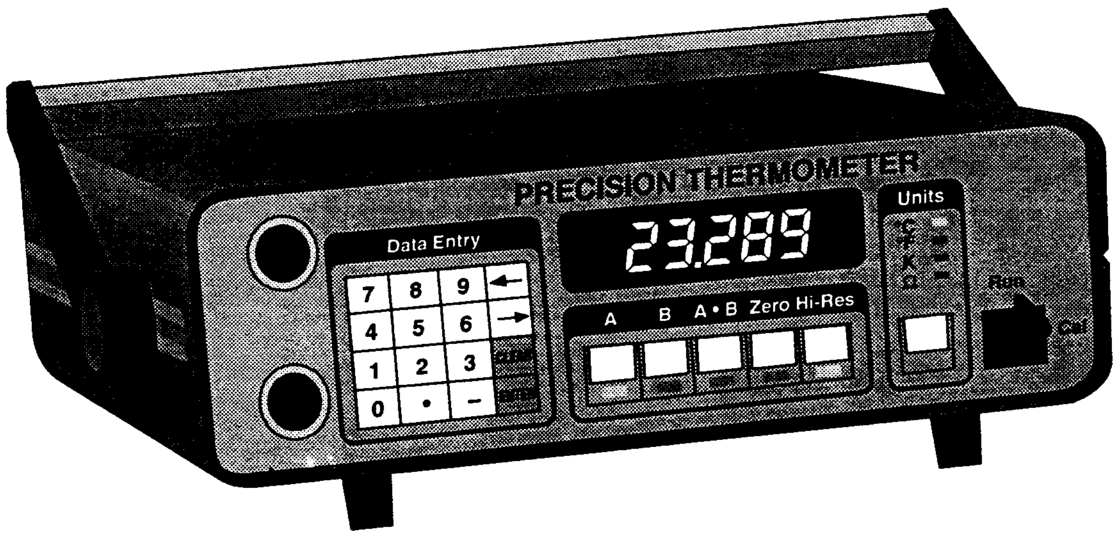
DP251

Precision RTD Benchtop Thermometer



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Operator's Manual

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Remove the Packing List and verify that you have received all the equipment, including the following (quantities in parentheses):

DP251	(1)
ac Power Cord	(1)
Calibration Report	(1)
Operator's Manual	(1)

If you have any questions about the shipment, please call the OMEGA Customer Service Department.

When you receive the shipment, inspect the container and the equipment for signs of damage. Note any evidence of rough handling in transit. Immediately report any damage to the shipping agent.

NOTE

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TABLE OF CONTENTS

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Chapter 1 Introduction

1.1 Description

The DP251 Precision Digital Thermometer, is based on ac bridge technology, the performance and multi-channel capabilities of which make it ideal for a wide range of applications.

The DP251 operates with any 4-wire Pt100 (100 ohm) Platinum Resistance Thermometers (prt) to provide temperature measurement in °C, °F, K (Kelvin) plus resistance in ohms. The ac Resistance Ratio Bridge technology provides a basic accuracy for the instrument alone of ±0.01°C (±10mK - see temperature equivalents below), or up to ±20mK with calibrated prts. A more detailed specification can be found in the specifications, however, the overall system accuracy will always depend on the quality of probe used.

Temperature Equivalents:
1 milli-degree C = 0.001°C = 1m°C = 1mK = 1.8m°F
1 milli-degree F = 0.001°F = 1m°F = 0.56mK = 0.56m°C

The DP251 Precision Thermometer has a useful range of features. Two measurement inputs A & B are provided, enabling A, B, or their difference A-B, to be displayed. Both A and B inputs will operate with 8 or 16 channel (models DP250-8 and DP250-16) multiplexers, enabling up to 32 prts to be measured. The DP250-8 and DP250-16 multiplexers are a specially designed option for the DP251. When calibrated thermometers are used with the DP251, either with or without multiplexers, the calibration data can be entered via the keypad on the front panel, from where it is stored in internal memory. A fuller description of the data entry options available to the user can be found in Chapter 4. Security is important for data entry and a key operated switch on the front panel helps to ensure that only authorized personnel can access the calibration mode. Finally, the front panel also incorporates a "Zero" button to allow A, B or A-B displays to be set to zero to enable single channel or differential mode to be displayed relative to a set point.

Optional accessories for the DP251 include RS232C and/or IEEE488 computer interfaces, a scaleable analog output for recording to chart or other types of recorders and the 8 or 16 channel input multiplexers (models DP250-8 and DP250-16) as described above.

1.2 Definitions and Terminology used in this Manual

i) 1°C = 1K

ii) mK, (milli-Kelvin), is commonly used to describe 0.001°C

iii) All push button actions shown by square brackets [ ], for example pressing the ENTER button is shown [ENTER]

iv) Alpha, or α, represents the fundamental "slope", or temperature sensitivity of the Platinum wire used in resistance thermometers. Generally speaking, the higher the alpha value, the better the thermometer.

v) As the DP251 has thermometer "inputs" which are also used for connection to multi-channel multiplexers, also with thermometer "inputs", it useful to differentiate between them. In this manual, "inputs" on the DP251 are referred to as Inputs and those on the multiplexers are referred to as Channels.

vi) Platinum resistance thermometers are regularly referred to with several alternative abbreviations as follows:

PRT
PT100 - PRT with 100Ω resistance at 0°C
RTD

Note: In this manual Platinum Resistance Thermometers are also referred to as probes or sensors.

vii) System accuracy refers to the overal, combined accuracy of the DP251 and the prt in use, plus a small amount to allow for additional margin.

1.3 Basic Principles Of Operation

DP251 operates with 100 ohm Platinum resistance thermometers (prts) by first measuring the ratio (n) of their resistance (Rt), to that of a very stable internal reference resistor (Rs). The instrument is calibrated with its reference resistor so that it is able to determine very precisely, using n = Rt/Rs, the actual resistance of the thermometers connected to an input, from $R_t = n \times R_s$.

For resistance thermometers, the relationship between resistance and temperature varies slightly from one prt to another. Therefore no matter how accurately the DP251 measures the probe resistance, if we do not know the relationship between resistance and temperature for a particular probe, we will not be able to accurately measure temperature.

Model DP251 uses probe calibration data to overcome this problem and creates a "look-up" table, stored in EPROM non-volatile* memory within the instrument. The look-up table enables the DP251 to convert resistance accurately to temperature, uniquely for each probe used (up to 32 when DP250-8 or DP250-16 multiplexers are connected). It is very important therefore that thermometers are used on their correct Input or Channel for accurate measurement.

The SYSTEM accuracy is a combination of the DP251 accuracy at measuring resistance and the calibration uncertainty placed on the thermometers by the calibrating laboratory. Typically this sum for OMEGA probes type PRP-2, PRP-3 and PRP-4, PRP-5 is ±0.025°C depending on the temperature range.

* Non-volatile memory retains information stored in it, even when all power is removed from the instrument.

Chapter 2 Parts Of The Thermometer

2.1 Front Panel

Figure 2-1 shows the DP251 front panel, the functional parts of which are described below.

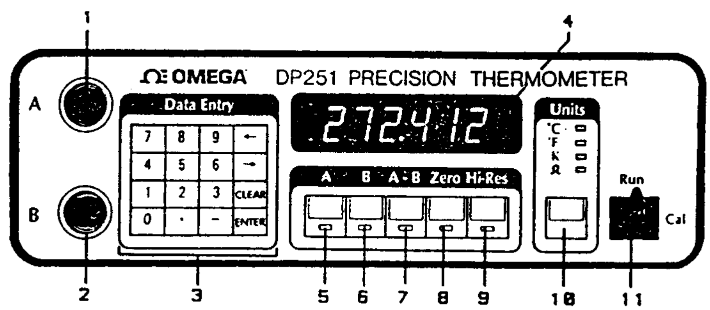

Figure 2-1. Front Panel

Number	Description
1	Channel A Input Socket
2	Channel B Input Socket
3	Numeric Keypad
4	Digital Display
5	Channel A Selector Switch
6	Channel B Selector Switch
7	Channel A - Channel B Selector Switch
8	Zero Switch
9	Hi-Resolution Switch
10	Units Selector Switch
11	Run / Calibrate Switch

2.1.1 Probe Input Connectors A and B:

5 pin DIN sockets to allow the connection of suitable resistance thermometers to the DP251. Connection details are shown in Figure 2-2.

Note: Each front panel input is connected in parallel to a 5 pin terminal socket on the rear panel for use with 4 wire probes without DIN plugs - therefore Input A must only have a probe connected to the front socket **OR** the back socket, **NOT** to both. Similarly for Input B. However it is permissible to have a thermometer connected to the front socket of Input A and a thermometer connected to the rear socket of Input B and vice versa.

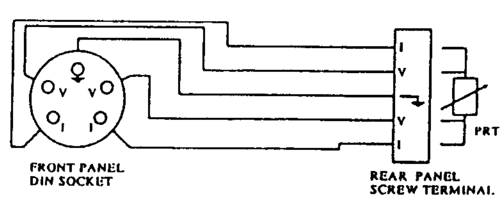

Figure 2-2. Probe Input Connectors

2.1.2 Data Entry Keypad:

The 16 key Keypad permits entry of data into the DP251 memory. It operates in conjunction with visual instructions displayed on the instrument readout and is primarily for storing thermometer calibration data. As data entry can be corrupted by unauthorized entry, access to this function on the keypad is limited to those personnel with a key to fit the Run/Cal lock (see Section 2.1.6). Other functions include bright/dim control of the display, using the right/left arrows respectively, (→ / ←).

