



## **F300 Mk II Precision Thermometry Bridge**

**Operator's Handbook**  
F300-14-002 Issue 5



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**GENERAL**

This instrument has been designed and tested to comply with the Electromagnetic Compatibility Directive 89/336/EEC and Low Voltage Directive 93/68EEC in accordance with EN 61010 -1 :1995 relating to the safety requirements for electrical equipment for measurement, control and laboratory use.

Before connecting the instrument to the mains supply please ensure the following safety precautions have been read and understood.

**SAFETY SYMBOLS**

The following symbols are used to describe important safety aspects of this instrument, these symbols appear on the instrument and in the operation instructions.



**Attention Symbol:** Indicates a potentially hazardous condition exists and that it is necessary for the operator to refer to the instruction manual to ensure the safe operation of this instrument.



**Hot Surface Warning:** Indicates a hot surface that may be at a temperature capable of causing burns, refer to the instruction manual for further safety information.



**Caution Risk of Electric Shock:** Indicates hazardous voltages may be present, refer to the instruction manual for further safety information.



**Protective Conductor Terminal:** For protection against electrical shock during a fault condition. This symbol is used to indicate terminals that must be connected to electrical ground before operating equipment.

**SUMMARY OF SAFETY PRECAUTIONS**

The following general safety precautions must be observed while operating or servicing this instrument. Failure to comply with these precautions may result in personnel injury or death.

**INSTRUMENT ELECTRICAL EARTH**

This instrument is designed as a Class 1 electrical safety insulation device. To ensure continued protection from electric shock the instrument chassis must be connected to an electrical ground. The instrument is supplied with an AC power cable with an earth connection.

**LIVE CIRCUITS DANGER**

Do not connect the power supply to or operate this instrument with the protective covers removed. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltages may exist with the power cable removed. To avoid injuries always disconnect power and discharge circuits before touching them.

**DO NOT MODIFY THIS INSTRUMENT OR SUBSTITUTE PARTS**

Because of the danger of introducing additional hazards; do not perform any unauthorized modification or install substitute parts to the instrument. Only fuses with the rated current, voltage and specified type should be used, failure to do so may cause an electric shock or fire hazard. Return the instrument to Automatic Systems Laboratories for service and repair to ensure the safety features are maintained.

**DO NOT OPERATE IN EITHER DAMP OR EXPLOSIVE ENVIRONMENTS**

This instrument is not designed to operate while wet, in an environment of condensing humidity or in the presence of flammable gases or vapors. The operation of this instrument in such an environment constitutes a safety hazard.

**HOT SURFACES DANGER**

Equipment marked with a Hot Surface warning symbol should be regarded as operating at temperatures capable of causing burns. Do not touch, handle or transport hot components or liquids until they are at safe temperatures. Care should be taken not to spill or splash water or volatile fluids on or into hot surfaces or liquids.

**CERTIFICATION**

Automatic Systems Laboratories certifies that this product met its published specifications at the time of shipment from our factory. All calibration measurements performed in the manufacture of this instrument are traceable to the National Physical Laboratory (London).

**ASSISTANCE**

For after sales support and product service assistance please contact Automatic Systems Laboratories Customer Support Group. Contact information is provided in the operation instruction manual.

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## 1. Introduction

The Model F300 is an advanced multi stage ratio transformer potentiometer for comparing two, four terminal resistors. It can be used with a variety of PRTs to achieve precise temperature measurement or control.

External control of all functions is possible using the optional computer interfaces (RS232, IEEE-488).

A number of operating modes are provided so that direct, relative or differential measurements may be made in units of ratio or ohms. PRT calibration which permits display of temperature, in Celsius or Kelvin, is also available.

Overall system accuracy will depend on the quality of PRT used.

Temperature Equivalents:

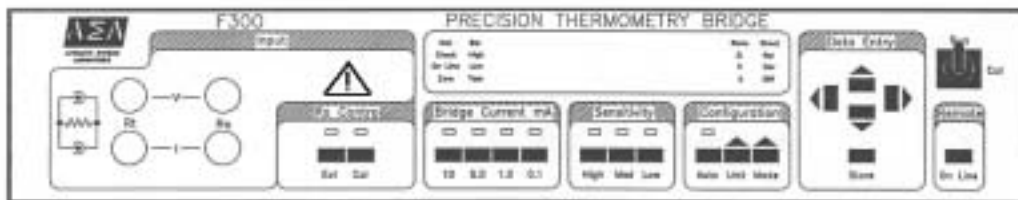
$$1 \text{ milli-degree C} = 0.001^\circ\text{C} = 1\text{m}^\circ\text{C} = 1\text{mK} = 1.8\text{m}^\circ\text{F}$$

$$1 \text{ milli-degree F} = 0.001^\circ\text{F} = 1\text{m}^\circ\text{F} = 0.56\text{mK} = 0.56\text{m}^\circ\text{C}$$

### 1.1 Definitions and Terminology used in this Manual

- i)  $1^\circ\text{C} = 1\text{K}$
- ii)  $1 \text{ mK (milli-Kelvin)} = 0.001^\circ\text{C}$  (one milli-degree Celsius)
- iii) Alpha, or  $\alpha$ , is the temperature coefficient, or temperature sensitivity, of the Platinum wire used in PRTs. Generally speaking, the higher the alpha value, the better the PRT.
- iv) PRTs are regularly referred to with several alternative abbreviations as follows:
  - PRT (Platinum Resistance Thermometer)
  - Pt100 (PRT with nominally  $100\Omega$  resistance at  $0^\circ\text{C}$ )
  - RTD (Resistance Temperature Device)Platinum resistance thermometers may also be referred to as probes or sensors.
- v) System accuracy refers to the overall, combined accuracy of the F300 and the PRT in use.

## 2. Controls and Connections



**Figure 2-1 Front Panel Controls and Connections**

Figure 2-1 shows the front panel controls and connections. These are detailed below:

i) Bridge Resistors

Rt Two BNC coaxial connectors for the unknown four terminal resistor (PRT).

Rs Two BNC coaxial connectors for an external standard or reference resistor. Also used in differential measurements as the second resistor (PRT) connections.

The upper BNC connectors of Rt and Rs are used for voltage sense and the lower BNC connectors for the current carrying leads.



**WARNING**

These are isolated connectors and are **NOT** to be used as earth connections.

ii) Rs Control

Ext push button to select the external standard resistor. The LED indicator lights when external is selected. See section 5.1

Cal push button to select the internal Rs calibration facility. The LED indicator lights when selected. See Section 5.2 for the calibration procedure.

iii) Bridge Current mA

Four interlocked push buttons to select the bridge operating current. A LED indicator shows the selected value.

iv) Sensitivity

Three interlocked push buttons to select the sensitivity of the detector. The sensitivity selectors also affect the gain of the analogue output available at the rear panel, but only in 'manual' mode. Gain is automatically set in 'auto' mode, and the buttons are non-operative.

