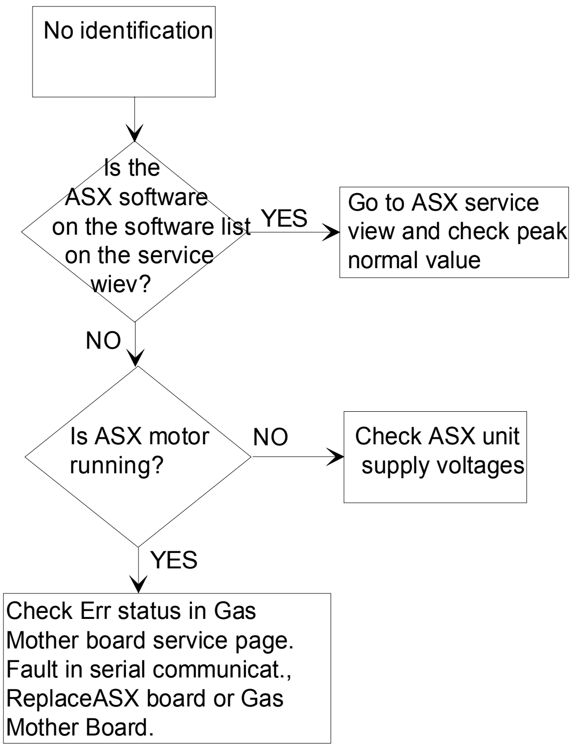



**Figure 18 ASX troubleshooting flowchart**

## 4.6 PVX board troubleshooting

CAUTION The measuring unit PVX-100 can be repaired and calibrated only at the factory.

NOTE: Never apply DIFFERENTIAL pressure higher than 25 $cmH_2O$ to the spirometry tubing. Make sure that both spirometry tubes are always connected.

NOTE: Never apply overpressure or negative pressure of more than 300 $cmH_2O$ to the spirometry tubing.

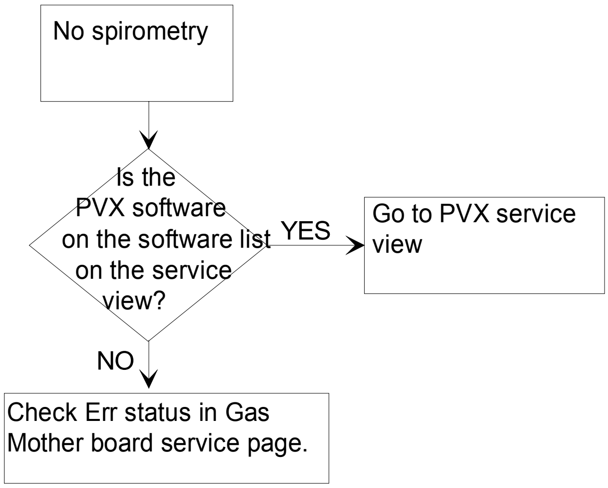



**Figure 19 PVX board troubleshooting flowchart**

NOTE: The PVX software string does not appear on the list when using the combination of G-AOV module and monitor software S-___94.

### 4.6.1 Spirometry tubing leak test

1. Select airway pressure (Paw) and flow waveforms (Flow) on the monitor screen.
2. Connect a clean spirometry tube to the module and a clean D-lite to the other end of the tube. Block the D-lite's sampling line port, for example with a luer stopper.

NOTE: If the module has the male and female patient spirometry connectors (pediatric option), make sure that the date marking on the D-lite is 10/94 or newer.

3. Take the D-lite in your hand and occlude both ends tightly with your fingers (or with both hands). Pressing firmly with the fingers creates a pressure inside the D-lite.
4. Check that a pressure of at least 5 cmH2O is generated. If the system leaks heavily, no pressure will be generated. If there is a small leak in the connections, the monitor will measure a pressure difference which is then interpreted as flow and seen on the monitor screen. The pressure waveform decreases slowly and the flow waveform either goes above, or below the zero line, depending on which of the connectors leak.

## 4.7 Gas mother board troubleshooting

Due to the complexity of the LSI circuitry there are only a few faults in the CPU digital electronics that can be located without special equipment.

Check that the RAM, EPROM, CPU and other IC's that are on the sockets are properly attached.

See Gas mother board service pages for more information.

### 4.7.1 Instructions after replacing the software or Gas mother board

After replacing the software or Gas mother board:

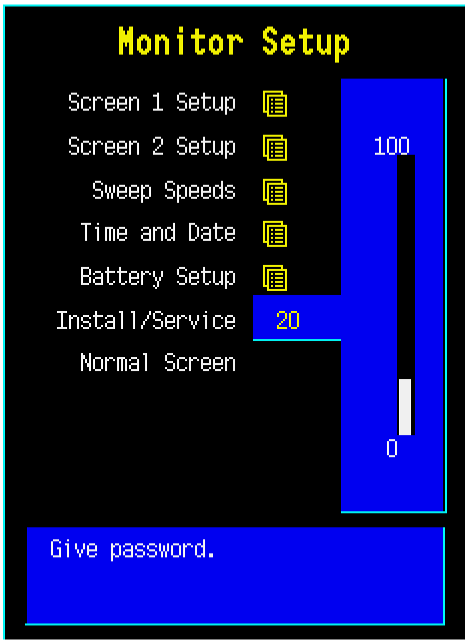
- perform the sampling system leak test
- check the flow rates
- perform the gas calibration

