10 Channel Temperature Monitor

Model ITM 10

Operator's Handbook

Oxford Instruments
Scientific Research Division
Old Station Way, Eynsham
Witney, Oxon. OX8 1TL, England
Telephone (0865) 882855
Fax: (0865) 881567
Telex: 83413

CONTENTS

1 SAFETY

The following general safety precautions must be observed during the operation, service and repair of this instrument.

1.1 Protective Ground

To minimise shock hazard the instrument must be connected to an electrical ground. The ground wire (green/yellow) in the instrument AC power cable must be connected to the installation electrical ground system. Do not use extension cords without a protective earth conductor. Do not disconnect the protective ground inside or outside the instrument. Do not have external circuits connected to the instrument when its protective ground is disconnected.

1.2 Repair and Adjustment

Ensure that the instrument is disconnected from the AC power supply (switching off the front panel POWER switch is not sufficient) before the covers are removed or fuses are replaced, otherwise dangerous voltages are accessible. Capacitors inside the instrument and power connector filter, if fitted, may remain charged after removal of AC power. These should be discharged before starting work.

For fault finding and calibration the AC power supply may require reconnection. This work may only be carried out by skilled personnel who are aware of the hazard involved.

2 INTRODUCTION

2.1 Use of this Manual

This manual provides operating and service information for the Oxford Instruments Intelligent Temperature Monitor model ITM10.

Sections 1-4 provide essential information and should be read before operating the instrument for the first time.

The remainder of the manual provides more detail on specific aspects and may be referred to as required. Section 16 attempts to identify some of the more common operating pitfalls ánd may be useful if problems are encountered.

ITM10 is a microprocessor based instrument and is controlled by an operating program contained in a programmable memory chip (EPROM). This program is referred to as the ITM10 ***firmware***. The firmware is coded with a two part number (e.g. 1.01) where the first digit indicates a major version of the firmware and the second two digits cover minor revisions.

2.2 Description of ITM10

ITM10 is a 10 Channel Temperature Monitor specifically intended for use in cryogenic applications. In its most common application ITM10 will be used to monitor temperatures within a superconductive magnet and its cryostat whilst the magnet is being cooled down.

The basic ITM10 Scans up to 10 Input Channels via a single Measuring Channel. In normal operation, scanning takes place continuously. ITM10 displays temperature on a four and one half digit display, covering a range of up to -19999 to +19999. Any channel may be selected for display, and the most recently measured reading for that channel is display instantly.

A front panel display allows the most recent reading for any channel to be observed.

A built-in RS232 interface allows the temperature for any channel to be read by computer. And the computer may also be used to control the operation of the ITM10.

In its basic form, the ITM10 employs a single channel input circuit board. This means that all 10 sensors must be of the same type. An optional, second input circuit board may be fitted, carrying two further input channels. With this board fitted, up to 3 different types of sensor may be used. There is no limitation on which of the 10 sensor channels is associated with which of the 3 hardware input channels.

Sensor calibration data and many of the controller operating parameters are held in a non-volatile memory, which is retained when the controller is switched off.

3 INSTALLATION

3.1 Supply Connections

Before applying power to the instrument, ensure that the voltage selector on the rear panel is correctly set for the intended supply voltage.

If necessary, open the voltage selector panel using the slot provided, withdraw the voltage selector and replace it in the correct orientation for the intended voltage. Check that the correct fuses are fitted, then close the voltage selector panel.

Fuse ratings are:

100-120v	1.6A Type T (Slow Blow)
200-240v	0.8A Type T (Slow Blow)

3.2 Sensor Connections

Connections to the sensors are by means of a 50 way D-socket on the rear panel. The table below shows pin numbers of the plug for each of the channels. (At first sight the pin numbering may seem odd. However it will be found to reflect a uniform progression along the connector, encompassing all three rows of contacts).

Channel Connections

CHANNEL NUMBER	INPUT HIGH	INPUT LOW	CURRENT +ve	CURRENT -ve
1	1	18	34	2
2	19	35	3	20
3	36	4	21	37
4	5	22	38	6
5	23	39	7	24
6	40	8	25	41
7	9	26	42	10
8	27	43	11	28
9	44	12	29	45
10	13	30	46	14

Common Connections

Thermocouple Compensation	17
Internal Analogue Ground	16
Internal Digital Ground	33
Chassis Ground	50

Connections between this socket and the actual sensors will vary with the type of sensor in use, as shown in the table below.

	Thermo-couple	Metal Resistor	Ge/Carbon Resistor	Si/GaAs Diode
Input High	V+	V+	V-	V-
Input Low	V-	V-	V+	V+
Current +ve	n/c	I+	I+	I+
Current -ve	n/c	I-	I-	I-

Note that the polarity of the voltage input connections is reversed for semiconductor resistors and diodes. For these sensors, the sensor resistance or sensor voltage falls with increasing temperature.

Where several sensors are wired with a common lead, this should be used as the V- lead. It may either be taken to the individual channel V- pins, all connected in parallel or it may be taken to pin 16 (analogue ground).

If room temperature reference junction compensation of thermocouple sensors is to be used, (not recommended for cryogenic applications), the V- leads of all the thermocouples must be commoned and connected to pin 17, rather than to the individual channel pins. It is important to note that the the room temperature compensating sensor is mounted at the rear panel of ITM10. To get accurate compensation it is essential that the thermocouple reference junction is at the same temperature. This in turn means that the cable linking the sensor to ITM10 must use thermocouple compensating cable. If the rear panel in the region of the connector is likely to be exposed to temperature fluctuations, it will be an advantage if a draught shield is placed around the plug, and the RT sensor.

The Input connections are electrically isolated from the controller ground and the chassis ground. Unless sensor connections are commoned at their source, or connected together for use with RT compensation as described above, they are mutually isolated.

3.3 Serial Data Line Connections

The bi-directional serial data link from the computer is connected via a 25 way D-socket on the rear panel. The socket is configured as a standard DCE configuration. This means it may be connected directly to the 25 way D-plug (configured as a DTE) found as the RS232 port on many computers. Pin names given below follow the standard RS232 conventions of naming with respect to the DTE.

Pin connections are:

2	Transmitted Data (To ITM, From Computer)
3	Received Data (To Computer, from ITM)
4	RTS (Linked to 5)
5	CTS (Linked to 4)
6	DSR (+5V when ITM10 is powered up)
7	Signal Ground
8	CD (+5V when ITM10 is powered up)

All other pins are open circuit.

Voltage levels for the transmitted and received data are:

Tx Data High	> +5.5V
Tx Data Low	< -5.5V
Rx Data High Threshold	< +2.6V
Rx Data Low Threshold	> +1.4V
Max Rx Input Voltage	+/-30V

Data protocols are:

Baud Rate	9600
Tx Start Bits	1
Tx Data Bits	8
Tx Stop Bits	2

Rx Start Bits	1
Rx Data Bits	8
Rx Stop Bits	1 or more

For normal ASCII exchanges the 8th data bit is treated as a parity bit. It is always set to "0" on transmitted data. It is ignored on received data.

3.4 Auxiliary Port Connections

An auxiliary port is provided in the form of a 15 way D socket on the rear panel. In the standard version of the ITM10, it is unused.

3.5 IEEE-488 Interface

For use on the General Purpose Interface Bus. (GPIB, HPIB or IEEE-488) an IEEE-488 to RS232 conversion unit is available. This locates externally and is linked by a cable to the RS232 socket on ITM10. It requires a separate mains power supply. Operating instructions are supplied with this unit.

3.6 Room Temperature Thermocouple Reference

All thermocouples have at least two active junctions. The MEASURING junction is held at the temperature being measured whilst the REFERENCE junction is held at some known temperature. For some applications it is convenient to allow the reference junction to vary with room temperature (RT Reference). A separate sensor then monitors room temperature close to the reference junction and compensates for the effect of room temperature fluctuations. (RT Compensation).

For the highest precision work a fixed reference junction temperature is always preferable. However in many applications the convenience of an RT reference outweighs the slight loss of accuracy. In general, RT compensation is suitable for high temperature applications but ***not recommended for cryogenic work***. There are three reasons for this:

i)Thermocouple sensitivity tends to fall at low temperatures so a small RT error will cause a larger low temperature error.

ii)A given temperature error (in degrees) is more likely to be significant at low temperature than at high temperature.

iii)The actual thermocouple wires must be taken all the way from the cryostat to the controller, since no compensating cable (see below) is available for common cryogenic thermocouples.

4 LOCAL OPERATION

4.1 Front Panel Controls

The front panel controls are grouped together in logically related blocks.

POWER

The main ON/OFF switch. A green lamp illuminates whenever the instrument is switched on.

ADJUST

The red RAISE and LOWER buttons provide the main means of adjusting any parameter. In ITM10 their main use is for adjusting the display reading during the configuration and calibration process. They have no effect on their own but are always used in conjunction with one of the other buttons. Whenever a parameter is being adjusted, its current value is shown on the main display. Setting a value involves pressing RAISE and/or LOWER until the required value is shown.

Operation of the RAISE and LOWER controls has been designed to allow large changes to be made relatively quickly whilst at the same time enabling any value to be set exactly. Pressing RAISE or LOWER briefly will cause the value to change by one unit. If the button is held in, the last figure will start to change at about 5 units per second. After 2 seconds, an approximately 10-fold increase in rate will occur, followed after another 2 seconds by a further rate increase and so on. Altogether there are 4 different rates. Whenever RAISE or LOWER is released, the next lower speed will be selected. This allows the user to "home-in" on the required value most ergonomically.

CONTROL

Control of the instrument may either be LOCAL from the front panel, or REMOTE via the RS232 interface. The LOC/REM button may be used to switch between LOCAL and REMOTE.

When LOCK is lit, the instrument is locked into either local or remote control and the LOC/REM button has no effect. At power up, ITM10 is locked in LOCAL, since at that time the instrument has no way of knowing if there is a computer connected to the RS232 interface.

When ITM10 is in REMOTE, many of the front panel controls are inoperative. Those controls which only affect the display, will still work but those which could change the operation of the instrument are disabled.

SCAN

In normal operation, ITM10 will continuously scan round all its active sensor channels. A 10 segment bar-graph display allows the progress of this scan to be monitored.

Two buttons, HOLD and SCAN, with associated lamps, allow this process to be interrupted and resumed respectively. When HOLD is used to interrupt scanning, the scanner will step directly to the channel currently being displayed and stay on this channel until either scanning is resumed, or a new channel is selected for display.

CHANNEL

A two digit display shows the number of the Channel currently being displayed on the main temperature display. This will normally be a number between 1 and 10.