The relative sensitivities are High, Medium, Low.

v) Configuration

- Auto** A push button to switch between automatic and manual operating modes. The LED indicator lights when in the automatic mode.
- Units** A push button to select the desired output units. Each press of the button causes the display units indicator to move to the next unit type. Repeated presses cause the units indicator to roll around to the first unit type. The standard units are 'ratio' or 'Ohms'. Temperature units, Celsius or Kelvin, are available if PRT calibration is installed.
- Mode** The mode switch is used to select the operating mode. Each press of the push button causes the operating mode to change. 'Direct', 'Relative', 'Deviation' and 'Differential' modes are available. Modes are available as shown in Table 2-1.

<b>Mode</b>	<b>Auto / Manual Setting:</b>
Direct	manual or automatic
Relative	automatic
Deviation	manual only
Differential	automatic only

**Table 2-1 Mode available in Auto / Manual Configuration**

The selected units and the operating mode are indicated in the display panel immediately above the selector switches as shown in Figure 2-2.

vi) Left-Right Push Buttons

Two push buttons to manually select the display digit to enter a pre-set value. When the display is set-up for adjustment, the active digit light will flash. At both ends an extra move causes the active digit selector to roll around to the other end of the display.

vii) Up-Down Push Buttons

Two push buttons to manually enter pre-set values. This switch will increment or decrement the selected digit with carry and borrow to the next decade.

viii) Store

The Store push button is used when entering data. Pressing the push button loads the displayed value in the F300 computing unit memory. In some operating modes the button is active and if pressed will cause the display to show the relevant reference parameter. This can then be adjusted using the Up-Down, Left-Right push buttons. A further press of the switch loads the new value to the instrument's memory.

ix) On-Line

A push button switch to set the instrument on line. On-Line status is indicated by a legend in the display panel which lights when the instrument is set On Line.

Activation of "on-line" causes all previously set front panel conditions to default to basic start-up values. The instrument front panel function keys are locked out and the instrument is now under external control.

x) Run / Cal Switch

A switch to enable data entry mode for probe calibration data.

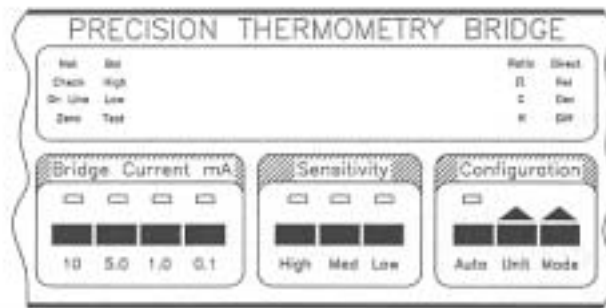


Figure 2-2 Front Display Panel

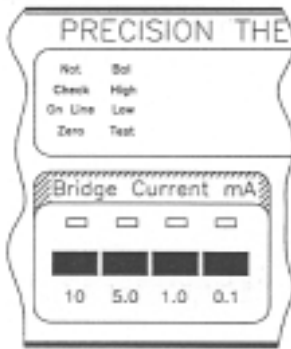


Figure 2-3 Status Indicators



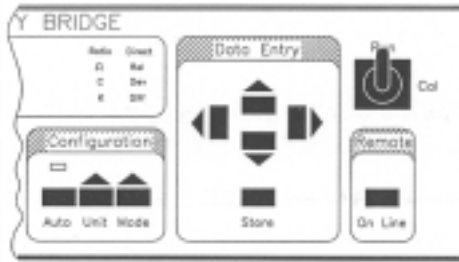


Figure 2-4 Configuration Selection Controls and Display Indicators

2.1.2 Display Panel

The display panel is divided into four areas: status, displayed value, units indicators and operating mode. Different combinations light to indicate the status of the instrument.

Not Bal	Two indicators which may light together to indicate bridge not balanced. When balanced only the Bal indicator shows.
Check	If permanently on indicates a fault condition has been detected. If the check indicator lights and part of the display flashes then an operator input using the Up-Down, Left-Right and Store switches is required.
High/Low	Indicates the out of balance polarity. Both indicators are out when bridge is balanced.
On-Line	Indicates that the instrument is on-line.
Test	Test Indicates that a test procedure has been invoked. <b>Note: This facility is only available to a Test or Service Engineer</b>
Ratio, Ohms, °C, K	The units of the displayed value. The temperature legends only light if a PRT calibration option is fitted.
Direct	Indicates that the displayed value is a Direct reading of ratio, ohms, °C or K.
Rel	This mode indicates that the displayed value is relative to some other value entered by the operator. 'Rel' is a fully balanced mode, making measurements of change available over the full dynamic range of the bridge.
Dev	Indicates the Deviation mode. The bridge is set to an operator defined value in the selected units. The displayed value is the out of balance Deviation. This mode can be used for set-point control operation, where the out of balance voltage, available at the rear panel, can be input to a controller.
Diff	Indicates the Differential mode. The F300 alternates between the internal and external (Rsi and Rse) resistors and computes the ratio Rse/Rsi. This enables true differential measurement to be made with the display in the selected units.

2.1.3 Rear Panel

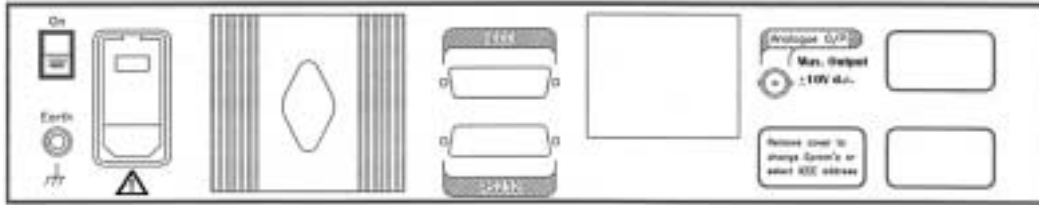


Figure 2-5 Rear Panel Connections and Option Ports

i) AC Power Input Socket

The AC Power input unit incorporates a voltage selection tumbler, to enable the user to match the F300 to the local AC voltage supply, and two fuse holders. The correct 20mm fuses to install are as follows:

Voltage	Fuse
220/240V	T500mA (250V AC)
100/120V	T1A (250V AC)

ii) Power ON/OFF switch

I = Power ON                      0 = Power OFF

The power switch itself will be illuminated (green), when the F300 power is switched ON. Care should be taken not to limit access to the power ON/OFF switch.

iii) Analogue Output

A BNC connector carrying the bridge out of balance signal. A positive voltage indicates that the bridge setting is high. The outer conductor is earthed.

iv) Earth Terminal

A jack/binding post which is connected to the main instrument earth point. It can be used for the PRT or resistor screens only if they are not earthed through another connection.