2.1.3 Display:

A 6-digit numeric, vacuum fluorescent display. Since the 6 digits include the minus (-) sign for negative temperatures, those lower than -99.999°C/F will be limited to 2 decimals resolution, for example -100.00°C/F. To obtain 3 decimal resolution in these cases, switch to K (Kelvin) as this requires no minus (-) sign.

2.1.4 Main Selection Switches:

A Selects the probe connected to Input socket A (front or back panels) for display.

B Selects the probe connected to Input socket B (front or back panels) for display.

A-B Selects display to read the difference between A and B thermometers.

Zero Nulls the present DP251 reading and the display then indicates any subsequent changes relative to this value.

Hi-Res Sets the DP251 to high resolution mode, for example, normally 0.001°C, °F, or K, or 0.001 ohm when set to Ω (ohms).

2.1.5 Units:

Selects display units °C, °F, K or Ω (ohms). Continuous operation of the Units switch cycles the selection top to bottom.

2.1.6 Run / Cal

This key operated switch allows the operator to enter calibration data "pairs" or coefficients for Inputs A and B and for up to 16 thermometers connected to each Input via the DP250-8 or DP250-16 multiplexers. A data "pair" is a value for temperature and the resistance value for a probe at that temperature. The data so entered is used to produce an internal "look up" table unique to that probe, enabling the best accuracy conversion from resistance to temperature.

2.2 Rear Panel

Figure 2-3 shows the DP251 rear panel, the functional parts of which are described below.

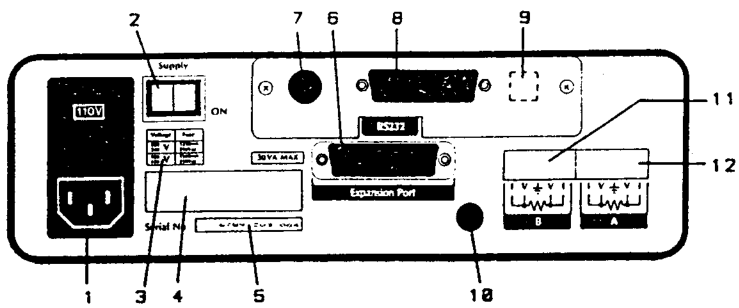

Figure 2-3. Rear Panel

Number	Description
1	Grounded Power Outlet
2	Power ON / OFF Switch
3	Fuse Rating Label
4	Address Label
5	Serial Number Label
6	Multiplexer Expansion Port
7	Analog Output
8	IEEE / RS232 Output Socket
9	IEEE Address Switch
10	Fan Output (RH versions only)
11	Channel B Input Connector
12	Channel A Input Connector

Note: The IEEE Address Switch (number 9) will only be accessable when the IEEE option is installed.

2.2.1 ac Power Input Socket:

Accepts an IEC type power connector.

The ac Power input unit incorporates a voltage selection tumbler, to enable the user to match the DP251 to the local ac voltage supply, and two fuse holders. The correct 20mm fuses to install are as follows:

Voltage	Fuse
220/240V	T250mA (250 Vac)
100/120V	T500mA (250 Vac)

2.2.2 Power ON/OFF switch:

The switch itself will be illuminated (green), when the DP251 is turned ON.

2.2.3 Digital/Analog Output Options:

If installed, this is at the top of the rear panel. Depending on which options are installed and which way the Output Options board is installed, the following will be accessible:

- Analog Output only
- RS232C Interface only
- IEEE488 Interface only
- Analog Output and RS232C Interface
- Analog Output and IEEE488 Interface

Where the IEEE488 Interface is installed, an IEEE address select switch, for setting the DP251 in the range 1 to 7, is provided. Address 0 enables the RS232C interface, if installed.

2.2.4 Expansion Port:

Below the Output Options panel. A 25 pin D type socket (female) for power and data highway connection to the DP250-8 or DP250-16 multiplexers.

2.2.5 Probe Input Connectors A and B:

5 pin Terminal connectors. This rear panel connection is for use where 5 pin DIN plugs are not installed to thermometer cables.

Note the warning regarding front and back panel probe connectors in Section 2.1.1.

Chapter 3 Installation

3.1 Power Supply Connection

3.1.1 Checking Voltage and Fuse Rating

WARNING: DO NOT CONNECT THE POWER CORD OR SWITCH THE UNIT ON UNTIL THE VOLTAGE AND FUSE RATING OF THE INSTRUMENT HAS BEEN CHECKED AND CHANGED IF NECESSARY.

The supply voltage setting of the DP251 is shown on the power inlet socket on the rear panel. Check that this corresponds to the local voltage and that the fuse installed is as specified.

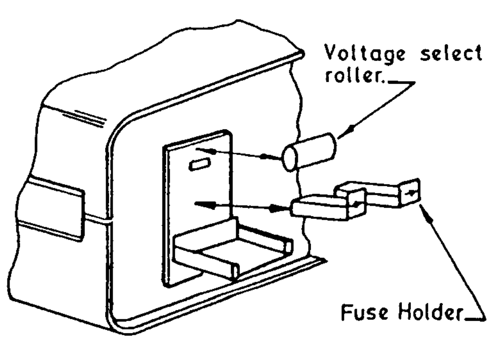

Figure 3-1. Power Input Unit and Fuse Rating Block

3.1.2 Setting the Voltage and Fuse Rating

Selection is achieved by levering open the power inlet filter from the top with a flat bladed screwdriver. Insid is a plastic cam - remove this and then replace it so that the voltage to be set is displayed through the window. See Figure 3-1.

Where fused power plugs are installed to the supply cable provided, the correct fuse rating is 3 Amp. The supply cable provided with the DP251 is color coded as follows:

Ground	Green/Yellow
Live	Brown
Neutral	Blue

3.1.3 Turn-On and Start Up Display:

Once you are certain that all is correct, connect the DP251 to a single phase, 50/60 Hz, grounded power outlet and, with the RUN/CAL switch in the RUN position, switch ON. Initially do not connect a temperature probe to either input channel. After switch-on all the switch lights, (LEDs, or light emitting diodes), should be "on" and the digital display will proceed through a short self test with all digits showing the number "8". Also, all the decimal points will illuminate one at a time. This is to check the integrity of the display and it's drivers. After this initial procedure, the display will change to show the IEEE address (if this option is installed), and/o "RS232" whether or not this is installed. When the display test has finished, the DP251 will set to the default start up condition, that is Channel A, °C and low resolution. The display will indicate the error code "E-1", which indicates no probe is connected, or open circuit exists on input A. See Error Codes in Chapter 10 for a full list and description of error codes.

Turn off the DP251, connect a thermometer to Input A and now turn on the instrument again. After the initial display test the display should now indicate a temperature in °C and low resolution. Check that you can change units to °F, K and Ω (ohms) and then back to °C by repeatedly pressing the Units switch. Check alsc that you can select high resolution with "Hi-Res" and that the display can be set to zero with the "Zero" buttor Unless you have a second thermometer connected to Input B, then selecting it will cause the E-1 message t be displayed, as will selecting A - B. Note that in high resolution mode, DP251 takes a little longer to display a first reading and to subsequently update the reading (see Specifications).

If any error messages other than E-1 are displayed, then refer to Error Codes in Chapter 10 to find their meaning and probable cause. If no suitable explanation can be found for any fault, contact OMEGA.

Chapter 4 Operating the DP251 Thermometer

Note: Make sure that calibration data for your probes has been entered, before carrying out temperature measurement.

4.1 Normal (RUN) Operation

The DP251 must be set to **RUN** on the key operated switch for all functions in the sections below. All measurements are made in RUN mode.

4.1.1 Probe Input Selection

Figure 4-1 shows the selection switches to display Inputs A and B plus the differential value A - B. To select the required display, simply press the appropriate button once. For example, if you want to display the temperature measured by the probe connected to Input B, press [B]. If a DP250-8 or DP250-16 multiplexer is connected to Input B, then the temperatures displayed will also depend on which Channel is selected on the multiplexer. See Chapter 5 for operation with multiplexers.

To display the differential temperature A - B press [A-B], however probes must be connected to both Inputs, directly or via a multiplexer, otherwise an error message will be displayed.

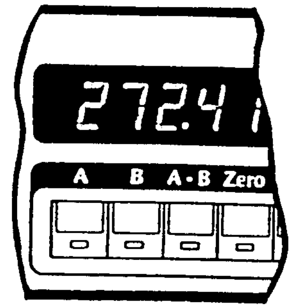

Figure 4-1. Channel Selection Switches

4.1.2 Zero/Hi-Res Functions Selection

Figure 4-2 shows the switches to select Zero and Hi-Res.

Zero: This function is used to display temperature relative to a set point. To activate Zero press [Zero] once only. When this button is pressed the value displayed is subtracted from all subsequent readings, until

i) Zero button is pressed again
ii) The Input or Channel number is changed
iii) Units are changed

When Zero is used with the Input A or B display selected, the status LED above the Zero button flashes. If the Zero facility is activated when A-B is selected, the LED lights continuously.

