USER'S HANDBOOK

for

THE DATRON 4708 AUTOCAL MULTIFUNCTION STANDARD

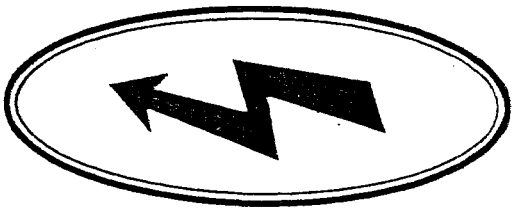
850245

Issue 1 (DECEMBER 1988)

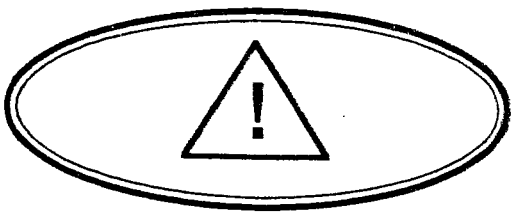
Due to our policy of continuously updating our products, this handbook may contain minor differences in specification, components and circuit design to the instrument actually supplied. Amendment sheets precisely matched to your serial number are available on request.

DANGER
HIGH VOLTAGE

THIS INSTRUMENT IS CAPABLE OF DELIVERING
A LETHAL ELECTRIC SHOCK !
when connected to a high voltage source



FRONT or REAR terminals carry the Full Input Voltage
THIS CAN KILL !



Guard terminal is sensitive to over-voltage
It can damage your instrument !

Unless **you** are **sure** that it is **safe** to do so,
DO NOT TOUCH
the **I+ I- Hi** or **Lo leads** and **terminals**

DANGER

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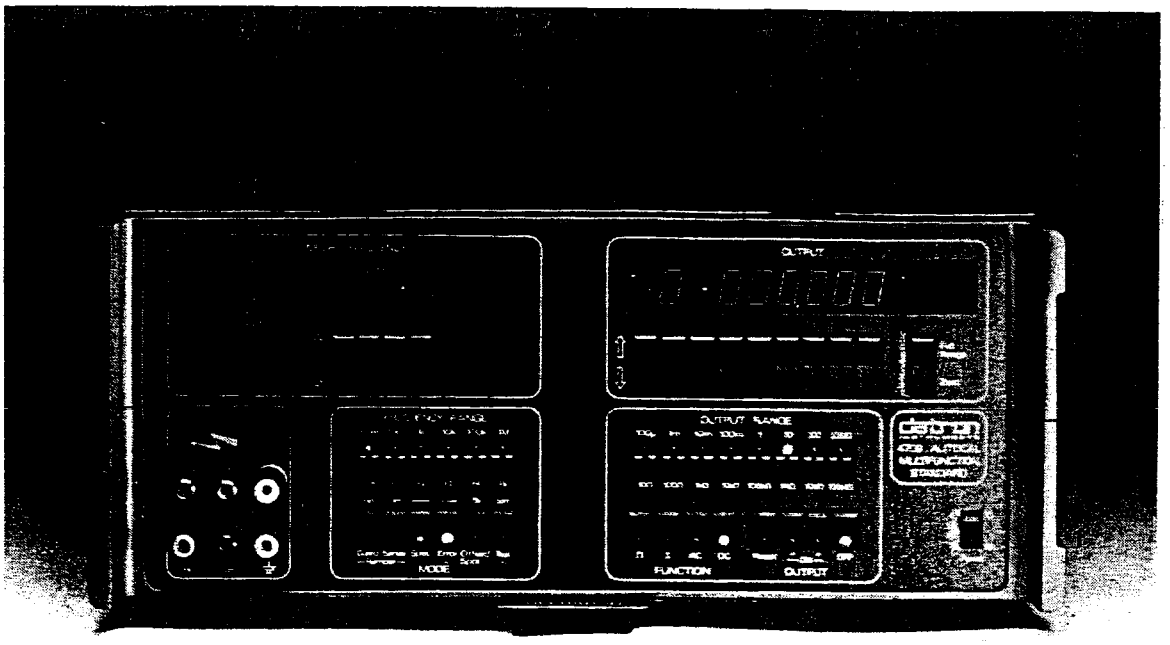
AUTOCAL MULTIFUNCTION STANDARD



General View of Datron 4708 Autocal Multifunction Standard

Introduction

The Datron 4708 Autocal Multifunction Standard is a high-precision calibrator which features exceptionally high stability and full systems capability. It is characterized by a wide-range coverage of DC Voltage, AC Voltage, DC Current, AC Current and Resistance functions in a single unit.

The basic instrument consists of a mainframe to which the various output options may be added.

Option 10 (factory-fitted) provides a DC Voltage function.

Option 20 (factory-fitted) provides an AC Voltage function.

Option 30 (factory-fitted) adds calibration sources of DC Current, AC Current and Resistance.

The 4708 incorporates a reference module which maintains a high accuracy specification over the ambient temperature range of 23°C ± 10°C. A high level of stability is achieved by use of super-selected reference components and ultra-stable gain-defining resistors. The 'Autocal' feature ensures that its 24-hour specifications are usable; not merely figures of merit.

The 4708 uses a microprocessor for control management, simplifying its use in complex manual operations, such as calibration of high-quality digital multimeters. The IEEE 488 interface provides a comprehensive remote programming capability, allowing programmed calibration of the 4708 itself.

Standard and Optional Facilities

DC Voltage Ranges

By fitting Option 10, the instrument provides DC Voltage calibration facilities in eight decade ranges from ±100μV to ±1000V. 100% overrange is incorporated, except on the ±1000V range (see page 3-3), when the output is limited to 1100V.

Resolution and Accuracy

The maximum resolution is 7.5 digits with a facility for displaying the specified accuracy of any output voltage. The 4708 specifications are shown in Section 6.

AC Voltage Ranges

By fitting Option 20, the instrument provides AC Voltage calibration facilities in seven decade ranges from 1mV to 1000V. 100% overrange is incorporated, except on the 1000V range (see page 3-3), when the output is limited to 1100V.

Resolution and Accuracy

The maximum resolution is 6.5 digits with a facility for displaying the specified accuracy of any output voltage. The 4708 specifications are shown in Section 6.

DC Current Ranges

By fitting Option 30, in conjunction with Option 10, the instrument can be used to calibrate DC Current in five decade ranges from 100μA to 1A. The Datron Model 4600 may be used to extend DC Currents to 11A.

Resolution and Accuracy

The maximum resolution is 6.5 digits with a facility for displaying the specified accuracy of output current. The 4708 specifications are shown in Section 6.

AC Current Ranges

By fitting Option 30, in conjunction with Option 20, the instrument can be used to calibrate AC Current in five decade ranges from 100μA to 1A. The Datron Model 4600 may be used to extend AC Currents to 11A.

Resolution and Accuracy

The maximum resolution is 6.5 digits with a facility for displaying the specified accuracy of output current. The 4708 specifications are shown in Section 6.

Resistance

By fitting Option 30, in conjunction with Option 10, the instrument can be used to calibrate resistance in eight decade ranges from 10 ohm to 100M ohm.

Resolution and Accuracy

The maximum resolution is 7.5 digits with a facility for displaying the specified accuracy of any output resistance. The 4708 specifications are shown in Section 6.

Frequency

The output frequency of the 4708 extends from 10Hz to 1MHz in five overlapping decade ranges, at a resolution of 1% of nominal Frequency Range. Any five frequency values within the range of the instrument can be stored in volatile memory. For higher accuracy, five 'Spot Calibrated' frequency values per Output Range can be recalled from non-volatile memory storage.

Autocal

All Datron AUTOCAL instruments are designed to make the removal of the covers for calibration unnecessary, as full routine calibration of all ranges and functions can be carried out from the front panel or over the IEEE 488 bus.
Accidental or unauthorized use of the calibration routine is prevented by a key operated switch on the instrument rear panel. The procedure for calibrating this instrument is contained in Section 8.

Output Deviation

A user may deviate the output voltage from the output display value by introducing a gain 'Error' within the general range ±10%. Additionally, for DC functions, the output may be 'offset' by up to ±2% of the range in use, or 200μV, whichever is greater.

Remote Sense

The specified output voltage may be sensed at the load, using 4-wire connections. Remote or Local Sense is selectable from the front panel.

Remote Guard

This facility allows the instrument's internal guard shields to be externally connected.

Self-test

On power-up, the internal calibration memory is automatically checked. At any time when the output is off and not under remote control, a user may conduct a sequenced test of the displays, keyboard, safety circuitry and Reset function.

Message Readout

Messages to the user are presented on the MODE display: The two main groups are:

Fail
An internal fault condition has been detected.

Error
A user has selected a task which is outside the instrument's capability.

Systems Use

The instrument can form part of a system by means of the IEEE 488 standard digital interface. The method of connecting to the system controller and the command codes are described in Section 5.

Safety

For protection of the user, safety trip circuits are incorporated to switch the OUTPUT OFF, in the event of instrument failures which might generate dangerous output voltages.

UNDER NO CIRCUMSTANCES SHOULD USERS TOUCH ANY OF THE OUTPUT, SENSE OR GUARD TERMINALS UNLESS THEY ARE FIRST SATISFIED THAT NO DANGEROUS VOLTAGE IS PRESENT.

Optional Facilities

The available options for the 4708 are as follows:

Option 10:	DCV function
Option 20:	ACV function
Option 30:	DC Current, AC Current and Resistance functions
Option 42:	Rear output terminals (as a factory-fitted alternative to front panel terminals).
NB:	The rear output option is not recommended for best performance in calibrating high bandwidth, low level instruments.
Option 90:	Rack mounting kit.

Accessories:

The instrument is supplied with the following accessories:

Description		Part Number
Power Cable		920012
Set of Calibration keys		700068
User's Handbook		850245
Calibration and Servicing Handbook		
(2 volumes)	(Volume 1)	850246
	(Volume 2)	850247

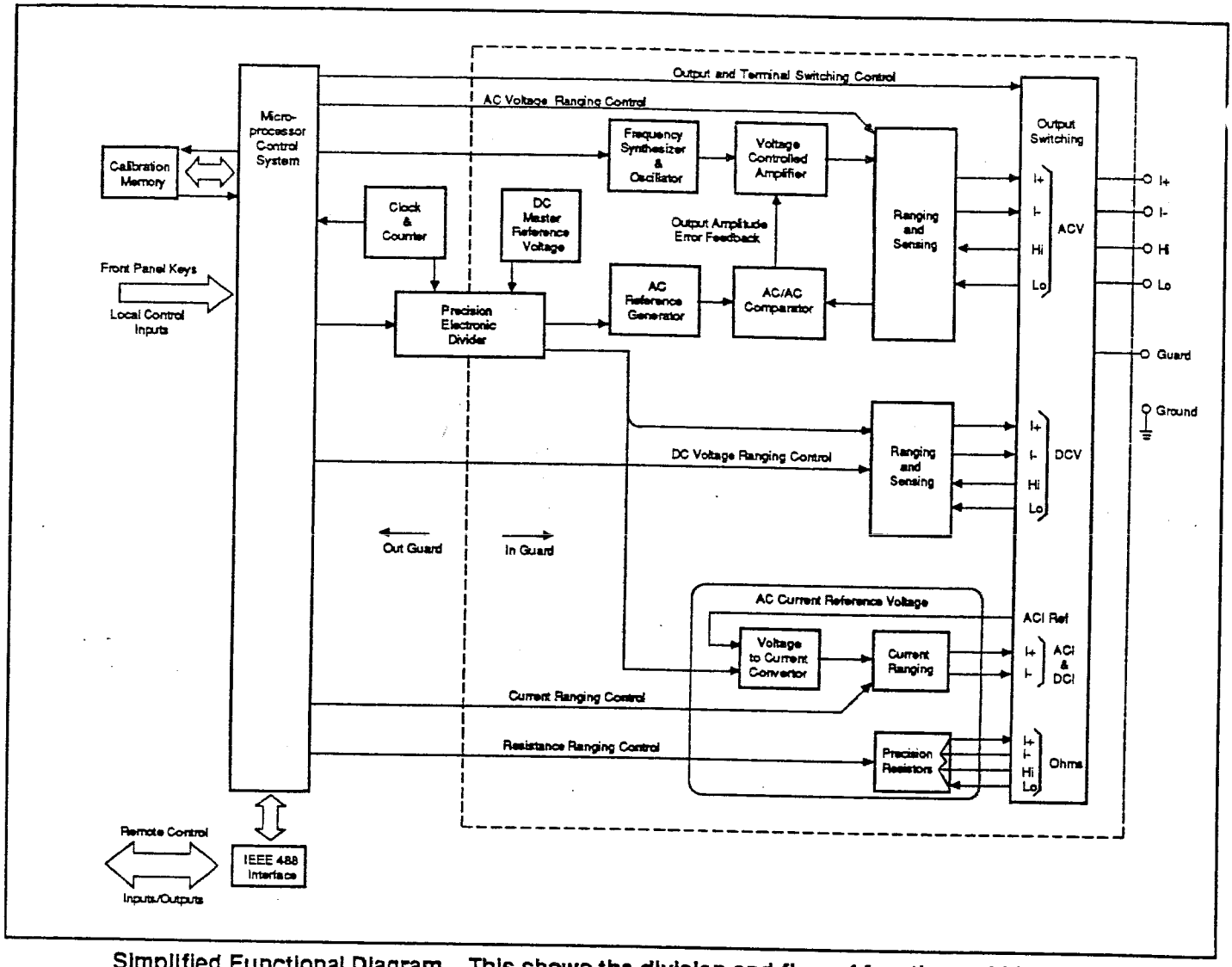
In addition the following accessories are available for use with the 4708 instrument:

Description	Part Number
RMK Rack Mounting kit (Option 90)	440094
Special Lead Kit	440070
Model 4600 Transconductance Amplifier	
Slave Mode Lead Kit (4600)	440151
Analog Lead Kit (4600)	440154

Additional Documentation

The Calibration and Servicing Handbook contains information required to adjust and service the 4708 instrument. It contains detailed descriptions of the circuits, trouble shooting and calibration procedures, parts lists, layout drawings and circuit diagrams.

Principles of Operation



Simplified Functional Diagram. This shows the division and flow of functions within the 4708

Inputs

The 6802 microprocessor controls the output in response to three main inputs:

i) Front panel keys

ii) IEEE 488 bus messages in 'Remote' operation

iii) Corrections placed in non-volatile memory during 'Autocalibration'. These modify the values which control the output.

After processing, the computing system changes the output of the instrument to respond to the input instructions.

Reference Voltages

A 20V DC 'Master' Voltage Reference establishes the fundamental accuracy of the instrument. From this 20V, a precision electronic divider derives an adjustable 'Working' reference voltage between 0V and 20V, whose value depends on digital inputs from front panel keys and calibration memory.

Precision Electronic Divider

In the out-guard section the selected output value, including calibration corrections, is set into a digital comparator as a 25-bit number. This is counted out by a crystal controlled binary counter, resulting in a 125Hz square wave whose mark : period ratio accurately represents the output value selection. When transferred into guard, it chops the Master Reference voltage. A 7-pole active low-pass filter integrates the chopped reference, to generate the ripple-free DC Working Reference Voltage.

DC Voltage Output

The working reference for DC Voltage Output is a stable DC voltage, accurately variable at high resolution between 0 and +20V.

DC Voltage Ranging

Low Voltage Ranges (100µV - 10V FR). The basic range of the 4708 is ±10V Full Range (±19.999999V Full Scale), derived directly from the working reference. The 1V and 100mV ranges are achieved by attenuation:

The 100mV range attenuator is also used for 10mV, 1mV and 100µV ranges, and the digital input to the precision divider is scaled to provide the correct working reference values.

Range	Working reference values
10mV	—2V → +2V
1mV	—200mV → +200mV
100µV	—20mV → +20mV

High Voltage Ranges (100V and 1000V)

The 100V range is a direct amplification of the working reference. The 1000V range employs step-up AC transformation.

Output Switching.

In addition to switching between functions, the output switching circuits isolate terminals on OUTPUT OFF. Remote/Local Sense and Guard switching is incorporated.

