9820 Series

Time Electronics

* Voltage up to 1kV AC & DC
* Current up to 10A AC & DC plus Resistance

The Time Electronics 9820 Series are highly stable sources designed for calibration of DMMs and other electrical equipment. The 9820 Series are ideally suited for automatic, PC-based DMM calibration, using Time's EASYCAL Calibration Software Package.

V DC ±20mV to ±1000V;
max resolution 20nV for 20mV range;

Typical accuracy 1 yr ±(10ppm of setting + 20ppm of range) ±3µV
V AC 20mV to 1000V; max res. 20nV; 15Hz to 20kHz; 5Hz resolution;

Typical accuracy 1 yr ±(0.05% of setting + 0.01% of range) ±30µA
Waveforms Sine, Square, ± Ramp, Trapezoidal, Triangle, 1/2 Wave
A DC ±200µA to 10A;

Max res 200pA for 200µA range;

Typ. acc. 1 yr ±(50ppm of setting + 100ppm of range) ±30µA
A AC 200µA to 10A; max res. 200pA; 20Hz to 1kHz;

Typ. accuracy 1 yr ±(0.04% of setting + 0.01% of range) ±50µA
Resistance 10ohms to 10Mohms;

Typical accuracy 50ppm/yr

GP-IB interface for computer based calibration

9821

100ppm/yr Accuracy
Full Multifunction Calibrator with
4 1/2 Digit Display.

9822

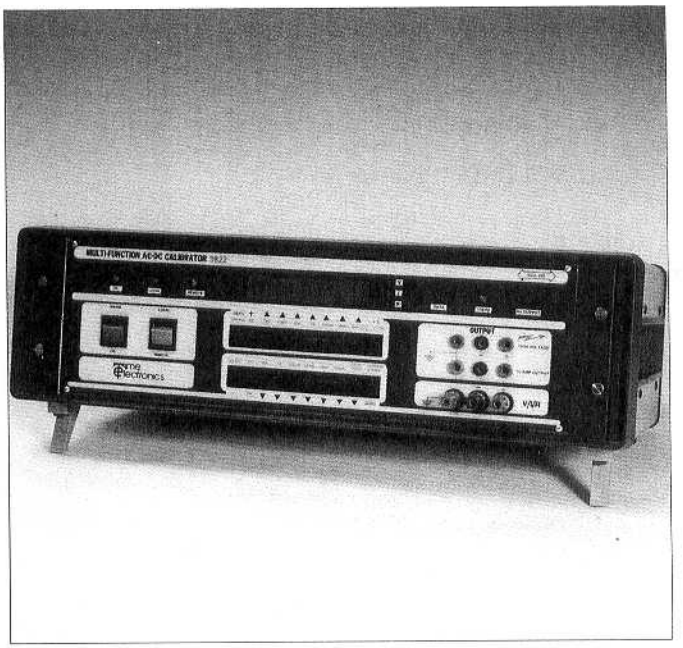
30ppm/yr Accuracy
High Res 5ppm, 6 1/2 Digit Display.

9823

10ppm/yr Accuracy
High Precision with 6 1/2 Digit Display

Data Sheet 9822
Programmable Multi-Function Calibrator

- 0 - 1kV AC/DC Voltage
- 0 - 10A AC/DC Current
- 10Ω - 10MΩ Resistance
- Autocal facility
- IEEE-488 interface
- 2 Year warranty



Introduction

Multimter Meter Calibration
The 9822, with AC/DC voltage and current ranges plus resistance makes it suitable for the calibration of analogue and digital multi-meters typically up to 6 digit resolution. The IEEE-488 interface allows automatic control and provides the accuracy and speed needed for low cost calibration of large numbers of multi-meters.

IEEE Interface as Standard
The 9822 comes with the IEEE-488 interface as standard and the intelligent microprocessor allows the 9822 to be programmed with high level commands.

Deviation and Zero Offset Function
When selected, the deviation function will allow the output to be adjusted directly as a percentage. This can be used to show the error of a unit under test immediately. The zero offset function allows compensation of zero offset values. These features combined are particularly useful for linearity checks.

19999 Full Scales with 5% Over-Range
For accurate calibration of DMM's, the ranges on the 9822 have been designed to match the full scales of most digital meters.

Built-in 10 Amp Range.
There is no need to use bulky add-on amplifiers for high current generation as the the 9822 has a 10 amp range built in.

Autocal
With autocal, recalibration of the 9822 can be made from the front panel controls or the IEEE bus. Low cost recalibration is therefore possible using IEEE programmable standards. An interlock facility is provided to ensure calibration integrity.

Safety
Emphasis has been placed on safety features. High voltage (40V - 1100V), and the 10 amp range have separate output terminals. On selection of an output greater than 40V, there is a programmed 3 second delay, an audible warning bleep and a continuous flashing warning light on the front panel. Output short circuit protection is provided on all ranges and error messages are displayed when invalid functions are selected.

6 Wave Forms from 15 Hz - 20 kHz
Square, trapezoidal, sine, triangular, ramp up, ramp down and a half wave are all provided for true R.M.S. calibration work. An additional slow sweep output will check for stiction on analogue meters.

Self-Test and Internal Error Detection
The 9822 self-test program can be run at any time to check that all functions are operating correctly. Additionally, the internal error detection system continuously monitors circuits within the instrument and output load conditions for errors.

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Telephone: 01732 355993 Fax: 01732 770312

NAMAS CALIBRATION No 0324

Specifications

The accuracy specifications given below apply for a period of 1 year at a temperature of 20°C ± 2°C, after a minimum warmup period of 1 Hour, relative to calibration standards. Specifications describe maximum conditions and apply from 10%-100% of range. Specifications stated in ppm and as ± output + ± range.

D.C. VOLTAGE

RANGE	24 HOUR STABILITY	ACCURACY 90 DAY	ACCURACY 180 DAY	ACCURACY 1 YEAR	T.C. ppm/°C	OUTPUT RESISTANCE	DRIVE CURRENT	RESOLUTION
20mV	10+5	20+5	25+5	30+5	5	10Ω	S/C	20nV
200mV	7+5	20+5	25+5	30+5	4	10Ω	S/C	200nV
2V	3+2	20+5	25+5	30+5	3	0.1Ω	100mA	2uV
20V	3+2	20+5	25+5	30+5	3	0.1Ω	100mA	20uV
200V	15+10	35+10	40+10	50+10	5	10Ω	10mA	200uV
1kV	15+10	35+20	40+20	50+20	5	10Ω	10mA	2mV

Note : All specifications ± 4uV. Noise : 20mV to 20V ranges = 1ppm of range, 200V to 1kV ranges = 5ppm of range (0.1Hz to 1Hz RMS.)

A.C. VOLTAGE (Sine Wave)

RANGE	FREQUENCY	24 HOUR STABILITY	ACCURACY % 90 DAY	ACCURACY % 180 DAY	ACCURACY % 1 YEAR	T.C. ppm/°C	OUTPUT RESISTANCE	OUTPUT CURRENT
20mV	40Hz-1kHz	0.01+0.005	0.03+0.008	0.04+0.008	0.05+0.008	15	10Ω	S/C
200mV	1-2kHz	0.03+0.02	0.07+0.05	0.08+0.05	0.1+0.05		10Ω	S/C
2V	2-20kHz	0.05+0.03	0.35+0.1	0.4+0.1	0.5+0.1		0.1Ω	100mA
20V							0.1Ω	100mA
200V	40-450Hz	0.02+0.005	0.045+0.01	0.05+0.01	0.06+0.01	15	10Ω	10mA
1kV								

Note : Frequency Accuracy ± 0.01%, T/C 20ppm/°C, Resolution 5Hz, range 15Hz to 20kHz. Drive Current shown as peak values. All A.C specifications ± 30uV.

D.C. CURRENT

RANGE	24 HOUR STABILITY	ACCURACY 90 DAY	ACCURACY 180 DAY	ACCURACY 1 YEAR	T.C. ppm/°C	OUTPUT RESISTANCE	DRIVE CURRENT	RESOLUTION
200uA	30+10	50+30	70+30	100+30	10	10GΩ	15V	200pA
2mA	25+10	50+30	70+30	100+30	10	1GΩ	15V	2nA
20mA	20+10	50+30	70+30	100+30	10	100MΩ	15V	20nA
200mA	20+10	50+30	70+30	100+30	10	10MΩ	15V	200nA
2A	50+20	100+60	140+60	200+60	15	1MΩ	5V	2uA
10A	0.03%+0.02%	0.07%+0.03%	0.08%+0.03%	0.1%+0.03%	30	100kΩ	1.2V	20uA

Note : All specifications ± 30nA.

A.C. CURRENT (20Hz to 1kHz Sine Wave)

RANGE	24 HOUR STABILITY	ACCURACY % 90 DAY	ACCURACY % 180 DAY	ACCURACY % 1 YEAR	T.C. ppm/°C	OUTPUT RESISTANCE	DRIVE CURRENT	RESOLUTION
200uA	0.01+0.008	0.04+0.01	0.045+0.01	0.05+0.01	20	10GΩ	15V	200pA
2mA	0.01+0.008	0.04+0.01	0.045+0.01	0.05+0.01	20	1GΩ	15V	2nA
20mA	0.01+0.008	0.04+0.01	0.045+0.01	0.05+0.01	20	100MΩ	15V	20nA
200mA	0.01+0.008	0.04+0.01	0.045+0.01	0.05+0.01	20	10MΩ	15V	200nA
2A	0.02+0.008	0.05+0.01	0.06+0.01	0.07+0.01	30	1MΩ	5V	2uA
10A	0.04+0.02	0.07+0.03	0.08+0.03	0.10+0.03	50	100kΩ	1.2V	20uA

Note : All specifications ± 50nA. 2 & 10 Amp specifications to 500Hz.

RESISTANCE

VALUE OHMS	24 HOUR STABILITY	90 DAY	ACCURACY 180 DAY	1 YEAR	T.C. ppm/°C
10	200	700	750	800	10
100	25	50	60	70	5
1k	10	25	40	50	5
10k	6	25	40	50	5
100k	6	25	40	50	5
1M	15	60	70	80	5
10M	60	200	250	300	10

Notes :
A.C. Specifications include the effects of noise and distortion in the 10Hz to 20kHz frequency range.

4% over-range available on all ranges.

Voltage and current limits are stated as Peak Values.

General Information

Power:	110V120V/220V/240V A.C. (± 5%) 50/60 Hz.
Dimensions / Weight	515 x 170 x 315 mm / 15kg

Ordering Information

Description	Order Code
30ppm Programmable Multi-Function Calibrator	**9822**
NAMAS Calibration Certificate	**9126**
NPL Traceable Calibration Certificate	**1098**

9822 PROGRAMMABLE

MULTI-FUNCTION

CALIBRATOR

TECHNICAL MANUAL

9822 MULTI-FUNCTION AC/DC CALIBRATOR

All Time Electronics' instruments are subject to continuous development and improvement and in consequence may incorporate minor detail changes from the information contained herein.

9822 PROGRAMMABLE

MULTI-FUNCTION CALIBRATOR

TECHNICAL MANUAL

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Version 2.1 11/01/88

TECHNICAL MANUAL CONTENTS

1) INTRODUCTION 3

2) SPECIFICATION 5

3) FRONT PANEL CONTROLS 9

4) LOCAL OPERATION 14

5) REMOTE OPERATION 22

6) FAULT DIAGNOSIS 33

7) TECHNICAL DESCRIPTION 36

8) CALIBRATION TECHNIQUES 40

9) CALIBRATION 43

10) SPARE PARTS 48

11) GUARANTEE AND SERVICE FACILITIES 49

12) DIAGRAMS AND LAYOUTS 50

13) INDEX 51

SECTION 1. INTRODUCTION

1.1 DESCRIPTION

This calibrator provides, in one instrument, calibration facilities for AC/DC Volts, AC/DC Current and Resistance.

Simple controls and a clear, 8 digit LED display make operation straight forward. Remote operation via the IEEE (GPIB) bus is a standard feature and allows the instrument to be used for automatic calibration. All logic functions are controlled by a microprocessor, which also monitors the output. On overload, the output is automatically switched off and an error message is displayed. Safety features are incorporated for high voltage outputs. The instrument is supplied in a high quality 19" Eurocard frame and is suitable for either bench use or mounting in a 19" rack system.

Ranges:-

D.C. Voltages . . . . . 20 mV to 1 KV (1.1 KV in over-range)

A.C. Voltages (RMS) . 20 mV to 1 KV

D.C. Current . . . . . 200 uA to 10 A (11 A in over-range)

A.C. Current . . . . . 200 uA to 10 A

Resistance . . . . . 7 Decade values from 10 Ohms to 10 M Ohms

The D.C. Voltage and Current ranges allow a 4% over-range on the lower ranges, with 10 % over-range on the 10 Amp and 1 KV ranges, giving a maximum output of 1100 V or 11 Amps D.C.

The Deviation function allows the output to be adjusted in percentage terms by +/- 10%.

The Zero Offset allows the use of zero to be offset by a preset value.

The combination of Deviation and Zero Offset is particularly useful for linearity checking.

'User' function allows operating modes to be changed by the user.

See section 4 for details.

A self-test program is available and can be run at any time to check that all digital functions are operating correctly.

NOTE: If an output error is detected during normal operation **'OP ERROR'** is displayed.

The autocal facility enables calibration from the front panel or via the IEEE bus. To prevent calibration by unauthorised personnel, this function can only be selcted by insertion of a plug into the socket on the rear panel.

A Multical Automatic Calibration System can be configured by adding an IEEE bus controller, display monitor, floppy disk and printer.

1.2 SAFETY

Emphasis has been placed on safety features. The 200 V, 1 KV and 10 Amp ranges have separate output terminals.
EEC safety regulations require that an additional operation must be performed before voltages greater than 40 V can be generated.
Additionally there is a 3 second delay and an audible warning before the voltage appears on the output terminals. This important feature ensures that high voltages cannot be accidentally selected, prevents damage to the equipment being calibrated and minimises the chance of an electric shock to the operator.
As a further warning, an indicator on the left side of the display flashes at all times when a high voltage is present at the output terminals.

SECTION 2. SPECIFICATIONS

MAINS OPERATING VOLTAGE
240 V SELECTED : 200 - 260 V A.C. 50 / 60 Hz
110 V SELECTED : 100 - 120 V A.C. 50 / 60 Hz

MAINS CONNECTOR
I.E.C. PLUG.

IEEE CONNECTOR
24 Pin Connector in accordance with IEEE STD. 488, 1978

IEEE ADDRESS SECTION
8 Way DIL switch on rear panel.

POWER CONSUMPTION
(No Output) 30 Watts.

OPERATING TEMPERATURE RANGE
10°C to 30°C

STANDARD CALIBRATION TEMPERATURE
20°C +/- 1°C

WARM - UP TIME
3 Hours.

DIMENSIONS
520 mm x 160 mm x 320 mm incl. feet. (IN CASE)
Standard 3U 19" Rack Mounting.

WEIGHT
15 Kilos (IN CASE) 10 Kilos (RACK MOUNTED)

OUTPUT CONNECTORS
200 V / 1 KV / 10 A - 4 mm Sockets.
20 mV to 20 V / 200 uA to 2 A / 10 Ohms to 10 M Ohms - Low Thermal EMF Terminals.

MAX. COMMON MODE VOLTAGE.
60 V.D.C., 40 V.A.C.

NOTES : After a range change, Thermal Equilibrium may take some time to be restored, especially after use of the 10 Amp range. An allowance for this must be made.

Compliance Voltages and Output Currents are Peak values, **NOT R.M.S.**, unless otherwise stated.

2.1 9822 SPECIFICATIONS

The accuracy specifications given below only apply at a temperature of 20°C +/-1°C., after a minimum warm-up time of 1 Hour, for 1 year. All specifications apply from 10% to full scale. Specifications are stated as Output + Range and are relative to Calibration Standards.

D.C. VOLTAGE

RANGE	STABILITY 24 HOURS	ACCURACY PPM 90 DAY	180 DAY	1 YEAR	T.C. PPM/°C	OUTPUT RESISTANCE	DRIVE CURRENT
20 mV	10+5	20+5	25+5	30+5	5	10 Ohms	S/C
200 mV	7+5	20+5	25+5	30+5	4	10 Ohms	S/C
2 V	3+2	20+5	25+5	30+5	3	0.1 Ohms	100 mA
20 V	3+2	20+5	25+5	30+5	3	0.1 Ohms	100 mA
200 V	15+10	35+10	40+10	50+10	5	10 Ohms	10 mA
1 KV	15+10	35+20	40+20	50+20	5	10 Ohms	10 mA

Note - All specifications +/- 4uV for thermal effects.

A.C. VOLTAGE (SINE WAVE)

RANGE	FREQUENCY	STABILITY 24 HOURS	ACCURACY % 90 DAY	180 DAY	1 YEAR	T.C. PPM/°C	OUTPUT RESISTANCE
20 mV	40 Hz-1 KHz	0.01+0.005	0.03+0.008	0.04+0.008	0.05+0.008	15	10 Ohms
200 mV	1 - 2 KHz	0.03+0.02	0.07+0.05	0.08+0.05	0.1+0.05	15	10 Ohms
2 V	2 - 20 KHz	0.05+0.03	0.35+0.1	0.4+0.1	0.5+0.1	15	0.1 Ohms
20 V						15	0.1 Ohms
200 V	40 Hz-1KHz	0.02+0.005	0.045+0.01	0.05+0.01	0.06+0.01	15	10 Ohms
1 KV	40 Hz-1KHz	0.02+0.005	0.045+0.01	0.05+0.01	0.06+0.01	15	10 Ohms

Note - All specifications +/- 30 uV.

D.C. CURRENT

RANGE	STABILITY 24 HOURS	ACCURACY PPM 90 DAY	180 DAY	1 YEAR	T.C. PPM/°C	OUTPUT RESISTANCE	COMPLIANCE VOLTS(TYP)
200 uA	30+10	50+30	70+30	100+30	10	10 G Ohms	15 V
2 mA	25+10	50+30	70+30	100+30	10	1 G Ohms	15 V
20 mA	20+10	50+30	70+30	100+30	10	100 M Ohms	15 V
200 mA	20+10	50+30	70+30	100+30	10	10 M Ohms	15 V
2 A	20+10	100+60	140+60	200+60	15	1 M Ohms	5 V
10 A	300+200	700+300	800+300	1000+300	30	100 K Ohms	1.2 V

Note - All Specifications +/- 30 nA.

A.C. CURRENT (20 Hz TO 1 KHz SINE WAVE)

RANGE	STABILITY 24 HOURS	ACCURACY PPM 90 DAY	180 DAY	1 YEAR	T.C. PPM/°C	OUTPUT RESISTANCE	COMPLIANCE VOLTS(TYP)
200 uA	100+80	400+100	450+100	500+100	20	10 G Ohms	15 V
2 mA	100+80	400+100	450+100	500+100	20	1 G Ohms	15 V
20 mA	100+80	400+100	450+100	500+100	20	100 M Ohms	15 V
200 mA	100+80	400+100	450+100	500+100	20	10 M Ohms	15 V
2 A	200+80	500+100	600+100	700+100	30	1 M Ohms	5 V
10 A	400+200	700+300	800+300	1000+300	50	100 K Ohms	1.2 V

Note - All specifications +/- 50 nA. Also 2 and 10 Amp Range specifications to 500 Hz.

RESISTANCE

VALUE OHMS	STABILITY 24 HOURS	ACCURACY PPM 90 DAY	180 DAY	1 YEAR	T.C. PPM/°C
10	200	700	750	800	10
100	25	50	60	70	5
1 K	10	25	40	50	5
10 K	8	25	40	50	5
100 K	8	25	40	50	5
1 M	15	60	70	80	5
10 M	60	200	250	300	10

NOTES -

1) Frequency - Accuracy +/- 0.01%, Temp Coeff. 20 PPM/°C
Resolution 5Hz, Range 15 Hz To 20 KHz.

2) Waveforms - Sine, Square, Ramp Up, Ramp Down, Trapezoidal, Triangular And Half Wave.

3) Output Drive - 20 mV And 200 mV = S/C
2 V And 20 V = 100 mA
200 V And 1KV = 10 mA
} A.C. and D.C. VOLTAGE ONLY.

4) Noise - 10 mV to 10 V Ranges - 1 ppm of range. (0.1 Hz to 1 Hz RMS)
100 V and 1 KV Ranges - 5 ppm of range. (0.1 Hz to 1 Hz RMS)

A.C. Specifications include effects of distortion and noise in the 10 Hz to 20 KHz frequency range.

2.2 EXPLANATION

The following examples are given as an aid to interpretation of the tables which form the 9822 specification.

(1) D.C. Volts Measurement.

The error in 0.5 V.D.C. output on the 2 V range, 2 months after calibration at the same temperature as the initial calibration, the accuracy will be + / - 24 uV calculated as follows :

OF SETTING TERM :	
(a) + / - 20 ppm of 0.5 Volts	+ / - 10 uV
OF RANGE TERM :	
(b) + / - 5 ppm of 2 Volts	+ / - 10 uV
ZERO TERM :	
(c) + / - 4 uV	+ / - 4 uV
	24 uV

(NOTE : 100 PPM = 0.01%)

(2) A.C. Current Measurement.

The error for a 200 mA output on the 200 mA range, 9 months after calibration at a temperature 5 °C different from the original calibration temperature.

OF SETTING TERM :	
(a) + / - 400 ppm of 200 mA	+ / - 80 uA
OF RANGE TERM :	
(b) + / - 100 ppm of 200 mA Range	+ / - 20 uA
TEMPERATURE STABILITY TERM :	
(d) 20ppm/deg * 5 = 100ppm of 200mA	+ / - 20 uA
	120 uA

(NOTE : The 'ZERO' term can be missed out as it is very small.)

SECTION 3. FRONT PANEL CONTROLS

3.1 FRONT PANEL (SEE FIG. 3.1)

A) Power Switch

This rocking action switch controls the mains power. The Mains ON/OFF function is by manual operation only and cannot be controlled via the IEEE bus.

B) On Indicator

Indicates the instrument is switched on.

C) Local / Remote Switch

This rocking action switch selects LOCAL operation, which allows manual operation, via the front panel controls (IEEE bus control disabled), or REMOTE operation, which allows control via the IEEE bus (Front panel locked out).

D) Local Indicator

Indicates the instrument is under manual operation via the front panel controls.

E) Remote

Indicates the instrument is being controlled via the IEEE bus.

F) Control Switches

There are 20 switches arranged in two rows. These are located in the centre section of the front panel. Each switch has an LED indicator. The switches have a dual function which are shown on the front panel in RED and BROWN. To obtain the RED function it is necessary to first press the select switch.

In the following descriptions the switches are numbered -

Top Row, left to right : Nos 1 --> 10.

Bottom Row, left to right : Nos 11 --> 20.

The function of the LED indicators on each switch is also explained.

SWITCH 1

DEV% (BROWN) -
Operates in a toggle action to change between deviation display and normal output. See section 4 for operation in Deviation mode.

USR FNC (RED) -

Allows the user to select various operating modes. See section 4 for details.

INDICATOR - ON : Indicates deviation is being displayed.
OFF : No deviation applied.
FLASHING : Nominal output displayed but actual output has deviation applied.

SWITCH 2

'+' (BROWN) - Sets output polarity positive.

'D.C.' (RED) - Selected voltages and current output will be D.C.

INDICATOR - ON : Indicates D.C. selected.

SWITCHES 3 to 8

'▲' (BROWN) - These six switches increment the adjacent digit of the display.

1 KV to 20 mV (RED) - These 6 switches select the voltage ranges.

INDICATOR - ON : Indicates range selected.

SWITCH 9

'▲' (BROWN) - Increments the least significant digit of the output display.

Res (K Ohm) (RED) - Selects the Resistance function.

INDICATOR - ON : Indicates Resistance function selected.

SWITCH 10

'FS' (BROWN) - Automatically selects full scale output.

'HV ON' (RED) - The safety interlock key for selection of outputs greater than 40 V. See Section 4.

INDICATOR - Not used.

SWITCH 11

'SELECT' (RED) - This single function switch selects the red identified functions. This switch should be pressed and released before pressing another switch.

INDICATOR - ON : Indicates that the next switch pressed will select a 'RED' function..

OFF : Indicates that the next switch pressed will select a BROWN function.

SWITCH 12

' - ' (BROWN) - Sets output polarity negative.

'A.C.' (RED) - Selected Voltage and Current outputs will be A.C.

INDICATOR - ON : Indicates A.C. is selected.

SWITCHES 13 to 18

'▼' (BROWN) . These six switches decrement the adjacent digit of the output display.

'10 A' to '200 uA' (RED) - These switches select the current ranges.

INDICATOR - ON : Indicates range selected.

SWITCH 19

'▼' (BROWN) - Decrements the least significant digit of the output display.

'FREQ / WAVE' (RED) - Allows frequency and waveform to be selected. See Section 4 for operation.

INDICATOR - ON : Indicates frequency and waveform can be selected.

SWITCH 20

'ZERO' (BROWN) - Sets output to zero.

'OFFSET STORE' (RED) - Allows an offset to be applied to the output. See Section 4 for operation.

INDICATOR - Not used.

G) 8 Digit LED Display

Displays the set output, deviation and USR Functions.

H) V Indicator

Indicates the output is 'VOLTAGE'.

I) I Indicator

Indicates the output is 'CURRENT'.

J) R Indicator

Indicates the output is 'RESISTANCE'.

K) Data Light

Flashes when data transfer is taking place on the IEEE Bus. (Remote operation). It also flashes during manual operations.

L) 10 Amp Indicator

Indicates the 10 Amp sockets are active.

M) H.V. Indicator

Indicates the H.V. (High Voltage) sockets are active.

N) H.V. Output Sockets

3 x 4 mm sockets (Red, Black, Green) for the 200 V and 1 KV output.

Red is Positive.
Black is Negative.
Green is Mains Earth.

O) 10 Amp Output Sockets

3 x 4 mm (Red, Black, Green) sockets for 10 Amp output.

P) V / I / R Output Terminals

3 x 4 mm (Red, Black, Green) low thermal EMF terminals for the 20 mV to 20V, 200 uA to 2 A and Resistance ranges.

3.2 REAR PANEL (SEE FIG 3.2)

A. AUTO-CAL SECURITY SOCKET
B. IEEE ADDRESS SELECTION SWITCH
C. IEEE CONNECTOR
D. MAINS POWER CONNECTOR
E. MAINS VOLTAGE SELECTOR
F. MAINS FUSES

FIGURE 3.1 FRONT PANEL

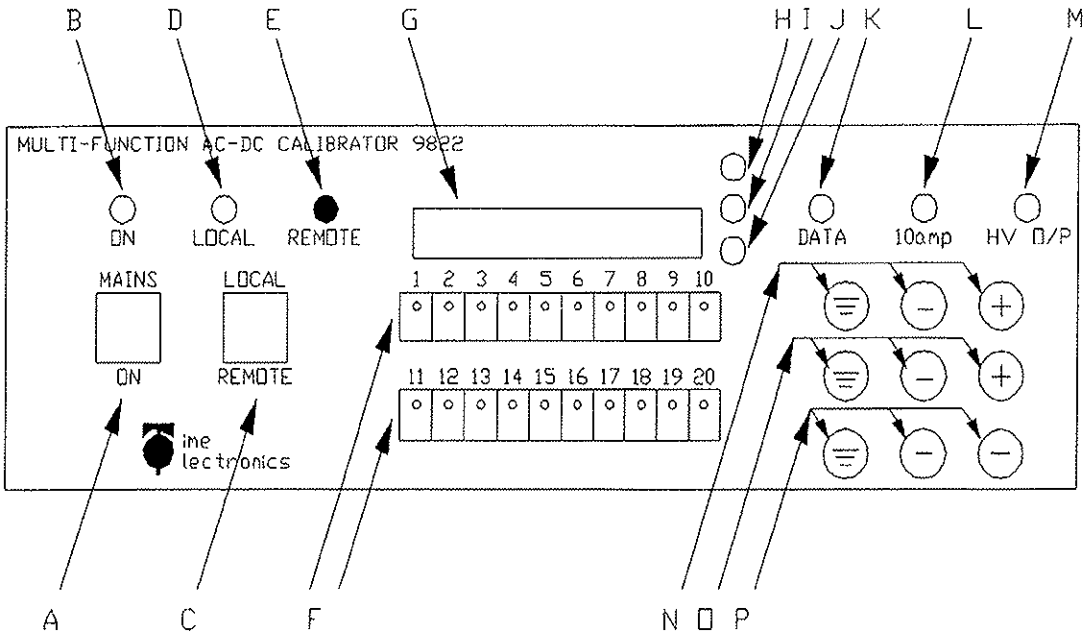
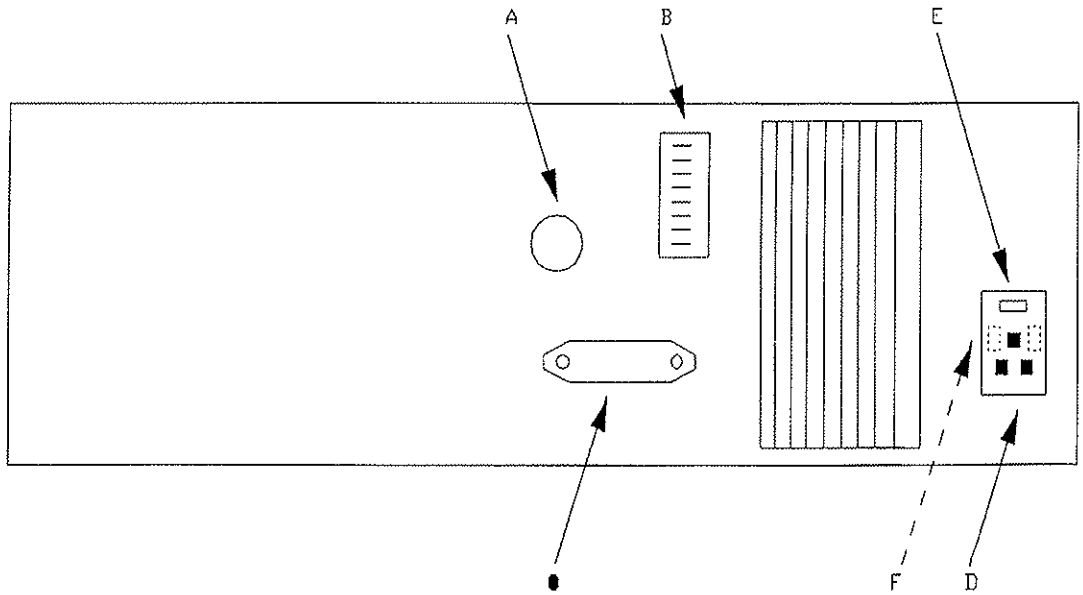


FIGURE 3.2 REAR PANEL



SECTION 4. LOCAL OPERATION

4.1 MAINS VOLTAGE SELECTION

Situated at the rear of the instrument, on the power module, are the mains inlet socket, two fuses and the voltage selector. The mains voltage is displayed in a small window. Access to the fuses and mains selector is via a lever down flap. To change the mains voltage, switch off the mains, remove the lead, open the flap and replace the selector in the required position. Replace the selector and close the flap.

4.2 SWITCHING ON

At power on, the instrument will display the PROM version number and then switch to the 20 mV D.C. range and select zero output.

If **'ERROR 6'** is displayed, the calibration factors have been lost and the unit will need to be re-calibrated. See section 9.

IMPORTANT NOTE : This instrument should not normally be operated with the IEEE address 0 or 16 set, or with the the calibration key in. These addresses are reserved for autocal recalibration. Operation in this condition may result in the loss of the calibration factors.

4.3 OPERATION

Manual operation of the instrument is enabled by setting the instrument into LOCAL mode and selecting the required function.

4.4 SELECTING A D.C. RANGE AND OUTPUT VALUE

1.) Press SELECT
2.) Press a VOLTAGE or CURRENT range key.
3.) Press the + or - switch to select output polarity.
4.) Press switches marked with upward or downward arrows to increment or decrement the output.
5.) Full scale or Zero output can be selected directly by pressing the F.S. or Zero keys.
6.) A) OFFSET - Set up the offset required as an output as described above. Then press SELECT followed by OFFSET STORE. This value will then be stored, and added to or subtracted from (if a negative offset was set) any ouput value subsequently selected.
During the period when the offset is in use, the left hand digit of the display will show a flashing horizontal bar.
To cancel offset, press SELECT and reselect a range.

B) Percentage Deviation - This can be applied to the output as follows :
Press DEV%. The display will change to a 5 - Digit format indicating percent age deviation.This can be set in the range of -9.9999% to +9.9999% by pressing the arrowed increment or decrement switches. To return to the normal output display, press DEV% again. When a deviation has been set,the LED on the DEV% switch will flash as a reminder that a deviation is being applied to the output.

To cancel deviation mode press SELECT and reselect a range, or zero the deviation and press 'DEV%' to return to the output display.

4.5 SELECTING A HIGH VOLTAGE OUTPUT

The 200 V and 1 KV ranges use the HIGH VOLTAGE output terminals. The H.V. OUTPUT LED will also light and a bleep will be heard every seven seconds.

Present EEC regulations require additional safety features to be incorporated when output voltages in excess of 40 V can be selected. If the total value of the selected output plus any deviation and zero offset is greater than 40 V, an operation additional to a normal selection is required to obtain an output. Note that this operation can be modified by User Function 4. (See paragraph 4.8)

1.) Select the required output on the display.
2.) Press SELECT followed by HV ON. The SELECT LED will flash.
3.) A buzzer will sound and within 3 seconds the output will ramp up to the selected value.
4.) When the output reaches the selected value, the SELECT LED will stop flash ing, but the dot at the left hand end of the display will continually flash all the time a high voltage is present at the output terminals.

NOTES :

A) There will also be a delay in obtaining an output if the polarity of a high voltage is reversed. This is carried out as follows -

Select Polarity
Press SELECT
Press HV ON

B) When a high voltage range is selected, the instrument cannot be switched from A.C. to D.C. or vice versa. To do this, a low voltage range must first be selected.
C) Only D.C. and 40 Hz - 400 Hz Sine Wave outputs are allowed on the H.V. ranges.
D) See Section 8.7 for Earthing of the High Voltage output.

4.6 SELECTING AN A.C. RANGE, FREQUENCY/WAVEFORM & OUTPUT

1.) The selection of A.C. range and output is identical to the D.C. selection procedure described in the previous paragraphs. Deviation and offset values are available, but it should be noted that any offset is an A.C. offset, not D.C.

2.) To select a 60 Hz sinewave after power on, press SELECT followed by A.C. The A.C. LED will light.

3.) If a change of frequency or waveform is required the selection procedure is as follows :-

A) Press SELECT
B) Press FREQ. The display will show :-

_1_00060

The left hand digit indicates the type of waveform (see table 4.1 and Fig 4.1 on page 22). The right hand 5 digits represent the frequency in Hz. The example above shows that a 60Hz sine wave has been selected.

C) To change the output waveform, increment or decrement the waveform digit using the arrowed switches beneath the waveform number.

D) The frequency may be incremented or decremented by pressing the keys below the displayed frequency value. Any frequency between 15Hz and 20KHz in 5Hz steps may be selected.

4.) Full wave rectified outputs of waveforms 1, 5 and 6 are available by selecting the negative polarity (-) switch. The display will show the selected A.C. output preceded by a minus sign. Note that the frequency of all the waveforms will double and the R.M.S. values of the sine wave will remain the same.

5.) Some examples of uses of the different waveforms follows.

A) Square wave - Checking the performance of true RMS meters. The meter reading should hardly alter when changing from sine to square wave.

B) Ramp up / Ramp down - Checking the linearity of chart recorders.

C) Triangular - Stiction test for analogue meters.

D) Trapezoidal - Checking oscilloscope amplitude and trigger calibration.

E) Full wave - Checking the DC coupled performance of a true RMS DVM.

TABLE 4.1 TYPES OF WAVEFORM

DIGIT	WAVEFORM	CALIBRATED IN
1	SINE	RMS
2	SQUARE	PK/PKx2
3	RAMP UP	PK/PK
4	RAMP DOWN	PK/PK
5	TRIANGULAR	PK/PKx2
6	TRAPEZOIDAL	PK/PKx2
7	D.C.	-

NOTE : Only Sine Wave and D.C. available on H.V. ranges.

4.7 SELECTING A RESISTANCE

1.) Press SELECT and RES (K) . The display will show 0.01K (i.e. 10 Ohms).

2.) Press the top row arrowed switches to select a resistance value between 10 Ohms and 10 M Ohms. Values can be set in decades only.

3.) Note that Deviation and Offset are not available on the resistance ranges.

4.8 SELECTING A USER FUNCTION

User Functions can be displayed by pressing 'SELECT' followed by 'USR FNC'. The 3 user functions can be changed by pressing the keys immediately below the digit.

Display shows :-

DIGIT No. 1 - 8

Table 4.2 lists the functions controlled by each digit.

TABLE 4.2 USER FUNCTIONS

DIGIT	FUNCTION
1	No Function
2	No Function
3	No Function
4	HIGH VOLTAGE SET-UP CONTROL - See table 4.3
5	No Function
6	SET KEYBOARD OPERATING MODE - See table 4.4
7	No Function
8	SET OUTPUT ERROR MODE

DIGIT 4 : HIGH VOLTAGE SET-UP CONTROLS

TABLE 4.3 HIGH VOLTAGE SET-UP CONTROL

MODE	ALARM	RAMP	SAFETY INTERLOCK KEY
0	Y	Y	Y
1	N	Y	Y
2	Y	N	Y
3	N	N	Y
4	Y	Y	N
5	N	Y	N
6	Y	N	N
7	N	N	N

NOTE : The safety interlock key in this table is an additional feature incorporated to prevent the inadvertent application of dangerous voltages to the output terminals. Selection of modes 4 - 7 of this user function however, overcome this safety feature and users must be aware of the dangers especially in Mode 7 in which the voltage is applied to the terminals without warning.

DIGIT 6 : KEYBOARD OPERATING MODES

This function allows four different modes of carry-over with or without auto-repeat as shown in table 4.4. Selection of the carry-over function enables a 9 to 10 carry-over. Without it, the carry-over will be 9 to 0.

TABLE 4.4 KEYBOARD OPERATING MODES

MODE	CARRY OVER	AUTO REPEAT
0	N	N
1	Y	N
2	N	Y
3	Y	Y

The auto-repeat facility, availiable in modes 2 or 3, gives continuous repetition of the held down key.

DIGIT 8 : OUTPUT ERROR MODES

Output Errors are detected when the calibrator is unable to drive the load with the selected output, e.g. a short circuit on a voltage range or an open circuit on a current range.

NOTE : Output errors are not detected on the 20mV, 200mV and Resistance ranges.
The user can select one of four ways in which the unit will respond to an output error.

Mode 1. The output will be set to zero immediately and 'OP ERROR' displayed. To continue using the instrument, the fault must be rectified and the output re-selected. The display will then show the re-selected value.