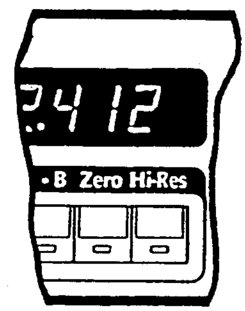

Figure 4-2. Zero / Hi-Resolution Switches

Hi-Res: When initially turned on the DP251 displays to 2 decimal places in all Units. To increase resolution to 3 decimal places press [Hi-Res] once. Press [Hi-Res] again to reduce resolution back to 2 decimals. In addition to changing the display resolution, the Hi-Res button also changes the update time for the display - see Specifications.
Note that when temperatures of lower than -99.999 are to displayed, Hi-Res will not be able to select 3 decimal places as the only 6 digits are available including the -ve sign. This can be overcome by switching either to °C or K, depending on the displayed temperature.
For example -100.000°C = 173.15K, or
-100.000°F = -73.333°C.

4.1.3 Dim/Bright Display Selection

Figure 4-3 shows the switches on the keypad to select dim or bright display.

Press [←] to change the display from bright to dim

Press [→] to change the display from dim to bright

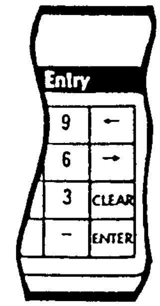

Figure 4-3. Dim / Bright Display Switches

4.2 Data Entry (CAL) Operation

The key operated switch on the DP251 must be set to **CAL** for all functions in the sections below.

Note: To enter any numerical values via the keypad in the Data Entry routines first press [ENTER], the required number and then press [ENTER] again. For example, the value 9.635 must be entered as [ENTER] 9.635 [ENTER].

All data entry is performed on the 16 key keypad as shown in Figure 4-4.

See "General Comments" at the end of this section for additional notes.

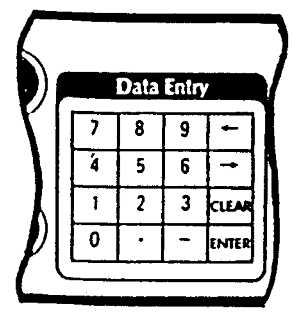

Figure 4-4. Data Entry Keypac

4.2.1 Data Entry Options:

The DP251 allows you 5 alternative mathematical methods of converting resistance to temperature and therefore 5 choices for entering probe calibration data. This will depend on the type of thermometer and its calibration, see Chapter 7 on Sensor Information for more detail.

i) ITS90 coefficients:- intended for probes with high "Alphas" of 0.00390 to 0.00392 - generall laboratory type thermometers

iii) Callendar van Dusen coefficients:- for industrial or low "Alpha" thermometers of 0.00385.

iii) DIN:- used with uncalibrated industrial probes with 0.00385 Alpha value, to provide a genera conversion of resistance to temperature.

iv) Callendar van Dusen data pairs:- as (ii) except where data is provided in data pairs of resistance anc temperature.

v) DIN90:- As (iii) except using modified coefficients from a draft proposal referred to the IEC fo adoption. This brings the coefficients for DIN in line with ITS90 temperatures.

Uncalibrated probes conforming to IEC751/DIN 43760/BS1904 would normally use method 3, which provides a conversion identical to readily available "DIN" or "BS1904" tables. However these tables were created using temperatures as defined by the obsolete Temperature Scale IPTS68, and as such have errors. OMEGA has included the new version, as adoption is likely in the near future.

4.2.2 General Rules for Data Entry

When the question prompt is displayed, such as "r LO?", first press [ENTER], to confirm that you understand what data is required. The display then changes to the "=" cursor, when the numerical data can be entered and then press [ENTER] again to confirm and to move to the next entry.

Mistakes in data entry can be corrected easily provided the number has not been "Entered" - in other words, the final [ENTER] has not been pressed.

i) If the data has been entered, (i.e. [ENTER] pressed), the next prompt will be displayed and no correction is possible. Turn the key to [RUN] to exit the CAL mode, then back to [CAL] to start again. So always double check data entered before pressing [ENTER].

ii) If the data has not been entered it can be edited. Use [←] or [→] keys to move the flashing digit and re-type over the incorrect data. Alternatively, pressing [CLEAR] while on a flashing digit will clear the whole number, which can then be re-typed.

iii) To move the decimal point, position the flashing digit on it using [←] or [→] and press [CLEAR]. The decimal point is removed and can be inserted elsewhere using the [←] or [→] keys.

4.2.3 Starting the Data Entry Routine - For all 5 Conversion Methods:

i) Insert the key and turn the RUN/CAL switch to the CAL position, and the display will indicate "CAL" for nominally 2 seconds before changing to "ChAn?" This question asks the operator - which Channel (Input), A or B, is data entry required? At the same time the LEDs below the A and B switches alternate on/off.

ii) Select the Input required by pressing the appropriate button - for example if data entry is required for Input A, then press [A] once.

Switch actions: [CAL][A]

iii) If a multiplexer is connected, (in this case to Input A), the next display will ask the question "Ch ?", and after a few seconds the display will change to "=", which is the prompt for you to enter the multiplexer channel number which requires probe data entry. At this prompt, enter the channel number via the keypad as follows:

a) as a two digit number, for example, 01, 09 or 13
b) a single digit may be entered followed by [ENTER]

For example, if channel number 7 is required, use the following key sequence, [0][7] or [7][ENTER].

Switch actions: [0][7] Please note: [7] is example only

iv) If no multiplexer is connected, or after the multiplexer channel is selected, the display indicates the 5 data entry options sequentially as shown in Figure 4-5.

To select the option you require for your probe, 1, 2, 3, 4 or 5, press the appropriate number on the keypad.

For example, if data entry is required in Callendar van Dusen coefficients - press [2]. On selecting the data conversion method, the display will momentarily flash confirmation of the operator's choice.

Switch action: [2] (Conversion equation type 2 is example only)

Total switch actions, with multiplexer:

[CAL][A][0][7][2]

Total switch actions, without multiplexer:

[CAL][A][2]

---1---
ITS90
---2---
CALLEn
---3---
din
---4---
CAL Pr
---5---
din 90

Figure 4-5. Temperature Selection Scrolling Menu

v) The DP251 will now request data from the probe calibration certificate. This will vary according to th choice of resistance to temperature conversion made, but before moving to the appropriate sectio please note the general rules above on entering and correcting data.

vi) Now go to the following section for:

ITS90	- Section 4.2.4
CvD coeff.	- Section 4.2.5
DIN	- Section 4.2.6
CvD d.p.	- Section 4.2.7
DIN 90 (draft)	- Section 4.2.8

4.2.4 ITS90 Data Entry:

On selecting 1 - the ITS90 equations - data entry is required for the following information which, apart from (ii) and (iii) (see general comments Section 4.2.9), should be available from the thermometer calibration certificate.

i)	r0.01 ?	Resistance R at +0.01°C (Triple point of Water)
ii)	r Lo ?	Minimum resistance value for the conversion table
iii)	r hi ?	Maximum resistance value for the conversion table
iv)	AP EE	Positive temperature Coefficient A exponential, for example, if A = 5.3×10^{-3}, enter -3
v)	AP diG	Positive temperature Coefficient A digits, for example, if A = 5.3×10^{-3}, enter 5.3 (if -5.3, then enter as -5.3)
vi)	bP EE	Positive temperature Coefficient B exponential, enter the same way as for AP EE
vii)	bP diG	Positive temperature Coefficient B digits, enter the same way as for AP diG
viii)	CP EE	Positive temperature Coefficient C exponential, enter the same way as for AP EE
ix)	CP diG	Positive temperature Coefficient C digits, enter the same way as for AP diG
x)	An EE	Negative temperature Coefficient A exponential, enter the same way as for AP EE
xi)	An diG	Negative temperature Coefficient A digits, enter the same way as for AP diG
xii)	bn EE	Negative temperature Coefficient B exponential, enter the same way as for AP EE
xiii)	bn diG	Negative temperature Coefficient B digits, enter the same way as for AP diG

Example:

Display Prompt	Value	Key Input
"r0.01 ?"	100.05	[ENTER][1][0][0][.][0][5][ENTER]
"r Lo ?"	79	[ENTER][7][9][ENTER]
"r hi ?"	198	[ENTER][1][9][8][ENTER]
"AP EE"	-4	[ENTER][-][4][ENTER]
"AP diG"	2.458	[ENTER][2][.][4][5][8][ENTER]

and so on with bP, CP, An and bn

When all data has been entered, the display initially goes blank. As the DP251 starts to generate the resistance - temperature look up table, the actual number of points to be generated will appear on the display and will count down to 0, at which point the process will be complete. The message "stored" confirms that the look up table has been created and safely stored in memory, but in case you require to enter data for another channel, the message "ChAn?" appears along with Inputs A and B turning alternately on/off.

If more channels require data entry, follow the procedure as described under the appropriate method.

If no additional data entry is required, turn the RUN/CAL switch to [RUN], when the screen will display the message "Abort". This message indicates that you have left Data Entry (CAL) mode and is accompanied by an audible "beep".

