TECHNICAL MANUAL

VECTORSURGE II

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SPECIFICATIONS

Mains supply voltage	110/120/200/220/240 volts AC
Mains supply frequency	50/60 Hz
Power	70 V.A. Nominal
Primary Fuses	2 x 500 mA M205
Secondary Fuses	2 x 500 mA DA 205 1 x 1.5 amp DA 205

Power Transformer Secondary Voltages

1 (Chassis mounted)	30V at 2 amps with 15V tap 15V at 500 mA

Outputs

Maximum patient current each circuit (1k OHM load, both channels driven)	60 mA
Maximum patient voltage each circuit	80V
Current waveform	rectangular
Pulse width	50 microseconds (nominal)
Pulse frequency	10 kHz (nominal)
Beat frequency	0-250 Hz (nominal) 0-400 Hz (maximum)

Dimensions

Length	418 mm
Height	134 mm
Depth	280 mm

Weight

Unpacked	8.5 kg.
Packed	9 kg.

BRIEF OUTLINE

The Metron "vectorsurge" Interferential Therapy Unit comprises a control circuit which produces two 50 microseconds rectangular pulse waveforms (frequency 10 kHz, symmetrical AC waveforms). The waveforms are fed to two power amplifiers with the output stages operated in class B mode. Output of the power amplifiers is coupled to each patient circuit with a step-up transformer which also serves to isolate the patient circuit. A high-power resistor in the patient circuit limits the current output, which is measured directly by the patient-current meters. Additional limiting of output current is provided by the regulated protected power supply of the power amplifiers. A separate supply is used to power the control circuit.

A digital electronic timer is used to control the patient treatment time. At the end of the selected time period the timer triggers an SCR, disconnecting the drive to the output transformers. The same SCR is used to isolate the transformer drive signal if the apparatus is switched on with the intensity control advanced. The timer and digital displays have a power supply derived from the same transformer as the power amplifiers.

WARNING

* The output current available at each patient circuit is of a high enough intensity to be potentially dangerous.

* As a therapy device, the machine may only be used by qualified personnel.

* The machine is not for trans-thoracic use (the electrodes must not be positioned such that a current may flow through the chest area).

* The machine should not be used on a person with an implanted cardiac pacemaker.

TECHNICAL DESCRIPTION

Part 1 - The Control Circuit

The control circuit produces two rectangular symmetrical waveforms of frequency 10 kHz and pulse width 50 microseconds.

The two waveforms are rhythmically shifted in and out of phase at a selected frequency (the "beat frequency"). The beat frequency may be set to a fixed value or set to sweep over a particular frequency range.

One of the waveforms is amplitude modulated at a frequency of approximately 250 Hz to a depth of 50% of maximum and the envelope has a triangular modulation. This amplitude modulation produces "vector rotation" of the patient stimulation current.

The circuit may also be set to "surge" the output signals. "Surging" refers to in-phase amplitude modulation of the signals. The modulation is 100%. The surge frequency may be varied in the range approximately 0.05 Hz to 1 Hz.

A schematic diagram of the control circuit is shown on page 4.

The Control Circuit - in more detail

The control circuit comprises four sub-sections:

- the master oscillator and pulse-width modulation circuit
- the sweep control circuit
- the dual signal generator
- the surge and output circuit

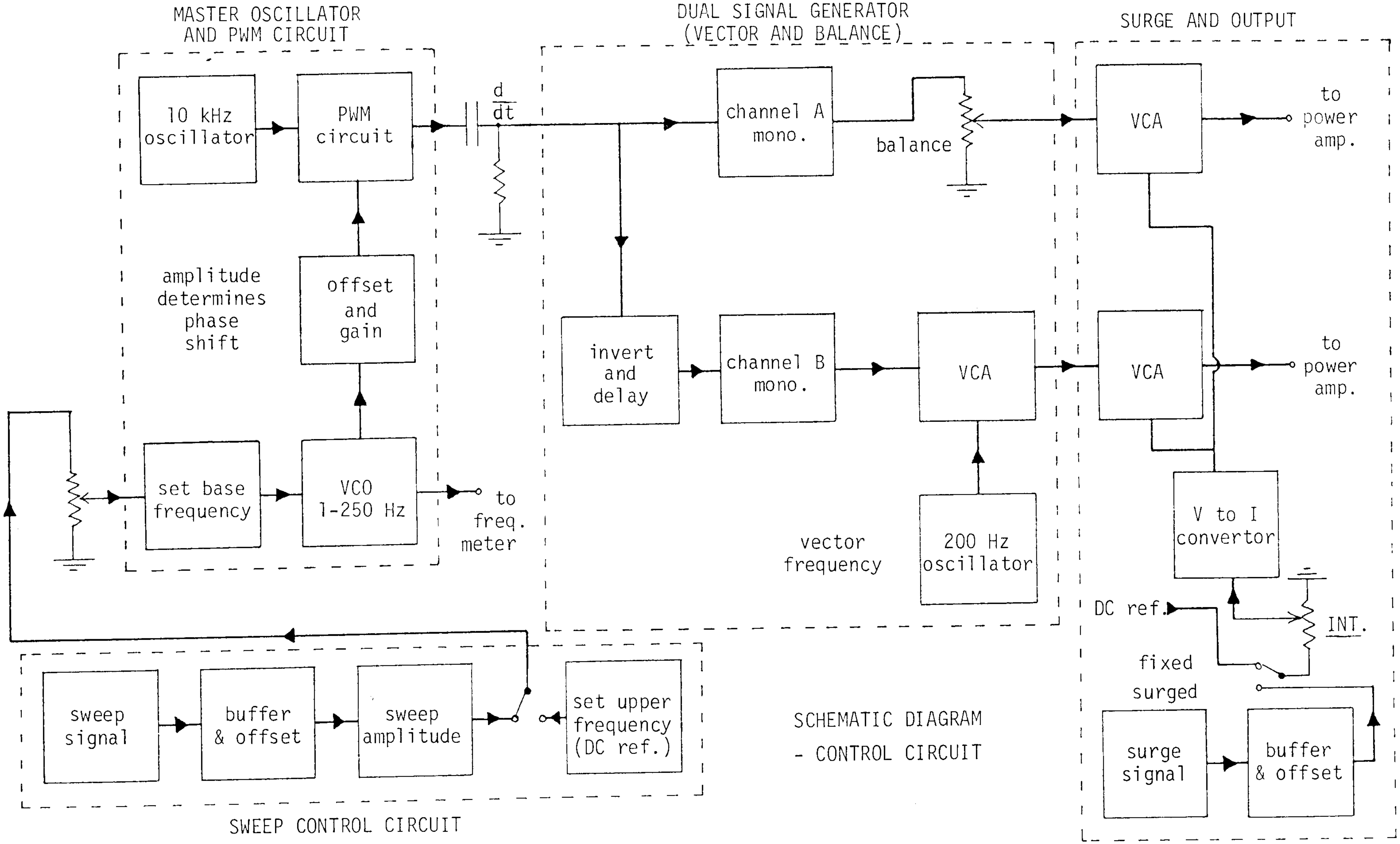
1.1 THE MASTER OSCILLATOR AND PULSE WIDTH MODULATION CIRCUIT

The complete circuit is shown in circuit diagram sheet 2. An astable multivibrator (IC5 (a)) produces a train of rectangular pulses of width approximately 0.3 microseconds and frequency approximately 10 kHz. These pulses trigger a monostable multivibrator (IC5 (b)). The pulse width of this monostable is controlled by a voltage controlled oscillator (VCO) comprised of IC3 (b), IC4 and IC3 (d).

When the VCO is set to a frequency, f, the monostable (IC5 (b)) produces pulses of frequency 10 kHz with the pulse width varying from approximately 6 microseconds to 56 microseconds at the frequency, f.

The output of IC5 (b) is thus a rectangular pulse waveform with the pulse width cycling at the frequency of the VCO.

The VCO operates over the frequency range approximately 0.5 Hz to 400 Hz (see 1.5 below).



SCHEMATIC DIAGRAM
- CONTROL CIRCUIT

1.11 TESTING THE MASTER OSCILLATOR

Connecting a CRO to pin 5 of IC5 (a) should show a rectangular pulse waveform of period approximately 100 microseconds and pulse width approximately 0.3 microseconds.

1.12 TESTING THE PWM CIRCUIT

Connecting a CRO to pin 9 of IC5 (b) (test point B) should show a rectangular pulse of frequency approximately 10 kHz. With the "frequency" controls of the machine set to minimum (fully anticlockwise) the pulse width should vary smoothly from about 6 microseconds to 56 microseconds at a frequency of about 0.5 Hz. (For frequency adjustment see calibration procedure, step 3).

The 200 k OHM trimmer potentiometer is used to set the minimum pulse width to a value which will not produce double-triggering of IC5 (b) (approximately 6 microseconds) and the 20 k OHM trimmer potentiometer is used to set the maximum pulse width (approximately 56 microseconds) and reliable triggering of IC5 (b). If the 20 k OHM potentiometer is advanced too far, the pulse-width will become inordinately large and pulses will run into each other, upsetting the base frequency of 10 kHz.

In correct operation the pulse produced by IC5 (b) should vary from approximately 6 microseconds (with no double-triggering) to 56 microseconds (with no run-on into the next pulse). (See calibration procedure, step 4).

1.2 OUTPUT FROM THE PULSE WIDTH MODULATION CIRCUIT

The output from the pulse width modulation circuit is differentiated by a 100 pF capacitor/10k OHM resistor combination to produce a leading positive going pulse and a trailing negative going pulse. The trailing pulse is delayed, the delay varying between 6 microseconds and 56 microseconds at the frequency of the VCO.

The leading (positive) pulse is inverted and used to trigger a monostable, IC6 (a), which produces a 6 microseconds rectangular pulse. This pulse is differentiated and the negative pulse from the trailing edge is used to trigger IC6 (b). See circuit diagram sheet 3.

A 20k OHM trimmer potentiometer is used to set the pulse width of IC6(a) to approximately 6 microseconds, i.e. to synchronize the negative pulse which triggers IC6 (b) with the negative pulse which triggers IC7 (b).