Mode 2. The output will be set to zero immediately and 'OP ERROR' displayed. The output will be reinstated if the overload disappears and the previous output value displayed.

Mode 3. Upon detection of an error, the instrument will wait for 0.5 seconds before setting the output to zero and displaying 'OP ERROR'. The fault must be rectified and the output re-selected.

Mode 4. The instrument will continue to drive the output and 'OP ERROR' will be displayed after 0.5 seconds.

4.9 SELF TEST MODE

To select self test mode, set all 8 IEEE switches (on rear of unit) to the ON position before switching on the instrument.
When switched on, the instrument will carry out an internal test sequence as follows. Each segment of the 8 digit display will light in turn, followed by all the front panel LEDs (with the exception of the F.S., ZERO, + & - LEDS which are not tested). If no errors are detected, the word 'PASS' will appear on the display.

If an error is detected, the word ERROR followed with a number from 1 to 6 will be displayed. The meaning of these numbers is explained in table 4.5

TABLE 4.5 FAULT DISPLAYS

NUMBER	FAULT	REPLACE
1	RAM	Processor board
2	GPIA	IEEE board
4	PIA	Processor board. (IC1 6821)
5	PIA	Processor board. (IC2 6821)
6	CAL RAM	Calibration RAM (X2816)
8	CAL RAM	Calibration RAM (X2816)

See section 6 for details of board replacement.

*** ERROR 6**

This test is carried out every time the unit is switched on regardless of the IEEE address. If the calibration factors are corrupted ERROR 6 will be displayed. To clear this condition, run the self test with the calibration key plugged in. This exercise leaves the calibration RAM empty so re-calibration is required. (See Section 9).

If ERROR 6 persists, then change the non-volatile RAM.

NOTE: Running self test with the calibration key plugged in will result in the loss of calibration data.

To exit from self test mode, turn the instrument off, set the unit address on the IEEE switches and switch on again.

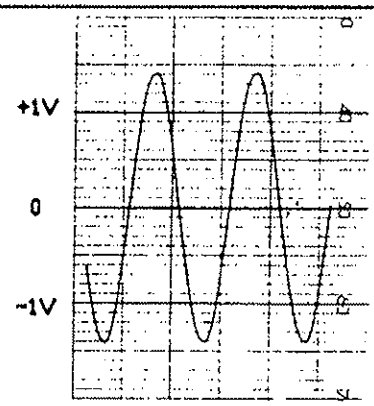
4.10 STICTION TEST.

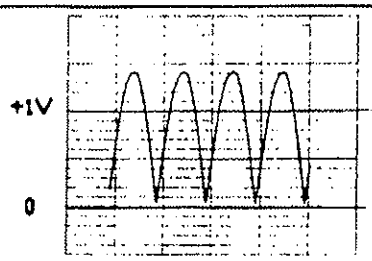
This test enables the movement of an analogue meter needle to be checked if the user suspects that it is sticking at certain points. To carry out this test, proceed as follows.-

A) Press SELECT.
B) Press FREQ/WAVE.
C) Select waveform 5.
D) Press Zero key to select 0.025Hz frequency output. Display shows *5 00000.*
E) Select a full range suitable for the meter under test.
F) The meter needle will move smoothly up and down if the scale is stiction free.

FIG.4.1 - A.C. WAVEFORMS

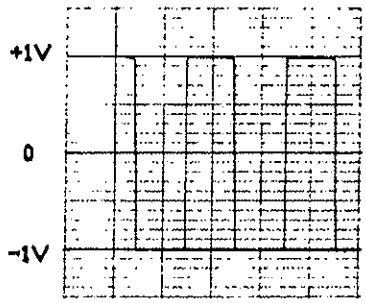
Waveform 1:
1V R.M.S. Sine wave.



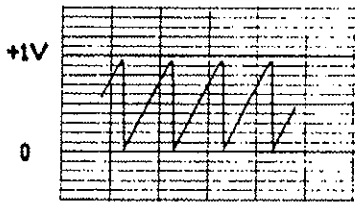


FULL WAVE RECTIFIED
[Obtained by selecting negative polarity]

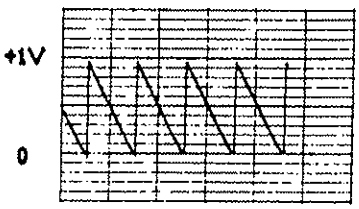
Waveform 2:
1V R.M.S. Square wave.



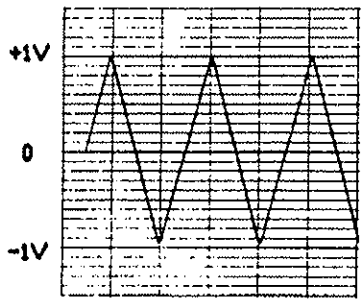
Waveform 3:
Sawtooth (Ramp up)

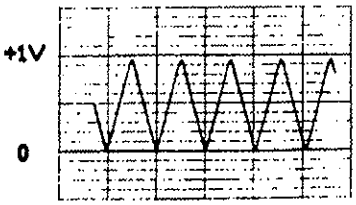


Waveform 4:
Sawtooth (Ramp down)



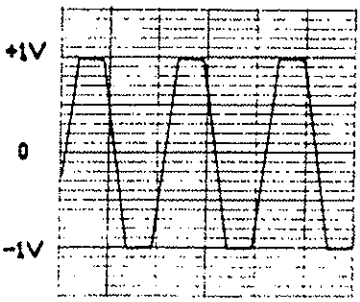
Waveform 5:

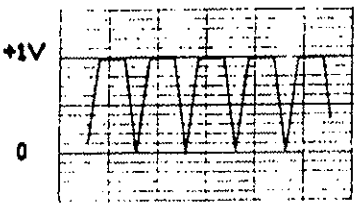




1/2 WAVE TRIANGULAR
[Obtained by selecting negative polarity]

Waveform 6:





1/2 WAVE TRAPEZOIDAL.
[Obtained by selecting negative polarity]

SECTION 5. REMOTE OPERATION

5.1 INTRODUCTION

The IEEE-488 interface sometimes called GPIB (General Purpose Interface Bus) or HPIB (Hewlett Packard Interface Bus) allows remote control of the instrument by a suitable computer. Repetitive calibration work can be speedily and accurately carried out, giving printed results if required.

The IEEE-488 defines a complete interface system for the interconnecting of instruments and computers using a bit parallel, byte serial bi-direction bus.
Protocols, connections and cables are also defined, enabling computer controlled systems to be quickly realised.

The main limitations of the IEEE are :-

1.) A maximum of 15 devices on the bus.
2.) The maximum bus length should not be greater than 20m or number of devices x 2, which ever is the shorter.

5.2 DATA TRANSFER AND DEVICE ADDRESSING

Before a controller can send data it has to identify the recipient. Each device on the IEEE is given an address to which it will respond when called by the controller, in this way data can be transferred between selected devices in an orderly manner. The rate at which it is transferred is controlled by hand shake signals, the speed being governed by the slowest device active on the bus. Set baud rates are unnecessary with the system.
Further information on the IEEE-488 can be found in the condensed description of the Hewlett Packard Interface Bus.

5.3 IEEE CABLES/CONNECTORS

The IEEE-488 cable contains 24 wires terminated at both ends with identical plug/sockets which allow for daisy - chaining of additional cables to extend the bus. See Table 5.1 for details of connections.

Cables used on IEEE systems are available in various lengths to suit different layouts. The following are recommended types:-

Manufacturer/Supplier	Part No.	Length
Belden	9642	1m
Belden	9643	2m
Belden	9644	4m
Belden	9645	8m
Time Electronics	9596	1m
Time Electronics	9597	2m

5.4 IEC BUS CONNECTIONS

A user requiring to connect the calibrator to a European standard bus (IEC), must be aware of the differences in connector pin assignments from the IEEE bus and provide a suitable interface. Table 5.1 compares the pin designations for each standard.

5.5 IEEE CONNECTOR

The pin connections and dimensions of the IEEE connector are illustrated below and in table 5.1.

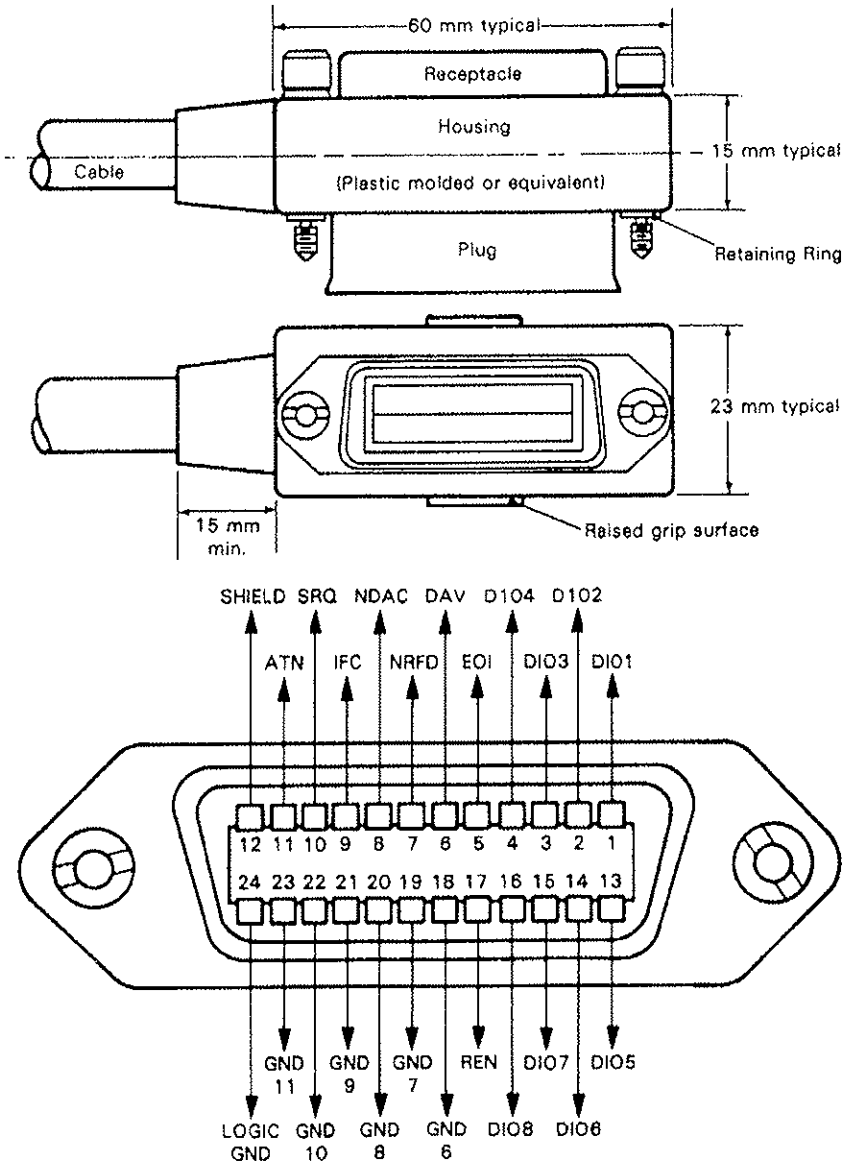


Fig. 5.1 I.E.E.E. CONNECTOR

TABLE 5.1 COMPARISON OF PIN DESIGNATIONS IEEE/IEC

IEEE STANDARD		IEC STANDARD	
PIN		PIN	
1	D101	1	D101
2	D102	2	D102
3	D103	3	D103
4	D104	4	D104
5	EOI	5	REN
6	DAV	6	EOI
7	NRFD	7	DAV
8	NDAC	8	NRFD
9	IFC	9	NDAC
10	SRQ	10	IFC
11	ATN	11	SRQ
12	SHIELD	12	ATN
13	D105	13	SHIELD
14	D106	14	D105
15	D107	15	D106
16	D108	16	D107
17	REN	17	D108
18	GND 6	18	GND 5
19	GND 7	19	GND 6
20	GND 8	20	GND 7
21	GND 9	21	GND 8
22	GND 10	22	GND 9
23	GND 11	23	GND 10
24	LOGIC GND	24	GND 11

5.6 IEEE ADDRESS SELECTION

Before operating the calibrator over the IEEE bus, set the address on the rear of the unit to the required address and operating mode.

Addresses 0 and 16 are reserved for recalibration in AUTO-CAL mode and should not be used unless recalibrating the instrument. Address 31 is used to select self test mode.

The eight switches are read only when the instrument is first switched 'ON'. Therefore it is necessary to turn the unit 'OFF' if a new IEEE address is required. See table 5.2

TABLE 5.2 IEEE ADDRESS SELECTION

SWITCH SETTING	DECIMAL ADDRESS	SWITCH SETTING	DECIMAL ADDRESS
0 0 0 0 0	0	1 0 0 0 0	16
0 0 0 0 1	1	1 0 0 0 1	17
0 0 0 1 0	2	1 0 0 1 0	18
0 0 0 1 1	3	1 0 0 1 1	19
0 0 1 0 0	4	1 0 1 0 0	20
0 0 1 0 1	5	1 0 1 0 1	21
0 0 1 1 0	6	1 0 1 1 0	22
0 0 1 1 1	7	1 0 1 1 1	23
0 1 0 0 0	8	1 1 0 0 0	24
0 1 0 0 1	9	1 1 0 0 1	25
0 1 0 1 0	10	1 1 0 1 0	26
0 1 0 1 1	11	1 1 0 1 1	27
0 1 1 0 0	12	1 1 1 0 0	28
0 1 1 0 1	13	1 1 1 0 1	29
0 1 1 1 0	14	1 1 1 1 0	30
0 1 1 1 1	15		

A '1' in the table corresponds to the left (on) position of the switch. Switch 1 (top) selects the least significant bit. The lower three switches, which are normally set to the 'off' position, are used to select the instruments operating modes as follows:

Switch 6 - IEEE talk (transmit) mode.

Switch 7 - IEEE listen (receive) mode.

Switch 8 - Dual Primary Addressing mode. In this mode, the unit will respond to two primary addresses differing only in the least significant bit. For example, if the unit address selection switches are set for an address of 8, the unit will also respond to address 9.

NOTE: The instrument only looks at the address switch at power up.

5.7 IEEE COMMANDS

LOCAL LOCKOUT

The front LOCAL/REMOTE switch must be in the remote position for IEEE operation. The instrument will not respond to any IEEE commands when set to local.

INTERFACE CLEAR COMMAND IFC

This command initiates a complete reset of the unit, which is then unable to respond to any further IEEE commands for 1 second.

IEEE COMMAND FORMAT

IEEE commands are comprised of characters from the ASCII set. A series of commands can be used to simulate the manual operation of the unit.

The commands must be in one of the following formats:

1.) A single upper case character (A to Z).
2.) Upper case character followed by a number.
3.) A signed decimal number (8 digits maximum).

Commands may be sent individually or built into a string separated with a 'slash character' (/). For the command string to execute it must be terminated with either a line feed or carriage return character.

IEEE COMMAND EXECUTION

Before an IEEE command can be executed 4 conditions must be met.

1.) The unit must be switched to 'remote' on the front panel.
2.) IEEE cable and controller connected. The IEEE address and the talk/listen switches set correctly on the rear panel switch.
3.) The command must be a valid command (invalid commands are ignored).
4.) The command must be followed by a valid terminator.

TABLE 5.3 IEEE COMMAND LIST

D	Transmit display to bus controller.
E1 to E4	Select unit action upon output error detection.
F15 to F20000	Select output frequency.
G1 or G2	Set / Cancel Group execute trigger response.
H	Set output to full scale.
I	Select serial poll operation.
K1 or K2	Enable/Disable Front panel controls.
L	Set output to zero.
O1 to O7	Output resistance between 10 Ohms and 10 M Ohms. O1 - 10 Ohms O5 - 100 K Ohms O2 - 100 Ohms O6 - 1 M Ohms O3 - 1 K Ohms O7 - 10 M Ohms O4 - 10 K Ohms
Pn	Change output by 'n' percent.
R1 to R12	Select range from 20 mV to 1 KV and 200 uA to 10 Amps. R1 - 20 mV R7 - 200 uA R3 - 200 mV R5 - 2 mA R3 - 2 V R9 - 20 mA R4 - 20 V R10 - 200 mA R5 - 200 V R11 - 2 A R6 - 1 KV R12 - 10 A RA - AUTORANGE
T1 or T2	Set terminator character appended to a transmission.
W1 to W7	Select waveform. W1 - Sine W2 - Square W3 - Ramp up W4 - Ramp down W5 - Triangle W6 - Trapezoidal W7 - D.C.
Z	Take present output as Zero Offset.
/	Command separator.

5.8 SINGLE LETTER COMMANDS

Command D

It is important to understand the sequence of operation on the IEEE bus when a data read-back command is executed. When the 'D' Command is sent it prepares the instrument to transmit (ie. act as a talker). The controller program must then execute an 'INPUT' statement to actually initiate the data transfer. The data must be terminated with the correct character to complete the transfer.

Invalid terminating characters cause the IEEE bus to hang.

The terminator is controller dependent and the instrument allows either CR or LF to be used, as determined by the Command T1 or T2. Note that the T1 ot T2 command (terminating setting) must be done before the 'D' command is executed.

When the unit is in the over-range condition the front panel display shows 1..... but this is not transmitted on read-back. The character string 'OVERRNG'is sent. In all other cases the read-back is exactly as seen on the display.

EXAMPLE (HP BASIC)

```
10 REMOTE 708
20 OUTPUT 708;"T2"          !SET TERMINATOR
30 OUTPUT 708;"D"           !TRANSMIT DISPLAY
40 ENTER 708;A$             !READ RETURNED VALUE IN
50 PRINT A$                 !PRINT IT
```

Command H

Sets output to full scale on the selected range. On the High Voltage ranges it will cause a three beep audio warning which lasts 3 seconds. The output will then appear on the terminals, this mode of operation is a safety feature.

EXAMPLE (CBM BASIC)

```
10 OPEN 1,7                 : REM OPEN ADDRESS 7 TO INSTRUMENT
20 PRINT #1,'H'             : REM SET OUTPUT TO FULL SCALE
30 END                      : REM END
```

Command I

Sets the instrument to generate a serial poll request for service by the bus controller should an 'OP ERROR' arise.

EXAMPLE (HP BASIC)

```
10  REMOTE 708                          !OPEN IEEE ADDRESS 8
20  OUTPUT 708;"I"                      !SETS UNIT TO GENERATE SERIAL POLL
                                         REQUEST ON OUTPUT ERROR
30 OUTPUT 708;"E4/R4/5"                 !SET ERROR MODE, 20V RANGE WITH
                                         5 VOLTS OUTPUT
40 ON INTR 7 GOSUB 1000                 !DEFINE ACTION ON SERIAL POLL
50 V1=0 @ X=0
60 X=X+1                                !WAIT FOR ERROR LOOP
70 GOTO 60
1000                                    !SUBROUTINE TO PRINT POLL RESPONSE
1010 STATUS ,1;A 1020 P=SPOLL (708)
1030 PRINT P                            !DISPLAY SERIAL POLL RESULT
1040 ENABLE INTR 7;8
1050 RETURN                             !RETURN TO WAIT LOOP
```

Command L

Sets the output to 'zero' on the present range.

Command Z

Takes the present output value as an offset. The display indicates zero with the top segment of the display flashing. When a new output value is sent it will be added to the offset stored. The offset is cleared by:

1.) A new range command
2.) Selecting a resistance output
3.) Setting the offset to zero

In autocal mode, indicated by a flashing 'C' on the display, the offset is stored in the non volatile memory and is used as a calibration factor.

5.9 LETTER & NUMBER COMMAND

E1 To E4 Output Error Mode

Selects one of four possible error modes which determine the action taken by the unit on detection of an output error.

E1 : (default) Displays 'OP ERROR' and turns off output immediately on detection of an output error, remains in this condition until reset by another command.

E2 : Displays 'OP ERROR' and turns off output immediately on detection of OP ERROR, will automatically restore output and display if the error is removed.

E3 : Waits for an error condition to last for 0.5 seconds before turning off output and displaying OP ERROR.

E4 : Waits for an error condition to last for 0.5 seconds before displaying OP ERROR and leaves output ON.

F15 to F20000 frequency setting commands

Commands F15 to F20000 select output frequency. Enter 'F' followed by the required frequency. Any frequency between 15Hz and 20KHz (in 5Hz steps) may be selected.

G1/G2 enable/disable group execute trigger

G1 - Enables Group Execute Trigger response.
G2 - Disables Group Execute Trigger response.

Group Execute Trigger (GET) is a command issued by the bus controller to make several devices respond simultaneously, the devices having been previously told how to respond when the GET command is received.

EXAMPLE (HP BASIC)

```
10 REMOTE 708                !OPEN IEEE ADDRESS 8
20 OUTPUT 708;"G1"           !SETS UNIT TO RESPOND TO GET
30 OUTPUT 708;"R2"           !COMMAND TO EXECUTE
40 TRIGGER 708               !EXECUTE COMMAND
50 OUTPUT 708;"G2"           !COMMAND TO EXECUTE
60 TRIGGER 708               !EXECUTE COMMAND TO EXIT GET MODE
```

K1/K2 enable/disable front panel control

K1 - Sets instrument to respond to front panel control.
K2 - Disables front panel controls.

P(n) set percentage deviation

Set deviation '**n**' on present output where '**n**' is in the range of +9.9999 and -9.9999.

EXAMPLE (CBM BASIC)

```
10 PRINT #1,"P3.456"         REM SET output 3.456% high
20 PRINT #1,"P-0.02"         REM SET output 0.02% low
```

R1 To R12 Range Setting Commands

Selects a voltage or current range from IEEE command table.

COMMAND SELECTED	RANGE	PROGRAM IN
R1	20 mV	mV
R2	200 mV	mV
R3	2 V	Volts
R4	20 V	Volts
R5	200 V	Volts
R6	1 KV	Volts
R7	200 uA	uA
R8	2 mA	mA
R9	20 mA	mA
R10	200 mA	mA
R11	2 A	Amps
R12	10 A	Amps

RA: Automatically selects the range for the output required. Default : R1.

T1/T2 select transmission terminator

Sets the last character appended to a transmission from the instrument.

T1 (default) : carriage return.
T2 : line feed.

W1 to W7 waveform setting commands

Select waveform or D.C. see IEEE command table in Table 5.3.
NOTE : On the high voltage ranges (R5 & R6) only Sine Wave and DC (W1 & W7) are permitted, it is not possible to change the Waveform without first going to a lower range.
Default is W7 (DC).

5.10 SETTING AN OUTPUT VALUE

Transmit the voltage or current required as an ASCII string.

EXAMPLES (HP BASIC) on the 2 Volt range (R3)

OUTPUT 708;"-0.3765" *!SET OUTPUT TO -0.3765 VOLTS*

OUTPUT 708;"2.9" *!SETS OUTPUT TO OVER-RANGE DISPLAY SHOWS 1..... , OUTPUT SET TO APPROX 2.08 VOLTS.*

OUTPUT 708;"0.00000007" *!SETS OUTPUT TO ZERO, TOO MANY DECIMAL PLACES*

NOTES :
1.) The 7th digit is always rounded to 0, 2, 4, 6, or 8.
2.) On D.C. (W7) or sine wave A.C. (W1) the output limit of any range is 208000 or 1100v on the 1 KV ranges.
3.) On the 10 Amp ranges, output limit is 11 Amp.

5.11 SETTING VOLTAGES ABOVE 40 VOLTS

When a voltage above 40 V is selected, (except when using certain output error mode), an alarm sounds 3 times before the voltage is applied to the output terminals. To avoid damaging circuitry by applying large rates of voltage change, the output ramps up to the set value. It takes about approx. 5 seconds to reach 1 KV output.

On the 200 V and 1 KV ranges, only Sine wave and D.C. are permitted. Changing the waveform on these ranges is disabled by the software in the instrument. Frequencies above 400 Hz will give large amplitude errors.

Changing range to the 200 V or 1KV ranges where the output would be set to more than 40 V causes the output to be set to zero.

The left hand decimal point on the display flashes when an output of 40 V or greater is on the terminals.

5.12 CALIBRATION OVER THE IEEE BUS

The automatic calibration (auto-cal) feature enables independent calibration of the zero, positive and negative outputs of all D.C ranges and full scale of all A.C. ranges either via the IEEE bus or manually.

1.) Switch off and select IEEE address 0 or 16. Calibration can only be performed using one of these addresses which are specifically designed for this purpose.
2.) Switch on and insert CAL key. The front panel display will show a flashing 'C'.
3.) Work through the ranges setting Zero and Full Scale alternately.

EXAMPLE (HP BASIC)

```
OUTPUT 708;"R4"          ! SELECT RANGE TO CALIBRATE
OUTPUT 708;"0"           ! SET OUTPUT TO ZERO, MEASURE ZERO
                           OUTPUT n.nnn VOLTS
OUTPUT 708;"Z-n.nnnn"    ! CHANGE SIGN AND STORE IN CALIBRATOR
                           AS ZERO OFFSET
OUTPUT 708;"20"          ! SET OUTPUT TO 20 VOLTS,MEASURE
                           OUTPUT AND CALCULATE THE
                           PERCENTAGE ERROR m.mmm
OUTPUT 708;"Pm.mmm"      ! STORE CAL FACTOR IN INSTRUMENT
```

Repeat the last two steps for negative full scale and A.C.When the measuring instrument is progammable the complete process can be performed automatically. Note that the Resistance cannot be calibrated with the autocal.

See Section 9 for more details on calibration.

SECTION 6. FAULT DIAGNOSIS

6.1 FAULT DIAGNOSIS INTRODUCTION

This section gives details of some possible problems, and how to correct them, together with information about board replacement. Faulty items may be returned for repair or new spares obtained (See Section 10 Spare Parts List) from Time Electronics (or their authorised dealer), quoting type and serial number, and giving details of the fault where possible.

Time Electronics offer an exchange service for all printed circuit boards and the power module.

6.2 FAULT CHECK LIST

1) If the unit is completely dead with no front panel lights, check the following:

A) Mains supply.
B) Mains fuse blown in plug.
C) Mains fuse blown in combination appliance inlet.
D) Internal fuses blown (see fuse replacement).

2) If instrument responds to manual control but not to IEEE control and the data light does not flash, check the following:

A) Defective IEEE cable.
B) Unit is incorrectly addressed.
C) Incorrect terminating characters.
D) Processor board not correctly plugged in.

3) If unit responds to manual control but not to IEEE control and the data light flashes, the probable fault is an incorrect command.

4) Unit powers up but not working correctly.
A) Run Self Test. See table 4.5 for error codes.

5) Unit displays ERROR 6.
A) Cal RAM corrupted.

6) Unit occasionally resets to power on (20mV range) condition and makes a short bleep.
A) Mains interference is causing the microprocessor to stop, tripping the watch-dog circuitry to give an automatic restart. Additional mains filtering required.

6.3 FUSE REPLACEMENT

Four types of fuses are used in this instrument.

1) 2 Amp, 20mm quick blow - 5V supply.
2) 800 mA for 240 V/1.6 Amp for 110 V, 20mm anti-surge - Mains input.
3) 2.5 Amp, 20mm A/S - 18V supply.
4) 250 mA, 5/8 inch quick blow - V/I/R output fuse.

Replacement fuses are available from Time Electronics and R.S. Components. See SECTION 10 (Spare Parts) for order details.

6.4 FUSE LOCATION AND REPLACEMENT PROCEDURE

1) Mains fuse :- This fuse is located in the mains inlet filter. To replace, disconnect equipment from mains and lever down hinged cover to reveal fuse holders. This fuse should be 800 mA for 240 V operation, or 1.6 Amp for 110 V operation.

2) 5V supply : - The 5V supply fuse is mounted on the left- hand printed circuit board of the power unit.

3) +/- 18V fuses :- These fuses are mounted on the right hand printed circuit board of the power unit.

4) V/I/R fuse :- This fuse is mounted on the reference board underneath the module.

6.5 MAINFRAME

The calibrator is constructed on a 19 inch Eurocard frame. Cards and modules plug into the frame from the rear of the unit.

All modules and printed circuit boards connect to the 64-way data bus via a DIN 41612 type connector.

The front panel is removed by unscrewing the four captive screws at each corner. Then lift away from the frame .

6.6 FAN REPLACEMENT

The fan is situated at the left hand side of the instrument, behind the front panel and it cools the 10 Amp board. Should the fan fail, it is replaced as follows :

1. ENSURE MAINS SUPPLY IS DISCONNECTED BEFORE ATTEMPTING TO DISMANTLE THIS INSTRUMENT.
2. Remove the instrument from the free standing case.
3. Remove the two cross head screws situated at each end of the top front cross member.
4. Release the cross member and lay it back on top of the unit.
5. Take off the four fan retaining nuts and washers.

6. Remove the fan supply plug from the power module.
7. The fan can now be lifted out of the mainframe.
8. Fit replacement fan using reverse procedure.

6.7 10 AMP BOARD REPLACEMENT

Should the 10 Amp board fail, it is replaced as follows :

1. ENSURE MAINS SUPPLY IS DISCONNECTED BEFORE ATTEMPTING TO DISMANTLE INSTRUMENT.
2. Remove the unit from the free standing case.
3. Remove the front panel and the cross member (screws at each end).
4. Remove the plug connecting the 10 Amp board to the power module.
5. Remove the plug connecting the 10 Amp board to the current module.
6. Disconnect the wires to the output terminals.
7. The 10 Amp board can now be removed from the mainframe.
8. Fit replacement board using the reverse procedure.

6.8 POWER MODULE REPLACEMENT

To remove the power unit module which is located on the right hand side of the frame viewed from the rear, first unscrew the four captive screws in the corners of the power unit rear panel. The power unit can then be pushed out of the rear of the frame. **DO NOT PULL ON THE MAINS LEAD.**

Replacement is in the reverse order.

6.9 REPLACEMENT OF IEEE AND PROCESSOR BOARDS

The IEEE and processor boards are located behind the IEEE rear panel. Remove the panel by unscrewing the four captive screws at each of its corners.
Disconnect the multipin plug that connects the rear panel to the IEEE panel. Before the boards can be removed, the black retaining clips located at the bottom of the frame must be depressed.
NOTE : The IEEE multipin connector is NOT polarized and can be accidentally reversed during replacement. To avoid this, ensure that the embossed arrow heads on the plug and socket are aligned. Care must also be taken to ensure the correct alignment of the IEEE address switch in the rear panel cut out.

6.10 ANALOGUE BOARD REPLACEMENT

All analogue boards are located behind the rear panel on the left of the frame when viewed from the rear. To replace a board, remove this panel locate the board to replace, depress card retaining clip and pull board back. On all boards additional connectors need to be disconnected as the board is removed.

NOTE : To remove the H.V. board it is also necessary to remove the IEEE panel.

SECTION 7. TECHNICAL DESCRIPTION

7.1 INTRODUCTION

This section contains a brief technical description, starting with the mainframe and associated modules, followed by the plug-in boards.

The technical description is divided into the following parts:

1. The Mainframe
2. The Front Panel Electronics Board
3. 10 Amp Output board
4. The Power Module
5. Microprocessor Board
6. The IEEE Interface Board
7. H.V. Board
8. A.C. Board
9. Reference Board
10. Current Convertor Board
11. Digital to Analogue Board and Module
12. The Resistance Board

7.2 MAINFRAME

A 19" Eurocard frame houses all boards and modules which plug into a 64 way bus via DIN 41612 type connectors.

7.3 THE FRONT PANEL ELECTRONICS BOARD

The microprocessor reads the keypad and drives the display through a 74C923 keypad encoder and a ICN 7218 8 digit display driver respectively. Two 8 bit latches on the data bus drive the L.E.D.s above the switches.

Address decoding for these I.C's is performed by a 74LS138 and a 7400 also on the P.C.B.

7.4 THE 10 AMP BOARD

This board generates an unregulated low voltage + / - 4 Volts at 10 Amps from the unregulated supplies. The low voltage is then regulated by a push pull output stage to give the 10 Amp output.

The output current is sensed by a 0.01 Ohm 4 terminal shunt resistor. The voltage generated (0.1 Volts for 10 Amps) is amplified to 1 Volt by a differential amplifier and fed back to the Reference Module sense I/P to control the output.

7.5 THE POWER MODULE

The power module contains a 100VA rated mains transformer, D.C. regulated supplies and select circuitry for the LOCAL/REMOTE switch and indicators.

The mains transformer has two 120V RMS primary windings and 9V, 11V and two 22V RMS secondary windings.

The 9V winding connects, via a 2A fuse, to a full wave bridge rectifier and smoothing capacitor. It supplies a regulated 5V D.C. at 1A for the microprocessor board, the IEEE board, the front panel display and the A.C. board.
This supply is additionally full wave rectified to supply an unregulated 14V D.C. supply at 1A. An unregulated 5V D.C. supply derived from this line drives the circuit relays and can be pulled up on command for latching the relays.

The two 22V RMS windings are rectified and supply an unregulated output of +/- 28V D.C. These supplies are also regulated to +/- 18V D.C. for the analogue circuitry.

The 11V winding is cascaded with the 22V winding to give an unregulated +/- 50V D.C. supply.

7.6 THE MICROPROCESSOR BOARD

Mounted on the microprocessor board are the microprocessor, its clock, a PROM, the power-on-reset circuitry, address decoding and 32 lines of parallel input/output (I/O).
The microprocessor used is the Motorola MC 6802. A 3.2768MHz crystal divided down internally by the 6802 supplies the 8192 kHz clock.
Parallel I/O is provided by two MC6821 peripheral interface adaptors (PIA). Each of the 32 I/O lines is provided with a pull-up resistor.

An on board link provides for the installation of either a 16K (2516), 32K (2532) or 64K (2764) PROM.

The power-on circuitry is a low frequency oscillator held off by the microprocessor stop, the oscillator does not receive a pulse and automatically resets.

Auto-cal models are fitted with a non-volatile RAM (type X2816).

7.7 THE IEEE INTERFACE BOARD

The IEEE interface board is constructed around the Motorola MC68488 general purpose interface adaptor (GPIA). The I/O lines of the 68488 are driven through MC3448 drivers. The address select switches are mounted directly on the board and their condition is gated onto the 6802 bus via a 74LS244 tristate buffer.

7.8 THE H.V. AMPLIFIER BOARD

This board amplifies the 0 - 10 Volt output from the reference board up to 0 - 1000 Volts. A potential divider made up of a 9M9 and 100 K wirewound, hermetically sealed resistors, divides the 0 - 1000 V down for a 0 - 10 V sense voltage. Also mounted on this board is the audio bleep circuitry.

7.9 THE A.C. CONVERTOR BOARD

The reference voltage from the reference board is fed into a digital to analogue convertor (D/A) mounted on this board. The control codes for the D/A are held in an EPROM, the sequence of which is controlled by an 8-digit binary counter, driven from a frequency synthesizer circuit. The D/A control codes determine the shape of the A.C. output onto the 6802 bus.

7.10 THE REFERENCE BOARD

The encapsulated reference circuitry consists of two precision, aged zener diodes running at their optimum current. The output from these diodes is averaged and amplified supply the master reference voltage of + 10.48576V. This voltage is inverted by a precision inverter to give -10.48576V. Either the positive or negative reference voltage is applied to the output by a low thermal FET switch controlled by a logic input.

The reference voltage is split to drive two D/A convertors :

A) The 14 bit monolithic convertor (AD 7534) mounted on this board via a buffer, an inverter and a calibrator. This convertor makes up the least significant bits and hence is termed the LS bits D/A. A trimmer (LS bits gain) adjusts the magnitude of reference fed to this convertor, while another trimmer (balance) adjusts any offset between the positive and negative reference voltages.

B) The precision 6-bit D/A convertor on the D/A board

7.11 THE CURRENT CONVERTOR BOARD

Mounted on this board are 5 current shunt resistors for the 200 uA to 2A current ranges and the associated four terminal switching circuitry. The three lower current ranges are switched by a FET analogue switch, while the 200 mA and 2 A ranges are switched with relays.

This board also supplies the control signals for the 10 A output board. These signals are :

A) 10 A select.
B) Sense return which routes the output current through one of five shunt resistors on the current convertor board which then generates the 0 - 1 V sensing voltage.
C) Drive to the high voltage output stage.
D) Output from the high voltage output stage.

7.12 D/A CONVERTOR BOARD

This board consists of an encapsulated module and a R-2R resistor ladder network.

The encapsulated module contains logic, buffer amplifiers and switching.

The R-2R resistor ladder consists of high quality low temperature coefficient resistors which have been carefully chosen, both in value and type, to give optimum stability. The value of each resistor can be adjusted by a multi-turn trimmer to give very high linearity. The output from the ladder is buffered and returned to the reference board.

7.13 THE RESISTANCE BOARD

Mounted on this board are 7 Wirewound, hermetically sealed resistors together with their associated trimming circuitry covering the range 10 Ohms to 10 M Ohms, trimmed to better than 10 PPM.

Also mounted on this board are 8 relays which select 1 of the 7 resistors or the voltage / current output.

SECTION 8. CALIBRATION TECHNIQUES

8.1 INTRODUCTION TO CALIBRATION TECHNIQUES

This section indicates some of the common errors made when using the calibrator.

8.2 OUTPUT RESISTANCE

Output resistance causes a drop in output voltage when a load is applied. The percentage error depends on the ratio of load resistance to output resistance

Ratio of Load Resistance to Output Resistance	Percent Error in Selected Output Voltage
100,000 : 1	0.001
10,000 : 1	0.01
1,000 : 1	0.1
100 : 1	1.0
10 : 1	9.0
1 : 1	50.0

This table applies to D.C. and A.C. For A.C., capacitive loading must also be added to resistive load. The table below gives reactance of capacitors (in ohms).

CAPACITOR	REACTANCE @ 50 HZ	REACTANCE @ 10 KHZ
100 pF	32 M Ohms	160 K Ohms
1000 pF	3.2 M Ohms	16 K Ohms
0.1uF	32 K Ohms	160 Ohms

For most applications the ratio is very high and the error can be ignored. One important exception is the Thermal Transfer where the ratio can be 1000 : 1 or less. This will give errors in excess of 0.1% unless compensated for.

Another exception is the calibration of a 60 mV analogue meter. It is often better to use the 2 Volt range as the output resistance is much lower than the 200 mV range and the accuracy at 1/20 full is still sufficiently high for analogue meters.

8.3 USING SHUNTS TO MEASURE SMALL A.C. CURRENTS

Using a shunt and a digital voltmeter (DVM) to measure the 2 mA and 200 uA ranges gives rise to two possible errors :-

1.) Low Shunt Value.

Low value shunts give very small voltages which are very difficult to measure on

DVM's, the non-linear A.C. to D.C. conversion techniques used, often give large zero errors which cannot be corrected by simply taking off the zero reading.

2.) 1 K Ohm shunts and above.

The input impedance on most high performance DVM's is usually 1 M Ohm. This causes a 0.1% error when reading across a 1 K Ohm. It is therefore necessary to correct this or use a buffer amplifier to isolate the DVM from loading the shunt.