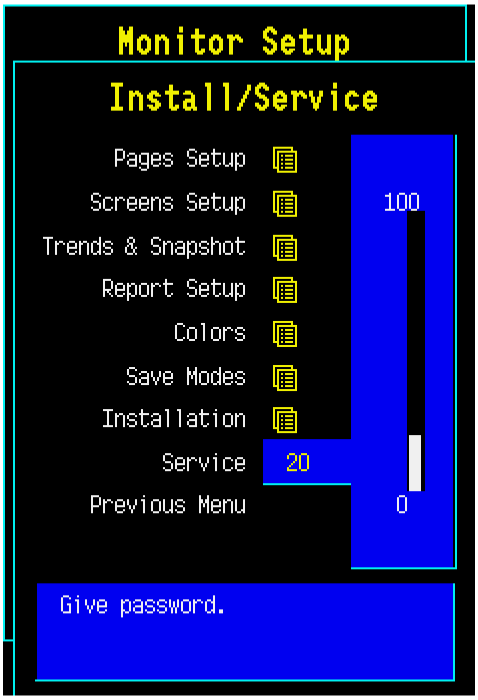
## 4.8 Error messages

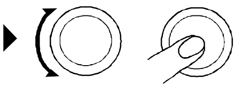
| Message | Explanation |
|---|---|
| Occlusion | The sample tube inside or outside the monitor is blocked or water trap is occluded. If occlusion persists, measured gas values disappear. |
| Air leak | - the water trap is not connected<br>- the gas outlet is blocked<br>- there is a leak in the sampling line inside the module. If air leak persists measured gas values disappear. |
| Replace trap | Indicates residue build-up on the water trap membrane. This decreases air flow. |
| Zero valve error | Opening the valve does not change working pressure enough. |
| Gas calibration is not available during the first 5 minutes/during occlusion/during air leak | Calibration not allowed during the first 5 minutes after power up and in mentioned situations. |
| Select agent | No agent selected. |
| Continuous occlusion. Check sampling line and water trap. | Occlusion over 40 seconds. |
| Air leak detected. Check water trap and sample gas out-flow. Press normal screen to continue. | Air leak over 40 seconds. |

| | |
|---|---|
| $CO_2$ | |
| Zero error | Unsuccessful zeroing |
| Unstable | Unsuccessful calibration |
| $CO_2$ over scale | $CO_2$ signal exceeds the maximum waveform area |
| $O_2$ | |
| $O_2$ zero error | Unsuccessful zeroing |
| $O_2$ over scale | $O_2$ signal exceeds the maximum waveform area |
| $O_2$ Unstable | Unsuccessful calibration |
| $N_2O$ | |
| $N_2O$ zero error | Unsuccessful zeroing |
| $N_2O$ Unstable | Unsuccessful calibration |
| Ane agents | |
| AA zero error<br>Zero error | Unsuccessful zeroing |
| AA unstable<br>Unstable | Unsuccessful calibration |
| AA over scale | AA signal exceeds the maximum waveform area |
| Menu messages during calibration | |
| Zero error | Unsuccessful zeroing |
| Adjust | Calibration gas accepted and monitor is ready for adjusting the gas values to match the calibration gas concentration |
| Unstable | Unsuccessful calibration |

# 5 SERVICE MENU

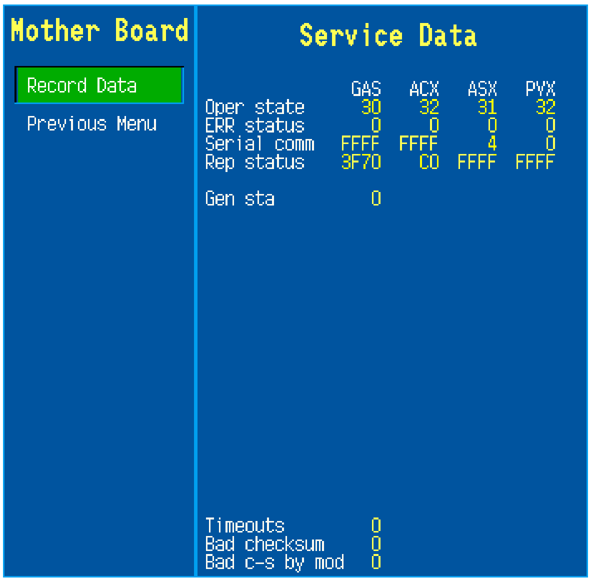


1. Press the **Monitor Setup** key.
2. Select ***Install/Service*** (password 16-4-34).
3. Select ***Service*** (password 26-23-8).
4. Select ***Parameters - Gas Unit***.

## 5.1 Gas mother board




### Service Data

**Oper State**

Internal operation state of the module:

| | |
|---|---|
| 0...9 | function performed, if staying on, failure is indicated |
| 10...29 | Initialization |
| 30...39 | Normal operation state |
| 40...49 | Zeroing |
| 50...59 | Calibrating |

**ERR status**

Indicates measuring unit malfunction:

GAS:

| | |
|---|---|
| 0 | no error |
| 1 | error in ACX measuring system |
| 2 | error in ACX communication |
| 10 | error in ASX measuring system |
| 20 | error in ASX communication |
| 40 | error in PVX measuring system |
| 80 | error in PVX communication |

Possible failure source: Gas CPU, ACX, ASX or PVX.