### 3. Initial Operation

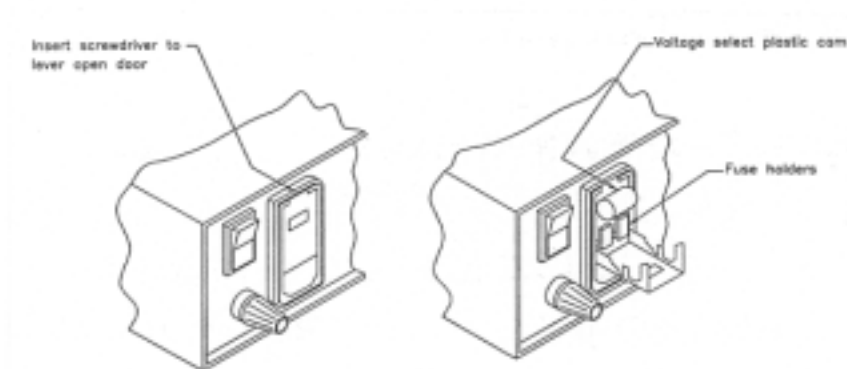
#### 3.1 Power Supply Connection

##### Checking Voltage and Fuse Rating



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

The supply voltage setting of the F300 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 in section 2.1.3.



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

##### 3.1.1 Setting the Voltage and Fuse Rating

Lever open the power input unit from the top with a flat bladed screwdriver. Inside is a plastic cam: remove this and replace it so that the voltage to be set is displayed through the window.

Where fused power plugs are connected to the supply cable provided, the correct fuse rating is 3 Amps. The supply cable provided with the F300 is color coded as follows:

Ground	Green/Yellow (Protective Conductor Terminal)
Live	Brown
Neutral	Blue

#### 3.2 Test Procedure

- 3.2.1 Connect a stable four terminal resistor in the range 10 to 400 ohms, to the Rt connectors, as shown in. Figure 3.2 F300 Set-up for initial checks. Select 1mA current, high sensitivity, auto, direct mode and ratio units. Depress and hold the three sensitivity switches, switch the instrument on and hold the switches until the message "CLEAR" is shown. This will clear the instrument's non-volatile RAM of any settings left over from testing.

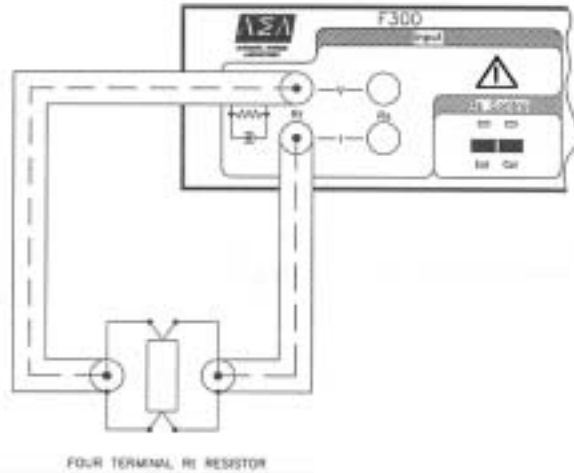


Figure 3-2 F300 Set-up for initial checks

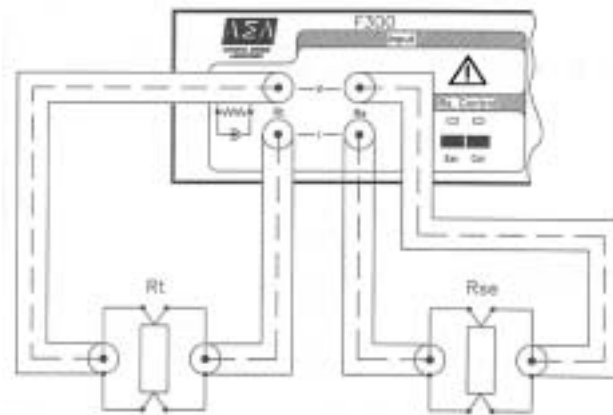


Figure 3-3 Resistance measurement with an External Reference Resistor

3.2.2 With a computer interface fitted the information regarding its configuration is displayed as follows:

IEEE nn

Where 'nn' is the device address of the F300.

RS232:

rS nnnnn

where 'nnnn' is the baud rate of the RS232 interface followed by:

a b c

where

a is '7' or '8' (bits per character)

b is 'n', '0' or 'P' (parity none, odd or even)

c is '1' or '2' (stop bits)

For more details see Section 7

After a few seconds the bridge should indicate a balanced status with the occasional momentary 'not balanced', 'high/low' status. The display should indicate the balanced ratio and remain stable.

Select ohms, using the UNITS button and Rs Cal and check that the up/down and left/right controls operate to enter a pre-set value. Restore the original value and pressing store unless the external test resistor is known accurately. See Section 5.2.

Select "Celsius" by again pressing the units button. The indicator lights only if calibration data has been entered, or calibration EPROMs fitted, otherwise units indicated return to ratio.

The display should now indicate the temperature in degrees Celsius, calculated from a calibration table held in internal non-volatile memory. See Section 8.1.

Connect a second four terminal resistor to the Rs channel and select differential mode (using the MODE button) with "ratio" units. The F300 will now alternate between internal and external Rs and display the ratio:

$$(R_t / R_{si}) - (R_{se} / R_{si})$$

Select ohms and the display will indicate difference in resistance of:

$$R_t - R_{se}.$$

This procedure checks all the main functions of the F300 but a complete quality audit requires a larger number of accurately known resistors or a reference transformer.

## 4. Operating Modes: Principles of Operation

In most cases the Model F300 Bridge is automatically balanced. This is indicated by the Auto LED above the Auto select push button.

### 4.1 Direct Mode

In Direct Mode the displayed value is the bridge setting translated into the selected units including calibration if provided.

Selecting 'Ratio' (via the 'Units' button), gives a display of the  $R_t/R_s$  ratio. The computed RT resistance value is shown when ohms units are selected.

A direct display in °C or K can be obtained, computed from the  $R_t$  resistance and the PRT calibration data which is stored in internal non-volatile memory (NVR).

The Direct Mode display refers to the internal reference resistor,  $R_{si}$ , or to an external standard resistor,  $R_{se}$ , whichever is selected.

The Direct Mode is also used when entering  $R_s$  calibration data. The operation of the  $R_s$  Cal and Ext is discussed below.

In manual balance mode, the bridge can be altered by increasing or decreasing the relevant digits (in the selected units) using the left/right, up/down push buttons.

This facilitates convenient set point control and system checks.

### 4.2 Relative Mode

The Relative Mode gives a display of the bridge setting relative to an operator defined offset in the selected units.

The Relative Mode is selected by pressing the 'Mode' select push button to change the mode select display until the 'Rel' indicator lights.

On entering the Relative Mode the 'Check' status indicator will light and the most significant display digits will flash.

For convenience the direct value displayed may be entered as the offset by pressing STORE immediately, zeroing the display. When used in this way, this function performs as a "zero" button.

Alternatively the value may be changed using the up/down, left/right push buttons then pressing store.