8.4 OUTPUT CURRENT LIMITATIONS ON VOLTAGE RANGES

The instrument warns when the maximum output current is exceeded for more than 10 milli seconds by displaying 'OP ERROR' (O/P Mode 1).

Two important exceptions to output error detection should be noted.

1.) No error is detected on the 200 mV and 20 mV ranges as the output current is limited by the output resistance of 10 Ohms.

2.) As output errors lasting less than 10 mS are not detected, a slightly clipped peak of an A.C. waveform may not cause an output error.

8.5 OUTPUT VOLTAGE LIMITATIONS ON CURRENT RANGES

Output errors are generated when there is insufficient terminal voltage to drive the set current through the load. Error condition must last for more than 10 mS to be detected. Note that some meters and transducers have a large inductance and may need 20 or 30 Volts A.C. to drive them although their D.C. resistance is very low.

8.6 INTERFERENCE REJECTION

As none of the output terminals has a path to mains earth at voltages less than 80 Volts, it is good practice to earth the instrument by taking one of the terminals to earth or by ensuring that the instrument being calibrated is properly earthed. However, care should be taken that an earth loop is not created by inadvertently earthing the calibrators terminal when it is already earthed via the instrument under calibration.
On current ranges with very high output impedance, series mode noise can be induced onto the output but may be suppressed by the use of screened leads.

In addition to inherent electrical noise from internal circuitry, the output can contain fluctuations which originate externally and often cover a wide spectrum of frequencies. The most effective solution is to locate the source and provide suitable filtering eg. capacitor suppression on arcing contacts.

8.7 EARTHING THE HIGH VOLTAGE OUTPUT

The V/I/R and 10 Amp terminals are true bi - polar outputs, but the HV output terminals are not. Therefore, when using a positive HV ouput the negative terminal should be earthed as normal, but when a negative HV output is required, it is recommended that the earth be transferred from the negative terminal to the positive terminal. Alternatively the low voltage negative terminal may be earthed, this automatically earths the correct side of the HV output.

8.8 THERMAL EMF

Thermal EMF's are significant when low level DC Voltage measurements are being made. Thermal EMF errors are unpredictable and arise when dissimilar metal junctions are at different temperatures. To minimise them, the same metal should be used throughout the measuring circuit, avoiding the use of steel probes, nickel plated terminals and tinned copper wire where possible. If the use of dissimilar metal junctions in the measuring circuit is unavoidable, it should be ensured that they are offset by other junctions of the same metals at the same temperature. Allowance for thermal EMF's should then be made by making a measurement twice with reversed polarities. Time Electronics can supply Low Thermal EMF leads, (see Spare Parts List).

8.9 RESISTANCE MEASUREMENTS

Three types of errors in resistance measurement are listed below -

1.) Thermal EMF's can effect the accuracy of resistance measurement if not zeroed out properly.
2.) Self heating of the resistor being measured. Use of a lower current will minimize this but the resulting lower voltage is more difficult to measure.
3.) Noise and pick-up on the higher value resistors. The use of screened leads may help but may not remove noise completely.

Errors caused from 1 and 2 can usually be completely removed, but errors from noise pick-up on the high values will always be present.

SECTION 9. CALIBRATION

9.1 INTRODUCTION

The automatic calibration (auto-cal) feature enables independent calibration of the zero, positive and negative outputs of all DC ranges and full scale of all A.C. ranges either from the front panel or via the IEEE bus. The calibration factors are stored twice in memory and when switched on the factors are compared to check for any corruption. Should an error be found the message 'ERROR 6' will be displayed on the front panel.

When using auto-cal, all calibration factors may be zeroed and the operation of the calibration memory verified by inserting the CAL key and selecting self test (ie. all IEEE address switches to the left and switch on). Self test can be run without inserting the CAL key which leaves the calibration factors unchanged.

If the CAL key is inserted when the unit is not addressed for auto-cal, the display will flash 'ERROR 7'.

Calibration comes in two parts, Range and Linearity, of which it is normally necessary to perform the range calibration, and then check the linearity.

Should an unacceptable linearity error be found, it will then be necessary to perform the linearity adjustments and repeat the range calibration procedure.

To adjust the linearity, it is necessary to disconnect all circuitry associated with the resistor ladder, then measure and adjust the resistance values of the R and 2R components such that the R (approx. 20 K) is 2 x R (approx. 10 K).

9.2 EQUIPMENT REQUIRED FOR CALIBRATION

1.) Range Calibration.
All range calibration is performed by the measurement of voltages and currents to accuracies at least four times the specifications.
The recommended technique is with a Potential Divider / Null / Standard Cell, or alternatively, a good digital voltmeter of known performance recently certified may be used.

Recommended D.V.M.'s are Solartron 7081/7071, Datron 1071/1081.

2.) Linearity Calibration.
To set up the R-2R ladder an instrument for measuring 10 K Ohms and 20 K Ohms resistance with 1 Ohm resolution is needed. The absolute accuracy is unimportant providing that the linearity error is within +/- 0.01%, which is usually the case with a D.V.M. if the range is not changed.

9.3 SETTING UP PROCEDURE

Ensure that the instrument under calibration and the Standards are allowed a warm up period of 2 hours at a constant temperature of 20 °C +/- 1 °C. This temperature should remain constant during the calibration procedure. Refer to figure 9.1 for potentiometer positions.

9.4 SETTING INTO AUTO-CAL MODE

The instrument is set into auto-cal mode as follows:

1.) Switch off and select IEEE address 0 or 16.
2.) Switch on and insert CAL key. The front panel display will show a flashing C.

9.5 RECALIBRATING RANGES FROM THE FRONT PANEL

All ranges can be calibrated independently or in any sequence, it is necessary to set the zero before adjusting full scales.

1.) Select the range to be calibrated.
2.) For ZERO calibration, (D.C. only) set a value on the display which makes the output zero, then press SELECT followed by ZERO which will set the output to zero. Press ZERO again and the display will zero. There is no adjustment for A.C. zero, should an A.C. zero need adjusting, there is fault condition.
3.) For FULL SCALE calibration, set the display to full scale or to the value required as the point to check against a standard (eg. checking the 2V range against a standard cell). Press DEV, adjust the output to the correct value and press DEV again. This saves the calibration factor. The negative and A.C. full scales are adjusted in the same way.

9.6 RECALIBRATING OVER THE IEEE BUS.

1.) Select the range to be calibrated.
2.) Set the output to zero by setting a value to cancel the zero error, then send command 'Z' to store this value. Note there is no adjustment for A.C. zero.
3.) Set the output to full scale and select deviation required to adjust output to correct value with command 'PX.XXX'. When another command is received the value is saved.

After calibration, carry out the following operations STRICTLY in the order given:

A) Remove the CAL key.
B) Switch off.
C) Reselect the unit address.

NOTES :
1.) Addresses 0 and 16 only should be used for calibration.
2.) If the unit is operated in auto-cal mode with the CAL key not inserted, the devia-

tion and offset functions will not work.
3.) The IEEE address is only read when the instrument is first switched on.

9.7 REFERENCE CIRCUITRY

The reference circuitry is in the encapsulated module and consists of 2 precision aged zeners running at their optimum current. The output from these is averaged and amplified to give a +10.48576 V master reference. This reference is then inverted by a precision invertor to give -10.48576 V. A low thermal FET switch controlled by a logic input on pin 9, switches either the +Ve or -Ve reference out to pin 12.

At this point the reference voltage is split to drive two D/A convertors - A 14 bit monolithic convertor (AD 7534) on the reference board and the precision 6 bit D/A convertor on the D/A board. The 14 bit convertor makes up the least significant bits and is referred to as the LS Bits D/A convertor.

9.8 LS BITS D/A CONVERTOR

The reference voltage is buffered, inverted and calibrated before it is fed into the LS Bits D/A.

The LS Bits gain trimmer is used to adjust the magnitude of the reference voltage feed into the 14 bit D/A and a balance trimmer is used to offset any difference between the +Ve and -Ve voltage.

9.9 PRECISION 6 BIT D/A CONVERTOR ASSEMBLY

This convertor is made in two parts :- An encapsulated module contains logic, buffer amps, switching and the D/A board with the R-2R wire wound resistor ladder.

The value of each resistor in the ladder can be individually adjusted with its associated multiturn trimmer to give a very high linearity. The high quality, low temperature coefficient resistors in this chain have been carefully chosen, in both value and type, to give optimum stability and should only be replaced by a similar type.

The output from the LS Bits is brought in as the 7 bit in the 6 bit convertor - hence making up the full compliment of 20 bits.

The output of the ladder network is buffered and then returned to the reference board.

9.10 LS BITS BALANCE

The first adjustment to make is the LS Bits balance. Measurements should be taken from the output terminals with a resolution down to 10 uV and 0.01% accuracy. The calibrator should be on the 10 Volt range and set to +0.3000 V. Adjust the 'LS BALANCE' trimmer to obtain an equal, but opposite polarity reading on the meter

when selecting + or - on the calibrator. The absolute value at this point is unimportant.

9.11 LS BITS CALIBRATION

Measuring from the output terminals with the calibrator set to +0.3000 V on the 10 V range, adjust the LS Bits Cal pot. to read 0.3000 V, +/- 20 uV

9.12 LINEARITY CALIBRATION

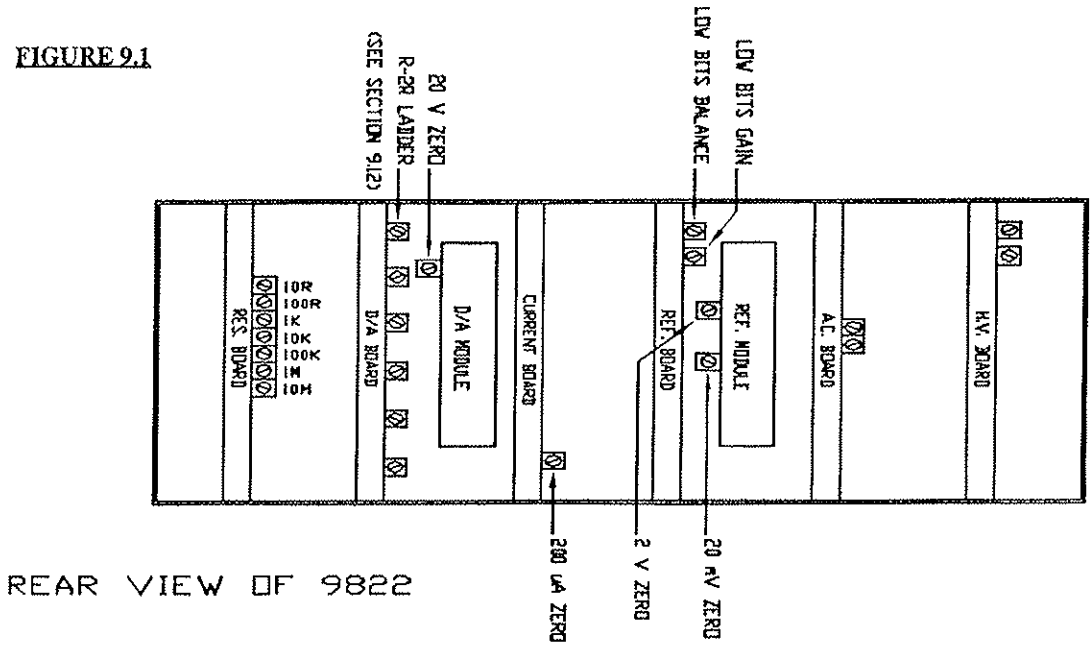
NOTE : Before proceeding with the linearity adjustment, first check linearity of the top decade down to 0.4 V to ascertain whether or not adjustment is required. Only the top decade can be adjusted. If the lower decades are non-linear then a fault exists in the 14 LS Bits, the linearity of which is governed by the 14 bit DAC on the Reference Board. After linearity adjustment is made it is necessary to recalibrate this instrument.

See diagram in Section 12 for measurement points. The equipment required is an Ohm Meter with a F.S. reading of 20 K Ohms and a resolution of 1 Ohm. To set up the R-2R ladder correctly all that is required is to set one resistance value to twice the resistance value of R, to within 0.01%. The absolute value is unimportant.

Unplug the D/A Board. Remove the module and unplug IC4, (OP27 located between the module connector and the edge connector). Measure the resistance across the points marked X and Y in the diagram and adjust the resistance to 9.967K Ohms using the associated trimmer also shown in the diagram. (See Section 12). Similarly, adjust the resistance across the points marked Y to 19.934 K Ohms with the associated trimmer without changing the meters range. Continue until all decades are correct. Refit the module and the OP27 op-amp and replace the board.

The instrument will now require complete calibration. Full scales and zeroes must be calibrated and also the LS Bits balance should be checked.

FIGURE 9.1



REAR VIEW OF 9822

9.13 RESISTANCE CALIBRATION

Adjustment of each decade is done by its own adjustment potentiometer. The trimmers must set each decade to within the accuracy specified for each range, as shown in the table below.

RANGE	POINT	MEASUREMENT	ADJUSTMENT
10 Ohm	V/I/R	10 Ohm +/- 2.5 mOhm	Adjust R4
100 Ohm	V/I/R	100 Ohm +/- 2.5 mOhm	Adjust R7
1 K Ohm	V/I/R	1 K Ohm +/- 12.5 mOhm	Adjust R10
10 K Ohm	V/I/R	10 K Ohm +/- 125 mOhm	Adjust R13
100 K Ohm	V/I/R	100 K Ohm +/- 1.25 Ohm	Adjust R17
1 M Ohm	V/I/R	1 M Ohm +/- 30 Ohm	Adjust R19
10 M Ohm	V/I/R	10 M Ohm +/- 1 K Ohm	Adjust R21

SECTION 10. SPARE PARTS

ITEM	ORDER CODE
12V Relay (S2)	6314
12V Relay (S4)	6312
8 way D.I.L. switch	6306
IEEE Connector	6420
Mains Fuse 800 mA	6128
Mains Fuse 1.6 A	6130
Fuse 5/8" 250 mA	6102
Fuse 20mm 2 A	6111
Fuse 20mm 2.5 A	6122
IEEE Driver (3448)	4555
IEEE Interface (68488)	4556
Crystal (3.2768 MHz)	4559
Microprocessor (6802)	4583
PIA (68A21)	4585
12 Bit timer (14040)	4590
Press switch with LED	6452
7 Seg LED	4631
Display Driver ICM7218A	4592
LED Driver 74LS273	4594
K/B Encoder 74C923	4595
Non Volatile RAM	4566
Terminal Red	6224
Terminal Black	6225
Fan	7504
A.C. Convertor Board	9418
Current Convertor Board	9421
D to A Convertor Board	9403
H.V. Board	9415
IEEE Board	9573
uP Board	9574
Power Module	9429
Reference Board	9404
Resistance Board	9414
10 Amp Board	9428

NOTE : When ordering spare parts it is necessary to state the serial number of the instrument. Please note that in some cases if a design has been superseded, the latest version will be supplied.

SECTION 11. GUARANTEE AND SERVICE FACILITIES

The unit is guaranteed for a period of one year from its delivery to the purchaser.

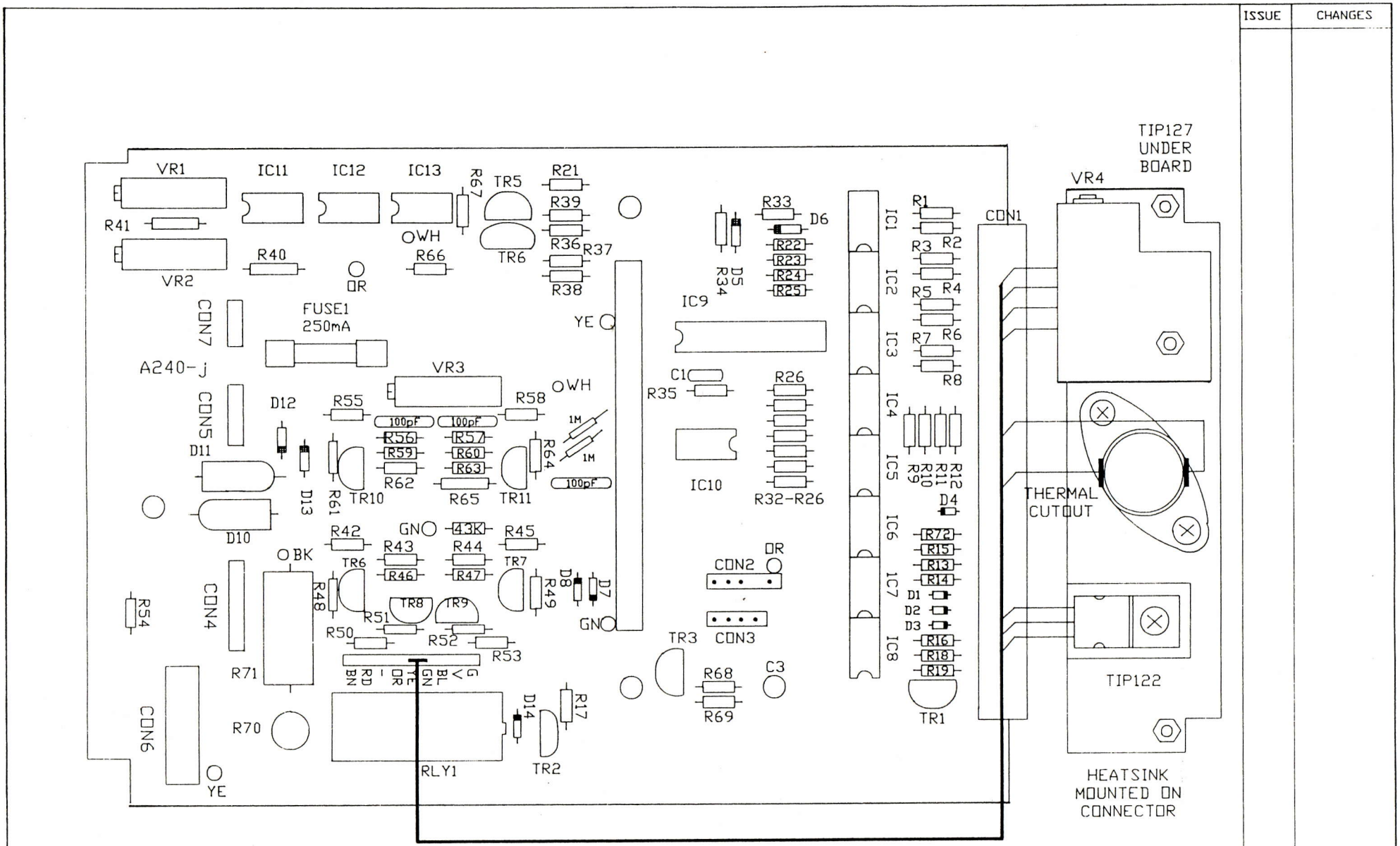
We maintain comprehensive after sales facilities and the unit can, if necessary, be returned to us (or our authorised dealer) for servicing. The type and serial number should always be quoted, together with details of any fault, and the service required.

Time Electronics can re-calibrate your instrument and issue a 5 page calibration certificate, traceable to N.P.L. or alternatively obtain a NAMAS certificate.

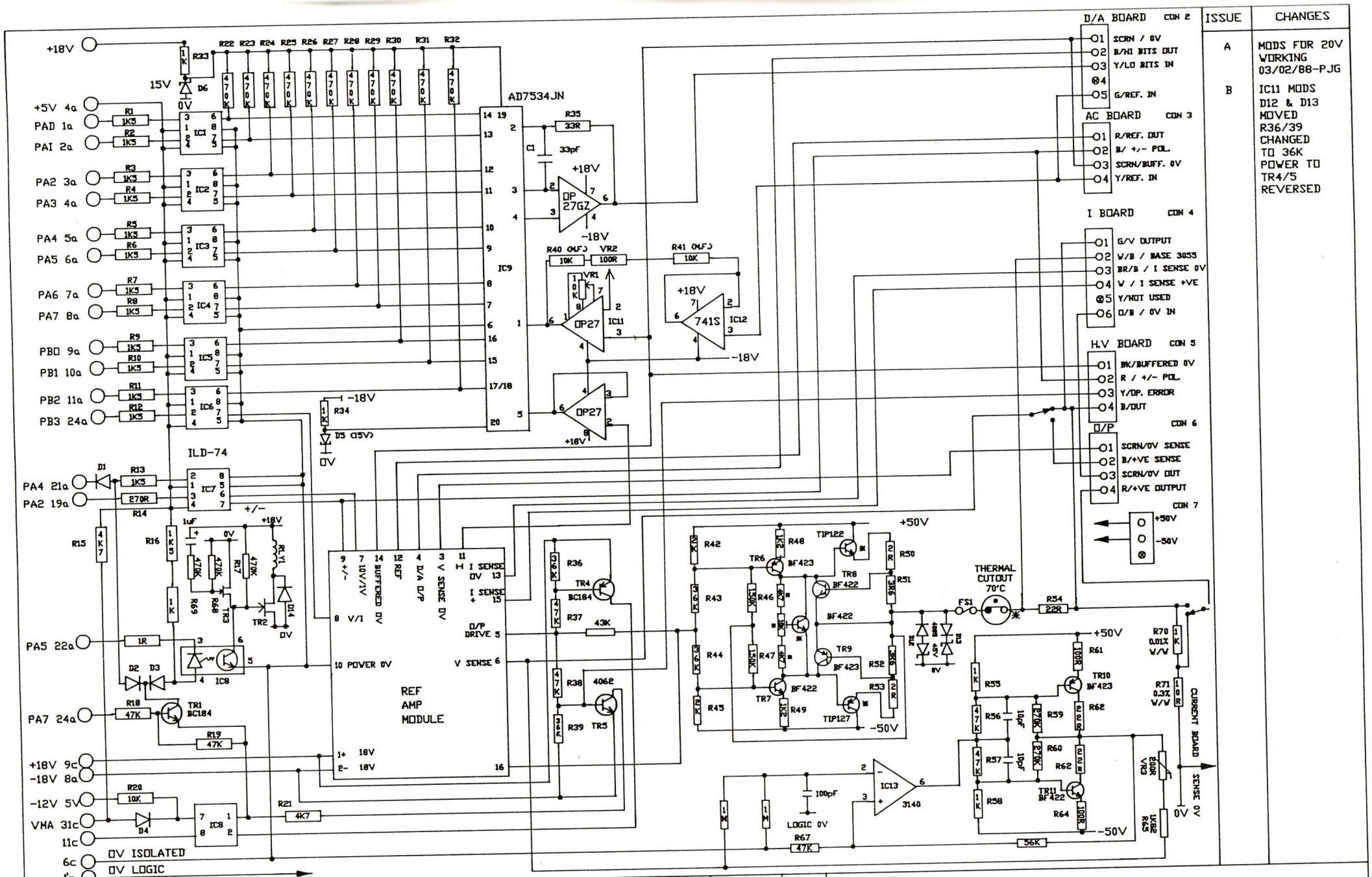
Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. WE CAN ACCEPT NO RESPONSIBILITY FOR INSTRUMENTS ARRIVING DAMAGED. Should the cause of failure during the guarantee period be due to misuse or abuse of the unit, or if the guarantee period has expired, the repair will be put in hand without delay, and charged unless other instructions are received. Please note that if you require a new NAMAS certificate during the warranty period, this will be charged at the current rate on our price list.

TIME ELECTRONICS LIMITED
BOTANY INDUSTRIAL ESTATE
TONBRIDGE
KENT
TN9 1RH

TEL : TONBRIDGE (01732) 355993
FAX : 01732 770312



TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	REF BOARD LAYOUT	
	APPRD				
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	9404L01
	DATE	19/2/88			



ISSUE	CHANGES
A	MODS FOR 20V WORKING 03/02/88-PJG
B	IC11 MODS D12 & D13 MOVED R36/39 CHANGED TO 36K POWER TO TR4/5 REVERSED

'*' REFERS TO COMPONENTS MOUNTED ON HEATSINK

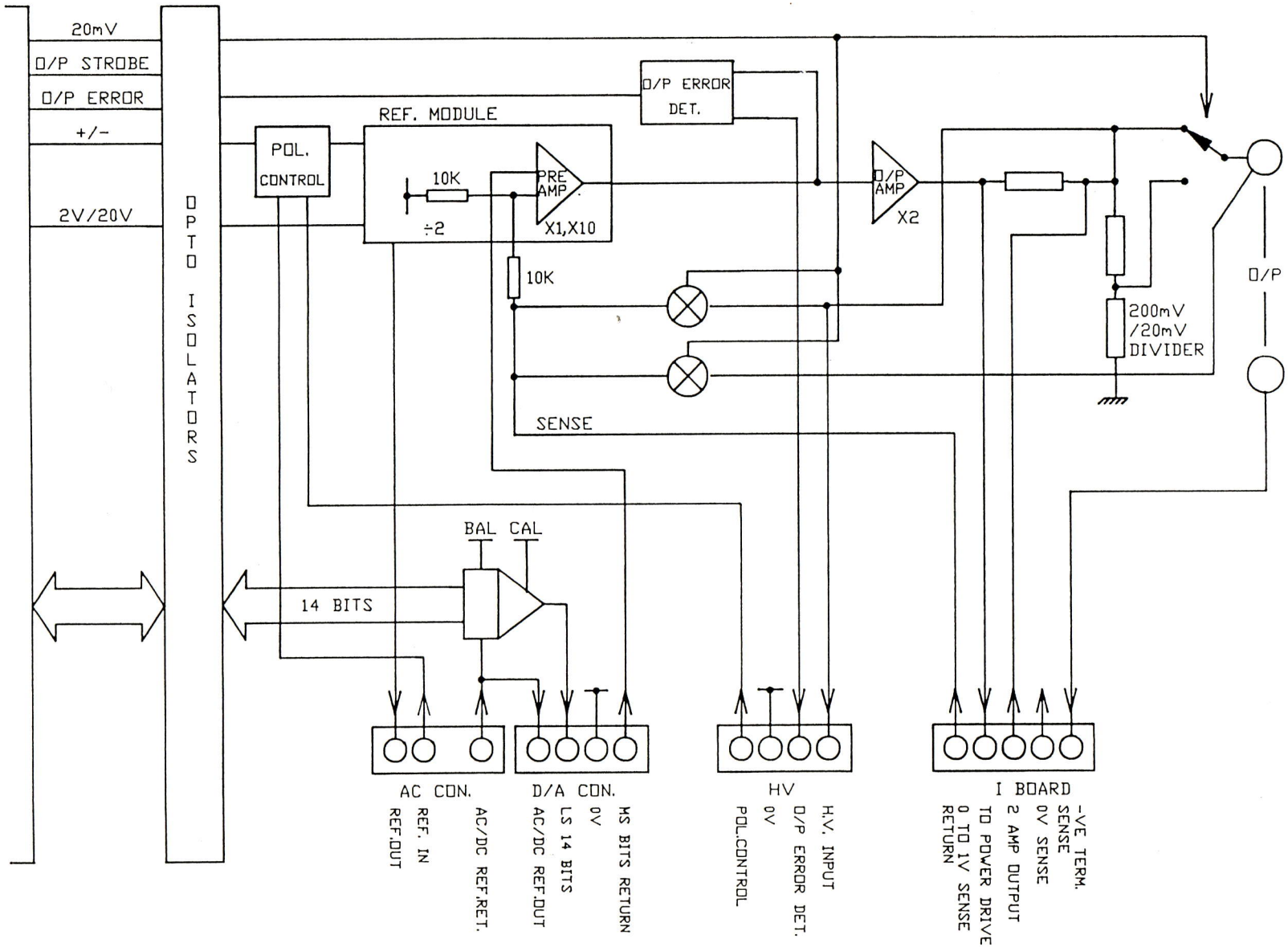
TIME ELECTRONICS LTD

DRAWN	C,A,L	TITLE
APPRD		
SCALE		
DATE	24.2.87	

REFERENCE BOARD CIRCUIT DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No CIRCUIT/9404C03



ISSUE	CHANGES
A	3/7/85
B	MODS. FOR 20V WORKING 22/02/88 P.J.G.

TIME ELECTRONICS LTD

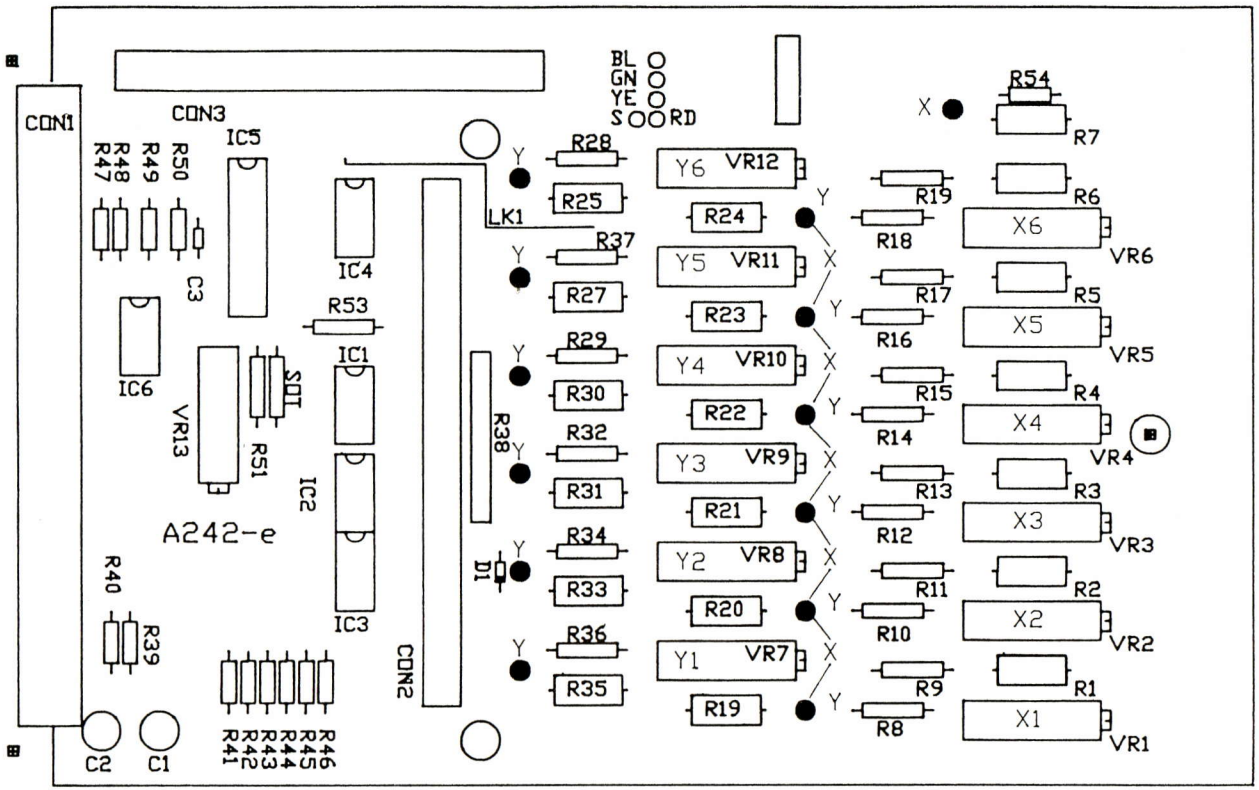
DRAWN	J.B.
APPRD	
SCALE	
DATE	3/7/85

TITLE: 9800 REFERENCE BOARD BLOCK DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

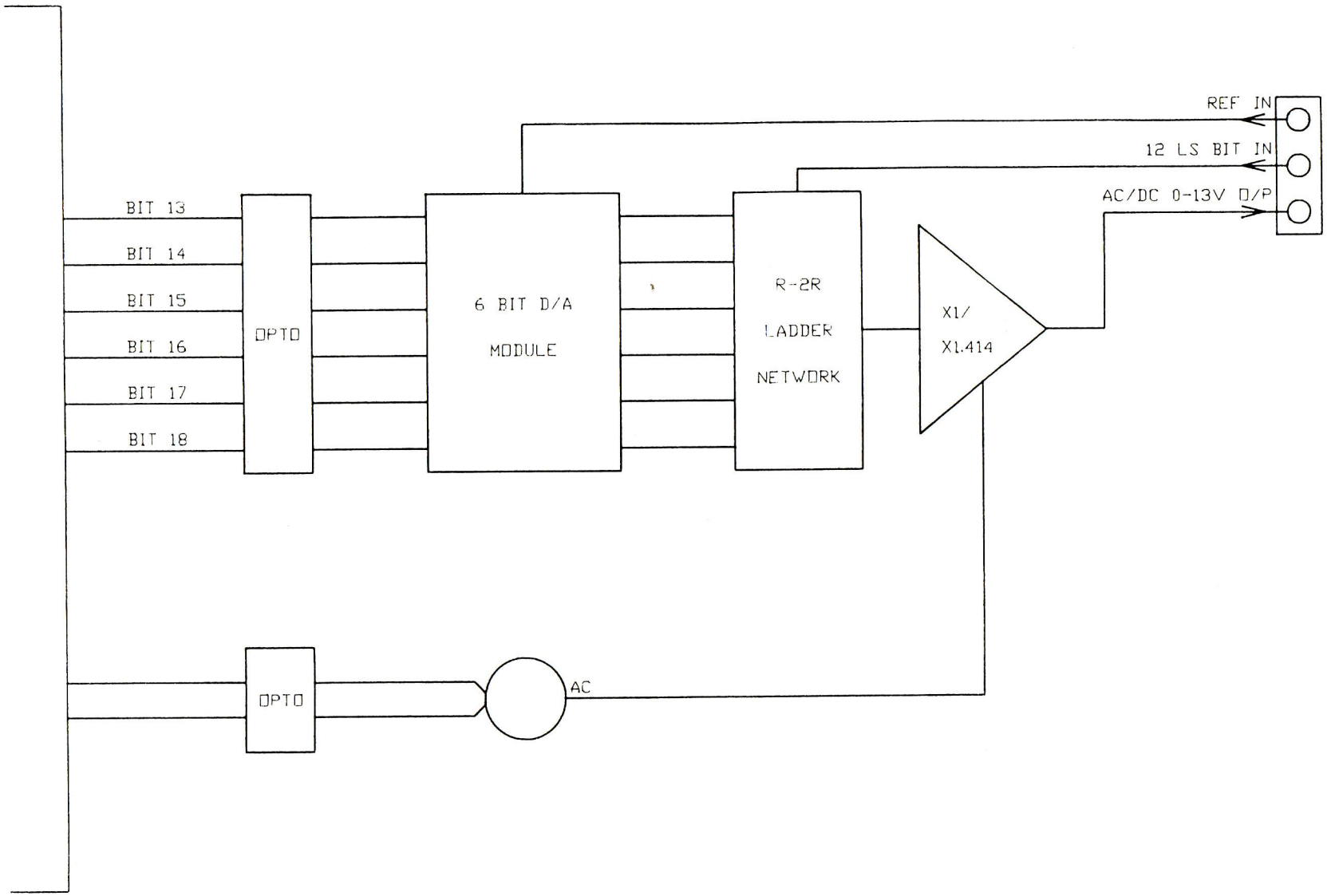
DRG No: 9404B01

ISSUE	CHANGES



TIME ELECTRONICS LTD	DRAWN	C/A/L	TITLE	D/A BOARD CALIBRATION POINTS	
	APPRD				
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	LAYOUT/9403L01
	DATE	27,8,87			

ISSUE	CHANGES
A	3/7/85



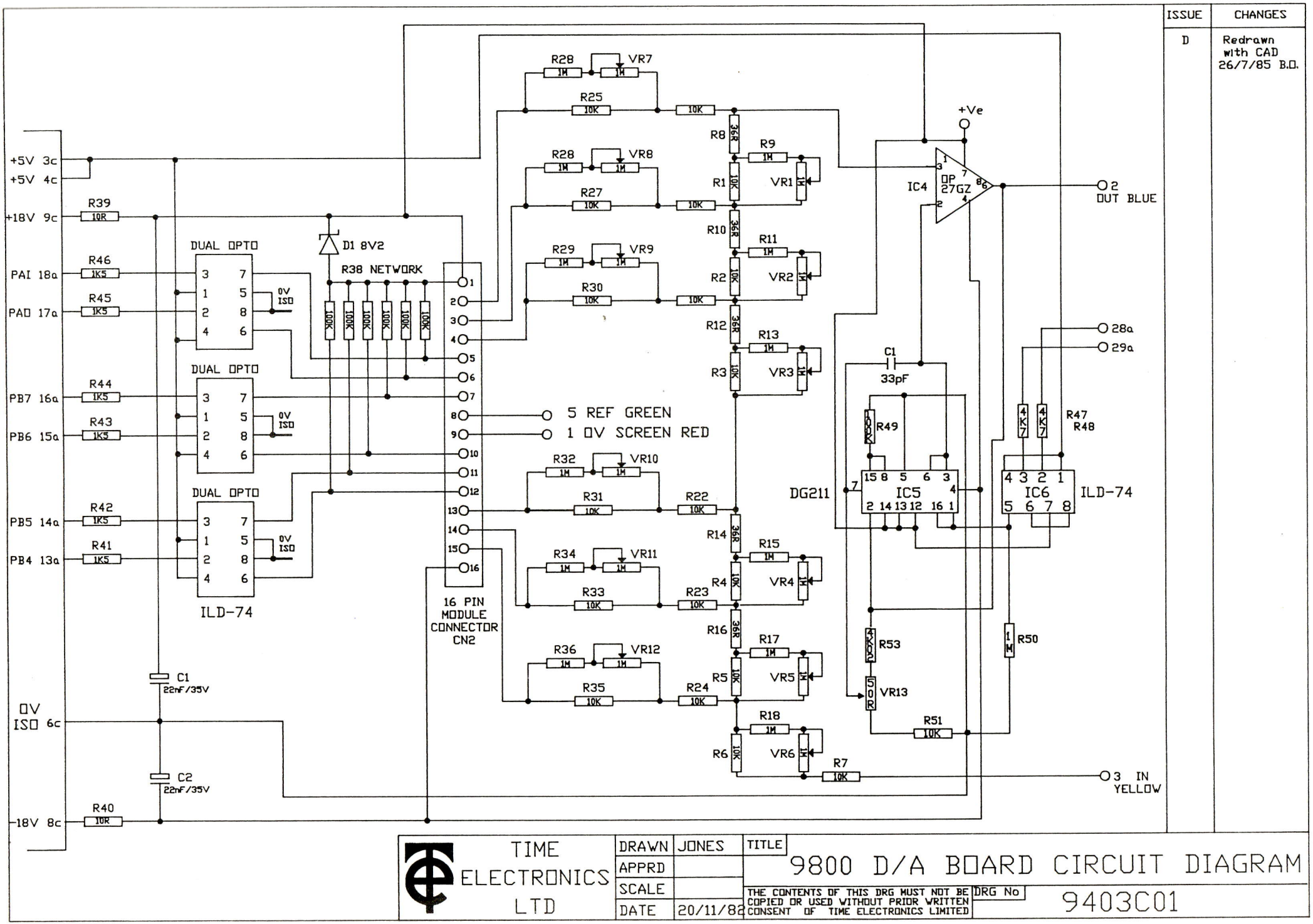
TIME ELECTRONICS LTD

DRAWN	J.B.	
APPRD		
SCALE		
DATE	3/7/85	

TITLE: 9800 D/A BOARD BLOCK DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No: 9403B01



ISSUE	CHANGES
D	Redrawn with CAD 26/7/85 B.O.