1.21 SYNCHRONIZING THE TWO CHANNELS

The channel 1 signal is generated by the negative pulse applied to pin 8 of IC6 (b). The channel 2 signal is generated by the negative pulse applied to pin 8 of IC7 (b). When the 20k OHM ("set pulse delay") trimpot (sheet 3 of circuit diagram) is correctly adjusted, the delay between the channel 1 and channel 2 signals will vary smoothly from 0 to 50 microseconds at the VCO frequency (see calibration procedure, step 5).

1.3 VECTOR AND BALANCE CIRCUITS

IC6 (b) and IC7 (b) produce rectangular pulses of width approximately 50 microseconds. Each IC has a 10k OHM trimmer potentiometer which is used to set the mark space ratio to exactly 1:1.

The rectangular symmetric pulse output of IC6 (b) is applied to a 10k OHM "balance" potentiometer.

The rectangular symmetric pulse from IC7 (b) feeds into a voltage controlled amplifier (VCA), IC9.

AC signals applied to the control voltage pin (pin 5) of IC9 produce the amplitude modulation for "vector rotation" of the patient treatment currents.

IC7 (a) produces the AC signal for the VCA. The signal is a triangular waveform of frequency approximately 250 Hz and amplitude approximately 10 VPP.

The frequency of this oscillator is not critical.

Output from IC7 (a) feeds via a buffered amplifier (IC8 (c and d)) to the channel B VCA. Thus IC9 (channel B) is amplitude modulated. The depth of modulation is set to 50% (see calibration procedure, step 8).

1.31 ADJUSTING THE PULSE WIDTH

A CRO should be connected to pin 9 of IC6 (b) (test point E) or IC7 (b) (test point F). The 10k OHM trimmer potentiometer (e) or (f) circuit diagram sheet 3) is adjusted for a mark space ratio of 1:1 (see calibration procedure, steps 6 and 7).

1.32 ADJUSTING THE CHANNEL BALANCE

A dual beam CRO should be connected to the outputs of the machine with 470 OHM dummy loads connected. The "balance" control on the front panel of the machine should be set to the mid-position and "frequency" controls to a fixed frequency of approximately 20 Hz. The "intensity" control should be set to the mid-position.

The 50k OHM trimmer potentiometer (l) in channel B ("equalize gain", sheet 3) should be adjusted for equal amplitude signals. (See calibration procedure, step 13).

N.B. The amplitude of the channel B signal is measured to the mid point of the modulation envelope.

1.33 ADJUSTING THE VECTOR AMPLITUDE

The amplitude modulation of the channel B signal has an envelope frequency of approximately 250 Hz and a depth of modulation of 50%. The amplitude modulation is set by adjusting the 50k OHM "vector amplitude" trimmer potentiometer (h). (See sheet 3 of circuit diagrams).

A CRO is connected to the output of IC9 (test poing I). The CRO timebase is set to 5 milliseconds/div. a 250 Hz waveform envelope will be seen. The 50k OHM trimmer potentiometer (h) should be adjusted to produce 50% amplitude modulation. (See calibration procedure, step 8).

1.4 THE SURGING CIRCUIT

The surging circuit comprises a triangle waveform generator (IC10) which feeds via IC11 (a) and IC11 (b) to a V to I convertor (IC11 (c)). The output of the V to I convertor is applied to the control voltage inputs (pin 5) of two VCA's (IC12 and IC13) via the "intensity" control.

When the surge selector switch is set to the "on" position the surging circuit is connected to the "intensity" control. When the surge selector switch is set to the "off" position the input to the "intensity" control is a fixed 4.3V reference signal. The setting of the "intensity" control determines the voltage applied to the V to I convertor and so determines the amplitude of the signals supplied to the power amplifiers.

Output of the VCA's (IC12 and IC13) are fed to the main amplifiers.

The triangular waveform produced by IC10 is of very low frequency - 0.05 Hz to 1 Hz, determined by the setting of the "surge rate" control on the front panel. IC11 (a) is needed to present a high impedance load to IC10.

N.B. A CRO connected to IC10 pin 6 is likely to change the surge frequency or prevent IC10 from oscillating unless the input impedance is sufficiently high (over 10M OHM).

IC11 (b) is used to offset the signal produced by IC10 so that the voltage applied to the "intensity" control sweeps from approximately 0V to exactly 4.3V.

1.41 ADJUSTING THE SURGING CIRCUIT

A CRO should be connected to the output of IC11 (b) (test point H). The "surge rate" control on the front panel should be set to maximum (fully clockwise). The CRO timebase should be set to 500ms/div.

The 10k OHM offset adjust potentiometer, (i), (circuit diagram sheet 4) should be adjusted so that the voltage fluctuates between approximately 0V and exactly 4.3V.

The CRO is then connected to the machine output and the timebase set to 20 microseconds/div. The maximum signal observed should have an amplitude which is equal to the amplitude when the surge is switched off.

1.5 THE SWEEP CONTROL CIRCUIT

The "beat frequency" of the apparatus is the frequency of the VCO in the master oscillator and PWM circuit (1.1 above). The VCO frequency is determined by the control voltage applied to pins 5 and 6 of IC3 (b), (circuit diagram sheet 2).

The 10k OHM, 3 turn potentiometer ("lower frequency" control on front panel) connected to pin 5 of IC3 (b) is used to set any base frequency in the range approximately 0.5 to 250 Hz. The adjacent 500 OHM trimmer potentiometer is used to set the minimum frequency (step 3, calibration procedure).

When the front panel "upper frequency" control is fully anticlockwise the 10k OHM resistor connected to the pin 6 input of IC3 (b) is at 0 volts potential.

When the front panel "upper frequency" control is rotated clockwise, a DC signal generated by the sweep control circuit is applied to the 10k OHM resistor connected to pin 6 of IC3 (b). (See circuit diagram sheet 1). This DC signal has a triangular waveform of very low frequency determined by the R and C components connected to pin 6 of IC1.

The DC signal generated by the sweep control circuit varies between 0 volts and approximately -4 volts. This signal, applied to the VCO causes the frequency to sweep from the base frequency f (set by the 10k OHM, 3 turn "lower frequency" potentiometer) to a maximum frequency of approximately f + 150 Hz. The same signal attenuated by potentiometer (the "upper frequency" control) reduces the frequency sweep.

1.51 ADJUSTING THE SWEEP RANGE

The signal applied to the 10k OHM resistor connected to pin 6 of IC3 (b) must vary from a negative value to exactly 0 volts. The 10k OHM trimmer potentiometer (j) connected to pin 3 of IC2 (a) is used to set the minimum signal excursion to exactly 0 volts (measured at test point G). The 5k OHM trimmer potentiometer (k) connected to pin 1 of IC2 (a) is used to set the maximum signal excursion to a value which will produce a frequency sweep of 150 Hz, when the "upper frequency" control is rotated fully clockwise.

Trimmer potentiometer (g) is adjusted so that when the "sweep range" switch is held to the right the (fixed) frequency obtained is the same as the maximum obtained during a sweep. The "upper frequency" control should be set fully clockwise for this adjustment (steps 9 and 11 of calibration procedure).

N.B. These adjustments should only be carried out after the minimum frequency of the VCO has been set to approximately 0.5 Hz (step 3 of calibration procedure completed).

Part 2 - The Power Amplifiers, Power Supplies and Frequency Meter

Output signals from the control circuit are fed to two power amplifiers operating in class B mode. A relay switches the power amplifier output between a 56 OHM 5W dummy load and an output transformer.

The 56 OHM load is connected when either -

- the unit is switched off OR
- the timer is not in operation OR
- the power is switched on with the intensity control advanced.

If the power is switched on with the intensity control at minimum and the timer is set there will be a brief (approximately two seconds) delay before the relay switches from the 56 OHM load to the output transformer. The delay is incorporated to ensure that no switch-on current pulses are applied to the patient circuit when the mains power switch is operated.

The output transformers supplying the patient circuit are double insulated and constructed in accordance with Australian Standard AS3208. The transformers have a voltage step-up ratio of 6.6:1. A 5W series resistor in the patient circuit is used to limit the output current. A metering circuit connected in parallel with the 5W resistor is calibrated to indicate the patient current.

A short-circuit protected 30V, 1A power supply is used to power the power amplifiers. A 15V tap on the 30V transformer is used to generate a 12V 500mA supply for the timer and frequency meter.

A separate 15V winding on the transformer is used to generate a ± 12V, 500mA supply to power the control circuit.

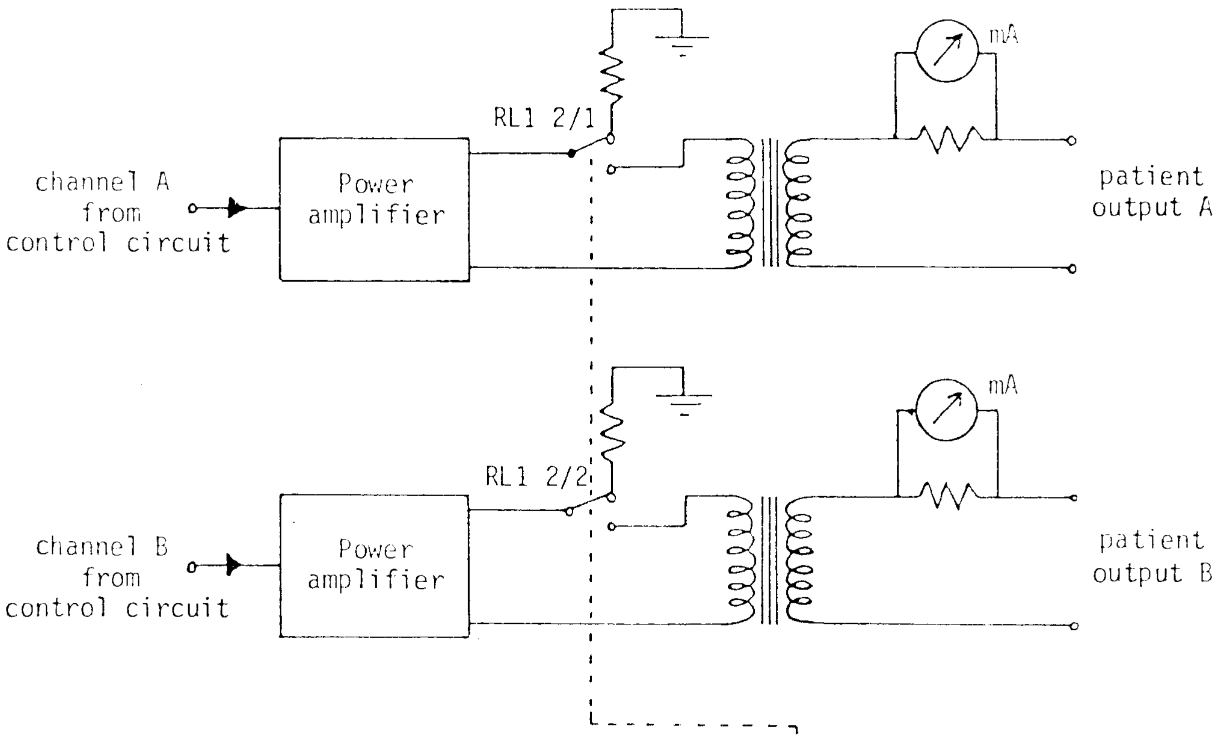
The frequency meter is a simple 3 digit count and display circuit. Rectangular pulses generated by the control circuit VCO are counted. Gating for count and display is by 1 Hz pulses generated by the timer circuit. Thus a 1 second count of the VCO output gives a direct frequency reading in Hz.

