AUTOMATIC SYSTEMS LABORATORIES

F900 Precision Thermometry Bridge

Operator's Handbook

F900-14-001 Issue 2.1

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

Declaration of Conformity

European Community Electromagnetic Compatibility Directive (89/336)
European Community Low Voltage Directive (93/68)

The following equipment:

Model F900 Precision Thermometry Bridge

manufactured by:

Automatic Systems Laboratories
275 King Henry's Drive
New Addington
Croydon
Surrey
CR0 0AE
United Kingdom

conforms to requirements of the European Community Electromagnetic Compatibility Directive (89/336) and of the European Community Low Voltage Directive (93/68).

Standards applied:	EMC Susceptibility	EN50082-1
	EMC Emissions	EN50081-1
	EMC Harmonic Current Emissions	EN61000-3-2
	Electrical Safety	BSEN 61010-1

Extended Warranty Offer

NAME..

COMPANY...

ADDRESS...

....

....

INSTRUMENT..

DATE
RECEIVED...

SERIAL No...

Thank you for purchasing this ASL equipment, which we trust will give you many years of trouble free use. All ASL equipment is covered against faulty workmanship or materials for a period of one year from the date of dispatch, on return to the factory/distributor.
To enable us to extend your warranty, please complete your details on this warranty card, and return to ASL either by FAX or post.

PLEASE NOTE: ***Return this warranty card and completed questionnaire to ASL within 28 days***

FAX No: +44(0)1689 800405

or post to:

AUTOMATIC SYSTEMS LABORATORIES
275 King Henry's Drive, New Addington, Croydon
Surrey CR0 0AE UNITED KINGDOM.

Please take a few minutes to complete this warranty card and questionnaire to qualify for an extended 14 Month Warranty.

How did you find out about ASL ?	☐ Magazine	☐ Recommended	☐ Other	Specify	
Did the instrument arrive in good condition ?	☐ Yes	☐ No	If No, reason		
Did you find the handbook easy to use ?	☐ Yes	☐ No	If No, reason		
Were you satisfied with the service provided by ASL ?	☐ Yes	☐ No	If No, reason		
Would you like any information on other ASL products ?	☐ Temperature	☐ Displacement	☐ Calibration	☐ Software	
Would you consider using other ASL products ?	☐ Yes	☐ No			
Would you like to be made aware of future product releases ?	☐ Yes	☐ No			
If you purchased software, did you find it easy to install ?	☐ Yes	☐ No	If No, reason		
Are there any additional features you would like to see on this instrument ?	....				
How could we improve the quality of our product ?	....				
What is the nature of your business ?	....				
What type of thermometers do you use or calibrate ?	....				
How many employees on your site ?	☐ 1-10	☐ 11-25	☐ 26-100	☐ 101-500	☐ 500+

Please remember, you only have 28 days to register.

ENGLISH — IMPORTANT SAFETY INFORMATION — 22/1/97

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.

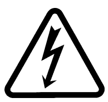
Before connecting the instrument to the mains supply please ensure the following safety precautions have been read and understood.

SAFETY SYMBOLS

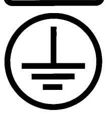
The following symbols are used to describe important safety aspects of this instrument, these symbols appear on the instrument and in the operation instructions.

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.

FRENCH INFORMATIONS IMPORTANTES SUR LA SECURITE 22/1/97

INFORMATIONS GENERALES

Cet instrument a été conçu et testé pour être conforme à la directive de compatibilité électromagnétique 89/336/CEE et à la directive de basse tension 93/68CEE, en accord avec la norme EN 61010 -1 :1995 relative aux prescriptions de sécurité des équipements électriques de mesure, de contrôle et d'utilisation en laboratoire.

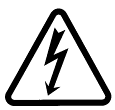
Avant de brancher cet instrument sur le secteur, veuillez vous assurer d'avoir lu et compris les mesures de sécurité suivantes.

SYMBOLES DE SECURITE

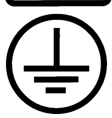
Les symboles suivants sont utilisés pour décrire des aspects importants sur la sécurité de cet instrument. Ils apparaissent sur l'instrument et dans les instructions de fonctionnement.

Symbole d'attention : indique l'existence d'une conditionpotentiellement dangereuse, et la nécessité pourl'opérateur de se référer au manuel d'instruction afin d'assurer le fonctionnement en sécurité de cet instrument.

Avertissement de surface chaude : indique une surfacechaude dont la température peut provoquer des brûlures.Consultez le manuel d'instruction pour de plus amples informations sur la sécurité.



Attention. Risque d'électrochoc : indique l'existence éventuelle de tensions dangereuses. Consultez le manueld'instruction pour de plus amples informations sur la sécurité.



Terminal de fil neutre : pour la protection contre lesélectrochocs lors d'une condition défectueuse. Ce symbole est utilisé pour indiquer les terminaux devant être connectés à la terre électrique avant d'utiliser le matériel.

RESUME DES MESURES DE SECURITE

Les mesures de sécurité générales suivantes doivent être respectées lors de l'utilisation ou de l'entretien de cet instrument. Le non respect de ces mesures peut entraîner les blessures ou la mort du personnel.

TERRE ELECTRIQUE DE L'INSTRUMENT

Cet instrument est conçu comme appareil d'isolation de sécurité électrique de classe 1. Pour assurer une protection continue contre les électrochocs, le châssis de l'instrument doit être connecté à une terre électrique. L'instrument est fourni avec un câble d'alimentation de courant alternatif (CA) de contact à la terre.

DANGER DES CIRCUITS SOUS TENSION

Ne branchez pas l'alimentation électrique à cet instrument, ou n'utilisez pas cet instrument sans les enveloppes protectrices. Le remplacement des composants et les ajustements internes doivent être faits par un personnel de surveillance qualifié. Ne remplacez pas les composants lorsque le câble d'alimentation est connecté. Sous certaines conditions, des tensions dangereuses peuvent exister lorsque le câble d'alimentation est retiré. Pour éviter des blessures, déconnectez toujours le courant électrique et déchargez les circuits avant de les toucher.

NE MODIFIEZ PAS CET INSTRUMENT OU NE REMPLACEZ PAS DE PIECES

A cause du risque d'introduction de dangers supplémentaires, n'effectuez aucune modification non autorisée, ou n'installez aucune pièce de substitution sur l'instrument. Seuls les fusibles de courant normal, de tension nominale et de type spécifié doivent être utilisés. Le non respect de cette condition peut provoquer un électrochoc ou un risque d'incendie. Renvoyez l'instrument à Automatic Systems Laboratories pour son service et sa réparation, afin d'assurer que les fonctions de sécurité sont maintenues.

N'UTILISEZ PAS CET INSTRUMENT DANS DES ENVIRONNEMENTS HUMIDES OU EXPLOSIFS

Cet instrument n'est pas conçu pour une utilisation s'il est humide, dans un environnement d'humidité de condensation ou en présence de gaz ou de vapeurs inflammables. L'utilisation de cet instrument dans un tel environnement représente un danger pour la sécurité.

DANGER DES SURFACES CHAUDES

Le matériel marqué d'un symbole d'avertissement de surface chaude doit être regardé comme fonctionnant à des températures capables de provoquer des brûlures. Ne touchez pas, ne manipulez pas ou ne transportez pas des composants ou des liquides chauds tant qu'ils ne sont pas à des températures sûres. Faites attention de ne pas renverser ou asperger de l'eau ou des fluides volatiles sur ou dans des surfaces ou des liquides chauds.

CERTIFICATION

Automatic Systems Laboratories certifie que ce produit répondait aux spécifications publiées au moment du départ de notre usine. Toutes les mesures de calibrage effectuées lors de la fabrication de cet instrument peuvent être trouvées au National Physical Laboratory (à Londres).

ASSISTANCE

Pour un support après-vente et une assistance de maintenance du produit, veuillez contacter le groupe d'assistance client d'Automatic Systems Laboratories. Des informations de contact sont données dans le manuel d'instruction sur le fonctionnement.

GERMAN WICHTIGE SICHERHEITSINFORMATIONEN 22/1/97

ALLGEMEIN

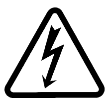
Dieses Gerät wurde so entworfen und getestet, daß es der Elektromagnetischen Verträglichkeits-Richtlinie 89/336/EEC und der Niederspannungs-Richtlinie 93/68EEC in Übereinstimmung mit EN 61010 -1 :1995 bzgl. der Sicherheitsanforderungen für elektrisches Gerät zum Messen, Regeln und für den Laborgebrauch entspricht.
Bevor das Gerät an das Stromnetz angeschlossen wird, stellen Sie bitte sicher, daß die folgenden Sicherheitsvorkehrungen gelesen und verstanden worden sind.

SICHERHEITSSYMBOLE

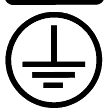
Die folgenden Symbole werden zur Beschreibung wichtiger Sicherheits-aspekte für dieses Gerät benutzt. Diese Symbole erscheinen auf dem Instrument und in den Betriebsanleitungen.

Achtung-Symbol: Zeigt an, daß ein potentiell gefährlicher Zustand besteht und daß es für den Betreiber notwendig ist, sich in der Betriebsanleitung zu informieren, um den sicheren Betrieb dieses Geräts zu gewährleisten.

Warnsymbol "Heiße Oberfläche": Zeigt eine heiße Oberfläche mit einer Temperatur an, die zu einem Brand führen könnte. Lesen Sie bitte die Betriebsanleitung für weitere Sicherheits-informationen.



Risiko eines Elektrischen Schlages: Zeigt an, daß gefährliche Spannungen auftreten können. Lesen Sie bitte die Betriebsanleitung für weitere Sicherheitsinformationen.