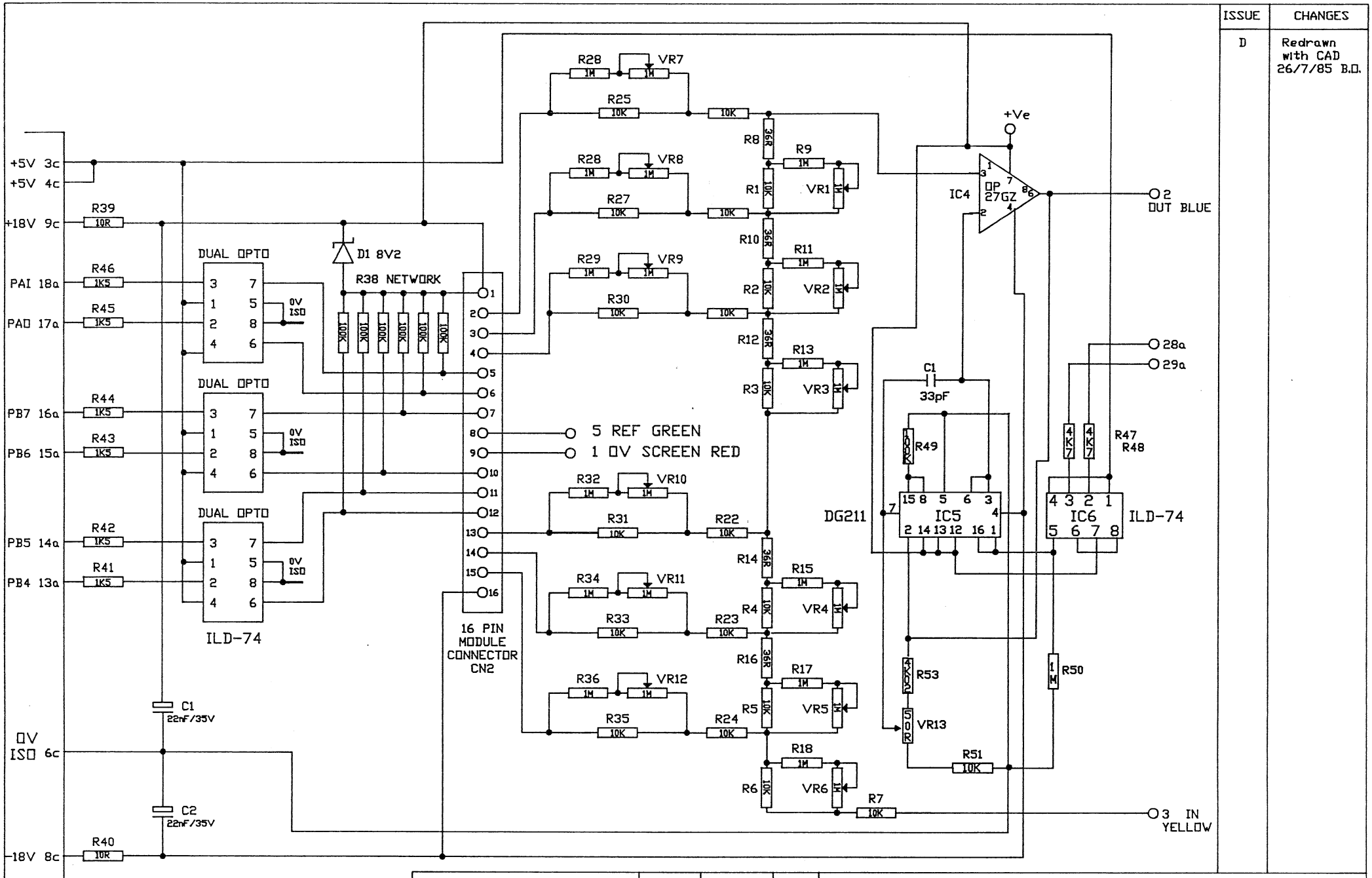
TIME ELECTRONICS LTD

DRAWN	JONES
APPRD	
SCALE	
DATE	20/11/82

TITLE: 9800 D/A BOARD CIRCUIT DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No 9403C01



ISSUE	CHANGES
D	Redrawn with CAD 26/7/85 B.D.

TIME ELECTRONICS LTD

DRAWN	JONES
APPRD	
SCALE	
DATE	20/11/82

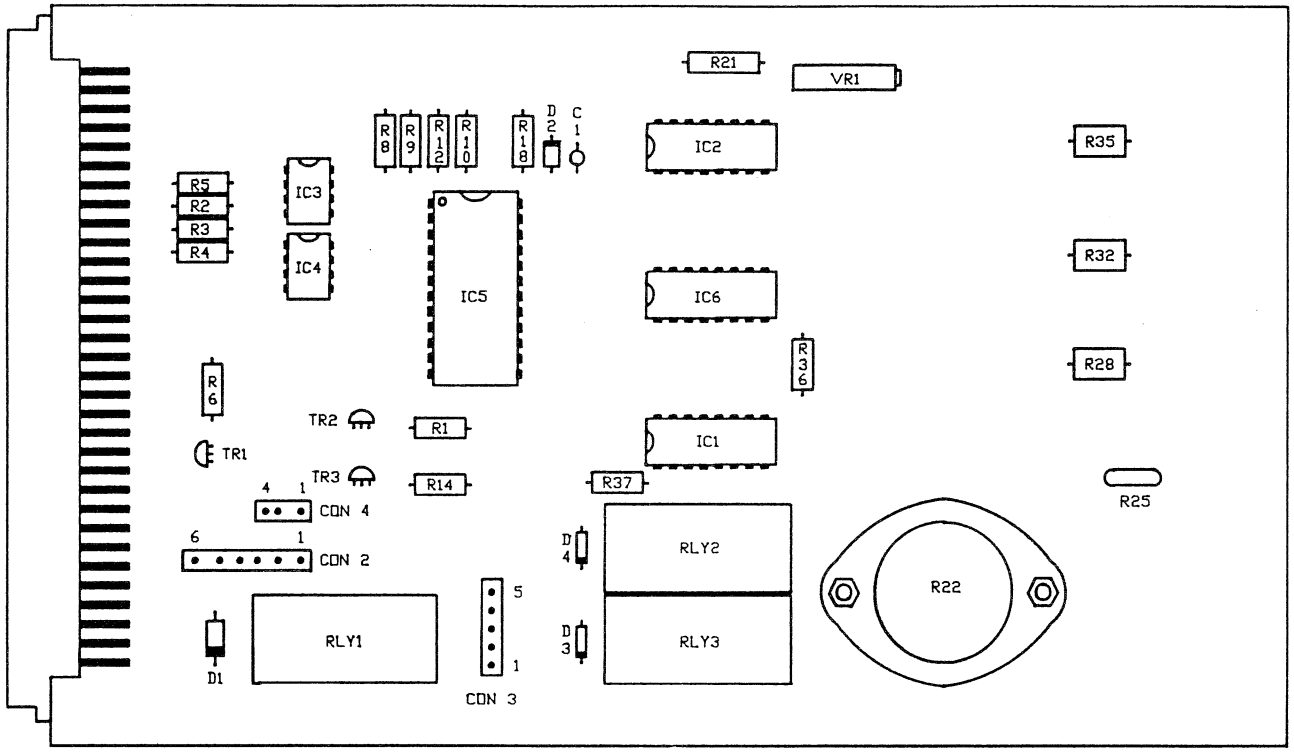
TITLE

9800 D/A BOARD CIRCUIT DIAGRAM

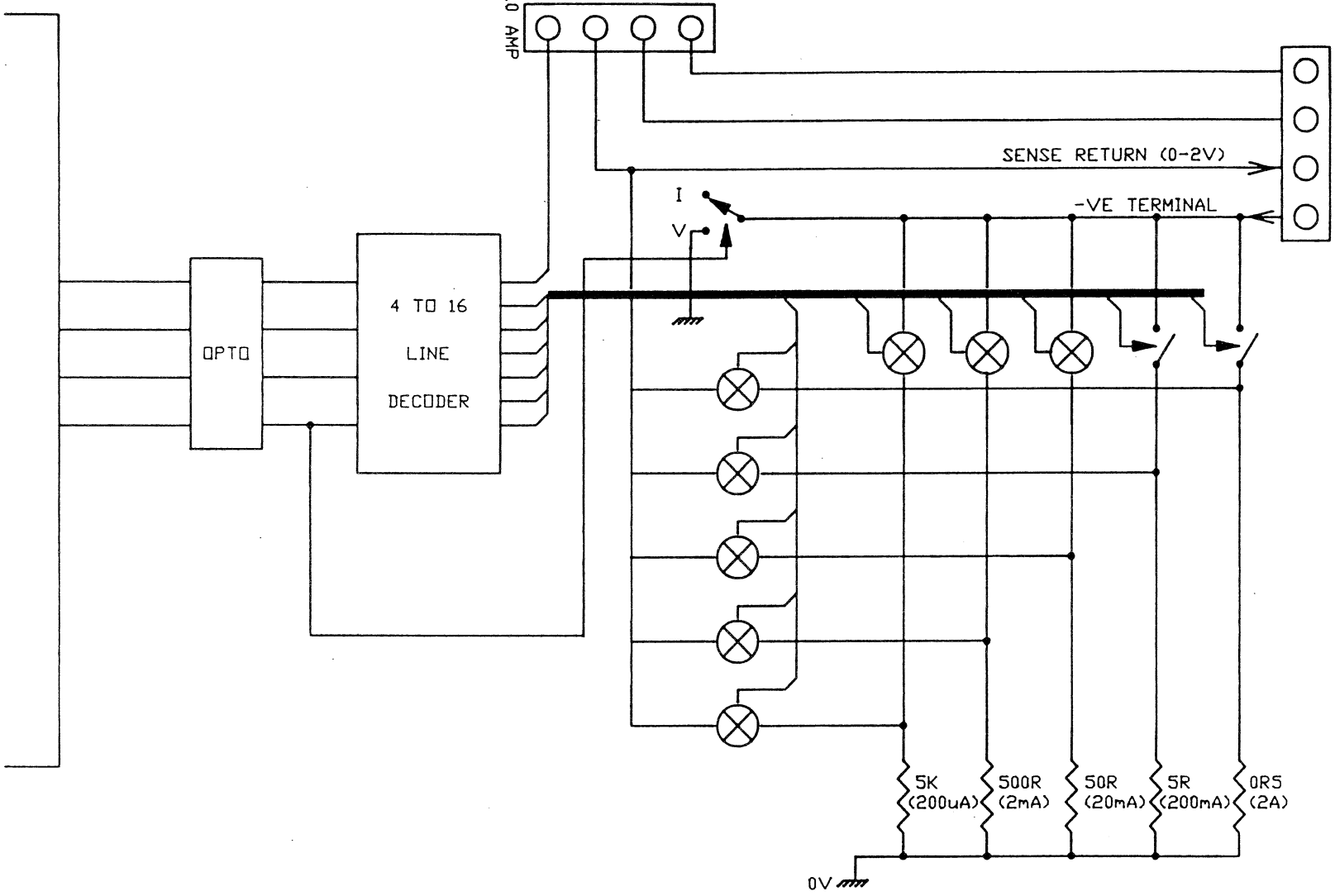
THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No 9403C01

ISSUE	CHANGES



TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	9800 CURRENT BOARD LAYOUT	
	APPRD				
	SCALE				
	DATE	9/2/88	THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	9421L01



ISSUE	CHANGES
A	3/7/85

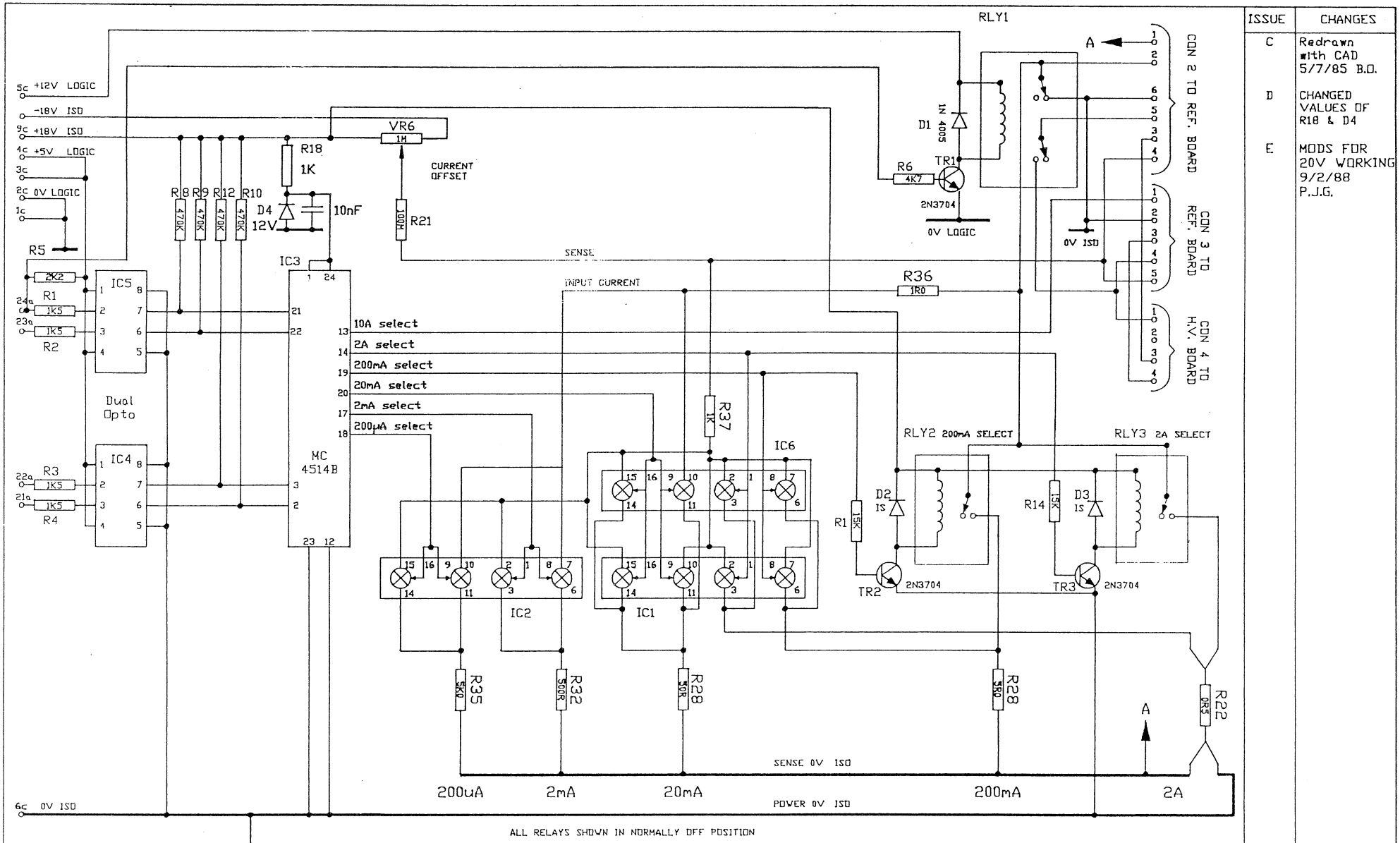
TIME ELECTRONICS LTD

DRAWN	J.B.
APPRD	
SCALE	
DATE	3/7/85

TITLE: 9800 CURRENT BOARD BLOCK DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No: 9421B01



4514 DECODE

RANGE	22	21	3	2	O/P PIN
100µA	H	L	L	L	18
1mA	H	L	L	H	17
10mA	H	L	H	L	20
100mA	H	L	H	H	19
1A	H	H	L	L	14
10A	H	H	L	H	13

DG308 SUPPLIES

pin	volts
4	-18 ISO
5	0 ISO
13	-18 ISO

ISSUE	CHANGES
C	Redrawn with CAD 5/7/85 B.D.
D	CHANGED VALUES OF R18 & D4
E	MODS FOR 20V WORKING 9/2/88 P.J.G.

TIME ELECTRONICS LTD

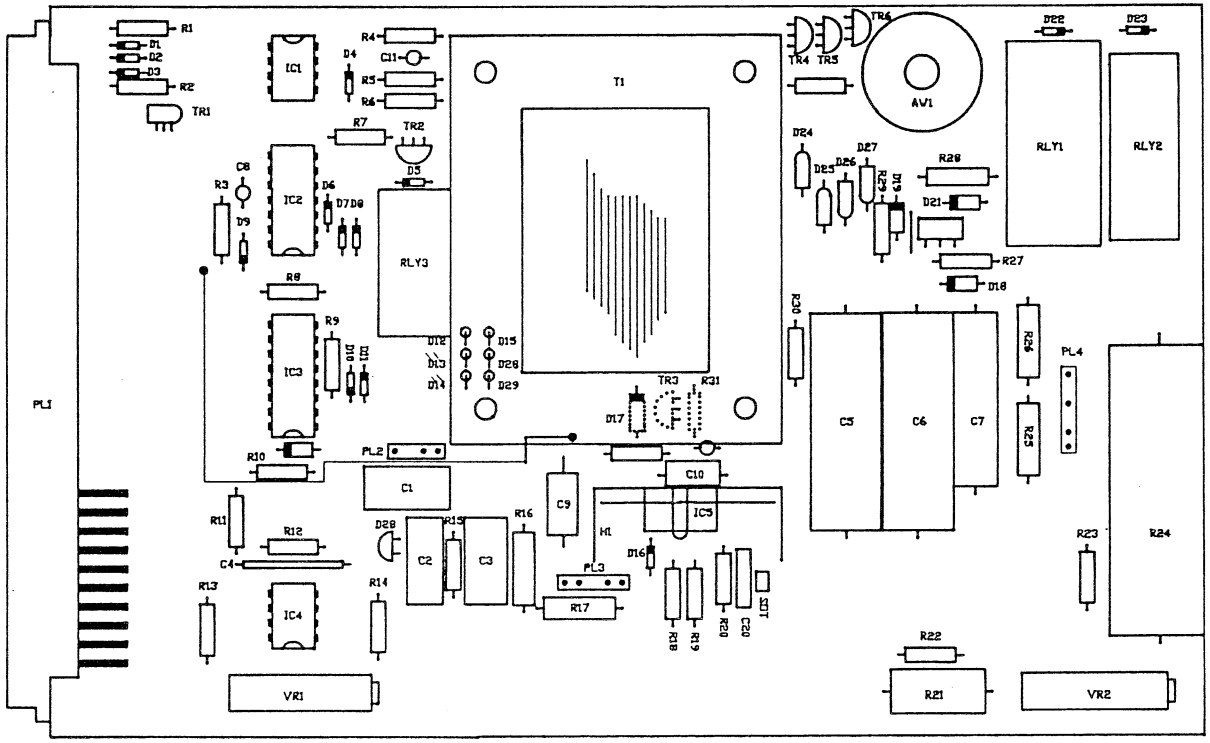
DRAWN	JONES
APPRD	
SCALE	
DATE	20/10/82

TITLE: 9800 CURRENT BOARD CIRCUIT DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No 9421C01

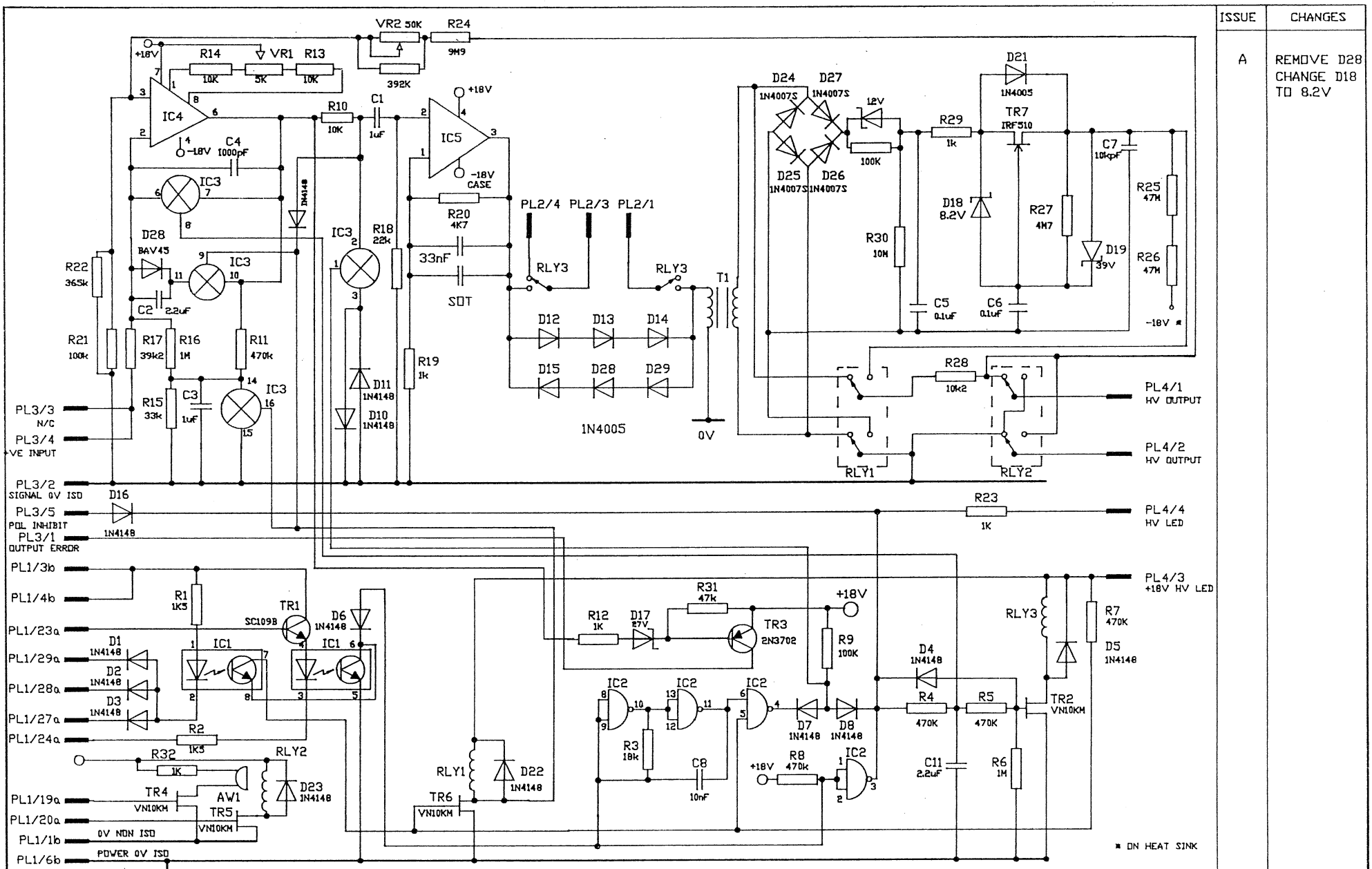
ISSUE	CHANGES



TIME ELECTRONICS LTD	DRAWN	B.O.	TITLE	9800 HIGH VOLTAGE BOARD PHYSICAL LAYOUT
	APPRD			
	SCALE			
	DATE	2/10/85		

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No 9415L01



ISSUE	CHANGES
A	REMOVE D28 CHANGE D18 TO 8.2V

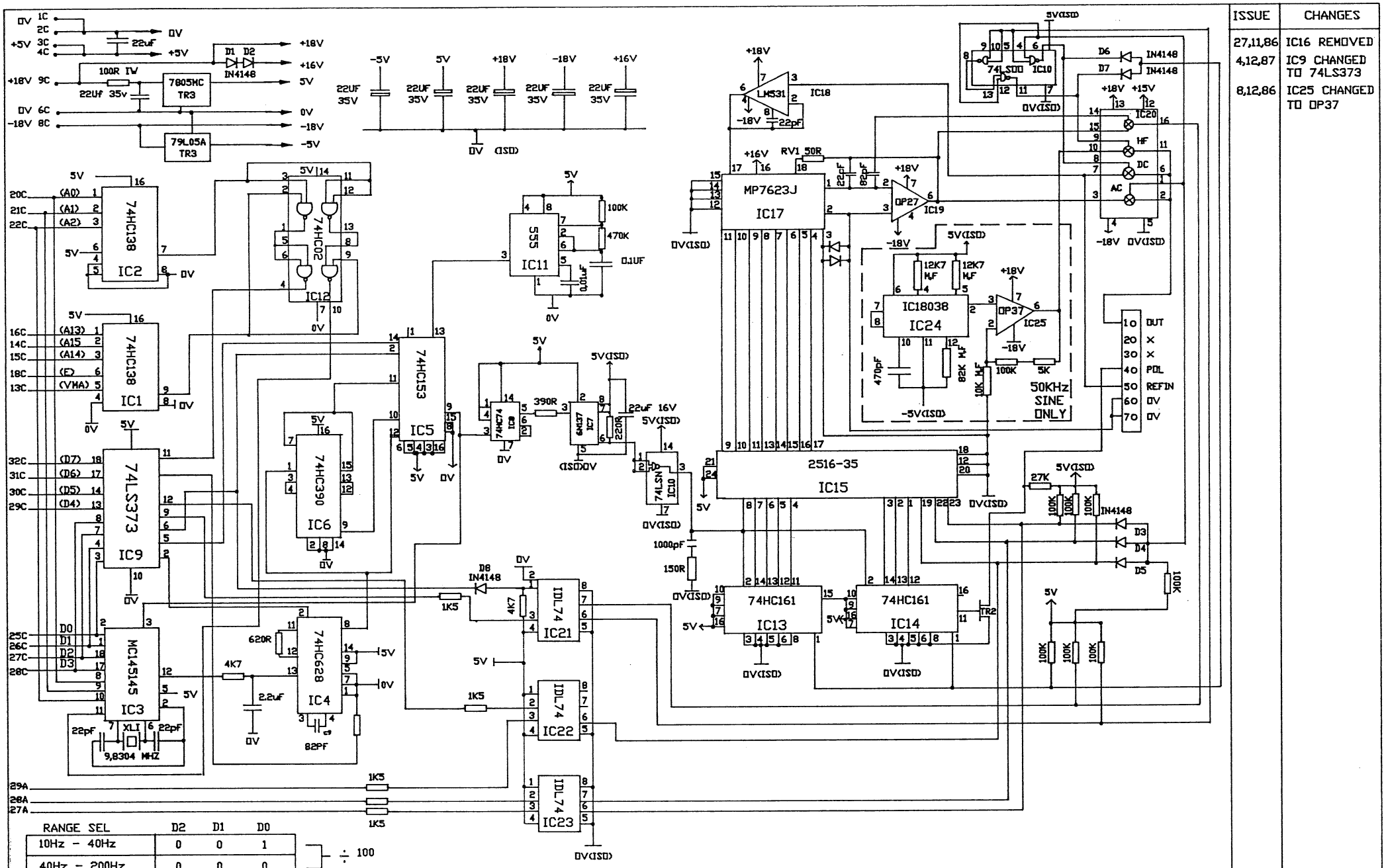
TIME ELECTRONICS LTD

DRAWN	B.O.	TITLE
APPRD		
SCALE		
DATE	11/10/85	

9800 HIGH VOLTAGE BOARD CIRCUIT DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No 9415C01



RANGE SEL	D2	D1	D0	
10Hz - 40Hz	0	0	1	÷ 100
40Hz - 200Hz	0	0	0	
200Hz - 400Hz	0	1	1	÷ 10
400Hz - 2KHz	0	1	0	
2KHz - 4KHz	1	0	1	÷ 1
4KHz - 20KHz	1	0	0	

ISSUE	CHANGES
27,11,86	IC16 REMOVED
4,12,87	IC9 CHANGED TO 74LS373
8,12,86	IC25 CHANGED TO OP37

TIME ELECTRONICS LTD

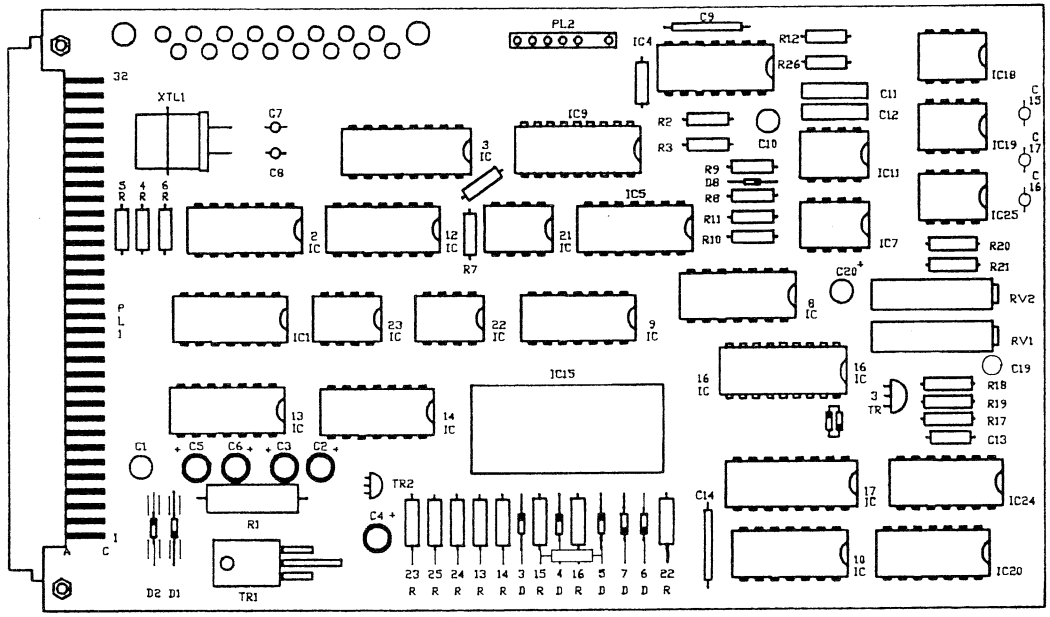
DRAWN	C.A.L	TITLE
APPRD		
SCALE	(1.4=1)	
DATE	10-3-86	

A.C. SYNTHESIZER BOARD

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

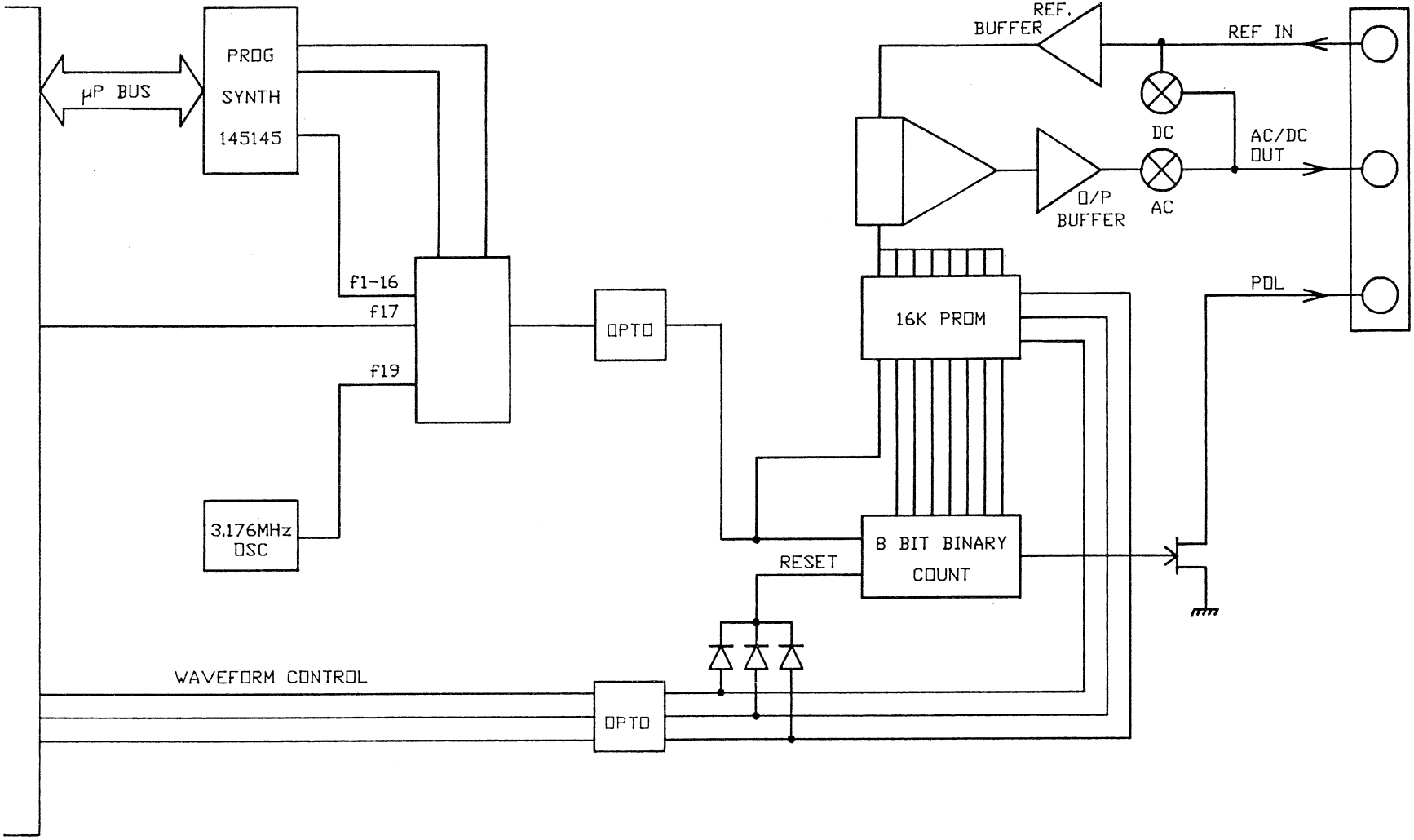
DRG No 9418C01

ISSUE	CHANGES



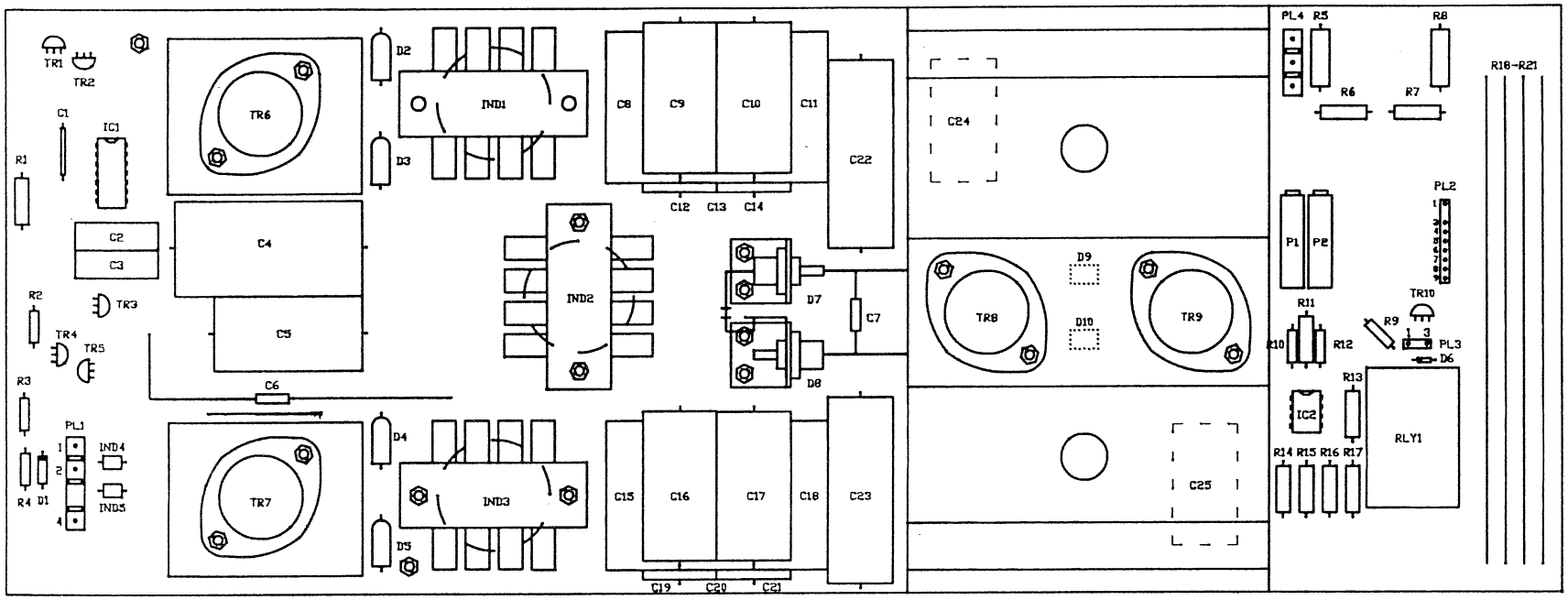
TIME ELECTRONICS LTD	DRAWN	C,A,L	TITLE	A.C. SYNTHESIZER BOARD	
	APPRD				
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	9418L01
	DATE	3,12,86			