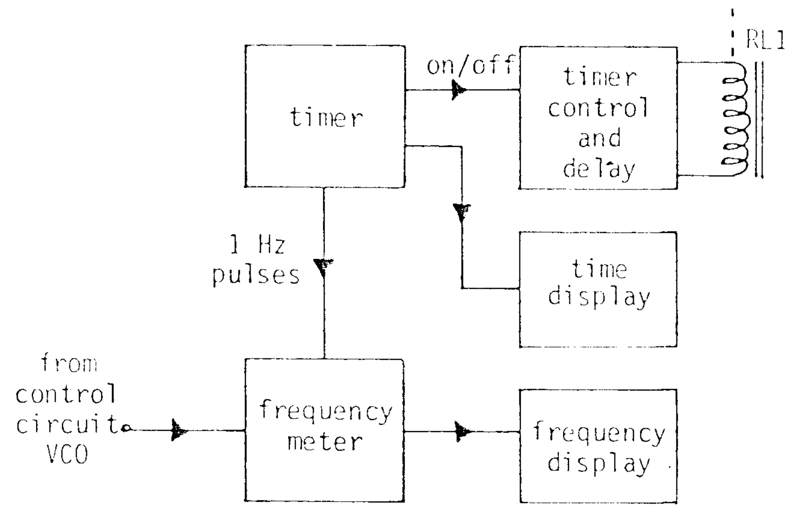
A schematic diagram is shown on page 11.

THE POWER AND FREQUENCY METER CIRCUITS - IN MORE DETAIL

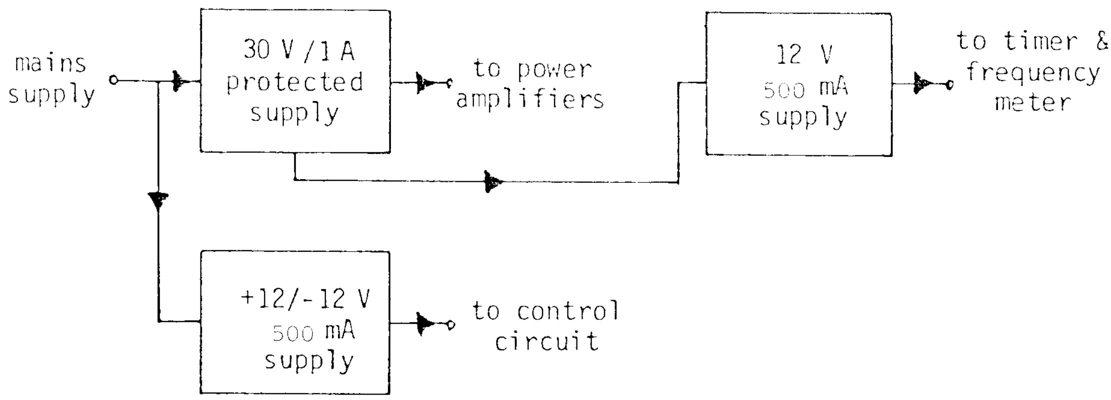
The power and frequency meter circuits comprise five sub-sections:

- the power amplifiers
- the timer control and delay circuit
- the 30V/12V supply
- the ±12V supply
- the frequency meter





POWER AMPLIFIERS,
POWER SUPPLIES,
TIMER AND
FREQUENCY METER



2.1 THE POWER AMPLIFIERS

The power amplifiers have a complementary push-pull arrangement. The voltage gain, of approximately 8 times, is set by the ratio of the feedback resistor (1500 OHM) to the BC 547 emitter resistor (180 OHM). The amplifiers are operated in class B mode: this produces good reproduction of square wave signals, with excellent transient response and negligible crossover distortion with a square input waveform. See circuit diagram sheet 5.

Output of each power amplifier is fed to a relay which switches between a 56 OHM 5W load resistor and the output transformer. The relay coil is energised by the timer control and delay circuit (see 2.2 below). A 2.5 mH inductor is connected to the amplifier output ahead of the relay so as to maintain the negative side of the 220μF output coupling capacitor at 0 volts potential regardless of the relay position.

No calibration or adjustment of the power amplifiers is necessary and trouble-shooting is by standard procedures.

2.2 THE TIMER CONTROL AND DELAY CIRCUIT

The timer control and delay circuit serves three roles:

(i) to switch the patient current according to the timer output.

(ii) to prevent patient current being supplied if the unit is switched on with the intensity control advanced.

(iii) to prevent transient currents being supplied to the patient circuit when power is switched on.

See circuit diagram sheet 8.

Output from the timer (section 3 following) is coupled to the gate of SCR C103B. Triggering of the SCR supplies current to the output delay circuit and the relay RL1 is not energised. Thus output from the power amplifiers (sheet 5) is diverted to 56 OHM load resistors.

When the SCR is latched (not conducting) no current is supplied to the output delay circuit. Relay RL1 will energise and output from each of the power amplifiers will be supplied to the output transformers.

When the unit is switched on a transient pulse is supplied to the SCR gate by charging of the 10μF 35V capacitor (sheet 8) connected to the 30V supply rail and the SCR conducts. The timer output is initially HIGH so the SCR is held in conduction. Manual setting of the timer makes the timer output LOW and the SCR can then be latched by reducing the "intensity" control to minimum. This allows the relay to energise and current is supplied to the patient circuit.

Thus the relay can only energise if:

(a) the timer has been set and

(b) the intensity control is set to a low position

An RC combination (22k OHM and 10 microfarads) in the output delay circuit introduces a delay before the relay is energised. This prevents current being supplied to the patient circuit before the power supplies have stabilized when first switched on.

A front panel mounted LED (the "patient current indicator") is connected in parallel with the relay. This LED is thus illuminated whenever the relay is operating and energy can be supplied to the patient circuit.

No adjustment of the timer control and delay circuit is necessary and trouble-shooting is by standard procedures.

2.3 THE 30V/12V SUPPLY

The 30V/12V supply circuit for the power amplifiers, timer and frequency meter is shown on circuit diagram sheet 10.

A 1.5A slow-blow fuse protects the 30V supply which uses a series regulator circuit comprising a BD647 darlington transistor heat-sunk to the chassis and a 30V 1W zener diode.

Current limiting is provided by a BD139 with its collector connected to the cathode of the 30V zener. The 0.68 OHM 2W resistor in the supply return between base and emitter of the BD139 determines the limiting current value.

A 500mA slow-blow fuse connected to the 15V tap of the transformer protects the 12V supply. The 15V signal is applied to a 12V series regulator IC.

No adjustments of the power supply are needed and trouble-shooting is by standard procedures.

2.4 THE ± 12V SUPPLY

The ± 12V supply for the control circuit is shown in circuit diagram sheet 9.

A 500mA fuse protects the supply which uses a series regulator IC for both the positive supply and the (lower current) negative supply. The positive supply normally experiences approximately 120mA current drain and the negative supply, approximately 25mA.

No adjustment of the power supply is needed and trouble-shooting is by standard procedures.

2.5 THE FREQUENCY METER

The frequency meter circuit is shown in circuit diagram sheet 6.

The rectangular AC waveform from the VCO in the control circuit (section 1.5 previously) is half-wave rectified to produce a train of 12V DC rectangular pulses. These are applied directly to the "clock" input of the MC14553 counter/multiplexer, IC15.

1 Hz pulses from the timer circuit (section 3 following) control the strobe and reset functions of IC15. The 1 Hz pulses are inverted by IC14(b), differentiated by the 270pF/10k OHM combination and applied to the "strobe" input of IC15 as negative going spikes on a 12V DC signal.

A 33k OHM/270pF combination delays the signal applied to IC14(a). The delayed signal is inverted and fed to IC14(d) where it is again inverted and differentiated by the 270pF 1k OHM combination. The 100k OHM/18k OHM resistor combination around IC14(d) provides a DC bias necessary to ensure that the output pulses are sufficient to trigger the "reset" function. Thus the pulses applied to the "reset" input are positive spikes superimposed on a rectangular positive DC signal. The "reset" pulse is delayed by approximately 10 microseconds with respect to the "clock" pulse.

The BCD output of IC15 is fed to an MC14511 decoder/driver IC (IC16) which powers three seven segment displays (Stanley type NKR 163,263) via 1k OHM ¼W resistors. Multiplex drive from IC15 is fed to three BC557 transistors which display or blank the relevant seven-segment display.

No adjustment of the frequency meter is necessary and trouble-shooting is by standard procedures.

Part 3 - The Timer and Time Base Generator Circuit

The time base generator circuit uses a mains frequency AC signal and produces three rectangular output pulses of frequency 4 Hz, 1 Hz and 1/60 Hz (i.e. 1 pulse per minute). The 1/60 Hz pulses are used in normal operation of the timer, to count down from the operator selected treatment time. 1 Hz pulses are used to generate the 1/60 Hz pulses. 4 Hz pulses are used to make the timer repidly count to the desired treatment time when the timer is initially being set. A circuit board mounted switch is set to suit the timer to either 50 Hz or 60 Hz mains frequency operation. A buzzer is incorporated in the timer circuit so as to audibly signal the end of the treatment time.

The timer can be set to any treatment time between 1 and 40 minutes.

A front panel mounted switch is used to set the timer. When the power is switched on the time display is initially blank and a control signal from the timer prevents the timer control circuit (section 2.2 previously) from supplying any current to the patient circuit.