4.2.5 Callendar van Dusen (using coefficients):

On selecting 2 - the Callendar van Dusen equations - data entry is required for the following information which, apart from (i) and (ii), should be available from the thermometer calibration certificate (see general comments Section 4.2.9)

i)	r0 ?	Probe resistance at 0°C
ii)	r Lo ?	Minimum resistance value for the conversion table
iii)	r hi ?	Maximum resistance value for the conversion table
iv)	AP EE	Coefficient A exponent, e.g., if $A = 5.3 \times 10^{-3}$, enter -3.
v)	AP diG	Coefficient A digits, e.g., if $A = 5.3 \times 10^{-3}$, enter 5.3 (if -5.3 then enter as -5.3).
vi)	bP EE	Coefficient B exponent, enter in the same way as for A
vii)	bP diG	Coefficient B digits, enter in the same way as for A
viii)	CP EE	Coefficient C exponent, enter in the same way as for A
ix)	CP diG	Coefficient C digits, enter in the same way as for A

Example:

Display Prompt	Value	Key Input
"r0 ?"	100.005	[ENTER][1][0][0][.][0][0][5][ENTER]
"r Lo ?"	79	[ENTER][7][9][ENTER]
"r hi ?"	198	[ENTER][1][9][8][ENTER]
"AP EE"	-3	[ENTER][-][3][ENTER]
"AP diG"	5.3	[ENTER][5][.][3][ENTER]

and so on with B EE, B diG, C EE and C diG

Where values for coefficients are not provided in CvD coefficient entry, for example if no calibration is carried out below 0°C, and no value for C is given, the value 0, or no entry should be made followed by [ENTER].

When all data has been entered, the display initially goes blank. As the DP251 starts to generate the resistance - temperature look up table, the actual number of points to be generated will appear on the display and will count down to 0, at which point the process will be complete. The message "stored" confirms that the look up table has been created and safely stored in memory, but in case you require to enter data for another channel, the message "ChAn?" appears along with Inputs A and B turning alternately on/off. If more channels require data entry, follow the procedure as described under the appropriate method.

If no additional data entry is required, turn the RUN/CAL switch to [RUN], when the screen will display the message "Abort". This message indicates that you have left Data Entry (CAL) mode and is accompanied by an audible "beep".

If the coefficients entered are as below:

$A = 3.90802 \times 10^{-3}$

$B = -5.802 \times 10^{-7}$

$C = -4.2735 \times 10^{-12}$

and R_0 = 100 ohms,

then the DIN standard, as in 4.2.6, has been entered.

4.2.6 DIN Standard

Entering 3 from the data entry menu selects the DIN Standard - data entry is required only for R_{min} ("r Lo") and R_{max} ("r hi"), as the coefficients, which are a special case within the Callendar van Dusen equation, are stored in memory. As usual R_{min} and R_{max} determine the temperature range over which the look up table will be created.

Example:

Display Prompt	Value	Key Input
"r Lo ?"	65.5	[ENTER][6][5][.][5][ENTER]
"r hi ?"	196.8	[ENTER][1][9][6][.][8][ENTER]

When all data has been entered, the display initially goes blank. As the DP251 starts to generate the resistance - temperature look up table, the actual number of points to be generated will appear on the display and will count down to 0, at which point the process will be complete. The message "stored" confirms that the look up table has been created and safely stored in memory, but in case you require to enter data for another channel, the message "ChAn?" appears along with Inputs A and B turning alternately on/off. If more channels require data entry, follow the procedure as described under the appropriate method.

If no additional data entry is required, turn the RUN/CAL switch to [RUN], when the screen will display the message "Abort". This message indicates that you have left Data Entry (CAL) mode and is accompanied by an audible "beep".

4.2.7 Callendar van Dusen - (using data pairs):

If you choose method 4 for data entry, the Callendar van Dusen equations are utilized by entering data pairs of resistance versus temperature. The data pairs are used to calculate the coefficients for the CvD equations, which are then used to create the temperature vs. resistance look up table.

The prompts are as follows:

i)	"r Lo ?"	Minimum resistance value for the conversion table
ii)	"r hi ?"	Maximum resistance value for the conversion table
iii)	t0° ?	Temperature nearest to 0°C
iv)	r t0?	Resistance at temperature nearest 0°C
v)	t 100°?	Temperature nearest 100°C
vi)	r t100	Resistance at temperature nearest 100°C
vii)	t° P ?	Another <u>positive</u> temperature
viii)	r t°P?	Resistance at <u>positive</u> temperature
ix)	t° n ?	A <u>negative</u> temperature
x)	r t°n?	Resistance at <u>negative</u> temperature

Example:

Display Prompt	Value	Key Input
"r Lo ?"	80	[ENTER][8][0][ENTER]
"r hi ?"	198.5	[ENTER][1][9][8][.][5][ENTER]
"t0 ?"	0.051	[ENTER][0][.][0][5][1][ENTER]
"r t0?"	100.020	[ENTER][1][0][0][.][0][2][ENTER]
"t 100°?"	99.993	[ENTER][9][9][.][9][9][3][ENTER]
"r t100"	138.498	[ENTER][1][3][8][.][4][9][8][ENTER]

and so on for tP, rtP, tn and rtn.

When all data has been entered, the display initially goes blank. As the DP251 starts to generate the resistance - temperature look up table, the actual number of points to be generated will appear on the display and will count down to 0, at which point the process will be complete. The message "stored" confirms that the look up table has been created and safely stored in memory, but in case you require to enter data for another channel, the message "ChAn?" appears along with Inputs A and B turning alternately on/off. If more channels require data entry, follow the procedure as described under the appropriate method.

If no additional data entry is required, turn the RUN/CAL switch to [RUN], when the screen will display the message "Abort". This message indicates that you have left Data Entry (CAL) mode and is accompanied by an audible "beep".

4.2.8 DIN (using proposed new coefficients to align temperatures with ITS90)

When 5 is selected from the menu an alternative method for generating a DIN look up table is available. Until this new equation set is approved by the IEC, it is stressed that this route is not officially recognized. The advantage is that it removes the errors associated with the current DIN which is based on the earlier and obsolete International Practical Temperature Scale IPTS68.

Example:

Display Prompt	Value	Key Input
"r Lo ?"	65.5	[ENTER][6][5][.][5][ENTER]
"r hi ?"	196.8	[ENTER][1][9][6][.][8][ENTER]

When all data has been entered, the display initially goes blank. As the DP251 starts to generate the resistance - temperature look up table, the actual number of points to be generated will appear on the display and will count down to 0, at which point the process will be complete. The message "stored" confirms that the look up table has been created and safely stored in memory, but in case you require to enter data for another channel, the message "ChAn?" appears along with Inputs A and B turning alternately on/off. If more channels require data entry, follow the procedure as described under the appropriate method.

If no additional data entry is required, turn the RUN/CAL switch to [RUN], when the screen will display the message "Abort". This message indicates that you have left Data Entry (CAL) mode and is accompanied by an audible "beep".

4.2.9 General Comments

i) r Lo ? This is the minimum resistance for DP251 to generate a temperature - resistance look-up table. This resistance should, in general, not be lower than the range over which the probe has been calibrated and for which coefficients have been provided. The DP251 will generate a conversion table over a wider range, but temperatures derived from extrapolation beyond the calibration minimum point, will not be traceable to International Standards. It is recommended that a value of nominally 2 ohms lower than the minimum calibration value is entered - this will avoid an "out of range" error message.

ii) r hi ? The maximum resistance for DP251 to generate a temperature - resistance look-up table. This resistance should, in general, not be higher than the range over which the probe has been calibrated and for which coefficients have been provided. The extrapolation rule above applies. It is recommended that a value of nominally 2 ohms higher than the maximum calibration value is entered - this will avoid an "out of range" error message.

iii) The maximum difference between r Lo and r hi must be no greater than 396Ω, or an error will occur. See error codes in Chapter 10. Almost certainly this range is greater than many probes and most applications. The calculation time for a smaller range is also shorter.

iv) Where values for coefficients are not provided in ITS90 or CvD coefficient entry, for example if no calibration is carried out below 0°C, and no An or bn values given, the value 0, or a no entry should be made followed by [ENTER].

v) Once the look up table "number countdown" has started, you can turn the RUN/CAL switch back to "RUN". If you do this, DP251 will start to measure temperature immediately at the end of the entry process and will not prompt you for further data.

vi) If you are entering data for more than one Input or Channel, then any combination of the 5 conversion methods may be used.

Chapter 5 Working with the DP250-8 or DP250-16 Multiplexer

DP250-8 (8 channel) and DP250-16 (16 channel) multiplexers, have been specially designed to allow thermometer Inputs A and B on the DP251 to be expanded to measure up to 16 channels each, with no degradation in instrument performance. Both direct (absolute) and differential measurements can be made when using the DP250-8 or DP250-16 multiplexer.

5.1 Connection and Control

Probe connection may be via the front panel, or the back panel for a easier installation. Each channel has high isolation, low resistance, 5-pin relays giving full 4 terminal measurement plus ground. Visual indication of the Input and Channel selected is provided. One or two DP250-8 or DP250-16 multiplexers can be operated from the keypad or remotely using the DP251 communications board. When operated via RS232 or IEEE the channel can be selected and the temperature read in any of the usual formats available to the DP251.