ACX:

0 no error

if not 0, replace ACX unit

ASX:

0 no error

if not 0, replace ASX unit

PVX:

0 no error

if not 0, replace PVX unit

**Serial Comm(unication)**
Serial Communication indicates a state of serial communication between the module processor and a measuring unit.

| | |
|---|---|
| GAS: | FFFF Continuously |
| ACX: | FFFF Continuously |
| ASX: | Value is for factory use only. |
| PVX: | Value is for factory use only. |

**Rep status**
Rep status is a four-digit number, where all digits, abcd , can have different values.

Gas rep status:

| | |
|---|---|
| a | |
| 0 | No sevoflurane or desflurane measurement available |
| 3 | ACX can measure sevoflurane and desflurane |
| b | |
| 0 | No gas measurements available |
| F | CO2, O2 N2O and AA measurements available |
| 3 | CO2 and O2 available |
| c | |
| 0 | No ACX, ASX, nor PVX board running |
| 1 | ACX board running |
| 3 | ACX and ASX board running |
| 5 | ACX and PVX board running |
| 7 | ACX, ASX and PVX board running |
| d | |
| 0 | Normal operation state |
| 1 | Occlusion |
| 2 | Air leak |
| 4 | Other sampling system error |
| 8 | Replace trap |

ACX rep status:

| | |
|---|---|
| a | |
| empty | Normal operation state |
| 1 | ACX initialization |
| b | |
| empty | Normal operation state |
| 2 | Occlusion |
| 4 | Air leak |
| c | |
| C | Normal operation state |
| others | values used in manufacturer's testing |
| d | |
| 0 | Normal operation state |
| others | values used in manufacture's testing |

ACX rep status FFFF continuously

| | |
|---|---|
| PVX rep status | FFFF continuously |

**General Status**

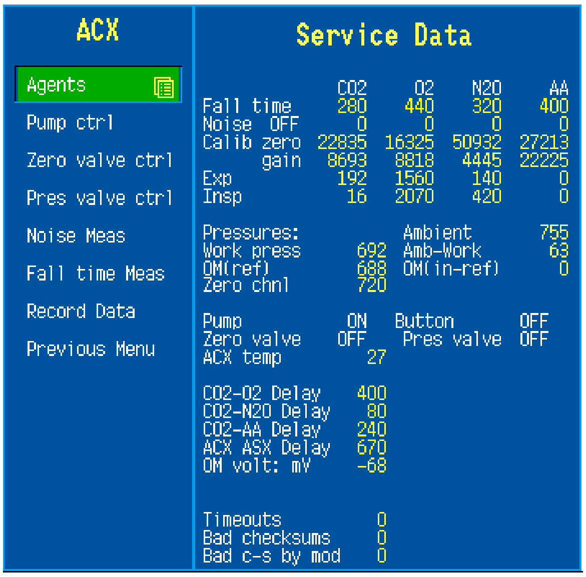
| | |
|---|---|
| 0 | Normal operation state |
| 8000 | Initialization |

If not 0 or 8000, replace the gas mother board.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.
**Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting indicates either serial communication failure or module not in place.

The timeouts etc numbers should not grow faster than 5 per second.

## 5.2 ACX service menu




**Pump ctrl** Turns pump on/off

**Zero valve ctrl** Turns zero valve on/off

**Pres valve ctrl** Turns pressure valve on/off

**Noise Meas** Noise measurement.

**Fall time Meas** Fall time measurement.

### Service Data

**Fall time**
Fall time indicates the response time of the measuring units. Select 'Fall time meas' from the menu. Notice that text 'feed' appears under each gas. Feed the calibration gas until every 'feed' is replaced by 'start'. Remove the sampling line quickly from the gas source.

Check that fall times are:
$O_2 < 480$ ms
$CO_2 < 360$ ms
$N_2O < 360$ ms
AA < 520 ms

NOTE: The measurement can be performed only with the modules using module software 884295.

**Noise measurement**
**$O_2$, $CO_2$ and $N_2O$**

Feed the calibration gas until the gas values are stabilized on screen. Start the measuring by selecting 'Noise meas' from the menu. After 10 seconds stop measuring by reselecting 'Noise meas'. Close the gas source. Noise values should be: $O_2 < 100$, $CO_2 < 20$, $N_2O < 150$.

**AA**
Select halothane for anesthetic agent. Feed the room air until gas values are stabilized. Perform the noise measuring as above, the value should be < 20.

NOTE: The measurement can be performed only with the modules using module software 884295.

**Calib zero and gain**

These values are calibration constants of zero and gain for each gas. The zero values may change at gas zeroing, the gain values at gas calibration.

When the monitor performs gas zeroing, the main software will write zero constants for the gases ($CO_2$, $N_2O$, AA, $O_2$) to the ACX memory. If some dust (or water) has entered the measuring chamber, zeroing of the gases require higher zero constants than before depending on the contamination level. If some gas requires higher value than 65536 the unit is not able to perform the zeroing and the message 'XXX ZERO ERROR' appears to the error list and the software recalls the previous zero constant for the concerned gas. If this happens at the initial start up the software will not pass the "calibrating gas sensor" state.

The $N_2O$ zero point is very sensitive for the measuring chamber contamination. Therefore the zero constant of $N_2O$ can be utilized in observing the contamination level of the ACX measuring chamber. The optimum value for the $N_2O$ zero constant with new and clean measuring chamber is 45000 indicating the ratio of 1:1 between the measuring and reference channel signals. The maximum acceptable value for the $N_2O$ zero constant is 51000, for a new measuring unit. The maximum value that the main software is able to set is 65536.