If the front panel mounted switch is depressed the timer begins to count down rapidly from 40 minutes. Releasing the switch sets the treatment time. If the front panel mounted switch is elevated the timer will rapidly count up. Thus the treatment time can be set by counting down from 40 minutes or counting up from 1 minute. Adjustment of the treatment time can also be performed at any time by depressing or elevating the switch.

Once the timer is activated the time display is illuminated and no signal is supplied to the timer control. Thus activation of the timer allows current to be supplied to the patient circuits. Note, however, that the intensity control setting overrides the timer and no patient current will be supplied unless the intensity control is set to minimum (see section 2.2 previously).

3.1 THE TIME BASE GENERATOR - IN MORE DETAIL

The time base generator circuit is shown in circuit diagram sheet 7.

The circuit comprises two BC549 transistors and two MC4518 dual BCD up counters. Mains frequency AC from the 15V transformer secondary is rectified and fed to the base of the first BC549. The BC549s square the signal and apply it to pin 1 of IC1). The two counters in this IC are connected to divide by 60 or 50 depending on the setting of the 50/60 Hz switch. Thus the timer is set for either 50 Hz or 60 Hz mains frequency operation.

1 Hz pulses from IC1 pin 14 are fed to IC2, which has its dual counters connected to divide by 60. Thus the output of IC2 is pulsed with a frequency of 1/60 Hz i.e. once per minute. The 4 Hz output pulses from IC1 pin 11 are used for rapid count up or count down of the timer.

The only adjustment to the time base generator is setting for 60 Hz or 50 Hz operation. The switch is normally preset at the factory. Trouble shooting is by standard procedures.

3.2 THE TIMER CIRCUIT - IN MORE DETAIL

The timer circuit is shown in circuit diagram sheet 7.

The circuit comprises two NKR263 seven segment displays, each driven by a 74C48 BCD to 7-segment decoder which is in turn driven by a 74C192 up/down decade counter. Signals to the decade counters are controlled by a 4093 quad schmitt trigger I.C. and a 4011 quad NAND I.C.

When power is first switched on a pulse is applied to the pin 14 (reset) input of IC7 and IC8. Thus the display is blanked and pin 4 of IC10 is low. With a low input to IC4(d), its output is high and a signal is applied to the timer control circuit (circuit diagram sheet 8). This prevents the relay RL1 from energising and no current is supplied to the patient circuit.

If the timer switch SW1 is depressed IC6(b) applies 4 Hz pulses to pin 4 of IC8. Pin 11 of IC7 is momentarily brought low and decimal 4 is loaded into the counter register. Pulses applied to pin 4 of IC8 thus cause it to count down from 40. While SW1 remains depressed the output of IC4(b) is kept high so the reset function of the time base generator is activated. Releasing SW1 sends the output of IC4(b) low and the time base generator starts counting to 1 minute.

If SW1 is elevated, IC5(d) applies 4 Hz pulses to pin 5 of IC8. Pin 11 of IC7 remains high so the counter registers start with both at decimal zero. Pulses applied to pin 5 of IC8 thus cause it to count up from zero. While SW1 remains elevated the output of IC4(b) is kept high. Releasing SW1 sends the output of IC4(b) low and the time base generator starts counting to 1 minute.

When the timer is operating, i.e. a count time is showing on the seven-segment displays, pin 4 of IC10 is high and the output of IC4(d) is low. This allows the relay RL1 (circuit diagram sheet 8) to operate and current is supplied to the patient circuit.

IC5(a) and IC5(b) serve to reset counters IC7 and IC8. When IC7 reaches a count of decimal 4 and IC8 reaches a count of 1 Pins 1 and 2 of IC5(a) go high, resulting in a high output on IC5(b) taking pin 14 (the reset pin) high which resets counters IC7 and IC8 to zero. When the display is blanked, pin 4 of IC10 is low so the output of IC4(d) is high and relay RL1 disconnects output from the patient circuits.

A delay circuit comprising a BC549 transistor with an associated 10μF/100k OHM RC combination is used to introduce a brief pause between counts of 1 and 40. If SW1 is held depressed the timer will rapidly count down to zero and blank the displays. The displays will remain blanked briefly before re-commencing a rapid count down from 40. If SW1 is held elevated the timer will count rapidly up to 40 then blank the displays. The displays will remain blanked briefly before re-commencing a rapid count up from 1. The delay is incorporated to make it easy to manually switch off the timer and terminate treatment without switching off using the mains power switch.

The output of IC4(d) is used to control a buzzer circuit. When the timer is switched on by depressing or elevating the switch, the output of IC4(d) is brought low. This switches off the BC547 transistor, allowing the 2200 microfarad capacitor to charge via a 2.7k OHM resistor. With a low input to the control pin (C) of the YMB12 buzzer the buzzer does not operate. At the end of treatment the output of IC4(d) goes high, bringing the YMB12 control pin high. The buzzer sounds, discharging the 2200 microfarad capacitor. At the same time the BC547 transistor conducts so the capacitor can not recharge. Re-setting the timer brings the output of IC4(d) low, switching off the buzzer and BC547 transistor, thus allowing the capacitor to recharge.

3.21 TESTING THE TIMER CIRCUIT

No adjustment of the timer circuit is necessary. Correct operation of the timer can be verified as follows:

- When the power is switched on the displays should be blank, the output of IC4(d) should be high and the output of IC4(b) should be low.

- Elevating the front panel switch should result in the displays counting upwards from 1 to 40. Pin 4 of IC4(b) should be high and remain high while the switch is elevated. Release of the switch should result in Pin 4 of IC4(b) going low.

- Depressing the switch should make the displays count downwards. While the switch is depressed the output (Pin 4) of IC4(b) is high. Once the switch is released, the output of IC4(b) goes low. The output of IC4(d) (Pin 11) is high whenever the display is blanked. When the display is illuminated IC4(d) pin 11 is low.

- Moving the switch from depressed to elevated should produce a smooth transition from counting down to counting up. A 0.1 microfarad capacitor on each of the contacts provides a switching delay to prevent transient jumps in the time setting.

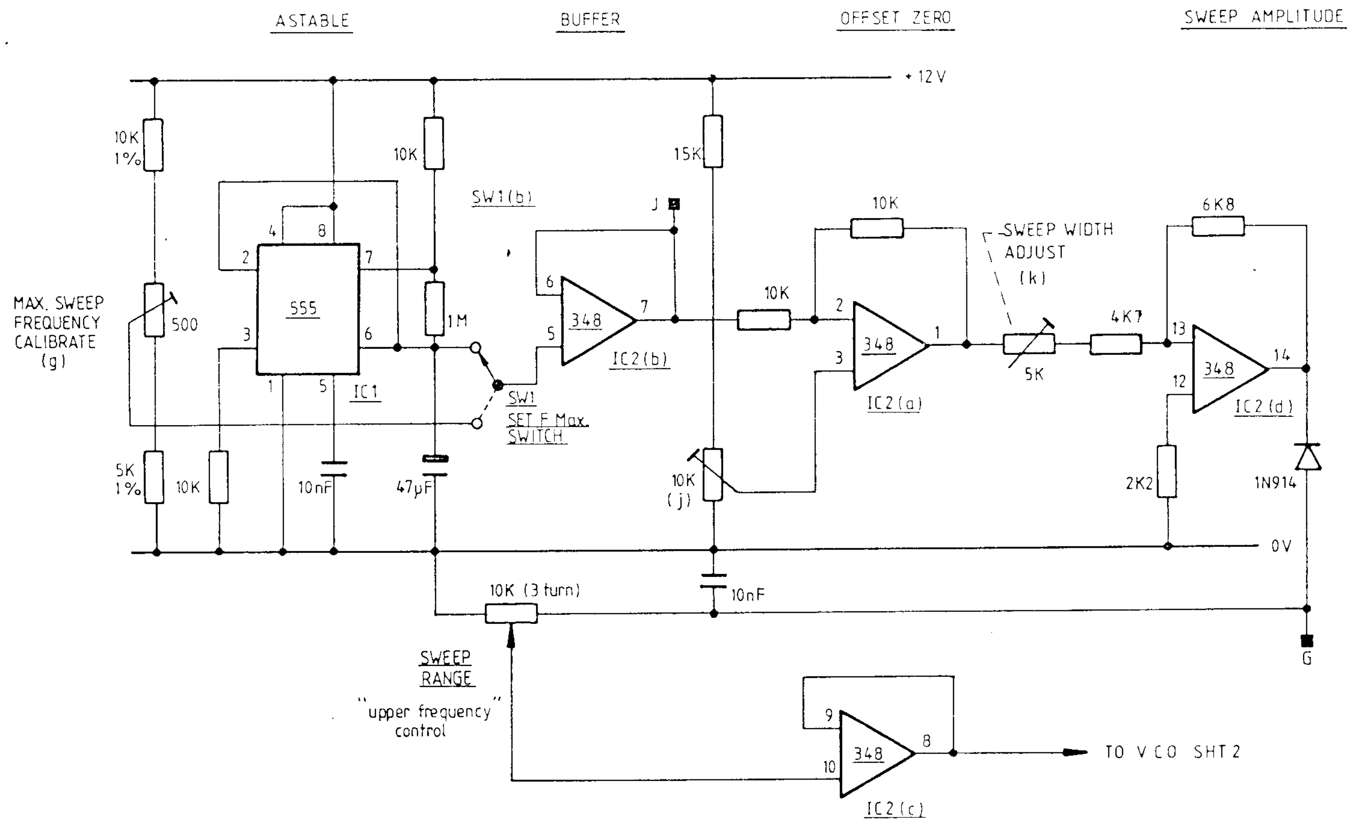
* When the timer has counted down to zero the displays should blank, the buzzer should sound and the relay RL1 should switch, disconnecting drive from the patient circuits. The patient current indicator lamp should extinguish. Note that the buzzer will only sound at full intensity if the timer has been on for a long enough time for the 2200 microfarad capacitor to charge fully.

If the above tests are positive and if the time base generator is verified as producing pulses at a frequency of 1 per minute, measured at pin 14 of IC2(b), then the timer and time base generator are functioning correctly.