AC Voltage Output

The working reference for AC Voltage Output is a stable DC voltage, accurately variable at high resolution between +0.1V and +2V DC.

AC Reference Generator

The higher accuracy of AC/AC comparison (over AC/DC) is exploited by converting the DC Working Reference into a stepped waveform whose characteristics match those of a sinewave. The amplitude of this 'Quasi-sinewave' is precisely controlled by the DC Working Reference value.

Sinewave Source

Frequency Synthesizer

From the frequency value set into the MODE/FREQUENCY display, the processor controls the synthesizer using an encoded 9-bit command. The synthesizer translates the command into a pulse train at a crystal-derived frequency between 240kHz and 4MHz, to be divided down for use as phase-reference for the Quadrature Oscillator.

N.B. If required, the Frequency Synthesizer, can be locked to an externally supplied 1MHz or 10MHz frequency, input via J53 on the rear panel.

Quadrature Oscillator

The oscillator's output frequency is set close to any demand, between 10Hz and 1MHz, by selecting the RC time constants of its dual integrators; and then by correcting to the actual demand by phase-comparison with the output from the synthesizer. The output sinewave purity and constant amplitude are precisely defined by a sophisticated control loop, and the RMS value of the sinewave is adjusted to be roughly proportional to the demanded output voltage or current. Timing data is output from the source to synchronize the actions of the AC Reference Generator and AC/AC Comparator.

Voltage-Controlled Amplifier (VCA)

This has variable gain, amplifying the output from the Sinewave Source and providing a buffered drive to the output circuits. Its gain is determined by the measured difference between the RMS values of the sensed calibrator output and the AC Reference; so the VCA provides the correcting fine adjustment for the output amplitude loop.

AC Voltage Ranging

1V Range

This is the basic AC voltage range of the 4708. As the AC working reference is variable between 0.1V and 2V RMS, it is compared in 1:1 ratio with the sensed output. The 1V Buffer output is thus passed directly to the output I+ and I- terminals.

100mV, 10mV and 1mV Ranges

The 1V Buffer output is reduced by precision attenuators before being connected to the terminals, the level being sensed before attenuation.

10V, 100V and 1000V Ranges

The 1V Buffer output is amplified on each of these ranges. A separate amplifier is provided for the 10V range, the output sense signal being obtained at the terminals and attenuated before comparison with the reference. A common power amplifier is used for both 100V and 1000V ranges. On the 100V Range the output is fed directly to the terminals, on the 1000V Range the output is stepped up by a transformer. On both ranges, the sensed terminal voltage is reduced to the reference level by precision attenuators.

Output Sensing

On the 1V range and above, the output is sensed at the front panel Hi and Lo terminals. With Remote Sense selected, these are isolated from I+ and I-, but in Local Sense Hi is internally connected to I+, and Lo to I-. As described above, the 10V, 100V and 1000V ranges' sense signal is attenuated before comparison with the reference.

AC/AC Comparator

The comparator generates an error voltage proportional to the difference between the RMS values of the AC reference and the sensed output. It alternately samples a number of cycles from its 'Ref' and 'Sense' inputs, computes and integrates the squares of their instantaneous values, and uses a 'Sample and Hold' technique to subtract one from the other, this being the 'error' voltage to control the VCA. The loop thus controls the 4708 output so that the RMS value of the comparator's sense input equates to that of its reference input.

DC Current

On changing functions to DC Current, the Working Reference voltage is switched to drive a voltage-to-current converter, and the **OUTPUT** display legend is changed to **μA, mA** or **A**. Over-voltage protection is provided, and the Output lines are fused.

AC Current

An AC Current output is produced by the voltage-to-current converter. The 100μA and 1A ranges are driven directly from the basic 1V range, and the others from the 10V range. Range selection is achieved by switching internal shunts. Output protection against over-voltage is provided, and the output lines are fused. The **OUTPUT** display legend is altered to **μA, mA** or **A**.

Resistance

Remote Sense.

One of a set of eight precision resistors is internally 4-wire connected to the **I+, I-, Hi** and **Lo** terminals by operation of each **RANGE** key. Simultaneously the 4-wire calibrated value of the resistor is displayed (**OUTPUT** display). Pressing the **OUTPUT Zero** key connects a true 4-wire short to the terminals, and the **OUTPUT** display indicates zero. This zero display value cannot be recalibrated.

Local Sense (Remote Sense LED Unlit).

The connections to the resistor remain the same, but the display value includes the resistance of the connections from the **Hi** and **Lo** terminals to the resistor. The arrangement provides a calibrated 2-wire facility with external connection to the **Hi** and **Lo** terminals. The **Zero** key shorts the **Hi** and **Lo** terminals, in this case the resistance between the terminals is displayed and may be recalibrated. When Ω is selected from any other function, the 4708 is forced into **Remote Sense**, but this may be deselected for 2-wire operation.

Autocalibration

By setting the **CAL ENABLE** security keyswitch on the rear panel to **ENABLE**, the 4708 can be calibrated. (Refer to Section 8). The output value is measured and the microprocessor is activated, to add any new corrections to factors already retained in non-volatile memory. The updated correction factors are applied in the normal **RUN** mode.

Processor

A 6802-series microprocessor controls the internal performance of the instrument, employing 26k bytes of program memory.

2k bytes of memory are used for stack and work space, and 2k bytes are made non-volatile by a battery-powered back-up supply, storing calibration correction factors.

With the exception of the Power **ON/OFF** switch, each front and rear panel control provides an input to the microprocessor system, which translates the information to command the 4708 analog and calibration functions.

The processor also controls the display, the IEEE 488 Interface Bus and the operation of the restart and error circuitry.

SECTION 2 INSTALLATION

This section contains information and instructions for unpacking and installing the Datron 4708.

Unpacking and Inspection

Every care is taken in the choice of packing materials to ensure that your equipment will reach you in perfect condition.

If the equipment has been subject to excessive mishandling in transit, the fact will probably be visible as external damage to the shipping carton. In the event of damage, the shipping container and cushioning material should be kept for the carrier's inspection.

Unpack the equipment and check for external damage to the case, sockets, keys, etc. If damage is found, notify the carrier and your sales representative immediately.

Standard accessories supplied with the instrument are as described in Section 1.

Preparation for Operation

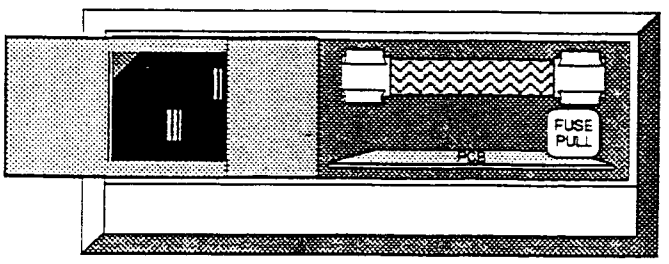
DANGER
THIS INSTRUMENT IS CAPABLE OF DELIVERING A LETHAL ELECTRIC SHOCK. THE I+, I-, Hi AND Lo TERMINALS ARE MARKED WITH ↯ SYMBOL TO WARN USERS OF THIS DANGER.

UNDER NO CIRCUMSTANCES SHOULD USERS TOUCH ANY OF THE FRONT TERMINALS UNLESS THEY ARE FIRST SATISFIED THAT NO DANGEROUS VOLTAGE IS PRESENT.

Power Input

The recess POWER INPUT plug, POWER FUSE and LINE VOLTAGE SELECTOR are contained in an integral filtered module at the center of the rear panel.

The protective window allows the fuse rating and line voltage selection to be inspected with the power socket connected. This window slides to the left once the socket has been disconnected, for access to the fuse and voltage selector printed circuit board.



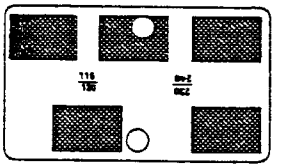
Power Cable

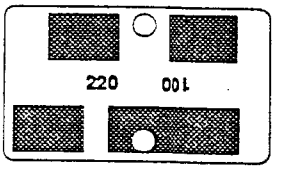
The detachable supply cable, comprising two meters of 3-core PVC sheath cable permanently moulded to a fully-shrouded 3-pin socket, fits in the POWER INPUT plug recess, and should be pushed firmly home.

The supply lead should be connected to a grounded outlet ensuring that the ground lead is connected. Connect Black lead to Line, White lead to Neutral and Green lead to Ground. (European: Brown lead to Line, Blue lead to Neutral, and Green/Yellow lead to Ground).

Line Voltage

The 4708 is operative within the line voltage ranges 100/115/120/220/230/240V ±10%, 50 or 60Hz. To accommodate the ranges, a small PC selector board is housed beneath the POWER FUSE.





Operating Voltage Selection

FIRST ensure the POWER CABLE is removed. Slide the window to the left to reveal the fuse and PC selector board.
Draw the fuse-extractor to the left and remove the fuse.
Remove the PC selector board and rotate until the desired voltage is on the left of the upper surface.
Reinsert the selector board firmly into the module slot.
The desired voltage is visible in the cutout below the fuse.
Return the fuse extractor to the normal position.
Insert the appropriate POWER FUSE (see below).
Slide the window to the right and insert the POWER CABLE.

Power Fuse

The fuse rating is:

3.15A for 220/240V line supply
6.25A for 100/120V line supply

It is located behind the window in the POWER INPUT module on the rear panel, and should be of the anti-surge or SLO BLO type.

WARNING
MAKE SURE THAT ONLY FUSES WITH THE REQUIRED RATED CURRENT AND OF THE SPECIFIED TYPE ARE USED FOR REPLACEMENT. THE USE OF MENDED FUSES AND

THE SHORT CIRCUITING OF FUSE-HOLDERS SHALL BE AVOIDED, AND RENDERS THE WARRANTY VOID.

Bench Mounting

The instrument is fitted with six plastic feet. It is intended to stand flat on a bench, positioned so that the cooling-air inlet and exhaust apertures are not obstructed. It is recommended that at least 30cm (12 inches) of free space is at the rear.

Rack Mounting

Option 90 permits the instrument to be mounted in a standard 19 inch cabinet.

To fit Option 90

CAUTION

Note that the 4708 is designed to be supported at front and rear. AT NO TIME should the 4708 be supported only by the front brackets. On no account should the upper and lower covers be removed.

Remove the two rear spacers from the case sides by releasing six screws. Fit the two rack-mounting slides to the rear of the case sides and secure using six of the shorter screws in the option kit.

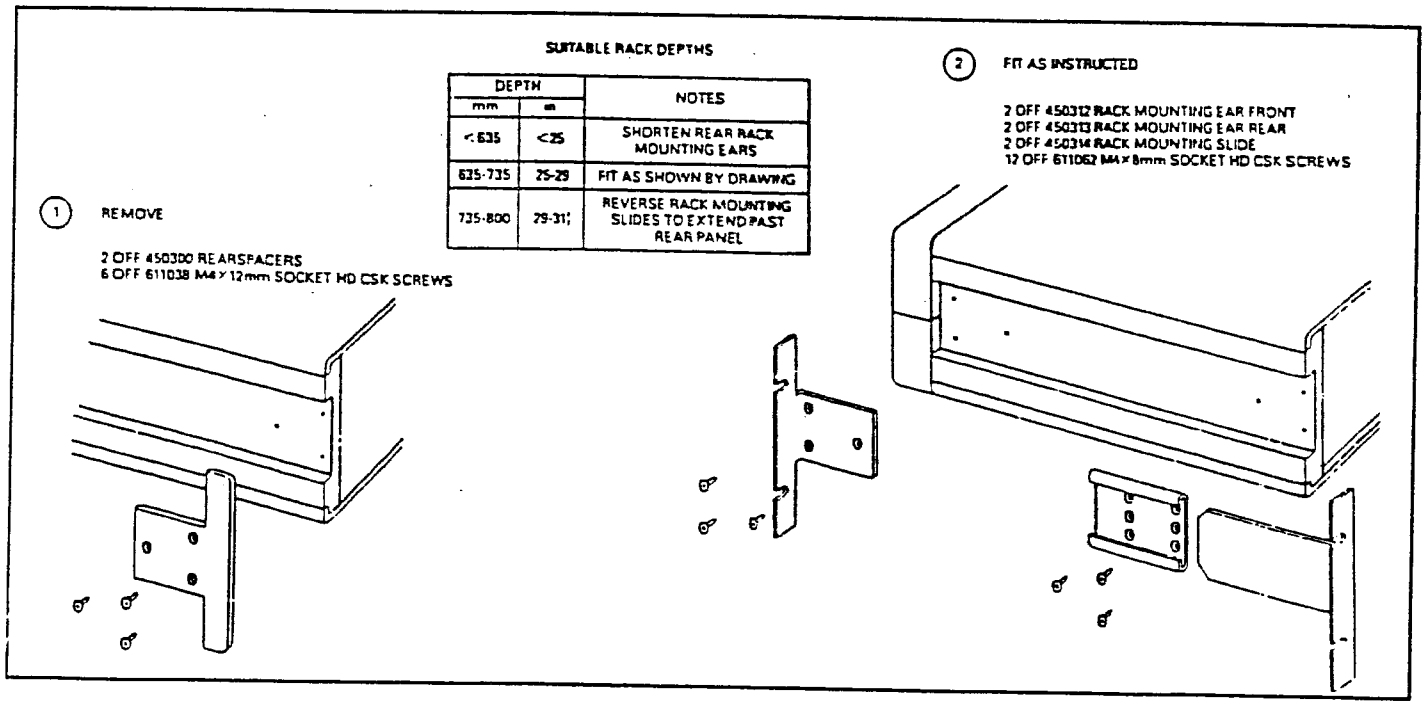
N.B. The slides may be reversed to give rearward extension.

Fit the two rear rack-mounting ears to the rear of the cabinet, with tongues facing forward. In shallow cabinets it may be necessary to trim the tongue.

CAUTION

Assistance is required to fit the 4708 into the cabinet.

Lift the 4708 into position in the cabinet, locate the tongues in the slides, and carefully slide backwards until the front ears butt up against the cabinet front. Secure the front ears to the cabinet. Also clear ventilation for fan cooling to operate properly.

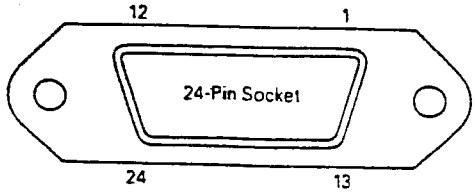


Connectors and Pin Designations

IEEE 488 Input/Output Socket J27

The IEEE input/output is a 24-way connector that is directly compatible with the IEEE 488 interface and the IEC 625 Bus.

Pin Layout



Pin Designations

J27 Pin No	Name	Description
1	DIO 1	Data Input Output Line 1
2	DIO 2	Data Input Output Line 2
3	DIO 3	Data Input Output Line 3
4	DIO 4	Data Input Output Line 4
5	EOI	End or Identify
6	DAV	Data Valid
7	NRFD	Not ready for Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Screening on cable (connected to 4708 Safety Ground)
13	DIO 5	Data Input Output Line 5
14	DIO 6	Data Input Output Line 6
15	DIO 7	Data Input Output Line 7
16	DIO 8	Data Input Output Line 8
17	REN	Remote Enable
18	GND 6	Gnd wire of twisted pair with DAV
19	GND 7	Gnd wire of twisted pair with NRFD
20	GND 8	Gnd wire of twisted pair with NDAC
21	GND 9	Gnd wire of twisted pair with IFC
22	GND 10	Gnd wire of twisted pair with SRQ
23	GND 11	Gnd wire of twisted pair with ATN
24	GND	4708 Logic Ground (Internally connected to 4708 Safety Ground)

Rear Output Terminals (Option 42)

The 4708 is fitted with either six front panel output terminals or six rear output terminals. The Rear Output alternative is fitted at the customer's request only at manufacture.

The 4708 cannot be fitted with both front and rear output terminals.

The functions of the six terminals are identical to those normally fitted on the front panel, and the external leads are connected in the same way. (See Section 4 for details).

External Reference Frequency Input Socket J53.