**Exp, Insp**

Gas concentration value from the ACX measuring unit.

**Pressures**

**Ambient** is the ambient pressure measured at the initialization. **Work press** is the internal pressure of sampling system measured by the ACX measuring board pressure transducer. The difference between these two pressures is **Amb-Work** and if the pump is functioning, it should normally be within 50...75.

**OM(in-ref)** is a pressure difference between the $O_2$ measurement flow and the $O_2$ reference flow. This pressure difference is automatically checked after every gas zeroing and it should be between 5 to 10 mmHg. If the pressure difference turns negative a message 'Replace trap' is displayed when the limit of -5 mmHg is exceeded.

In S-___97 and S-___98 software there is a software flaw in displaying the pressure difference, OM (in-ref). The flaw does not have any effect on the functioning of the ACX unit. The operational limit for the 'Replace Trap' message is -5 mmHg as in previous SW versions. The flaw is only in the displaying of the pressure difference value. With S-___97/98 software the pressure difference can be checked in a following way: turn the pressure valve ON for five seconds. This enables the updating of the OM (ref) value. Turn the pressure valve OFF and wait for five seconds. Now calculate the difference between Work press and OM (ref).

**Pump, zero valve**, and **pressure valve** are operated manually by highlighting and pushing the ComWheel. During patient monitoring, the valves are in OFF position

**ACX temp** indicates temperature inside the ACX bench, and the value is typically +10 °C higher than the prevalent room temperature.

**Delays** indicate the time delays within or between measurement units.

Delays are measured at the same time as fall times.

Check that the ACX_ASX delay is between 400-800.

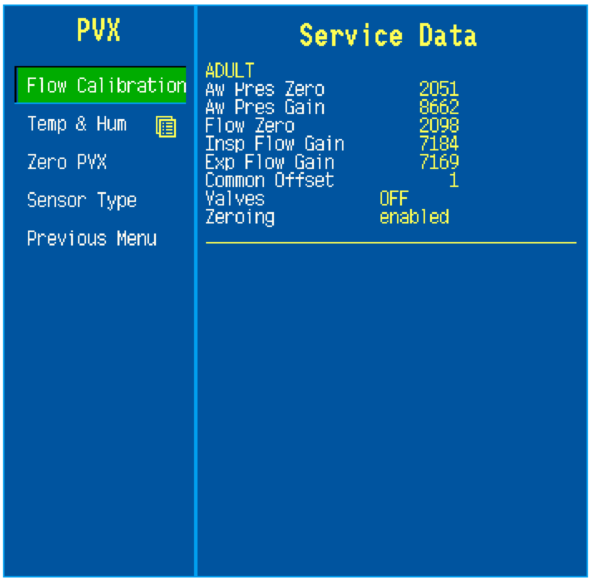
NOTE: The measurement can be performed only with the modules using module software 884295.

**Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.

**Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.

**Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected. The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 50 per second) indicates either serial communication failure or module not in place.

## 5.3 PVX service menu




### Service Data

**Aw Pres Zero**...The value of airway pressure zero is changing within the range of 1000 to 2400.

***) Aw Pres Gain**...Gain of pressure measurement. This value should be fixed to 8662.

**Flow Zero.**...The value corresponds to the pressure transducer B1 output during PVX zeroing. Number 0 corresponds to 0 V and 4095 corresponds to 10 V. The value is typically within the range of 100 to 4000.

**Insp Flow Gain**...Gain of inspired gas volume. Typically the value is between 5000 and 9000 depending on which sensor is used (adult/pediatric).

**Exp Flow Gain**...Gain of expired gas volume. Typically the value is between 5000 and 9000 depending on which sensor is used (adult/pediatric).

***) Common Offset**...Cancels common error which is caused by pressure from the pressure transducers. This is a transducer's own constant. The value should be between -230 and +230.

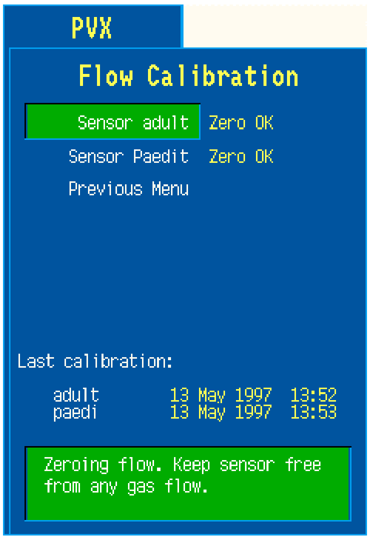
**Valves**...Position of zero valves.

**Zeroing**....Automatic zeroing is cancelled (disabled) or active (enabled).

*) NOTE: Items marked with asterisk (*) are not to be changed.

NOTE: The values shown are for the Adult module only. Changing the mode does not change the values.

### 5.3.1 Flow calibration



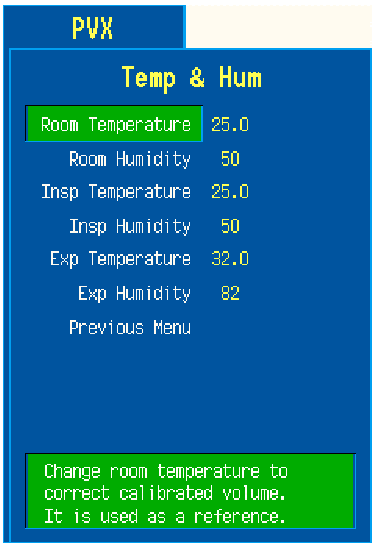

#### Flow calibration

PVX board is calibrated at the factory and due to the board's design calibration is not regularly needed. The calibration data is saved into the board's EEPROM memory and if the software EPROM of the board is changed the calibration must be performed. It is recommended to perform the calibration both with adult values using the D-lite, and with pediatric values using Pedi-lite.