Two associated buttons STEP ON and STEP BACK allow any required channel to be selected. When Channel 10 is reached, pressing STEP ON will start again at channel 1. Similarly STEP BACK will take channel 1 back to channel 10.

If ITM10 has been configured with less than 10 channels active. STEP ON and STEP BACK will only permit selecting the active channels. (These must be consecutive channels starting at channel 1).

TEMPERATURE DISPLAY

The main display indicates the measured temperature for the selected channel. When ITM10 is scanning normally, the value displayed will be updated every time the selected channel is measured. (Typically about once a minute). If a new channel is selected, by means of STEP ON or STEP BACK, the most recently measured value for that channel will be displayed immediately.

If HOLD has been selected, the display will be updated about 4 times a second, whilst displaying any channel. If a new channel is selected whilst in HOLD, the scanner will automatically be switched to measure the requested channel. The temperature displayed immediately after the channel is switched may be a very old reading if ITM10 has been in hold for a long time. This will be retained on the display for a short time whilst the measuring channel settles, then the display will start showing the current temperature for the chosen channel at about 4 updates per second.
The settling time may be adjusted to suit the type of sensor in use, but will typically be about 5 seconds.

The display block also includes an additional button marked CAL. This is a rarely used control and is recessed behind the front panel to prevent inadvertent operation. They may be operated using a pointed object, such as the point of a pencil. Its operation is described in section 5.

4.2 First Time Operation

Switch on the instrument by means of the POWER switch. Check that the green POWER lamp lights.

After about one second the word "PASS" will appear on the display. This indicates that the ITM10 has completed its self test and initialisation.

After a further pause the display will show the measured temperature for Channel 1 and scanning of the input sensors will start.

ITM10 will now be under LOCAL control from the front panel.

4.3 Sensor Selection

Pressing the STEP ON and STEP BACK buttons will allow the selected channel to be displayed. (If the instrument has only just been switched on, it will be necessary to wait until the scan has reached the selected channel before a meaningful reading is obtained).

4.4 Scan Control

In normal use, the scan will be allowed to continue. However there may be occasions when a temperature is changing rapidly and it is necessary to monitor a single sensor being updated more frequently. Pressing HOLD will stop the scanner at the chosen sensor channel.

5. CALIBRATION

5.1 Sensor Calibration

A calibration curve contained in the ITM10 memory provides the general shape of the sensor calibration curve for a particular sensor type. To match ITM10 to the exact characteristics of a specific sensor a calibration must be carried out at the two ends of the working range. This is achieved by means of the recessed CAL button. All the sensors used should have matched characteristics so that the same general calibration curve may be used. However the final calibration of the ends of the range may be carried out separately for each of the 10 sensors.

Use STEP ON and STEP BACK to select the sensor to be calibrated.
The calibration must be carried out with the scanner in HOLD at the selected channel. (Pressing CAL automatically selects HOLD to achieve this).

Cool the sensor to a known temperature as near to the bottom of the range as possible, or apply an equivalent input from a calibrator.

Press CAL and whilst holding it pressed, use RAISE and LOWER to set the correct temperature reading. ITM10 will update the "ZERO" value stored in its non-volatile memory.

Change to a temperature or calibrator input near the top of the range and repeat the process. ITM10 will update its stored "SPAN" value.

Repeat until both temperatures read correctly. The nearer the lower adjustment point is to the bottom of the range, the less interaction there will be.

ITM10 automatically decides whether to calibrate ZERO or SPAN depending on whether the input is in the lower or upper half of its range.

This same calibration process should be carried out for each of the channels in use, in turn. Note that it is not necessary to calibrate both the low and high temperature points of each sensor before moving on to the next channel. All the low temperature points may be calibrated first, followed by all the high temperature points, if this is more convenient.

After completing the calibration SCAN should be pressed, to resume normal operation.

6. REMOTE OPERATION

6.1 Introduction

ITM10 may be remotely operated by means of its RS232 interface. This allows a computer to interrogate the instrument and if required, to take control of it.

When in control, the computer has the option of locking out the front panel controls, or of allowing the front panel LOC/REM control to remain active, so that an operator may restore LOCAL operation if required.

6.2 Communication Protocols

All dialogue with ITM10 is in 9600 baud serial form.

Data sent by ITM10 is in the form of 1 start bit, 8 data bits and 2 stop bits.

Data sent by ITM10 during normal operation has the 8th (parity) bit always set to zero. When receiving normal data, ITM10 ignores the parity bit. (In the "Y" and "Z" diagnostic commands, all 8 bits are used for data).

All commands consist of a string of printing ASCII characters, terminated by a Carriage Return character. A Line Feed character may optionally be sent after the Carriage Return but is ignored by ITM10.

Unless the command starts with a "$" (dollar) character, all commands will evoke a response from ITM10. The response will consist of a string of one or more printing ASCII characters and will be terminated by a Carriage Return Character. This may optionally be followed by a Line Feed character.

The response will normally be sent immediately following the command. If a front panel button is pressed when the command is received, the response may be delayed until the button is released.

If the first character of a command is a "$", the command will be obeyed but no response will be sent. (See section 6.4).

None of the RS232 Modem control lines are required by ITM10, though signals are returned on some of the more common ones for maximum compatibility with other equipment.

ITM10 will accept a command string at all times. If a computer is unable to accept data from ITM10 at the full rate of the 9600 baud interface, the "W" command may be used to instruct ITM10 to send more slowly.

6.3 Commands and Responses

Commands to ITM10 all consist of a single upper-case letter, optionally followed by a numeric parameter, the whole being terminated by a Carriage Return. The response sent by ITM10 varies depending on the command. Usually it consists of the Command letter received, followed by the value of any data requested. Where a command instructs ITM10 to carry out an action rather than to send data, the command letter alone will be returned.

If a command is not recognised, has an illegal parameter or cannot be obeyed for any reason, an error response will be sent. This consists of a "?" (question mark), followed by all or part of the command string in question. To simplify error handling in the computer, the "?" will always be the first character returned.

The most common reason for a command error is attempting to execute a control command whilst ITM10 is in LOCAL control. If in doubt, the "X" command may be used to determine the current status.

6.4 Numeric Parameters

All numeric parameters are treated as signed integers and are sent as a string of decimal digits. The range of acceptable numbers is -32768 to +32767. Alternatively, positive numbers in the range 0 to 65535 will be accepted, if preceeded by a "#" (hash) symbol. Numbers outside this range will give an error.

For positive numbers, the "+" sign is optional, as are leading zeros. Any spaces, full stops and commas embedded within the number are ignored.

6.5 Use with OXFORD ISOBUS

The OXFORD ISOBUS allows a number of instruments to be driven in parallel from a single RS232 port on a computer, using a special cable assembly.

To allow separate instruments to be distinguished, each is allocated a unique address in the range 1 to 8. Depending on the instrument this may be set up in hardware, or held in non-volatile memory. In the case of ITM10 the latter option is used.

When operating on ISOBUS an instrument must be able to recognise and respond to commands addressed to it, whilst ignoring commands addressed to other instruments. This is achieved by starting all commands with a special ISOBUS control character.

When more than one powered-up instrument is connected on ISOBUS, no command should be issued which does not have an ISOBUS control character as its first character. Issuing such a command would result in an unintelligible response, as all instruments would reply together. (N.B. This will only result in lost data. No hardware damage will be caused).

Following the control character and its parameter (where required), the rest of the command follows the form described above. The response of the instrument depends on the initial control character in the following manner:

@n (At) addresses the command to instrument number n, where n is a digit in the range 1 to 8. This instrument obeys the command and returns its usual response. All other instruments ignore the command and send no reply.

$ (Dollar) instructs all instruments to send no reply. This is normally used to precede a command being sent to all instruments simultaneously, and prevents a conflict as they all echo the command together.

It may also be used in non-ISOBUS applications if the computer does not wish to receive a response.

It should be used with caution however, since all responses are suppressed, including the "?" error response. Thus the computer has no way of knowing if a command has been received or even if the instrument is connected.

If a command is to be addressed to a specific instrument, but no reply is required, it is permissible to use "$" and "@n" together. The "$" should always come first.

& (Ampersand) instructs an instrument to ignore any following ISOBUS control characters. It is included in the ISOBUS protocol to allow instruments whose command repertoire includes "@", "$", "&" or "!" to be used on ISOBUS. ITM10 does not require the use of this command.

!n (Exclamation) instructs the instrument that from now on its address is to be n. This command is included here since it is relevent to ISOBUS operation. However for obvious reasons, it should not be sent when more than one instrument is powered up and connected to ISOBUS. (It would result in all instruments having the same address!). The command is intended for initial setting up of instruments, one at a time. To avoid inadvertantly changing addresses, the "!" command will only be obeyed following a "U" command with a non-zero password. (See section 7).

7. COMMAND LIST

A brief summary of the available commands is given below. Fuller details are given in the following section.

Commands fall into 3 categories:

MONITOR COMMANDS which are always recognised.

CONTROL COMMANDS which are only recognised when in REMOTE control.

SYSTEM COMMANDS which are only recognised after receipt of the correct "UNLOCK KEY".

In the list which follows, "n" represents a decimal digit 0-9.

MONITOR COMMANDS (always recognised)

Cn	SET CONTROL LOCAL/REMOTE/LOCK
Qn	DEFINE COMMUNICATION PROTOCOL
Rn	READ PARAMETER n
Unnnn	UNLOCK FOR "!" AND SYSTEM COMMANDS
V	READ VERSION
Wnnnn	SET WAIT INTERVAL BETWEEN OUTPUT CHARACTERS
X	EXAMINE STATUS

CONTROL COMMANDS (recognised only in REMOTE)

An	SET AUTOMATIC SCANNING / HOLD
Dnn	SET DWELL TIME FOR SCAN (Units of 256mS)
Fnn	SET TO DISPLAY PARAMETER nn
Inn	SET INHIBIT TIME AFTER SCAN CHANGE (Units of 256mS)
Snn	SET SCAN CHANNEL

SYSTEM COMMANDS (recognised only after correct Unnnnn command)

Ln	LOAD LINEARISER TABLE n
Y	LOAD ENTIRE RAM CONTENTS
Z	DUMP ENTIRE RAM CONTENTS
!	SET ISOBUS ADDRESS (See section 8.5)

8. COMMAND SYNTAX

Cn COMMAND

The control command sets ITM10 into LOCAL or REMOTE and determines whether the LOC/REM button is LOCKED or active. At power up ITM10 defaults to the C0 state. Allowed values are:

C0	LOCAL & LOCKED (Default State)
C1	REMOTE & LOCKED
C2	LOCAL & UNLOCKED
C3	REMOTE & UNLOCKED

Qn COMMAND

Defines the communication protocol.