5.1.1 Multiplexer Address

Before a multiplexer can be used on channel A or B, the address must be set. The address switch is hidden behind a plastic rivet on the right hand side of the front panel of the multiplexer close to the A and B LEDs. When in use, the appropriate LED is illuminated to confirm to which Input it is connected. When two multiplexers are in use, one must be set for "A" and the other to "B" or there will be an address conflict. To adjust the multiplexer address, connect as described below and after removing the plastic rivet, use a small screw driver to set the switch to the required Input.

5.1.2 Connections

Connectors 0 - 15 (or 0 - 7, for 8 channel units) allow the thermometer probes to be connected at the front of the multiplexer, or to the rear if the screw terminals are used on the back panel. Each paralleled connector pair (shown in Figure 2-2 for the DP251) represents one channel, with the LEDs on the front panel indicating which channel is selected. The same LEDs are also used to indicate the selected channel when probe calibration data is being entered.

Power, calibration table data and channel select information is all carried on a ribbon cable between the DP251 and the DP250-8 or DP250-16. The ribbon cable is connected between the "Control Input" port on the DP250-8 or DP250-16 and the "Expansion Port" on the DP251. The 4 wire measurement signals plus ground are carried separately from the "Output" screw terminal on the DP250-8 or DP250-16 to the appropriate A or B Input on the DP251.

5.1.3 Turn On

After connecting the DP250-8 or DP250-16 to the required Input on the DP251 as described above, turn on and the display test will proceed as in Section 3.1.3. If necessary, reset the address switch to the required Input.

Connect a thermometer to channel 0, either via the front panel connector or the back panel connector, but not both. With no calibration data installed, the DP251 will be able to display resistance only, so set units to Ω (ohms). Using the A or B push buttons on the DP251, select the Input with the multiplexer attached, upon which the prompt for channel number will appear, "Ch?". Enter the channel number [0] and press [ENTER]. Note when the channel number is two digits, it is accepted automatically and pressing [ENTER] is not required.

5.2 Probe Data Entry

When DP250-8 or DP250-16 multiplexers are used, probe data is held in non-volatile memory, (EPROM), within the multiplexer itself, although data entry is performed in the same way as when using the DP251 alone and as described in Section 4.2. The 5 alternative methods of data entry, ITS90, Callendar van Dusen coefficients, DIN, Callendar van Dusen data pairs and DIN90, are available as with the DP251 alone.

Follow the data entry procedure in Section 4.2, taking particular note of the requirements when a multiplexer is connected. Once data entry has started the appropriate DP250-8 or DP250-16 channel will be selected to enable the data to be stored in the section of the EPROM reserved for that channel.

Chapter 6 Calibration

6.1 DP251

The ac bridge technology of the DP251 is inherently very linear, however this is improved further by calibration during final test. After soak testing, each DP251 is measured against four (4) precision resistors which are traceable to International Standards. This calibration information is then stored in non-volatile memory within the instrument, providing a corrected linearity to better than ±10mK. The long term stability of ac bridge technology makes this method of "linearization" valid over long periods of time and it will not normally be necessary to re-linearize the DP251 on a regular basis. Experience has shown that other instruments using this method have very little correction necessary after several years of use.

Unlike calibration data entry for prts, instrument linearization is not a user entry option.

6.2 Resistance Thermometers

For accurate temperature measurement, the DP251 uses stored data for each prt that it operates, although for less accurate work this data can be the general industrial specification for resistance thermometers, IEC751 which encompasses more familiar specs such as DIN43760. Additionally, 100 Ohm prts are available in low and high "Alpha" wire, although the former is the norm for industrial applications. See Chapters 7 and 8 on Sensors and on the International Temperature Scales respectively.

Calibrated Platinum resistance thermometers supplied with the DP251 will be traceable to the National Institute of Science and Technology and therefore to International Standards.

As described in Sections 7 and 8 in more detail, the relationship between temperature and resistance varies depending on several factors including their "Alpha" value. Consequently more than one equation is required for resistance to temperature conversion. Calibration data for the thermometers can also take the form of either "data pairs" or "coefficients". The DP251 therefore gives the user 5 alternative data entry formats. Section 7, provides more detailed instruction on data entry methods.

Chapter 7 Sensor Information

The DP251 will operate with any 4-wire 100 Ohm prt, often referred to as Pt100, however the best performance will only be extracted if good quality probes are used from reputable, proven sources. As with any measured parameter the performance of a measurement system is dictated by stability and repeatability and low quality Pt100's will most likely reduce the system performance.

For this reason, OMEGA provides a range of proven prt's specially for use with the DP251, as well as offering a service of customized probes to meet individual requirements.

7.1 High "Alpha" PRTs

The best possible system accuracy is achieved using high "Alpha" (α) probes, or more correctly probes using high α wire. This is because the way that they are constructed usually permits a better calibration uncertainty on the thermometer and therefore the system.

7.1.1 -183°C to 500°C PRT (Contact OMEGA)

R_0	100 Ω
α	≥0.00390
Range	-183°C to +550°C
Sheath	Fused Silica
Sheath Size	480mm x 8mm diameter
Cable Length	2 meters

7.1.2 0 to 550°C PRT (Contact OMEGA)

R_0	100 Ω
α	≥0.00390
Range	0°C to +550°C
Sheath	Fused Silica
Sheath Size	450mm x 6.35mm diameter
Cable Length	2 meters

7.2 Low "Alpha" PRTs

Low α probes contain a higher level of impurities in their platinum wire, which affects the resistance value at any given temperature. As impurities already exist, additional contamination has a reduced affect and so these thermometers are best in industrial applications, where for purposes of robustness the detector itself within the probe is constrained within other materials which can also be the source of contamination at elevated temperatures. The prt's supplied by OMEGA have been optimized for their stated ranges and, where calibrated, temperature cycled to enhance stability in use.

Probes which are used outside their design and/or calibration range, especially higher temperatures, risk alteration to their calibration either by induced thermal stresses, or by contamination caused by materials being used beyond their recommended ranges.

7.2.1 Uncalibrated, 1/3rd DIN PRT

R_0	100 Ω
α	< 0.00390, typically 0.00385
Range	-50°C to +250°C
Sheath	Stainless Steel
Sheath Size	350mm x 6mm diameter
Cable Length	2 Meters
Calibration	UNCALIBRATED, 1/3rd DIN

7.2.2 PRP-2, PRP-3 PRTs

R_0	100 Ω
α	< 0.00390, typically 0.00385
Range	-50°C to +250°C
Sheath	Stainless Steel
Sheath Size	350mm x 6mm diameter
Cable Length	2 Meters
Calibration	4 point, -50, 0, +100 and +250°C
Cal. Uncertainty	±0.01°C (NIST traceable)

7.2.3 PRP-4, PRP-5 PRT's

R_0	100 Ω
α	< 0.00390, typically 0.00385
Range	-70°C to +450°C
Sheath	Stainless Steel
Sheath Size	350mm x 6mm diameter
Cable Length	2 Meters
Calibration	4 point, -70, 0, +100 and +420°C
Cal. Uncertainty	±0.04°C -70 to -50°C; ±0.01°C >-50 to +250°C; ±0.1°C >+250 to +450°C (NIST traceable)

7.2.4 Environmental Chamber Probe (Contact OMEGA)

R_0	100 Ω
α	< 0.00390, typically 0.00385
Range	-70°C to +200°C
Sheath	Stainless Steel
Sheath Size	30mm x 3mm diameter
Cable Length	2 Meters, alternatives to order
Calibration	4 point, -50, 0, +100 and +200°C
Cal. Uncertainty	±0.05°C (NIST traceable)

Chapter 8 International Temperature Scale

The purpose of the International Temperature Scale is to define procedures by which certain specified practical thermometers of the required quality can be calibrated in such a way that the values of temperature obtained from them can be precise and reproducible, while at the same time approximating the corresponding thermodynamic values as closely as current technology permits.

Since 1968 when the IPTS68 was adopted, there have been significant advances in the techniques employed in establishing temperature standards and in the measurement of thermodynamic temperature. The ITS-90 gives practical effect to these improvements. Particular features are:

i) ITS-90 specifies the use of the platinum resistance thermometer up to the freezing point of silver, 961.78°C. Above this temperature radiation thermometry based on the Planck law of radiation is specified. The platinum-10% rhodium/platinum thermocouple is no longer specified for use in the scale, though it and other noble-metal thermocouples will continue to be used as secondary standards.

ii) Several new, more precise, fixed points have been introduced and the mathematical procedure have been revised so as to reduce the 'non-uniqueness' of the scale; that is, to reduce th differences which occur between different identically-calibrated thermometers. In particular, th calibration of a platinum resistance thermometer can no longer be extrapolated beyond the freezin point of zinc, 419.527°C, but requires a measurement at the freezing point of aluminum, 660.323°C.

iii) Alternative definitions are permitted in certain sub-ranges, so that the calibration of a thermomete can be terminated at almost any fixed point. This provision allows primary calibrations to be carrie out with suitable thermometers over reduced ranges, and will be of especial importance t metrologies who need to make precise measurements at ambient temperatures.

iv) The scale extends to 0.65 K by specifying the use of an interpolating gas thermometer and heliur vapor equations.

By virtue of these and other changes, ITS-90 has much improved continuity, precision and reproducibility, compared with IPTS68. The implementation of the scale according to it's definition calls for significant changes in equipment and procedure, but lower uncertainties of calibration will be achievable in all parts of the range. On the other hand, the instruments and equipment needed for it's dissemination to and from secondary calibration laboratories will be substantially the same.