Schutzleiteranschluß: Zum Schutz gegen einen elektrischen Schlag während eines Störungs-zustands. Mit diesem Symbol sind Anschlüsse gekennzeichnet, die vor der Inbetriebnahme des Geräts an die elektrische Erdung angeschlossen werden müssen.

ZUSAMMENFASSUNG DER SICHERHEITSVORKEHRUNGEN

Die folgenden allgemeinen Sicherheitsvorkehrungen müssen während des Betriebs bzw. der Wartung dieses Instruments befolgt werden. Das Versäumnis, diese Vorkehrungen zu befolgen, kann zu Körperverletzungen oder zum Tod führen.

ELEKTRISCHE ERDUNG DES GERÄTS

Dieses Gerät ist gemäß der Isolationsklasse 1 konstruiert. Um fortlaufenden Schutz gegen elektrische Schläge zu gewährleisten, muß das Gerätechassis an eine elektrische Erdung angeschlossen werden. Das Gerät wird mit einem Wechselstromkabel mit Schutzleiteranschluß geliefert.

GEFAHR DURCH SPANNUNGSFÜHRENDE STROMKREISE

Schließen Sie dieses Gerät nicht an das Stromnetz an oder betreiben es, während die Schutzabdeckungen entfernt sind. Komponentenersatz und interne Geräteeinstellungen dürfen nur von autorisiertem Wartungspersonal ausgeführt werden. Unter bestimmten Bedingungen können gefährliche Spannungen bestehen, während das Stromkabel entfernt ist. Zur Vermeidung von Verletzungen unterbrechen Sie vor jedem Berühren interner Komponenten die Stromzufuhr und nehmen Sie einen Potentialausgleich vor.

VERÄNDERN SIE DIESES GERÄT NICHT UND ERSETZEN SIE KEINE TEILE

Um die Entstehung zusätzlicher Gefahrenquellen zu vermeiden, nehmen Sie bitte keine ungenehmigten Modifikationen vor und installieren Sie keine Ersatzteile in dieses Gerät. Nur Sicherungen mit der angegebenen Strom- und Spannungsstärke und des spezifizierten Typs dürfen benutzt werden. Versäumnis dies zu tun, kann zu elektrischem Schlag oder Feuergefahr führen. Zur Wartung und Reparatur schicken Sie das Gerät bitte an Automatic Systems Laboratories zurück, um sicherzustellen, daß alle Sicherheitseigenschaften erhalten bleiben.

NICHT IN FEUCHTEN ODER EXPLOSIVEN UMGEBUNGEN BETREIBEN

Dieses Gerät ist nicht dazu ausgelegt, bei Feuchtigkeit, in einer Umgebung mit Kondensationsfeuchtigkeit oder im Bereich entzündbarer Gase oder Dämpfe betrieben zu werden. Das Betreiben des Gerätes in einer solchen Umgebung stellt eine Sicherheitsgefahr dar.

GEFAHR DURCH HEISSE OBERFLÄCHEN

Geräte, die mit dem Warnsymbol "Heiße Oberfläche" markiert sind, können Betriebstemperaturen erreichen, die zu Verbrennungen führen können. Berühren bzw. transportieren Sie heiße Komponenten oder Flüssigkeiten erst bei einer sicheren Temperatur. Schütten oder spritzen Sie kein Wasser oder verdunstende Flüssigkeiten auf heiße Oberflächen oder in heiße Flüssigkeiten.

ZERTIFIZIERUNG

Automatic Systems Laboratories bescheinigt, daß dieses Produkt die veröffentlichte Spezifikation zum Verladezeitpunkt ab unserem Werk eingehalten hat.
Alle bei der Herstellung dieses Produkts ausgeführten Kalibrierungen können bis zum National Physical Laboratory (London) rückverfolgt werden.

HILFELEISTUNG

Bitte wenden Sie sich an den Automatic Systems Laboratories Kundenservice (Customer Support Group) zur Unterstützung nach dem Kauf und zur Produktwartungshilfe. Kontaktinformationen finden Sie in der Betriebsanleitung.

TABLE OF CONTENTS

1 Introduction

The Model F900 is a high precision AC bridge for measuring resistance ratio. Its outstanding accuracy and sensitivity is achieved by using very high precision ratio transformers in a null balance potentiometer configuration.

A wide range of operator controls is provided, making the F900 a very flexible instruments, whilst remaining simple and convenient to use.

The bridge can be balanced manually, or automatically under the control of an internal microprocessor. In addition, all controls plus some extra facilities, are accessible remotely via the F900 computer interface.

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

The bridge design is such that it can be connected to a number of different types of PRT or RTD. The system can be set up so that absolute, relative or differential temperature measurements may be made, even with long PRT or RTD leads.

1.1 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

1.2 Definitions and Terminology used in this Manual

1°C = 1K

1 mK (milli-Kelvin) = 0.001°C (one milli-degree Celsius)

Alpha, or α, is the temperature coefficient, or temperature sensitivity, of the wire used in PRTs or RTDs. Generally speaking, the higher the alpha value, the better the PRT or RTD. Alpha is only used for industrial PRTs.

Thermometers are regularly referred to with several alternative abbreviations as follows:

PRT (Platinum Resistance Thermometer)

Pt100 (PRT with nominally 100Ω resistance at 0°C)

RTD (Resistance Temperature Device)

Platinum resistance thermometers may also be referred to as probes or sensors.

System accuracy refers to the overall, combined accuracy of the F900 and the PRT in use.

1.3 Range of Applications

The F900 measures resistance ratios in the range 0 to 1.299 999 999. Any standard resistor in the range 0 to 100 ohms can be used, making the F900 suitable for most platinum and Rhodium-Iron thermometer types.

The F900 performance has been optimised for work with lower resistance, making it an indispensable tool for measuring the new higher temperature PRTs.

1.4 Operator Controls

Using the front panel controls, the operator can select a wide range of operating parameters.

I) PRT current (including a x √2 facility for measuring the probe self-heating effect)

ii) Operating frequency (two frequencies provided)

iii) Detector gain

iv) Quadrature servo range

v) Detector source impedance: 1, 10 or 100 ohms

vi) Manual/automatic balance

vii) Analogue output range (optional)

In addition, a 'Zero' and 'Unity' ratio check is provided as a convenient way of confirming correct and accurate operation of the bridge.

The front panel analogue meter can be used to indicate the in-phase detector output, the proportion of the quadrature servo output being used, and the amount of residual signal (noise and interference) when the bridge is balanced.

For further details of bridge operating parameters, see sections 2 and 4.

1.5 F900 Accuracy

The accuracy which can be achieved in resistance ratio measurement is limited by the accuracy of the precision PRT ratios which, for the F900 is ± 0.02 parts per million (ppm) ratio.

Other errors can be induced which may reduce the performance. The more important of these are:

i) Lead resistance and capacitance

ii) Lead dielectric losses

iii) High quadrature e.g. PRT self inductance

iv) Second order AC effects, PRT mutual inductance

v) Interference: RF signals, supply sub harmonics

vi) Leakage currents to ground and across the PRT

The first four causes are due to AC Effects and are kept small by using a low operating frequency.

The F900 is provided with two frequencies so that any AC effects can be measured and evaluated.

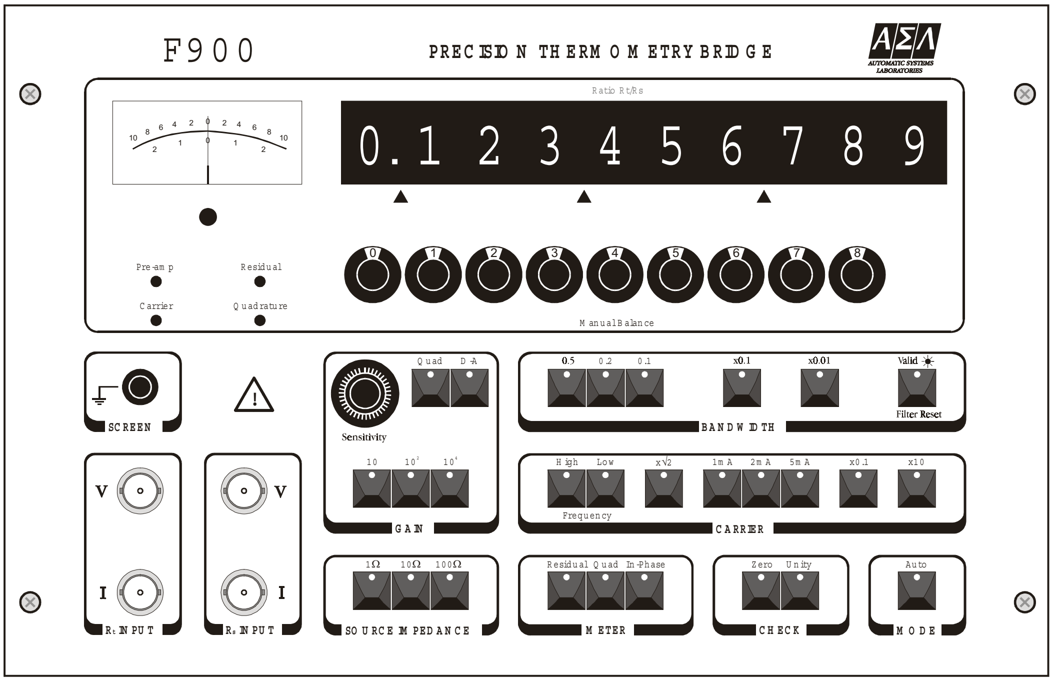
Most interfering signals are rejected by substantial filtering in the F900 detector. Large amounts of radio frequency interference, however, can cause intermodulation products resulting in spurious signals at the carrier frequency. Careful screening may be necessary in such environments.