The display is then a value relative to the offset and will be found useful for measuring changes for PRT self heating checks, calorimetry etc.

**Note: The F300 operates in "AUTO" mode only for "relative" operations.**

### 4.3 Deviation Mode

Deviation Mode is similar to direct manual mode and can be entered from an automatic balance condition.

The bridge ratio is frozen at the set value and the display indicates the degree of out of balance in the selected units. This has a limited range defined by the sensitivity buttons.

An out of balance analogue signal, suitable for input to a chart recorder or controller, is available from a rear panel connector. The magnitude of both the display and output signal depends on the sensitivity setting.

Deviation Mode is selected by repeatedly pressing the Mode Select button until the 'Dev' indicator lights in the mode display panel.

The 'Check' status indicator will also light indicating that the display can be changed to the desired set point using the up/down/left-right switches. The store push button may be pressed at any time to freeze the bridge at its current value. The instrument will then enter the Deviation Mode and the 'Auto' and 'Check' indicators will be cleared.

The display will show the Deviation from balance, the balance point being the set value.

### 4.4 Differential Mode

Differential Mode makes use of the external Rs facility to facilitate true differential measurement. The F300 alternates between Rt/Rsi and Rt/Rse and displays the difference between the Rt and Rs channel in the selected units:

Mode	Calculation
Ratio	Rse/Rsi
Ohms	$(R_t - R_{se})/R_{si} \cdot R_{siCAL}$
°C	$t_1 ((R_t)/R_o) - t_2 ((R_{se})/R_{seo})$
K	$T_1 ((R_t)/R_o) - T_2((R_{se})/R_{SEo})$

**Table 4-1 Differential Mode Calculations**

t1 ,t2 are the calibrated functions and both must be installed  $T_1 = 273.15 + t_1$  and  $T_2 = 273.15 + t_2$

**Note: The switching between the internal and external Rs connections will cause the bridge to go out of balance for a short time.**

A delay routine in the control software allows the bridge to settle before taking readings.

A software procedure monitors the instrument gain and balance status adjusting parameters to always make an 'on scale' out of balance measurement. A valid display can then be generated every time the instrument switches between the internal and external modes.

The effect is that the 'Not Bal', 'High' and 'Low' indicators will be more active in the Differential Mode than in the other modes, but the displayed data will nevertheless have a high level of integrity.

## 5. Rs Control

The F300 is fitted with a 100 ohm, 0.01% internal standard resistor,  $R_{si}$ , with a temperature coefficient better than 2ppm. It can be calibrated in ohms using  $R_s$  cal and an external standard, connected to  $R_t$ .

If the internal reference resistor is used for accurate work, this action should be done regularly unless the values prove stable, then once a year should suffice.

Provision has also been made for an external standard resistor,  $R_{se}$ , which can be chosen to suit a wide range of PRT types, provide balanced cable effects and a convenient approach to true differential measurement by using a second PRT and differential mode. It is more usual to use an external standard resistor for accurate work.

$R_s$  internal or external and  $R_s$  Cal are usually set up first and should not be altered during a measurement.

### 5.1 Internal/External $R_s$

To select the external  $R_s$  press the 'Ext' push button. The Ext LED indicator will light and the most significant digit will flash. The display will show the last entered value of external resistance, (or 100.0000 if a value has not been previously entered).

Use the Up-Down, Left-Right push buttons to set the value of the external resistor. Press the store button to load this into memory. This value will be used to calculate the output in units of ohms, Celsius and Kelvin whenever the Ext  $R_s$  is selected.

It is also used to calculate internal gain settings and so should be accurate to 1% or better. In Differential mode the F300 alternates between internal and external  $R_s$  and adjusts its gain automatically.

The F300 will use the external resistor whenever the 'Ext' LED indicator shows.

To revert to the internal resistor press the Ext  $R_s$  push button. The 'Ext' LED indicator will be off whenever the internal standard is selected.

### 5.2 $R_s$ Calibration

The internal reference resistor  $R_{si}$  can be calibrated by connecting a known standard resistor to  $R_t$  and entering its value.

If the instrument has not been calibrated the Cal LED will be off.

To calibrate  $R_s$ :-

Connect a standard resistor (preferably 100 ohms) to the  $R_t$  connectors. Balance the bridge in automode, 1mA current and in resistance units.

Press the Cal button, the display will change to show one digit flashing. Use the up, down, left and right keys to enter the calibrated value of the standard resistor on  $R_t$ .

Pressing store will cause the F300 to calculate the internal value. The internal value will be referenced to 100 ohms. This figure will be used when calculating resistance and temperatures.

NOTE:



The value will be retained when the power is interrupted. The internal resistor is not oven controlled and should not be relied on for long term stability. When cycling around the modes of the bridge, the Cal will be cleared.

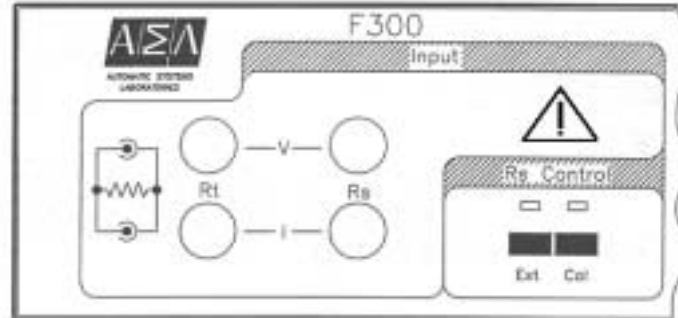


Figure 5-1 Sensor Connections and Rs Control

## 6. Analogue Output

The output voltage is proportional to the bridge out of balance and depends on the sensitivity setting, operating current and the standard resistor  $R_s$ , and is useable only in 'manual' mode.

Output voltage =  $I.R_s.G \times \text{Ratio}$

$I$  = current setting (amps)

$R_s$  =  $R_{si}$  or  $R_{se}$  (ohms)

$G$  =  $10^2$  low sensitivity

$10^4$  medium sensitivity

$10^6$  high sensitivity

The output is positive when the bridge setting is above the true balance point. This corresponds to a high, 'Not Bal' indication on the front panel.

For low sensitivity, 1mA bridge current and 100 ohms  $R_s$ , an output of 1V represents a bridge ratio out of balance of 0.100 000.

The medium setting gives a factor of 100 increase in output sensitivity.

The high setting gives a further 100 fold increase in the output sensitivity, so 1V represents a ratio out of balance of 0.000 01.

The range of the analogue output is  $\pm 10V$ . The output stage can drive up to 100m of coax cable or 10nF capacitance and 1mA current. It is compatible with most controllers, chart recorders and data-logger inputs.

## 7. Digital Interfacing

Two interfaces are available which gives the F300 the ability to communicate with a computer. The interface can be either GPIB (IEEE-488) or serial (RS232C). It allows data to be read, and any mode of operation to be set including several auxiliary functions not normally available to the user. Below is a list of the commands, along with a brief explanation.