ISSUE	CHANGES
A	3/7/85
B	17/2/88



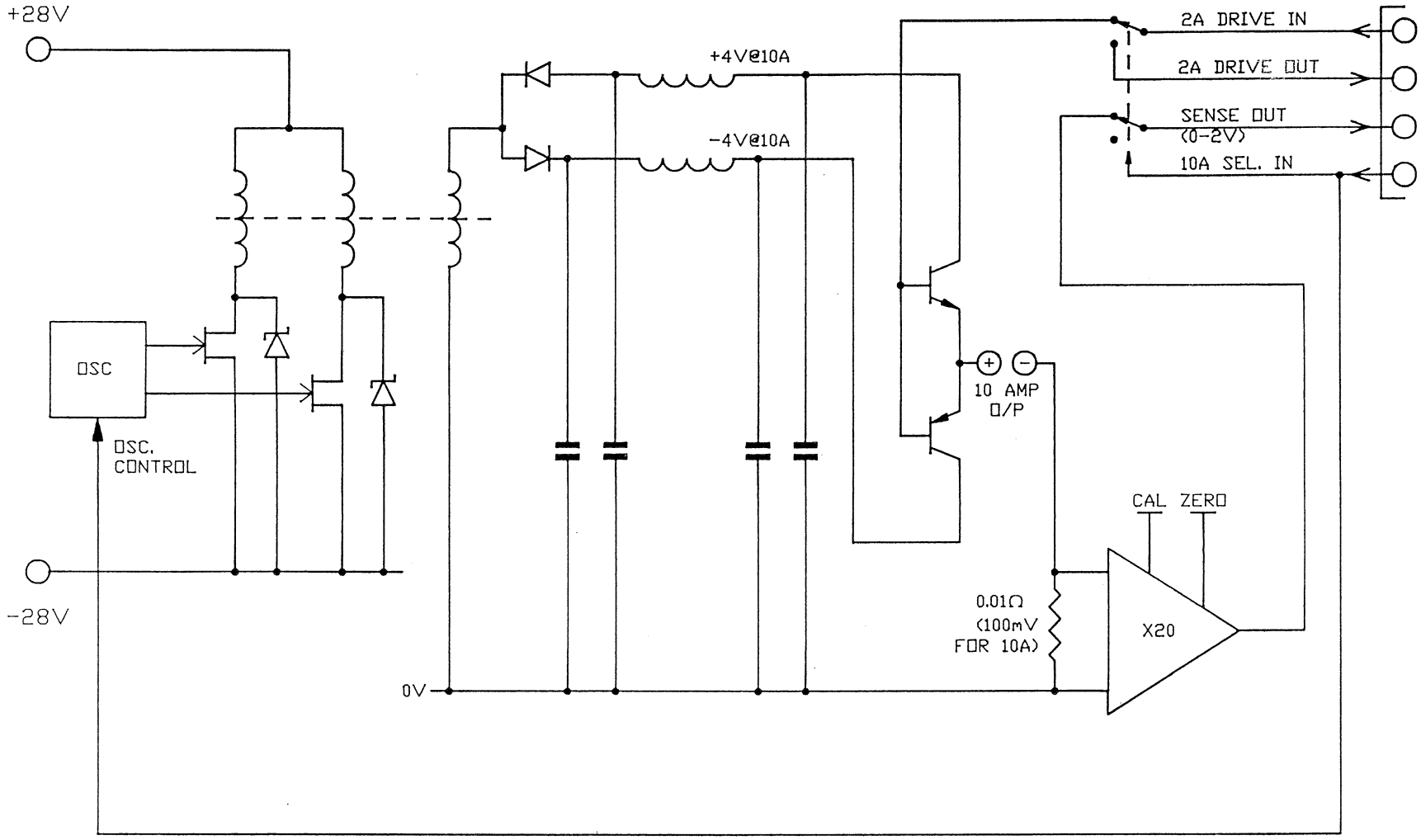
TIME ELECTRONICS LTD	DRAWN	J.B.	TITLE	9800 AC BOARD BLOCK DIAGRAM	
	APPRD				
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	9418B01
	DATE	3/7/85			

ISSUE	CHANGES

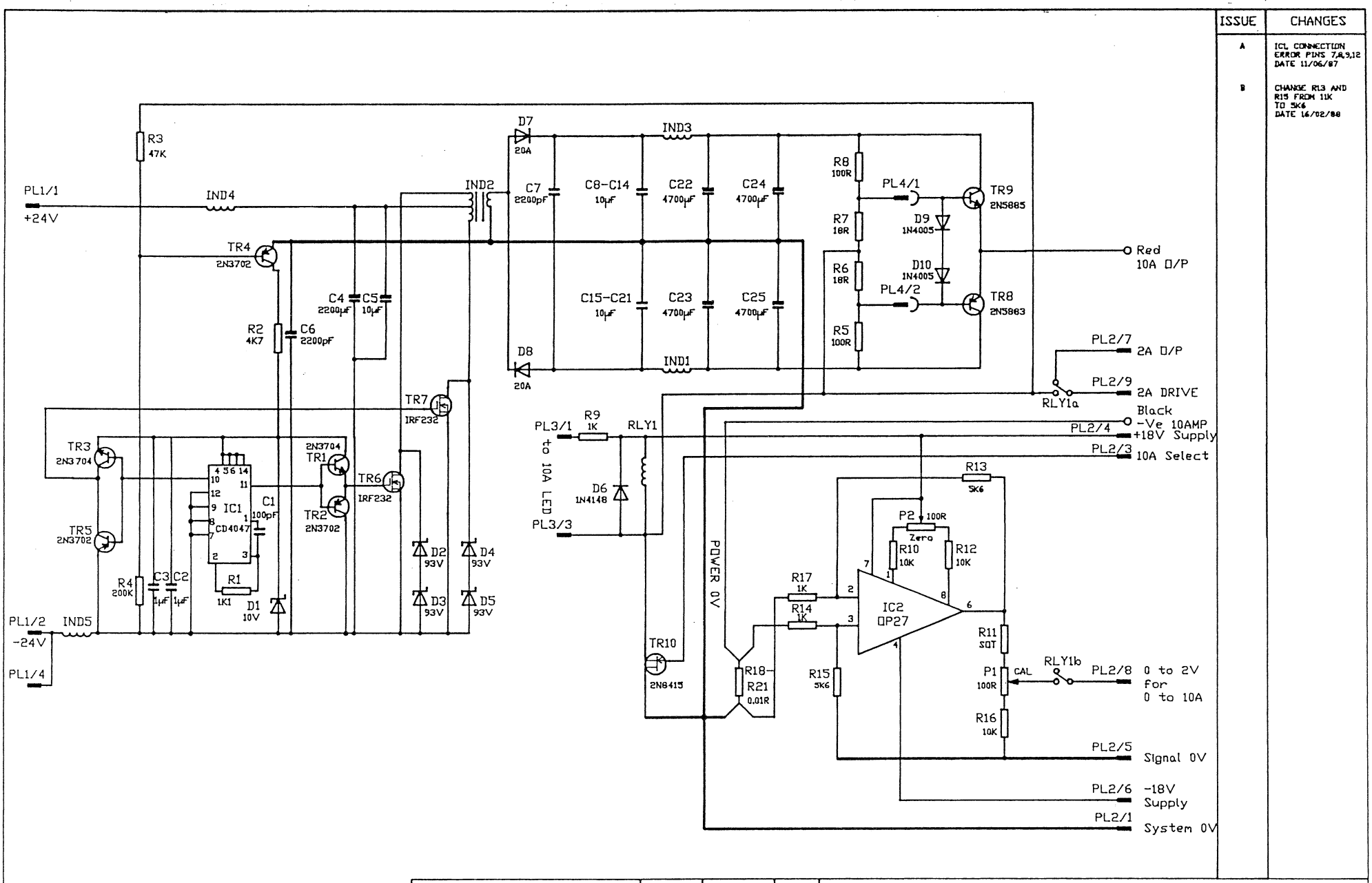


TIME ELECTRONICS LTD	DRAWN	B.D.	TITLE	9800 10 AMP BOARD LAYOUT	
	APPRD				
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	9428L01
	DATE	16/9/85			

ISSUE	CHANGES
A	3/7/85
B	4/2/88



TIME ELECTRONICS LTD	DRAWN	J.B.	TITLE	9800 10 AMP BOARD BLOCK DIAGRAM
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No 9428B01
	DATE	3/7/85		



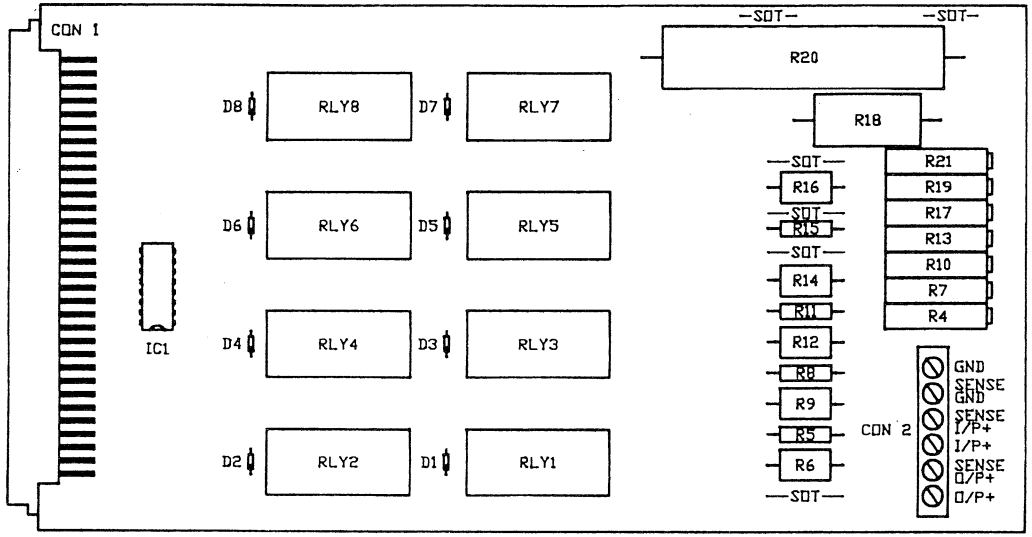
ISSUE	CHANGES
A	ICL CONNECTION ERROR PINS 7,8,9,12 DATE 11/06/87
B	CHANGE R13 AND R15 FROM 11K TO 5K6 DATE 16/02/88

TIME ELECTRONICS LTD

DRAWN	B.D.	TITLE
APPRD		10 AMP BOARD CIRCUIT DIAGRAM
SCALE		
DATE	25/9/85	DRG No 9428C01

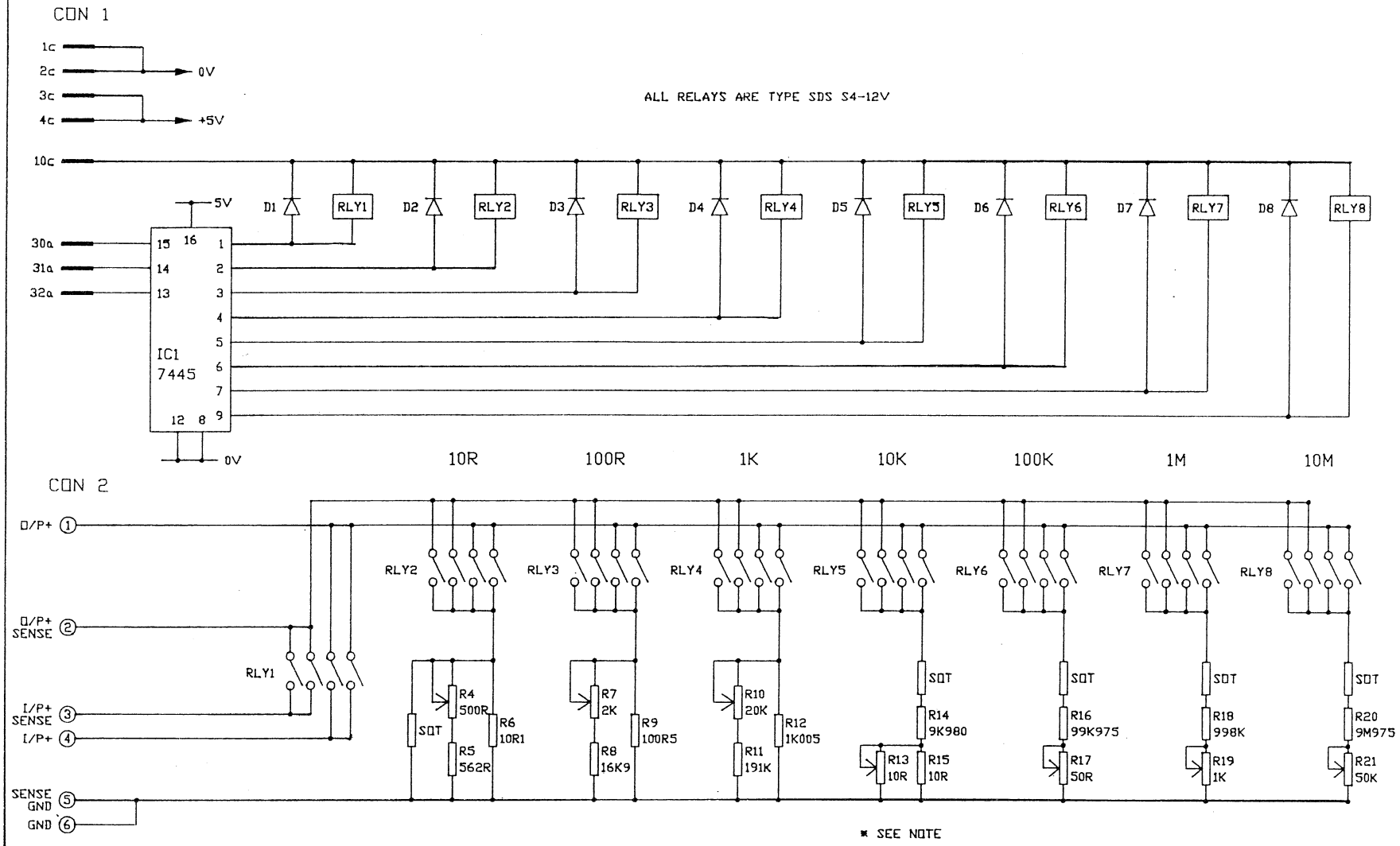
THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

ISSUE	CHANGES

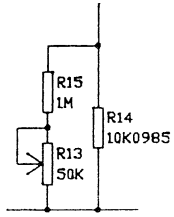


TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	9800 RESISTANCE BOARD
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No 9414L01
	DATE	12/2/88		

ISSUE	CHANGES
E	DRAWN ON ACAD 11/02/88



NOTE -
IN SOME UNITS THE 10K RANGE MAY BE WIRED DIFFERENTLY AS SHOWN THUS -



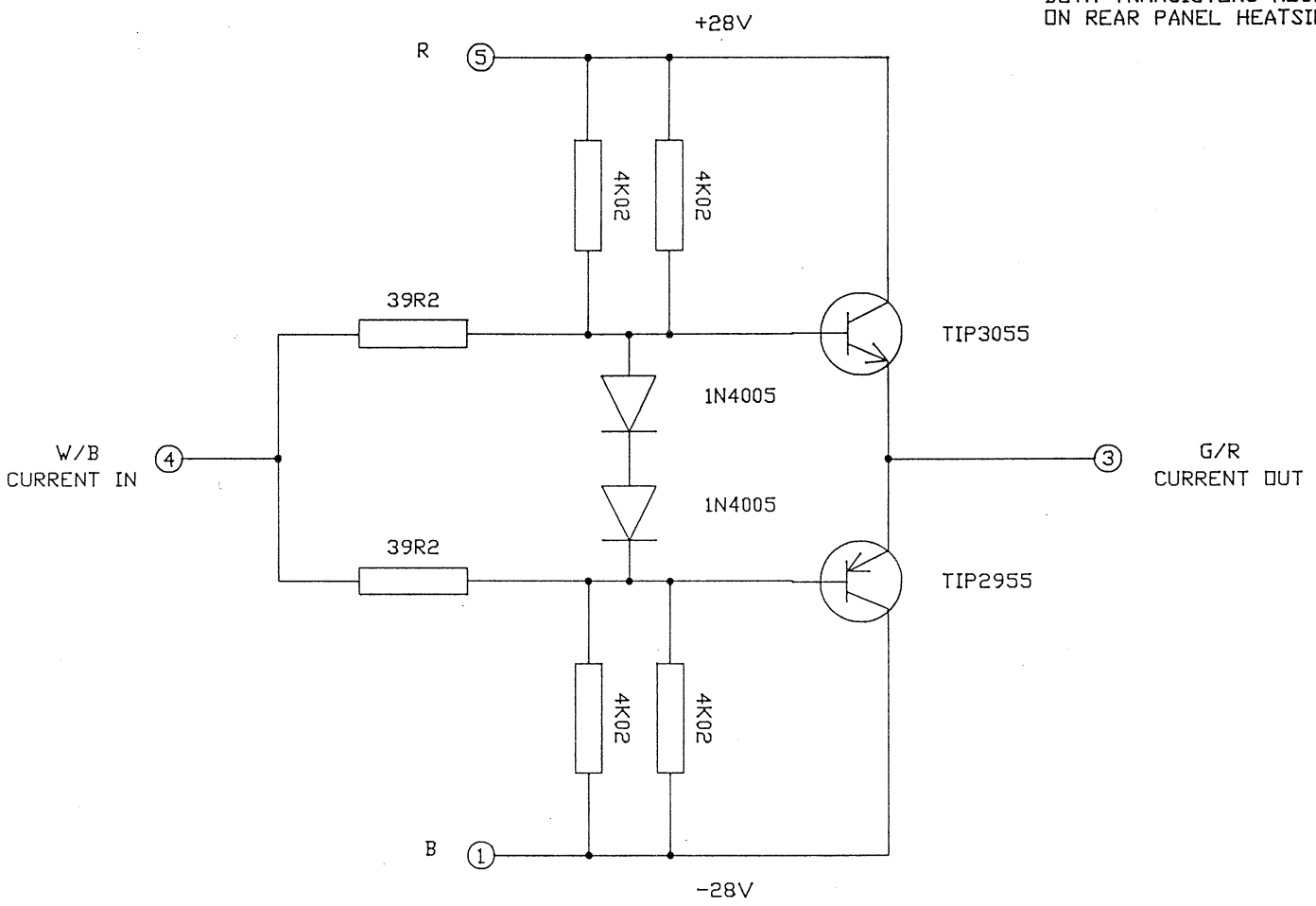
TIME ELECTRONICS LTD

DRAWN	P.J.G.	TITLE
APPRD		PROG. RES. BOARD DIAGRAM
SCALE		
DATE	10/2/88	DRG No 9414C01

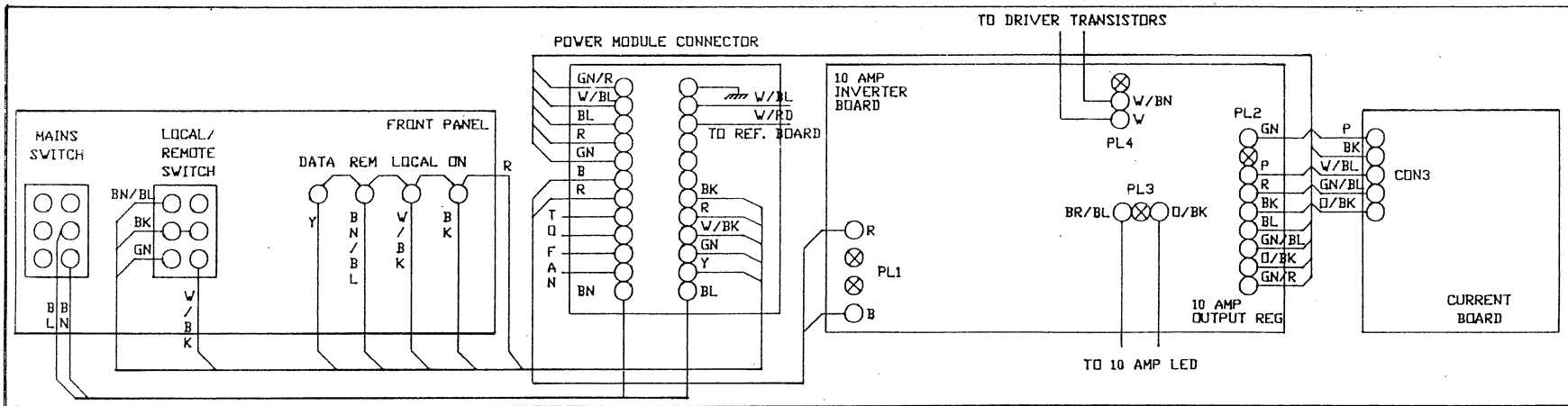
THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

ISSUE	CHANGES

BOTH TRANSISTORS MOUNTED
ON REAR PANEL HEATSINK.

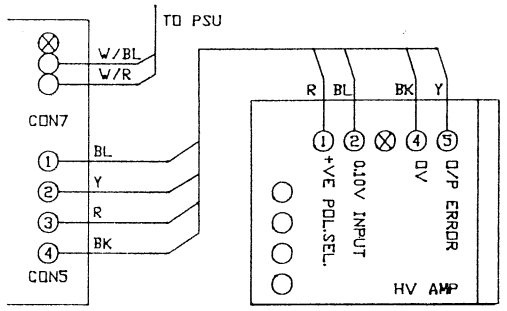


TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	9822 TRANSISTOR NETWORK	
	APPRD				
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	9572C10
	DATE	16/2/88			

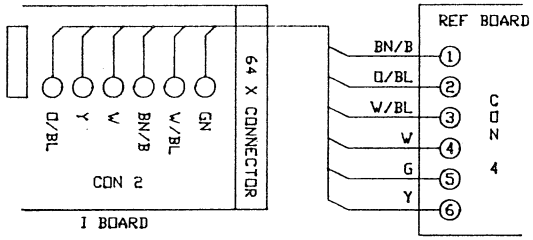


ISSUE	CHANGES

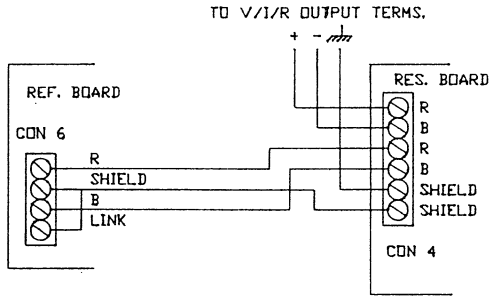
REF - HV WIRING



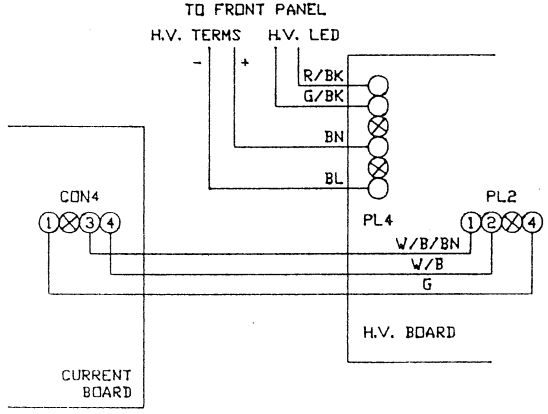
REF - I BOARD WIRING



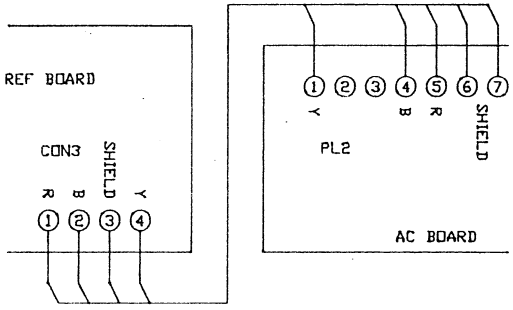
REF - RES. BOARD WIRING



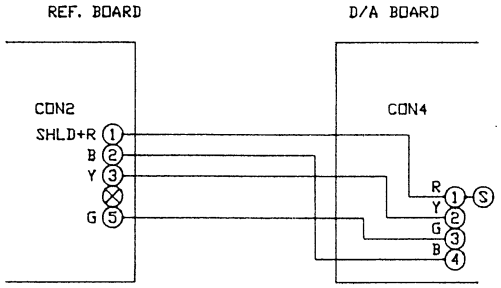
CURRENT - H.V, H.V. - FRONT PANEL



REF-AC BOARD WIRING



REF - D/A BOARD WIRING



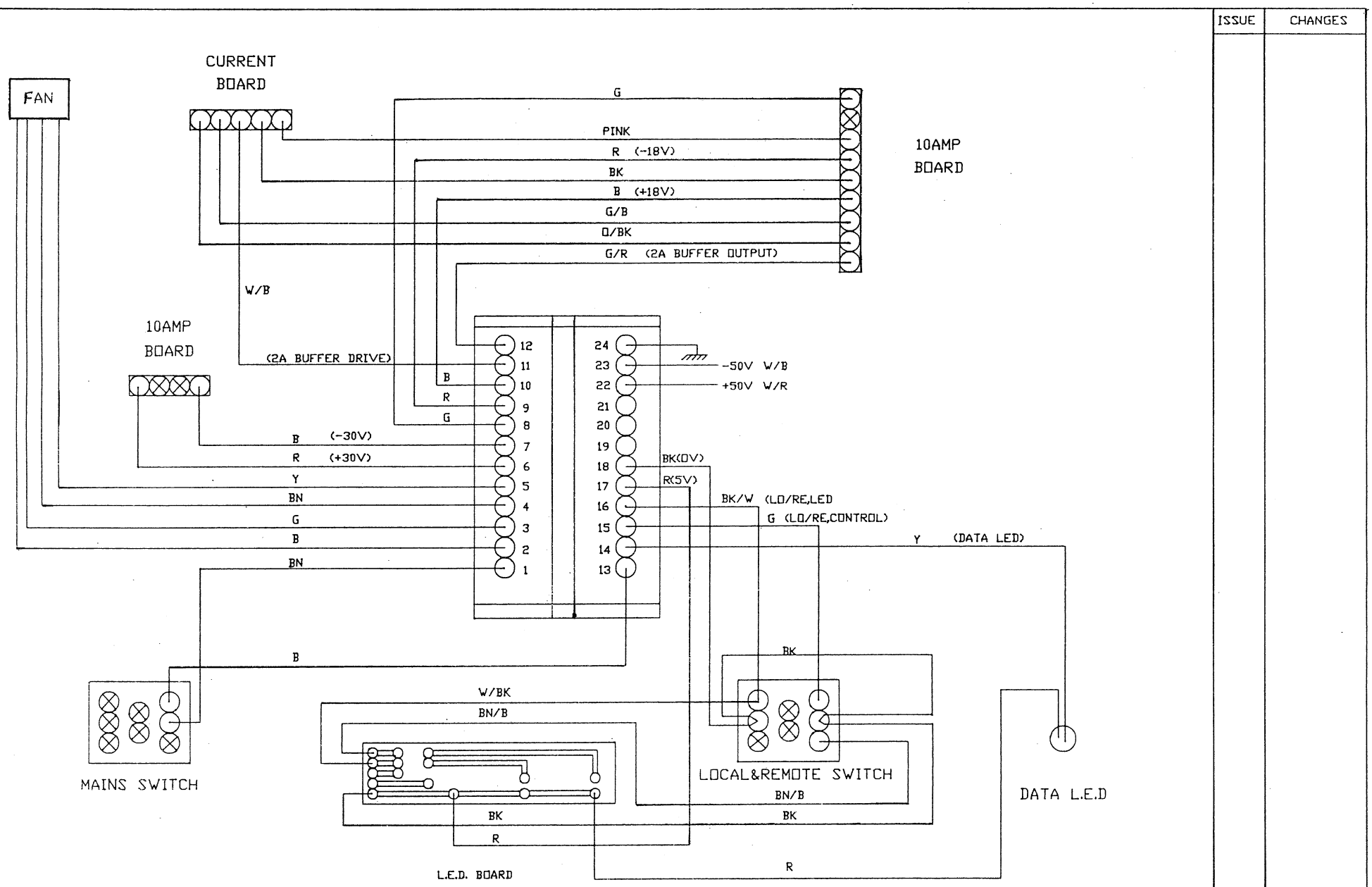
TIME ELECTRONICS LTD

DRAWN	P.J.G.	TITLE
APPRD		
SCALE	NON/APP	
DATE	15/2/88	

9822 INTER-BOARD WIRING

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No WIRING/9822W03



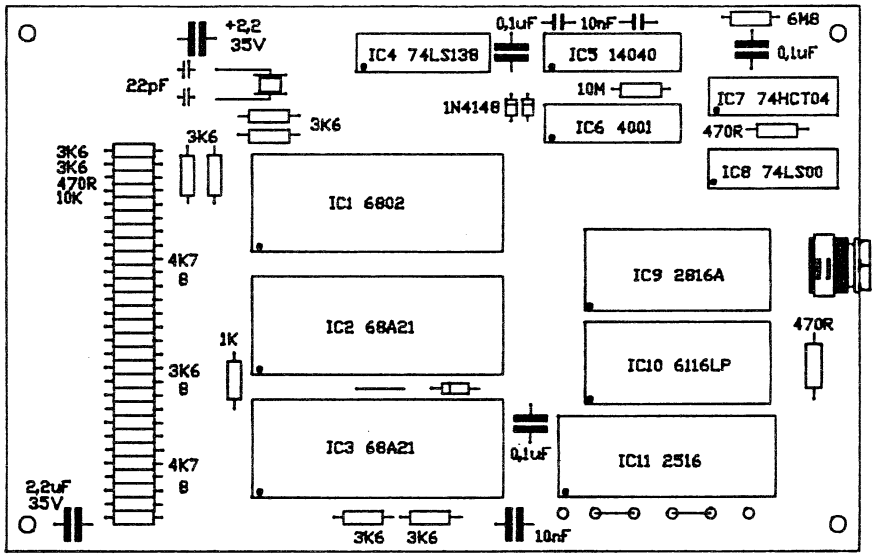
ISSUE	CHANGES

TIME ELECTRONICS LTD

DRAWN	C.A.L	TITLE
APPRD		9821, 22, 23 WIRING FROM PSU CON.
SCALE		
DATE	13-3-86	DRG No 9822W01

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

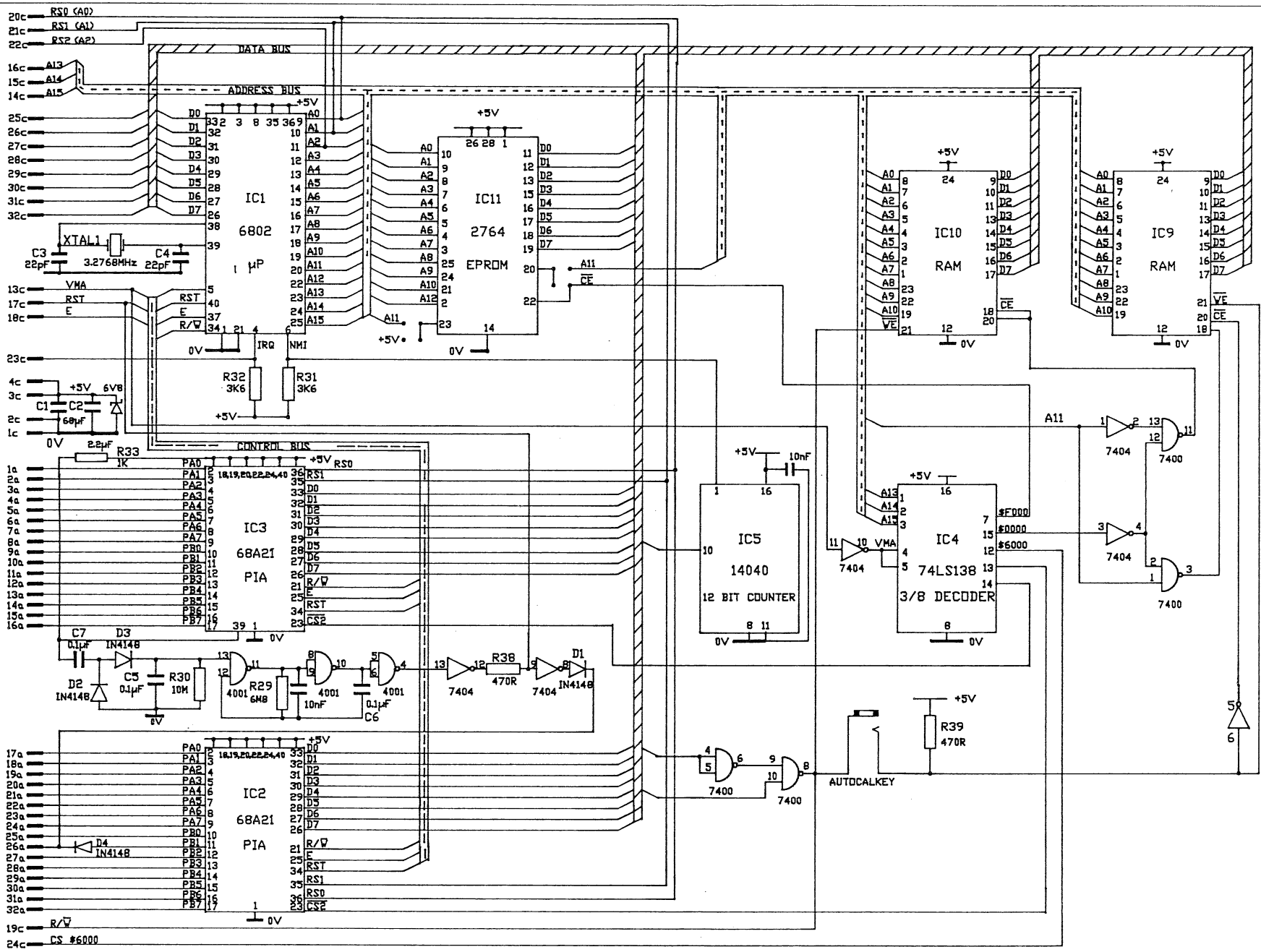
ISSUE	CHANGES



TIME ELECTRONICS LTD

DRAWN	C/A/L	TITLE
APPRD		PROCESSOR BOARD LAYOUT
SCALE		
DATE	20/8/87	DRG No 9574L02

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED



ISSUE	CHANGES
A	30/8/85
B	26/01/88
C	02/01/91

PULL UP RESISTORS

IC2			IC3		
A0...A7	R12...R5	4K7	A0...A7	R28...R21	4K7
A8	R4	10K	A8...A15	R20...R13	3K6
A9	R3	470R			
A10	R2	3K6			
A11	R1	3K6			
A12...A15	R34...R37	3K6			

TIME ELECTRONICS LTD

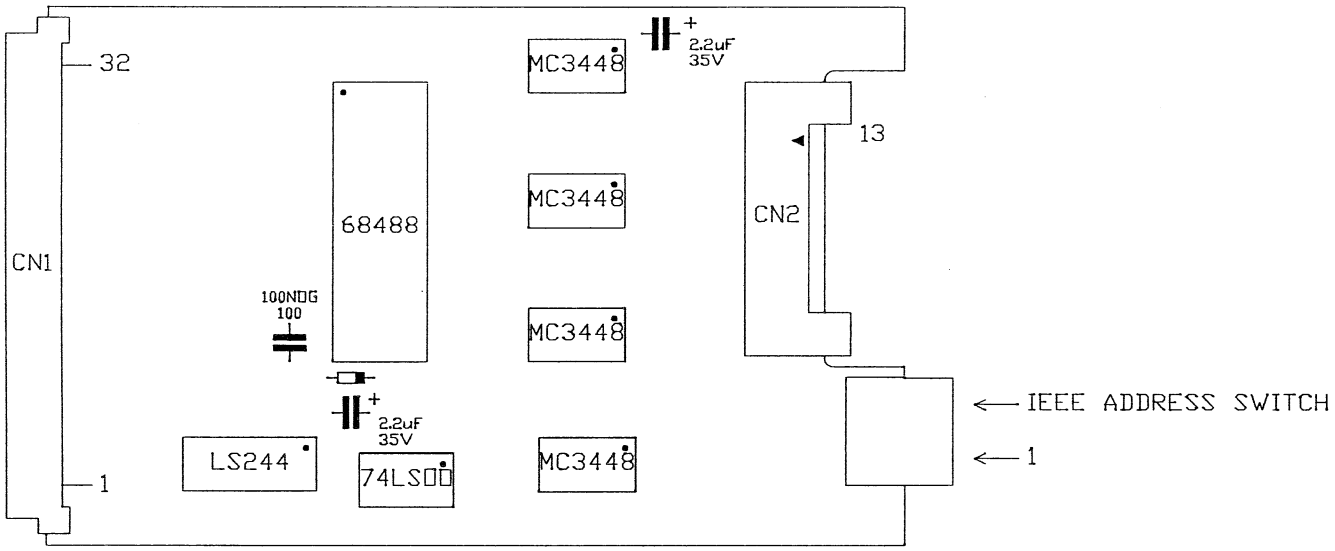
DRAWN	B.O.	TITLE
APPRD		µP BOARD A270 V1.2 CIRCUIT BOARD
SCALE		
DATE	30/8/85	DRG No 9574C01

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

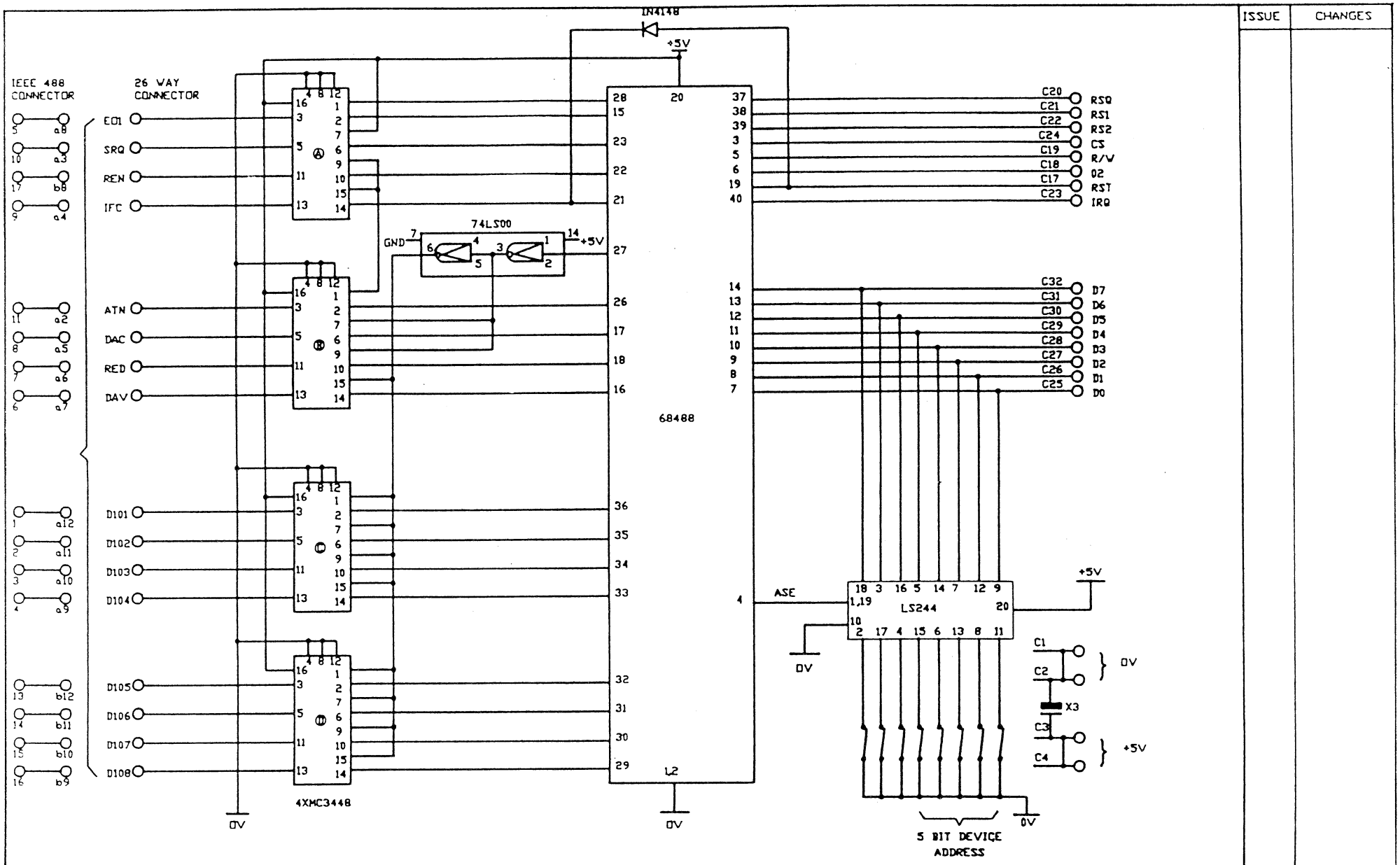
ISSUE	CHANGES

CN1 - BUS CONNECTOR

CN2 - IEEE BUS CONNECTOR



TIME ELECTRONICS LTD	DRAWN	C/A/L	TITLE	IEEE BOARD LAYOUT
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No
	DATE	24/8/87		LAYOUT/9573L01