CALIBRATION PROCEDURE: VECTORSURGE II

Step	CRO setting		Test Point	Procedure
	V/div	Time/div		
1				<u>Set controls:</u> 'frequency' - both to minimum 'surge' to fast, switch on 'intensity' to mid-position 'balance'to mid-position
2				<u>Set trimpots:</u> all to mid-position except 'c' (fully clockwise)
3	2V	500 ms	A	* Adjust 'a' for triangular waveform, 3 divisions period (7 VPP) * Set lower frequency control to maximum * Adjust 'm' for frequency reading on displays of 260 Hz * Set lower frequency control to minimum * Readjust 'a' if necessary
4	5V	10µs 2µs 10µs	B	* Adjust 'b' for half-period sweep (e.g. 10µs → 10µ+ 40µs) * Adjust 'c' for smallest minimum pulse width without double triggering * Readjust 'b' if necessary
5	Dual Beam 2V	10µs then 2µs	C and D	Adjust 'd' to synchronize 'C' signal minimum delay to 'D' delay
6	2V	10µs	E	Adjust 'e' for 1:1 mark/space ratio (e.g. 40µs:40µs)
7	2V	10µs	F	Adjust 'f' for 1:1 mark/space ratio (e.g. 40µs:40µs)
8	1V	5 ms	I	Adjust 'h' for 50% modulation of signal envelope (e.g. 6 div peak to peak, 3 div trough to trough)

Step	CRO setting		Test Point	Procedure
	V/div	Time/div		
9	1V	0.2 ms	J	Observe minimum height of line during sweep. Holding frequency sweep switch over and adjust 'g' for same height of line as observed previously
10	1V	0.2 ms	G	Set sweep upper frequency to maximum. Adjust 'j' for sweep to 0 volts maximum and frequency going briefly to 1 Hz on meter
11	-	-	-	Hold frequency sweep switch over and adjust 'k' for 150 Hz reading on meter
				Check sweep range and fine-tune if necessary. e.g. if sweeping to 148 when 'k' adjusted to 150, reset 'k' to 152 and back off 'g' to 150
12	0.5V	200 ms	H	Adjust 'i' for minimum signal 0 volts i.e. 0 to 4V triangular waveform
13	10V Dual Beam	5 ms	Outputs	Connect 470 OHM 5W dummy loads. Set surge switch to 'off' position. Set balance control to mid position. Switch timer on. * Adjust intensity for ± 1.9 divisions signal (channel A) on CRO. Adjust 'x' for meter reading of 40 mA. * Repeat for channel B. (Note ± 1.9 div is to centre of thick top and bottom on this (vectored) channel) * Adjust 'l' for balance as indicated on meters
14	-	-	-	Check operation of timer, SCR protection and all controls, switches and indicators



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CHECKED

INTERFERENTIAL UNIT

SWEEP CONTROL CIRCUIT

APPROVED

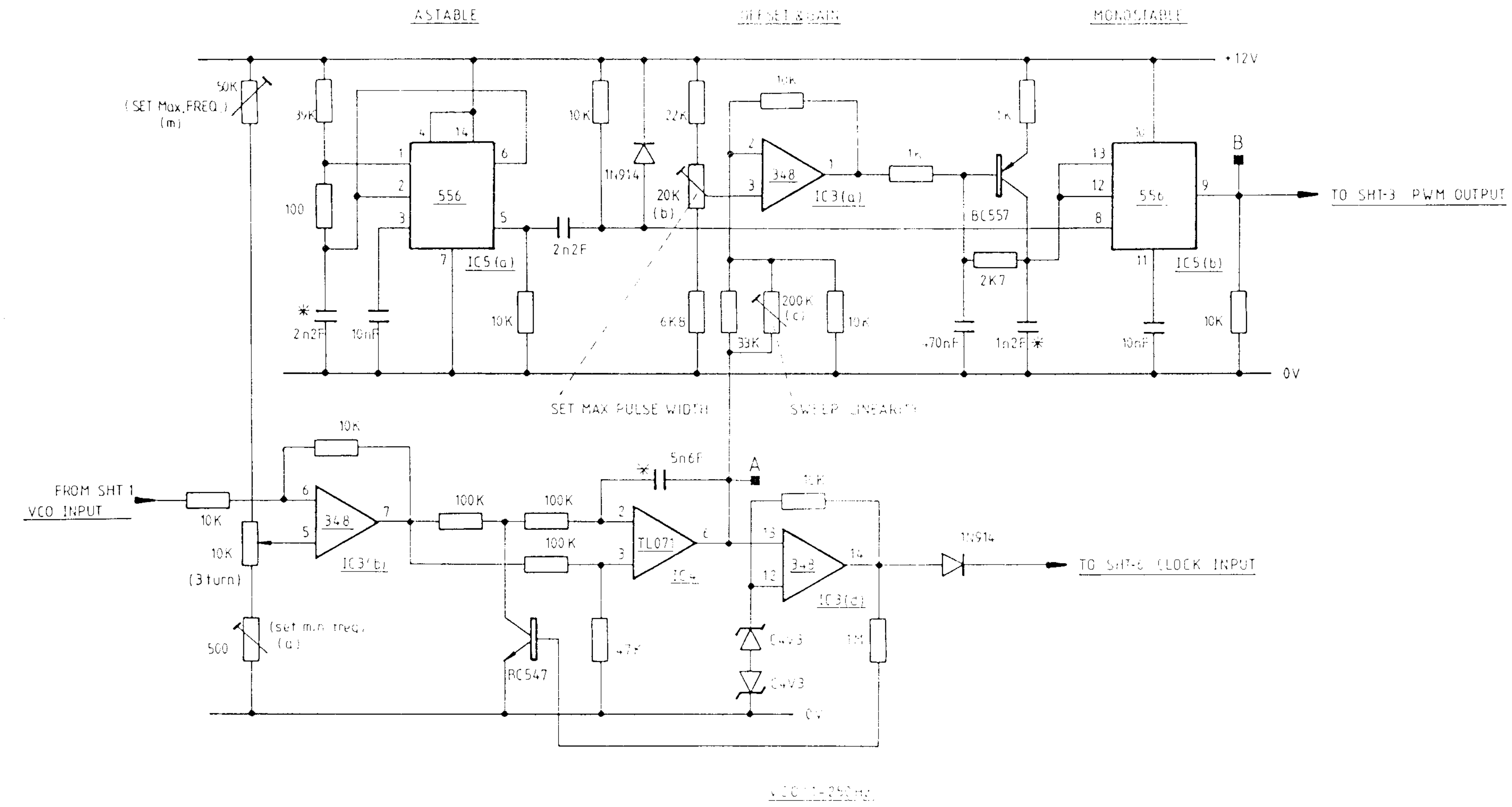
DRAWN
M. IVERSEN.
21-2-83

ISSUE
A

DRAWING No
I/F-00~~3~~2

SHEET
1 OF 11

DATE	REVISION	DRAWN
10/85	CCT. UPDATE, NOW VECTOR SURGE II-DRG. I/F-003	M.IVERSEN
10/83	REDRAWN_DRG No CHANGED FROM I/F.001 TO I/F.002	M.IVERSEN



✱ POLYESTER GREENCAP

10/85	CCT. UPDATE, NOW VECTOR SURGE. II-DRG. I/F 003	M. IVERSEN
10/83	REDRAWN_DRG No CHANGED FROM I/F-001 TO I/F-002	M.IVERSEN.
DATE	— REVISION —	DRAWN

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CHECKED

INTERFERENTIAL UNIT
—MASTER OSC./ PULSE WIDTH MODULATION - CCT.—

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M IVERSEN
21-2-83

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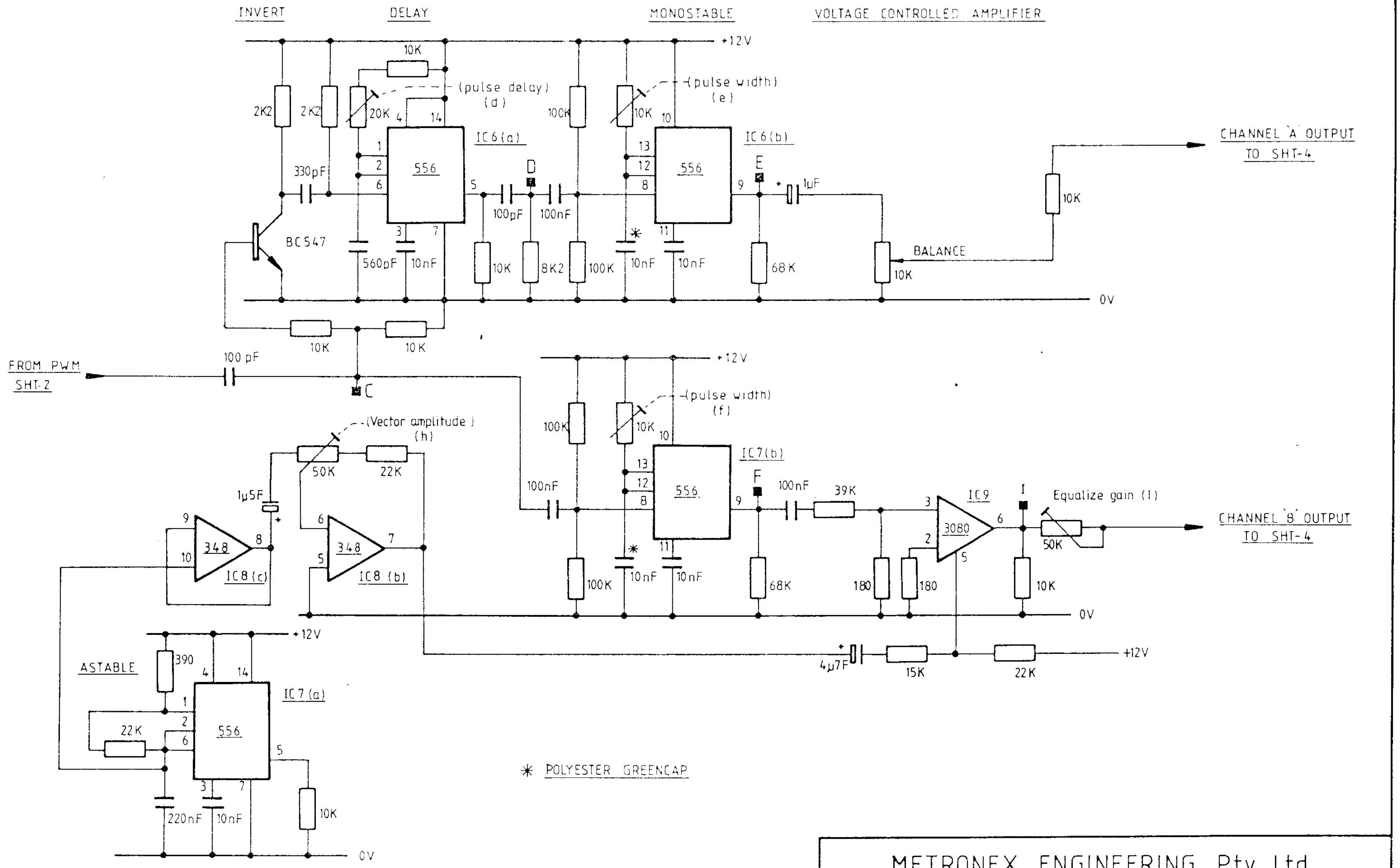
A