The commands are:

A (Auto)	-	Switch between auto and manual mode
B (Balanced)	-	Read last balanced ratio in current units
C (Calibrate)	-	Used in conjunction with T to calibrate an internal resistor
D (Data)	-	Read current ratio in current units
E (External)	-	Send Rs resistance
I	-	Set bridge current
L	-	Set local lockout
M (Mode)	-	Select mode (e.g. differential)
O (Offset)	-	Send offset for use in relative mode
P (Preset)	-	Set the bridge to a required ratio
S (Sensitivity)	-	Set sensitivity
T (Trim)	-	Set trim for use in calibrate mode
U (Units)	-	Select units
X (External)	-	Select internal or external standard resistor
! (Error)	-	Get Error status
? (Status)	-	Get current command status

### 7.1 IEEE-488 Interface

The F300 IEEE-488 option allows the F300 to communicate with a remote computer. The F300 microcomputer gives priority to the interface and so measurements may be slower during long exchanges.

### 7.2 Setting the IEEE Address

The IEEE address is set using switches near the IEEE connector on the rear panel.

The switches are numbered 1 to 8. The address is set using switches 4 through 8 to set a binary number. Switch 'Open' represents 1 and Switch 'Closed' 0, with the switch 8 representing the least significant bit.

It is suggested that address 0 is not selected, as this is usually reserved for the controlling computer. The maximum address number is 31.

Switch no:	Designation	Value
1	-	Open
2	-	-
3	-	-
4	Bit 4	16
5	Bit 3	8
6	Bit 2	4
7	Bit 1	2
8	Bit 0	1

Table 7-1 IEEE Address Switches

### 7.3 Using the Interface

The connector used is to the IEEE-488 standard.

The F300 is controlled by sending strings of ASCII characters via the IEEE interface. The string can be terminated by either a carriage return, line feed, or carriage return and line feed. Data is returned from the F300 as an ASCII string terminated by a carriage return and a line feed. The method used to send and receive strings is dependent on the computer or controller being used.

**Note:** Before communicating with the F300, the on-line indicator must be switched on.

### 7.4 Detailed Explanation of Commands

Below is a list of commands used to control the F300 from a remote computer or controller. Brackets in the syntax sections indicate optional characters.

Command A	
Function:	Allows the F300 to be switched between automatic and manual operation.
Syntax:	An, where n is either "0" or "1".
Parameters:	n = 0 switches F300 to manual operation
	n = 1 switches F300 to auto operation
Initial State:	n = 1, automatic operation

Command B	

Function:	Allows the last valid data to be read. The number returned is the last setting at which the bridge was balanced, and is in the units selected
Syntax:	B

<b>Command C</b>	
Function:	Allows the calibrate function of the F300 to be enabled or disabled (see command T)
Syntax:	Cn, where n is either "0" or "1"
Parameters:	n = 0 disables the calibrate function n = 1 enables the calibrate function
Initial State:	n = 0 calibrate function disabled

<b>Command D</b>	
<b>* RS232 Operation Only</b>	
Function:	Allows the current bridge data to be read, with its balance status. Data will be sent in one string in the following form "1.000000B". The last character "B", "L" or "H" indicates whether the bridge is balanced, low or high.
Syntax:	D

<b>Command E</b>	
Function:	Allows the computer to specify the value of the external standard resistor. This must be done before the bridge is used with an external standard resistor (see command X)
Syntax:	E((s)nnn)n.n(nnnnn), where s is +; n is any digit;() indicates optional sections.
Parameters:	The parameter passed is a positive number with three digits before the decimal point (leading zeros must be included).
Initial Value:	0

<b>Command I</b>	
Function:	Allows the computer to select a bridge current
Syntax:	In, where n is a digit between 0 and 3
Parameters:	n = 0 sets a current of 0.1mA
	n = 1 sets a current of 1.0mA
	n = 2 sets a current of 5.0mA
	n = 3 sets a current of 10mA
Initial Value:	0 = 0, current of 0.1 mA

<b>Command L</b>	
Function:	Local lockout. When in remote mode it may be necessary to disable the front panel on-line switch to prevent a user returning to local operation. This can be done by sending the local lockout command. If the user then tries to switch off-line, the display will flash "L.L. out" and remain on-line
Syntax:	Ln
Parameter:	n = 0 disable local lockout
	n = 1 enable local lockout
Initial Value:	0

<b>Command M</b>	
Function:	Allows the computer to select the mode of the F300 e.g. relativeNB: If a mode is selected that is unobtainable, an illegal command error is given
Syntax:	Mn, where n is a digit between 0 and 3
Parameters:	n = 0 selects direct mode
	n = 1 selects relative mode
	n = 2 selects deviation mode
	n = 3 selects differential mode
Initial value:	n = 0, direct mode

<b>Command O</b>	
Function:	Allows the computer to set an offset ratio for use in relative mode
Syntax:	On (.nnn nnn nnn), where n is any digit
Parameters:	The parameter passed is a positive number representing a ratio, with one digit before the decimal point. If less than one, a leading zero is required
Initial Value:	Last bridge ratio

<b>Command P</b>	
Function:	Allows the computer to pre-set the bridge ratio to a required value. The setting is passed in the units last selected by the computer.
Syntax:	P((s)nnn)n.n(nnnnn), where s is +/-; n is any digit;() indicates optional sections.
Parameters:	The parameter passed is the current bridge setting. The format must correspond to the current units, or else an invalid data error will occur. Leading zeros must be included where required.
Initial Value:	Last bridge ratio.

<b>Command S</b>	
Function:	Allows the computer to select the sensitivity of the F300
Syntax:	Sn, where n is a digit between 0 and 2
Parameters:	n = 0 selects low sensitivity
	n = 1 selects medium sensitivity
	n = 2 selects high sensitivity
Initial Value:	0, low sensitivity

<b>Command T</b>	
Function:	Allows the trim value for use in the calibrate mode to be set
Syntax:	T((s)nnn)n.n(nnnnn), where s is +/-; n is any digit;() indicates optional sections.
Parameters:	The parameter passed is a value by which the ratio is multiplied before display. The resistance is affected accordingly. Degrees C and Kelvin are calculated based on the subsequent resistance. Cal is activated by the "C" command. This is the figure calculated by Rs Cal (see section 5.2). It must have one digit before the decimal point (if less than one, a leading zero is required - see command C)
Initial Value:	1.0

<b>Command U</b>	
Function:	Allows the computer to select the displayed units. NB: Celsius and Kelvin can only be selected when calibration data is present.
Syntax:	Un, where n is a digit between 0 and 3
Parameters:	n = 0 selects ratio
	n = 1 selects units of resistance
	n = 2 selects units of degrees Celsius
	n = 3 selects units of degrees Kelvin
Initial Value:	n = 0, units of ratio

<b>Command X</b>	
Function:	Allows the computer to select the internal or external standard resistor (see command E)
Syntax:	Xn, where n is either "0" or "1"
Parameters:	n = 0 selects internal standard resistor
	n = 1 selects external standard resistor
Initial Value:	n = 0, internal standard is selected



<b>Command !</b>	
Function:	Causes the F300 error status to be transmitted to the controlling device.
Syntax:	!
Parameters:	Parameter passed to the controller is of the form:ERROR nn where nn = 00 no errors 01 input buffer overrun 02 illegal command03illegal parameter 04 temperature too hot 05 temperature too cold 06 Rt and/or Rs not connected

<b>Command ?</b>	
Function:	Causes the state of all commands to be transmitted to the controlling device.
Syntax:	?
Parameters	String sent to the controller is of the form: XaCbIcSdAeUfMg* indicates unit was 'on-line' where a b c d e f and g are the current settings of the functions: eg.XOCOI2S2A1U1MO* where XO indicates internal Rs selected.