Currently only 2 values of n are significant:

Q0	"Normal" (Default Value)
Q2	Sends <LF> after each <CR>

Rn COMMAND

The READ command allows the computer to interrogate any of a number of variables. The returned value is always an integer as defined in section 6.4. Allowed values for n are listed below. (R11 and above are intended as service diagnostics and are unlikely to be of use to the user).

R1	SENSOR 1 TEMPERATURE
R2	SENSOR 2 TEMPERATURE
R3	SENSOR 3 TEMPERATURE
R4	SENSOR 4 TEMPERATURE
R5	SENSOR 5 TEMPERATURE

R6	SENSOR 6 TEMPERATURE
R7	SENSOR 7 TEMPERATURE
R8	SENSOR 8 TEMPERATURE
R9	SENSOR 9 TEMPERATURE
R10	SENSOR 10 TEMPERATURE
R11	HARDWARE I/P CHANNEL 1 FREQ/4
R12	HARDWARE I/P CHANNEL 2 FREQ/4 (IF FITTED)
R13	HARDWARE I/P CHANNEL 3 FREQ/4 (IF FITTED)

Unnnnn COMMAND

The UNLOCK command allows access to the SYSTEM commands. This set of commands are intended for diagnostic and configuration purposes and have the power to erase or modify the contents of the non-volatile memory. The U command must be followed by the correct KEY parameter before these "dangerous" commands may be used. The value of the KEY is given in section 10.7 of this manual. The whole of section 10 should be read before any attempt is made to use the key!

A lower level of key protection is provided for the "!" command, to avoid accidental errors. Allowed values of U are:

U0	LOCKED (Power-up Default)
U1	"!" COMMAND UNLOCKED
Unnnn	"L", "Y" & "Z" COMMANDS UNLOCKED

V COMMAND

The VERSION command requires no parameters. It returns a message indicating the instrument type and firmware version number.

Wnnnn COMMAND

The WAIT command sets a delay interval before each character is sent from ITM10 via the serial interface. This allows ITM10 to communicate with a slow computer with no input buffering. The parameter nnnn specifies the delay in milliseconds. It defaults to zero at power-up.

(N.B. the W command does not reduce the rate at which ITM10 can accept data from computer.)

X COMMAND

The EXAMINE command allows the computer to read the current ITM10 STATUS. It requires no parameters and will return a message string of the form:

XnAnCnSnnFnn

where the digits "n" have the following meaning:

Xn	SYSTEM STATUS	(Always zero currently)
An	AUTO SCAN STATUS	(as for A COMMAND but see below)
Cn	LOC/REM/LOCK STATUS	(n as for C COMMAND)
Snn	SCANNER CHANNEL	(nn = 1-10)
Fnn	FRONT PANEL DISPLAY CH.	(nn = 1-10)

An COMMAND

The AUTO scan command selects automatic SCAN (n = 1) or HOLD (n = 0).

Dnn & Inn COMMANDS

Set the Dwell and Inhibit times for the automatic scanner. The Dwell time is the total time the scanner remains on each channel. The Inhibit time is the time after the scanner has changed channel, before measurements are taken. This time is necessary to allow the measuring circuit to settle after it has been presented with a new input. The Inhibit time must be less than the Dwell time, or no measurements would be taken before the scanner moved on.

The parameters for D and I are measured in units of 256mS (the basic time interval used within the scanner). Thus D20 represents a dwell time of 5.12 seconds.

Allowed values for nnn are 1 to 64 for the dwell time and 1 to (Dwell - 1) for the inhibit time, giving a maximum dwell time of approx. 16.5 seconds per channel.

Fnn COMMAND

The FRONT PANEL DISPLAY command sets which channel will be displayed on the main display. This may either be one of the measurement channels (nn = 1 to 10) or an internal frequency measurement as described above for the "R" command (nn = 11 to 13). Note that if one of the latter options is selected, the front panel Channel display will show "0" to indicate that this is not a valid temperature reading. (F11 to F13 are primarily intended for diagnostic purposes rather than operational use).

Snn COMMAND

The SET SCAN CHANNEL command immediately sets the scanner to the selected channel (nn = 1 to 10). If ITM10 is in automatic SCAN, it will remain in the selected channel for the DWELL time then step on to the next channel (nn + 1) and continue the scanning sequence, without affecting the displayed channel. If ITM10 scanner is in HOLD, the "Snn" command will set both the SCAN channel and the DISPLAY channel to nn and the scanner will remain on this channel until a further command is received.

Y COMMAND

The Y command allows the entire contents of the RAM memory to be loaded in binary, via the serial interface. It is not intended as a user command.

Z COMMAND

The Z command allows the entire contents of the RAM memory to be dumped in binary, via the serial interface. It is not intended as a user command.

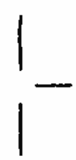
9. SENSOR RANGE CONFIGURATION

9.1 Introduction

Each sensor channel of ITM10 may be configured to a range suitable for use with a specific sensor. In the basic form of the instrument, fitted with a single input channel circuit board, all the sensor channels will normally employ the same range. If the optional extra 2-channel input board is fitted, three different ranges may be employed, allocated at will to any of the 10 sensor channels.

Normally an instrument is supplied with the specified range(s) configured ready for use. However it is possible to reconfigure it for use with different sensors should this be required.

The existing configuration for any channel may be determined by the code displayed whilst the STEP ON button is pressed. Limitations of a 7-segment display, mean that the characters are a rather stylised mixture of upper and lower case. "K" is particularly obscure and is shown as:



ITM10 comes with data for many of the most commonly used ranges included in the program memory. A further 3 ranges may be accommodated as custom calibrations in the non-volatile memory. For some sensors ranges are available with either a Centigrade or Kelvin display. To identify these, the sensor code for all Centigrade ranges has an extra decimal point following the final digit.

The table in section 9.2 shows range details for the standard ranges included within the program memory. (The standard ranges may be changed from time to time in response to variations in sensor popularity). The temperature range listed is the useful working range. On many ranges ITM10 will continue to indicate slightly outside this range.

The remainder of section 9 shows how to configure the instrument for use on one of these installed ranges. Section 10 takes configuration a stage further and shows how a completely new custom range may be designed and installed. In the following description, abbreviated component references are used. Thus SW1 refers to SW301 on channel 1, SW501 on channel 2 and SW401 on channel 3.

9.2 Range Data

CODE	SENSOR	RANGE	Tref	SW1 (Rear Switch)	SW2 (Front Switch) (See Note 1)
STANDARD RANGES					
Lin	Linear Range	0-999.9		(As required, See Note 2)	
Null	Centre Zero	+/-19999		(As required, See Note 2)	
Con 1	Conductance	0-19.999mS		00001 11110	01001 01010
TG 5	AuFe 0.03/Chr	2-500K	4.2K	11000 11111	00000 11000
TG 5	AuFe 0.03/Chr	2-500K	77K	11000 11100	00000 11000
TG 5	AuFe 0.03/Chr	2-500K	273K	11000 10100	00000 11000
TG 57	AuFe 0.07/Chr	2-500K	(Tref and Switches as for AuFe 0.03)		
TT 5	Copper/Const.	20-500K	77K	10100 11111	00000 11000
TT 5	Copper/Const.	20-500K	RT	10100 11111	00000 10100
TT 4.	Copper/Const.	-250-400C	77K	10001 10111	00000 11000
TT 4.	Copper/Const.	-250-400C	RT	10001 11100	00000 10100
TK 10	Chromel/Alumel	0-1000C	0C	01111 10111	00000 11000
TK 10	Chromel/Alumel	0-1000C	RT	01111 10111	00000 10100
TK 13.	Chromel/Alumel	-200-1370C	0C	01110 10100	00000 11000
TK 13.	Chromel/Alumel	-200-1370C	RT	01110 11111	00000 11000
RF 5	RhFe Resistor	1.5-500K	Curve-A	01111 11111	10010 10000
RF 51	RhFe Resistor	1.5-500K	Curve-B	01111 11111	10010 10000
RP 5	Plat Resistor	20-500K	Pure	10010 11111	01010 10000
RP 51	Plat Resistor	50-500K	Ballasted	10010 11111	01010 10000
RL 3	CLTS	2-300K		10111 01111	01010 10100
DS 3	Si Diode (OI)	2-300K		00010 00000	00110 11000
DS 31	Si Diode (LS)	2-300K		00000 00000	00110 11000
CC 35	C-Glass CR500	2-300K	(Typ only)	00001 11011	10001 01010
CA 21	100R Allen Brad	4-250K		00111 11000	01001 01010
CA 22	270R Allen Brad	4-250K		00011 10010	01001 01010
CS 01	470R Speer	0.250-9.999K		00011 11010	00101 01010

Notes:

1.Switch settings in this table are intended as a guide only. In particular the span and zero settings defined by SW1 may change for different sensors. In the case of thermocouples, the zero switch setting will vary with the reference junction temperature. Settings are given above for some of the more common combinations. Others may easily be obtained empirically (see section 10.5).

2.The Lin and Null ranges are general purpose ranges and may be set up for any desired span and zero. Both provide a linear relationship between input and display. One provides a unipolar display, whilst the other is centre zero.

3.Note that whilst it is theoretically possible to use a Room Temperature reference junction with a cryogenic thermocouple such as AuFe/Chromel, this is not recommended. The accuracy and stability obtained are unlikely to be acceptable for cryogenic applications.

4.The spread of 27 Ohm Rhodium Iron Sensors is such that two typical curves are included. Curve A should be used for those sensors having a 4.2K resistance of 2 ohms or greater, whilst Curve B should be used for sensors with a 4.2K resistance less than 2 ohms. Use of the appropriate curve should result in linearisation errors of less than 1K over the full temperature range. For a more accurate fit to a specific sensor, a custom
calibration should be ordered.

5.Two platinum ranges are provided, one for a pure platinum element, the other for a ballasted element to BS1904/DIN43760. The latter element is more readily available but its performance below 73K is currently unspecified. (The data between 50K and 73K is based on BS1904:1964 rather than BS1904:1984).

9.3 Access to Configuration Controls

Configuring ITM10 involves setting switches on the input board and selecting the appropriate linearisation data table. To carry out this work the top cover of the instrument must be removed. Before attempting this, read the Safety Information in Section 1 of this manual.

To remove the top cover, first remove the 4 screws securing it. The cover may then be slid towards one side, until the opposite side may be lifted clear of the side casing.