DRAWING No
I/F-003

SHEET
2 OF 11



10 / 85	CCT. UPDATE_NOW VECTOR SURGE II_DRG. I/F-003	M.IVERSEN
7/85	22K REPLACED BY 33K FROM +12V-PIN 5 IC8	D.K.TOMAN
10/83	1μF AND 22K DELETED FROM PIN 5 OF IC8 1μF REPLACED BY 4μ7F TO PIN 5 OF IC9 22K REPLACED BY 1μ5F TO PIN 8 IC10(C)	A.R.WARD
10 / 83	REDRAWN_DRG No CHANGED FROM I/F-001 TO I/F-002	M.IVERSEN.
DATE	——— REVISION ———	DRAWN

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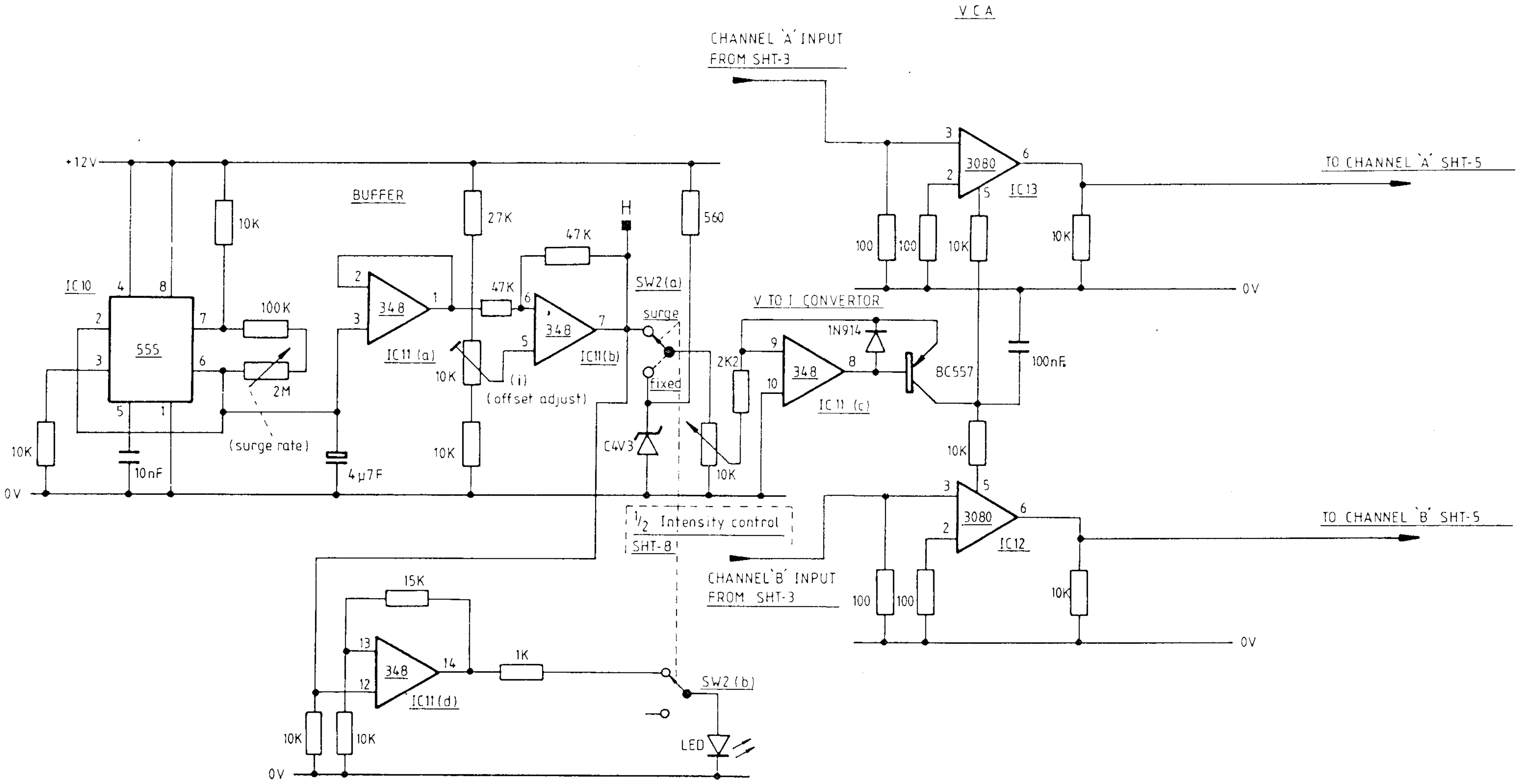
CHECKED

INTERFERENTIAL UNIT

—VECTOR AND BALANCE CIRCUIT—

APPROVED

DRAWN	ISSUE	DRAWING No	SHEET
M. IVERSEN. 21-2-83	A	I/F-00~~3~~2	3 OF 11



10 / 85	CCT. UPDATE_NOW VECTOR SURGE II_DRG. I/F-003	M. IVERSEN
10 / 83	REDRAWN-DRG No CHANGED FROM I/F-001 TO I/F-002	M. IVERSEN.
DATE	REVISION	DRAWN

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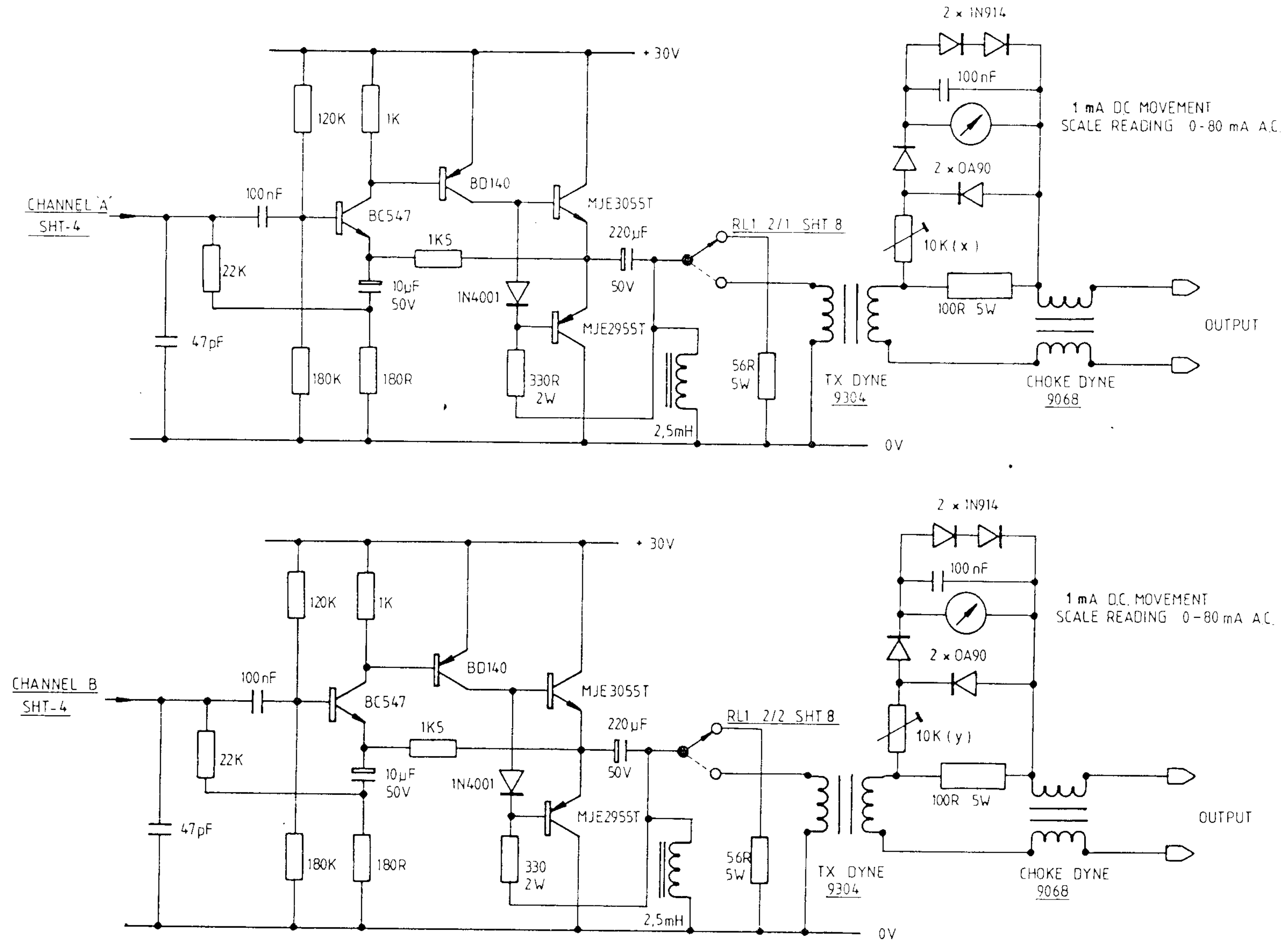
CHECKED	INTERFERENTIAL UNIT —SURGING CCT. AND BEAT FREQUENCY INDICATOR—			
APPROVED	DRAWN M. IVERSEN 21-2-83	ISSUE A	DRAWING No I/F-00~~3~~2	SHEET 4 OF 11



DATE	REVISION	DRAWN
5/86	10K Trimpots replacing 50K types (x, y) 1 mA F.S.D. Meters replacing 200uA types	A WARD