If you would like more detailed information regarding ITS90, contact OMEGA.

Chapter 9 Communications / Output Options

An optional output board may be installed in the DP251, and can be supplied with any combination of 3 interfaces:

- RS232C serial digital communications interface
- IEEE488 parallel digital communications interface
- dc Analog Output

The board itself is normally factory installed but can be retrofitted by the user. The interface board has 3 separate areas, each devoted to one of the options as indicated below and may be installed in the DP251 in one of two orientations depending on which digital interface is used. If an analog output is included, an outpu socket is installed at both ends of the board to enable access no matter which digital interface is being used.

When the DP251 is turned on, the display will show "rS232" even if no board or RS232C is installed. If IEEE488 is installed, the start up display will show "IEEEn", where n is the number from 1 to 7 for the IEEE controller address in the DP251.

9.1 Retro-fitting or Changing an Interface Board

The interface board will normally be factory installed but can be installed by a competent technician. As the interface board can be dual purpose, for example, both RS232C and IEEE 488 may be installed, it may from time to time be necessary to reverse the board to access one or other interface.

WARNING:
Turn off the instrument and remove the power supply cord, before removing the instrument case.

9.1.1 Retro-fitting

1) Remove the 4 screws holding the top half of the instrument case and lift off vertically.

2) The interface board may be installed with any combination of RS232C, IEEE488 or Analog outputs. Select the digital output required and hold the board over the DP251 such that this output is at the rear of the instrument.

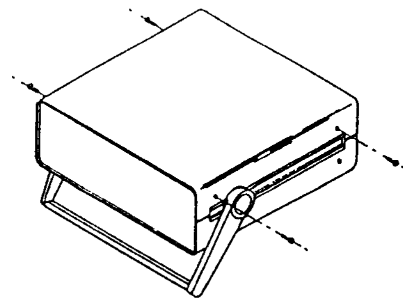

Figure 9-1. Removing Screws

3) The interface board is held into the DP251 between two metal spacers at the front end and two screws into captive nuts on the back panel. Connect the appropriate ribbon cable on the board to it's connector on the DP251 mother board and then lower the interface and secure in place.

4) Replace the instrument top case and secure with the 4 screws.

9.2 RS232C Interface

With the RS232C option installed, communication happens via the 25-pin male, D-type connector on the back panel as shown in Figure 9-2.

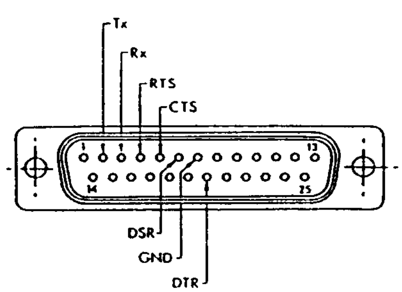

Figure 9-2. RS232 Connector

9.2.1 Pin Connections

Computer			DP251		
Function	25-Pin Connector	9-Pin Connector	Function	25-Pin Connector	Connections
Tx	2	3	Rx	3	
Rx	3	2	Tx	2	
RTS	4	7	CTS	5	To 6
CTS	5	8	RTS	4	To 20
DSR	6	6	DTR	20	To 4
GND	7	5	GND	7	
DTR	20	4	DSR	6	To 5

9.2.2 RS232C Settings

As supplied by the factory, unless requested otherwise, the RS232C interface is configured as follows:

19,200 Baud
8 Character bits
No Parity
2 Stop Bit

These parameters can be changed using the following procedure;

1) Remove the 4 screws holding the top half of the instrument case, after first turning off and removing the power cord.

2) Lift off the top half of the case and, assuming that the interface board is installed such that the RS232C connection is to the rear, locate the DIP switch at the rear of the board on the left when looking at the DP251 from the front. The DIP switch has a row of small lever switches down one side, the one nearest the rear is number 1, so the front lever is number 8.

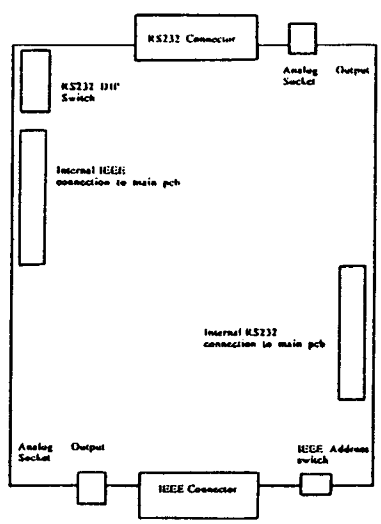

Figure 9-3. Board Layout

3) When a lever is in the down position, this is ON or 1, so you can adjust the switches according to the following tables.

Baud Rate

Baud rates	Switches		
	1	**2**	**3**
4800	1	0	0
9600	1	1	0
19200	1	1	1

Parity

	Switches	
	4	**6**
No Parity	1	x
Even Parity	0	1
Odd Parity	0	0

x = either a 1 or a 0

Data Bits

	Switch
	5
7 Bits	0
8 Bits	1

Stop Bits

	Switch
	7
1 Stop Bit	0
2 Stop Bits	1

NOTE: Switch 8 is not used.

Examples:

To set 4800 Baud, no parity, 8 data bits and 1 stop bit, select the following:

Switch No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Position	1	0	0	1	1	x	0	x

Note: x = either a 1 or a 0

To set 9600 Baud, even parity, 8 data bits and 2 stop bits, select the following:

Switch No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Position	1	1	0	0	1	1	1	x

Note: x = either a 1 or a 0

When set to your requirements, replace the instrument top lid and secure with the 4 screws.

9.2.3 Interpretation

Commands sent are executed after a line feed, or carriage return line feed combination. If the input buffer within the DP251 becomes full, (64 bytes including carriage return (CR) line feed (LF)), the commands are also executed as far as the end of the buffer.

The DP251 returns data almost immediately after receiving the command ?, Q, T or D. The controlling device must therefore be ready to receive as soon as the command is sent. All data returned is terminated with a CR LF sequence. No leading or trailing spaces are sent. When command A is used, the DP251 sends data after every measurement update. Section 9.2.4 gives full details of the command set.

9.2.4 Commands and Syntax

All of the primary functions available from the DP251 front panel can be accessed via the serial interface, typically from an external computer or terminal.

Following is a list of the commands that can be sent to the DP251 - all are single letters followed by up to 2 single digit parameters, with the exception of the multiplexer commands which have 2 alphabetical characters followed by 2 digits.

COMMAND A

Function: Requests the DP251 to send back the probe setting, the temperature (or resistance) and the units every time the display is updated. The probe may be A, B or D (differential), and units may be C, F, K or Ω.

Examples: "A 0.00C", or "B273.150K".
Note that the return string is always 9 characters long plus CR,LF, except in ohms in high resolution mode when it is 10 characters long + CR,LF.

Syntax: An, where n = 0, 1, 2, 3 or 4

Parameters:
n = 0 selects probe A
n = 1 selects probe B
n = 2 selects probe A - B (differential)
n = 3 selects alternate mode
n = 4 cancels continuous output

Initial State: Not applicable
Note: Sets service request mask when used with IEEE interface, see Section 9.3.4

COMMAND C

Function: Clear or general reset - resets the DP251 to it's switch-on state.

Syntax: C

Parameters: None

Initial State: Not applicable

COMMAND F

Function: Sets the sensitivity of the analog output (if installed).

Syntax: Fn, where n = 0, 1, 2 or 3

Parameters:
n = 0 selects 10v/degree or ohm
n = 1 selects 1v/degree or ohm
n = 2 selects 0.1v/degree or ohm
n = 3 selects 0.01v/degree or ohm

Initial State: n = 3, 0.01v/degree or ohm

COMMAND L

Function: Local lockout - enables or disables the DP251 front panel controls.

Syntax: Ln, where n = 0 or 1

Parameters:
n = 0 enables front panel (lockout off)
n = 1 disables front panel (lockout on)

Initial State: n = 0, lockout off

COMMAND M

See Section 9.4

Syntax Mn, where n = @, A,B,C or D

Parameters
n = @ cancels Service Request
n = A sets probe to A and Service Request on when reading available.
n = B sets probe to B and Service Request on when reading available.
n = C sets probes to A-B and Service Request on when reading available.
n = D sets probes to alternate A then B and Service Request on when reading available.