Where a second input board is fitted for 2/3 channel use, this will locate over the channel 1 board. With the input multiplexer board in place, it will then be necessary to remove the rear panel for access to the switches on the channel 1 board.

On the upper board, the switches are associated with the two channels in a logical manner, such that the channel 3 switches are nearer the left hand side of the instruments. On all boards SW1 is nearer the rear panel. N.B. The full component references used on the PCB for SW1 are SW301, SW501 and SW401 for channels 1-3 respectively. Except when referring to a specific channel, the first digits are omitted here.

9.4 Hardware Configuration

Configuring the input stage hardware involves setting up the correct pattern on the two sets of DIP switches associated with the channel being configured. The preceding table gives the correct pattern for each of the standard ranges. In each case a "1" represents a switch in the "ON" position (nearer the left side of the instrument) SW1 is the set of switches nearest the rear panel.

It is not necessary to know the function of the switches, in order to set them correctly. However a brief indication may prove helpful.

SW1 is split into two sections each of 5 switches. SW1/1 to SW1/5 define the input span, whilst SW1/6 to SW1/10 define the input zero. The pattern on the switches may be regarded as a binary number with the highest numbered switch being the least significant bit. The all "ON" position gives the smallest span and zero whilst the all "OFF" position gives the largest.

SW2/1 to SW2/3 define the magnitude of the sensor energisation current, when required.

SW2/4 selects constant current energisation for metallic resistance thermometers.

SW2/5 selects constant voltage energisation for semiconductor resistance thermometers.

SW2/6 selects normal voltage sense operation.

SW2/7 selects a negative zero offset for supressed zero ranges.

SW2/8 selects a positive zero offset for elevated zero ranges.

SW2/9 selects a small zero offset for use with semiconductor resistance thermometers.

SW2/10 is unused.

9.5 Setting the Number of Active Channels

Before associating the correct linearisation data table for each channel, it is necessary to define how many channels are to be active. If less than 10 channels are required, the scan may be set to include only those channels in use. (N.B. The active channels must run consecutively starting from channel 1, with the unused channels having the highest numbers).

To set the number of channels active, proceed as follows:

Switch the instrument on and enter the TEST mode, by holding the RAISE and LOWER buttons depressed, whilst pressing and releasing the LOC/REM button.

> **WARNING** Do not press the internal RED reset button, whilst RAISE and LOWER are depressed. This will cause a complete erasure of the Non-Volatile memory, with loss of all calibration and any custom ranges which may have been installed.

The message

tESt

will appear followed shortly by:

t 00

Press RAISE three times, to display:

t 03

Then press LOC/REM. The display will show

n xx

where xx represents a 2 digit number indicating the number of active channels.

Press RAISE or LOWER until the required value is displayed, then press LOC/REM to store this value.

The display will return to showing:

t 03

You may now proceed to configure the linearisation data table for each of the active channels, or skip to section 9.8 if no changes are required to the configuration.

9.6 Linearisation Configuration

To select the correct software data table, proceed as follows.

It is first necessary to associate a sensor channel (1 of 10), with a hardware input channel. In the basic instrument, this must be channel 1. If the optional second input card is fitted, this may be channel 1 to 3.

If you are not already in TEST mode from the previous stage, enter it now as described above. Then press RAISE or LOWER as necessary until the display shows:

t 06

Press LOC/REM and the display will show:

C xx

where xxis the sensor Channel being configured (1 to 10). Use RAISE and LOWER to select the channel you intend configuring, then press LOC/REM. The display will show:

S xx

where xx is the Sensor type to be associated with that channel, i.e. which of the three physical input channels is to be used.
Note that the CHANNEL display will also have been updated to show the channel being configured.

Use RAISE and LOWER to select the correct value in the range 1 to 3. (If only a single input board is fitted, S must be set to 1). Then press LOC/REM to select the

Sensor type. The display will revert to the main test menu, showing:

t 07

(on the assumtion that this is the next step you wish to carry out). Assuming this is correct, press LOC/REM and the display will show:

LOAd

for about a second, indicating that you are now about to load a sensor linearisation. This will be followed by the display:

Lin

which is the code for the first one of the available standard ranges.

Press RAISE or LOWER to cycle through the available ranges until the code for the required range is displayed. Custom ranges that have not had data installed, will show as a blank display.

Press LOC/REM and the range will be configured. ITM10 will then revert to the test menu, showing:

t 06

ready for the next channel.

The same process may now be repeated for each of the other active channels.

9.7 Setting the Scan Rate

It is convenient at this point to consider whether any change is required to the rate at which the sensor channels are scanned. The rate chosen represents a compromise between the time required to scan all 10 channels, and the settling time required after a new channel is selected before a stable measurement may be obtained. The latter depends to some extent on the type of sensor in use. A carbon resistor operated at very low currents will tend to take longer to reach a stable reading than a thermocouple or rhodium iron resistor for example. The scan is characterised by two separate times. The DWELL time determines how long the scanner remains on each sensor. The INHIBIT time determines the period after a channel change before a reliable measurement is available. Obviously the inhibit time must be made less than the dwell time if any measurements are to be made.

It is recommended that it is made at least a second less than the dwell time. This will allow several measurements to be made (readings are taken every 256mS). If this show a drift, it provides a clear indication that the dwell and inhibit times in use are two short.

The dwell and inhibit times may be set from the test mode by using LOC/REM to select test:

t 03

This provides a display:

d xx

where xx is the current dwell time. This time is measured in units of 256mS. Thus a value of 20 represents a dwell time of 5.12 seconds per channel, scanning all 10 channels in 51.2 seconds. RAISE and LOWER may be used to adjust this in the range 1 to 64. (0.25 seconds to 16.5 seconds approximately).
When the required value is obtained, pressing LOC/REM will select this value change the display to read:

h xx

indicating the inhibit time. This is measured in the same units and adjusted in the same way. The maximum value allowed is one less than the dwell time previously set. When the correct value is obtained LOC/REM select it as usual, and return to the test menu. For most purposes the factory default settings of 20 for Dwell and 16 for Inhibit will prove ideal. If a particular application requires changing the Dwell and Inhibit times, these may also be set via the RS232 Remote interface as described above
in sections 7 and 8.

9.8 Completing the Configuration

At any stage, when the "t xx" prompt is displayed, RAISE or LOWER may be used to display:

t 00

Pressing LOC/REM at this point will leave the test mode, and restart ITM10 with the "PASS" message.

After re-configuring any sensor channel(s), it will be necessary to carry out the calibration described in section 7.

10. SENSOR RANGE DESIGN

10.1 Introduction

The preceding section described how to configure ITM10 to use a range already installed in either the program or non-volatile memories. This section describes how a range may be designed and loaded into one of the non-volatile memory tables. To load the data requires entering some 260 numbers, without error. It is strongly recommended that the numbers be prepared as a data table on a computer and loaded automatically. That way errors may be corrected without having to start again at the beginning.

Before installing a new range, check that the data table to be loaded is not already in use. Once new data is loaded, the old data will be irretrievably lost (See section 9.5).

10.2 Types of Sensor

The first stage in designing a range is to decide what type of sensor is to be used.

The various sensors may be divided into a number of classes on the basis of the input configuration they require.

Thermocouples act as voltage sources and their output voltage is measured.

Metallic Resistance Thermometers have a resistance which rises approximately linearly with temperature. ITM10 passes a constant current through the sensor and measures the voltage produced (4-wire resistance measurement).

Semiconductor Resistance Thermometers have a resistance which falls very non-linearly with temperature. By measuring the sensor conductance, a function is obtained which rises with increasing temperature and is more nearly linear. ITM10 achieves a 4-wire conductance measurement by controlling the sensor current in such a way that the voltage across the sensor is held constant. The sensor current is then measured to indicate temperature. Apart from providing a more linear measuring function, this method has the added advantage that sensor dissipation is automatically reduced as the temperature falls.

Semiconductor Diodes have a voltage which falls with rising temperature. ITM10 provides a constant current energisation for these, as for metallic resistance thermometers, but the connections to input high and low are reversed, so that input high still receives a voltage which rises with increasing temperature.

10.3 Selecting Input Configuration

Having decided upon the sensor type the input stage configuration may be determined and the settings for SW2/4 to SW2/9 established.

	SW2/4	SW2/5	SW2/6	SW2/7	SW2/8	SW2/9
THERMOCOUPLE	OFF	OFF	ON	(See Below)		OFF
METAL RESISTOR	ON	OFF	ON	OFF	OFF/ON	OFF
SEMI. RESISTOR	OFF	ON	OFF	ON	OFF	ON
SEMI. DIODE	ON	OFF	ON	ON	OFF	OFF

SW2/7 and SW2/8 set the polarity of the zero offset. For thermocouples the setting of these is determined by the relation between the bottom end of the range and the thermocouple reference junction temperature. Where the reference junction temperature is close to or above the bottom of the range, SW2/7 should be ON. Where it is substantially below the bottom of the range, SW2/8 should be ON. For metallic resistors, if the sensor resistance at the low end of the range is close to zero, SW2/8 may be left off (no zero offset). Otherwise it should be set to ON.

Where a thermocouple range is intended for use with a compensated room temperature reference, SW2/8 should be ON.

10.4 Selecting Sensor Energisation

For resistance thermometers and diodes the preferred sensor energisation may be set by SW2/1 to SW2/3.

For Metal Resistors and Diodes, constant current energisation is used and the possible currents are:

	SW2/1	SW2/2	SW2/3
10 uA	OFF	OFF	ON
100 uA	OFF	ON	OFF
1 mA	ON	OFF	OFF

Note that these currents are nominal values and there will be up to 10% variation between instruments. For semiconductor resistors, the current reduces with falling temperature. The current to select, is that which may flow at the highest operating temperature. This is determined by SW2/1 to SW2/3 in accordance with the table above.

10.5 Selecting Zero and Span

Remember that SW1/1-5 and 6-10 correspond to binary numbers defining the span and zero respectively, in a logarithmic sequence (Section 9.4). To set these it is necessary to be able to simulate the sensor input conditions whilst monitoring the voltage between TP3 and TP0 on the input board.

First establish a zero switch setting SW1/6-10 by trial and error, such that with an input corresponding to the bottom of the range, the voltage at TP3 is as close to zero as possible, whilst remaining positive. (Typically this will be around 0.5 volts).

Now change to an input for the top of the range, and set SW1/1-5 to achieve a voltage as close to 5 volts as possible, without exceeding 5.25 volts. (Typically 4.5 - 5.0 volts).