Apart from the normal device dependent commands that are sent to the F300 as ASCII strings, there are three general IEEE functions that apply to the bridge. These are remote/local control, local lockout and device clear. Consult the instruction manual for your computer or controller for further information.

7.4.1 Device Clear

Device clear switches the F300 to its power on state. The interface is reset, clearing the input buffer, and the bridge reverts to local operation.

7.4.2 Compatibility of Interface: IEEE-488 (1979)

SH1	Full source handshake
AH1	Full acceptor handshake
T8	Basic talker (unaddress on MLA)
L4	Basic listener (unaddress on MLA)
LEO	No extended address
TEO	“ “ “
SRO	No service request
RL1	Remote local function
LL1	Local lockout
PPO	No parallel poll
DC1	Device clear - reverts to power on state

Table 7-2 Specification of the F300 Interface

7.5 RS232 Interface

7.5.1 Setting the Interface Parameter

Using the DIL switch on the rear panel, various characteristics of the RS232 interface can be selected. These include baud rate, parity, number of stop bits and length of character.

The switches are numbered from 1 to 8; with 'Open' representing 1 and 'Closed' representing 0.

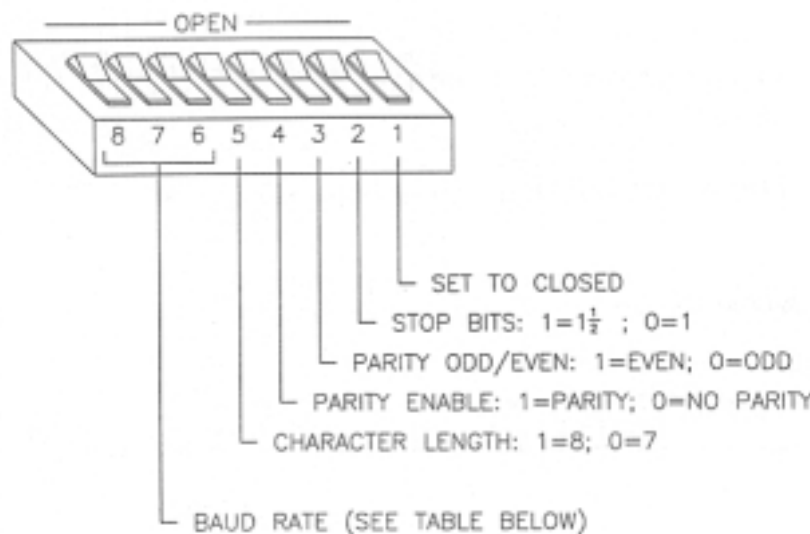


Figure 7-1 RS232 Switch Setting

Switch			Baud rate
8	7	6	
0	0	0	19200
1	0	0	110
0	1	0	300
1	1	0	600
0	0	1	1200
1	0	1	2400
0	1	1	4800
1	1	1	9600

Table 7-3 RS232 Baud Rate - DIL Switch Settings

7.5.2 Using the Interface

The RS232 interface installed in the F300 allows a computer or controller to control the operation of the F300. The connector is a 25 way "D" type plug, configured as Data Terminal Equipment DTE.

Over the page is a list of the pin designations.

Pin	Data	Comment
2	Transmitted Data output from F300	
3	Received Data input to F300	
4	Request to Send	F300 sets true after completing diagnostics
5	Clear to Send	F300 will not send data until clear to send is true.
7	Signal Ground	
20	Data Terminal Ready	F300 sets true after completing diagnostics

**Table 7-4 RS232 Interface - Pin Designations**

If the clear to send line is not used, it should be connected to Data Terminal Ready or Request to Send.

The F300 is controlled by sending commands consisting of strings of ASCII characters via the interface.

The string can be terminated by either a carriage return (CR), line-feed (LF), or carriage return and line feed.

Data is returned from the F300 as an ASCII string terminated by a carriage return and a line feed.

**Note: Before communicating with the F300, the on-line function must be switched on.**

In addition, the F300 can be configured to send the displayed reading as a string over the RS232 output at the end of each measurement cycle. (In the same format as "D" command).

This facility is set on by sending "G0". The normal output mode is restored by sending "G1".

Command G	
Function:	Set the output mode to continuous or triggered.
Syntax:	Gn
Parameters:	n = 0 continuous output
	n = 1 triggered output using
	"D" command.
Initial Value:	n = 1 triggered output

## 8. Calibration

### 8.1 Probe Calibration Data Entry

This calibration facility allows the operator to enter coefficients via the instrument front panel so that a PRT calibration table can be generated that covers a sub-range of ITS-90.

The coefficients that can be entered are:

RO.01 (Resistance at the triple point of water)

Positive

a, b, c, d

Negative

a, b

and Omega ( $\omega$ ) at 660°C

These allow calibration over the range.

83.8058k (-189.3442 °C) to 961.78 °C

Once the calibration table has been generated it is stored in non-volatile memory allowing the instrument to be switched off without loss of data.

The F300 allows two tables to be entered, one for the Rt PRT and the other for the Rs PRT if differential mode is to be used.

All coefficients have to be input in European format.

Table 8-1 ITS-90 Coefficients US-European conversion chart cross-references US to European format. In order to relate coefficients from European calibrations with the US notation it is important to know the 'sub-range' of calibration which is usually found on the calibration certificate.

Range	United States	Europe
83.8058K to 273.16K	a4 and b4	a and b (negative)
273.15K to 961.78°C	a6, b6, c6 and d	a,b,c, & d (positive)
273.15K to 660.323°C	a7, b7, and c7	a,b, and c (positive)
273.15K to 419.527°C	a8 and b8	a and b (positive)
273.15K to 231.928°C	a9 and b9	a and b (positive)
273.15K to 156.59865°C	a10	a (positive)
273.15K to 29.7646°C	a11	a (positive)
234.3156K to 29.7646°C	a5 and b5	a and b (positive or negative)

**Table 8-1 ITS-90 Coefficients US-European conversion chart**

## 8.2 Operation

The user calibration facility is invoked by switching the Run/Cal switch to CAL

The display will change to:

ON OFF ?

with 'on' flashing. The Run/Cal switch can now be switched to Run.