COMMAND P

Function: Set probe input for display

Syntax: Pn, where n = 0, 1 or 2

Parameters:
n = 0 selects the A input for display
n = 1 selects the B input for display
n = 2 selects A - B (differential) for display

Initial State:	n = 0, probe A being measured and displayed

COMMAND	**? or Q**
Function:	Query, the DP251 will return the status of the function
Syntax:	?a or Qa, where a is P, R, U, Z or _
Parameters:	a = P queries the probe setting - return setting 0, 1 or 2
	a = R queries the resolution - return setting 0 or 1
	a = U queries the units - return setting 0, 1, 2 or 3
	a = Z queries the zero function - return setting 0 or 1
	a = _ queries all settings plus reading (25 characters + CR,LF)
Initial State:	Not applicable

COMMAND	**R**
Function:	Sets the DP251 resolution as 2 or 3 decimal places
Syntax:	Rn, where n = 0 or 1
Parameters:	n = 0 selects 2 decimal places (3 decimals for ohms)
	n = 1 selects 3 decimal places (4 decimals for ohms)
Initial State:	n = 0, 2 decimal places

COMMAND	**S**
Function:	Remote control of the optional DP250-8, DP250-16 multiplexers (if used)
Syntax:	Smn, where m = A or B and n is a number 00 to 15
Parameters:	m = A directs control to the multiplexer on channel A
	m = B directs control to the multiplexer on channel B
	n = the number of the channel on the selected multiplexer
Initial State:	SA00, SB00
	Note: 4 characters must be sent to form a valid command, for example SA02, SB13

COMMAND	**T or D**
Function:	Asks the DP251 to send the probe setting, the reading to the present resolution and the units. The probe may be A, B or D (differential) and the units may be C, K, F or Ω.
Examples:	"A 0.003C", or "B 75.149K". Note that the string is always 9 characters long plus CR,LF except in ohms in high resolution mode when it is 10 characters long + CR,LF.
Syntax:	T or D
Parameters:	None
Initial State:	Not applicable

COMMAND	**U**
Function:	Sets the units on the DP250 to °C, °F, K or Ω (ohms)
Syntax:	Un, where n = 0, 1, 2 or 3
Parameters:	n = 0 selects °C
	n = 1 selects K
	n = 2 selects °F
	n = 3 selects Ω (ohms)
Initial State:	n = 0, °C

COMMAND	**Z**
Function:	Sets present reading to zero (null), or clears a zero if already set
Syntax:	Z
Parameters:	None
Initial State:	No zero

9.3 IEEE488 Interface

The optional IEEE488 interface allows the DP251 to be controlled by an external computer and apart from some additional features, it uses the same device dependent commands as described under the RS232C interface. All the primary functions on the front panel can be controlled.

If the IEEE option is installed, then the DP251 will display it's device address during the start up display routine as follows:

"IEEE n"

where n is the device number 1 to 7.

9.3.1 Pin Connections

Pin connections for IEEE488 are shown in Figure 9-4

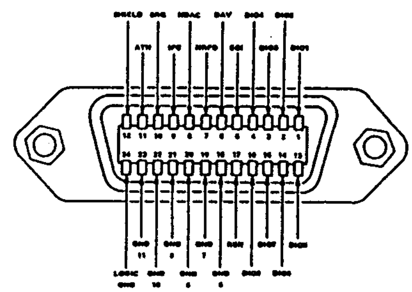

Figure 9-4. IEEE Connector

9.3.2 IEEE488 Setting

Address Selection: To set the device address the rotary switch, on the interface panel at the instrument rear, is used. The switch has positions 0 to F, though only addresses 1 to 7 should be used. Positions 9 to F simply repeat the sequence. Address 0 is used for the RS232C controller, so is not available for IEEE. When delivered, the switch is set to 3. The address switch is only interrogated at turn-on or after a clear command, so if the address is changed the DP251 will continue to respond to the old address unless turned off/on or sent a "clear".

The interface has no remote/local switching facility, so the DP251 does not have to be turned on-line before commands are sent.

To return the DP251 to it's turn-on state, the IEEE488 device clear command can be used, having the same effect as the device dependent command "C".

Figure 9-5 shows the address selection switch.

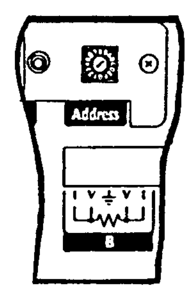

Figure 9-5. Address Selection Switch

9.3.3 Specification

For people with a knowledge of the IEEE488 (1987) standard, the DP251 IEEE interface has the following specification:

i)	SH1	Full source handshake
ii)	AH1	Full acceptor handshake
iii)	T8	Basic talker (unaddress on MLA)
iv)	L4	Basic listener (unaddress on MLA)
v)	LE0	No extended addressing
vi)	TE0	No extended addressing
vii)	SR1	Service request available
viii)	RL0	No remote local function
ix)	LL0	No local lockout function
x)	PP0	No parallel poll
xi)	DC1	Device clear - reverts to power-on state

9.3.4 Commands and Syntax

All of the primary functions available from the DP251 front panel can be accessed via the parallel interface, typically from an external computer or terminal.

Following is a list of the commands that can be sent to the DP251 - all are single letters followed by up to 2 single digit parameters, with the exception of the multiplexer commands which have two letters followed by a two digit parameter.

COMMAND **C**
Function: Clear or general reset - resets the DP251 to it's switch-on state.
Syntax: C
Parameters: None
Initial State: Not applicable

COMMAND **F**
Function: Sets the sensitivity of the analog output (if installed).
Syntax: Fn, where n = 0, 1, 2 or 3
Parameters: n = 0 selects 10v/degree or ohm
n = 1 selects 1v/degree or ohm
n = 2 selects 0.1v/degree or ohm
n = 3 selects 0.01v/degree or ohm
Initial State: n = 3, 0.01v/degree or ohm

COMMAND L

Function: Local lockout - enables or disables the DP251 front panel controls.
Syntax: Ln, where n = 0 or 1
Parameters: n = 0 enables front panel (lockout off)
n = 1 disables front panel (lockout on)
Initial State: n = 0, lockout off

COMMAND M

See Section 9.4
Syntax Mn, where n = @, A,B,C or D
Parameters n = @ cancels Service Request
n = A sets probe to A and Service Request on when reading available.
n = B sets probe to B and Service Request on when reading available.
n = C sets probes to A-B and Service Request on when reading available.
n = D sets probes to alternate A then B and Service Request on when reading available.

COMMAND P

Function: Set probe input for display
Syntax: Pn, where n = 0, 1 or 2
Parameters: n = 0 selects the A input for display
n = 1 selects the B input for display
n = 2 selects A - B (differential) for display
Initial State: n = 0, probe A being measured and displayed

COMMAND ? or Q

Function: Query, the DP251 will return the status of the function
Syntax: ?a or Qa, where a is P, R, U, Z or _
Parameters: a = P queries the probe setting 0, 1 or 2
a = R queries the resolution setting 0 or 1
a = U queries the units setting 0, 1, 2 or 3
a = Z queries the zero function setting (0 = no zero set, 1 = zero set)
a = _ queries all settings plus reading
Initial State: Not applicable

COMMAND R

Function: Sets the DP251 resolution as 2 or 3 decimal places
Syntax: Rn, where n = 0 or 1
Parameters: n = 0 selects 2 decimal places (3 decimals for ohms)
n = 1 selects 3 decimal places (4 decimals for ohms)
Initial State: n = 0, 2 decimal places

COMMAND S

Function: Remote control of the optional DP250-8 and DP250-16 multiplexers (if used)
Syntax: Smn, where m = A or B and n is a number 00 to 15
Parameters: m = A directs control to the multiplexer on channel A
m = B directs control to the multiplexer on channel B
n = the number of the channel on the selected multiplexer
Initial State: SA00, SB00
Note: 4 characters must be sent to form a valid command, for example SA02, SB13.

COMMAND	**T or D**
Function:	Asks the DP251 to send the probe setting, the reading to the present resolution and the units. The probe may be A, B or D (differential) and the units may be C, K, F or Ω (ohms).
Examples:	"A 0.003C", or "B 75.149K".
	Note that the string is always 9 characters long plus CR,LF except in ohms in high resolutio mode when it is 10 characters long + CR,LF.
Syntax:	T or D
Parameters:	None
Initial State:	Not applicable

COMMAND	**U**
Function:	Sets the units on the DP251 to °C, °F, K or Ω (ohms)
Syntax:	Un, where n = 0, 1, 2 or 3
Parameters:	n = 0 selects °C
	n = 1 selects K
	n = 2 selects °F
	n = 3 selects Ω (ohms)
Initial State:	n = 0, °C

COMMAND	**Z**
Function:	Sets present reading to zero (null), or clears a zero if already set
Syntax:	Z
Parameters:	None
Initial State:	No zero

9.4 **COMMAND M** (Service Request Mask)

A Service Request Function is set up using the "M" command. The "M" command is issued with a single byte parameter (see the list below) which specifies the output required from the DP251. Once selected the DP251 will continuously output information until a cancel command is received. The Display on the DP251 will flash as data is sent.

BIT 2,1,0	000	Cancel Service Request
	001	set to channel A and set service request when data available
	010	set to channel B and set service request when data available
	011	set to channel A -B and set service request when data available
	100	set alternately to channel A then B and set service request when data available
BIT 3	Add multiplexer channel number to the data output from the DP251	
BIT 4	Not used	
BIT 5	Not used	
BIT 6	RSV (Service Request Bit)	
BIT 7	Sets DP251 to give an output when an error occurs	

When using the Service Request Mask the bits are sent to the DP251 in order of significance.

Example:

To set the DP251 to send channel A data when it is available send "M01001001"

To cancel output from the DP251 send "M01000000"

9.5 Analog Output

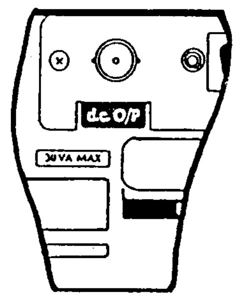

Figure 9-6. Analog Output

The DP251 analog output provides a dc output voltage in the range of ±10 volts that is directly proportional to the displayed reading and selected scale factor. The analog output is updated on completion of every balance cycle and is obtained by digital to analog conversion from the digital measurement.