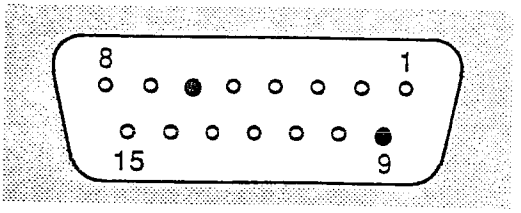
This BNC socket is located next to the cooling air intake filter. It enables the frequency synthesizer to be locked to a customer's own frequency standard provided that it meets the following criteria:

Voltage:	500mV to 15V peak-to-peak
Frequency:	1MHz ± 1% or 10MHz ± 1%

N.B. The socket has an input resistance of approximately 50Ω

External Reset Socket & 4600 Digital Connector J54

Pin Layout

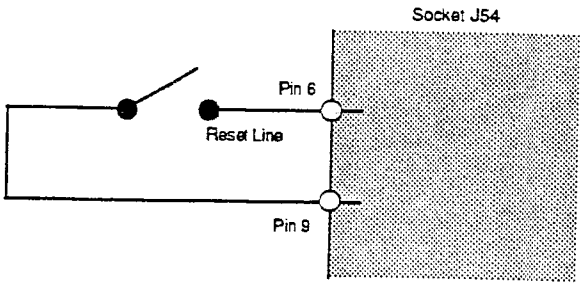


Pin Designation

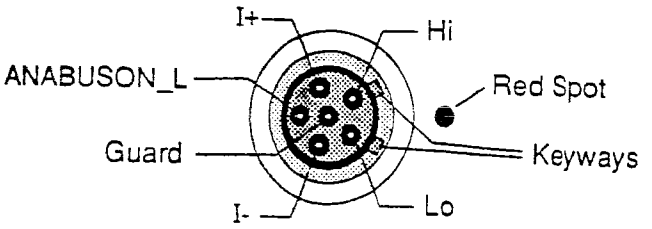
Pin	Name	Function
1	SHIELD	Case Ground
2	0V_6	Digital Common
3	IWR_R	Write Strobe (Rising Edge)
4	0V_6	Digital Common
5	0V_6	Digital Common
6	ICAL_RST_L	Not used on 4600
7	IA_H_D_L	Address/Data on AD0-AD4
8	IRD_L	Read Strobe (Active Low)
9	IDIGBUSON_H	+5V (5k) when 4708 is on.
10	0V_6	Digital Common
11	IAD0	Bi-directional Address/Data Lines, controlled by Strobes and IA_H_D_L
12	IAD1	
13	IAD2	
14	IAD3	
15	IAD4	

External Reset Switch Wiring

This D-type socket located next to the optional rear output connectors may be used to input an external reset to restore the 4708 to its power-up state (DCV, 1V Range).



4600 Analog Connect or J56 Pin Layout and Designations



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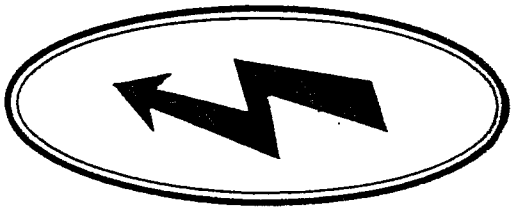

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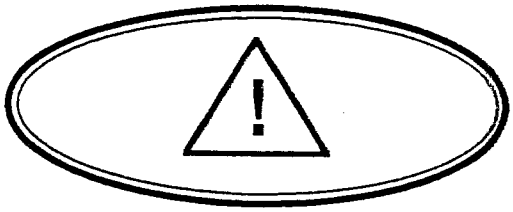

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Unless **you** are **sure** that it is **safe** to do so,

DO NOT TOUCH

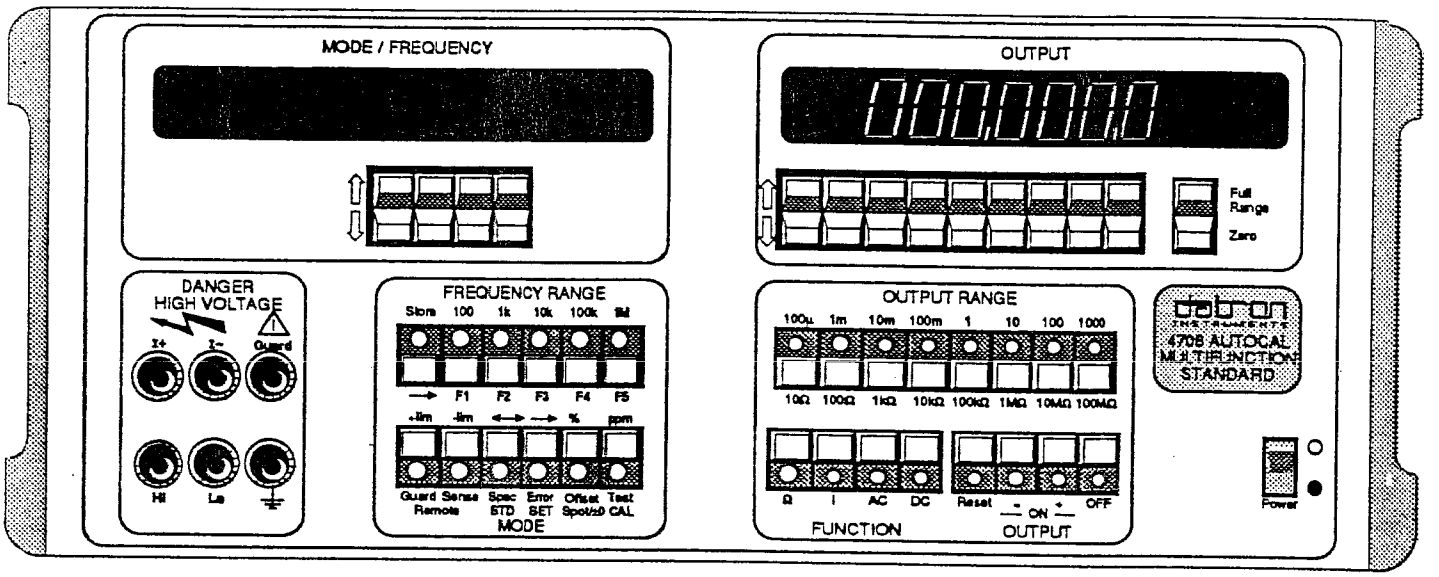
the **I+ I- Hi** or **Lo leads** and **terminals**

DANGER

SECTION 3 OPERATING CONTROLS

This section summarizes the main operating features of the 4708. For detailed operating procedures refer to Section 4.

Front Panel



Power-up State

The controls are outlined in blocks, left and right, associated with the appropriate display. The right-hand blocks generally deal with function and output definition, whereas the left-hand blocks are concerned with frequency, mode and terminal configurations.

Front Panel Keys

All user commands from front panel keys are executed through main program firmware. A Key LED lit signifies that conditions are valid for the selected operation, and not merely that the key has made contact.

At any time, the instrument status is described by the combination of LED states, display values and display messages.

Generally, if an invalid condition is selected, an error message will be displayed and a buzzer will sound, the command is ignored and the 4708 remains in its previous state.

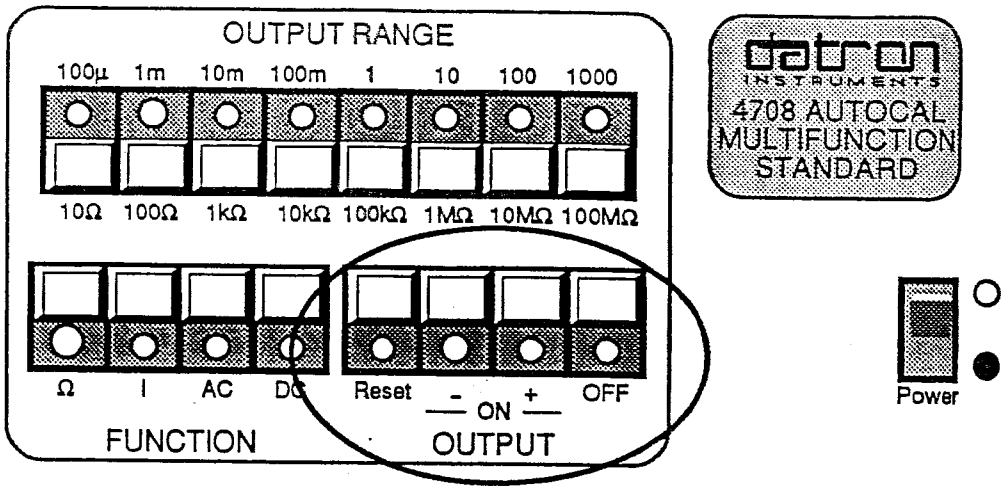
Power Switch

WARNING
THE POWER SWITCH SHOULD NOT BE SET TO ON UNTIL THE LINE VOLTAGE AND POWER FUSE RATING HAVE BEEN SELECTED AS DETAILED IN SECTION 2 (INSTALLATION)

When set to the ○ **OFF** position, the 2-pole Power switch isolates the instrument from the supply.

When switched to ● **ON**, the instrument powers up, runs a self-test program and is configured into the following state:

OUTPUT	OFF
FUNCTION	DC
OUTPUT RANGE	1
OUTPUT DISPLAY	.000,000,V
FREQUENCY RANGE	Not selected
MODE/FREQUENCY DISPLAY	Blank
MODE	Not selected
Guard	Local connection (unlit)
Sense	Local connection (unlit)
Key LEDs Lit	OUTPUT OFF, DC, 1



OUTPUT ON/OFF

The 4708 should normally be connected and set up with its **output off.** This isolates the **I+, I-, Hi** and **Lo** terminals from their internal circuitry regardless of **RANGE, FUNCTION, FREQUENCY** or **MODE** selections. The **OUTPUT OFF** LED is lit.

Pressing the **OUTPUT ON** key connects the **I+, I-, Hi** and **Lo** terminals to their energized internal circuits.

OUTPUT OFF Default

Certain instrument states are prohibited, and some transfers between states are restricted by program firmware. For safety reasons some of these transfers result in the output being switched off. Refer to Section 4, Operating Routines.

OUTPUT ON - +

On DC Voltage or Current, the polarity at the Output terminals is determined by the Key used to switch the output on, as labelled. In addition, polarity may be reversed by using the ↑ ↓ keys to step the output across zero value. The **ON** LEDs describe the polarity **AT THE OUTPUT TERMINALS,** not on the **OUTPUT** display. (In "error" and "offset" modes these two could be opposite).

In AC Voltage, AC Current and Resistance functions, the **ON +** key will cause the selected outputs to appear at the output terminals. The **ON -** key will cause the error buzzer to sound and **Error 8** to appear in the **MODE/FREQUENCY** display.

OUTPUT OFF Trip - Fail 5 Message

Under certain abnormal conditions which might compromise safety, the 4708 output will trip off, accompanied by a **FAIL 5** message on the **MODE** display. Control is removed from the front panel keys.

If the **FAIL 5** message is present, there is no automatic recovery from the tripped state whether internal conditions have or have not returned to normal.

Reset Key

The **Reset Key** has two functions:

1. It allows the user to reset the safety trip to test whether conditions have returned to normal. If they have; the **FAIL** message will disappear, the previous instrument state will be restored but with **OUTPUT OFF**, and front panel control will be returned to the user. If conditions are still abnormal the **FAIL** state will persist, and a further attempt may be made after a suitable interval. The **Reset** LED is inoperative except in **'TEST'** mode.

2. It returns the instrument to power-up conditions in all cases except the following:
   - Self-test mode
   - FAIL conditions
   - In remote control mode (where it is inoperative).

Other Messages

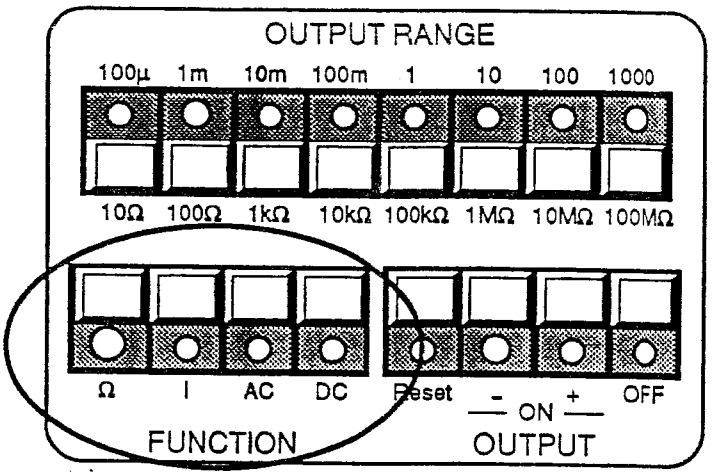
A full list of 4708 messages appears in Section 4. The fault conditions which generate Fail messages are analyzed in the Calibration and Servicing Handbook.

FUNCTION Keys

When changing from one function to another the output is automatically set to OFF. When changing from Ω, to AC or DC, the OUTPUT value is automatically set to zero. If the corresponding OUTPUT RANGE or value is not available on the new function, the 4708 displays Error 8 and sounds its error buzzer.

Ω selection forces the 4708 into Remote Sense for 4-wire operation.

Selected Function	Specified Output	
DC	DC Voltage	or Error 9 and buzzer if any of the Options are not fitted
AC	AC Voltage	
Ω	Resistance	
DC and I	DC Current	
AC and I	AC Current	

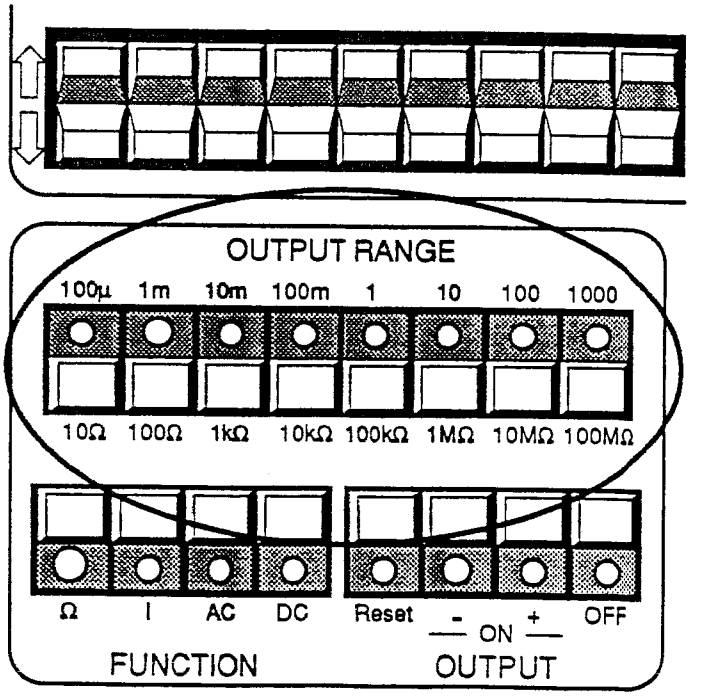


OUTPUT RANGE Keys

Each **OUTPUT RANGE** key scales the output as selected by the user, setting the legend and decimal point on the **OUTPUT** display to match. Full range values for voltage and current are marked above the keys. Nominal values of each precision resistor for the Ω function are marked below the keys.
Voltage and current ranges are selectable as follows, the actual output value being selected by use of the **OUTPUT** display ↑↓ keys.

DC Voltage	:	100µV to 1000V
AC Voltage	:	1mV to 1000V RMS
DC Current	:	100µA to 1A
AC Current	:	100µA to 1A RMS
Resistance	:	10Ω to 100MΩ

If OUTPUT is ON when changing ranges, it remains on unless the change is to 1000V range, or ranging up to more than 75V RMS in AC or 110V in DC on 100V range. In these cases OUTPUT defaults to OFF. Any range selection which would exceed the internally defined voltage-frequency limit is automatically inhibited. These limits are described on page 3-7.