To reduce the effect of leakage currents to ground, the F900 incorporates an active guard circuit. For a detailed discussion, see section 4-4.

2 Controls and Connections

2.1 Front Panel

Figure 2-1 F900 Front Panel.



2.1.1 Bridge Input Connectors

2.1.1.1 R_s Input

Two co-axial connectors that supply the current drive and voltage sense to an external standard resistor.

2.1.1.2 R_t Input

Two co-axial connectors that supply the current drive and voltage sense to the resistor or PRT being measured.

WARNING

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

NOTE! *Always connect voltage (v) connectors before current (I), and disconnect 'I' before 'v'.*

2.1.2 Earth Connection

It is recommended that long cables are screened, the screen being connected to this point only which is connected to the main instrument earth point. See figure 2-2.

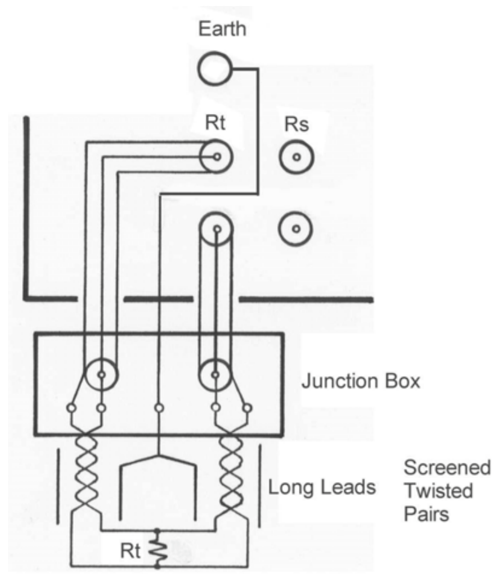


Figure 2-2. Recommended Connection for Long Leads.

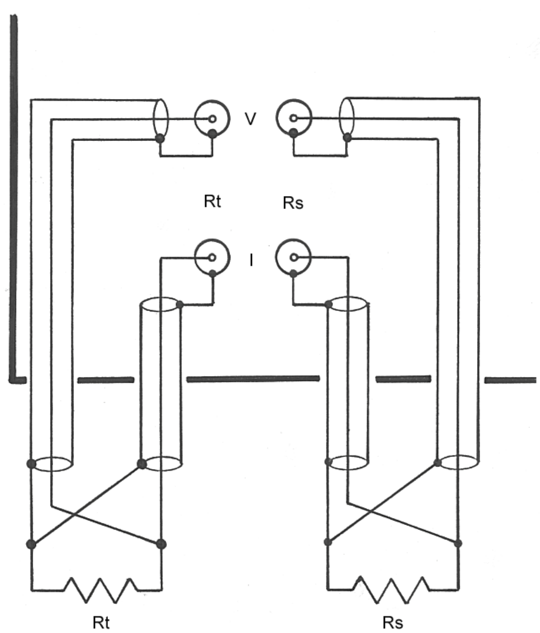
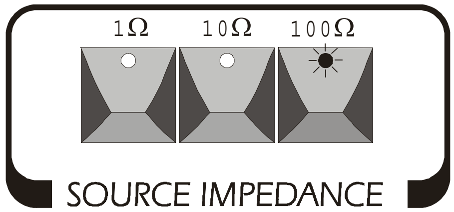


Figure 2-3. Four Terminal Connection to F900.

2.1.3 Source Impedance

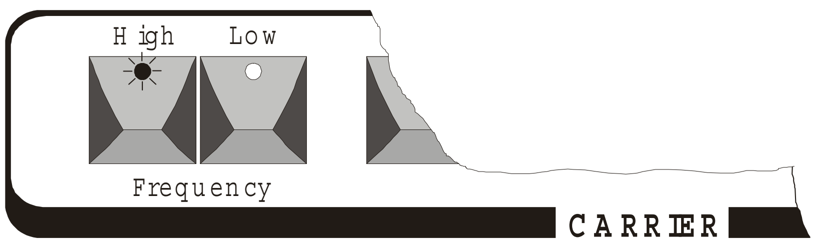


The function of the source impedance is to match the bridge pre-amplifier noise impedance to the bridge source impedance, maintaining optimum signal to noise ratio.

The source impedance can be calculated according to the formula in section 4.6.

Set as required. An LED indicates the selected source impedance

2.1.4 Carrier Frequency



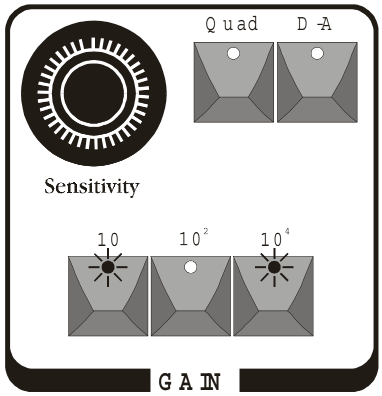
The F900 operates on either a high or low carrier frequency.

The operator can take measurements at both carrier frequencies to check for any spurious AC effects in the measurement.

The carrier frequency can be set to high or low by selecting the required button.

The illuminated LED indicates the value selected. For more details, see section 4.2.

2.1.5 Gain



The F900 gain controls are used to set the

In-Phase detector coarse gain

In-Phase detector fine gain

Reference amplifier gain, quadrature servo range

D to A range

2.1.6 In-Phase detector gain

The in-phase detector gain determines the F900 measurement sensitivity and the scale for the analogue meter.

The gain is set with the coarse gain buttons 10, 10^2, 10^4 and the sensitivity fine gain control.

The coarse gain buttons are dual function, in normal operation they are used to set the in-phase detector coarse gain.

When the Quad function button is selected, Quad LED 'ON' they are used to set the reference amplifier gain, quadrature servo range.

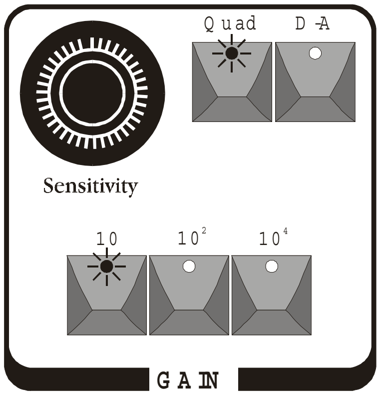
The coarse gain buttons provide a gain range from x1 all LED's 'OFF' to a maximum gain of x10^7 all LED's 'ON'.

For normal operation set the coarse gain to x10^5.

The sensitivity fine gain control is continuously variable from 0 to 10 with a gain range from x0 to x10.

For normal operation set the sensitivity fine gain control to 5, check against transformer ratio taps, in manual mode. A one digit change in the seventh decade of the digital display should result in an out of balance of ten graduations on the lower analogue meter scale with a coarse gain of 10^5.

2.1.7 Quadrature



The F900 has an automatic balancing quadrature servo.

The quadrature servo corrects for any reactive elements in the external standard resistors or PRT.

The quadrature servo range is determined by the reference amplifier gain.

The reference amplifier gain, quadrature servo range by can be set using the Quad function key and the 10, 10^2 coarse gain buttons.

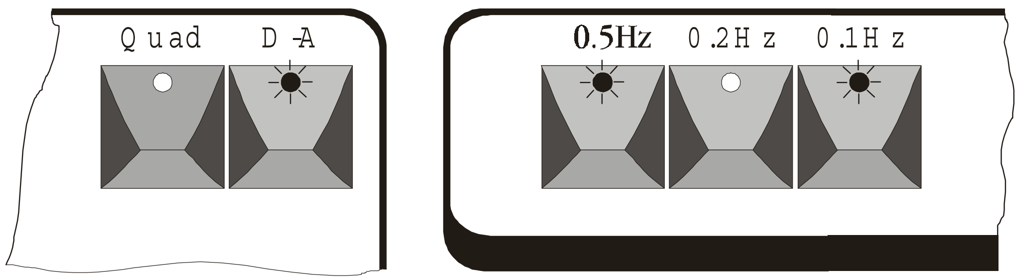
The coarse gain buttons are dual function, in normal operation they are used to set the in-phase detector coarse gain.

When the Quad function button is selected, Quad LED 'ON' they are used to set the reference amplifier gain, quadrature servo range.

The coarse gain buttons provide a reference amplifier gain range from x1 all LED's 'OFF' to a maximum gain of $x10^2$.

For normal operation set the reference amplifier gain to x10.

2.1.8 D-A



The F900 has two analogue outputs Sk1 and Sk2.

The D-A function key, with the three dual function bandwidth keys set the scale of the analogue output, Skt 1 BNC located on the instrument rear panel.

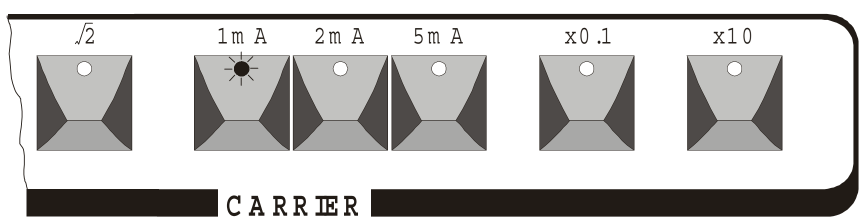
Three consecutive digits of the indicated ratio can be selected by pressing one of the three bandwidth buttons to generate an output voltage.

The three digits selected can be decades 345, 456 or 567.

A reading of 000 in the selected decades gives 0.00 volts and 999 gives 9.99 volts.