1. Connect a spirometry tube with the D-lite sensor to the airway module. To improve the accuracy, the endotracheal tube and all accessories which are in normally use should be attached also during the calibration.
2. Enter service menu (**Monitor Setup** ***- Install Service - Service - Parameters***).
3. Enter the PVX menu. After the flow is zeroed ('Zero OK' message displayed) attach calibration pump or spirometry tester to the flow sensor (D-lite or Pedi-lite). Select the sensor type.
4. Set the calibration volume for adult to 1000 ml and for pediatric to 300 ml.
5. Work on the calibration pump slowly, approximately 1 pump in 5 seconds, pump until 'adjust'-message appears. If you use the spirometry tester, perform the calibration according to the tester instructions.
6. Adjust the reading to match the calibration volume (1000 ml for the D-lite and 300 ml for the Pedi-lite).

NOTE: The last calibration dates are saved in the main CPU board memory.

### 5.3.2 Temp & Hum service menu




If circumstances noticeably differ from normal, or additional accuracy is required, the use of Temp & Humidity menu may be advisable.

Especially small errors in tidal values may indicate that temperature and humidity settings of the monitor differ too much from the used system.

**Room Temperature and Humidity**
These are needed only in calibration procedure.

**Insp Temperature**
The temperature of inspired gas. The value is used in calculations. Change if necessary.

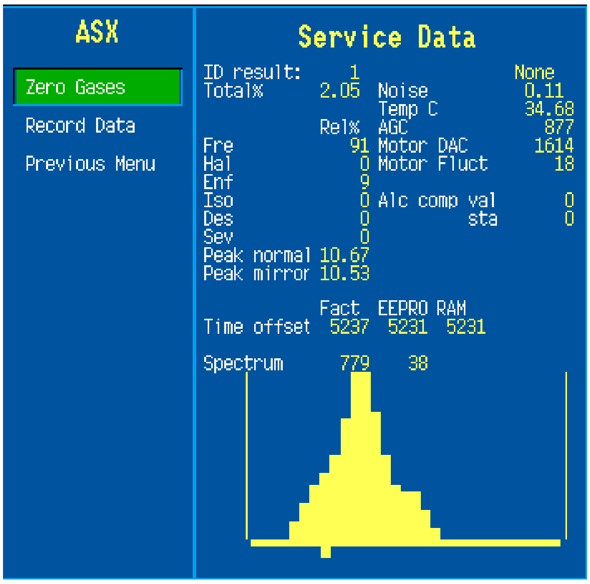
**Insp Humidity** The humidity of inspired gas. The value is used in calculations. Change if necessary.

**Exp Temperature** The temperature of expired gas. The value is used in calculations. Change if necessary.

**Exp Humidity** The humidity of expired gas. The value is used in calculations. Change if necessary.

## 5.4 ASX service menu

NOTE: The ASX service menu in monitor software S-xxx94 or newer supports only modules equipped with the ASX-200.




### Service Data

**ID result** displays the identified gas or mixture

**Total %** is the anesthetic agent concentration measured by ASX bench.

**Rel %** is the relative percentage of each measured agent in the mixture.

**Noise** value should be less than 80. Check the value only when no gas is fed and after a minimum of one minute stabilization time.

Temp C is the temperature inside the ASX unit.

**AGC** (Automatic Gain Control) should be between 100 and 3500.

**Motor DAC** is a motor speed control voltage, 100...3900, and **Motor Fluct** is the speed fluctuation, should be < 200.

**Alc comp val** is the compensation factor for alcohol content measured during halothane, enflurane or isoflurane measuring. **Sta** shows the status of compensation, 0 means off, and 1 means on.

The value without a leading text is for factory use only.

**Peak normal, Peak mirror** give the place of the spectrum's peak in the channel numbers. The peak normal value should be 10.3- 10.7 with calibration gas R23, and 12.9-13.1 with R22. If the value is not within the range, the gas calibration must be performed (see User's manual for instructions).

**Time offset** is the time between motor synchronization pulse and filter 0° angle. **Fact** is the factory value for it, **EEPRO** is the user calibration result, stored in the ASX, and **RAM** is the user calibration result, stored in the gas mother board.