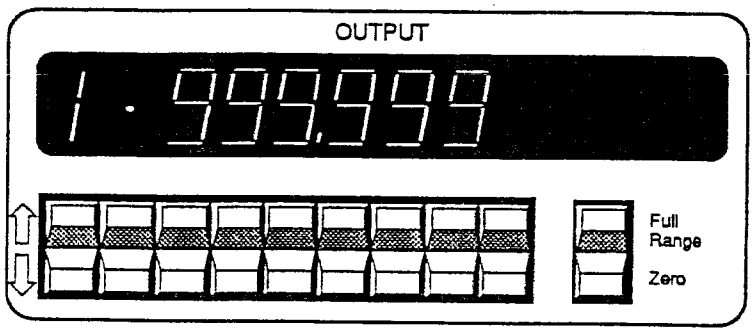


Key Selections	100µ 10	1m 100	10m 1k	100m 10k	1 100k	10 1M	100 10M	1000 100M
DC Voltage	100µA	1mV	10mV	100mV	1V	10V	100V	1000V
AC Voltage	*	1mV	10mV	100mV	1V	10V	100V	1000V
DC Current	100µA	1mA	10mA	100mA	1A	10A[1]	*	*
AC Current	100µA	1mA	10mA	100mA	1A	10A[1]	*	*
Resistance	10Ω	100Ω	1kΩ	10kΩ	100kΩ	1MΩ	10MΩ	100MΩ

*Error 8 [1] Error 8 if 4600 not connected in slave mode configuration

OUTPUT Display and ↑ ↓ Keys

Output Resolution



The Output and display are resolved as follows:

Range	100µ 10	1m 100	10m 1k	100m 10k	1 100k	10 1M	100 10M	1000 100M
DCV	4.5	5.5	6.5	7.5	7.5	7.5	7.5	7.5
ACV	-	4.5	5.5	6.5	6.5	6.5	6.5	6.5
DCI	6.5	6.5	6.5	6.5	6.5	6.5	-	-
ACI	6.5	6.5	6.5	6.5	6.5	6.5	-	-
Ω (2-wire)	4.5	5.5	6.5	7.5	7.5	7.5	7.5	7.5
Ω (4-wire)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5

The **OUTPUT** display is supplemented by legends, which always indicate the correct units for the Range and Function selected

Output and Display Control

Each vertical pair of ↑ ↓ keys is assigned to the display digit above it. Thus the value registered on the display may be set within the range permitted by the function selected. Each momentary press of the ↑ key adds 1 to its digit: pressing the ↓ key subtracts 1. If **OUTPUT** is **ON**, the Output terminal value is also changed by the same increments as the display (subject to the instrument interlocks).

On Ω ranges, only the overrange (leftmost pair of) ↑ ↓ keys are operative. These duplicate the action of the **Full Range/Zero** Keys.

The Resistance value displayed is the calibrated value of the standard internal resistor selected (not the nominal value). This may be updated during periodic calibration. The value displayed depends on the selection of **Local** (2-wire) or **Remote** (4-wire) **Sense**, and should be recalibrated in the correct Sense mode (See Section 8).

Auto-Increment/Decrement

When a ↑↓ key is pressed for more than 1/2 second, its digit is increased or decreased at a rate of approximately 3 digits per second until the key is released.

Overflow and Underflow

As a digit is stepped from 9 to 0, the value of the next higher-order digit is increased by 1. Stepping from 0 to 9 decreases the value by 1. The whole display therefore acts as a counter, with full 'carry' and 'borrow' action.

Range of Adjustment for DC Functions

The ↑↓ keys adjust the readings between a minimum of 00000000 and 19999999 full scale on 100mV - 100V and between 0000000 and 1999999 for Current Ranges. The 1000V Range has a Full Scale of 1100.0000; on the 100µV, 1mV and 10mV ranges the resolution is truncated.

Range of Adjustment for AC Functions

The ↑↓ keys adjust the reading between a minimum of 0090000 (9% of Nominal Range), and maximum of 1999999 full scale on 100mV - 100V and Current Ranges. The 1000V Range has a Full Scale of 1100.000; on the 1mV and 10mV ranges the resolution is truncated.

N.B. There is no range of adjustment on Resistance functions.

Leading Zeroes

For fractional readings, a leading zero is presented to the left of the decimal point to emphasise its position, except for **OUTPUT RANGE** selections 1m and 1.

DC ZERO and polarity. On DC voltage and current, a polarity sign is present except at zero. The numerical display represents the magnitude of the output.

As the display value is stepped to zero, the polarity sign disappears, and the opposite sign appears as stepping continues in the same direction. If the **OUTPUT** is **ON** during the sequence, the change in output polarity is signalled by a change-over from one polarity **ON** LED to the other.

N.B. If the 4708 is in **Offset** Mode, with an offset present, the display and output zeroes do not coincide. It is therefore possible to have a **positive** sign on the display, and the **ON** - LED lit; and vice-versa.

When using the ↑↓ keys or **Zero** key to obtain a zero, the polarity is not changed over and the same **OUTPUT ON** LED remains lit. The polarity LEDs change over only when the opposite polarity appears at the output terminals.

Full Range Key

When the **Full Range** key is pressed, the display reverts to the nominal value of the range selected. If **OUTPUT** is already **ON**, the terminal value follows the display value unless:

1. The combination of output voltage and frequency would exceed the instrument's internally defined limits. (Refer to Section 6).

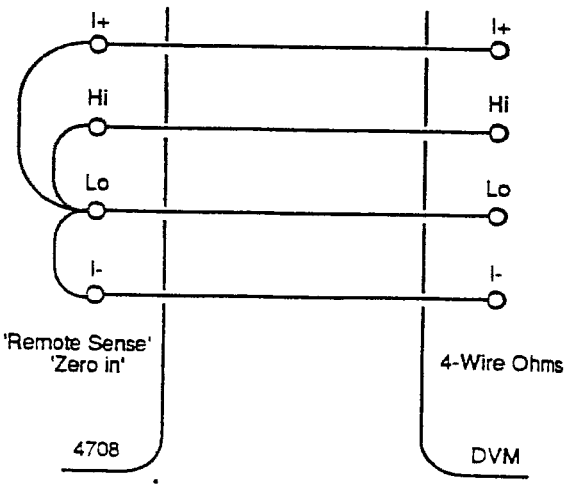
2. **OFFSET or ERROR** Mode is selected: the user-input offset or gain error is not cancelled from the output.

Zero Key

This reduces the display value to zero. If **OUTPUT** is **ON**, the terminal value is also set to zero:

DC Voltage — an active zero is presented to the output terminals.
AC Voltage — an internal short circuit is connected across the output terminals.
DC and AC Current — output terminals are open-circuited.

On Ω ranges in **Remote Sense** with **OUTPUT ON**, the **Zero** key connects a true 4-wire internal short circuit to the **OUTPUT** terminals as shown below. With **Remote Sense** LED UNLIT, the same short is connected, but the actual resistive value of this short may be calibrated (See Section 8 and diagram below).



True 4 - Wire Ohms Zero

Deselection of Zero in AC Functions

The size of the characters on the 'Zero' display is significant. A half-size '0' above any ↑ ↓ key indicates that it cannot be used to deselect Zero, because it increments values which are less than 10% of nominal range. Any ↑ key with a full size '0' above it (and any key to its left) deselects Zero and adds its increment.

Selection of High Voltage Outputs

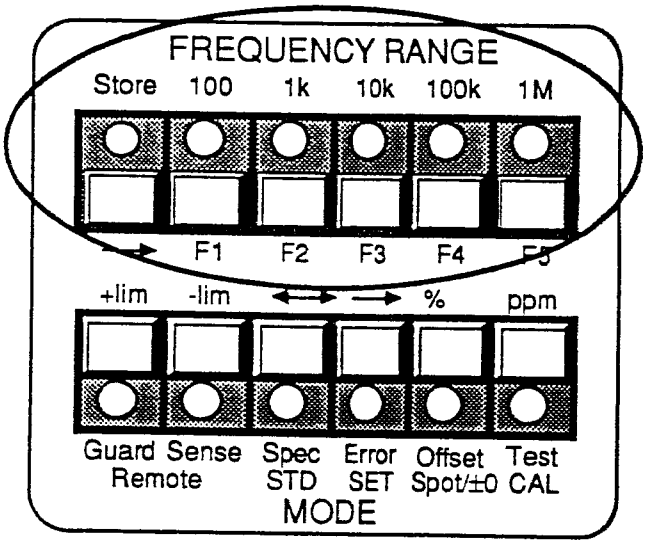
The 4708 is capable of delivering LETHAL output voltages so program interlocks are used to ensure that users do not inadvertently select outputs in excess of 110V in DC or 75V RMS in AC. Details of the High Voltage selection procedure are given in Section 4.

Frequency

The AC voltage output of the 4708 extends from 10Hz to 1MHz in five overlapping decade ranges, at a resolution of 1% of nominal Frequency Range. Any five frequency values within the range of the instrument can be stored in volatile memory.

FREQUENCY RANGE keys

Decade Ranging

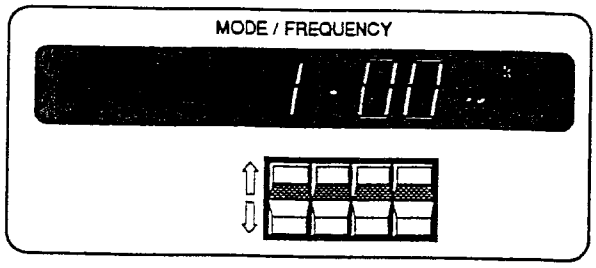


Generally, selection of a new range changes the frequency by a whole number of decades; but ranging-up from a frequency between 10Hz and 30Hz, or ranging-up to the 1MHz range when the decade frequency would have been higher, causes **Error 7** to be displayed and buzzer to sound.

Selection of Nominal Range Value

Once a Frequency Range has been selected, the frequency can be set to the nominal value of the range by re-pressing its key.

FREQUENCY DISPLAY



Resolution

The output frequency is adjustable in steps of 1% of the selected FREQUENCY RANGE nominal value, matching the display resolution. Legends are appended on the display as appropriate, and a leading zero is presented to the left of the decimal point for fractional values.

FREQUENCY ↑ ↓ Control Keys

Each vertical pair of ↑ ↓ keys is assigned to the display digit above it. The frequency registered on the display is adjusted by manipulation of these keys. Each momentary press of the ↑ key adds 1 to its digit, and each ↓ key subtracts 1. If **OUTPUT** is **ON**, the output frequency is also changed by the same increments as the display (subject to the instrument interlocks). Keys below decimal points are inactive.

Auto-Increment/Decrement

When a ↑ ↓ key is pressed for more than 1/2 second its digit is increased or decreased at a rate of approximately 3 digits per second until the key is released.

Overflow and Underflow

As a digit is stepped from 9 to 0, the value of the next higher-order digit is increased by 1. Stepping from 0 to 9 decreases the value by 1. The whole display therefore acts as a counter, with full 'carry' and 'borrow' action.

Autoranging

Stepping the frequency beyond the span of a range automatically switches range up or down, but further steps are inhibited until the ↑ or ↓ key is released (the key could be below a decimal point). When the range-change occurs, the alarm buzzer sounds and the FREQUENCY display is blanked for approx. 1 second.

When the display is reinstated, the 4708 has remembered the last frequency on the old range, and sets the new range to its next increment frequency in the original direction. After releasing the original key, stepping can be continued to any increments of the new range.

Autorange Limits

The 4708 displays an Error 7 and sounds its buzzer when any attempted frequency increment or decrement is made which would produce an invalid combination of **FUNCTION, OUTPUT RANGE** or **FREQUENCY**. Neither will it increment or decrement to a frequency beyond the limits of the next frequency range up or down.

OUTPUT/FREQUENCY CONSTRAINTS

AC Voltage and Frequency

Under most conditions, the output amplitude and frequency are adjustable throughout their full scales:

Voltages — from 90μV to 1100V RMS
Frequencies — from 10Hz to 1MHz

On the 100V and 1000V Ranges, certain combinations of voltage and frequency cannot be selected.
The diagram below illustrates the boundaries.

The 10V Range span is also shown for comparison.

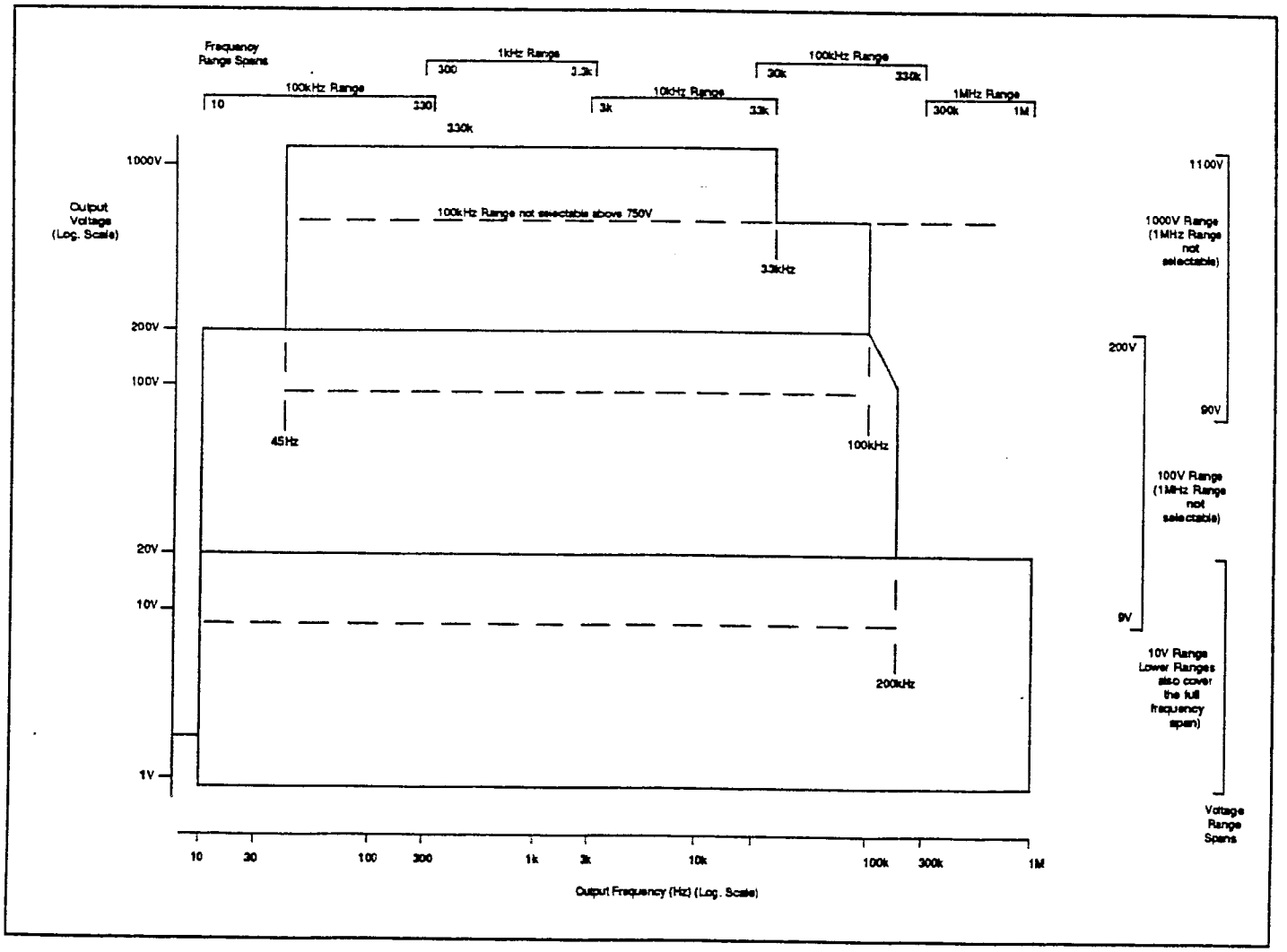
The 4708 refuses to select any Voltage/Frequency combination outside these constraints. The temporary message Error 7 is displayed for approximately 1 second before reverting to the original display.