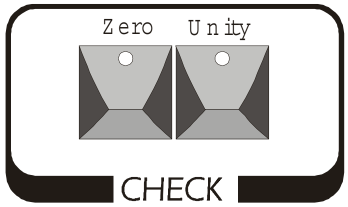
When a button is pressed, the three selected digits remain on while the rest of the display momentarily blanks, indicating the chosen decades.

2.1.9 Carrier Current



A range of measuring currents is provided which caters for most types of PRT.
The x √2 switch increases the selected operating current by x √2 which can be used for checking PRT self heating.

2.1.10 Check



Bridge operation can be verified by selecting 'Zero' then 'Unity' checks.

Suitable resistors should be connected to R_t and R_s, with appropriate bridge settings.

The zero check will verify operation of the bridge input circuit, decade switching, D/A, quad servo, active guard circuit and the bridge balance circuit when the input voltage is set to zero. It will indicate whether any offset exists in the bridge balance circuit.

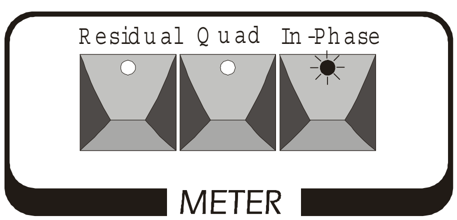
The unity check will verify operation of the bridge input circuit, ratio transformer, precision followers, decade switching, D/A, quad servo, active guard circuit and the bridge balance circuit.

Unity check switches the R_t potential leads across the R_s potential leads.

Any variation in the impedance of the input leads to the bridge input circuit can be shown by carrying out a complement check or by inserting a series resistance into each of the potential leads in turn.

Examples of zero, unity and complement checks are given in section 3.2.

2.1.11 Meter Select



The front panel analogue meter can be used to indicate either:

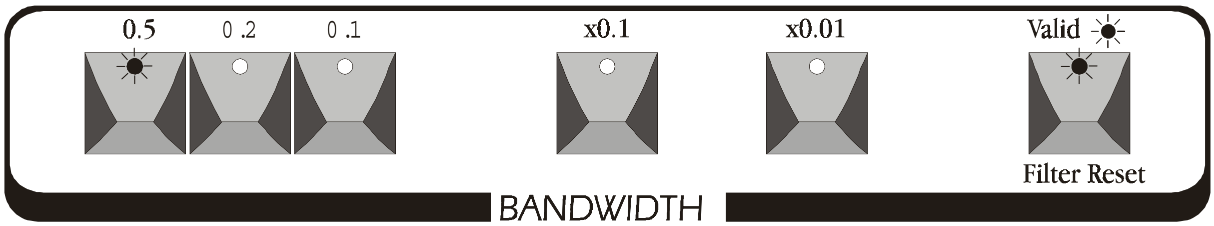
a) In-phase out of balance

b) Quadrature balance servo position

c) Residual signals

In normal operation the meter is usually switched to indicate the in-phase out of balance.

2.1.12 Bandwidth



To achieve the required measurement resolution it is often necessary to reduce the measurement bandwidth.

The F900 employs a combination of analogue and digital filter techniques to control the measurement bandwidth.

To set the required bandwidth, select the 0.5Hz, 0.2Hz or 0.1Hz button, for lower bandwidths select the x0.1 or x0.01 multiplier.

Refer to the bandwidth selection table to determine the achievable resolution for the selected R_s resistor and carrier current.

Bandwidth Selection Table

		Bandwidth Hz									
Rs	Carrier	0.5	0.2	0.1	0.05	0.02	0.01	0.005	0.002	0.001	Units
1	10 mA	0.082	0.052	0.037	0.026	0.017	0.012	0.008	0.005	0.004	ppm
1	50 mA	0.017	0.010	0.007	0.005	0.003	0.002	0.002	0.001	0.001	ppm
10	1 mA	0.260	0.165	0.116	0.082	0.052	0.037	0.026	0.016	0.012	ppm
10	10 mA	0.026	0.016	0.012	0.008	0.005	0.004	0.003	0.002	0.001	ppm
25	1 mA	0.163	0.103	0.073	0.052	0.033	0.023	0.016	0.010	0.007	ppm
25	5 mA	0.033	0.021	0.015	0.010	0.007	0.005	0.003	0.002	0.001	ppm
100	1mA	0.083	0.052	0.037	0.026	0.017	0.012	0.008	0.005	0.004	ppm

2.1.13 Filter Reset

The F900 use digital filter techniques to reduce the measurement bandwidth by averaging a number of samples per reading.

The Filter Reset button resets the filter sample count without updating the reading.

The Filter Reset button has no function in manual balance mode.

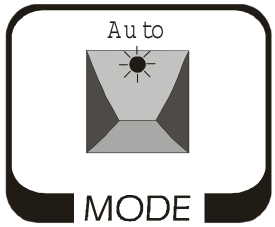
2.1.14 Valid LED

The function of the Valid LED in auto balance mode is to provide a visual indication LED ON of a valid reading.

The LED will be pulsed OFF as the display is updated.

In manual balance mode the Valid LED has no function and will remain permanently ON.

2.1.15 Mode



The Mode control sets the instrument for Manual or Automatic balance.

Automatic balance Mode, Auto led On under control of the internal microprocessor the instrument will automatically achieve and maintain a balanced state.

Manual balance Mode, Auto led Off the operator uses the manual balance rotary knobs and the analogue meter to balance the bridge.

BRIDGE PARAMETER	PARAMETER SELECTION	FOR MORE DETAILS
SOURCE IMPEDANCE 1, 10, 100	Select to match the bridge pre-amp input impedance to the source impedance for optimum noise performance. The source impedence depends on the standard resistor, PRT resistance and lead resistance. Default setting is 100.	Section 4.6
CARRIER FREQUENCY Low, High	Set as required. Make measurements at both frequencies to evaluate any AC effects in the measurement. Default setting is 'HIGH'.	Section 4.2
GAIN Coarse x1 to x10^7	Set gain to achieve required resolution in manual or automatic modes. The normal setting is 10^5	Section 2.1.5
GAIN Sensitivity	For normal manual or automatic modes set to x5. Make fine adjust to x5. Make fine adjustments to optimise balancing in 'Auto' mode.	Section 2.1.5
REFERENCE AMP/QUAD GAINx1, x10, x10^2	Set to a minimum that does not result in saturation of the quad servo. Check that the reference amplifier is not saturated. See table 5.3. Default setting is x10.	Section 2.1.5 Section 4.11 Figure 4-7
CARRIER CURRENT	Select maximum carrier current that does not exceed the ratio transformer saturation limits or cause excessive self-heating of the PRT. Refer to the PRT manufacturer's instructions. Check self-heating with x√2 facility. Default setting is 1 mA.	Section 2.1.6
CHECK Zero, Unity	The bridge operation can be verified by performing a zero and unity check. Suitable resistors should be connected to Rt and Rs with appropriate bridge settings. Default setting is normal operation.	Section 2.1.7
METER In-phase, Quad, Residual	Use front panel meter to measure the amount of in-phase, quadrature and residual signals coming through the detector. Default setting is In-Phase.	Section 2.1.8
BANDWIDTH (Hz) 0.5, 0.2, 0.1 x0.1, x0.01	Select the minimum bandwidth to achieve the required resolution. The bandwidth controls have no affect in manual balance operation. Default setting is 0.5 Hz.	Section 2.1.9

Figure 2-7. Bridge settings - Quick Reference Guide

2.2 Rear Panel

Figure 2.8. shows the F900 Rear Panel.

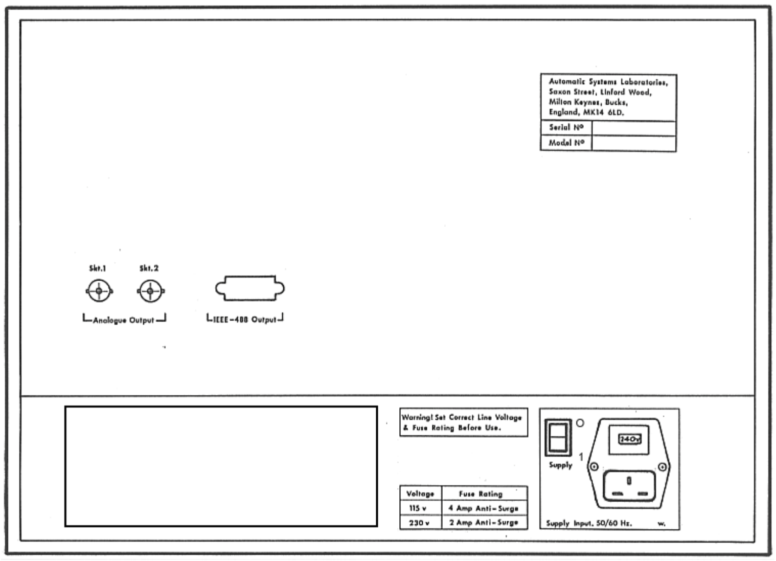


Figure 2-8. Rear Panel

2.2.1 AC Power Input Socket

The AC Power input unit incorporates a voltage selection tumbler, to enable the user to match the F900 to the local AC voltage supply, and two fuse holders. The correct 20mm fuses to install are as follows:

Voltage	Fuse
220/240V	T2A (250V AC) 2 Amp slow blow
100/120V	T4A (250V AC) 4 Amp slow blow

2.2.2 Supply Power ON/OFF switch

I = Power ON O = Power OFF

The power switch itself will be illuminated (green), when the F900 power is switched ON. Care should be taken not to limit access to the power ON/OFF switch.