**Spectrum** values relate to the scales of the spectrum display.

# 6 SPARE PARTS

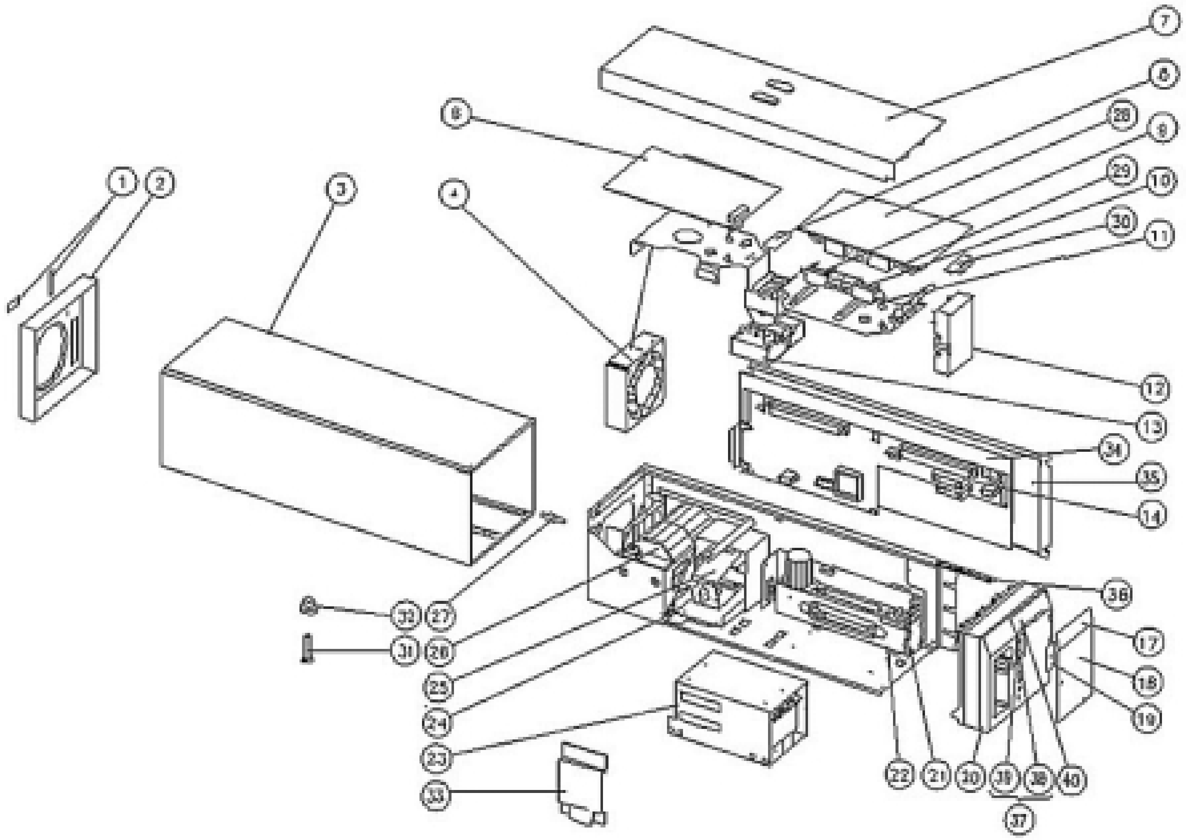


**Figure 20 Exploded view of Airway Module**

## 6.1 Spare parts list

### 6.1.1 G-AO rev. 01..05, G-AiO rev. 00...05, G-AOV rev. 00...04, G-AiOV rev. 00...04, G-O rev. 00...01

| Item | Description | Order No | Replaced by |
|---|---|---|---|
| - | Block screw for cables | 546096 | |
| - | Nafion tube (A or B, 500 mm: see manual) | 733383 | |
| - | Nafion tube (C, 300 mm) | 733382 | |
| - | Spring for D-Fend | 875598 | |
| - | Membrane keypad, G-AO / G-AOV | 879371 | |
| - | Thumb screw, AS/3 Airway Module | 879511 | |
| 1 | Rear panel sticker, All Airway Modules ; S/5 | 8000246 | |
| 1 | Rear panel sticker, DE | 880462 | 894181 |
| 1 | Rear panel sticker, EN | 880460 | 894181 |
| 1 | Rear panel sticker, FR | 880461 | 894181 |