There will be some interaction between the two sets of switches and a second iteration may be found to be necessary.

10.6 Calculation of Linearisation Data

Take the raw sensor data; voltage, resistance or conductance as appropriate; and split it into 256 equal intervals. Work out the temperature for each point defining these intervals (257 points in all counting first and last).

Note the actual values of the first point T(0) and last point T(256). These will be needed shortly.

Now normalise the data such that the first point is zero and the last is 65535. If T(0) is the first and T(256) the last, each point T(i) may be normalised to give N(i) by:

$$N(i) = (T(i)-T(0))*65535/(T(256)-T(0))$$

Use T(0) and T(256) to calculate a display offset, and display gain:

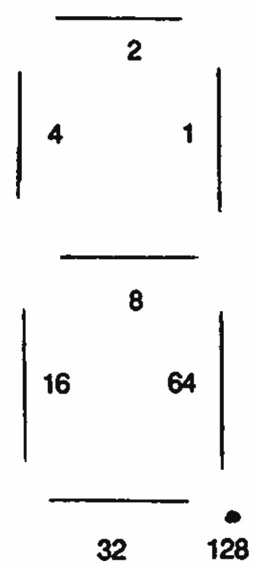
$$N(offs) = 32768 + T(0)$$
$$N(gain) = (T(256)-T(0))/2$$

N.B. T(0) and T(256) should be integral multiples of the intended least significant digit.

Now select a decimal point code N(decimal) using the following list:

N(decimal)	Number of Decimal Places
0	No Decimal Point
1	0
2	1
4	2
8	3
16	4

Finally compute values for the sensor display codes N(code1) to N(code4) for the four characters, by adding together the values of all the segments to light, using the diagram below to asign a value to each segment.



Combine these into two pairs by:

N(code12) = 256*N(code1) + N(code2)
N(code34) = 256*N(code3) + N(code4)

10.7 Loading Linearisation Data

First unlock the memory protection with the command "U9999". (This is the elusive key !)

Then send "Ln" where n is a number in the range 1-3 and determines which of the 3 custom linearisation tables is to be loaded.

Now send the following 264 numbers in the order listed below. Each number must be preceded by a # (hash) and terminated by a carriage return. (Note only the number is sent, not the text "N(0)" etc.).

Number	Example	Notes
N(0)	#0	Will always be 0
N(1)	#200	
N(2)	#387	
-	-	
- etc.	-	
-	-	
N(255)	#65300	
N(256)	#65535	Will always be 65535
N(gain)	#5000	
N(offs)	#32768	
N(decimal)	#2	For 1 decimal place
N(code34)	#28220	For "st"
N(code12)	#15422	For "te"
0	#0	Spare, must be zero
0	#0	Spare, must be zero

The data is now loaded. To install this data, follow the procedure given in section 9 to locate and load the code for the new sensor.

11. THEORY OF CALIBRATION AND LINEARISATION

In the interests of long term stability and ease of adjustment, ITM10 contains no conventional calibration presets. Instead the calibration constants are held in the non-volatile memory and "adjusted" to match a particular sensor by means of the front panel controls. This section covers the theory behind this.

11.1 *Hardware Calibration*

The input signal is amplified to produce a signal within the range 0 to 5 volts at TP3 on the input board.

The role of the span and zero switches SW1 is to ensure that a given input range occupies as much as possible of this 0 to 5 volt range without ever going outside it. The ratio between successive switch positions is never less than 0.7 so it is always possible to fill at least 70% of the 0 to 5 volt range.

The 0 to 5 volt signal is passed to the following voltage to frequency converter, where it is converted into a frequency in the range 0 to 65kHz approx. This is read as a 16 bit number by the microprocessor.

11.2 Input Software Calibration

The raw frequency count has a ZERO value added and is multiplied by a SPAN, to convert it to a number which runs from 0 to 65535 for the full working range. This serves two purposes. It allows interpolation between the switch steps and it allows variation between individual sensors to be calibrated out. When RAISE and LOWER are operated with the CAL button pressed, it is the values of ZERO and SPAN which are adjusted.

11.3 Linearisation

The lineariser proper takes the 16-bit (0-65535) number from the input calibration and remaps it to a new 16-bit number corrected for sensor non-linearity. This is achieved by defining 256 equally spaced linear segments. The correct segment is established and a linear interpolation performed within this segment.

Use of a set of linear segments requires much greater memory storage than would be required for example for a polynomial fit. However it is quicker to calculate, in real time and given the "kinked" nature of many cryogenic sensor calibrations, generally gives a better fit.

It is the linearised 16-bit number which is used within ITM10 for control purposes.

11.4 Display Calibration

To produce the required physical representation of the 16-bit number for display purposes a further multiplication and zero shift now takes place using the GAIN and OFFSET parameters. These map the 0-65535 to the required signed number expressed as degrees. The values of GAIN and OFFSET are determined as part of the range calibration (as described in section 10.6). It is only at this final stage that the accuracy of the numbers may be reduced by rounding. Internally within ITM10 all arithmetic is done on the full 16-bit number.

12. SERVICING

12.1 Circuit Description

The majority of the circuitry involved in ITM10 is conventional and can be readily understood from the circuit diagrams. The notes which follow cover those areas where some additional explanation may be required.

The power supply is totally conventional, providing a 5v supply for the logic. The raw 11 volts from which the 5v is obtained, is used on the main PCB to monitor mains volts. Should this fall below 8 volts, a RESET is performed, protecting the data in the Non-Volatile Memory. (If ITM10 is operated on very low mains volts, it may keep resetting. This may be identified by the "PASS" message reappearing during use.)

The main transformer also generates an 18v AC supply for the input circuits. A separate transformer on the input board splits this into separate isolated supplies for the input amplifier and the current source. Regulated reference supplies of +/-6.2v are generated on the input board.

(The power supply is common to that used on the ITC4 Temperature Controller and also generates a 45V heater supply which is unused on ITM10).

ITM10 may employ either a single input channel or three input channels if the optional second 2-channel board is fitted. The circuitry associated with all three channels is identical.

The input amplifier uses a chopper stabilised amplifier for best stability. This incorporates internal protection against electro-static discharge (ESD) and further protection is provided by the input filter and the fully floating supplies.

The ladder networks associated with SW1 have been designed to give approximately equal ratios of 0.7 between steps.

The sensor current source U103A floats on its own power supply. However it derives its reference supply from the main input stage reference rails, using the three amplifier instrumentation configuration U103 B, C & D, to provide the necessary common mode rejection.

Note when testing the current source, there must be some electrical path between the current source and the input amplifier, to ensure that this remains within the common mode range of the amplifier. In use, this path is provided via the sensor leads. For testing, it is suggested that pins 3 and 5 of the input connector should be linked.

Referencing the current source from the main input reference permits an easy re-configuration for a true 4-wire conductance measurement. This is achieved by opening SW2/6 and SW2/4 and closing SW2/5. The main amplifier now operates open loop and the overall feedback loop is closed via the current source. The normal zero network is used to define an expected sensor voltage and the feedback loop now slaves the sensor current to achieve this. A capacitor across SW2/6 ensures AC stability in this configuration.

The high level signal from the input stage is fed via a filter to a voltage to frequency convertor and thence via a high speed opto-isolator to a counter on the microprocessor board.

The microprocessor circuit is conventional and incorporates CPU, EPROM, RAM, CTC and USART chips. The keyboard and display are mapped directly as i/o ports on the microprocessor bus and the CPU handles all the display decoding and multiplexing in software. A single output port controls the input scan multiplexer. The output of this port is taken to the Relay Board where it is further decoded and latched to select the sensor
switching relays.

Each input channel on the Relay Board has a pair of 2-pole relays associated with it, which are energised when that channel is selected. In addition, 3 further pairs of relays link the selected sensor channel to one of three input channels.
Links associated with this switching allow the two unused channels to be connected to a "dummy sensor" (usually a short circuit). This ensures that the inactive input channels do not drift into saturation, from which they would take longer to recover when next selected. The links may be fitted in either of two positions to emulate either a conductance or a resistance measuring channel.

12.2 Test Mode

ITM10 performs a basic self test of the microprocessor and memory at switch on, before displaying the "PASS" message. A more detailed hardware test mode is accessed by pressing the LOC/REM button whilst holding RAISE and LOWER pressed.

One application of this has already been described in section 9.5. Other test routines which may be of use to the user are described below. Selecting a given test involves using RAISE and LOWER to display the test number required, then pressing LOC/REM to activate the test.

An alternative way to enter the Test mode is by pressing the RED RESET button on the main circuit board. This will operate even if a fault is present on the front panel board.

**** WARNING ****

Never press any other button whilst the internal RED button is depressed. To do so could result in erasure of the NON-VOLATILE memory content with the loss of any installed custom ranges.
(See the following "IN CASE OF DIFFICULTY" section for an exception to this rule.

Test 01 lights each LED or display segment in turn, then pulls each of the auxiliary output lines low in turn. When the test is complete, ITM10 re-enters the test mode.

Test 02 tests the control buttons. When the test is entered, the display will be blank. If the buttons are pressed, one at a time, each should light a single segment in the upper half of the display. Stuck buttons will give a permanently lit segment. If more than one segment lights for a single button, track shorts are indicated. To leave test 2, POWER must be switched off.

Test 04 allows the front panel display to be set to indicate one of the internal parameters rather than the normal measured temperature. This produces the same effect as the 'Fn" command described in section 10, without the need to connect a computer. When test 4 is selected, the display will show:

F 00

RAISE and LOWER may be used to select an option in the range 0 to 13 for front panel display. The options are as given in the list for the "R" command in section 10. When the required option has been selected, pressing LOC/REM will implement it. ITM10 will return to normal operation but with the selected parameter on display. To restore a normal display, the display STEP ON or STEP BACK buttons may be used.

Tests 03, 05, 06 & 07 provide configuration as described in section 9 above.

13. IN CASE OF DIFFICULTY

This section indicates some of the more common pitfalls and operator errors.

RAISE and LOWER appear not to work

Controller is set to REMOTE

"PASS" message appears during operation

Low mains voltage. ITM10 is resetting. It will switch to MAN with output at zero. Check mains voltage setting is correct.

Calibration changes when RAISE/LOWER pressed

CAL button stuck in. (This can happen if the red display window has become detached and dropped down between the button and the panel).

Cannot get SPAN & ZERO calibration correct together

The calibration points chosen are not sufficiently near the ends of the range, so ITM10 is adjusting the same constant, (e.g. the ZERO) at both points (see section 7.1).