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CHECKED

INTERFERENTIAL UNIT

POWER AMPLIFIERS AND OUTPUT CIRCUIT

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22-10-85

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A

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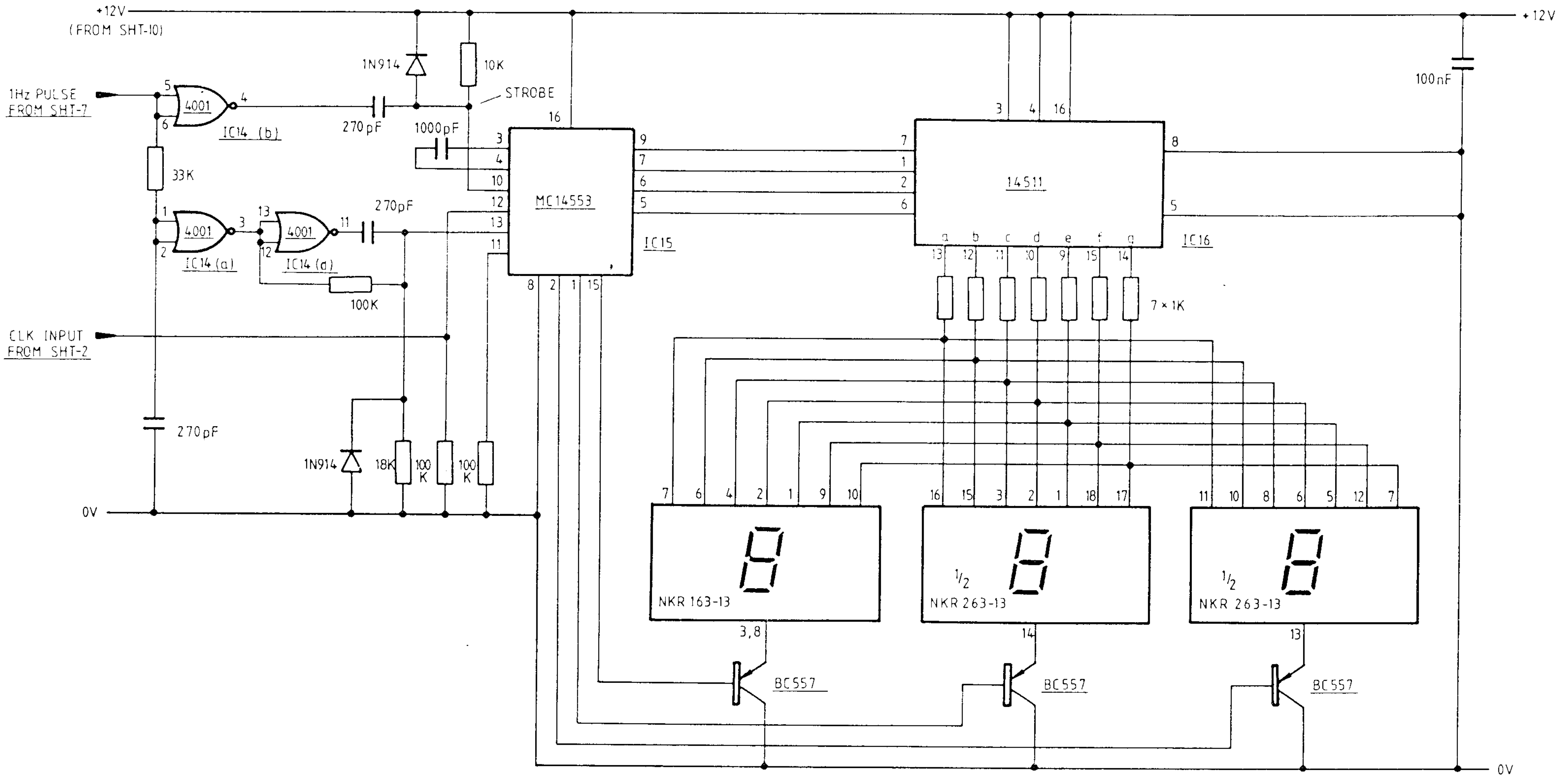
I/F-00~~3~~2

SHEET
5 OF 11



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10 / 85	CCT. UPDATE. NOW VECTOR SURGE II. DRG. I/F-003	M. IVERSEN
10 / 83	REDRAWN - DRG No CHANGED FROM I/F-001 TO I/F-002	M. IVERSEN.
DATE	REVISION	DRN.

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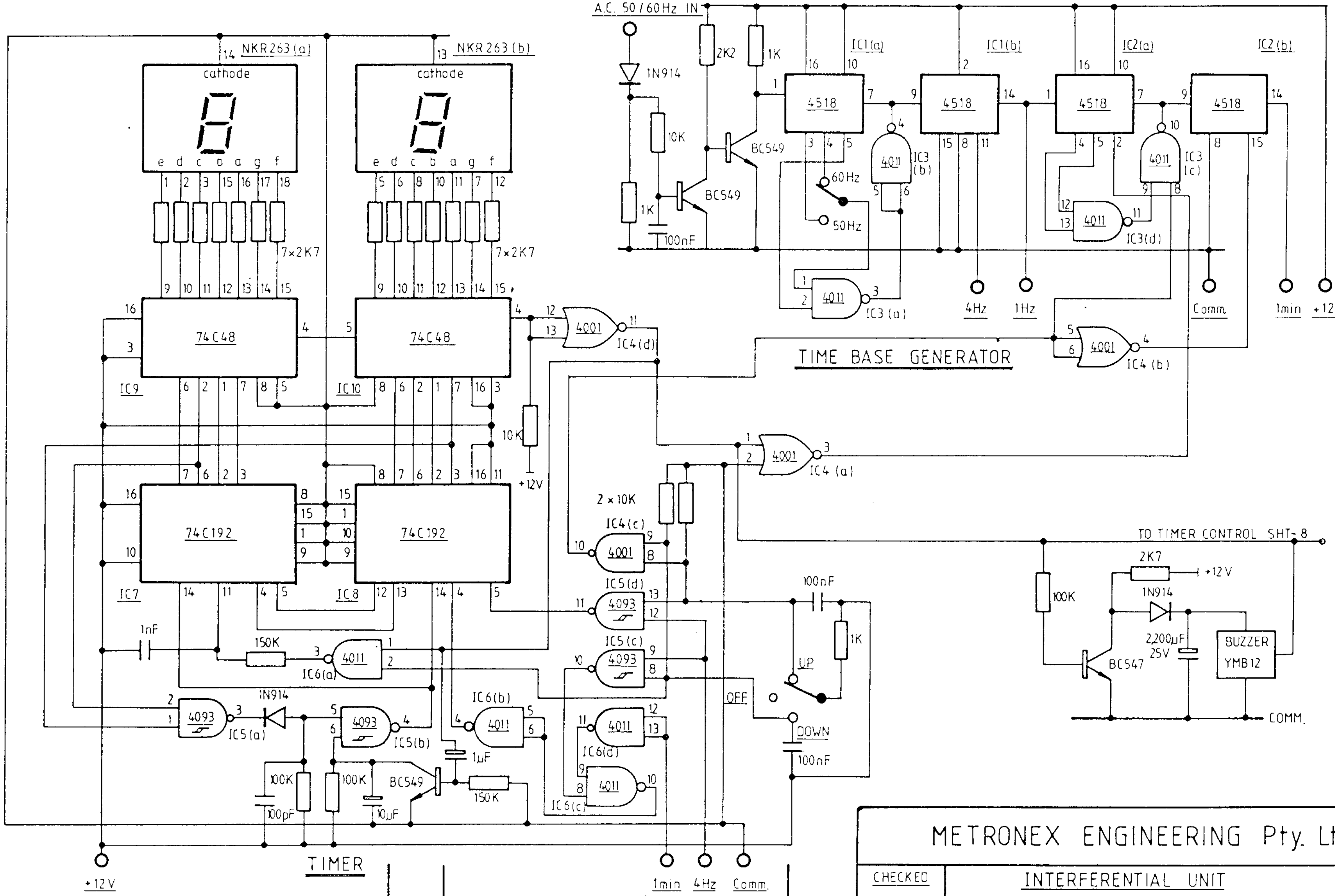
CHECKED	INTERFERENTIAL UNIT BEAT FREQUENCY INDICATOR CIRCUIT			
APPROVED	DRAWN M. IVERSEN. 21-2-83	ISSUE A	DRAWING No I/F-003	SHEET 6 OF 11



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CHECKED

INTERFERENTIAL UNIT

TIMER & TIME BASE GENERATOR CIRCUIT

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22-10-85

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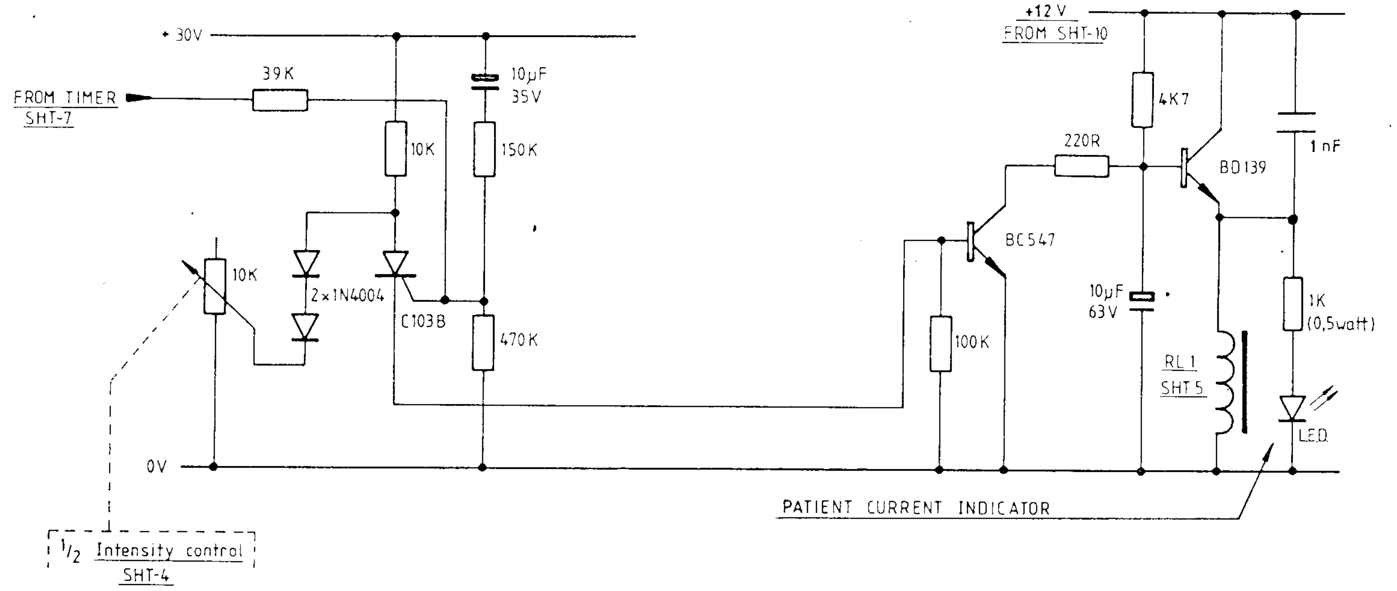
I/F-003 2