ISSUE	CHANGES

TIME ELECTRONICS LTD

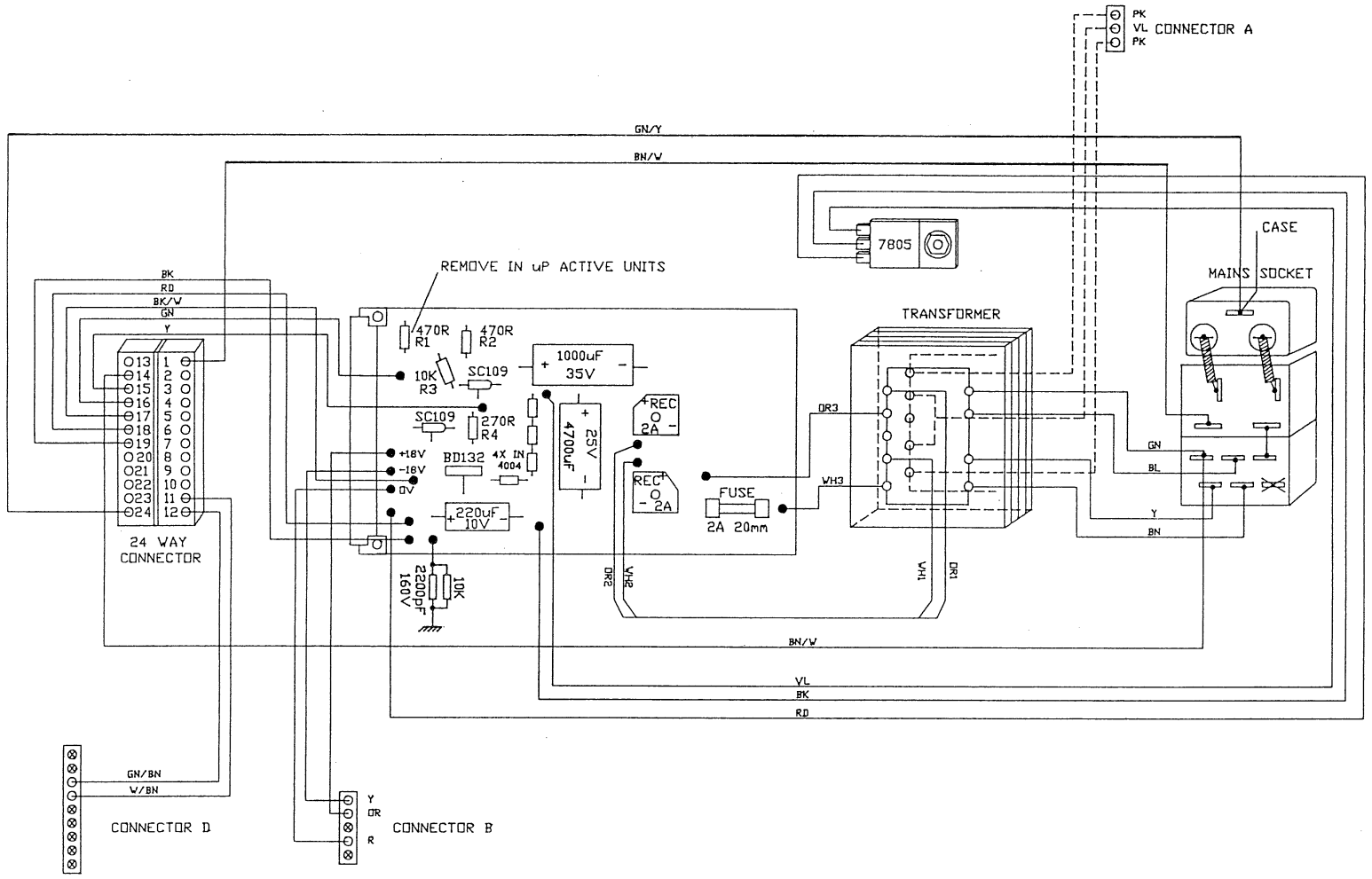
DRAWN	P.J.G.
APPRD	
SCALE	
DATE	18/2/88

TITLE: IEEE INTERFACE BOARD

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No: CIRCUIT/9573C01

ISSUE	CHANGES

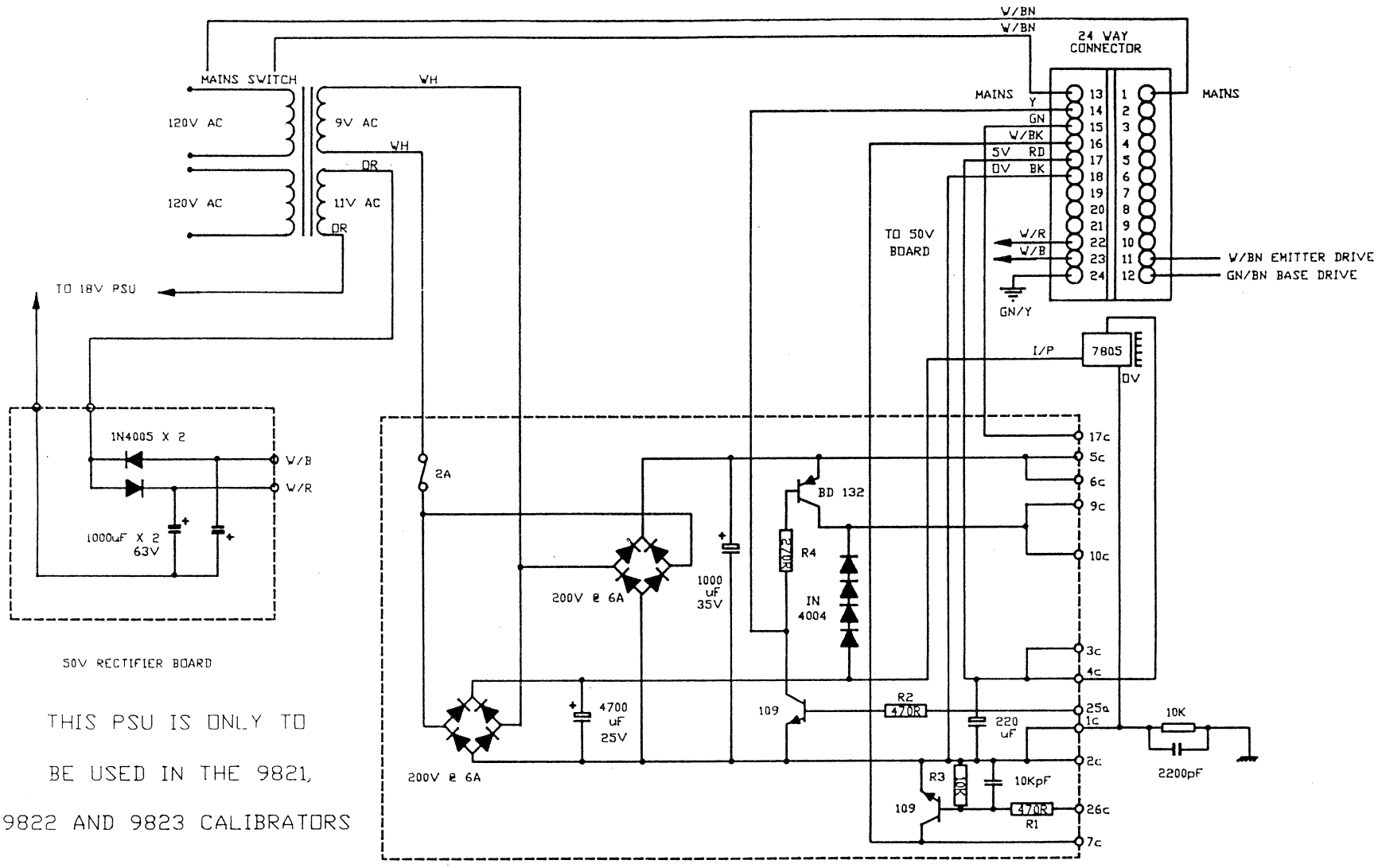


TIME ELECTRONICS LTD	DRAWN	C/A/L	TITLE: 9800 P.S.U. LAYOUT AND WIRING
	APPRD		
	SCALE		
	DATE	31/3/87	

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

DRG No: 9572L02

ISSUE	CHANGES



THIS PSU IS ONLY TO BE USED IN THE 9821, 9822 AND 9823 CALIBRATORS

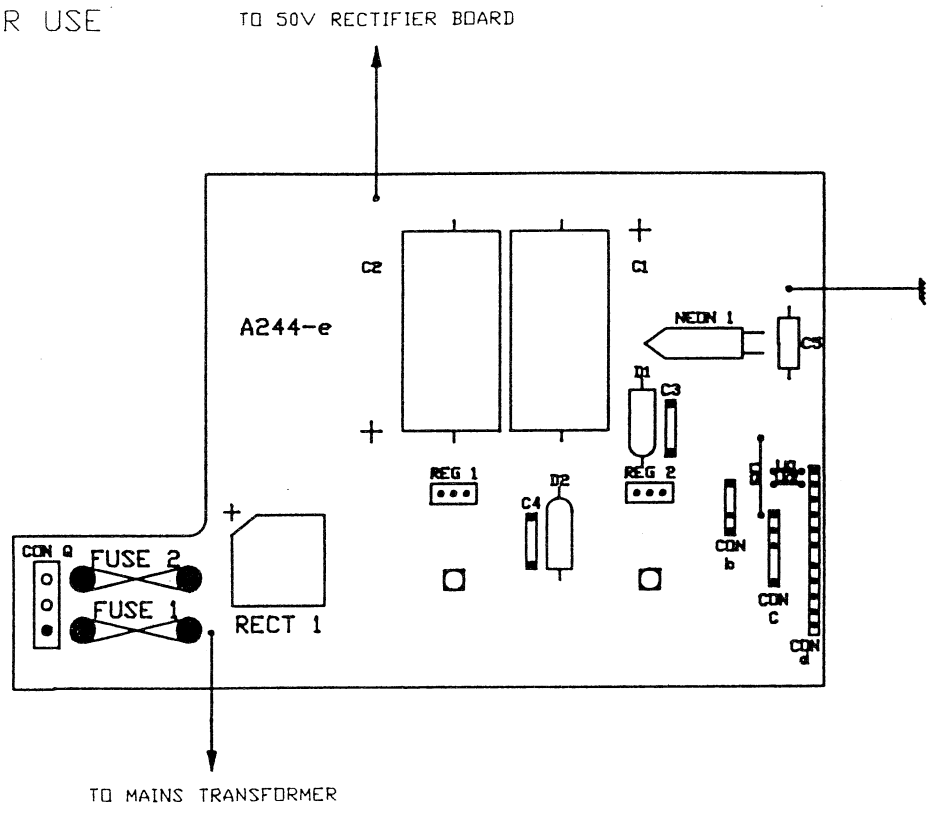
TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	POWER SUPPLY MODULE CIRCUIT DIAGRAM
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No 9572C02
	DATE	28/1/88		

ISSUE	CHANGES

THIS BOARD ONLY FOR USE

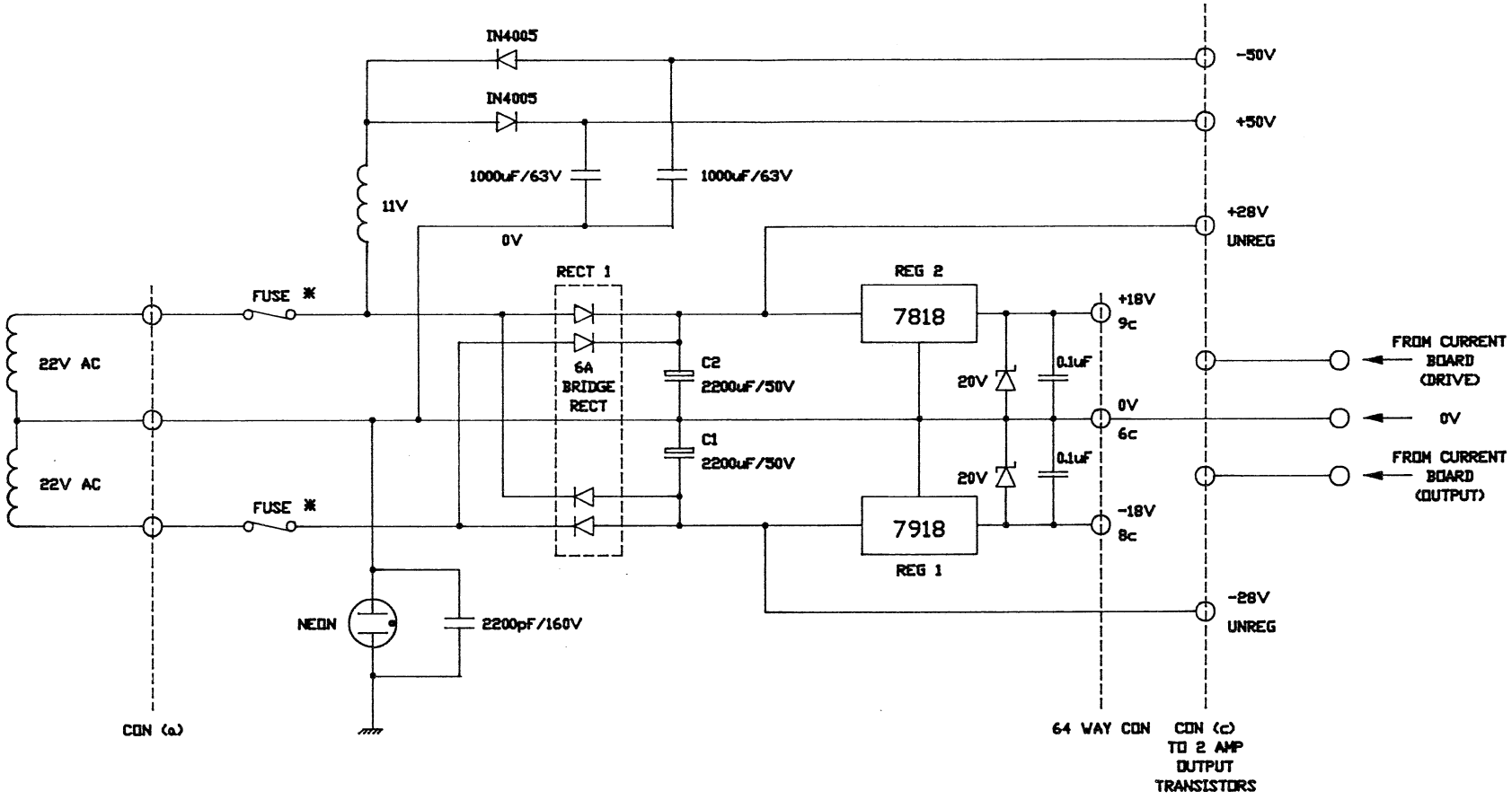
IN 9821, 9822, 9823

CALIBRATORS



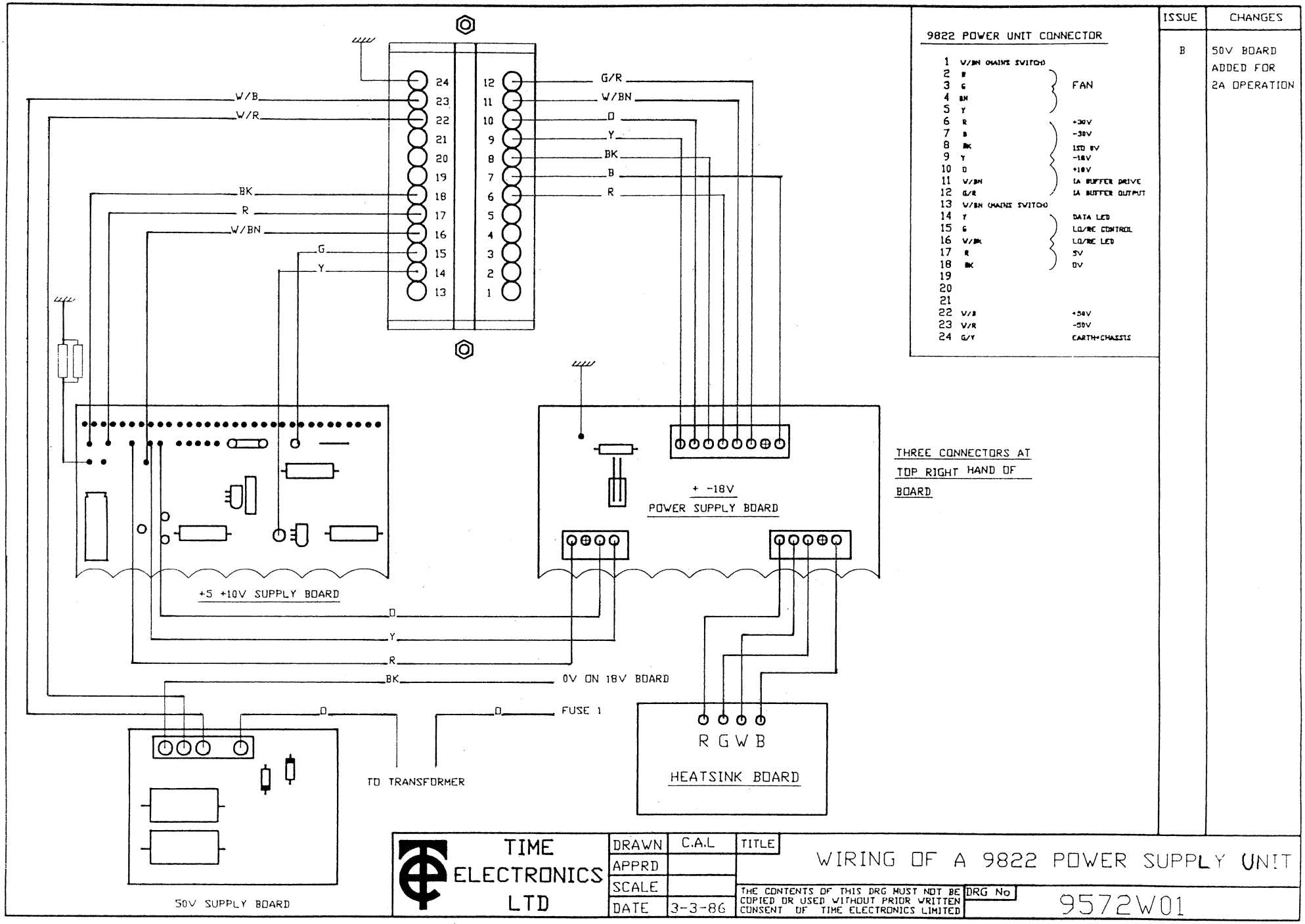
TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	+/- 18 VOLT REGULATOR BOARD LAYOUT
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No 9572L04
	DATE	27/1/88		

ISSUE	CHANGES
A	FUSES CHANGED TO 3.15A FROM 2.5A.
B	-18V PIN CORRECTION 08/09/88
C	+/-50V POWER LINES ADDED TO CIRCUIT 02/01/91-S.A.H.



* - 3.15A FOR 9821/22/23
2.5A FOR OTHER UNITS

TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	9800 SERIES +18V POWER SUPPLY
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No 9572C05
	DATE	28/1/88		



9822 POWER UNIT CONNECTOR

1	W/BN CHAINS SWITCH	
2	B	FAN
3	G	
4	BN	
5	Y	
6	R	+30V
7	B	-30V
8	BK	15Ω 8V
9	Y	-18V
10	O	+18V
11	W/BN	1A BUFFER DRIVE
12	G/R	1A BUFFER OUTPUT
13	W/BN CHAINS SWITCH	
14	Y	DATA LED
15	G	LO/RE CONTROL
16	W/BK	LO/RE LED
17	R	5V
18	BK	0V
19		
20		
21		
22	W/B	+50V
23	W/R	-50V
24	G/Y	EARTH+CHASSIS

ISSUE	CHANGES
B	50V BOARD ADDED FOR 2A OPERATION

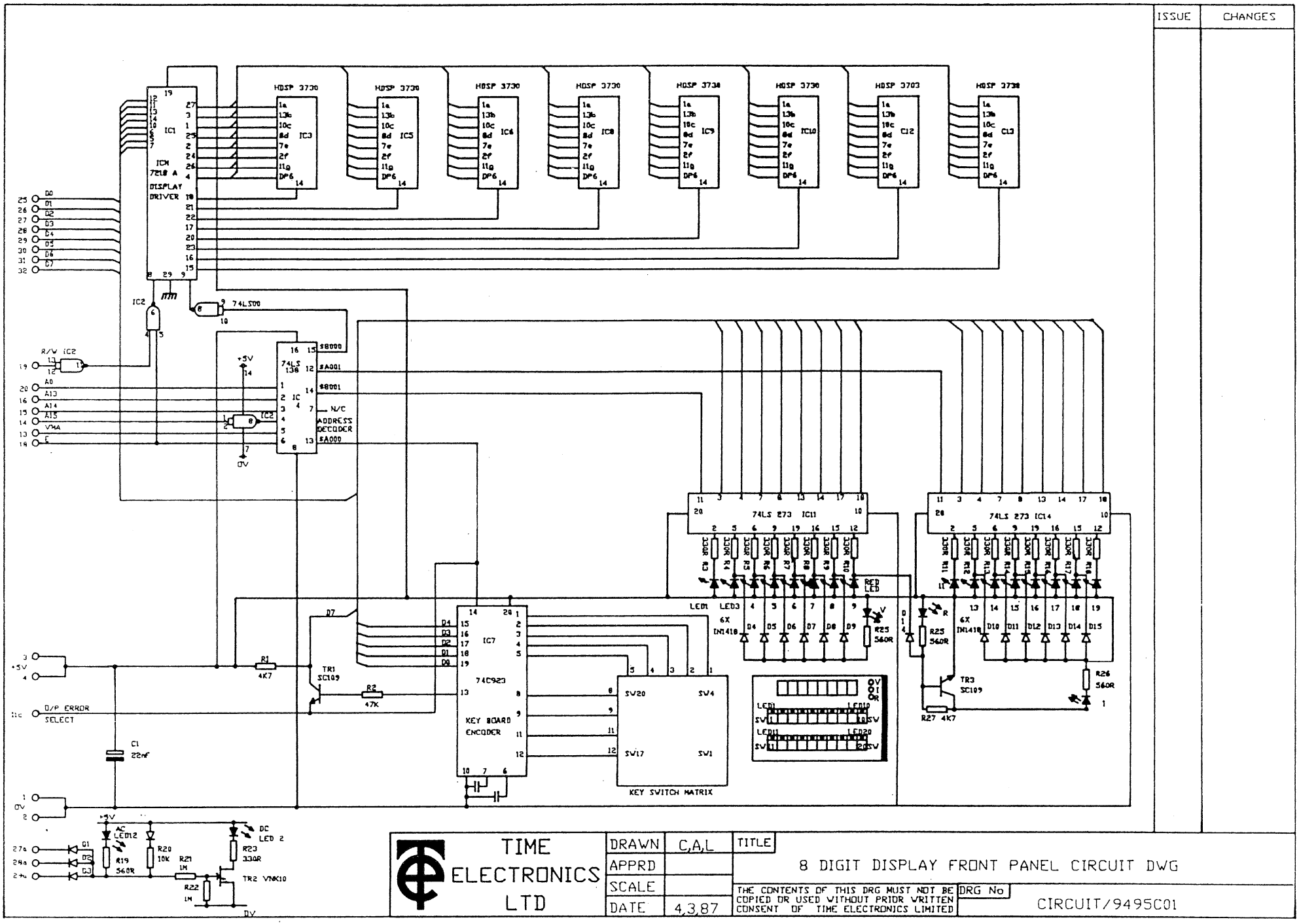
TIME ELECTRONICS LTD

DRAWN	C.A.L	TITLE
APPRD		
SCALE		
DATE	3-3-86	

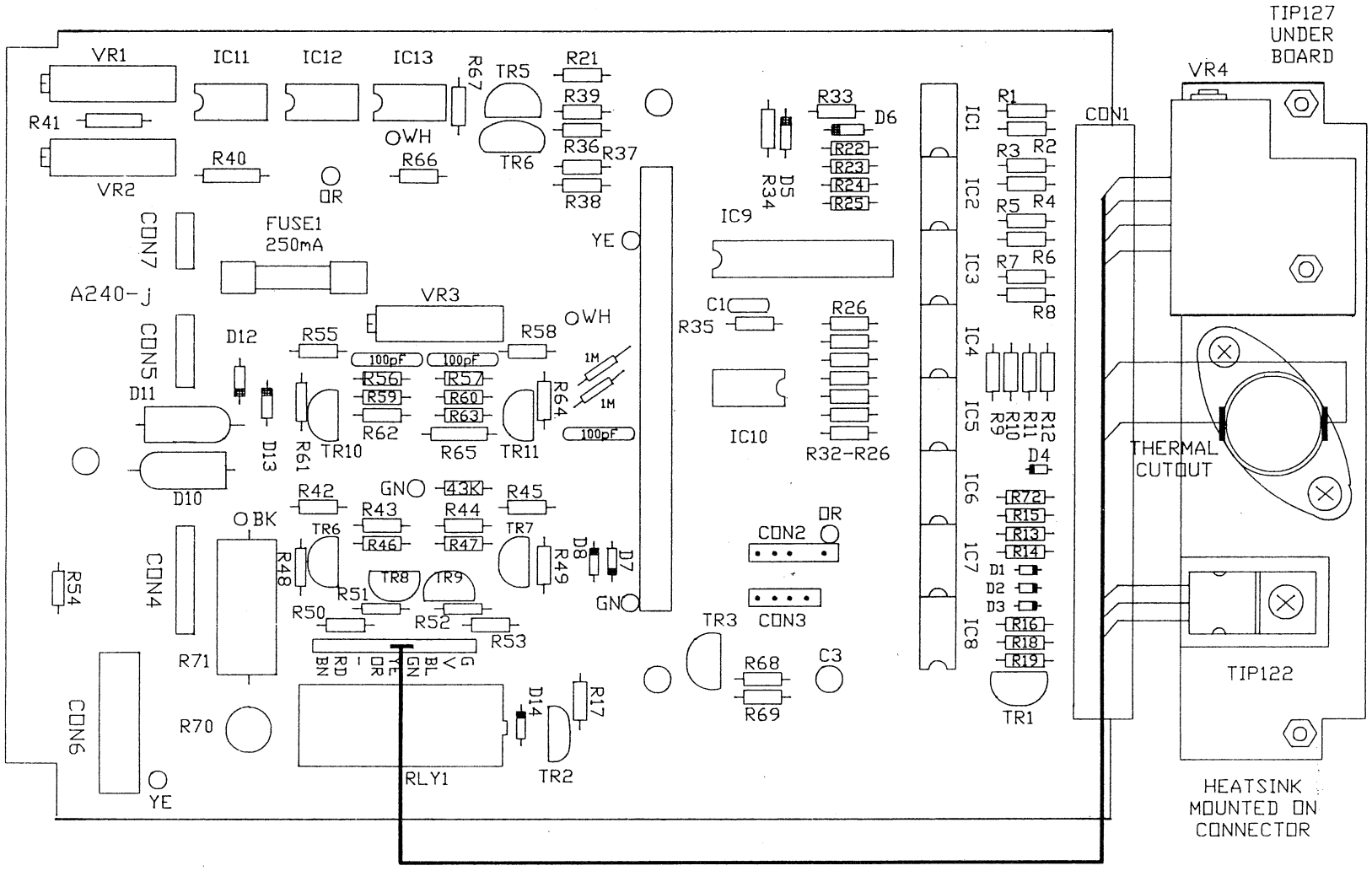
TITLE: WIRING OF A 9822 POWER SUPPLY UNIT

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

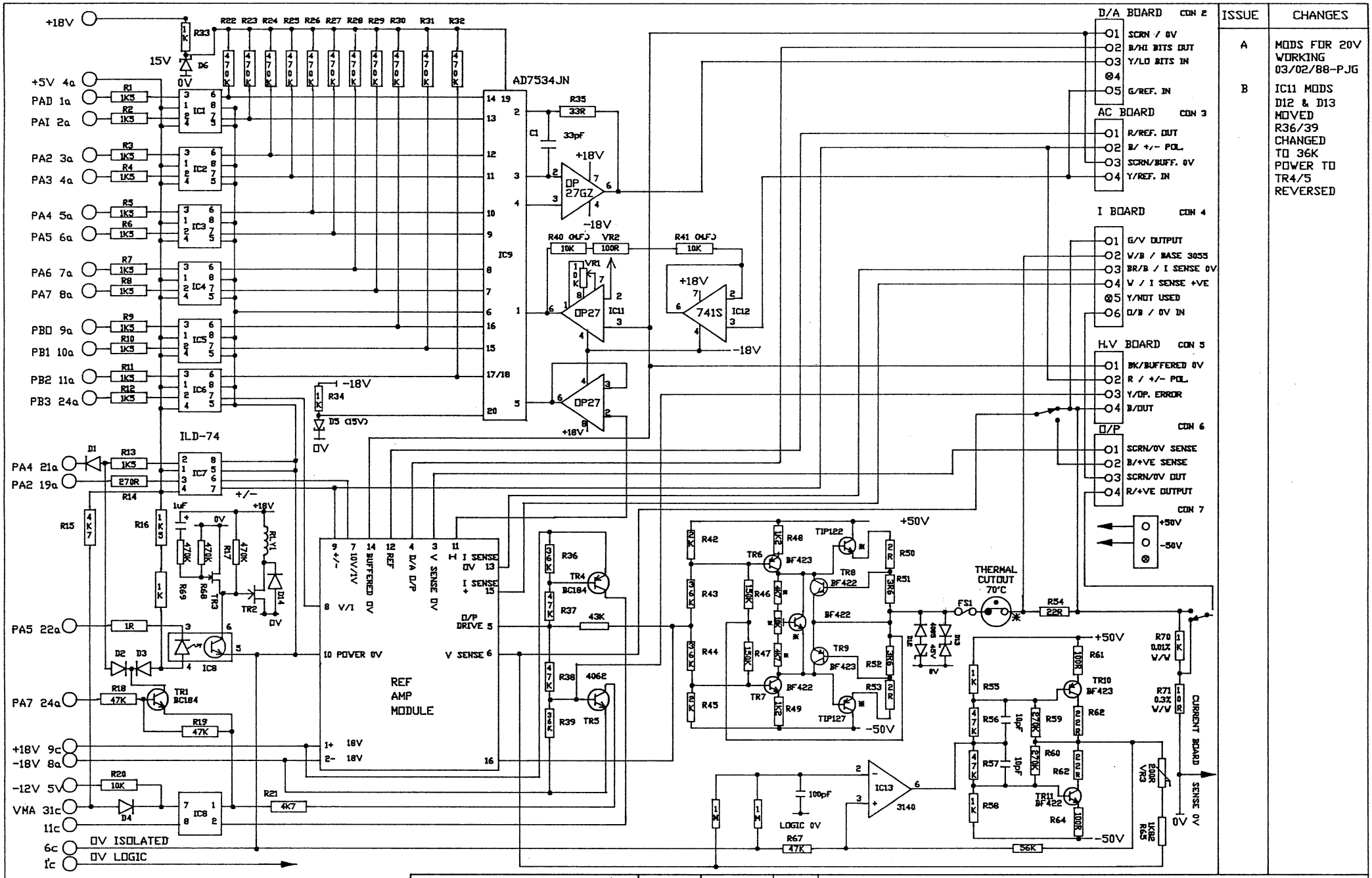
DRG No: 9572W01


ISSUE
CHANGES
HDSP 3730
IC1
ICM 7218 A
DISPLAY DRIVER
IC2
74LS00
R/W
A0
A13
A14
A15
VMA
E
74LS 138
IC4
ADDRESS DECODER
$8000
$A001
$8001
$A000
N/C
+5V
0V
74LS 273 IC11
74LS 273 IC14
RED LED
6X IN1418
R25 560R
R26 560R
R27 4K7
TR3 SC109
IC7
74C923
KEY BOARD ENCODER
KEY SWITCH MATRIX
SW20
SW4
SW17
SW1
R1 4K7
TR1 SC109
R2 47K
C1 22nF
O/P ERROR SELECT
AC LED12
DC LED 2
R19 560R
R20 10K
R21 1M
R22 1M
R23 330R
TR2 VN10K
TIME ELECTRONICS LTD
DRAWN C,A,L
APPRD
SCALE
DATE 4,3,87
TITLE
8 DIGIT DISPLAY FRONT PANEL CIRCUIT DWG
THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED
DRG No
CIRCUIT/9495C01

ISSUE	CHANGES



TIME ELECTRONICS LTD	DRAWN	P.J.G.	TITLE	REF BOARD LAYOUT
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No 9404L01
	DATE	19/2/88		

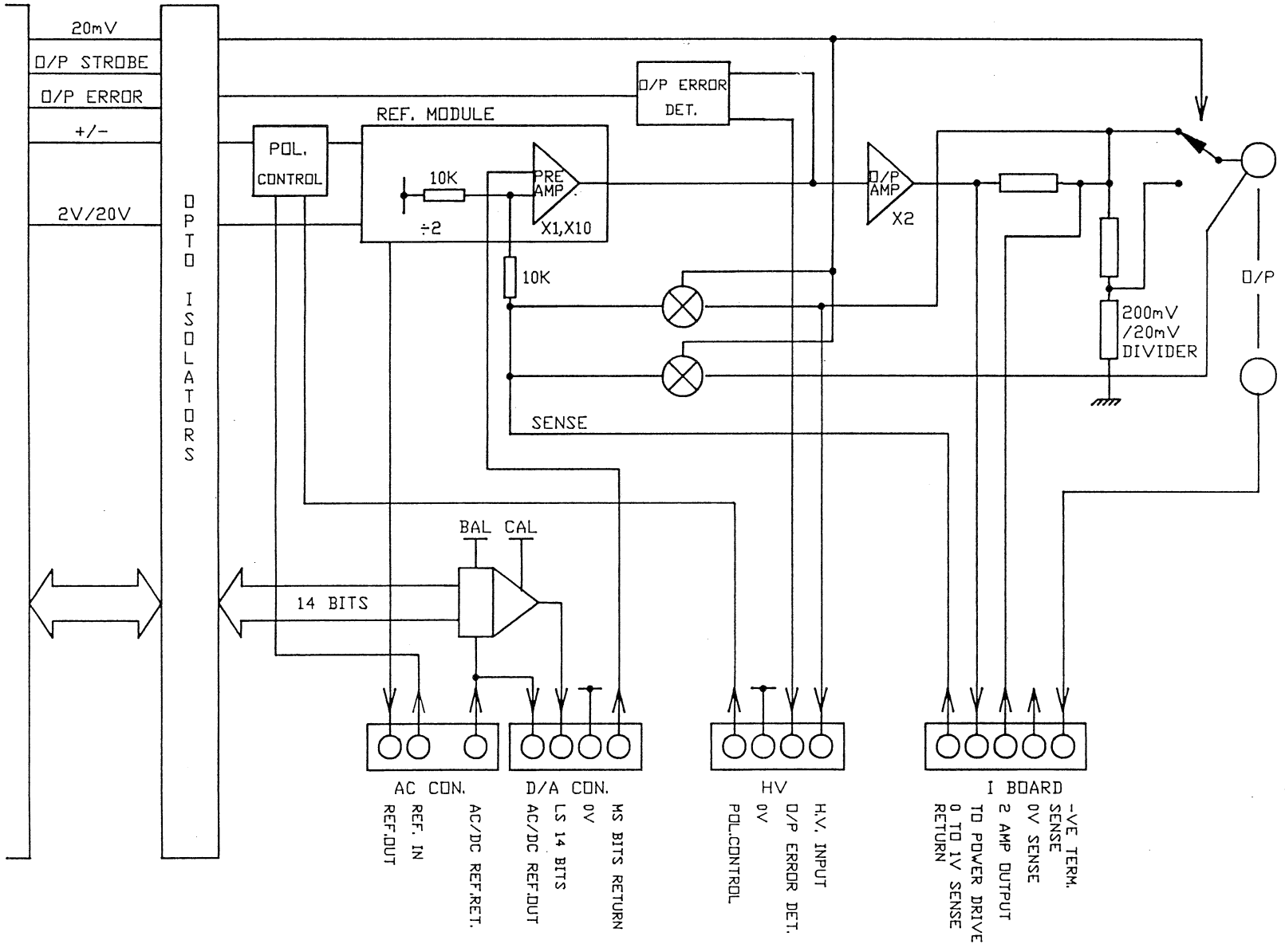


ISSUE	CHANGES
A	MODS FOR 20V WORKING 03/02/88-PJG
B	IC11 MODS D12 & D13 MOVED R36/39 CHANGED TO 36K POWER TO TR4/5 REVERSED

TIME ELECTRONICS LTD

DRAWN	C,A,L	TITLE
APPRD		REFERENCE BOARD CIRCUIT DIAGRAM
SCALE		
DATE	24.2.87	DRG No CIRCUIT/9404C03

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED



ISSUE	CHANGES
A	3/7/85
B	MODS. FOR 20V WORKING 22/02/88 P.J.G.