The span DIP switches (SW1/1 to SW1/5) are wrongly set so that the voltage at TP3 stops a long way short of 5 volts (see section 10.5).

Measured Display will not Reach Full Range

Either the span or zero switches (SW1/1 to SW1/10) are wrongly set so that the voltage at TP3 goes below zero or above 5.75 volts at the extremes of the range (see section 10.5).

No Display or Abnormal Display (e.g. Multiple Decimal Points)

This probably indicates a hardware defect but can occasionally be due to corruption of the non-volatile RAM content. There are two *reset* procedures which may assist in diagnosing the problem.

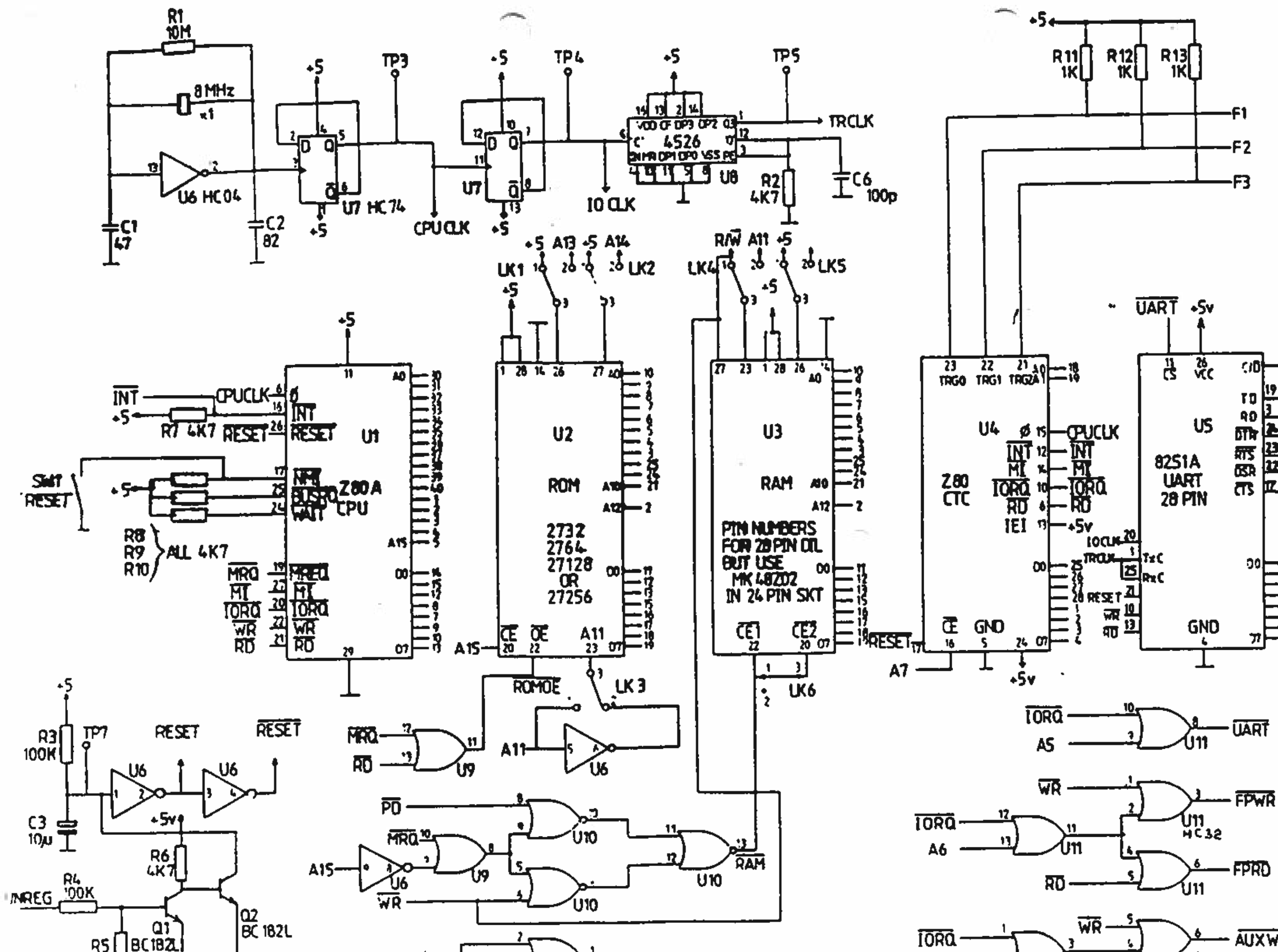
A ***two-button reset*** is carried out by holding the RAISE button pressed, whilst pressing and releasing the internal RED test button SW1 on the main PCB (See section 9). This partially resets the RAM content and will always restore a "PASS" message and a normal display if no other faults are present.

A ***three-button reset*** should be used with extreme caution. It completely resets the entire memory, wiping out all calibration information and any custom linearisation curves which have been installed. It should only be used when the RAM content is known to be beyond recovery (e.g. after replacement of the RAM chip). It is carried out by holding both RAISE and LOWER pressed whilst pressing and releasing SW1 on the main PCB. After a three-button reset, any custom ranges must be re-installed, the range configuration described in Section 9.5 must be carried out and finally the Zero and Span calibration described in Section 7 must be carried out.

14. SPECIFICATION

SENSOR CHANNELS	10
HARDWARE INPUT CHANNELS	1 standard, 3 optional
INPUT RANGE	5mV TO 2V FSD
INPUT OFFSET	-2v to +2v
CURRENT SOURCE	10uA, 100uA, 1mA (+/-10%)
SENSOR TYPES	
Voltage Input	5mV to 2V FSD
Resistance Input	4-wire, 5 Ohm to 200 K Ohm FSD
Thermocouple	See List. (RT comp. on Celcius ranges)
Pt, RhFe Resistor	4-wire resistance measurement
Ge, Carbon Resistor	4-wire conductance measurement
Si, GaAs Diode	Volts sense at constant current
SENSOR SELECTION	Automatic Scan or Manual Selection
SCANNER DWELL TIME	0.25 seconds to 16.5 seconds
INHIBIT TIME	0.25 seconds to 16.25 seconds
DISPLAY	Instant recall of last reading
DISPLAY TYPE	0.56 inch RED LED
DISPLAY RANGE	-19999 TO +19999
INPUT SAMPLE INTERVAL	256 mS
INPUT RESOLUTION	16 Bit
INTERNAL ARITHMETIC	16 Bit
RS232 INTERFACE	Configured as DCE
HANDSHAKE	None Required
BAUD RATE	9600 Baud
IEEE-488 INTERFACE	Option, via external convertor.
CONNECTORS	
POWER IN	IEC 3 pin
SENSOR INPUT	50 way D socket
AUXILIARY I/O	15 way D socket (Not Used on ITM10)
RS232	25 way D socket
POWER REQUIREMENTS	100-240V 50/60Hz
POWER CONSUMPTION	120VA approx
CASE STYLE	Freestanding Metal Case

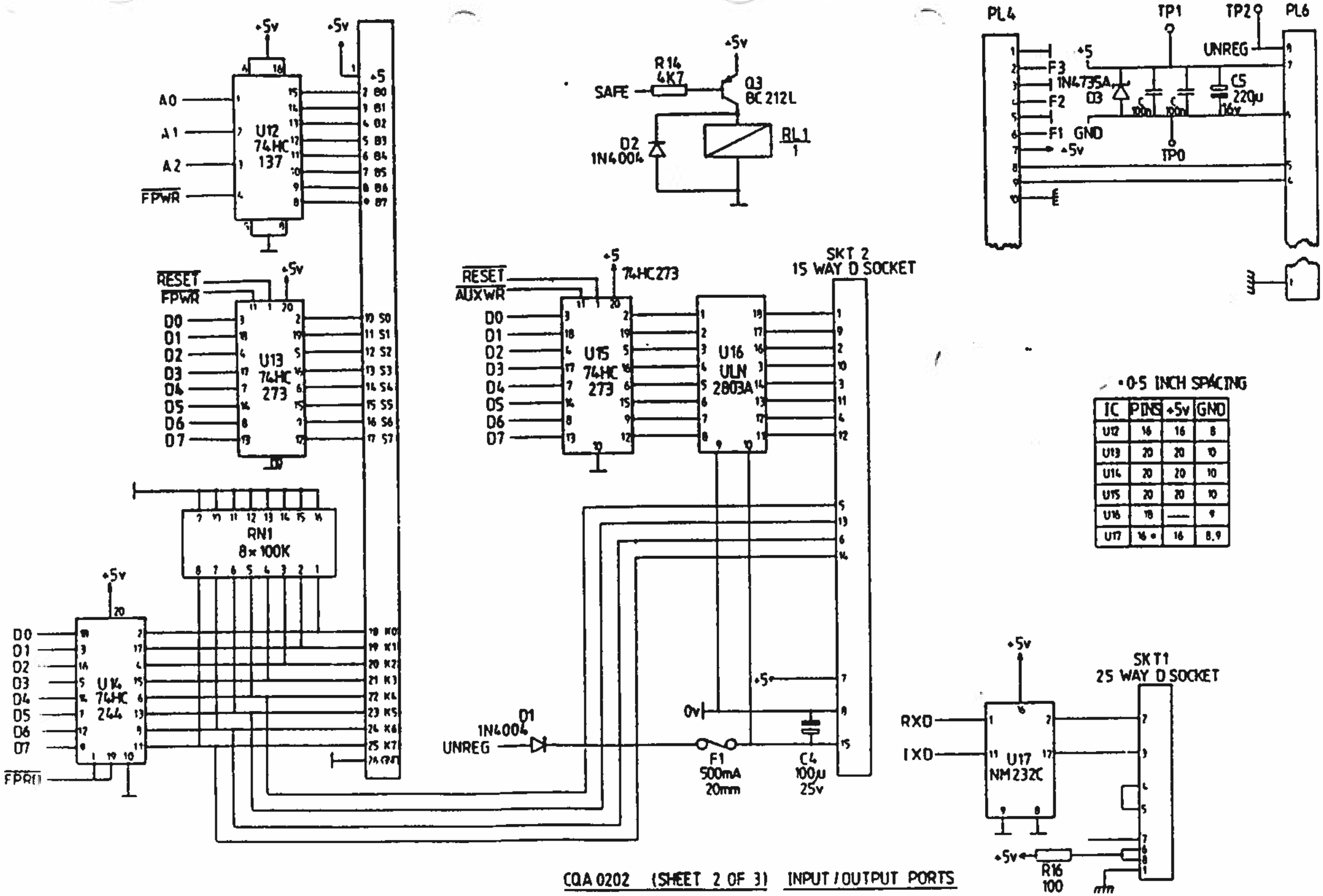
	Optional Rack Mount Ears
DIMENSIONS	
FREESTANDING	446mm x 106mm x 298mm
RACK MOUNT	19 inch x 2U x 298mm
WEIGHT	6.5kg