2.2.3 Skt 1: Analogue Output

Three consecutive digits of the indicated ratio are converted to an analogue form and scaled 0 - 9.99 Volts for 000 - 999. The required decades can be 567, 456 or 345 as selected from the front panel. See section 2.1.10.

2.2.4 Skt 2: Analogue Output

Output from the in-phase detector indicating the out of balance (bandwidth 1 Hz).

The sensitivity is determined by the 'Gain' select switches and 'Gain' control. See section 2.1.5 and 2.1.6.

2.2.5 IEEE-488 Interface

See section 5 for details.

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 F900 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 2.2.1.

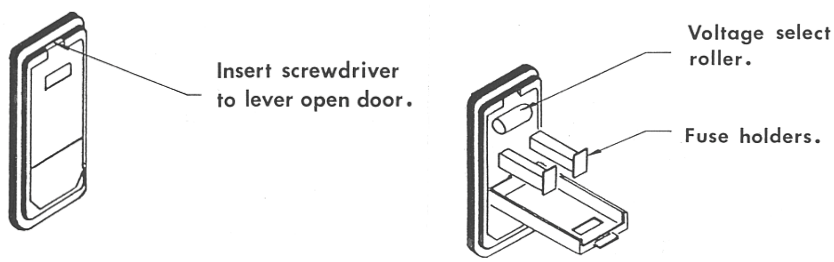


Figure 3-1. Power Input Unit and Fuse Rating Block.

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 F900 is colour coded as follows:

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

3.2 Instrument initial performance check

When the instruments fuse rating and power supply setting is correct, the instrument can be connected to the local supply and switched on.

3.2.1 Power on default settings

When switched on, the instrument will default to the following settings:

a) Source impedance:	100R
b) Gain:	10^4
c) Carrier:	1mA
d) Frequency:	HIGH
e) Check:	Normal (Zero and Unity off)
f) Meter:	In phase (Quad and Residual off)
g) Bandwidth:	0.5Hz
h) DAC:	Decades 5 to 7
I) Mode:	Manual (Auto Off)

Correct operation of the instrument can be confirmed by carrying out the following procedures.

Connect the two 100 ohm test resistors (as supplied) to the R_s and R_t BNC inputs, as shown in Figure 3-2.

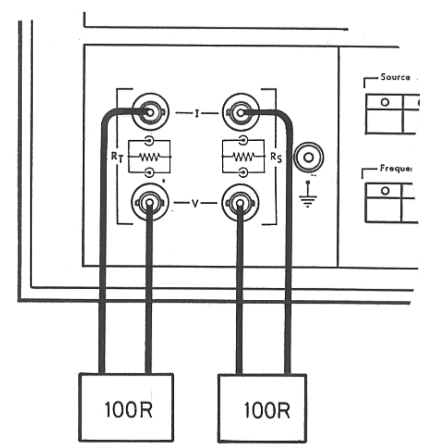


Fig. 3-2 Test Resistor Connections

WARNING Always connect the voltage (v) connectors before the current (I) connectors, disconnect 'I' before 'v'

3.2.2 Instrument Zero check

Set the Coarse Gain to 10^5
Set the Gain Sensitivity potentiometer to read 5.00 on its scale.
Set the Bandwidth to 0.1Hz.

Press the 'Zero Check' button, zero check LED on.

The bridge can be checked in Automatic or Manual balance mode.

Manual Balance Mode

Ensure the balance mode is set for Manual balance, Auto led Off.
Set the manual balance rotary switches to read 0.000 000 00
The instrument should balance to a ratio

0.000 000 000 +/-10 LSD.

Automatic Balance Mode

Set the Mode switch for Automatic balance, Auto led On.
The instrument should automatically balance to a ratio

0.000 000 000 +/-10 LSD.

3.2.3 Instrument Unity Check

Press the 'Unity Check' button, unity check LED on.

The bridge can be checked in Automatic or Manual balance mode.

Manual Balance Mode

Ensure the balance mode is set for Manual balance, Auto led Off.
Set the manual balance rotary switches to read 1.000 000 00
The instrument should automatically balance to a ratio

1.000 000 000 +/-20 LSD.

Automatic Balance Mode

Set the Mode switch for Automatic balance, Auto led On
The instrument should automatically balance to a ratio

1.000 000 000 +/-20 LSD.

3.2.4 Instrument Ratio Check

Set the Mode switch for Automatic balance, Auto led On.

Press the 'Unity Check' button again and the unity LED should extinguish, putting the bridge in normal measurement mode. The bridge should balance to a value that is the actual ratio R_t/R_s of the two resistors used.

4 Theory of Operation

4.1 Basic Principles of Operation

The F900 is a high accuracy transformer bridge with a simple potentiometer configuration. The main elements of the bridge are:

- i) A carrier generator
- ii) Precision ratio transformer
- iii) Active guard circuit
- iv) Gain controlled amplifier
- v) In-phase detector
- vi) Automatic balance quadrature servo
- vii) Residual peak detector

The F900 uses a microcomputer to perform all the control and interface functions.

The carrier generator produces a low distortion sinusoidal constant current that flows equally through the standard, R_s, and R_t (PRT) resistors. See Figure 4-1.

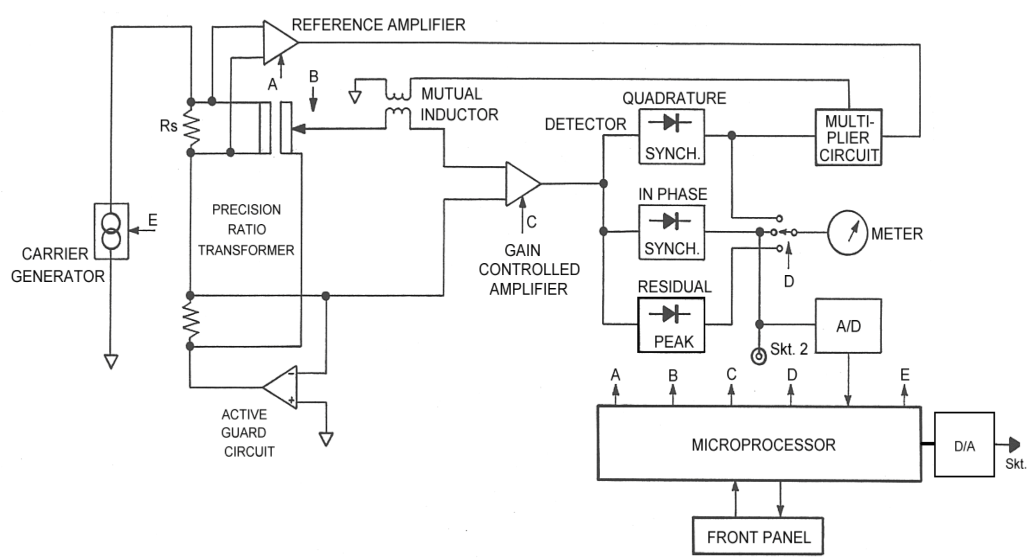


Figure 4-1. The F900 Potentiometer Configuration.

The voltages produced are therefore in exact ratio to the resistances. The voltage across the standard resistor, VS, is applied to the primary of the high precision ratio transformer. The voltage on the adjustable secondary is compared to the voltage across the unknown resistor, VT, the difference being greatly amplified by the low noise, high gain detector.

The transformer ratio, n, is adjusted until the detector output is zero, whence:

$$\frac{R_t}{R_s} = \frac{V_t}{V_s} = n \text{ (the transformer ratio)}$$

The quadrature servo operates continuously to balance any reactive effects. See section 4.11.

The effects of lead resistance are eliminated by using a four terminal configuration.

The transformer has a very high input impedance, so that little current flows through the potential leads.

4.2 Carrier Generator

This consists of a stable, low distortion oscillator which produces a sinusoidal current which is phase locked to the supply frequency. One of the two frequencies can be set, via the front panel controls, making it possible to check spurious AC effects.

SUPPLY FREQUENCY (Nominal)	CARRIER FREQUENCY (NOMINAL)	
	LOW	HIGH
50Hz	25Hz	75Hz
60Hz	30Hz	90Hz

Figure 4-2. Carrier Frequency Selection

The choice of operating current is determined by the type of PRT used. A higher current results in greater resolution, but increased heat dissipation in the PRT. This self heating can be checked by using the x √2 facility.

4.3 Precision Ratio Transformer

The three stage transformer is used to generate voltage ratios in the range 0.000 000 000 to 1.299 999 999.

The input impedance of the transformer, which appears across the standard resistor, is greater than 10^9 ohms.

For the transformer to work correctly, the standard resistor should be no more than 100 ohms. The voltage on the primary must also be limited, depending on operating frequency, due to saturation of the magnetic cores. See Figure 4-3 below.

CARRIER FREQUENCY	MAX VOLTAGE ACROSS R_s (VOLTS RMS)
Low	1.0 (fig.4.7)
High	1.0

Figure 4-3. Ratio Transformer Saturation Limits

4.4 Active Guard Circuit

See Figure 4-1.

This provides the necessary earth for the bridge circuit by maintaining one of the PRT potential leads at a 'virtual earth' without a physical connection to earth.

This has the advantage of reducing the effects of leakage currents to earth in, for example, high temperature applications.

4.5 Gain Controller Amplifier

This consists of a number of major elements:

i) Low noise pre-amplifier

ii) Extensive filtering to eliminate supply harmonics and other interfering signals

iii) Adjustable gain stages - coarse and fine

iv) Overload detection circuits.

4.6 Low Noise Pre-amplifier

The pre-amplifier consists of a low noise amplifier with adjustable impedance matching.