AC Current and Frequency

AC Current is adjustable between 9μA and 2A RMS at frequencies from 10Hz to 5kHz. Currents from 2A to 11A are available (10Hz - 20kHz). Error 7 indicates an invalid Current/Frequency selection.

FREQUENCY MEMORY

This facility allows storage of up to five user-selected frequencies. Once stored, each can easily be retrieved or changed from the front panel. They are retained until power is removed from the instrument or **reset** key is depressed.



Store Key

Only five of the **FREQUENCY RANGE** keys select ranges. The first press of the sixth key, **Store**, reassigns the other five as frequency memories. It has toggle action: a second press deselects the memory function.

F1-F5 Memory keys

When the **Store** LED is ON, these keys select individual memory locations.

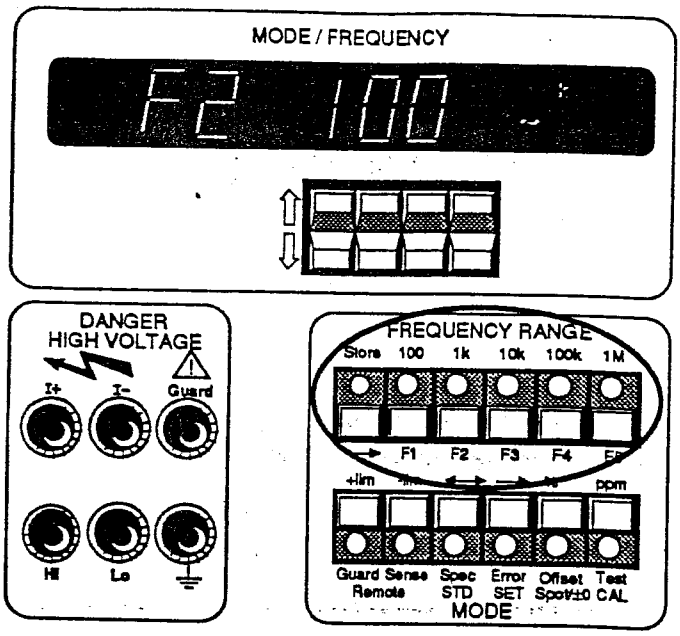
N.B. Although the **FREQUENCY RANGE** keys double as memory selectors, this does not imply that a particular memory can only accept frequencies from its key's range. It is emphasized that any displayable frequency can be stored in any of the five locations.

Power-up Default

Because the stores are volatile, the following default frequencies are stored in the five memory locations each time the 4708 is powered-up:

F1	30Hz
F2	300Hz
F3	3kHz
F4	30kHz
F5	300kHz

Details of storage and retrieval procedures are described in Section 4.



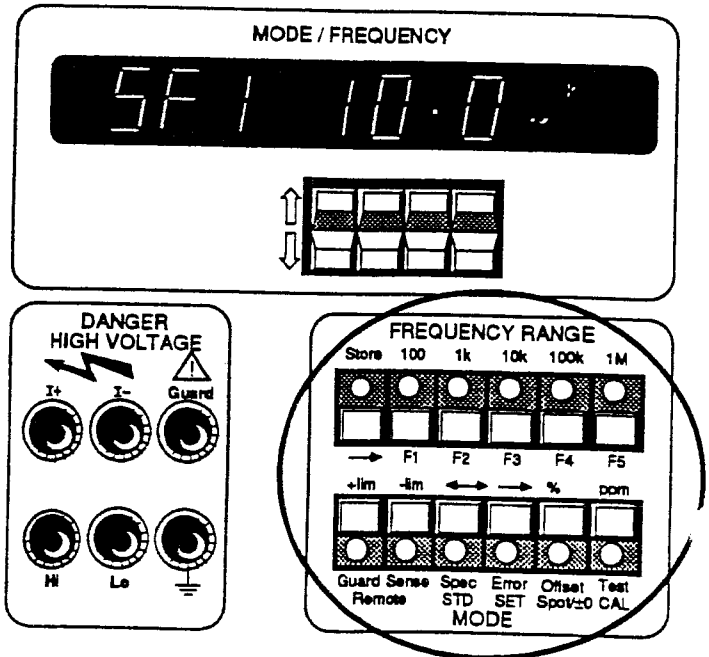
SPOT F FREQUENCY MEMORY

When in Calibration Mode, five user-selected 'Spot' calibrated frequencies can be stored in non-volatile calibration memory, for each of the seven Output Ranges. At these frequencies the 4708 output can be specially Auto-calibrated. Each spot calibrated frequency can then be subsequently recalled when in Run Mode by two key depressions.

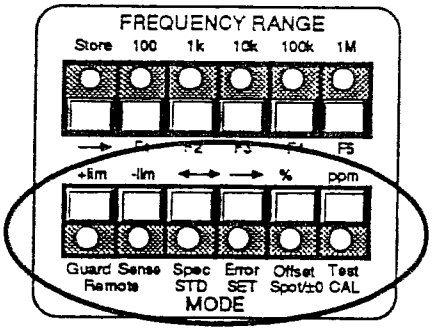
Spot Key

This is used to reassign the F1-F5 memory keys so that they access the non-volatile memory.

'Recall' procedures are detailed in Section 4.
'Store' procedures are detailed in Section 8.



MODE Selection keys

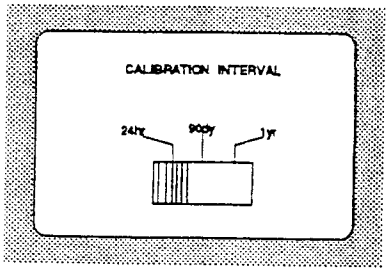


The **MODE** selection keys are located on the lower left of the front panel. The Remote Guard and Remote Sense keys are described under **'I+, I-, Hi, Lo, Guard and ⏚'**.

STD, SET, ±0 and **CAL** are calibration modes, printed in red and described in Section 8.

SPEC MODE

The **Spec** key controls the toggle-action 'Specification' function. By pressing the key, the 4708 specification tolerances are displayed on the **MODE** display, referred to its current **FUNCTION, OUTPUT, FREQUENCY** and **CALIBRATION INTERVAL** selection. A second press cancels the function. For **24-hour** calibration intervals, the 'accuracy relative to calibration standards' figures are displayed but for **90 days** and **1 year** intervals they are 'Traceable' accuracy figures which include Datron's Calibration Uncertainty.



Rear Panel CALIBRATION INTERVAL switch

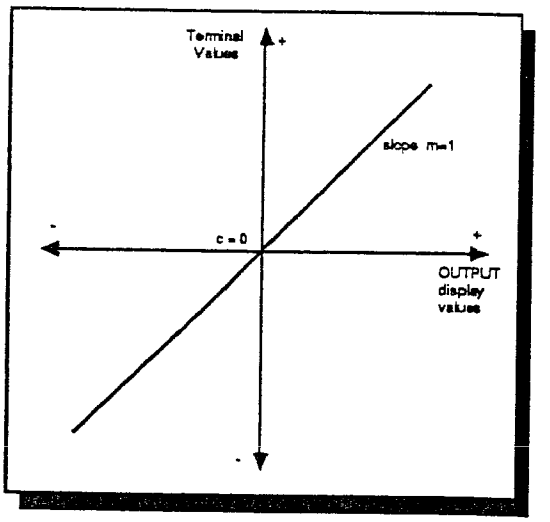
While in **Spec** mode, all primary functions of the other **MODE** keys are cancelled (although the selected Guard and Sense connections remain). The keys are reassigned to their secondary functions: **+lim, -lim, %** and **ppm** become active. When Spec mode is intiated, the magnitude of the specification tolerance itself determines whether ppm or % is selected. The double-ended arrow above the **Spec** key shows that all four secondary modes are available.

Full details of the operation of Specification mode are given in Section 4.

ERROR AND OFFSET MODES

These keys are used to deviate the output at the terminals from the value on the **OUTPUT** display. The two modes may be selected together.

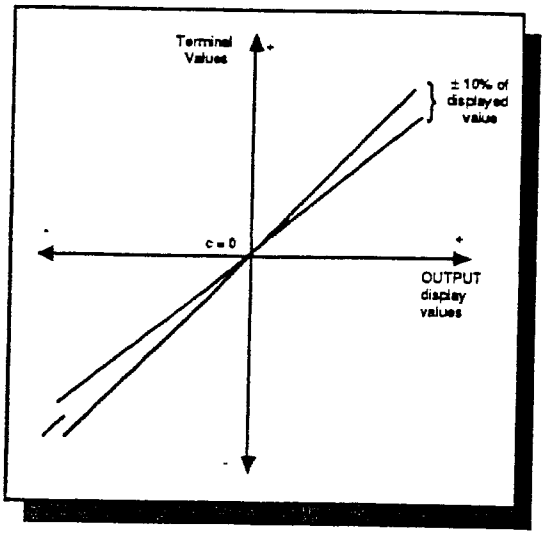
Error and Offset Modes NOT Selected



The terminal value is a linear function of the **OUTPUT DISPLAY** value:

Error mode selected

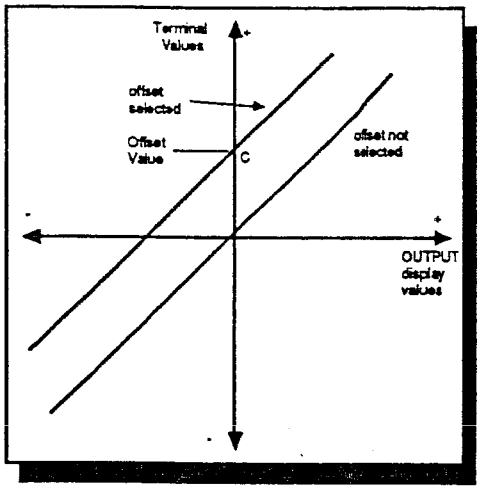
This mode allows a gain error deviation of up to ±10% of displayed value to be applied to the terminals. Full details are given in Section 4.



Offset mode selected (DC Functions only)

In Offset mode, the intercept (c) may be adjusted to any value within the Offset limit.

Offset Limits: 100µV and 1mV Ranges: ±200µV
Other Ranges: ±2% of Full Range value

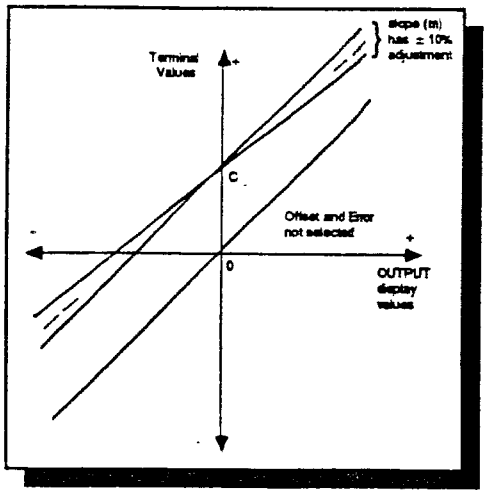


Offset and Error Mode Combination

Offset cannot be selected or deselected when the 4708 is already in Error Mode.

The intercept (c) is established first in Offset mode, then the slope (m) is adjusted in Error mode.

Full details of the operation of Error, Offset and the combined mode are given in Section 4.

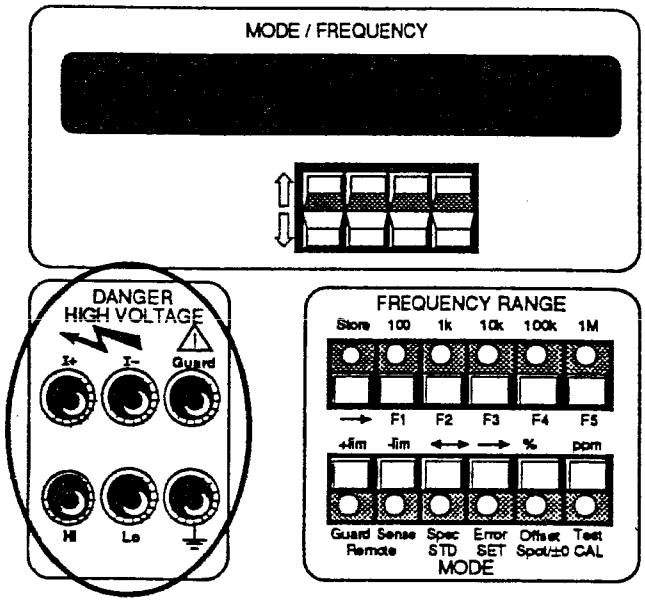


Test mode selected.

Full details of the operations in Test mode are given in Section 4.

I+, I-, Hi, Lo, Guard and ⏚ (Ground) Terminals

Local and Remote Switching



These terminals are located on the lower left of the Front Panel.

I+ and I- Terminals

The output from the internal power circuits is delivered to the I+ terminal, I- being its Return Analog Common.

Hi and Lo Terminals

These terminals provide a differential input to the amplitude sensing circuitry.

Remote Sensing

The **Remote Sense** key has 'toggle' action.
Successive presses alternate between **ON** and **OFF**.

N.B. **Sense Connections can only be switched with OUTPUT OFF.**

The specified voltage output of the 4708 may be produced either at its output terminals (Local Sense for high impedance loads) or at the load terminals (Remote Sense for cases in which lead resistance and load impedance produce a significant effect).

With remote Sense OFF, the I+ terminal is isolated, and the voltage output is fed to the **Hi** terminal.

With **Remote Sense ON**, the output voltage is fed across the **I+** and **I-** terminals only, and must be sensed externally, using leads connected to the **Hi** and **Lo** terminals.

Remote Sense is not available on 100μV - 100mV ranges. It is not applicable to Current outputs.

On **Ohms** ranges, **Local Sense** is used for 2-wire connections, and **Remote Sense** for 4-wire. (Changing **FUNCTION** into Ω forces the 4708 into **Remote Sense**, but this may be deselected for 2-wire operation). The **Remote Sense** LED always indicates the true connection:

Lit = Remote;
Unlit = Local

Guard Terminal

The Guard terminal is permanently connected to the internal guard shields:

Remote Guard

The Remote Guard key has 'toggle' action.
Successive presses alternate between **ON** and **OFF**.

With **Remote Guard OFF**, Guard is internally connected to the **I- terminal**.

With Remote Guard ON, the internal link to **I-** is removed. The Guard terminal can then be connected externally to reduce common mode interference.

Ground Terminal

The ⏚ Ground terminal connects directly to the 4708 internal Ground shields and to Safety Ground via the power cable.

Output Connections

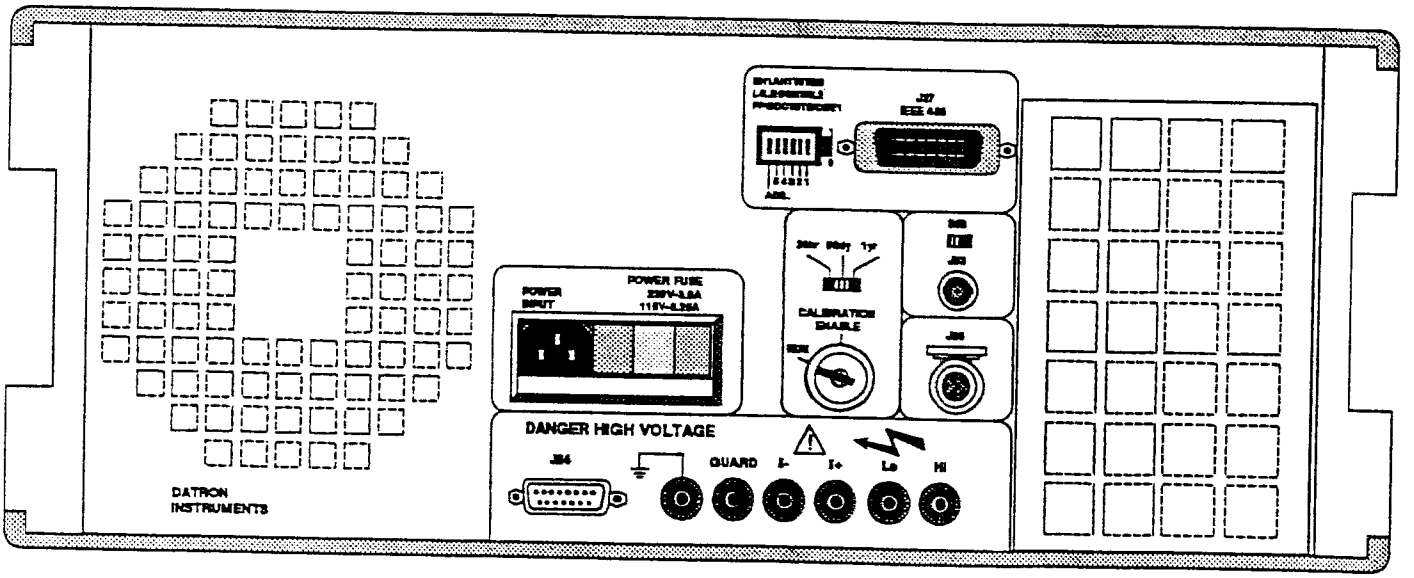
Connections to the output terminals may be made either with leads or via a shrouded connector.