If you wish to enter data press store while 'on' is flashing. If however, you wish to use the rear panel mounted EPROMS, then press the 'right' push button so that 'off' is flashing and then press store.

If you selected 'on' then the display will change to:

r t rS ?

with 'Rt' flashing.

Unless you have previously entered data for the Rt probe you will not be allowed to select Rs. So press store when Rt is flashing and the calibration utility will go onto the entry of the ITS-90 coefficients.

The display will read:

rO.01?

This is just a prompt, so press store and the display will show:

0 1 0 0 . 0 0 0

Using the up/down and left/right push buttons as normal, enter the resistance of the PRT at the triple point of water.

When your number is correct press store and the display will change to:

AP EE?

The F300 is now prompting for the exponent of the coefficient 'a' above 0 °C. Press store and the display will show:

0 0 0 0 . 0 0 0

Enter the exponent value in the range -1 to -20. E.g., if 'a' (above 0 °C) =  $-2.6175 \times 10^{-4}$  then the value '-4' must be entered.

Note that only the integer part of the value will be taken account of.

Press store and the display will change to:

AP DIGS?

The F300 is now prompting for the digits (mantissa) of the 'a' (positive) coefficient. Press store, the display will become:

0 0 0 0 . 0 0 0

Using the data entry keys enter the value of the mantissa, e.g., for the above example this would be '-2.6175'. Press store, the display will change to:

BP EE?

The F300 is now prompting for the exponent part of 'b' (above 0 °C).

Press store and then enter the value of the exponent as for coefficient 'a'. Press store and the next display is :

BP DIGS?

Press store and enter the value of the mantissa for 'b' (above 0 °C) as you did for 'a'.

Repeat the operation for the coefficients 'c' and 'd' (above 0 °C).

These are prompted:

CP.EE?

CP DIGS?

dP EE?

dP DIGS?

After entering 'd', the next prompt is

AN EE?

The F300 is now asking for the value of the exponent of 'a' (below 273.16K).

Press store and enter the value in the usual way. Press store again, the display will show:

AN DIGS?

Press store and enter the mantissa for 'a' (below 273.16K). Press store again, the F300 will now prompt for the exponent of 'b' (below 273.16K):

BN EE?

Press store and enter the value.

BN DIGS?

Press store again and enter the mantissa for 'b' (below 273.16K).

Press store and the display will show:

660?

The F300 is now asking for the value of Omega ( $w$ ) at the temperature of 660°C. Enter the number, (there should be no exponent).

Press store and the F300 will start to generate the probe calibration, the display will show a count to 407, the total number of points produced.

000-407

The calculation process takes about 3 minutes.

If your PRT is only calibrated over a sub-range of ITS-90 (which in fact is almost certain) then at least one of the coefficients will not be known. In this case just enter the exponent and mantissa as Zero. Again if not exceeding temperatures of 660°C, enter zero for the 660°C? prompt.

Once the calibration is finished the F300 will return to its normal measurement mode.

A further calibration table may be entered for the Rs channel by re-entering the calibration function and selecting 'Rs'.

**Note:** When entering a negative number the value of any given digit will be incremented by the down push button and decremented by the up push button. (The overall value of the number does, however, change in the correct way.)

## 9. Specification

### 9.1 Resistance Measurement Specification

The F300 measures the ratio of two resistors  $R_t$  and  $R_s$ .  $R_s$  may be either the internal reference resistor,  $R_{si}$ , or an externally connected resistor  $R_{se}$ .  $R_t$  can be in the range 0 to 4000 ohms.  $R_s$  can be in the range of 1-1000 ohms. The ratio  $R_t/R_s$  can be in the range 0 to 3.999999.

#### 9.1.1 Display Range

The maximum display range is + 999 999 9. The decimal point and display resolution are set automatically dependent on the operating mode.

The bridge ratio can be in the range 0.000 00 to 3.999999, but measuring the out of balance extends the available resolution to 1ppm. The last digit is 0.25ppm full scale.

#### 9.1.2 Internal Reference Resistor

An internal reference resistor  $R_{si}$  is provided.

Value: 100 ohms  $\pm$  50ppm

Temperature coefficient:  $< 1\text{ppm} / ^\circ\text{C}$

Long term stability: better than 1ppm/month.

#### 9.1.3 Accuracy

Accuracy of ratio  $R_t/R_s$ :  $\pm 5\text{ppm}$  of fsd over full range.

#### 9.1.4 Resolution

The smallest detectable change is limited by electrical noise produced by the instrument and external interference. Detector noise is less than 10nV RMS in 1Hz bandwidth giving an analogue resolution of 0.05mK RMS (1mA in 100 Ohms).

Digital resolution depends on the selected operating parameters.

#### 9.1.5 Current Settings

Currents of 0.1, 1.0, 5.0, 10mA, RMS  $\pm\%$  are available.

#### 9.1.6 Operating Frequency

The bridge operates at 1.5 times the local line frequency and is phase locked to it.



9.1.7 Quadrature

At a frequency of 75Hz/90Hz the reactive component of most PRTs and standard resistors is insignificant and is rejected by the phase sensitive synchronous detector.

With higher values of  $R_t$  or  $R_s$  and long cables the quadrature component increases and may produce an in-phase error if a maximum is exceeded.

Quadrature can be minimized by using low resistance, low loss, low capacitance coaxial cables of equal length on  $R_t$  and  $R_s$  inputs.

9.2 Temperature Measurement Specification

The performance of the F300 as a temperature measuring instrument depends on the resistance PRTs used, and varies over the range. Maximum errors quoted in the PRT calibration certificate and reference resistor certificate, and the F300 errors must be added to give the combined accuracy figure.

9.2.1 Typical Performance

Rs	Typical probe	Current	Typical probe range	Typical resolution
1 $\Omega$	0.25 $\Omega$	10mA	-200°C to 1064°C	1 $\mu\Omega$ / 0.001°C
10 $\Omega$	2.5 $\Omega$	5mA	-200°C to 1064°C	10 $\mu\Omega$ / 0.001°C
10 $\Omega$	25 $\Omega$	1mA	-200°C to 150°C	10 $\mu\Omega$ / 0.00025°C
100 $\Omega$	45 $\Omega$	0.1mA	300°C to 0.5K	300 $\mu\Omega$ / 0.0006°C
25 $\Omega$	25 $\Omega$	1mA	-200°C to 660°C	25 $\mu\Omega$ / 0.0001°C
100 $\Omega$	100 $\Omega$	1mA	-200°C to 800°C	100 $\mu\Omega$ / 0.0001°C
1000 $\Omega$	1000 $\Omega$	0.1mA	-100°C to 100°C	1m $\Omega$ / 0.0001°C

Figure 9-1 F300 - Typical Performance

9.2.2 Resolution

The digital resolution is typically 0.1 milli-degree with a Pt100 at 1mA.