CQA 0202 (SHEET 1 OF 3)
CPU, MEMORY AND TIMING

IC	PINS	+5V	GND
U1	40	11	29
U2	28	28 LK1	14
U3	28	28 LK5	14
U4	28	24	5
U5	28	26	4
U6	14	14	7
U7	14	14	7
U8	16	16	8
U9	14	14	7
U10	14	14	7
U11	14	14	7

ROM	LK1	LK2
2732	1	1
2764	1	1
27128	2	1
27256	2	2

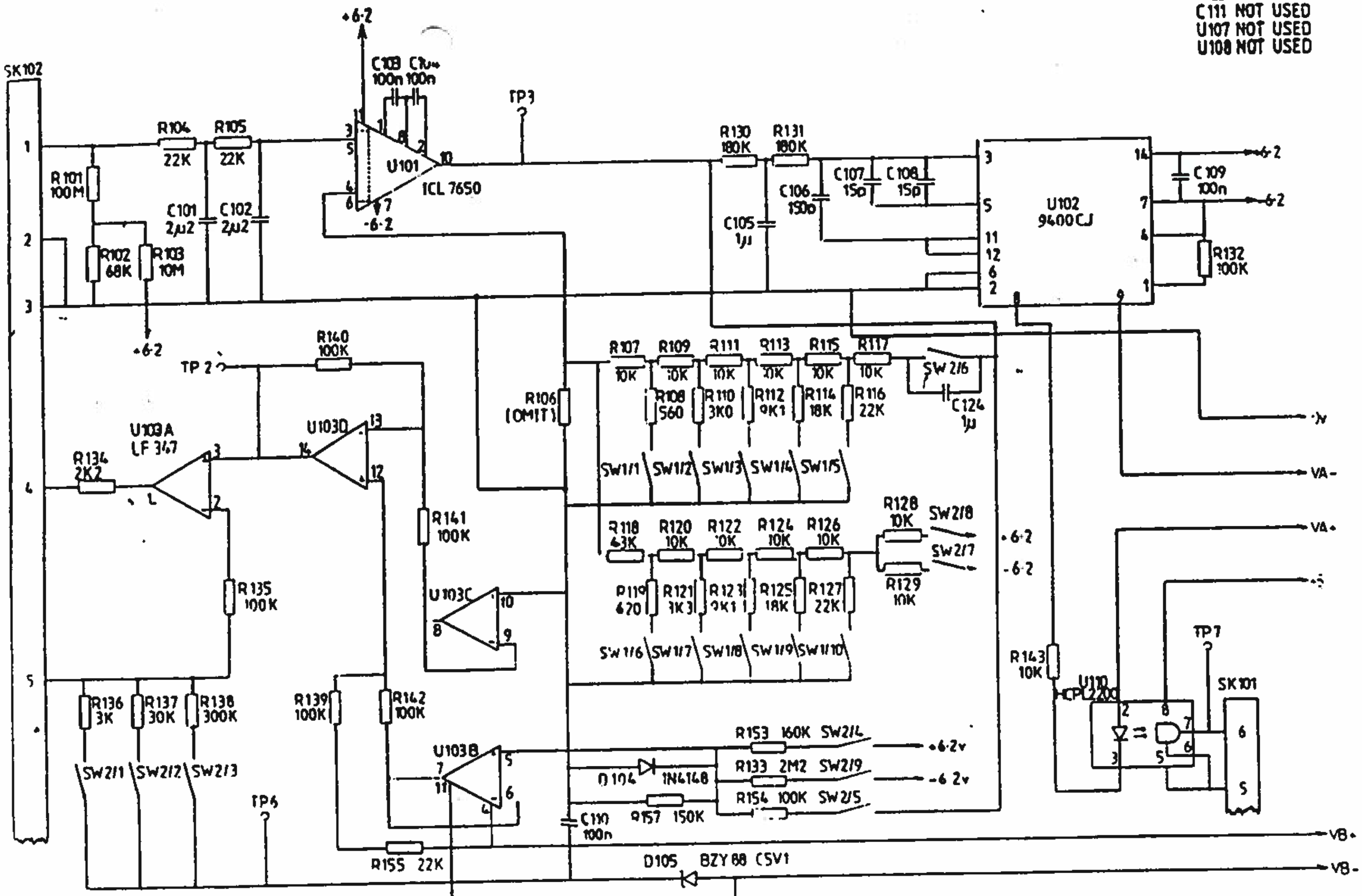


•0·5 INCH SPACING

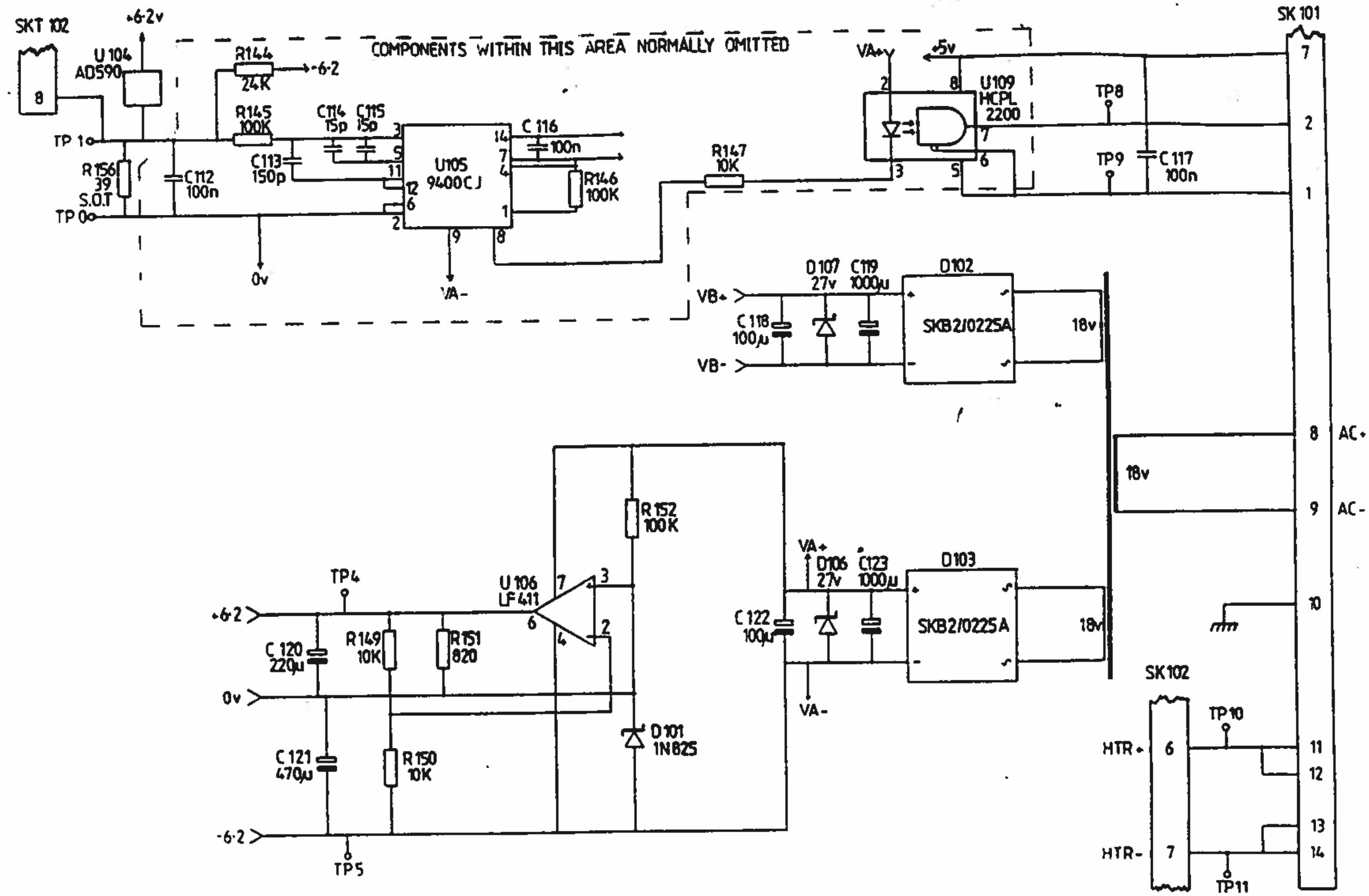
IC	PINS	+5v	GND
U12	16	16	8
U13	20	20	10
U14	20	20	10
U15	20	20	10
U16	18	—	9
U17	16 •	16	8,9