TIME ELECTRONICS LTD

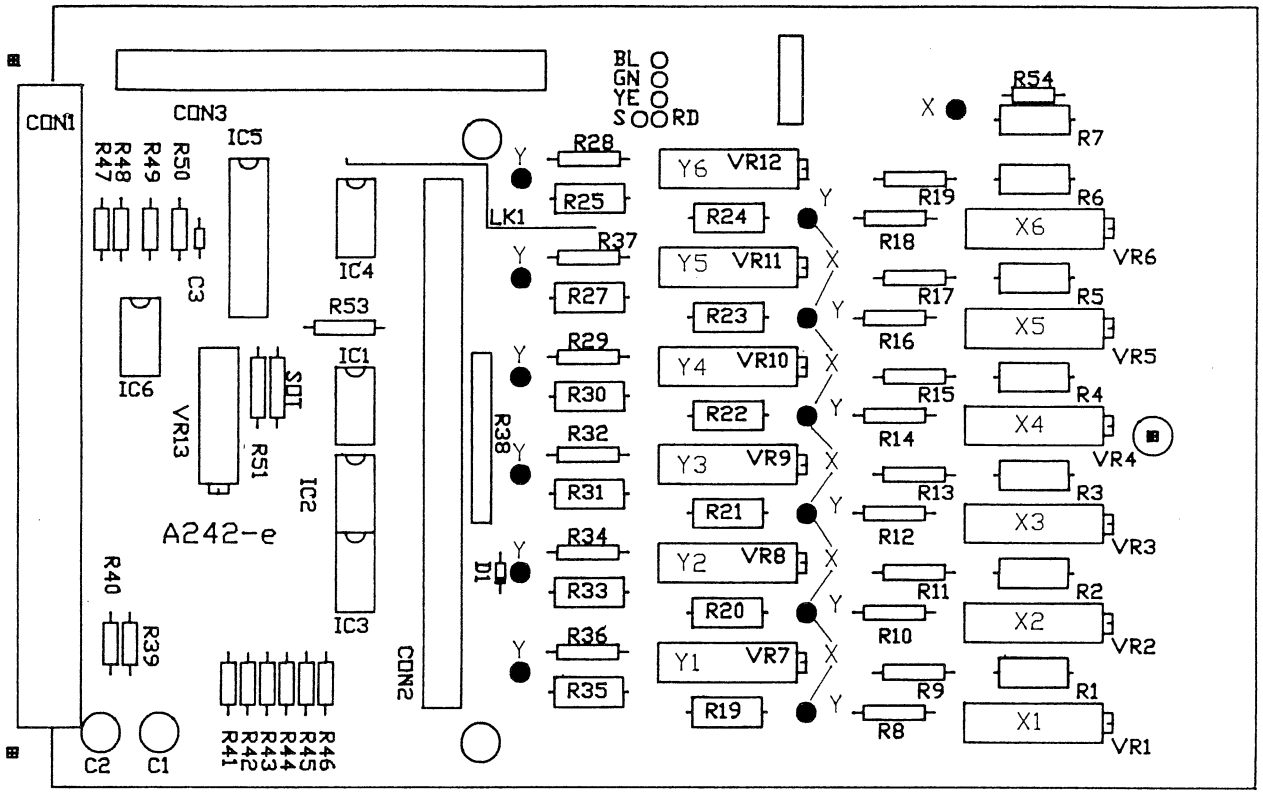
DRAWN	J.B.
APPRD	
SCALE	
DATE	3/7/85

TITLE: 9800 REFERENCE BOARD BLOCK DIAGRAM

THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED

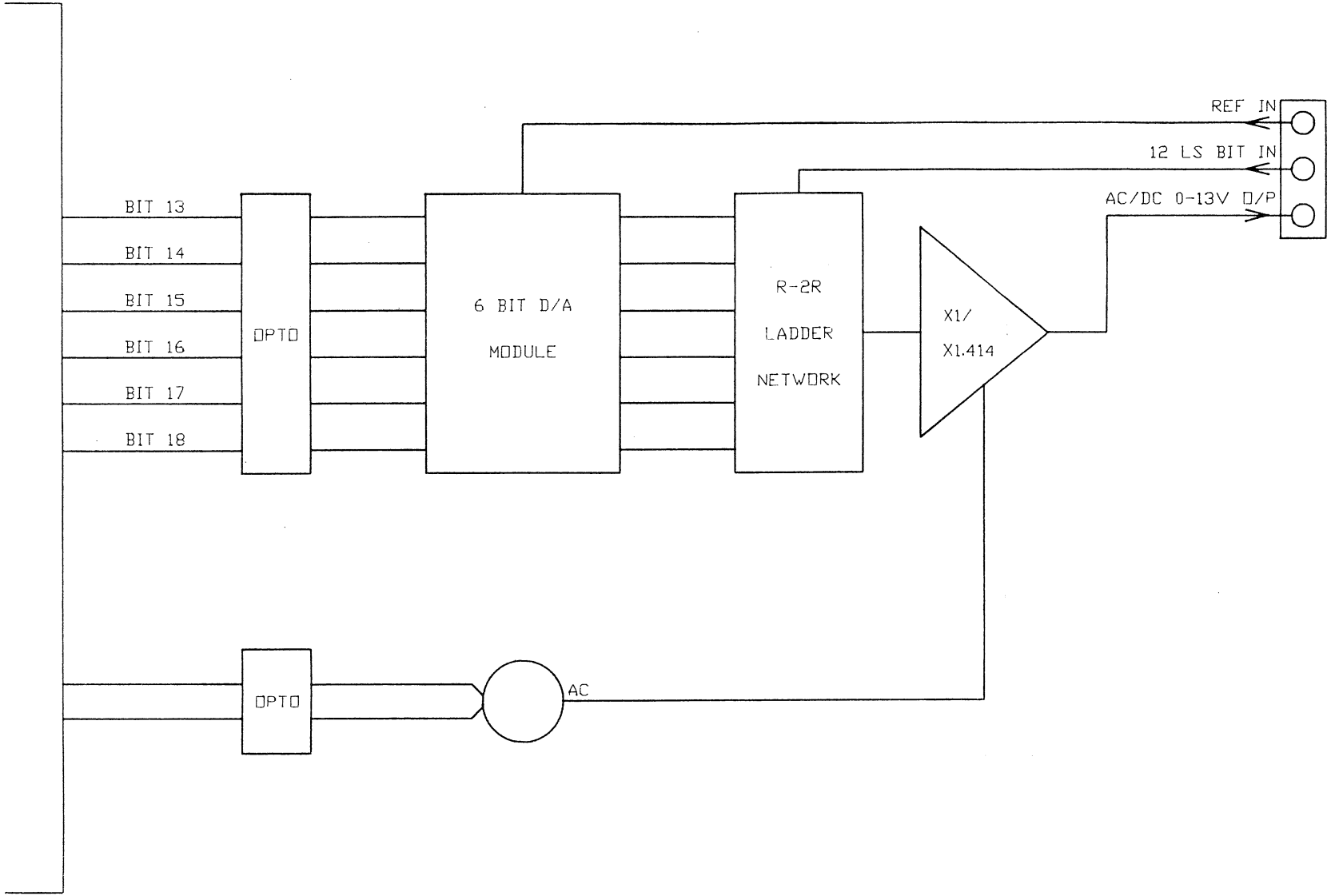
DRG No 9404B01

ISSUE	CHANGES



TIME ELECTRONICS LTD	DRAWN	C/A/L	TITLE	D/A BOARD CALIBRATION POINTS
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No LAYOUT/9403L01
	DATE	27,8,87		

ISSUE	CHANGES
A	3/7/85



TIME ELECTRONICS LTD	DRAWN	J.B.	TITLE	9800 D/A BOARD BLOCK DIAGRAM
	APPRD			
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No 9403B01
	DATE	3/7/85		

TABLE 5.3 IEEE COMMAND LIST

D	Transmit display to bus controller
E1 to E4	Select unit action upon output error detection.
F15 to F20000	Select output frequency.
G1 or G2	Set / Cancel Group execute trigger response.
H	Set output to full scale.
I	Select serial poll operation.
K1 or K2	Enable/Disable Front panel controls.
L	Set output to zero.
O1 to O7	Output resistance between 10 Ohms and 10 M Ohms. O1 – 10 Ohms O5 – 100 K Ohms O2 – 100 Ohms O6 – 1 M Ohms O3 – 1 K Ohms O7 – 10 M Ohms O4 – 10 K Ohms
Pn	Change output by 'n' percent.
R1 to R12	Select range from 20 mV to 1 KV and 200 uA to 10 Amps. R1 – 20 mV R7 – 200 uA R3 – 200 mV R5 – 2 mA R3 – 2 V R9 – 20 mA R4 – 20 V R10 – 200 mA R5 – 200 V R11 – 2 A R6 – 1 KV R12 – 10 A RA – AUTORANGE
T1 or T2	Set terminator character appended to a transmission.
W1 to W7	Select waveform. W1 – Sine W2 – Square W3 – Ramp up W4 – Ramp down W5 – Triangle W6 – Trapezoidal W7 – D.C.
Z	Take present output as Zero Offset.
/	Command separator.

9823
10ppm Programmable Multi Function Calibrator

GPIB Command Manual

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Document Version: V1 (02/11/2009)

Contents

Remote GPIB (IEEE) Operation 2

1.1 Introduction 3
1.2 Data transfer and device addressing 3
1.3 GPIB (IEEE) Cables and connectors 3
1.4 IEC Bus connections 4
1.5 GPIB (IEEE) Connectors 4
1.6 GPIB (IEEE) Address selection 5
1.7 GPIB (IEEE) Commands 7
1.8 Single letter commands 9
1.9 Letter & Number command 11
1.10 Setting and output value 13
1.11 Setting voltage above 40V 13

Chapter 5. Remote GPIB (IEEE) Operation

1.1 Introduction

The IEEE-488 interface sometimes called GPIB (General Purpose Interface Bus) allows remote control of the instrument by a computer. Repetitive calibration work can be fully automated and fast, less skilled users can undertake complete calibration procedures. Additionally results are stored and certificates can be immediately printed out.

1.2 GPIB (IEEE) data transfer and addressing

Before a controller can send data it has to identify the recipient. Each device on the GPIB (IEEE) is given an address to which it will respond when called by the controller, in this way data can be transferred between selected devices in an orderly manner. The rate at which it is transferred is controlled by hand shake signals, the speed being governed by the slowest device active on the bus.

1.3 GPIB (IEEE) Cables and connectors

The IEEE-488 cable contains 24 wires terminated at both ends with identical plug/sockets which allow for daisy chaining of additional cables to extend the bus. See Table 5.2 for details of connections.
Cables used on GPIB (IEEE) systems are available in various lengths to suit different layouts. The following are recommended types :-

Manufacturer/Supplier	Part No	Length
Belden	9642	1m
Belden	9643	2m
Belden	9644	4m
Belden	9645	8m
Time Electronics	9596	1m
Time Electronics	9597	2m

GPIB (IEEE bus) Cables part numbers

1.4 IEC Bus connections

A user requiring to connect the calibrator to a European standard bus (IEC), must be aware of the differences in connector pin assignments from the IEEE bus and provide a suitable interface. Table 5.2 compares the pin designations for each standard.

1.5 GPIB (IEEE) Connectors

The pin connections and dimensions of the IEEE connector are illustrated below and in table 5.2.

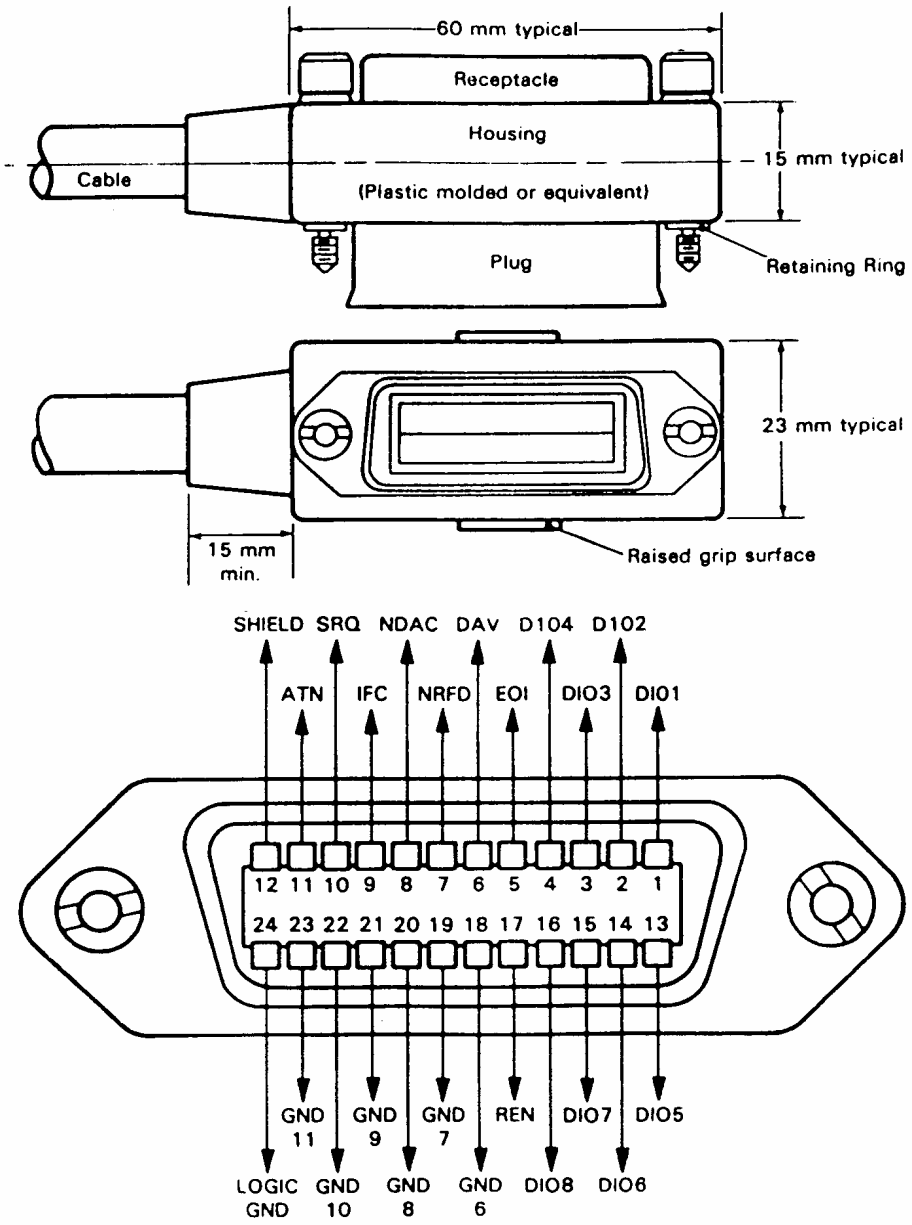

Fig. 5.1 I.E.E.E. CONNECTOR

IEEE STANDARD		IEC STANDARD	
PIN		PIN	
1	D101	1	D101
2	D102	2	D102
3	D103	3	D103
4	D104	4	D104
5	EOI	5	REN
6	DAV	6	EOI
7	NRFD	7	DAV
8	NDAC	8	NRFD
9	IFC	9	NDAC
10	SRQ	10	IFC
11	ATN	11	SRQ
12	SHIELD	12	ATN
13	D105	13	SHIELD
14	D106	14	D105
15	D107	15	D106
16	D108	16	D107
17	REN	17	D108
18	GND 6	18	GND 5
19	GND 7	19	GND 6
20	GND 8	20	GND 7
21	GND 9	21	GND 8
22	GND 10	22	GND 9
23	GND 11	23	GND 10
24	LOGIC GND	24	GND 11

Table 5.2 Pin designation comparison. IEEE and IEC

1.6 GPIB (IEEE) Address selection

Before operating the calibrator over the GPIB (IEEE bus), set the address on the rear of the unit to the required address and operating mode. The GPIB (IEEE) address is set on the top five positions of the DIP switch which is located on the rear panel. They are in binary format i.e. 1,2,4,8,16. The address is the addition of the switches selected in the ON position e.g. to select address 3 requires positions 1 and 2 ON, see example below.

GPIB (IEEE) Addresses 0 and 16 are reserved for recalibration mode and should not be used unless recalibrating the instrument. Address 31 is used to select self test mode.

Note : The eight switches are read only when the instrument is first switched ON. Therefore it is necessary to turn the unit OFF if a new GPIB (IEEE) address is required. See table 5.3

SWITCH SETTING	DECIMAL ADDRESS	SWITCH SETTING	DECIMAL ADDRESS
0 0 0 0 0	0	1 0 0 0 0	16
0 0 0 0 1	1	1 0 0 0 1	17
0 0 0 1 0	2	1 0 0 1 0	18
0 0 0 1 1	3	1 0 0 1 1	19
0 0 1 0 0	4	1 0 1 0 0	20
0 0 1 0 1	5	1 0 1 0 1	21
0 0 1 1 0	6	1 0 1 1 0	22
0 0 1 1 1	7	1 0 1 1 1	23
0 1 0 0 0	8	1 1 0 0 0	24
0 1 0 0 1	9	1 1 0 0 1	25
0 1 0 1 0	10	1 1 0 1 0	26
0 1 0 1 1	11	1 1 0 1 1	27
0 1 1 0 0	12	1 1 1 0 0	28
0 1 1 0 1	13	1 1 1 0 1	29
0 1 1 1 0	14	1 1 1 1 0	30
0 1 1 1 1	15		

Table 5.3 GPIB (IEEE) Address selection

A ‘1’ in the table corresponds to the ON position of the switch. Switch 1 (top) selects the least significant bit. The last three switches, which are normally set to the OFF position, are used to select the instruments operating modes as follows:

Switch 6 - GPIB (IEEE bus) talk (transmit) disable.

Switch 7 - GPIB (IEEE bus) listen (receive) disable.

Switch 8 - Dual Primary Addressing mode. In this mode, the unit will respond to two primary addresses differing only in the least significat bit. For example, if the unit address selection switches are set for an address of 8, the unit will also respond to address 9.

1.7 GPIB (IEEE) Commands

LOCAL LOCKOUT

The front LOCAL/REMOTE switch must be in the remote position for IEEE operation. The instrument will not respond to any IEEE commands when set to local.

INTERFACE CLEAR COMMAND IFC

This command initiates a complete reset of the unit, which is then unable to respond to any further IEEE commands for 1 second.

IEEE COMMAND FORMAT

IEEE commands are comprised of characters from the ASCII set. A series of commands can be used to simulate the manual operation of the unit.

The commands must be in one of the following formats:

1.) A single upper case character (A to Z).
2.) Upper case character followed by a number.
3.) A signed decimal number (8 digits maximum).

Commands may be sent individually or built into a string separated with a ‘slash character’ (/). For the command string to execute it must be terminated with either a line feed or carriage return character.

IEEE COMMAND EXECUTION

Before an GPIB (IEEE) command can be executed 4 conditions must be met.

1.) The unit must be switched to ‘remote’ on the front panel.
2.) GPIB (IEEE) cable and controller connected. The GPIB (IEEE) address and the talk/listen switches set correctly on the rear panel switch.
3.) The command must be a valid command (invalid commands are ignored).
4.) The command must be followed by a valid terminator.

Table 5.3 GPIB (IEEE) Command list

GPIB (IEEE) Command	Operation
D	Transmit display to bus controller
E1 to E4	Select unit action upon output error detection.
F15 to F20000	Select output frequency.
G1 or G2	Set / Cancel Group execute trigger response.
H	Set output to full scale.
I	Select serial poll operation.
K1 or K2	Enable/Disable Front panel controls.
L	Set output to zero.
O1 to O7	Output resistance between 10 Ohms and 10 M Ohms. O1 - 10 Ohms O5 - 100k Ohms O2 - 100 Ohms O6 - 1M Ohms O3 - 1k Ohms O7 - 10M Ohms O4 - 10k Ohms
Pn	Change output by ‘n’ percent.
R1 to R12	Select voltage or current range R1 - 20mV R7 - 200uA R3 - 200mV R5 - 2mA R3 - 2V R9 - 20mA R4 - 20V R10 - 200mA R5 - 200V R11 - 2A R6 - 1kV R12 - 10A
RA	AUTORANGE
T1 or T2	Set terminator character appended to a transmission.
W1 to W7	Select waveform. W1 - Sine W5 - Triangle W2 - Square W6 - Trapezoidal W3 - Ramp up W7 - D.C. W4 - Ramp down
Z	Take present output as offset.
/	Command separator.

1.8 Single letter commands

Command D

It is important to understand the sequence of operation on the IEEE bus when a data read-back command is executed. When the ‘D’ Command is sent it prepares the instrument to transmit (i.e. act as a talker). The controller program must then execute an ‘INPUT’ statement to actually initiate the data transfer. The data must be terminated with the correct character to complete the transfer.

Invalid terminating characters cause the GPIB (IEEE bus) to hang.

The terminator is controller dependent and the instrument allows either CR or LF to be used, as determined by the Command T1 or T2. Note that the T1 to T2 command (terminating setting) must be done before the ‘D’ command is executed.

When the unit is in the over-range condition the front panel display shows 1….. but this is not transmitted on read-back. The character string ‘OVERRNG’ is sent. In all other cases the read-back is exactly as seen on the display.

EXAMPLE (HP BASIC)

```
10 REMOTE 708
20 OUTPUT 708; “T2”          !SET TERMINATOR
30 OUTPUT 708; “D”           !TRANSMIT DISPLAY
40 ENTER 708; A$             !READ RETURNED VALUE IN
50 PRINT A$                  !PRINT IT
```

Command H

Sets output to full scale on the selected range. On the High Voltage ranges it will cause a three beep audio warning which lasts 3 seconds. The output will then appear on the terminals, this mode of operation is a safety feature.

EXAMPLE (BASIC)

```
10 OPEN 1,7                  :REM OPEN ADDRESS 7 TO INSTRUMENT
20 PRINT #1,‘H’              :REM SET OUTPUT TO FULL SCALE
30 END                       :REM END
```

Command 1

Sets the instrument to generate a serial poll request for service by the bus controller should an ‘OP ERROR’ arise.

EXAMPLE (HP BASIC)

```
10 REMOTE 708                    !OPEN IEEE ADDRESS 8
20 OUTPUT 708;“I”                !SETS UNIT TO GENERATE SERIAL POLL
                                  REQUEST ON OUTPUT ERROR
30 OUTPUT 708;“E4/R4/5”          !SET ERROR MODE, 20V RANGE WITH
                                  5 VOLTS OUTPUT
40 ON INTR 7 GOSUB 1000          !DEFINE ACTION ON SERIAL POLL
50 V1=0 @ X=0
60 X=X+1                         !WAIT FOR ERROR LOOP
70 GOTO 60
1000                             !SUBROUTINE TO PRINT POLL RESPONSE
1010 STATUS ,1;A 1020 P=SPOLL(708)
1030 PRINT P                     !DISPLAY SERIAL POLL RESULT
1040 ENABLE INTR 7;8
1050 RETURN                      !RETURN TO WAIT LOOP
```

Command L

Sets the output to zero.

Command Z

Takes the present output value as an offset. The display indicates zero with the top segment of the display flashing. When a new output value is sent it will be added to the offset stored. The offset is cleared by:

1.) A new range command
2.) Selecting a resistance output
3.) Setting the offset to zero

In remote AutoCal mode, indicated by a flashing ’C’ on the display, the offset is stored in the non volatile memory and is used as a calibration factor.

1.9 Letter & Number command

E1 To E4 Output Error Mode

Selects one of four possible error modes which determine the action taken by the unit on detection of an output error

E1 : (default) Displays ‘OP ERROR’ and turns off output immediately on detection of an output error, remains in this condition until reset by another command.

E2 : Displays ’OP ERROR’ and turns off output immediately on detection of OP ERROR, will automatically restore output and display if the error is removed.

E3 : Waits for an error condition to last for 0.5 seconds before turning off output and displaying ‘OP ERROR’.

E4 : Waits for an error condition to last for 0.5 seconds before displaying ‘OP ERROR’ and leaves output ON.

F15 to F20000 frequency setting commands

Commands F15 to F20000 select output frequency. Enter ’F’ followed by the required frequency. Any frequency between 15Hz and 20KHz (in 5Hz steps) may be selected. F0 selects 0.025Hz for stiction tests.

G1/G2 enable/disable group execute trigger

G1 - Enables Group Execute Trigger response.
G2 - Disables Group Execute Trigger response.

Group Execute Trigger (GET) is a command issued by the bus controller to make several devices respond simultaneously, the devices having been previously told how to respond when the GET command is received.

EXAMPLE (HP BASIC)

```
10 REMOTE 708          !OPEN IEEE ADDRESS 8
20 OUTPUT 708;“G1”     !SETS UNIT TO RESPOND TO GET
30 OUTPUT 708;“R2”     !COMMAND TO EXECUTE
40 TRIGGER 708         !EXECUTE COMMAND
50 OUTPUT 708;“G2”     !COMMAND TO EXECUTE
60 TRIGGER 708         !EXECUTE COMMAND TO EXIT GET MODE
```

K1/K2 enable/disable front panel control

K1 - Sets instrument to respond to front panel control.
K2 - Disables front panel controls.

P(n) set percentage deviation

Set deviation '**n**' on present output where '**n**' is in the range of + 9.99 and -9.99.

EXAMPLE (BASIC)

10 PRINT #1,"P3.45" *REM SET output 3.45% high*
20 PRINT #1,"P-0.02" *REM SET output 0.02% low*

R1 To R12 Range Setting Commands

Selects a voltage or current range from IEEE command table.

COMMAND SELECTED	RANGE	PROGRAM IN
R1	20 mV	mV
R2	200 mV	mV
R3	2 V	Volts
R4	20 V	Volts
R5	200 V	Volts
R6	1 KV	Volts
R7	200 uA	uA
R8	2 mA	mA
R9	20 mA	mA
R10	200 mA	mA
R11	2 A	Amps
R12	10 A	Amps

RA : Automatically selects the range for the output required. Default : R1.

T1/T2 select transmission terminator

Sets the last character appended to a transmission from the instrument.

T1 : (default) carriage return.
T2 : line feed.

W1 to W7 waveform setting commands

Select waveform or D.C. see IEEE command table in Table 5.3.
NOTE : On the high voltage ranges (R5 & R6) only Sine Wave and DC (W1 & W7) are permitted. It is not possible to change the Waveform without first going to a lower range.
Default is W7 (DC).

1.10 Setting an output value

Transmit the voltage or current required a an ASCII string.

EXAMPLES (HP BASIC) on the 2 Volt range (R3)

OUTPUT 708;"-0.3765" *!SETS OUTPUT TO -0.3765 VOLTS*

OUTPUT 708;"2.9" *!SETS OUTPUT TO OVER-RANGE DISPLAY SHOWS '1…' , OUTPUT IS APPROX 2.08V*

OUTPUT 708;"0.00000007" *!SETS OUTPUT TO ZERO, TOO MANY DECIMAL PLACES*

NOTE :
1.) The 5th digit is always rounded to 0, 2, 4, 6, or 8.
2.) On D.C. (W7) or sine wave A.C (W1) the output limit of any range is 20800 or 1100v on the 1 KV ranges.
3.) On the 10 Amp ranges, output limit is 11 Amps.

1.11 Setting voltage above 40V

When a voltage above 40V is selected, (except when using certain output error modes), an alarm sounds 3 times before the voltage is applied to the output terminals. To avoid damaging circuitry by applying large rates of voltage change, the output ramps up to the set value. It takes about approx. 5 seconds to reach 1kV output.

On the 200V and 1kV ranges, only Sine wave and D.C. are permitted. Changing the waveform on these ranges is disabled by the software in the instrument. Frequencies above 1kHz will give large amplitude errors.

Changing range to the 200V or 1kV range where the output would be set to more than 40V causes the output to be set to zero.

The left hand decimal point on the display flashes when an output of 40V or greater is on the terminals.

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9823 Multifunction Calibrator

Calibration Adjustment Procedure

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Document Version: V5 (7/08/2002)

Contents

Chapter 1 General information 3

1.1 Before and After calibration 4
1.2 Calibration factors and manual adjustments 5
1.3 Resetting calibration factors 5
1.4 Calibration notes 6

Chapter 2 Calibration adjustment procedure 7

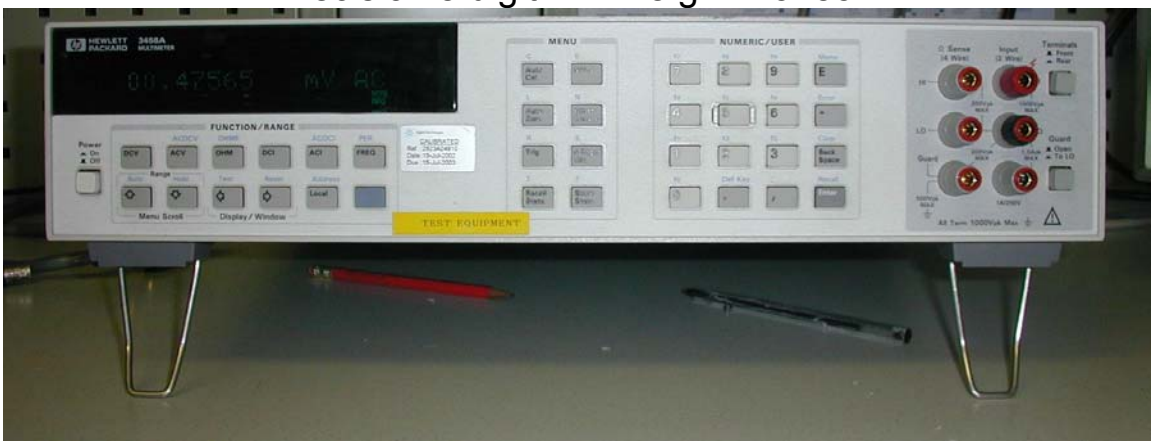
2.1 Entering calibration mode 8
2.2 Selecting ranges 8
2.3 Output terminals 9
2.4 Calibration of DC voltage ranges 10
2.5 Calibration of AC voltage ranges 15
2.6 Calibration of DC current ranges 17
2.7 Calibration of AC current ranges 20
2.8 Calibration of resistance ranges 22
2.9 Calibration completion details 23

Example Time Electronics calibration certificate 24

Chapter 1 General Information

Calibration equipment required to perform a calibration of the 9823:

Precision 8 digit DMM e.g. HP3485A



Low thermal e.m.f. leads

Special Time Electronics constructed precision (+/-0.05%) 4 terminal current shunt to extend the DMM measuring capability to 10 Amps if required. The shunt is in a specially sealed oil filled case. This ensures excellent temperature stability when under load. The shunt is available from Time Electronics.

Switch on the 9823 and DMM and leave to warm up for at least 2 hrs before calibration.

The temperature for calibration should be 22°C +/- 2°C.

IMPORTANT NOTE:

Some versions of the 9823 have front panels markings 100V, 10V, 1V, 100mV, 10mV, 1A, 100mA, 10mA, 1mA, 100uA. These represent the nominal value and a 100% over-range is available on each to provide full scale outputs of twice the values stated above.

Other versions have markings 200V, 20V, 2V, 200mV, 20mV, 2A, 200mA, 20mA, 2mA, 200uA. These represent the actual full scale output.

Please note the 1KV and 10A ranges are unchanged and represent the full scale output.

1.1 Before and After Calibration

It is advisable that a complete set of calibration results are taken before a calibration adjustment is started. This is known as a 'BEFORE' and it is important because it verifies that the 9823 is operating correctly on all ranges and indicates if any ranges will need adjustment. If any of the ranges are well outside specification this indicates that the 9823 may be faulty or that the calibration factors have become corrupted (see 1.3 to reset all calibration factors). Please refer to the Time Electronics example calibration certificate at the end of this document for details of the allowed error, please note these are 24 hour stability specification for zero settings and the 90 day specification for full scale settings. Time Electronics initial calibration policy is to ensure that the 9823 is well within it's one year specification to remain in calibration for a 1 year period. Generally if the 9823 is within specification and no adjustment is required then an 'AFTER' calibration certificate is not always needed. The 'AFTER' adjustment calibration run should only be done after **all** adjustments have been made as described in this document.

1.2 Calibration factors and manual adjustments

The 9823 stores most of its calibration factors (both zero and full scale) in non-volatile format in a EEPROM memory chip located on the Processor board. The calibration factors are stored twice in memory and when the unit is switched on the 2 sets are compared to check for corruption. Should an error be found, the message “Error 6” will be displayed. If this is the case, or other unexpected performance is encountered it will be necessary to reset (zero) all the calibration factors and undertake a complete recalibration (see 1.3 below).

The calibration factors can only be changed when the calibration key (supplied with unit) is inserted into the rear panel socket to activate calibration mode. When the unit is in calibration mode a ‘C’ is shown in the display’s left most digit.

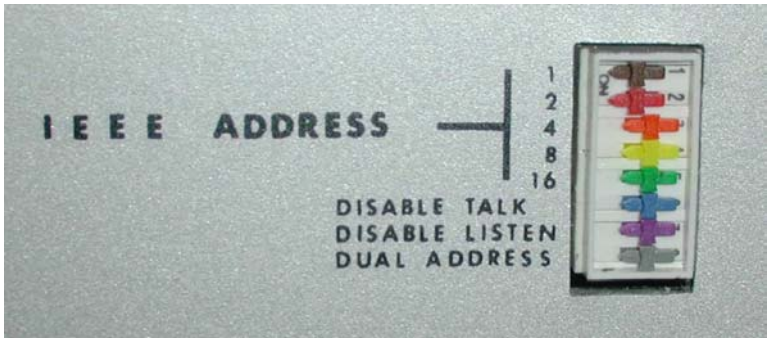
Please note that some of the calibration adjustment is still done using multi-turn trimmers which are mounted on the circuit boards. These adjustments are identified in this document as ‘MANUAL’ after the section title.

1.3 Resetting Calibration Factors

To reset **all** calibration factors, switch off the unit, set all 8 IEEE dip switches (on rear panel) to the ON position, insert the cal key, and switch on. At power up the unit will carry out a self-test sequence. Each segment of the 8-digit display will light up in turn, followed by all the front panel leds (except FS, ZERO, + & -). If no errors are detected, the word “Pass” will appear on the display. If an error occurs, the word “Error” followed by a number 1-6 will be displayed (see technical manual for details). After the self-test is completed, the unit’s calibration factors will be automatically reset to zero. The unit should be switched off and IEEE address 16 selected before switching on again to start the calibration adjustment.

Please note the IEEE address is set on the top five positions of the DIP switch which is located on the rear panel. They are in binary format i.e. 1,2,4,8,16. The address is the addition of the switches selected in the ON position e.g. to select address 3 requires positions 1 and 2 ON, see picture below.

Note: If the cal key is inserted when the unit has not been set to address ‘16’, the display will flash “Error 7” and calibration adjustment cannot proceed.



Before calibrating the 9823, please read this section to ensure that you understand all of the following points :

a) AC Zero, Frequency response, and Linearity

The 9823 cannot be adjusted during the standard calibration adjustment in the following :

AC Volts Zero
AC Current Zero
AC Frequency response
Linearity

All of the above can be tested and recorded on the calibration certificate if required (see example certificate at the end of this document). If the 9823 is out of specification on any of the above please contact Time Electronics or local authorized agent for advice.

b) AC Ranges

All AC voltage ranges are calibrated at 200Hz.

All AC current ranges are calibrated at 60Hz.

There is **no** zero adjustment on AC ranges. Please note that performance of the 9823 at less than 10% of full scale is not specified (see specification in technical manual). In particular on 200uA AC range it is virtually impossible to eliminate the electrical noise pickup. The user must understand that a current source has a very high output resistance (greater then 10M ohms, even on the 200uA range), therefore unless very special screened leads and correct grounding techniques are used, noise pickup will occur.

If an output of less then 10% of full scale is required, the range below should be selected to ensure full performance.

c) Calibration leads and Connections

Stray thermal e.m.f generation in leads and connections can affect the calibration. The terminals of the 9823 are specifically designed to minimize this effect. However if standard leads and connectors are used errors will occur. Leads and connectors that exhibit a very low thermal e.m.f. effect should be used on voltages below 10V (suitable lead sets are available from Time Electronics). To reduce AC noise pickup due to capacitive/inductive coupling, the leads should be kept as short as practically possible and screened.

Resistance calibration up to 100kOhm must be done using the 4-wire method. The 1MOhm and 10MOhm can be calibrated using the 2-wire method and screened (shielded) leads must be used to reduce noise pickup. The screen should only be connected to the green earth terminal on the 9823. If you are unsure about this, please refer to your DMM technical manual. Please note that the gold plated shorting links must be removed for 4 terminal calibration.

d) DMM filter settings

All high performance DMM's include analogue and digital filtering functions. All calibration of the 9823 should be performed with a filter time of 1 second or greater.

We also recommend increasing this to 3 seconds (or more) for voltages of less then 200mV, and for currents less then 2mA.

A filter time of at least 3 seconds should also be used for calibration of the 1MOhm and 10MOhm.

SAFETY PRECAUTIONS

When calibrating high voltage and high current ranges observe safety precautions. This is particularly important when using the 1kV range and due attention should be paid to the high voltage warning buzzer.

Chapter 2

Calibration adjustment procedure

The calibration adjustment of the 9823 is divided into 5 parts, and should be done in the following order only :

DC Voltage ranges
AC Voltage ranges
DC Current ranges
AC Current ranges
Resistance ranges

2.1 Entering Calibration Mode

Switch unit to **LOCAL** mode

Select address 16 on the IEEE switch on the back of the unit. Please note it is necessary to switch off the unit before changing the IEEE address.

Insert cal key into the rear panel socket.

After inserting the cal key a flashing ‘C’ should appear in the left hand side of the display. If this does not happen check that the cal key has been correctly inserted.

2.2 Selecting Ranges

The front panel selection buttons are dual function. Their function is indicated by the blue and red markings above and below each one.

Primary function	-	*Keys operate as indicated by **blue** legends*
Secondary function	-	*Keys operate as indicated by **red** legends*

Which function is active is determined by the **SELECT** button which toggles (alternates) between Primary and Secondary function. The LED on the **SELECT** button indicates the active function -

i.e. OFF - Primary/blue or ON - Secondary/red:

Note: When Secondary button function is active, pressing any button will automatically change the state of all buttons back to Primary function, and the **SELECT** LED will extinguish.

For example, to select 20V DC range:

Ensure that the **SELECT** button led is off - active state is Primary
Press **SELECT** button
Press **DC** button
Press **SELECT** button
Press **20V** button

The active state is now back to Primary and the required output value can now be set. The digits are incremented or decremented as required using the buttons marked with up/down arrows.

Throughout this document, we use shorthand to describe the button press sequences. For example, we would write the above button press sequence will be :

SELECT / DC / SELECT / 20V

2.3 Output terminals

The 9823 is equipped with three sets of output terminals. The main output is via 4 terminals marked V/I/R. These are designed to allow 4 wire connections to be made and are used where effects of lead resistance must be automatically compensated. The two outer terminals of each are known as sense terminals and for most calibration should be left linked to their respective +ve/-ve terminal by the special gold plated links which are supplied. These links should be left in place for all voltage and current re-calibration, however they should be removed for the 4 wire resistance re-calibration (100kOhms and less). The main output terminals are used for voltage ranges up to 20 V, current ranges up 2A, and the resistance ranges.

The 200V and 1kV ranges have their own set of output terminals. The 10 A range also has it’s own terminal set.