The input noise impedance can be selected to be 1, 10 or 100 ohms for optimum noise performance. Optimum performance is achieved when the detector input noise impedance is equal to the bridge output impedance. This is calculated as follows:

Bridge output impedance $= (R_s + 2R_1)n^2 + R_t + 2R_2)$

Where R_s = Standard resistor value

R_1 = Standard resistor potential lead resistance

R_t = PRT resistance

R_2 = PRT potential lead resistance

n = Transformer ratio at balance

The resistance of the current leads have no effect.

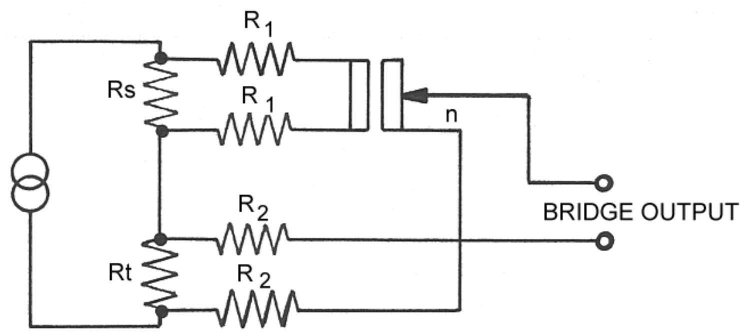


Figure 4.4 Bridge Output Impedance Calculation

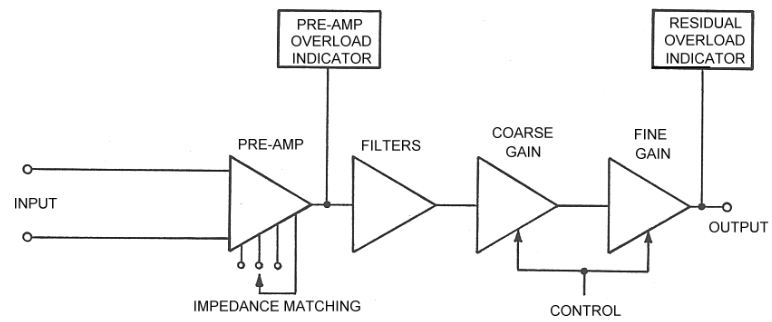


Figure 4.5 Gain Controlled Amplifier

4.7 The Detectors

See Figure 4-1.

The output of the gain controlled amplifier goes to three detectors:

i) In-phase synchronous detector

ii) Quadrature synchronous detector

iii) Residual peak detector

4.8 In-Phase Detector

This converts any signal at the carrier frequency and in the same phase as the carrier current to DC indicating the bridge 'out of balance'. The output goes to the meter, connector Skt 1 on the back panel and also to an analogue to digital converter.

4.9 Quadrature Detector

This detects any signal at the carrier frequency and in quadrature (i.e. 90 deg phase shifted) to the carrier current. If any signal is present, the detector integrates, the output ramping up or down depending on the relative phase. The output controls the multiplier circuit and the front panel meter (when selected).

The quadrature detector forms part of the automatic quadrature servo loop. See section 4-11.

4.10 Residual Detector

This is a simple peak detector for checking the total signal present on the output of the main amplifier. The detector can be switched to the meter using the front panel controls.

4.11 Automatic Quadrature Servo

4.11.1 Introduction

Due to the presence of active elements in the standard (R_s) and PRT (R_t) resistors, the signals developed across them may not be in exactly the same phase.

The bridge is therefore balanced by adjusting the ratio of the transformer and injecting a quadrature signal, derived from the voltage across the standard resistor, until the outputs of both the in-phase and the quadrature detectors are zero.

The in-phase balance may be adjusted manually, using the front panel rotary switched, or automatically, under control of the internal microprocessor. Quadrature is balanced continuously, in manual or automatic mode, by the automatic solid state quadrature servo.

4.11.2 Effects of Quadrature

If the standard and PRT (complex) impedances are $R_s + iQ_s$ and $R_t + iQ_t$ respectively, then the condition for full balance is:

$$nI(R_s + iQ_s) - I(R_t + iQ_t) + KI(Q_s + iR_s) = 0 \text{ volts} \qquad \text{---- (1)}$$

where

- n = transformer ratio
- I = operating current
- K = a factor indicating the amount of quadrature which is injected to achieve a null.

Note that the quadrature is $I(Q_s + i\,R_s)$ as it is derived from the voltage across the standard resistor and shifted in phase by 90 deg through the mutual inductor.

The bridge current cancels, whence, considering the real and imaginary parts:

$$R_s - R_t + K\,Q_s = 0 \qquad \text{---- (2)}$$

$$Q_S - Q_t - K\,R_s = 0 \qquad \text{---- (3)}$$

Substituting for K in (1) gives

$$\frac{R_t}{R_s} = n + \frac{Q_t\,Q_s}{R_s^2} - n\,\frac{Q_s^2}{R_s^2}$$

Since QT and QS are always small compared with R_t and R_s, then

$$\frac{Q_t}{R_t} = \theta_t$$ -PRT impedance phase angle (radians)

$$\frac{Q_s}{R_s} = \theta_s$$ -standard resistor phase angle (radians)

$$\frac{R_t}{R_s} \cong n$$

$$\frac{R_t}{R_s} = n\ (1 + \theta_t\theta_s - \theta_s^2)$$

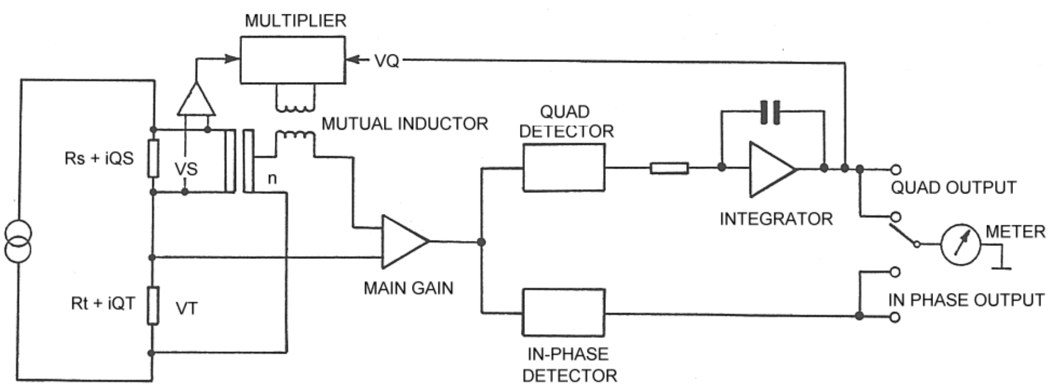


Figure 4.6 Quadrature Servo

4.11.3 Quadrature Servo Range

The amount of quadrature that can be compensated is limited by the range of the quad servo, equivalent to a maximum value for K. The output voltage, VQ, of the quad servo, as presented to the meter, indicates the amount of quadrature present on the bridge, i.e. proportional to K:

from (3) $$K = \frac{Q_t}{R_s} - \frac{Q_s}{R_s}$$

or $$K = (\theta_t - \theta_s)$$

The maximum range is determined by the gain, G1, of the reference amplifier as indicated in Figure 4-7. The limit on VS is due to saturation of the ratio transformer or reference amplifier.

QUAD	Quadrature Range	Maximum
GAIN	VQ = ± Full Scale on Meter	VS Allowed
Front Panel Selected	K Max – See Section 4.11.2	$VS = I.R_s$
1	$\pm 2 \times 10^{-5}$	Limited by saturation of ratio transformer. See Fig 4-3
10	$\pm 2 \times 10^{-4}$	100mV RMS
10^2	$\pm 2 \times 10^{-3}$	10 mV RMS

Figure 4-7. Quadrature Servo Range.

4.11.4 Choosing the Correct Quadrature Range

The minimum quad gain (and hence quadrature range), which does not result in saturation of the quadrature servo, should be used. If excessive quad gain is used, this can result in longer balance times in automatic mode.

4.12 The Internal Automatic Balance Procedure

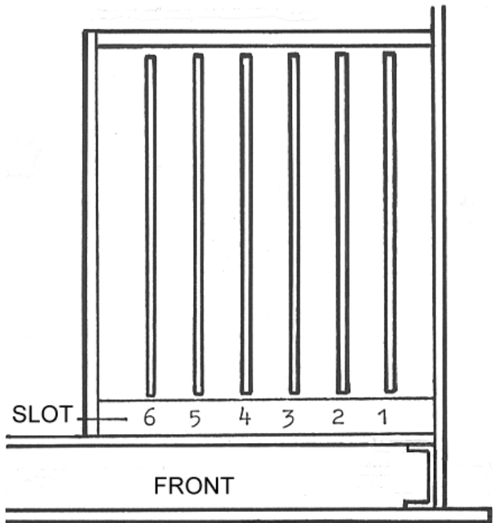
When automatic balance is selected, the internal microprocessor measures the out of balance and sets the ratio transformer in order to achieve a null. This is carried out one decade at a time; the gain of the main amplifier being increased by a factor of ten for each decade until it reaches the gain selected by the front panel.

If at any time the out of balance is too great, the gain is progressively decreased until the out of balance can be corrected, and the gain progressively increased again to the selected value.

Since the out of balance is measured, the optimum automatic balancing requires the correct gain. This is set nominally by the front panel switches, but a fine adjustment is provided by the ten turn potentiometer. This should be set to approximately 5.0 (five turns) for correct automatic operation.

The fine adjustment can be used to facilitate very sensitive out of balance measurements in the manual mode.