The analogue output can be used for higher sensitivity measurements with a noise level of typically 10 uK RMS using a Pt100 at 1mA.

9.3 Analogue output

Maximum Load: 10K, 10nf - 100m coax cable

Output Range: -10V to +10V DC

Bandwidth: 1Hz

9.4 PRT Linearization

No. Linearization Tables: 2,  $R_t$  and  $R_s$

Tables:

Range of Calibration: 83.8058K to 961.78 °C (Max)

Resolution of Table 0.01 W, linearly interpolated

Accuracy: Maximum error contribution is 1mK

Data: R0.01 Above 0 °C, a, b, c, d coefficients. Below 273.16K, a, b coefficients. w at 660°C.

Table Calculation Time: Approx. 3 minutes

Definition of W:

$$W = Rt/ R_{(0.01^{\circ}\text{C})}, \text{ where } t \text{ is any temperature}$$

## 9.5 Environment

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

Humidity: Specified to 90% RH at 40°C non-condensing.

Power Requirements: 240VAC ±8%, 220VAC ±8%, 120VAC ±8% or 100VAC ±8%

Supply Voltage range is user selectable on rear panel.

Frequency range: 47-63Hz.

Power consumption: 45 VA Max.

Dimensions: 442mm wide, 104mm high, 295mm deep  
(17.4" wide, 4" high, 12.6" deep)

NB: Additional clearance of about 50mm (2") is needed at the rear for cable entry.

Weight: 8.5Kg / 18.7lbs

## 9.6 Communications

RS232C: Factory set to 1200 Baud, 8 bits, no parity and 2 stop bits

IEEE-488 factory set to address 10

Analogue: -10Vdc to +10Vdc

## 10. Cleaning and Maintenance

### 10.1 Cleaning

Make sure the F300 is turned off and unplug the mains supply cable.

Clean the outside of the instrument with a soft, clean cloth dampened with mild detergent. Do not allow water to enter the instrument.



**WARNING** Never use alcohol or thinners as these will damage the instrument.

Never use a hard or abrasive brush.

### 10.2 Preventive Maintenance



**WARNING** Regular inspection of the mains supply cable is required to ensure that the insulation is not damaged.

### 10.3 General safety Warning



**WARNING** If the F300 is used in a manner not specified by ASL, then the protection provided by the instrument may be impaired.

### 10.4 Routine Maintenance

The F300 is tested and calibrated before dispatch, using special procedures and reference standards. It is not normally practical for customers to effect repairs and calibrations themselves, other than using the standard Cal facility as described in section 5.2.

Maintenance tasks are therefore limited to keeping the instrument and its leads clean with occasional Cal checks. In particular the connectors for the resistors  $R_t$  and  $R_s$  should be kept clean to prevent leakage currents flowing. The outer of the BNC connectors and the cable braid are not at earth potential and should not be earthed. Damaged cable and connectors are a common cause of poor and intermittent operation.

If difficulties are experienced with the F300 powering up then depress and hold the three sensitivity switches, turn the instrument on, and hold the switches until the message "CLEAR" is displayed. This operation clears the internal non-volatile RAM of any corrupt data. In the case of other problems the operator is advised to follow the basic operation instructions in section 3 to verify normal operation. If difficulties persist the following will serve as an aid to troubleshooting and will provide valuable information to ASL's service personnel.

The F300 Micro PCB is fitted with a lithium battery with a life expectancy of 10 years.

## 11. Accessories and Options

The following accessories and options are available for the F300 Bridge:

FA-1	1 pair coaxial leads, BNC to BNC, 3 metres long
FA-2	1 pair coaxial leads BNC to open end, 3 metres long

FA-3	1 adaptor box (BNC to terminal and BNC)
FA-4	2 Terminal Binding Post to BNC - 2 OFF
T25-650-1	Standard reference PRT $R_o = 25.5$ ohms (nominal). 2 metre cable 4 wire plus screen with spade terminal connections. Stem length 450mm, quartz. $R_{100}/R_o$ 1.3925 (min). Reproducibility 0.01K or better. Temperature range -189 to +650 °C.
T100-650-1	Physically similar to T25-650-1, but with $R_o = 100 + 0.05$ ohms. Suitable for use in laboratory environments, but not for general industrial applications. Temperature range -189 to +650 °C.
T25-660-1	Secondary transfer standard PRT 25.5 ohm 4 wire with 4 metres connecting cable to spade terminals. Temperature range 0 to +650 °C.
T100-450-2	Working reference PRT $R_o = 100$ ohms, 2 meter cable with spade terminals. Stem length 450mm stainless steel with quartz liner. Temperature range -100 to +450 °C. Alpha = 0.00385.
T100-450-3	As T100-450-2 except Alpha = 0.00392.
T100-600	Working reference PRT $R_o = 100$ ohms, 2 meter cable with spade terminals. Stem length 460mm quartz. Temperature range -50 to +600 °C. Alpha = 0.00385.
T0.25-962-1	High Temperature standards PRT. $R_o=0.25$ ohms. Temperature range up to 962 °C.
F300/24	Calibration EPROM for above thermometers which allows direct readout in °C or K (Alternative to using internal memory).
SB148/SB158	10 channel automatic/remote scanner. Expandable to 60 channels. IEEE-488 or RS232 compatible. Current source for unselected PRTs.
FR4	Four, oven controlled reference resistors for systems applications. 1, 10, 25 & 100 ohms.
RW	Oil filled Standards Resistors. 1, 10, 25, 100 & 1000 ohms.
RR	Laboratory Reference Resistors. 1, 10, 25, 100 & 1000 ohms.
RTE	Thermal enclosure for RW & RR resistors.
Soft300	PC compatible, graphical based Data Acquisition and Control Software.
F-Rack300	Rack mounting kit for 19" chassis.

## 12. Service and Warranty

F300 equipment and accessories, (unless stated otherwise), are covered by a 24 month warranty for parts and labor, but not including costs incurred in returning it to the factory for repair, from the date of dispatch from Automatic Systems Laboratories.

## 12.1 Technical Support

For all technical support, repair, warranty and service inquiries please contact:



Isotech North America  
158 Brentwood Drive, Unit 4  
Colchester, VT 05446

Phone: 802-863-8050  
Fax: 802-863-8125

sales@isotechna.com  
www.isotechna.com

## 12.2 Returned Instruments

All returned goods should be sent carriage paid insured and packed well, to the above address.

## 12.3 Documentation

The shipment should include:

- i) Your goods return note, a delivery note or an export invoice clearly stating **GOODS RETURNED FOR REPAIR**.
- ii) Your Company / Establishment order or contract reference number.
- iii) The name of your purchasing and technical contact.
- iv) A brief fault report.

## 12.4 Repair Quotations

We shall be pleased to advise estimated repair costs upon receipt and initial inspection of returned goods.

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