For Voltage outputs in local sense the two leads should be attached to the Hi and Lo terminals.

Various configurations of 4708 load connections are detailed in Section 4.

REAR PANEL

(Shown with alternative Rear Output terminals)



POWER INPUT

The recessed **POWER INPUT** plug, **POWER FUSE** and **LINE VOLTAGE SELECTOR** are located in the center of the rear panel, contained within a single moulded unit. Details of connections, selection of line voltage and fuse are given in Section 2.

REAR OUTPUT ALTERNATIVE (Option 42)

This can be incorporated at manufacture, to provide six output terminals on the rear panel instead of the six on the front. Their functions and connections are identical.

SOCKET J53 (External Reference Frequency Input)

This BNC socket is located next to the cooling air intake filter. It may be used to lock the internal frequency synthesizer to a customer's own frequency standard. Voltage and frequency criteria are given in Section 2. An on-off switch, S53, located above this socket is provided to enable this facility. If the switch is on and an external frequency is not present, error message **'Error EF'** is displayed.

SOCKET J54 (External Reset & 4600 Digital Connector)

This D-type socket is located next to the optional rear output connectors and provides digital control signals between the 4708 and a 4600 Transconductance Amplifier. It may also be used to input an external reset to restore the 4708 to its power-up state of DCV, 1V Range etc., if required. Pin Layout, Pin Designation and Switch Wiring details are given in Section 2.

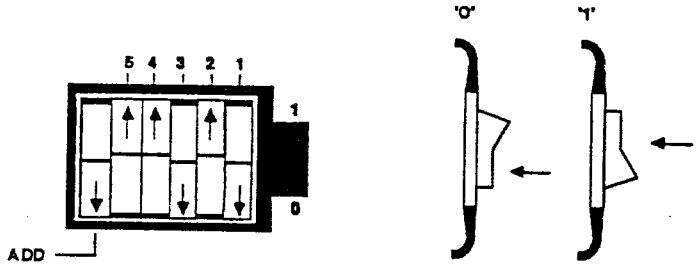
This connector is specifically designed to accept the digital control cable supplied as part of the 4600 slave lead kit (Part number 440151)

SOCKET J27 (IEEE 488 Input/Output)

The IEEE 488 Input/Output (D-type) socket J27 is a 24-way micro-ribbon connector that is directly compatible with the IEEE 488 interface and the IEC-defined system.

J27 is located at the top of the rear panel, outlined with the IEEE 488 address switch. The pin layout and designations appear in Sections 2 and 5.

IEEE 488 ADDRESS SWITCH



The 4708 may be addressed for use on the IEEE 488 interface bus. The address settings are given in Section 5.

SOCKET J56 (4600 Analog Connector)

Situated beneath J53, Socket J56 provides analog connections between the 4708 and a 4600 Transconductance Amplifier. This connector is specifically designed to accept the analog control cable supplied as part of the 4600 slave mode lead kit (Part number 440151).

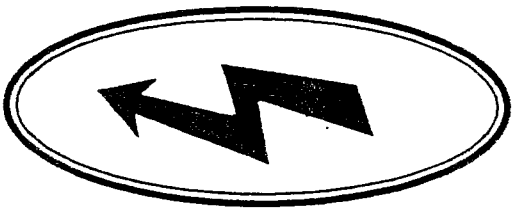
DANGER

HIGH VOLTAGE

THIS INSTRUMENT IS CAPABLE OF DELIVERING

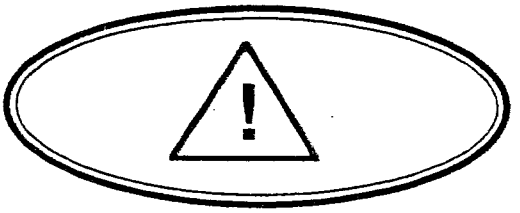
A LETHAL ELECTRIC SHOCK !

when connected to a high voltage source



FRONT or REAR terminals carry the Full Input Voltage

THIS CAN KILL !



Guard terminal is sensitive to over-voltage

It can damage your instrument !

Unless **you** are **sure** that it is **safe** to do so,

DO NOT TOUCH

the **I+ I- Hi** or **Lo leads** and **terminals**

DANGER

SECTION 4 USING THE DATRON 4708

Preliminaries

Before using the instrument it is important that it has been correctly installed as detailed in Section 2.

Limiting Characteristics

The following details are given in Section 6:

Function	Characteristics
All functions	Peak terminal voltages
DC Voltage	Output resistance and current limit
AC Voltage	Output resistance and current limit; capacitive loading limits
DC Current	Maximum load resistance and maximum compliance
AC Current	Maximum load resistance and maximum compliance
Resistance	Maximum currents and accuracy de-rating factors

SAFETY

The 4708 is designed to be Class 1 equipment as defined in IEC Publication 348 and UL 1244, concerning safety requirements.

Protection is provided by a direct connection via the power cable from ground to exposed metal parts and internal ground screens.

The line connection must only be inserted in a socket outlet provided with a protective ground contact, and continuity of the ground conductor must be assured between the socket and the instrument.

WARNING:
ANY INTERRUPTION OF THE PROTECTIVE GROUND CONDUCTOR INSIDE OR OUTSIDE THE INSTRUMENT, OR DISCONNECTION OF THE PROTECTIVE GROUND TERMINAL MAY MAKE THE APPARATUS DANGEROUS. INTENTIONAL INTERRUPTION IS PROHIBITED.

THE TERMINALS MARKED WITH THE ⚡ SYMBOL CARRY THE OUTPUT OF THE 4708. THESE TERMINALS AND ANY OTHER CONNECTIONS TO THE LOAD UNDER TEST COULD CARRY LETHAL VOLTAGES.

UNDER NO CIRCUMSTANCES SHOULD USERS TOUCH ANY OF THE FRONT (OR REAR) PANEL TERMINALS UNLESS THEY ARE FIRST SATISFIED THAT NO DANGEROUS VOLTAGE IS PRESENT.

CAUTION;

THE ⚠ SYMBOL IS USED TO REMIND THE USER OF SPECIAL PRECAUTIONS DETAILED IN THIS HANDBOOK AND IS PLACED ADJACENT TO TERMINALS THAT ARE SENSITIVE TO OVERVOLTAGE CONDITIONS.

REFER TO SECTION 6.

Interconnections

Importance of Correct Connections

The 4708 has been designed for use as an accurate source for precision calibration. To match the external circuitry to its superior specification, it is essential to take great care in making connections to the load.

Sources of Error

Thermal EMFs

These can give rise to series (normal) mode interference, particularly for low voltage outputs, and where large currents have a heating effect at thermo-electric junctions. Draughts can cause unbalanced cooling in an otherwise thermo-electrically balanced measuring circuit.

E-M Interference

Noisy or intense electric, magnetic and electromagnetic effects in the vicinity can disturb the measurement circuit.

Some typical sources are:

- Proximity of large electric fields
- Fluorescent lighting
- Inadequate screening, filtering or grounding of power lines
- Transients from local switching
- Induction and radiation fields of local E-M transmitters
- Excessive common mode voltages between source and load

The disturbances may be magnified by the user's hand capacitance. Electrical interference has greatest effect in high impedance circuits. Separation of leads and creation of loops in the circuit can intensify the disturbances.

Lead Impedance

The impedance of the connecting leads can drop significant voltages between the source and load, and generate adverse phasing effects particularly if the leads are long or the current in them is high.

Lead Insulation Leakage

This can cause significant errors in measurement circuits at high voltages. Some insulating materials suffer greater losses than others e.g. PVC has more leakage than PTFE.

AVOIDANCE TACTICS

Thermal EMFs

Screen thermal juntions from draughts.
Allow time for thermal equilibrium to be reached before taking readings.
Use conductors, joints and terminals with a good margin of current-carrying capacity.
Avoid thermo-electric junctions where possible.

e.g. Use untinned single-strand copper wire of high purity. Avoid making connections through Nickel, Tin, Brass and Aluminium. If oxidation is a problem use gold-plated copper terminals, and replace the terminals before the plating wears off. If joints must be soldered, low-thermal solders are available, but crimped joints are preferred. Use low-thermal switches and relays where they form part of the measuring circuits.

Balance one thermal EMF against another in opposition, where possible (switch and relay contacts, terminals, etc.).

E-M Interference

Choose as 'quiet' a site as possible (a screened cage may be necessary if interference is heavy).
Suppress as many sources as possible.
Always keep interconnecting leads as short as possible, especially unscreened lengths.
Run leads together as twisted pairs in a common screen to reduce loop pick-up area, but beware of leakage problems and excessive capacitance.

Where both source and load are floating, connect I- to ground at the source to reduce common mode voltages.

Lead Impedance

Keep all leads as short as possible. Use conductors with a good margin of current-carrying capacity. Use Remote Sense and 4-wire connections where necessary to establish the 4708 output specification at the load. Use 4-wire connections for values of resistance below 1kΩ.

Lead Insulation Leakage

Choose low-loss insulated leads - PTFE is preferred to PVC. When running leads together in screened pairs, avoid large voltages between leads in the same screen, especially if using PVC insulation.

Remote/Local Sense Configurations

The 4708 terminals are configured as follows:

Voltage ranges 100μV, 1mV, 10mV, 100mV
- Local sense only.

1V, 10V, 100V, 1000V
- user selects Local or Remote sense

All Current ranges - Local sense only.

All Resistance ranges
- Remote Sense gives 4-wire connection
- Local Sense provides 2-wire connection capability

The key LED indicates the true connection:
Lit = Remote, Unlit = Local

N.B. When changing to Ω function, the 4708 is automatically forced into Remote Sense for 4-wire operation.

4708 - CONNECTIONS TO THE LOAD

General Considerations

The choice of connection method is influenced by several factors:

a. Loading Effects

4-wire connections should be used for low load impedances. For high impedance loads, 2-wire connections can be employed.

The ratio : $\frac{\text{Total Lead Resistance}}{\text{Load Resistance}}$

gives the approximate error for 2-wire connection at low frequencies.
e.g. Two 1/2 Ohm leads with a load of 100kΩ to produce an error of approx. 10ppm.

At frequencies higher than about 100kHz, the error is also modified by reactive effects.

b. Noise and Output Level

Providing the E-M environment is reasonably quiet, interference due to noise pickup in the load connection is

insignificant for outputs of more than about 100mV, so unscreened leads can be used. But at lower signal levels, or in noisier environments, it is advisable to use screened cable.

c. Common Mode Disturbances

When in Local Guard, the guard shields and tracks for the Sense circuitry are connected internally to 'I-', the low impedance terminal of the 4708 output power source. This classical connection effectively guards out internal common mode disturbances. To reduce external disturbances it is advisable to make only one ground connection to the measurement circuit, and in the case of a guarded DMM, to make use of its external guard facilities. Also, where a line-powered load (such as a DMM being calibrated) has a ground connection, it should be to the same line ground as the 4708.

d. High Frequency Effects

i. Voltage. Up to about 100kHz, for outputs above 100mV, it is possible to use pairs of unscreened wires, provided that the E-M environment is quiet. Twist or run leads together; keep length less than 1 meter.

Above 100kHz, both lead and load capacitances reduce the load impedance. Similarly, lead and load inductances combine to increase the load impedance with frequency (but heavily reactive loads should be avoided). It is therefore advisable to make leads from low-capacitance coaxial or twin-axial cable. To avoid mutual coupling, Sense and Power leads should not run together in the same screen.

ii. Current. Above about 1kHz, with low output currents, high lead capacitance can introduce shunt errors. To reduce these errors, the leads should be kept as short as possible, and be of low-capacitance.

e. DANGER

THE 4708 OUTPUT CIRCUITS ARE NOT INTERNALLY CONNECTED TO GROUND. USERS ARE STRONGLY ADVISED TO CONNECT Lo OR I- EXTERNALLY TO GROUND (PREFERABLY AT THEIR COMMON JUNCTION), WHEN THE 4708 IS TO BE USED ON THE 100V OR 1000V RANGE. THIS ELIMINATES THE RISK OF Lo AND I- FLOATING TO HIGH VOLTAGE.

Setting Priorities

Because of:

a. the variety of environmental conditions and loads likely to be encountered when using the 4708,

b. the extensive set of combinations of outputs from the instrument, and

c. the accuracy required;

it is unrealistic to describe a definitive 'best' general method of connection to the load.

Combinations of the above factors can lead to conflicting requirements, and users may be faced with a choice between methods. In these cases it is sometimes necessary to arrive at a compromise solution by setting priorities.

Suggested Lead Connections for the 4708

Six suggestions for connecting the 4708 to its load are illustrated in the following pages 4-4 and 4-5. Each has found use with the combination of factors described, and together they cover the majority of predicted requirements.

Typical Lead Connections

Voltage and Resistance Outputs

CAUTION: All leads and cables must be proofed to at least 2kV.

NOTE: Refer also to reactive load specifications in Section 6.

Simple 2-wire Connection

Use for many applications where:

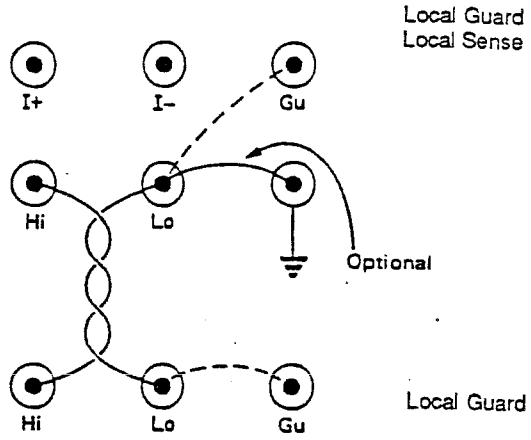
- The voltage drop in the leads is insignificant.
- The E-M environment is 'quiet'.
- External common-mode voltages are insignificant.

Use for measurements in the following ranges:

Voltage	DCV ≥ 100mV
	ACV ≥ 100mV
Frequency	F < 100kHz
Resistance	1kΩ ≤ R < 1MΩ

N.B. After selecting Ω, Remote Sense must be cancelled for 2-wire operation.

Select Local Sense and Local Guard.
Keep leads as short as possible, (not longer than 1 meter-twisted pair is preferable).



On 100V/1000V Ranges, Ground the Lo line for Safety.

Screened 2-wire Connection

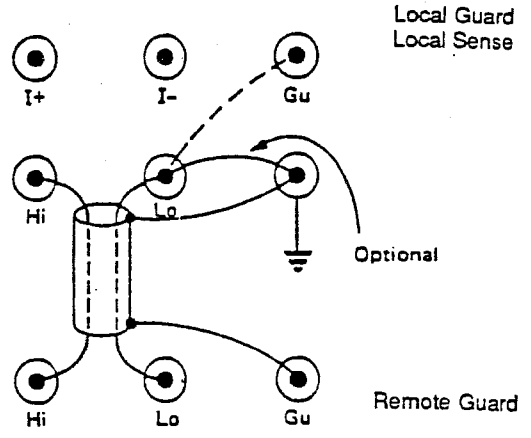
Use where:

- Sensitive measurements are being made.
- The E-M environment is relatively 'noisy'.
- External common-mode voltages are significant.