SHEET
7 OF 11

DATE
REVISION
DRAWN



5 / 86	1 nF added, 4K7 replacing 12 K in relay cct. Relay cct supply changed to +12 V	A. WARD
10 / 85	CCT. UPDATE. NOW VECTOR SURGE II_DRG. I/F-003	M IVERSEN
10 / 83	REDRAWN_DRG No CHANGED FROM I/F-001 TO I/F-002	M. IVERSEN.
DATE	REVISION	DRAWN

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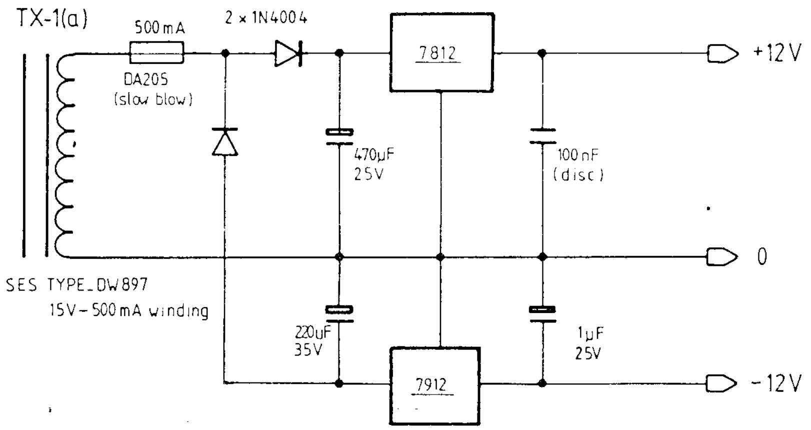
CHECKED	INTERFERENTIAL UNIT OUTPUT CONTROL CIRCUIT			
APPROVED	DRAWN M. IVERSEN. 21-2-83	ISSUE A	DRAWING No I/F - 00~~3~~2	SHEET 8 OF 11



SUPPLY CONNECTIONS

+12V to pin 4 LM348, pin 7 TL071, CA3080
-12V to pin 11 LM348, pin 4 TL071, CA3080

DATE	REVISION	DRAWN
10/85	CCT. UPDATE_NOW VECTOR SURGE II_DRG. I/F-003	M.IVERSEN.
10/83	REDRAWN-DRG No CHANGED FROM I/F-001 TO I/F-002	M.IVERSEN.

METRONEX ENGINEERING Pty. Ltd.

CHECKED

INTERFERENTIAL UNIT
-POWER SUPPLY-FOR SHTS 1-4

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21-2-83

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I/F-003′ 2

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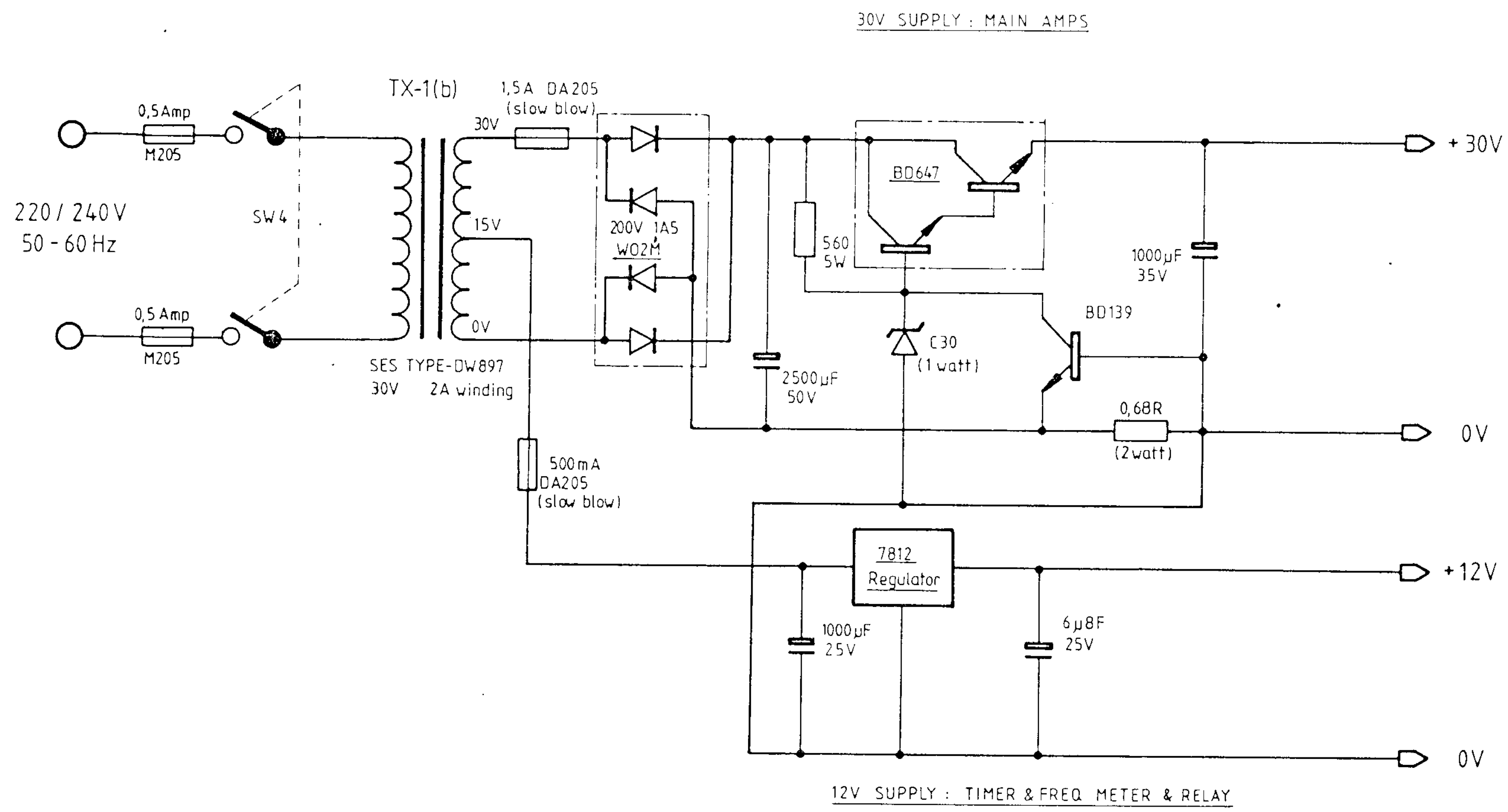
9 OF 11



DATE	REVISION	DRAWN
4 / 86	1R2 1W & 15V Tap to sht 8 Deleted	A R WARD
2 / 86	1R2 1W ADDED IN SERIES WITH 15V CT OF TX	A.R. WARD
10 / 85	CCT. UPDATE NOW VECTOR SURGE II DRG. I/F-003	M IVERSEN
10 / 83	REDRAWN DRG No CHANGED FROM I/F-001 TO I/F-002	M.IVERSEN

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INTERFERENTIAL UNIT

POWER SUPPLY FOR SHEETS 5-8 & 12

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21-2-83

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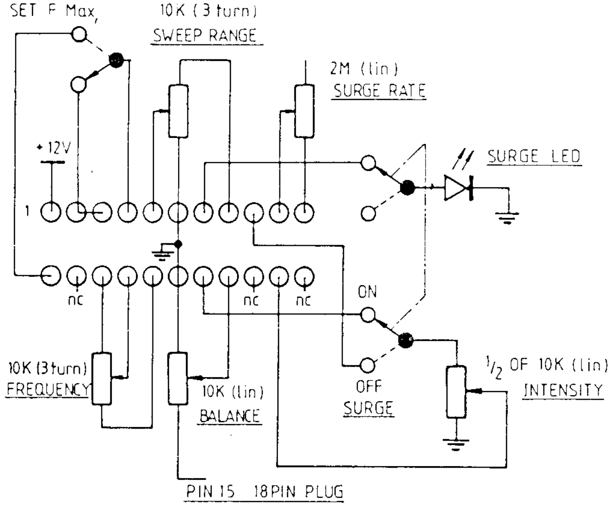
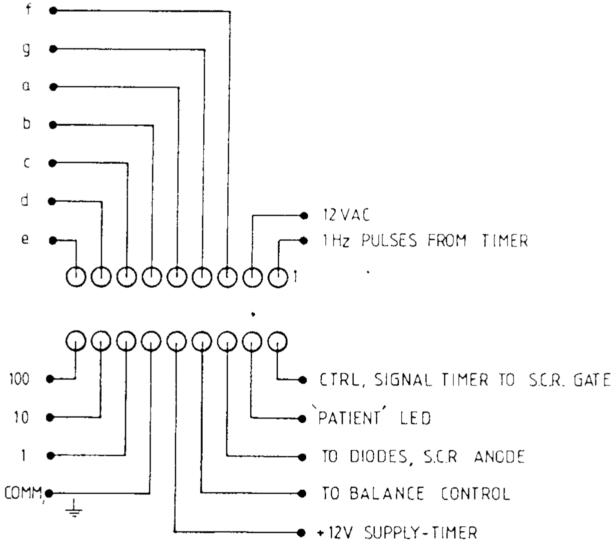
10 OF 11



22 PIN PLUG



18 PIN PLUG

METRONEX ENGINEERING Pty. Ltd.

CHECKED	INTERFERENTIAL UNIT PLUG CONNECTIONS			
APPROVED	DRAWN M. IVERSEN 22-10-85	ISSUE A	DRAWING No I/F-003/2	SHEET 11 OF 11

DATE REVISION DRAWN