2.4 Calibration of DC Voltage Ranges

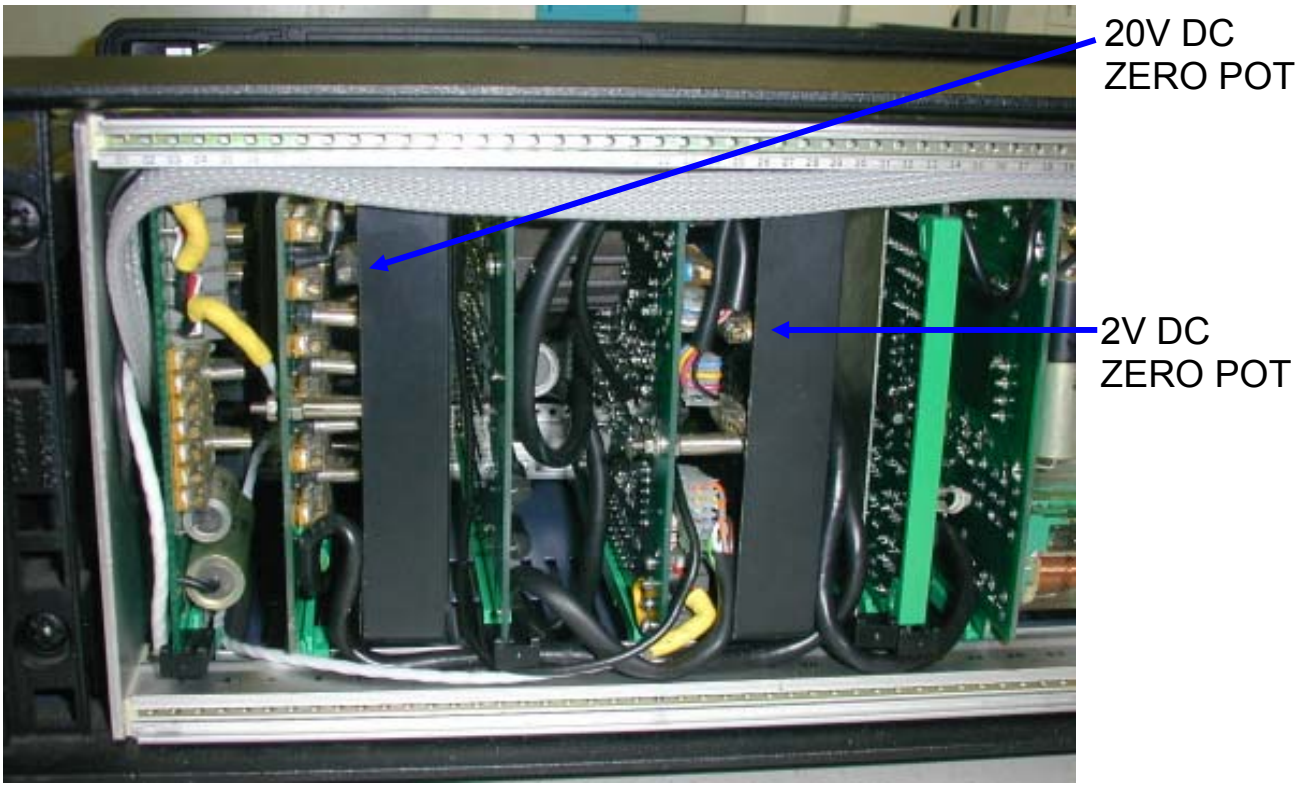
Remove the left hand rear panel, which is retained by 6 captive screws.

Connect low thermal leads from 9823 main terminals to voltage terminals on the DMM.

Select the appropriate range on the DMM for each range to be calibrated.

20 Volt Range Zero (MANUAL)
Press SELECT / DC / SELECT / 20V / ZERO.
Adjust 20 Volt zero pot indicated in the picture below for a reading of 0V +/- 40uV on the DMM.

2 Volt Range Zero (MANUAL)
Press SELECT / 2V / ZERO.
Adjust 2 Volt zero pot indicated in the picture below for a reading of 0V +/- 7uV on the DMM.
Go back and check 20 Volt zero and adjust if necessary.



+2 Volt Full-Scale

Press SELECT / 2V / FS. A 2V output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 2V +/- 17uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-2 Volt Full-Scale

Press SELECT / 2V / FS / -. A -2V output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for -2V +/- 17uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

+20 Volt Full-Scale

Press SELECT / 20V / FS. A 20V output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 20V +/- 140uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-20 Volt Full-Scale

Press SELECT / 20V / FS / -. A -20V output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for -20V +/- 140uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

200mV Range Zero
Press SELECT / 200mV / ZERO.
By using the + and - buttons and the up and down buttons, adjust the output to read 0V +/- 3uV.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

+200mV Full-Scale
Press SELECT / 200mV / FS. A 200mV output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 200mV +/- 4uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-200mV Full-Scale

Press SELECT / 200mV / FS / -. A -200mV output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for -200mV +/- 4uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

20mV Range Zero

Press SELECT / 20mV / ZERO.
By using the + and - buttons and the up and down buttons, adjust the output to read 0V +/- 3uV.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

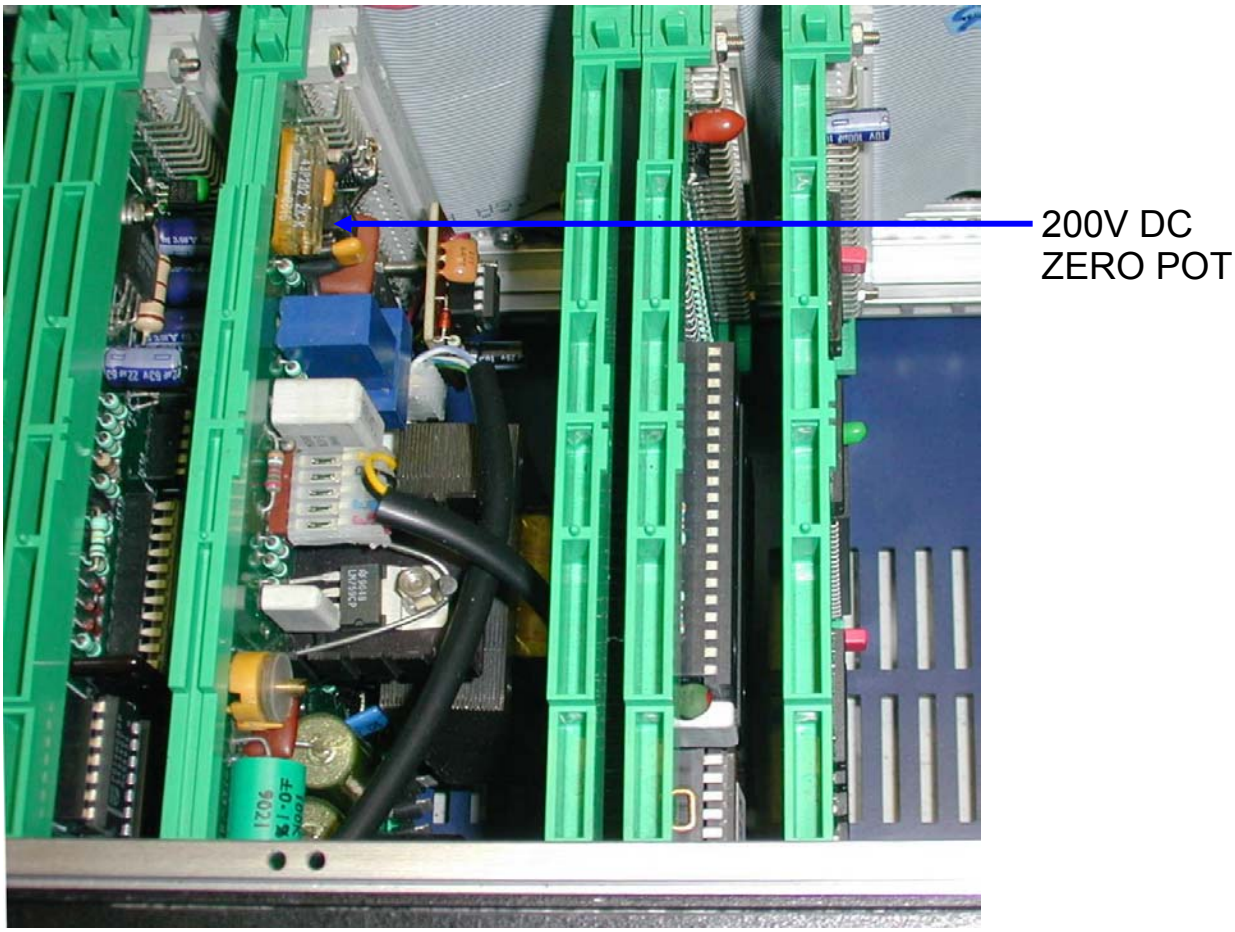
+20mV Full-Scale

Press SELECT / 20mV / FS. A 20mV output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 20mV +/- 3uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-20mV Full-Scale

Press SELECT / 20mV / FS / -. A -20mV output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for -20mV +/- 3uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

Remove the lid from the case by unscrewing the top two screws on ether side of the case, then lift off the lid.
Connect DMM voltage terminals to the 9823 high voltage terminals.
Press SELECT / 200V / ZERO.
Leave for 1 minute to settle.
Adjust trimmer as shown in the picture below for a reading of 0V +/- 2mV.



+200 Volt Full Scale

Ensure that the DMM will accept an input of 200V.
Press SELECT / 200V / FS. 200V will then be shown on the display.
Press HV ON. A 200V output will be produced on the high voltage terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 200V +/- 6mV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.
Press ZERO.

Please note *that for performance reasons the 9823 uses slow ramping for large changes in output voltages, approximately > 50V.*

-200 Volt Full-Scale

Ensure that the DMM will accept an input of 200V.
Press SELECT / 200V / FS / -. -200V will then be shown on the display.
Press HV ON. A -200V output will be produced on the high voltage terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for -200V +/- 6mV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.
Press ZERO. The output is ramped down to zero.

+1kV Full-Scale

Ensure that the DMM will accept an input of 1000V.
Press SELECT / 1kV / FS. 1000V will then be shown on the display.
Press HV ON. A 1000V output will be produced on the high voltage terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 1000V +/- 35mV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.
Press ZERO. The output is ramped down to zero.

-1kV Full-Scale

Ensure that the DMM will accept an input of -1000V.
Press SELECT / 1kV / FS / -. -1000V will then be shown on the display.
Press HV ON. A -1000V output will be produced on the high voltage terminals.
Press DEV%
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for -1000V +/- 35mV.
When the correct output voltage has been achieved, press DEV%**.** The DEV% button led goes out and the cal factor is then stored.
Press ZERO**.** The output is ramped down to zero.

2.5 Calibration of AC Voltage Ranges

Connect the 9823 main output terminals and select the appropriate range on the DMM.
All AC voltage ranges should be calibrated at 200Hz sine wave.
Press SELECT / AC / SELECT / FREQWAVE.
Select 200Hz by using only the up/down buttons for the three digits at the right hand side of the display.

20V AC Full-Scale
Press SELECT / 20V / FS. A 20V AC output will be produced on the main output terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 20V +/- 5mV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

2V AC Full-Scale
Press SELECT / 2V / FS. A 2V AC output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 2V +/- 0.5mV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

200mV AC Full-Scale
Press SELECT / 200mV / FS. A 200mV AC output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 200mV +/- 80uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

20mV AC Full-Scale
Press SELECT / 20mV / FS. A 20mV AC output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 20mV +/- 35uV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

200V AC Full-Scale

Ensure that the DMM will accept an input of 200V AC.
Press SELECT / 200V / FS. 200V AC will then be shown on the display.
Press HV ON. A 200V AC output will be produced on the high voltage output terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 200V +/- 60mV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.
Press ZERO. The output is ramped down to zero.

1kV AC

Ensure that the DMM will accept an input of 1000V AC.
Press SELECT / 1kV / FS. 1000V AC will then be shown on the display.
Press HV ON. A 1kV AC output will be produced on the high voltage output terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output voltage for 1kV +/- 320mV.
When the correct output voltage has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.
Press ZERO. The output is ramped down to zero.

2.6 Calibration of DC Current Ranges

Select the appropriate range on the DMM.

200uA Range Zero

Press SELECT / DC / SELECT / 200uA / ZERO.
By using the + and - button and the up and down buttons, adjust the output to read 0A +/- 30nA.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

+200uA Full-Scale

Press SELECT / 200uA / FS. A 200uA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 200uA +/- 38nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-200uA Full-Scale

Press SELECT / 200uA / FS / -. A -200uA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for -200uA +/- 38nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

2mA Range Zero

Press SELECT / 2mA / ZERO.
By using the + and - buttons and the up and down buttons, adjust the output to read 0A +/- 50nA.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

+2mA Full-Scale

Press SELECT / 2mA / FS. A 2mA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 2mA +/- 100nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-2mA Full-Scale

Press SELECT / 2mA / FS / -. A -2mA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for -2mA +/- 100nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

20mA Range Zero
Press SELECT / 20mA / ZERO.
By using the + and - buttons and the up and down buttons, adjust the output to read 0A +/- 200nA.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

+20mA Full-Scale
Press SELECT / 20mA / FS. A 20mA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 20mA +/- 800nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-20mA Full-Scale
Press SELECT / 20mA / FS / -. A -20mA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for -20mA +/- 800nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

200mA Range Zero
Press SELECT / 200mA / ZERO.
By using the + and - buttons and the up and down buttons, adjust the output to read 0 +/- 2uA.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

+200mA Full-Scale
Press SELECT / 200mA / FS. A 200mA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 200mA +/- 8uA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-200mA Full-Scale
Press SELECT / 200mA / FS / -. A -200mA output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for -200mA +/- 8uA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

2A Range Zero

Press SELECT / 2A / ZERO.
By using the + and - buttons and the up and down buttons, adjust the output to read 0A +/- 60uA.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

+2A Full-Scale

Check if the DMM will measure 2A. If not, use a 4 terminal current shunt.
Press SELECT / 2A / FS. A 2A output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 2A +/- 180uA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-2A Full-Scale

Check if the DMM will measure 2A. If not, use a 4 terminal current shunt.
Press SELECT / 2A / FS / -. A -2A output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for -2A +/- 180uA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

10A Range Zero

Press SELECT / 10A / ZERO
Connect 9823 10 amp output terminals to DMM current input
By using the + and - buttons and the up and down buttons, adjust the output to read 0A +/- 3mA.
When the o/p has been adjusted correctly, press SELECT / ZERO / ZERO.

+10A Full-Scale

Check if the DMM will measure 10A. If not, use a 4 terminal current shunt.
Press SELECT / 10A / FS. A 10A output will be produced on the high current output terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 10A +/- 7mA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

-10A Full-Scale

Press SELECT / 10A / FS / -. A -10A output will be produced on the high current output terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for -10A +/- 7mA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

Connect the 9823 main output terminals to the AC current terminals on the DMM.
Select an appropriate manual range on the DMM.
All AC current ranges should be calibrated at 60Hz sine wave.
Press SELECT / AC / SELECT / FREQWAVE.
Select 60Hz by using only the up/down buttons for the three digits at the right hand side of the display.

200uA AC Full-Scale
Press SELECT / 200uA / FS. A 200uA AC output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 200uA +/- 120nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

2mA AC Full-Scale
Press SELECT / 2mA / FS. A 2mA AC output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 2mA +/- 800nA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

20mA AC Full-Scale
Press SELECT / 20mA / FS. A 20mA AC output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 20mA +/- 8uA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

200mA AC Full-Scale
Press SELECT / 200mA / FS. A 200mA AC output will be produced.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 200mA +/- 80uA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

2A AC Full-Scale

Check if the DMM will measure 2A. If not, use a 4 terminal current shunt.

Press SELECT / 2A / FS. A 2A AC output will be produced on the main terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 2A +/- 900uA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

10A AC Full-Scale

Check if the DMM will measure 10A. If not, use a 4 terminal current shunt.

Press SELECT / 10A / FS.
A 10A AC output will be produced on the 10 amp output terminals.
Press DEV%.
Use the top row of buttons to increase the output or the bottom row to decrease it, adjust the output current for 10A +/- 10mA.
When the correct output current has been achieved, press DEV%. The DEV% button led goes out and the cal factor is then stored.

2.8 Calibration of Resistance Ranges

Connect a 4-wire lead set to DMM, then short all 4 leads at the opposite end. Then null (zero) the DMM. Remove the two gold links from the 9823's main terminals, then connect the 4 wire lead set to the 9823.
The 7 resistance values are individually adjusted using a multi-turn trimmer for each – see diagram following.

10 Ohm Calibration (MANUAL)
Press SELECT / Res(KΩ). 0.01 will be shown on the display.
Adjust 10R trimmer pot (R21) on the back of the 9823 resistance board for a DMM reading of 10 Ohm +/- 0.0002 Ohm.

100 Ohm Calibration (MANUAL)
Press 20mV. 0.10 will then be shown on the display.
Adjust 100R trimmer pot (R19) on the back of the 9823 resistance board for a DMM reading of 100R +/- 0.001 Ohm.

1k Ohm Calibration (MANUAL)
Press 200mV. 1.0 will be shown on the display.
Adjust 1K trimmer pot (R17) on the back of the 9823 resistance board for a DMM reading of 1k Ohm +/- 0.008 Ohm.

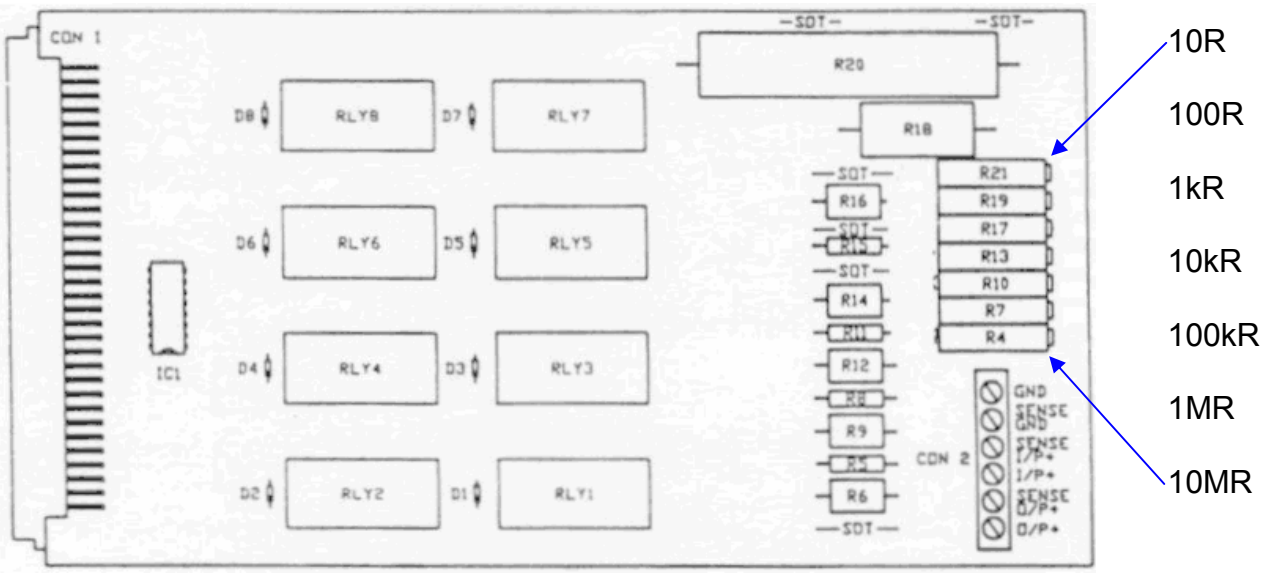
10k Ohm Calibration (MANUAL)
Press 2V. 10.00 will then be shown on the display.
Adjust 10K trimmer pot (R13) on the back of the 9823 resistance board for a DMM reading of 10k Ohm +/- 0.08 Ohm.

100k Ohm Calibration (MANUAL)
Press 20V. 100.00 will then be shown on the display.
Adjust 100K trimmer pot (R10) on the back of the 9823 resistance board for a DMM reading of 100k Ohm +/- 0.8 Ohm.

1M Ohm Calibration (MANUAL)
Use 2-wire resistance measurement for the 1MOhm and the 10MOhm.
Replace gold links on 9823 main terminals and use DMM 2-wire mode.

Press 100V. 1000.0 will then be shown on the display.
Adjust 1M trimmer pot (R7) on the back of the 9823 resistance board for a DMM reading of 1M Ohm +/- 20 Ohm.

10M Ohm Calibration (MANUAL)
Press 1kV. 10000.0 will then be shown on the display.
Adjust 10M trimmer pot (R4) on the back of the 9823 resistance board for a DMM reading of 10M Ohm +/- 500 Ohm.



2.9 Calibration completion details

The calibration adjustment is now complete. Switch the unit off, remove the cal key, replace the rear panel cover, and reset the IEEE address as required (not 0,16 or 32).
If a full calibration certificate is required test with the required calibration procedure (without the cal key in) and record the results.

Please note that the complete set of calibration results will include measurements at many points that are not calibration adjustment procedure. Refer to the Time Electronics example calibration certificate following.
Full traceability and environmental information should always be recorded on a calibration certificate.

If fully automated calibration of the 9823 is required, use Time Electronics' EasyCal calibration software. A complete system can be configured using EasyCal running on a PC with a GPIB interface card fitted. A procedure is available from Time Electronics that will automatically drive both an HP3485A DMM and the 9823. This allows the correct ranges on the DMM and the 9823 to be automatically selected and also sets up the correct outputs on the 9823. The calibration run will then proceed automatically. This is in effect a 'BEFORE' calibration and will identify any ranges that need adjustment. Adjustments should be made as described in this document before the whole EasyCal calibration run is repeated to produce an 'AFTER' (final calibration) certificate. Please contact Time Electronics for further information on the EasyCal system.

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Certificate of Calibration

Certificate No. HP 10094

Cover Sheet - 5 results sheets to follow

Issued on: 03 Apr 2002

Lab Details

Time Electronics

Botany Ind. Est.
Tonbridge
Kent
England
Tel: 01732 355993 Fax: 01732 770312

Approved Signatories
Steve Taylor Lewis Crowhurst

Instrument Details

Type: **V/I/R CALIBRATOR**

Manuf. : **TIME ELECTRONICS**

Model: **9823**

Serial No.: **1595 J7**

Customer Details

Tel:
Fax:

Lab Conditions

Temperature: **23.0** +/-2.0degC *Humidity: 50% +/- 10%*

Supply Voltage: **230** +/-15 Volts *Supply Frequency: 50Hz +/- 0.3Hz*

Comments

Calibrated to manufacturer's specifications.

Calibrating Instruments

5mR CURRENT SHUNT Serial No:112473 Cert No:18372 Cal Date:06/Mar/2002 Cal Due:05/Mar/2003
100mR CURRENT SHUNT Serial No:136697 Cert No:18420 Cal Date:14/Mar/2002 Cal Due:13/Mar/2003
HP 3458A Serial No:2823A24910 Cert No:8065Z857701A Cal Date:06/Jul/2001 Cal Due:05/Jul/2002

Procedure: *9823-TIME-CAL*
Calibrated by: *Steve Taylor*
Date of Calibration: *03 Apr 2002*
Signed .....

Certificate of Calibration

V/I/R CALIBRATOR
TIME ELECTRONICS
9823

Issued on 03 Apr 2002

Result Sheet 1 of 5

Serial No.:1595 J7

Cust/Owner:

Certificate No. HP 10094

Test Name	Rqd Value	Actual Value	Allowed Error	% of Spec	Pass/Fail
D.C VOLTAGE					
20mV RANGE	0.00 uV	-0.05 uV	3.00 uV	-2 %	Pass
20mV RANGE	20.0000 mV	19.9999 mV	3.10 uV	-4 %	Pass
20mV RANGE	-20.0000 mV	-20.0001 mV	3.10 uV	3 %	Pass
---					
200 mV RANGE	0.00 uV	0.57 uV	3.40 uV	17 %	Pass
200mV RANGE	200.0000 mV	200.0014 mV	4.40 uV	32 %	Pass
200mV RANGE	-200.0000 mV	-200.0006 mV	4.40 uV	13 %	Pass

2V RANGE	0.00 uV	0.21 uV	7.00 uV	3 %	Pass
2V RANGE	2.000000 V	2.000004 V	17.00 uV	22 %	Pass
2V RANGE	-2.000000 V	-2.000001 V	17.00 uV	4 %	Pass

20V RANGE	0.00 uV	1.52 uV	40.00 uV	4 %	Pass
20V RANGE	20.000000 V	19.999987 V	140.00 uV	-10 %	Pass
20V RANGE	-20.000000 V	-20.000023 V	140.00 uV	16 %	Pass

200V RANGE	0.00 mV	-0.93 mV	2.00 mV	-47 %	Pass
200V RANGE	200.00000 V	199.99934 V	6.00 mV	-11 %	Pass
200V RANGE	-200.00000 V	-199.99982 V	6.00 mV	-3 %	Pass

1KV RANGE	0.00 mV	-3.75 mV	20.00 mV	-19 %	Pass
1KV RANGE	1000.000 V	999.992 V	35.00 mV	-22 %	Pass
1KV RANGE	-1000.000 V	-999.991 V	35.00 mV	-25 %	Pass
A.C VOLTAGE					
20mV RANGE: 200Hz	20.000 mV	19.993 mV	0.0350 mV	-20 %	Pass

200mV RANGE: 200Hz	200.000 mV	199.984 mV	0.0800 mV	-20 %	Pass
---					
2V RANGE: 60Hz	2.00000 V	1.99987 V	0.530 mV	-24 %	Pass
2V RANGE: 200Hz	2.00000 V	1.99989 V	0.530 mV	-21 %	Pass
2V RANGE: 1KHz	2.00000 V	2.00024 V	0.530 mV	46 %	Pass
2V RANGE: 5KHz	2.00000 V	2.00039 V	5.00 mV	8 %	Pass
2V RANGE: 10KHz	2.00000 V	1.99852 V	5.00 mV	-30 %	Pass
2V RANGE: 20KHz	2.00000 V	2.00209 V	5.00 mV	42 %	Pass

Procedure: *9823-TIME-CAL*
Calibrated by: *Steve Taylor*
Date of Calibration: *03 Apr 2002*
Signed .....

This certificate has been produced by EasyCal4 Calibration Software from Time Electronics Ltd

Certificate of Calibration

V/I/R CALIBRATOR
TIME ELECTRONICS
9823

Issued on 03 Apr 2002

Result Sheet 2 of 5

Serial No.:1595 J7

Cust/Owner:

Certificate No. HP 10094

Test Name	Rqd Value	Actual Value	Allowed Error	% of Spec	Pass/Fail
20V RANGE: 60Hz	20.00000 V	19.99958 V	5.00 mV	-8 %	Pass
20V RANGE: 200Hz	20.00000 V	20.00105 V	5.00 mV	21 %	Pass
20V RANGE: 500Hz	20.00000 V	20.00169 V	5.00 mV	34 %	Pass
20V RANGE: 1KHz	20.00000 V	20.00274 V	5.00 mV	55 %	Pass
20V RANGE: 2KHz	20.00000 V	20.00469 V	14.00 mV	34 %	Pass
20V RANGE: 5KHz	20.00000 V	20.00046 V	50.00 mV	1 %	Pass
20V RANGE: 10KHz	20.00000 V	19.97750 V	50.00 mV	-45 %	Pass
20V RANGE: 15KHz	20.00000 V	19.97147 V	50.00 mV	-57 %	Pass
20V RANGE: 20KHz	20.00000 V	19.98523 V	50.00 mV	-30 %	Pass

200V RANGE: 60Hz	200.0000 V	199.9934 V	60.00 mV	-11 %	Pass
200V RANGE: 200Hz	200.0000 V	200.0002 V	60.00 mV	0 %	Pass
200V RANGE: 400Hz	200.0000 V	200.0112 V	60.00 mV	19 %	Pass
200V RANGE: 1kHz	200.0000 V	199.9976 V	60.00 mV	-4 %	Pass

700V RANGE: 60Hz	700.000 V	699.916 V	320.00 mV	-26 %	Pass
700V RANGE: 200Hz	700.000 V	699.971 V	320.00 mV	-9 %	Pass
700V RANGE: 400Hz	700.000 V	699.979 V	320.00 mV	-6 %	Pass
D.C CURRENT					
200uA RANGE	0.000 uA	0.003 uA	0.0300 uA	11 %	Pass
200uA RANGE	200.0000 uA	200.0017 uA	0.0380 uA	4 %	Pass
200uA RANGE	-200.0000 uA	-199.9972 uA	0.0380 uA	-7 %	Pass

2mA RANGE	0.00 uA	0.00 uA	0.0500 uA	4 %	Pass
2mA RANGE	2.00000 mA	2.00002 mA	0.110 uA	18 %	Pass
2mA RANGE	-2.00000 mA	-1.99996 mA	0.110 mA	0 %	Pass

20mA RANGE	0.00 uA	0.04 uA	0.230 uA	18 %	Pass
20mA RANGE	20.00000 mA	20.00011 mA	0.830 uA	13 %	Pass
20mA RANGE	-20.00000 mA	-19.99998 mA	0.830 uA	-3 %	Pass

200mA RANGE	0.00 uA	0.14 uA	2.00 uA	7 %	Pass
200mA RANGE	200.0000 mA	200.0011 mA	8.00 uA	13 %	Pass
200mA RANGE	-200.0000 mA	-199.9987 mA	8.00 uA	-16 %	Pass

2A RANGE	0.00 uA	5.95 uA	60.00 uA	10 %	Pass
2A RANGE	2.000000 A	2.000012 A	0.00018 A	7 %	Pass
2A RANGE	-2.000000 A	-1.999995 A	0.00018 A	-3 %	Pass

Procedure: *9823-TIME-CAL*
Calibrated by: *Steve Taylor*

Date of Calibration: *03 Apr 2002*

Signed .....

This certificate has been produced by EasyCal4 Calibration Software from Time Electronics Ltd

Certificate of Calibration

V/I/R CALIBRATOR
TIME ELECTRONICS
9823

Issued on 03 Apr 2002

Result Sheet 3 of 5

Serial No.:1595 J7

Cust/Owner:

Certificate No. HP 10094

Test Name	Rqd Value	Actual Value	Allowed Error	% of Spec	Pass/Fail
10A RANGE	0.00 mA	-0.37 mA	3.00 mA	-12 %	Pass
10A RANGE	10.00000 A	9.99830 A	0.00700 A	-24 %	Pass
10A RANGE	-10.00000 A	-9.99867 A	0.00700 A	-19 %	Pass
A.C CURRENT					
200uA RANGE: 60Hz	200.000 uA	200.004 uA	0.130 uA	3 %	Pass
2mA RANGE: 60Hz	2.00000 mA	2.00022 mA	0.850 uA	26 %	Pass
20mA RANGE: 60Hz	20.0000 mA	20.0005 mA	8.10 uA	6 %	Pass
200mA RANGE: 60Hz	200.000 mA	199.995 mA	80.00 uA	-6 %	Pass
2A RANGE: 60Hz	2.00000 A	1.99982 A	0.00090 A	-20 %	Pass
10A RANGE: 60Hz.	10.0000 A	10.0008 A	0.0100 A	8 %	Pass
RESISTANCE					
10 OHMS	10.00000 R	10.00000 R	0.00020 R	-1 %	Pass
100 OHMS	100.00000 R	100.00024 R	0.00100 R	24 %	Pass
1k OHMS	1.0000000 kR	0.9999995 kR	0.00800 R	-7 %	Pass
10 KILO OHMS	10.000000 kR	9.999983 kR	0.0800 R	-21 %	Pass
100 KILO OHMS	100.00000 kR	99.99991 kR	0.800 R	-11 %	Pass
1 MEGA OHMS	1.0000000 MR	0.9999946 MR	20.00 R	-27 %	Pass
10 MEGA OHMS	10.000000 MR	9.999884 MR	500.00 R	-23 %	Pass
FREQUENCY					
100Hz	100.000 Hz	100.004 Hz	0.0100 Hz	35 %	Pass
500Hz	500.000 Hz	500.015 Hz	0.0500 Hz	30 %	Pass
1KHz	1.0000 kHz	1.0000 kHz	0.100 Hz	28 %	Pass
2KHz	2.0000 kHz	2.0001 kHz	0.200 Hz	32 %	Pass
5KHz	5.0000 kHz	5.0002 kHz	0.500 Hz	32 %	Pass
10KHz	10.0000 kHz	10.0003 kHz	1.000 Hz	33 %	Pass
20KHz	20.0000 kHz	20.0007 kHz	2.00 Hz	33 %	Pass
LINEARITY: 20V RANGE					
LINEARITY:	19.00000 V	18.99999 V	138.00 uV	-6 %	Pass
LINEARITY:	18.00000 V	18.00000 V	133.00 uV	-1 %	Pass
LINEARITY:	17.00000 V	17.00000 V	128.00 uV	3 %	Pass
LINEARITY:	16.00000 V	16.00000 V	123.00 uV	2 %	Pass
LINEARITY:	15.00000 V	15.00002 V	118.00 uV	16 %	Pass
LINEARITY:	14.00000 V	14.00000 V	113.00 uV	0 %	Pass
LINEARITY:	13.00000 V	12.99999 V	108.00 uV	-7 %	Pass
LINEARITY:	12.00000 V	11.99998 V	103.00 uV	-17 %	Pass
LINEARITY:	11.00000 V	11.00001 V	98.00 uV	15 %	Pass
LINEARITY:	10.00000 V	10.00006 V	93.00 uV	70 %	Pass
LINEARITY:	9.00000 V	9.00004 V	88.00 uV	49 %	Pass
LINEARITY:	8.00000 V	8.00004 V	83.00 uV	52 %	Pass

Procedure: *9823-TIME-CAL*
Calibrated by: *Steve Taylor*
Date of Calibration: *03 Apr 2002*
Signed .....

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Certificate of Calibration

V/I/R CALIBRATOR
TIME ELECTRONICS
9823

Issued on 03 Apr 2002

Result Sheet 4 of 5

Serial No.:1595 J7

Cust/Owner:

Certificate No. HP 10094

Test Name	Rqd Value	Actual Value	Allowed Error	% of Spec	Pass/Fail
LINEARITY:	7.00000 V	7.00003 V	78.00 uV	42 %	Pass
LINEARITY:	6.00000 V	6.00003 V	73.00 uV	47 %	Pass
LINEARITY:	5.00000 V	5.00004 V	68.00 uV	64 %	Pass
LINEARITY:	4.00000 V	4.00002 V	63.00 uV	30 %	Pass
LINEARITY:	3.00000 V	3.00002 V	58.00 uV	32 %	Pass
LINEARITY:	2.00000 V	1.99999 V	53.00 uV	-25 %	Pass
LINEARITY:	1.00000 V	1.00000 V	48.00 uV	9 %	Pass

LINEARITY:	-19.00000 V	-19.00004 V	138.00 uV	26 %	Pass
LINEARITY:	-18.00000 V	-18.00004 V	133.00 uV	32 %	Pass
LINEARITY:	-17.00000 V	-17.00002 V	128.00 uV	18 %	Pass
LINEARITY:	-16.00000 V	-16.00003 V	123.00 uV	22 %	Pass
LINEARITY:	-15.00000 V	-15.00005 V	118.00 uV	42 %	Pass
LINEARITY:	-14.00000 V	-14.00004 V	113.00 uV	35 %	Pass
LINEARITY:	-13.00000 V	-13.00003 V	108.00 uV	25 %	Pass
LINEARITY:	-12.00000 V	-12.00004 V	103.00 uV	34 %	Pass
LINEARITY:	-11.00000 V	-11.00001 V	98.00 uV	15 %	Pass
LINEARITY:	-10.00000 V	-10.00004 V	93.00 uV	40 %	Pass
LINEARITY:	-9.00000 V	-9.00004 V	88.00 uV	50 %	Pass
LINEARITY:	-8.00000 V	-8.00003 V	83.00 uV	31 %	Pass
LINEARITY:	-7.00000 V	-7.00004 V	78.00 uV	46 %	Pass
LINEARITY:	-6.00000 V	-6.00002 V	73.00 uV	27 %	Pass
LINEARITY:	-5.00000 V	-5.00001 V	68.00 uV	17 %	Pass
LINEARITY:	-4.00000 V	-4.00001 V	63.00 uV	14 %	Pass
LINEARITY:	-3.00000 V	-3.00001 V	58.00 uV	19 %	Pass
LINEARITY:	-2.00000 V	-1.99998 V	53.00 uV	-36 %	Pass
LINEARITY:	-1.00000 V	-0.99998 V	48.00 uV	-38 %	Pass

LINEARITY:	0.90000 V	0.90000 V	48.00 uV	-1 %	Pass
LINEARITY:	0.80000 V	0.80000 V	47.00 uV	7 %	Pass
LINEARITY:	0.70000 V	0.70000 V	47.00 uV	2 %	Pass
LINEARITY:	0.60000 V	0.60001 V	46.00 uV	24 %	Pass
LINEARITY:	0.50000 V	0.50001 V	46.00 uV	23 %	Pass
LINEARITY:	0.40000 V	0.39999 V	45.00 uV	-24 %	Pass
LINEARITY:	0.30000 V	0.30000 V	45.00 uV	3 %	Pass
LINEARITY:	0.20000 V	0.20000 V	44.00 uV	11 %	Pass
LINEARITY:	0.10000 V	0.10001 V	44.00 uV	13 %	Pass

Procedure: *9823-TIME-CAL*
Calibrated by: *Steve Taylor*

Date of Calibration: *03 Apr 2002*

Signed .....

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Certificate of Calibration

V/I/R CALIBRATOR
TIME ELECTRONICS
9823

Issued on 03 Apr 2002

Result Sheet 5 of 5

Serial No.:1595 J7

Cust/Owner:

Certificate No. HP 10094

Test Name	Rqd Value	Actual Value	Allowed Error	% of Spec	Pass/Fail
LINEARITY:	-0.90000 V	-0.90004 V	48.00 uV	78 %	Pass
LINEARITY:	-0.80000 V	-0.79999 V	47.00 uV	-14 %	Pass
LINEARITY:	-0.70000 V	-0.69998 V	47.00 uV	-42 %	Pass
LINEARITY:	-0.60000 V	-0.60001 V	46.00 uV	27 %	Pass
LINEARITY:	-0.50000 V	-0.50001 V	46.00 uV	12 %	Pass
LINEARITY:	-0.40000 V	-0.39998 V	45.00 uV	-54 %	Pass
LINEARITY:	-0.30000 V	-0.30001 V	45.00 uV	14 %	Pass
LINEARITY:	-0.20000 V	-0.20000 V	44.00 uV	8 %	Pass
LINEARITY:	-0.10000 V	-0.10000 V	44.00 uV	-11 %	Pass

LINEARITY:	50.00 mV	50.00 mV	44.00 uV	10 %	Pass
LINEARITY:	10.00 mV	10.00 mV	44.00 uV	9 %	Pass
LINEARITY:	500.00 uV	502.13 uV	44.00 uV	5 %	Pass
LINEARITY:	100.00 uV	101.59 uV	44.00 uV	4 %	Pass
LINEARITY:	40.00 uV	41.33 uV	44.00 uV	3 %	Pass
LINEARITY:	20.00 uV	21.19 uV	44.00 uV	3 %	Pass

LINEARITY:	-50.00 mV	-49.99 mV	44.00 uV	-26 %	Pass
LINEARITY:	-10.00 mV	-9.98 mV	44.00 uV	-36 %	Pass
LINEARITY:	-500.00 uV	-481.54 uV	44.00 uV	-42 %	Pass
LINEARITY:	-100.00 uV	-80.74 uV	44.00 uV	-44 %	Pass
LINEARITY:	-40.00 uV	-22.03 uV	44.00 uV	-41 %	Pass
LINEARITY:	-20.00 uV	-1.25 uV	44.00 uV	-43 %	Pass

Procedure: *9823-TIME-CAL*
Calibrated by: *Steve Taylor*

Date of Calibration: *03 Apr 2002*

Signed .....

This certificate has been produced by EasyCal4 Calibration Software from Time Electronics Ltd