CQA 0202 (SHEET 2 OF 3) INPUT / OUTPUT PORTS

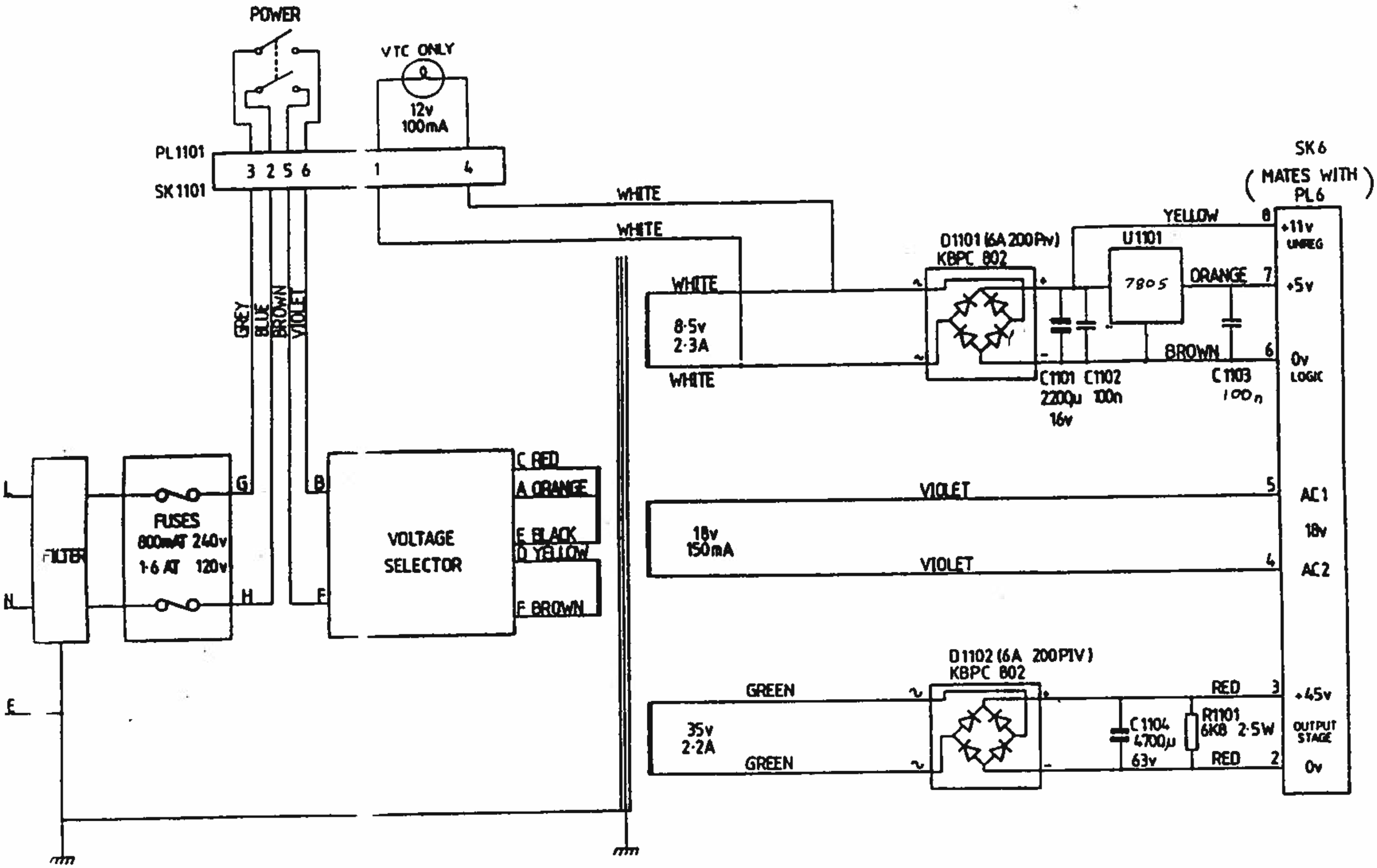
R133 NOT USED
C111 NOT USED
U107 NOT USED
U108 NOT USED



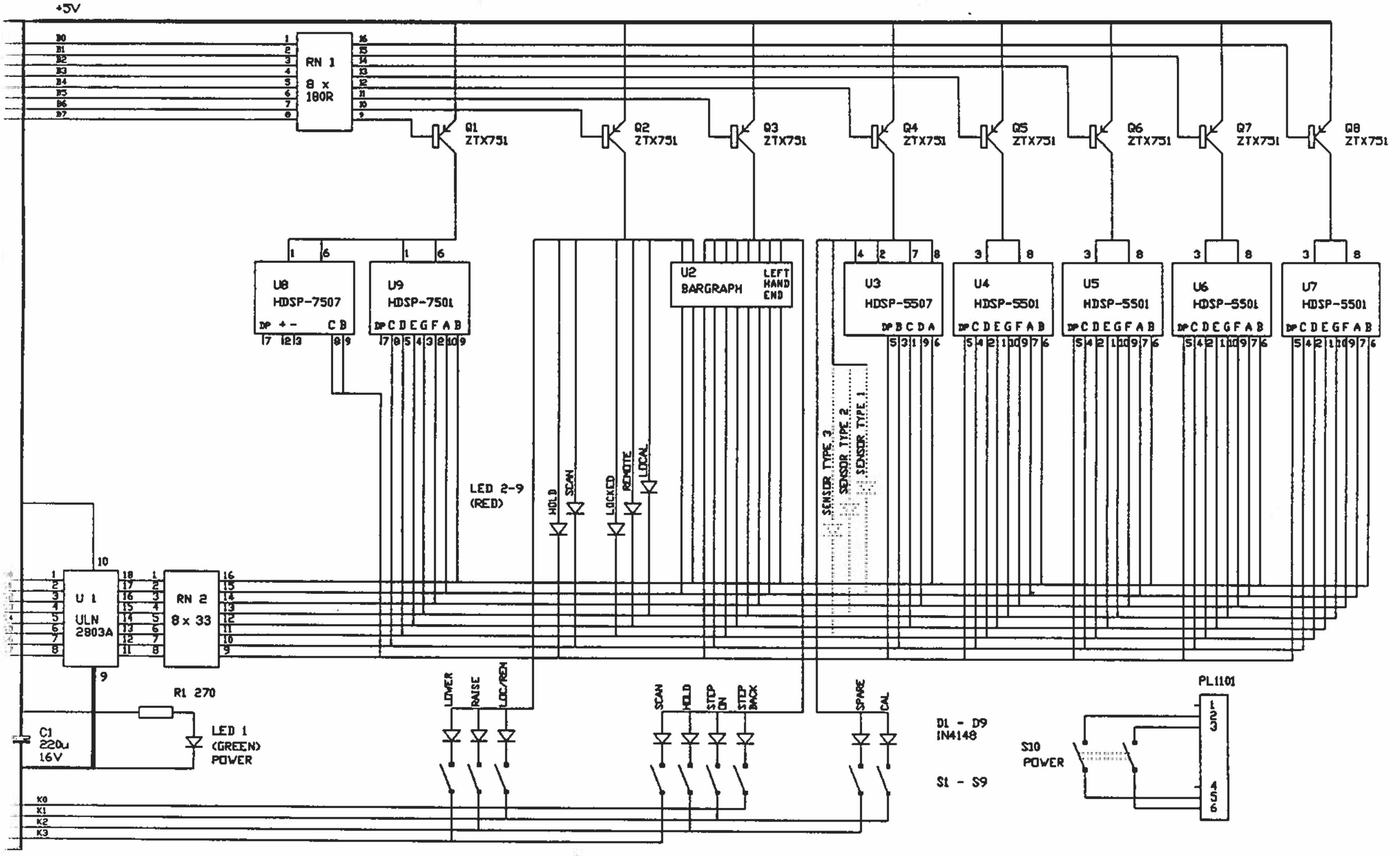
CQB 0302 (SHEET 1 OF 2) INPUT AMPLIFIER



CQB0302 (SHEET 2 OF 2) ITC INPUT PSU



CQA 1102 (SHEET 1 OF 1) POWER SUPPLY



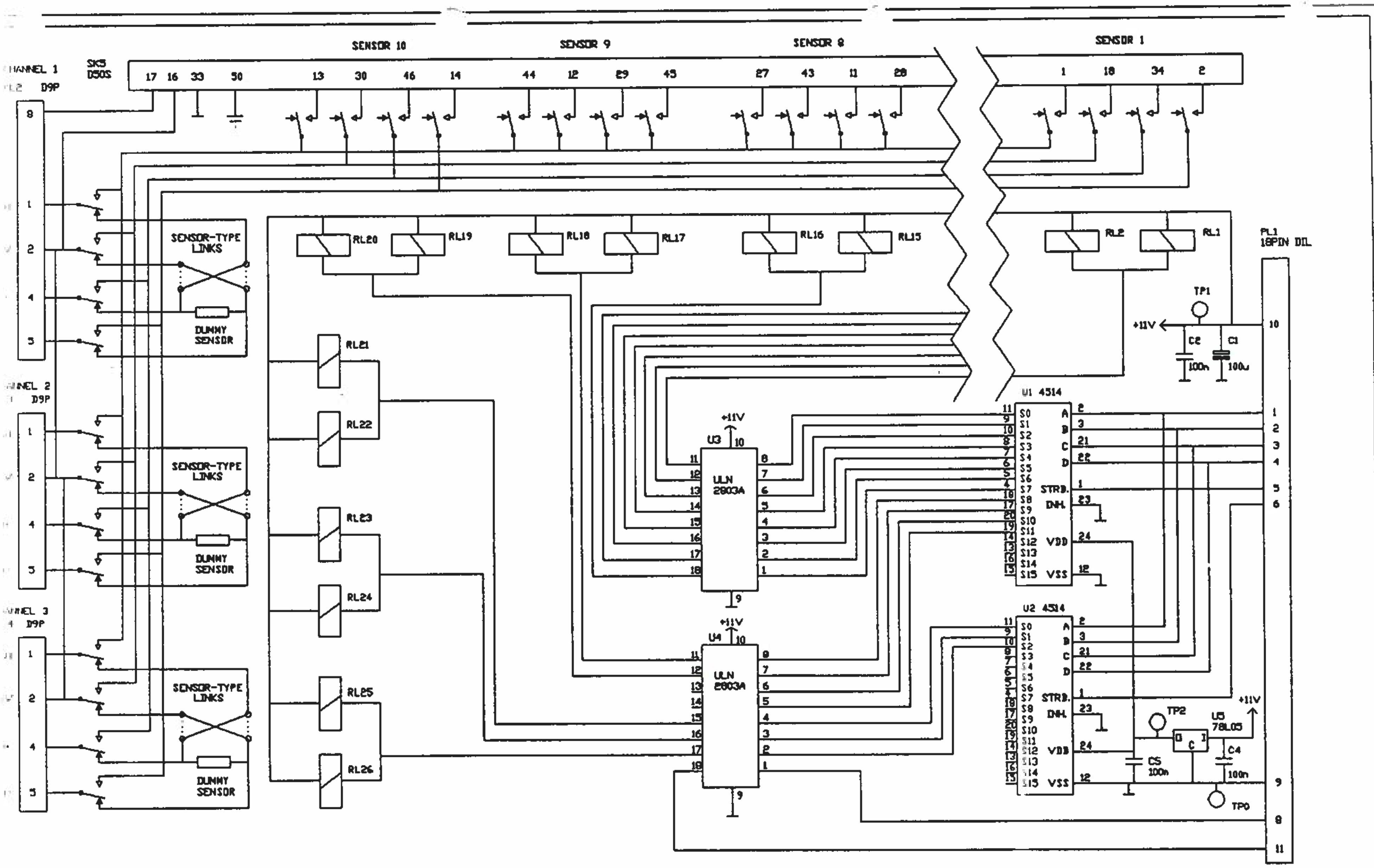
3/4/92	AFS	PRODUCTION RELEASE	
4/7/91	AFS	ORIGINAL	

ITM 10 KEY/DISPLAY BOARD

OXFORD

DRAWING NUMBER

A4/ CQF0102



3/4/92	AFS	PRODUCTION RELEASE
30/4/91	AFS	...ISIONAL

ITM 10 RELAY BOARD CIRCUIT DIAGRAM

OXFORD

DRAWING NUMBER

A4/ CQF0702