5 Computer Interfaces



SLOT	PCB Function
1	Computer Interface
2	Microprocessor
3	Microprocessor Interface
4	Carrier Generator
5	Quad Servo
6	Amplifier

Figure 5-1. F900 Card Frame (Top View)

5.1 General Information

The F900 is supplied with an IEEE-488.1 interface

5.2 Important Notes

i) The Interface OV, for IEEE-488 is connected to ground (supply - Green lead), internally to the F900.

ii) Switch off power to all instruments, peripherals or computer(s) associated with the F900 interfaces, before connecting the F900 or disconnecting the F900 from the Interface.

EQUIPMENT DAMAGE MAY RESULT IF THIS IS NOT COMPLIED WITH.

5.3 Device Address Selection (IEEE-488)

This switch is also used to set the device address for the IEEE-488 interface. See figure 5.2.

UNLESS OTHERWISE DIRECTED, ASL SETS THE IEEE-488 ADDRESS TO 4.

Any device address in the range 1 to 15 inclusive may be selected.

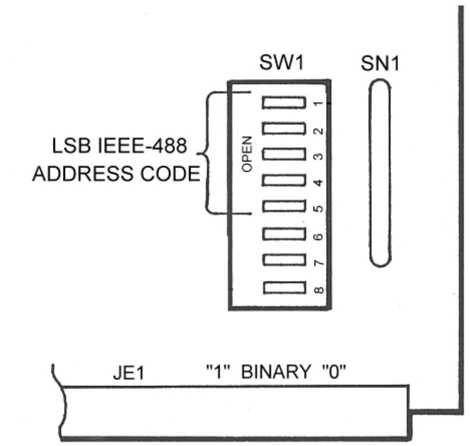


Figure 5-2. IEEE Address Code Select Switch

5.4 IEEE-488 Implementation

The F900 IEEE-488 interface includes the following subsets of the IEEE-488.1 :1987.

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)	LEO	No extended address
vi)	TEO	No extended address
vii)	SR1	Service request
viii)	RLO	No remote/local function (similar function available)
ix)	PPO	No parallel poll
x)	DC1	Device clear - reverts to power-on state
xi)	DTO	No group executive trigger
xii)	C0	No controller functions

For a fuller explanation, consult the IEEE-488.1 : 1987 standard and your computer/controller interface manual.

5.5 Interface Facilities

5.5.1 Introduction

The IEEE-488 interface allows commands to be sent to, and data retrieved from the F900 in the form of ASCII characters and strings.

Figure 5-3 below summaries the available commands and the required syntax.

COMMAND	DESCRIPTION
AU	Set auto balance mode
B	Set bandwidth
C	Set carrier current
CHK	Set check mode
DAC	Set DAC (analogue o/p) range
FRQ	Set carrier frequency
G	Set gain
MAN	Set manual balance mode
MET	Set meter mode
OFL	Switch bridge off-line
ONL	Switch bridge on-line
P	Preset ratio on bridge
PA	Preset ratio to current auto ratio
REF	Set ref amp gain (Quad range)
SRC	Set source impedance
SRM	Set mask for GPIB Service Request Function

Figure 5-3. Summary of Available Commands

The F900 controls can be set either from the front panel (in the off-line mode) or from remotely set values via the interface (in the on-line mode).
To achieve this, the F900 stores two sets of values, one from the front panel, the other from commands via the interface, and uses the values as determined by the on-line (ONL) and off-line (OFL) command.
The off-line front panel controls may be changed while the F900 is on-line, but the bridge will not respond to these until the F900 is set off-line. Similarly, the on-line settings may be changed via the interface while the bridge is off-line, but these will not take effect until the F900 is set on-line.

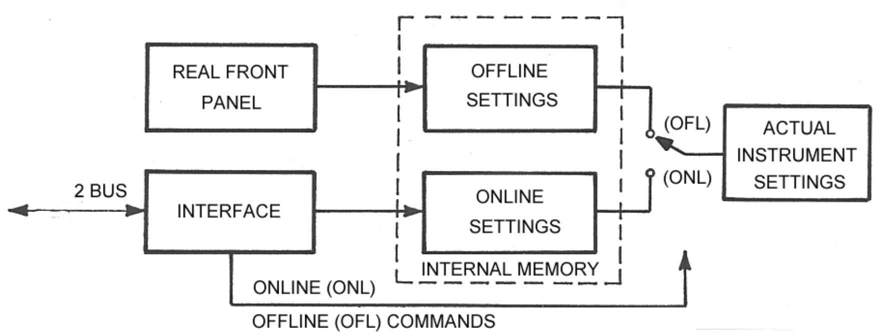


Figure 5-4. Schematic Representation of Remote Control Facilities

5.5.2 Description of Commands

COMMAND AU

Function: This instruction puts the bridge in auto balance mode

Syntax : AU

Parameters: None

COMMAND B

Function: This instruction selects the detector bandwidth

Syntax: Bn, where n = 0 to 8

Parameters:

n = 0	0.5Hz detector bandwidth
n = 1	0.2Hz detector bandwidth
n = 2	0.1Hz detector bandwidth
n = 3	0.05Hz detector bandwidth
n = 4	0.02Hz detector bandwidth
n = 5	0.01Hz detector bandwidth
n = 6	0.005Hz detector bandwidth
n = 7	0.002Hz detector bandwidth
n = 8	0.001Hz detector bandwidth

Initial value: n = 0 0.5Hz detector bandwidth

COMMAND C

Function: This instruction selects the bridge current

Syntax: Cn, where n = 0 to 8 and 10 to 18

Parameters: c is a code between 0 and 8 or 10 and 18

n = 0	0.1 mA	n = 10	0.1 x √2 mA
n = 1	0.2 mA	n = 11	0.2 x √2 mA
n = 2	0.5 mA	n = 12	0.5 x √2 mA
n = 3	1.0 mA	n = 13	1.0 x √2 mA
n = 4	2.0 mA	n = 14	2.0 x √2 mA
n = 5	5.0 mA	n = 15	5.0 x √2 mA
n = 6	10.0 mA	n = 16	10.0 x √2 mA
n = 7	20.0 mA	n = 17	20.0 x √2 mA
n = 8	50.0 mA	n = 18	50.0 x √2 mA

Initial value: n = 3 1.0 mA

COMMAND	**CHK**		
Function:	This instruction sets the check mode		
Syntax:	CHKn, where n = 0, 1 or 2		
Parameters:	c is a code between 0 and 2		
	n =0	normal operation	
	n = 1	zero check	
	n = 2	unit check	
Initial value:	n = 0	normal operation	

COMMAND	**DAC**	
Function:	This instruction sets the analogue output range	
Syntax:	DACn, where n = 0, 1, 2 or 3	
Parameters:	n = 0	range digit 2 to digit 4
	n = 1	range digit 3 to digit 5
	n = 2	range digit 4 to digit 6
	n = 3	range digit 5 to digit 7
Initial value:	n = 3	range digit 5 to digit 7

COMMAND	**FRQ**	
Function:	This instruction sets the carrier frequency	
Syntax:	FRQn, where n = 0 or 1	
Parameters:	n = 0	low frequency
	n = 1	high frequency
Initial value:	n = 1	high frequency

COMMAND **G**

Function: This instruction sets the gain of the bridge

Syntax: Gn, where n =0 to 7

Parameters:
n = 0 gain of 10^{o}
n = 1 gain of 10^{1}
n = 2 gain of 10^{2}
n = 3 gain of 10^{3}
n = 4 gain of 10^{4}
n = 5 gain of 10^{5}
n = 6 gain of 10^{6}
n = 7 gain of 10^{7}

Initial value: n = 4 gain of 10^{4}

COMMAND **MAN**

Function: This instruction puts the bridge in manual balance mode

Syntax: MAN

Parameters: None

COMMAND **MET**

Function: This instruction selects the meter mode

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

Parameters:
n = 0 in phase reading
n = 1 quadrature reading
n = 2 residual reading

Initial value: n = 0 in phase reading

COMMAND **OFL**

Function: This instruction switches the bridge off-line. Instructions may still be sent, but the bridge is controlled from the front panel switches, and the instructions will not be actioned until the ONL instruction is sent. See section 5.5.1 and Figure 5-4.

Syntax: OFL

Parameters: None

COMMAND ONL

Function: This instruction allows the bridge to be controlled from the external interface, as opposed to being controlled from the front panel switches. See section 5.5.1 and Figure 5-4.

Syntax: ONL

Parameters: None

COMMAND P

Function: This instruction allows a ratio to be preset on the bridge.

Syntax: Pn, where n = a ratio between 0 and 1.299 999 999

Parameters: n = a ratio between 0 and 1.299 999 999

Initial value: 0.000 000 000

COMMAND PA

Function: This instruction sets the current ratio in auto balance mode to be preset on the bridge. The bridge is then put into manual balance mode.

Syntax: PA

Parameters: None

Initial value: The current ratio in auto balance mode

COMMAND Q

Function: This instruction returns the current bridge status.

Syntax: Q

Parameters: Returned parameters represent the same values as those sent with each command.

COMMAND REF

Function: This instruction selects the reference amplifier gain (quad range)

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

Parameters:	n = 0	gain of 1	quad range 2 x 10^{-5}
	n = 1	gain of 10	quad range 2 x 10^{-4}
	n = 2	gain of 100	quad range 2 x 10^{-3}

Initial value: n = 1 gain of 10

COMMAND SRC

Function: This instruction selects a source impedance

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

Parameters: n = 0 then source impedance = 1 ohm

n = 1 then source impedance = 10 ohms

n = 2 then source impedance = 100 ohms

Initial value: n = 2 source impedance = 100 ohms

COMMAND SRM

Function: This instruction allows the user to set a mask for the GPIB service a request function.