| | | | |
|---|---|---|---|
| 1 | Rear panel sticker set, All Airway Modules | 894181 | 8000246 |
| 2 | Rear panel for airway modules | 883258 | |
| 3 | Airway module case | 878864 | 893258 |
| 3 | Airway module case | 878864 | 898318 |
| 3 | Airway module case, white | 893258 | 898318 |
| 3 | Case, Airway Module, S/5 white | 898318 | |
| 4 | Fan, AM/CCM | 880049 | |
| 6 | ACX-200 measuring board | 880270 | |
| 7 | Top protection cover | 878859 | |
| 8 | Flow cassette latch | 880343 | |
| 9 | Magnetic valve, without port plug | 58534 | |
| 10 | Magnetic valve, without port plug | 58534 | |
| 11 | Internal sampling tubings incl.system plate | 880375 | |
| 12 | CO2 Absorber, Airway Module | 880067 | |
| 13 | Damping chamber / Filter | 880068 | |
| 14 | Gas mother board | 880352 | 885174 |
| 14 | Gas mother board | 881775 | 885174 |
| 14 | Gas mother board, Airway Module | 885174 | |
| 17 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 898624 |
| 17 | Front Panel sticker, blanco (small) ; G-AiO(V), (M-C(O),M-CAiO rev.00-01) | 880471 | 8000204 |
| 17 | Front Panel sticker (small) ; G-AIO (rev.05), G-AiOV (rev.04) ; S/5 | 8000204 | |
| 17 | Front Panel sticker (small), DA ; G-AO (rev.04-5), G-AOV (rev.02-03) | 892221 | 8000202 |
| 17 | Front Panel sticker (small), DA ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000202 | |
| 17 | Front Panel sticker (small), DE ; G-AO (rev.04-05), G-AOV (rev.00-03) | 880546 | 8000193 |
| 17 | Front Panel sticker (small), DE ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000193 | |
| 17 | Front Panel sticker (small), EN ; G-AO (rev.04-05), G-AOV (rev.00-03) | 880376 | 8000192 |
| 17 | Front Panel sticker (small), EN ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000192 | |
| 17 | Front Panel sticker (small), ES ; G-AO (rev.04-05), G-AOV (rev.01-03) | 884405 | 8000196 |
| 17 | Front Panel sticker (small), ES ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000196 | |
| 17 | Front Panel sticker (small), FI ; G-AO (rev.04-05), G-AOV (rev.02-03) | 888876 | 8000199 |
| 17 | Front Panel sticker (small), FI ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000199 | |
| 17 | Front Panel sticker (small), FR ; G-AO (rev.04-05), G-AOV (rev.00-03) | 880454 | 8000194 |
| 17 | Front Panel sticker (small), FR ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000194 | |
| 17 | Front Panel sticker (small), IT ; G-AO (rev.04-05), G-AOV (rev.02-03) | 886760 | 8000197 |
| 17 | Front Panel sticker (small), IT ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000197 | |
| 17 | Front Panel sticker (small), JA ; G-AO, G-AOV ; S/5 | 8000389 | |
| 17 | Front Panel sticker (small), JA ; G-AO (rev.04-05), G-AOV (rev.02-03) | 888313 | 8000389 |
| 17 | Front Panel sticker (small), NL ; G-AO (rev.04-05), G-AOV (rev.02-03) | 886065 | 8000195 |
| 17 | Front Panel sticker (small), NL ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000195 | |
| 17 | Front Panel sticker (small), NO ; G-AO (rev.05), G-AOV (rev.03) | 893574 | 8000201 |
| 17 | Front Panel sticker (small), NO ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000201 | |
| 17 | Front Panel sticker (small), PT ; G-AO (rev.05), G-AOV (rev.03) | 895256 | 8000198 |
| 17 | Front Panel sticker (small), PT ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000198 | |
| 17 | Front Panel sticker (small), SV ; G-AO (rev.04-05), G-AOV (rev.02-03) | 885843 | 8000200 |
| 17 | Front Panel sticker (small), SV ; G-AO (rev.06), G-AOV (rev.04) ; S/5 | 8000200 | |
| 18 | Front Panel sticker (large) ; G-AiOV (rev.00-01) | 881301 | |
| 18 | Front Panel sticker (large) ; G-AiOV (rev.04) ; S/5 | 8000209 | |
| 18 | Front Panel sticker (large), G-AO (rev.06) ; S/5 | 8000203 | |
| 18 | Front Panel sticker (large) ; G-AOV (rev.00-01) | 881300 | |
| 18 | Front Panel sticker (large) ; G-O (rev.00-01) | 885233 | |

| | | | |
|---|---|---|---|
| 18 | Front panel sticker (large) ; G-OV (rev.00-01) | 886972 | |
| 18 | Front Panel sticker (large), G-AiO (rev.03-04) | 880472 | 8000205 |
| 18 | Front Panel sticker (large), G-AIO (rev.05) ; S/5 | 8000205 | |
| 18 | Front Panel sticker (large), G-AiOV (rev.02) | 890710 | 8000391 |
| 18 | Front panel sticker (large), G-AiOV (rev.03) | 886981 | 8000209 |
| 18 | Front Panel sticker (large), G-AO (rev.04-05) | 880377 | 8000203 |
| 18 | Front Panel sticker (large), G-AOV ; S/5 | 8000208 | |
| 18 | Front Panel sticker (large), G-AOV (rev.02-03) | 886980 | 8000208 |
| 18 | Front Panel sticker (large), JA ; G-AiOV ; S/5 | 8000391 | |
| 18 | Front Panel sticker (large), JA ; G-AOV (rev.02-03) | 888314 | 8000390 |
| 18 | Front Panel sticker (large), JA ; G-AOV (rev.04) ; S/5 | 8000390 | |
| 18 | Front Panel sticker (large), JA ; G-OV | 890712 | |
| 19 | Tube connector plug | 880294 | |
| 20 | Front panel unit | 881116 | 887477 |
| 20 | Front panel unit | 881116 | 888292 |
| 20 | Front panel unit | 885280 | 887477 |
| 20 | Front panel unit (G-AO rev. 01, G- AO rev.02 & G-AOV rev. 00) | 880374 | 887477 |
| 20 | Front panel unit (G-AO rev. 01, G- AO rev.02 & G-AOV rev. 00) | 880374 | 888292 |
| 20 | Front panel unit with SSS-connectors | 888292 | |
| 20 | Front panel unit w/o SSS-connectors | 887477 | |
| 21 | Lamp, ASX-100/200 | 878756 | |
| 22 | ASX-100 AA ID unit | 881107 | |
| 22 | ASX-200 AA ID unit | 882718 | |
| 23 | O2 measuring unit | 872898 | 888511 |
| 23 | O2 measuring unit, complete | 888511 | |
| 24 | Inlet ring,8x12x1.5mm | 65094 | |
| 25 | Pump, Airway Module | 881298 | 896238 |
| 25 | Sample Pump Spare Part Kit (G-Axxxx) | 896238 | |
| 26 | ACX-200 measuring unit | 879849 | |
| 27 | Sample out connector | 871981 | |
| 28 | PVX-100 without software | 881444 | |
| 29 | PVX tubings | 882723 | |
| 29 | PVX tubings | 885867 | |
| 30 | PVX board support | 880435 | |
| 31 | Cross recess screw M6x16 | 61678 | |
| 32 | Bushing, Airway Module | 879512 | |
| 33 | Bronze Plate | 884117 | |
| 34 | Insulating plate for 884116 | 879914 | |
| 35 | EMC cover, Gas Mother Board | 884116 | |
| 36 | Grounding Spring | 885602 | |
| 37 | Repair set for spirometry,Airway Mod | 886978 | |
| 38 | Spirometry connector,short male | 886636 | |
| 39 | Spirometry connector,short female | 886638 | |
| 40 | Fitting plate,G-AiO/G-AiOV/G-O/G-OV | 880550 | |

[1] NOTE: In case only the plastic spirometry connectors need repair, or compatibility with adult & pediatric Patient Spirometry accessories is needed, the **Repair set for spirometry connectors, order number 886978**, is recommended.