Default Settings

On power up of the DP251, the instrument will revert to the following default settings:

Measurement units	deg C
Measurement channel	"A"
Resolution	low resolution
Analog output scale factor	1000

9.5.1 Scale Factor

The analog output full scale voltage can be scaled to represent a change in displayed units of 1, 10, 100 or 1000 (displayed units may be °C, °F, or ohms). To view or alter the scale factor of the analog output, enter the scale factor menu by pressing the "-" switch of the data entry keypad. The display will flash "A-OP" to indicate that you have entered the analog output menu, it will then continue to cycle through displaying the available scale factor options with the associated data entry key for each scale factor selection.

To indicate the current set scale factor, when it appears on the display, it will repeatedly flash. To select the required scale factor, press the appropriate data entry keypad number associated with the required scaling factor.

Data Entry Keypad No.	Scaling Factor	Sensitivity
"0"	"1"	10v / degree or ohm
"1"	"10"	1v / degree or ohm
"2"	"100"	0.1v / degree or ohm
"3"	"1000"	0.01v / degree of ohm

On pressing the appropriate data entry keypad number, the display will flash your choice, store it and return the instrument to run mode. On completion of the next balance cycle, the analog output will be updated. Alternatively, to the keypad, the scaling factor can be set via the RS232 or IEEE interfaces (if installed) by sending the common Fn, where n = 0, 1, 2 or 3 as for the keypad.

9.5.2 Analog Output Connection

Connection to the analog output is via an insulated BNC output socket on the rear panel of the DP251 instrument. Connection to peripheral equipment should be made via a suitable twin core, twisted pair screened cable, (see Figure 9-7), to the instrumentation input amplifier of the peripheral equipment.

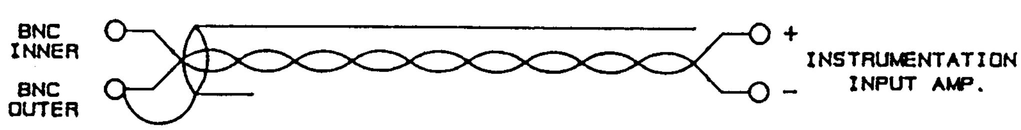

Figure 9-7. Twin Core, Twisted Pair, Screen Cable

9.5.3 Analog Output Operation

A more detailed explanation of the analog output operation follows. The DP251 analog output provides a dc output voltage in the range of ±10 volts that is directly proportional to the displayed reading and selected full scale reading. The analog output is updated on completion of every balance cycle, the measurement value is held in a variable called "DAC BUFF" in BCD format.

The contents of "DAC BUFF" is then converted to a floating point integer, scaled and converted to complementary offset binary ready to be output to the 16 bit D to A converter. The complementary offset binary 16 bit data is sent in two bytes to an 8 bit parallel to 16 bit parallel converter (ICI to IC5). The high order byte is set on the data bus first and latched through and held on the output of an 8 bit data latch (IC3) by addressing the appropriate latch through the address decoding (IC1 and IC2) 3 to 8 decoder and inverter respectively.

The low order byte is then set on the 8 bit data bus, latched through and held on the output of (IC5) 8 bit data latch, also the input of the 16 bit digital to analog converter. At the same time the high order byte is latched through and held on the output of (IC4) 8 bit latch, also the input of the 16 bit digital to analog converter completing the 8 bit parallel to 16 bit parallel conversion. The 16 bit complementary offset binary is then converted to a linear output current in the range of ±2mA by (IC6) digital to analog converter.

The analog current is converted to a corresponding output voltage by (IC7). Slope and zero presets are factory set to correct but may be adjusted if necessary.

Specification

Resolution 16 bit

Analog Output range ±10vdc

Scrutiny (front panel selectable) ±1, ±10, ±100, ±1000

Linearity ±0.0015% FS typical (±0.3mV)

Linearity ±0.003% FS max (±0.6mV)

Monotonicity 14 bit

Resolution Per Scaled Range

Scale	Analog Output	DP251
1000k	0.3mV	30mK
100k	0.3mV	3mK
10K	1mV	1mK
1k	10mV	1mK

Temperature Coefficient

Gain drift	±10ppm/°C typical ±25ppm/°C max
Zero drift	±5ppm FS/°C typical ±12ppm FS/°C max

Chapter 10 Error Codes

Error codes can be generated by the DP251 for a variety of reasons as follows.

Code	Meaning / Cause
E1	Balance error / No probe, probe open circuit or ratio over range.
E2	Temperature over range / Probe at temperature outside limits of look-up table.
E3	CAL ROM "A" error / No "A" ROM
E4	IEEE or RS232 error / Unrecognized instruction sent
E5	IEEE or RS232 error / Illegal argument sent
E6	RAM failure
E7	Not used
E8	Unable to track temperature change / temperature change too large.
E9	Look-up table too big / Table larger than 396 points.
E10	Singular matrix / Unable to create look-up table.
E11	Singular matrix / Unable to create look-up table.

Chapter 11 Options and Accessories

11.1 Communications/Output Options

Communications/Output options can generally be retrofitted to an existing DP251.

Order Suffix	Description
-RS2	RS232C Communications
-IEEE	IEEE 488 Communications
-A	Analog Output

11.2 Accessories

Part Number	Description
DP250-RACK	19" rack mount kit for DP251
DP251-SOFT	Lab Windows software for DP251
DP250-DT	DIN plug to 5-pin screw terminal plug converter
DP250-TD	5-pin screw terminal to DIN plug converter
DP250-DIN5	Package of 5 additional DIN plugs
DP250-STP5	Package of 16 additional 5-pin screw terminal plugs
DP250-CASE	Rugged carrying case for DP251 and probes

Chapter 12 SPECIFICATIONS

12.1 Accuracy

System performance is the combined total of the DP251 accuracy plus the calibration uncertainty of the probe. The instrument and system accuracy's with a variety of probes are shown below.

DP251 Only:- ±0.01°C (±10mK)

DP251 + PRP-2 or PRP-3 probe (-50°C to +250°C)

-50°C	0°C	+100°C	+250°C
±25mK	±25mK	±25mK	±25mK

DP251 + PRP-4 or PRP5 probe (-70°C to +450°C)

-70°C	-40°C	0°C
±45mK	±25mK	±25mK
+100°C	+250°C	+450°C
±25mK	±25mK	±100mK

DP251 + 200°C to 550°C probe (contact OMEGA for quote on 200°C to 550°C probe)

-189°C	0°C	+100°C
±20mK	±20mK	±20mK
+420°C	+550°C	
±20mK	±35mK	

DP251 + uncalibrated 100 Ohm DIN probe (see Chapter 7 for Internationally recognized probe categories).

Typical figures <u>only</u> - 1/3rd DIN

0°C	+100°C	+250°C
±150mK	±300mK	±600mK

12.2 Resolution

User selectable via front panel or under interface control (if installed), 0.01°C, °F or K and 0.001°C, °F or K. In ohms resolution is 0.01 or 0.001Ω on display, but 0.001 or 0.0001Ω via the interface. Display update rate is every nominally 2.5 seconds in high resolution and every 0.5 second in low.

12.3 Stability

Temperature Coefficient: ±0.0005°C/°C (0.5mK/°C)

Term Stability: Typically better than ±5mK/year (±0.005°C/year)

12.4 General Features

Measurement: 4-wire, auto-balance ac resistance ratio bridge.

Carrier Frequency: 375Hz

Display: 6 digit, filtered vacuum fluorescent display, indicating in °C, °F, K and Ω (ohms). Display update: 0.5/3 seconds in low/high resolution respectively.

Probe current: 1mA, constant current source.

Probe cables: 4 core + screen, 2 meters standard. Alternative cable lengths to special order. See Chapter 7 for more prt probe information.

Input Connectors: Front Panel - 5 pin DIN professional sockets, connected in parallel to rear panel inputs. Rear Panel - 5 pin screw Terminal sockets, connected in parallel to front panel connectors.

Digital Output (if installed): RS232C serial and/or IEEE488 parallel interface available as options - see more detail in Chapter 9.

Analog Output (if installed): ±10v dc output is available as an option resolution 1mK or 10 mK depending on front panel resolution setting. Linearity ±0.05% full scale.

12.5 Range

Dependent primarily on the probe used - typically within -200°C to +800°C. OMEGA can advise on suitable probes. See Chapter 7 on suitable sensors.

12.6 Environment

Operating Temperature: 15°C to 25°C for full accuracy, 0°C to 50°C maximum

Power Requirements: 240 Vac ±8%; 220 Vac ±8%, 120 Vac ±8% or 100 VAC ±8%
Supply Voltage range is user selectable on rear panel.

Dimensions: Metal case with adjustable rest/handle, 240mm Deep x 260mm Wide x 80mm High
(9.45" Deep x 10.24" Wide x 3.15" High)

Weight: 2.6kg (5.72lbs)

NOTES

NOTES

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of **13 months** from date of purchase. OMEGA Warranty adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that OMEGA's customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. OMEGA's Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

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1. P.O. number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems relative to the product.

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1. P.O. number to cover the COST of the repair/calibration,
2. Model and serial number of product, and
3. Repair instructions and/or specific problems relative to the product.

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