Syntax: SRMn, where n = 0 to 255 forming a bit wire mask

Parameters: n = 0 to 255 forming a bit wire mask

The functions of the bits are as below:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Data availabl e	Request Service bit	Not balanced	Balanced	Overload error	Not used	Not used	Not used
V=128	V=64	V=32	V=16	V=8	V=4	V=2	V=1

Bit 7: When set, will request service whenever the ratio is updated.

Bit 6: When a serial poll is performed on the F900, this bit is set indicating that the F900 was the source of the interrupt.

Bit 5: When set, will request service even if the F900 is not balanced.

Bit 4: When set, will request service when the F900 is balanced.

Bit 3: When set, will request service when a bridge overload error has occurred.

When a serial poll is performed on the F900, the status byte returned is in the same form as the mask shown above.

Setting a mask causes a request service function to be generated whenever the bridge condition corresponds with the service mask, which has been set.
Bit 6 (request service bit) and the bit which corresponds with the mask condition will be set and will be returned in the byte returned by the serial poll.

INITIAL VALUE: 0 (no mask set)

5.6 Obtaining a Measurement from the F900

All commands sent to the F900 must be in upper case letters and must be terminated by a line feed (ASCII 10) character.

Data returned by the instrument is terminated by carriage return (ASCII 13) and line feed (ASCII 10) characters.

Standard factory set address is 4. The IEEE address may be altered by the operator via the switch on the interface card fitted within the F900.

There are two methods of getting data back from the instrument:

a) No output command is required

A standard reading followed by the balance status letter may be requested simply by instructing the IEEE controller to read a number of bytes. The length of the standard reading is 15 bytes including CR and LF delimiting characters. Therefore this is the recommended number to read. Requesting fewer bytes will return an incomplete string. Requesting more bytes will return only one standard reading, because the F900 is set up to terminate communication on sending the line feed character (ASCII 10).

b) Send "SRMc" command ,where "c" is a number between 0 and 255, to set up a service request (SRQ) function on the F900, which may be serial polled by the controller to establish whether the service request condition has been met. The most common value for "c" will be "128" (bit 7), i.e. the instrument will request service when the ratio reading is updated on completion of the balance cycle.

It has generally been found to be more reliable to disable the auto serial poll function on the IEEE controller and for the program to perform a serial poll of the RSV bit periodically to establish whether data is available for output. If the request service bit is set, send interface bus read command to read the data, as in (a).

The bridge must be set "on-line" before using the interface, because the F900 stores two sets of bridge operating parameters: one for "on-line" operation via the interface and one for local operation via the front panel.

When a scanning/logging sequence is set up in a PC program, it is normal to set local lockout (LLO) to prevent the front panel controls of the instrument from being accidentally altered while the scan/log is in progress.

Note:
Sending a preset value to the bridge using the "P" or "PA" commands will automatically set the bridge into manual balance mode. To reset the bridge to automatic balance mode via the interface, use the "AU" command.

5.7 Returned Data

13 digits + CR + LF are returned in the form "+0.123456789B" + CR + LF, the first digit being the sign, the last digit being the bridge balance status. Bridge balance status may be "B", "L" or "H" or "E": for balanced, low, high or error (overload condition).

Data can be retrieved from the output buffer once per balance (program) cycle, which may be two seconds or more, depending on the bandwidth setting and the signal being measured.

5.8 Using the Status Query command

Send the command "Q" + CR + LF.

The status query command provides a positive indication that commands sent or bridge parameters changed have been acted upon. It also allows a check on current bridge status on the occurrence of errors.

The data returned is a string of 72 bytes including carriage return and line feed characters. It may be interpreted in the same way as the commands sent to control the bridge (see section 5.5.2).

5.9 Operation with a Switchbox

The switchbox system requires both an SB158 switchbox controller and up to six 10 channel SB148 switchboxes to provide a maximum of 60 channels.

Up to four external R_s (reference resistor) channels may be defined in hardware (factory set) on channels 6 to 9 of 148 switchbox number 0. Once defined, these channels may be used only for R_s. Where less than four R_s channels are defined, they are numbered downwards from 9, i.e. one R_s channel only will be set on channel 9, two R_s channels will be set on channels 8 and 9 and so on.

Standard factory set address for the switchbox controller is 7. The IEEE address may be altered by the operator via the switch on the interface card. (refer to the Switchbox Operator's Handbook).

Ports I, L, M, O on the switchbox IEEE card are used to set the channel number. Ports I, L, M are used to set the R_t channel, port O is used to set the R_s channel number. Port L represents hundreds, I represents tens, M represents units, O represents the R_s channel number. For example, the command "L0I5M6O9" sets R_t channel 56, R_s channel 9.

Data is not normally read back from the switchbox controller, except to verify that a switchbox controller is present and on-line.

6 Specification

6.1 Measurement Range

Measurement range: 0 to 260 ohms

Rated accuracy: 0 to 130 ohms

R_s range: 1 to 200 ohms.

6.2 Display Range

Display range of 0 to 1.299 999 999 ratio of two resistors, R_t & R_s.

6.3 Accuracy

0.02 ppm ratio error.

6.4 Resolution

Typically 0.3nV√Hz rms at 1 ohm matching impedance.

6.5 Sensor Current

1.0mA, 2.0mA, 5.0mA, x√2, x0.1, x10 User selectable.

Sensor current accuracy +/-0.1%.

6.6 Carrier Frequency

50Hz local supply: Low 25Hz
High 75Hz

60Hz local supply: Low 30Hz
High..90Hz

Phase locked to the local supply frequency.

6.7 Bandwidth

Sets the bandwidth of detector.

0.5Hz, 0.2Hz, 0.1Hz, 0.05Hz, 0.02Hz, 0.01Hz, 0.005Hz, 0.002Hz, 0.001Hz

User selectable.

6.8 Quadrature

At a frequency of 75Hz/90Hz the reactive component of most PRTs and standard resistors is insignificant and is rejected by the quad servo and 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 the maximum quad servo range is exceeded.

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

6.9 Temperature Measurement Specification

The performance of the F900 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 F900 errors must be added to give the combined accuracy figure.

6.10 Resolution

The digital resolution is typically 0.01 ppm with a Pt100 at 1mA.

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

6.11 Analogue output

Skt 1	+10Vdc max.
Skt 2	-10V to +10Vdc max.
Skt 2 Maximum Load	10K, 10nf – 100m co-axial cable
Skt 2 Bandwidth	1 Hz

6.12 Bridge Self Check

Zero Self Check	Checks the bridge for any offset errors.
Unity Self Check	Checks the bridge for any unity scale errors.

6.13 Environment

Operating Temperature:	10°C to 39°C	
Humidity:	Specified to 90% RH at 40°C non-condensing.	
Power Requirements:	240 VAC ±10%, 120 VAC ±10%,	220 VAC ±10% 100 VAC ±10%
	Supply Voltage range is user selectable on rear panel.	
Supply Frequency:	50 or 60 Hz.	(see instrument front panel)
Power consumption:	250 VA Max.	

Dimensions:

	Cased	Rack Mounted
Width	545 mm (20.7")	483 mm (19")
Height	382 mm (15")	311 mm (12.25")
Depth	500 mm (18.1")	430 mm (16.9")

Weight:

Cased	Rack Mounted
46 Kg (101 lbs)	35 Kg (77 lbs)

6.14 Communications

IEEE-488 Factory set to address 4.

7 Cleaning and Maintenance

7.1 Cleaning

Make sure the F900 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.

7.2 Preventive Maintenance

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

7.3 General safety Warning

WARNING If the F900 is used in a manner not specified by ASL, then the protection provided by the instrument may be impaired.

7.4 Routine Maintenance

The F900 is tested and calibrated before dispatch, using special procedures and reference standards.
It is not normally practical for customers to effect repairs.

Maintenance tasks are therefore limited to keeping the instrument and its leads clean. 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.

8 Accessories and Options

The following accessories and options are available for the F900 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 Ro = 25.5 ohms (nominal). 2 metre cable 4 wire plus screen with spade terminal connections. Stem length 450mm, quartz. R_{100}/Ro 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 Ro = 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 Ro = 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 Ro = 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. Ro=0.25 ohms. Temperature range up to 962 °C.
SB148/SB158	10 channel automatic/remote scanner. Expandable to 60 channels. IEEE-488 or RS232 compatible. Current source for unselected PRTs.
RW	Oil filled Standards Resistors. 1, 10, 25, 100 & 1000 ohms.
RTE	Thermal enclosure for RW & RR resistors.
TMS	PC compatible, graphical based Data Acquisition and Control Software.

Figure 8-1. Accessories

9 Service and Warranty

F900 equipment and accessories, (unless stated otherwise), are covered by a 12 month warranty for parts and labour, but not including costs incurred in returning it to the factory for repair, from the date of dispatch from Automatic Systems Laboratories.

9.1 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

9.2 Returned Instruments

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

9.3 Documentation

The shipment should include:

Your goods return note, a delivery note or an export invoice stating clearly GOODS RETURNED FOR REPAIR.

Your Company / Establishment order or contract reference number.

The name of your purchasing and technical contact.

A brief fault report.

9.4 Non UK Return

Automatic Systems Laboratories has a general authority arrangement with UK Customs to temporarily import goods free of duty and import tax. Therefore pre-advice of shipment, date, carrier etc., will enable us to arrange prompt importation with our freight agents.

9.5 Repair Quotations

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

9.6 Re-Export of Repaired Instruments

It is our normal practice to return repaired equipment all charges forward and include import charges, that is import documentation and UK freight charges on our repair invoice. Please advise if you require return costs to be included in our repair quotation or have any special shipping instructions.

NOTES

NOTES

NOTES

NOTES