The Front panel unit, order number 888292, does not contain a membrane keypad, fitting plate and small front panel sticker. Those should be added separately according to the Airway module type and revision.
The Flow cassette's and their order numbers can be found listed in the section Gas sampling system.

### 6.1.2 Planned Maintenance (PM) Kits:

| Airway Module, G-xxx | Order No. |
|---|---|
| all versions | 8001762 |

### 6.1.3 Gas Interface Board, B-GAS

| Item | Item description | Order No. |
|---|---|---|
| - | Fuse T4A 250V | *51134 |
| - | Grounding plate | 885404 |
| - | Block screw for cables | 546096 |

# 7 EARLIER REVISIONS

This manual supports all the other Airway Module revisions except the following ones. For further information on those revisions see corresponding manual.

| Revision | Manual slot/main manual | Note |
|---|---|---|
| G-AO Module revision 01<br>G-AiO Module revision 00 | Service Manual p/n 880850 | |
| G-AO Module revision 02<br>G-AiO Modules revision 01<br>G-AOV Module revision 01<br>G-AiOV Module revision 01 | Service Manual p/n 882580 | |
| G-OV Module revision 01<br>G-O Module revision 01 | Technical Reference Manual 885944-6/896624 | |

# APPENDIX A

# SERVICE CHECK FORM

## S/5 Airway modules

| | | | | | |
|---|---|---|---|---|---|
| Customer | | | | | |
| Service | | Module type | | S/N | |
| Service engineer | | | | Date | |

OK = Test OK

N.A. = Test not applicable

Fail = Test Failed

**All modules**

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 1. Internal parts | | | | 2. External parts | | | |
| 3. D-fend O-rings | | | | 4. OM ref. filter | | | |

Notes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. Fan | | | | | | | |
| 6. Module software | Gas Unit | | | | | | |
| | ACX | | | | | | |
| | PVX | | | | | | |
| | ASX | | | | | | |
| 7. Module bus communication | | | | 8. Membrane key | | | |
| 9. $N_2O$ calibration zero | | | | | | < 61000 | |
| 10. Ambient pressure | | | | 11. Special tubes | | | |
| 12. $CO_2$ absorber | | | | | | > 3 | |
| 13. Zero valve | | | | 14. Leak test | | | |
| 15. Sampling pump | | | | | | > 109 mmHg | |

16. Flow rates

| | | |
|---|---|---|
| Sampling flow | | 180-220 ml/min |
| Side flow | | 10-27 ml/min |
| $O_2$ meas. in flow | | 45-60 ml/min |
| $O_2$ ref. in flow | | 25-42 ml/min |
| $CO_2$ absorber flow | | 180-220 ml/min |

17. Pressures

| | | |
|---|---|---|
| Amb-Work | | 50-75 mmHg |
| OM (in-ref) | | > 4 mmHg |

| | | |
|---|---|---|
| 18. $O_2$ sensor output voltage | | min. 2800 mV |

| | OK | N.A. | Fail |
|---|---|---|---|
| 19. Gas calibration | ☐ | ☐ | ☐ |

20. Fall time measurement

| | | |
|---|---|---|
| $CO_2$ fall time | | < 360 ms |
| $O_2$ fall time | | < 480 ms |
| $N_2O$ fall time | | < 360 ms |
| AA fall time | | < 520 ms |

21. Noise measurement

| | | |
|---|---|---|
| $CO_2$ noise | | < 20 |
| $O_2$ noise | | < 100 |
| $N_2O$ noise | | < 150 |
| AA noise | | < 20 |

**AA ID option**

| | | |
|---|---|---|
| 22. ACX_ASX Delay | | 400-800 ms |

23. AA ID Peak normal and Peak mirror

| | | |
|---|---|---|
| Peak normal | | 10.30-10.70 |
| Difference | | ±0.30 |

| | OK | N.A. | Fail | | OK | N.A. | Fail |
|---|---|---|---|---|---|---|---|
| 24. Calibration gas I.D. | ☐ | ☐ | ☐ | | | | |

Notes ____________________

**Patient spirometry option**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25. Spirometry connectors | ☐ | ☐ | ☐ | 26. Spirometry leak test | ☐ | ☐ | ☐ |
| 26. Flow waveform | ☐ | ☐ | ☐ | 27. Spirometry tester | ☐ | ☐ | ☐ |

Notes ____________________

**All modules**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 29. Fan filter | ☐ | ☐ | ☐ | 30. Electrical safety check | ☐ | ☐ | ☐ |
| 30. Occlusion detection | ☐ | ☐ | ☐ | 31. Air leak detection | ☐ | ☐ | ☐ |
| 31. Apnea detection | ☐ | ☐ | ☐ | 32. Final cleaning | ☐ | ☐ | ☐ |

**Notes** ____________________

**Used spare parts** ____________________

**Signature** ____________________