Use for measurements in the following ranges:

Voltage	DCV ≥ 10μV
	ACV > 90μV
Frequency	F ≤ 1MHz
Resistance	1kΩ ≤ R < 1MΩ

After selecting Ω, Remote Sense must be cancelled for 2-wire operation.
Select Local Sense and Local Guard.
Keep leads as short as possible, (not longer than 1 meter).



On 100V/1000V Ranges, Ground the Lo line for Safety.

Screened 4-wire Connection using Coaxial cable.

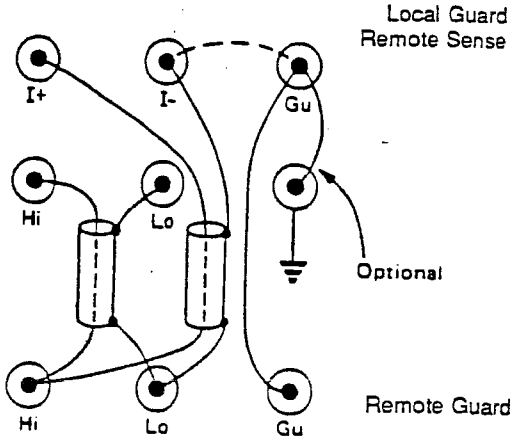
Use where:

- The load resistance is low enough to cause a significant voltage drop in the output connection.
- Sensitive measurements are being made.
- The E-M environment is relatively noisy.
- External common-mode voltages are significant.

Use for measurements in the following ranges:

Voltage	DCV ≥ 90mV
	ACV ≥ 90mV
Frequency	F ≤ 1MHz
Resistance	Not appropriate

Select Remote Sense and Local Guard.
Keep leads as short as possible, (not longer than 1 meter).

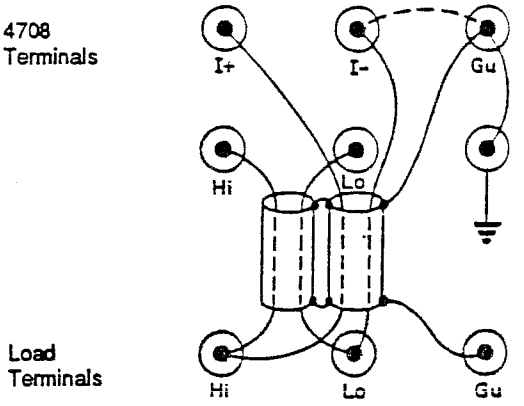


On 100V/1000V Ranges, Ground the Lo line for Safety.

Voltage and Resistance Outputs

Screened 4-wire Connection.
Alternative using Twin-axial cable.

On 100V/1000V Ranges, Ground the Lo line for Safety.



Current Outputs

Simple 2-wire Connection

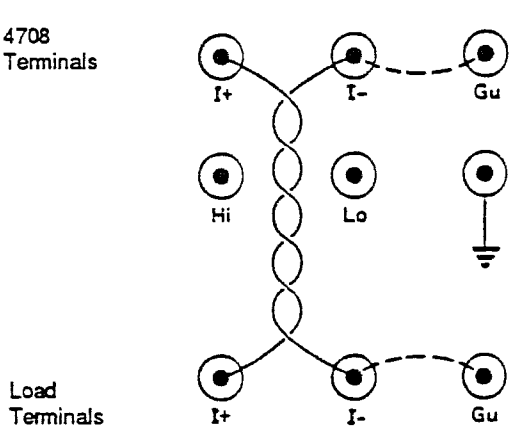
Use for the majority of applications where:
- The E-M environment is 'quiet'.
- External common-mode is insignificant.

'se for measurements in the following ranges:

Current	DCI > 1mA
	ACI > 100mA
Frequency	F < 5kHz

Local Sense selected automatically.
Select Local Guard.
Keep leads as short as possible, (not longer than 1 meter - twisted pair is preferable).

NOTE: Refer also to reactive load specifications in section 6.



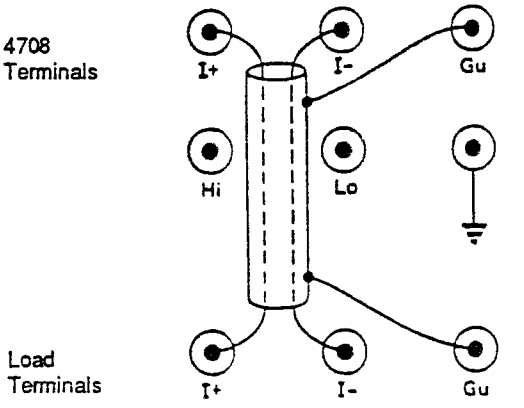
Screened 2-wire Connection

Use where:
- Sensitive measurements are being made.
- The E-M environment is relatively 'noisy'.
- External common-mode is significant.

Use for measurements in the following ranges:

Current	DCI > 9μA
	ACI > 9μA
Frequency	F < 5kHz

Local Sense selected automatically.
Select Local Guard.
'Keep leads as short as possible, (not longer than 1 meter - o-ax. or Twin-ax. is preferable).



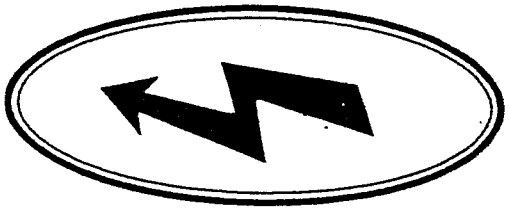
DANGER

HIGH VOLTAGE

THIS INSTRUMENT IS CAPABLE OF DELIVERING

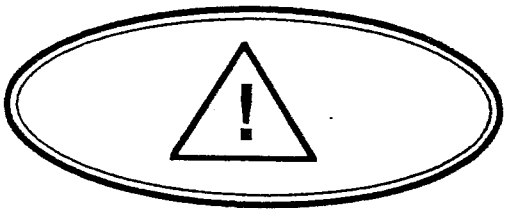
A LETHAL ELECTRIC SHOCK !

when connected to a high voltage source



FRONT or REAR terminals carry the Full Input Voltage

THIS CAN KILL !



Guard terminal is sensitive to over-voltage

It can damage your instrument !

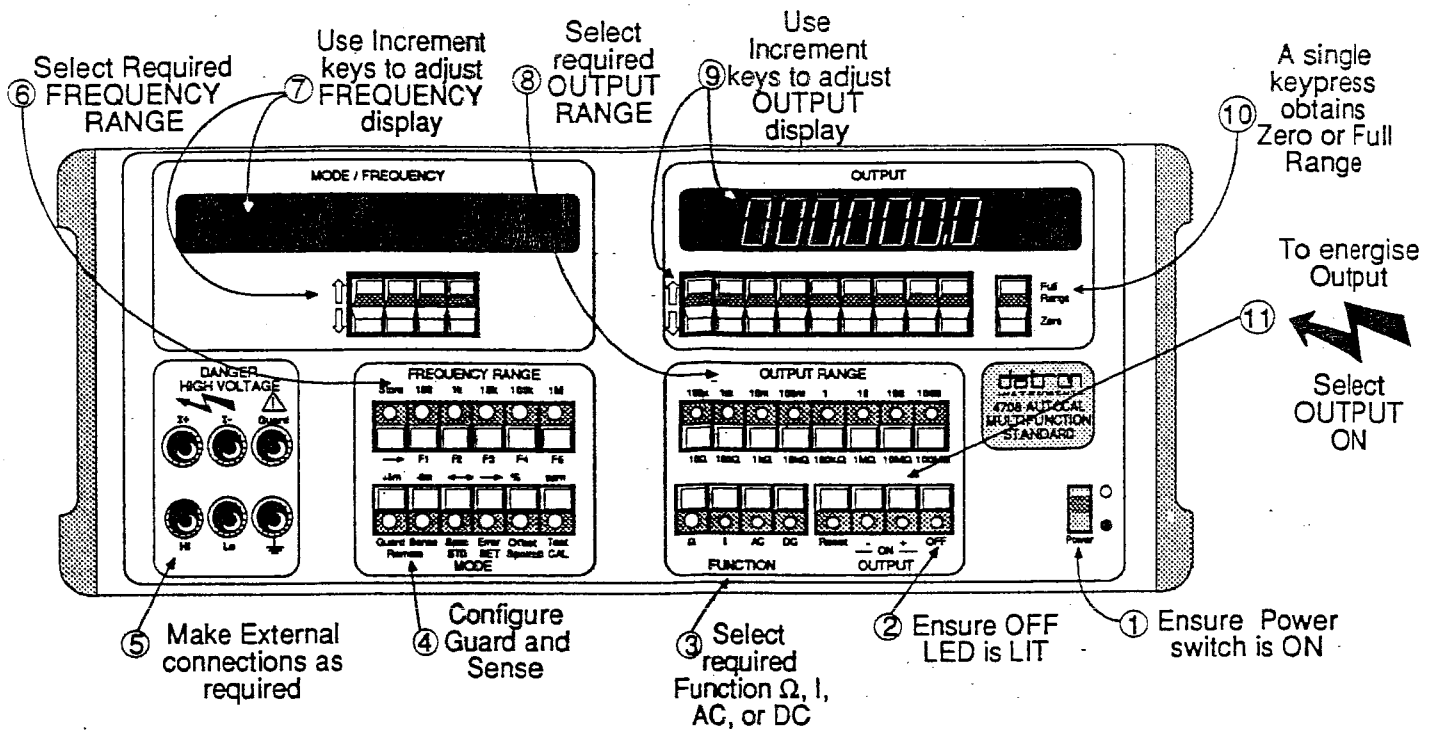
Unless **you** are **sure** that it is **safe** to do so,

DO NOT TOUCH

the **I+ I- Hi** or **Lo leads** and **terminals**

DANGER

General Sequence Of Operations



Display Messages

(See full list at end of this Section)

Error 1	: Spec. mode	- % : Uncertainty > 100% - ±lim : Off-scale limit
Error 2	: Cal. mode	: Output not ON.
Error 3	: Cal. mode	: Incorrect range or function for mode.
Error 4	: Cal. mode	: Correction exceeds store capacity.
Error 5	: Offset or Error Mode	: Requested output would have been off-scale.
Error 6	: Cal. mode	: Resistance exceeded.
Error 7	: 100V /1000V	: Selected output exceeds voltage/ frequency constraints.
Error 8	: Select error	: The operation requested by the user is not possible in present machine configuration.
Error 9	: Option not fitted.	: The requested range or function option is not fitted.
Error EF	: External Frequency	: The external frequency is not present, machine will perform out of specification.
Error OL	: Voltage Current	: Output is current-limited : Compliance limit reached

FAIL 1 : Excessive internal temperature.
FAIL 2 : Over-voltage
FAIL 3 : Control data corrupted
FAIL 4 : Precision divider fault
FAIL 5 : Safety circuits tripped
FAIL 6 : Calibration store fault
FAIL 7 : 400V power supply overload
Automatically resets except where hard fault occurs.
FAIL 8 : 38V power supply overload
FAIL 9 : 15V in-guard power supply overload
FAIL 10 : Model 4600 communication fault

'B' : Processor busy
(keyboard unreceptive).

Test mode messages:
SAFETY : Forced safety watchdog trip
running : Indicates test in progress
PASS : Calibration memory, over-voltage detector and 400V switching checked.

Operating Routines

The following operating routines are subdivided into two main types:

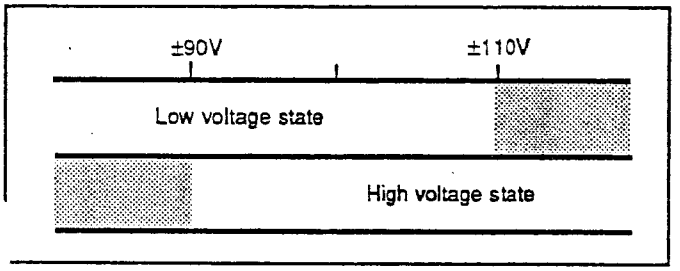
- Standard Operating Sequences
- Additional Facilities

Standard Operating Sequences

There are many common elements in the selection routines for both Voltage and Current operation. The diagram opposite shows the general sequence of operations. It should be used as the basis of any operating procedure, in conjunction with the individual selections detailed in the following pages.

DC Voltage Outputs

There are two overlapping voltage states. The 20V overlap allows ±10% adjustment about the typical full range value of 100V without changing state.



In the Low voltage state, the output may be switched ON directly but to transfer from Low to High Voltage state, deliberate user-actions are required.

N.B. The 4708 switches its output voltage OFF every time the 1000V RANGE is selected and when 1000V RANGE polarity is reversed.

Low Voltage selections (up to ±110V). Use the general sequence:

At operation (3) : Select **DC**.
At operation (4) and (5) : **No Remote Sense** on **100µ; 1m, 10m** and **100m** ranges.

High Voltage selections (above ±110V). Use the general sequence:

At operation (3) : Select **DC**
At operation (9) : **RANGE LED flashes** for selections **above ±110V**
At operation (11) : **Audible warning** - 5 pulses/sec for 3 secs.
: **After 3 second warning** - 4708 switches **OUTPUT ON.**

Whilst **OUTPUT ON** - Audible reminder pulses at approx. 1 sec. intervals, and **RANGE LED continues flashing.**
If **OUTPUT OFF** or **ON** switching is attempted during the 3 sec. delay the 4708 reverts to **OUTPUT OFF.**

Transfer into High Voltage State with OUTPUT ON.
By changing **RANGE:**
- the **OUTPUT** is switched **OFF**, and the selected **RANGE LED flashes.**

User reselects **OUTPUT ON:**
- 3 sec audible warning
- 4708 switches **OUTPUT ON**
- Audible reminder whilst **OUTPUT ON**
- **RANGE LED flashing**

By use of ↑ ↓ keys in **100V** or **1000V** range:
- **OUTPUT** remains **ON** at previous voltage
- **OUTPUT** display shows selected (High Voltage) value
- **RANGE** and **OUTPUT ON** LEDs **flash.**

User reselects **OUTPUT ON:**
- **3 sec audible warning**
- **4708** increases **OUTPUT** voltage to **OUTPUT** display value
- Audible reminder whilst in High Voltage state
- **RANGE LED flashing**
- **OUTPUT ON LED lit continuously**

Transfer out of High Voltage state with OUTPUT ON
By pressing **OUTPUT OFF** key:
ON+ or **ON-** LED remains lit until the **OUTPUT Voltage** has decayed into Low Voltage State (Approx. 1 sec from 1000V).
By use of ↑ ↓ keys or by changing **RANGE** down:
Transfer to Low Voltage State is automatic when the **OUTPUT Voltage** falls below 90V.
- **RANGE** LED stops flashing - stays lit
- **OUTPUT ON** LED stays lit
- Audible reminder is silent

Changing voltage state when in Error or Offset Mode

For safety reasons, the thresholds are always defined with respect to voltage levels at the **OUTPUT** terminals. Therefore, if the instrument is in Error or Offset mode, the threshold indications may not coincide with 110V and 90V on the **OUTPUT** display.

AC Voltage Outputs

Zero Output

Zero AC Voltage output from the 4708 can be obtained only by pressing the **Zero** key. Internal relay contacts short **I+** and **I**, and **Hi** to **Lo.**

Increment from Zero

The smallest AC output available on any range is 9% of full range, so any attempt to reduce the output below 9% is refused. Thus the smallest possible increment from Zero is to 10% of full range, using the appropriate key (any key to the right of this would attempt to increment to 1% or less, and be refused,

causing 'Error 8' and buzzer to sound). Half-size zeroes on the Zero display show which keys cannot be used to increment from Zero; full-size zeroes show those which can.

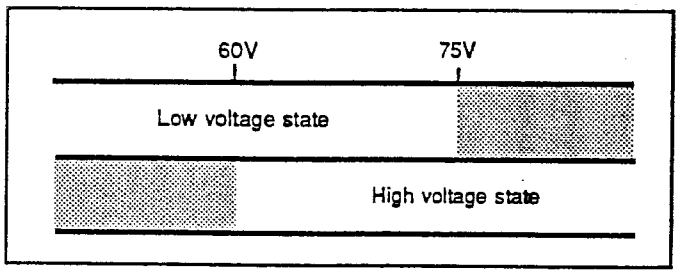
When the display is correctly incremented with OUTPUT ON, the output terminals are internally reconnected to the voltage output circuitry.

Zero Displays

Range	Zero Display	
1mV	.0oo,o	mV
10mV	0.ooo,o	mV
100mV	0o.ooo,o	mV
1V	.0oo,ooo	V
10V	0.ooo,oo	V
100V	0o.ooo,o	V
1000V	0oo.ooo	V

Output Voltage Selection

There are two overlapping AC voltage states. The 15V overlap allows some adjustment without changing state.



In the Low Voltage state, the output can be switched ON directly, but deliberate user-actions are required to transfer from Low to High Voltage state.

N.B. The 4708 switches its output voltage OFF each time the 1000V RANGE is selected.

Low Voltage Selections (up to 75V RMS). Using the general sequence:

At operation (3) : Select AC
At operations (4) and (5) : No Remote Sense on 1m, 10m and 100m ranges.

High Voltage selections (above 75V RMS). Using the general sequence:

At operation (3) : Select AC
At operation (9) : OUTPUT RANGE LED flashes for selections above 75V RMS.
At operation (11) : Audible warning - 5 pulses/sec for 3 secs.
After 3 sec. warning : 4708 sets OUTPUT ON.

While OUTPUT is ON : Audible reminder pulses continue at approx. 1 sec. intervals, and RANGE LED continues flashing.

If OUTPUT OFF OR ON switching is attempted during the 3 sec. delay the 4708 reverts to OUTPUT OFF.

OUTPUT ON Transfers

If OUTPUT is already switched ON in Low Voltage State when an attempt is made to select a voltage in excess of 75V RMS, the 4708 safety interlocks prevent the selection. Certain deliberate actions, detailed below, are then required by the operator to effect the selection.

Transfer from Low into High Voltage State, by manual upranging:

- 4708 switches OUTPUT OFF,
- Selected RANGE LED flashes,

Operator reselects OUTPUT ON:
- 3 sec audible warning
- 4708 switches OUTPUT ON
- Audible reminder while OUTPUT is ON
- RANGE LED continues flashing
- OUTPUT ON LED lit continuously.

Transfer from Low into High Voltage State, by incrementing the OUTPUT display:

- OUTPUT remains ON at previous voltage
- OUTPUT display shows selected value
- RANGE and OUTPUT ON LEDs flash.

Operator reselects OUTPUT ON:
- 3 sec audible warning
- 4708 increases output voltage to the OUTPUT display value
- Audible reminder while OUTPUT is ON
- RANGE LED flashing
- OUTPUT ON LED lit continuously.

Transfer from High into Low Voltage State, by pressing OUTPUT OFF key:

- ON LED remains lit until the output voltage has decayed (approx. 1 sec from 1kV).

Transfer from High into Low Voltage State, by decrementing the OUTPUT display, or by manual downranging:

- Transfer to Low Voltage State is automatic when the Output Voltage falls below 60V RMS.
- RANGE LED stops flashing - stays lit
- OUTPUT ON LED stays lit
- Audible reminder is silent

Changing Voltage State when in Error Mode

For safety reasons, the thresholds are always defined with respect to the voltage at the output terminals. When the instrument is in Error mode the displayed output voltage is modified by the gain error, so the threshold indications may not coincide exactly with 75V and 60V on the OUTPUT display.

Frequency Control
Refer to pages 3-6 to 3-8.

DC Current

'se the General Sequence:

At operation (3) : Select DC followed by I
At operations (4) and (5) : Remote Sense not available

N.B. Maximum compliance 3V on all ranges except with Model 4600 Transconductance Amplifier when compliance is limited to 2V.

AC Current

Zero Output
Zero AC Current output from the 4708 can be obtained by pressing the **Zero** key. This causes the internal software to isolate the **I+** and **I-** terminals from the internal circuitry, physcially interrupting the Output Current.

Increment from Zero
The smallest AC output available on any range is 9% of full range, so any attempt to reduce the output below 9% is refused. Thus the smallest possible increment from Zero is to 10% of full range, using the appropriate key (any key to the right of this would attempt to increment to 1% or less, and be refused). Half-size zeroes on the Zero display show which keys cannot be used to increment from Zero; full-size zeroes show those which can.

When the display is correctly incremented with **OUTPUT ON**, he **I+** and **I-** terminals are internally reconnected to the Current output circuits.

Zero Displays

Range	Zero Display
100µA	0o.oo o,o µA
1mA	0oo,ooo mA
10mA	0.ooo,oo mA
100mA	0o.ooo,o mA
1A	.0oo,ooo mA
10A	0.ooo,oo mA

Current Outputs
To generate AC output currents, use the General Sequence:

At operation (3) : select AC followed by I
At operations (4) and (5) : No Remote Sense

N.B. Maximum compliance 3V on all ranges except with Model 4600 Transconductance Amplifier when compliance is limited to 2V.
Changing functions switches **OUTPUT OFF.**

Resistance

Use the General Sequence:

At operation (3) : Select Ω - **Remote Sense** LED lights as 4708 is forced into 4-wire

At operation (4) : If 2-wire Ohms is required, press **Remote Sense** to deselect

At operation (5) : 4-wire Ohms - use I+ and I- terminals for energizing current.
Measure at **Hi** and **Lo** terminals.
2-wire Ohms - use **Hi** and **Lo** terminals (I+ and I- terminals internally fused at 1.0A, Hi and Lo terminals fused at 3.75mA; on Ω function).

At operation (8) : **RANGE** key value is **nominal.**
OUTPUT display value is as previously calibrated (At Full Range only, for 4-wire; at Full Range and Zero for 2-wire).

At operation (9) : Left hand (overrange) pair of ↑ ↓ keys have the same functions as **Full Range/ Zero** keys.
The other ↑ ↓ keys are inoperative except in Calibration function (See Section 8).

Additional Facilities

Frequency Store

Store Key
This key controls the storage and recall of five user-selected frequencies. The memories are volatile in that their contents are lost when the 4708 is powered-down. At power-up, the following five decade frequencies are stored automatically.

F1	30Hz
F2	300Hz
F3	3kHz
F4	30kHz
F5	300kHz

ACCESS TO STORED FREQUENCIES

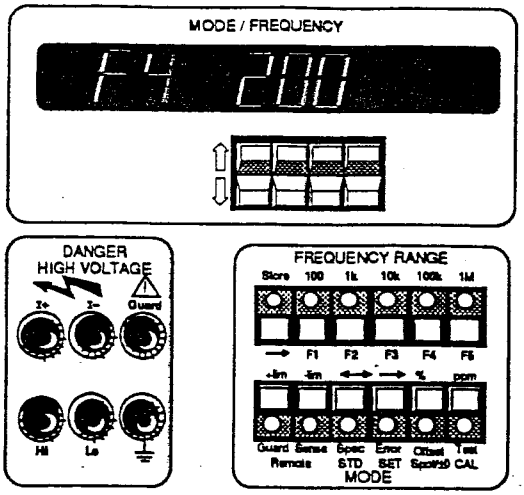
Recall a Stored Frequency
To set the 4708 to one of the five stored frequencies, simply;

Press and release the **Store** key
- Its green LED lights

Press and release the desired **F1-F5** key
- Its LED lights
- The **Store** LED remains lit
- The stored frequency is presented on the **FREQUENCY** display, accompanied by its store location (see illustration page 4-10).

Recall from a Different Memory
To switch to a different stored frequency:

Press and release the desired **F1-F5** key.
- The displayed indications change as appropriate.



4708 Frequency selection panel

Deselect Store

To revert to normal frequency facility:

Press the Store key again
- Its LED goes out
- The F1-F5 LED goes out
- The stored frequency remains unchanged

Re-program a Frequency Memory Store

To change the Frequency of a Memory Store, the following procedure stores any displayable frequency in any of the five locations:

Select the required FREQUENCY RANGE.
Use the FREQUENCY display ↑ ↓ keys to set the new frequency on display.
Press and hold the Store key
- Its green LED lights

Press and release the desire F1-F5 key
- Its LED lights
- The store location is also present on the display

Release the Store key
- Its LED remains lit

If desired, deselect Store as above

STORE KEY - SUMMARY

Press and Release: Access F1-F5 for stored frequency retrieval.

Press and Hold: Allows displayed frequency to be stored in F1-F5 memories

Spot Frequency

This facility exists to provide rapid access to five user-selected spot calibrated frequencies on each output Voltage and Current range. As there are seven Voltage ranges, and five Current ranges, this makes a total of sixty spots in all.

Selecting a new OUTPUT RANGE also calls up its five spot frequencies, ready for selection.

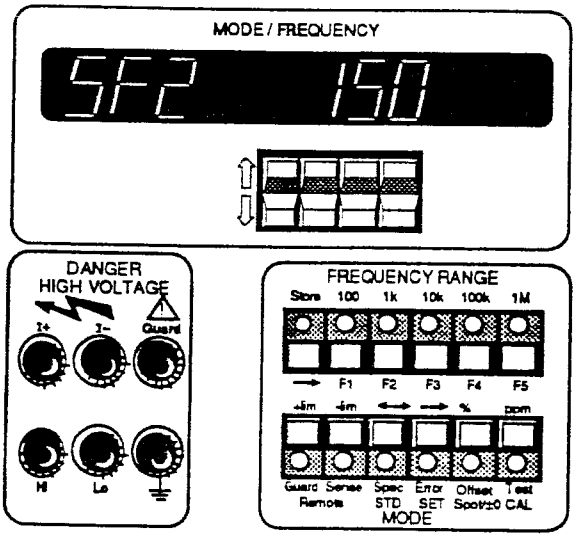
The 4708 output can be calibrated at each spot frequency, thus achieving ultra-high accuracy by eliminating the 'Flatness' component.

By using non-volatile memory, these frequencies and their associated calibration constants are retained in store, even when the 4708 is powered-down.

In order to change the frequency setting of a spot and recalibrate at the new frequency, it is necessary to enter 'cal' mode (with the rear panel CALIBRATION key-switch set to 'ENABLE').

The output level span available for calibration of Spot frequencies is restricted to within 10% of nominal full range.

The calibration procedure is described, together with the other routine calibrations, in Section 8.



4708 Frequency control panel when used for the manipulation of spot frequency

Spot key

This reassigns the use of the F1-F5 keys, to provide read-access to the non-volatile memory.

Recall

To set the 4708 to one of the existing spot frequencies, with output as previously calibrated, simply:

Press and release the Spot key
- Its LED lights
- The Store LED lights

Press and release the desired F1-F5 key
- Its LED lights
- The Store and Spot LEDs remain lit
- The spot frequency is presented on the FREQUENCY display, accompanied by its store location (see illustration).

Recall from a Different Memory

To switch to a different spot frequency.

Press and release the desired **F1-F5** key.
- The displayed indications change as appropriate.

If the spot has not previously been calibrated, the message '**SFX——**' is displayed (X is the store number). The most recent frequency setting is retained.

Output and Frequency Constraints

If the combination of voltage and frequency, or current and frequency, is outside the defined constraints, the command to change spot, output range or output value will be ignored.

Deselect Spot Frequency

To revert to normal frequency facility:

Press either **Spot** or **Store**
- **Spot** LED goes out
- Store LED goes out
- The selected **F1-F5** LED goes out
- **1k FREQUENCY RANGE** LED lights
- **FREQUENCY** display reverts to 1kHz
- 4708 frequency reverts to 1kHz
- The stored spot frequency remains unchanged

Re-program a Frequency Memory Store

To change the frequency of a spot frequency memory store, the 4708 must be placed into 'cal' mode. This procedure is detailed in Section 8.

'Spec' Mode

Spec key

This key allows a user to avoid constantly referring to the data sheet specifications, when it is necessary to determine the uncertainty for any set value.

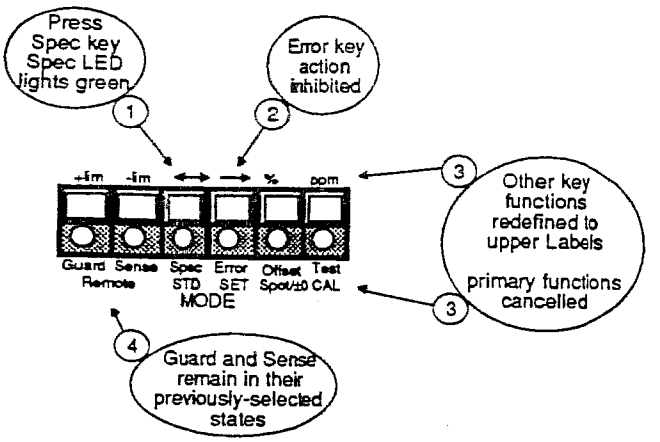
Uncertainty Data Selection

The range of 4708 specification uncertainties is held in internal memory. Spec mode selects the stored data appropriate to the current settings of **Function, Range, Output Value, Frequency** and **Calibration Interval**; then calculates and displays the overal uncertainty.

Initiation

To transfer into Spec mode:

Select the required Calibration Interval
(Rear Panel switch).
Then follow the sequence in the diagram:



On pressing the Spec key the uncertainty appears on the **MODE** display, displacing the Frequency readout (except for Store, Frequency cannot be changed when in 'Spec' mode). Initially the presentation is as shown in the following table:

Uncertainty	Display Units
≤ 1,999ppm of set value	ppm
> 1,999ppm of set value	%
Not displayable or > 100%	Error 1

Secondary Spec Modes

Once the **Spec** key has been pressed, the other **MODE** keys become reassigned to give a choice of four display modes:

ppm, %, +lim, -lim

ppm or % Uncertainty (of displayed value).
From 1ppm to 1999ppm, the uncertainty can be displayed in **ppm**. From 0.001% to 100%, it can be displayed in **%**. When the uncertainty is not defined, the message **Error 1** is displayed and the buzzer sounds.

Example of Error 1 Condition (Any Cal Interval)

Output Range	1V
Setting	Zero key pressed
Frequency	Any frequency
Uncertainty	Not defined at Zero

Mode display is Error 1.

+Lim or -Lim
To obtain a reading of an absolute limit of uncertainty:

Press the **+Lim** or **-Lim** key

The **MODE** display will switch to the same resolution as the **OUTPUT** display and its reading will be the positive or negative absolute limit of uncertainty (i.e. the **OUTPUT** reading plus or minus the absolute uncertainty error limit for that output).

As the reading approaches full scale, its positive limit may exceed full scale. If +lim is selected, Error 1 is displayed and the buzzer sounds.

FUNCTION and RANGE Control in Spec Mode

The **FUNCTION, OUTPUT RANGE** and **OUTPUT ↑ ↓** keys can be operated normally. The 4708 will adjust its **MODE** display to the uncertainty figure appropriate to each new selection.

FREQUENCY Selection in Spec Mode

The **MODE/FREQUENCY** display is assigned to its 'Uncertainty' presentation. Consequently the use of the **FREQUENCY RANGE, FREQUENCY ↑ ↓** and Store keys is inhibited.

Nevertheless, by pressing the **Store** key followed by one of the **F1-F5** keys **BEFORE** pressing **Spec**, all five 'Stored' frequencies can still be accessed.

In this case the **MODE** display normally presents the appropriate uncertainty figure. But a readout of the Stored frequency can be obtained by merely pressing and releasing the **F1-F5** key whose **LED is lit.** The store location and frequency will appear for about 1 second before changing back to the uncertainty figure.

4708 'Spec' Data

Section 6 breaks down the specification into:

a) Stability
b) Accuracy relative to Standards
c) Datron's Calibration Uncertainty

The **CALIBRATION INTERVAL** switch on the rear panel is labelled:

24 hr, 90 dy, and 1 yr.

The stored uncertainty data is selected from (b) and (c) above, as follows:

24hr : (b), 23°C ± 1°C
90dy : (b) + (c), 23°C ± 1°C
1yr : (b) + (c), 23°C ± 5°C

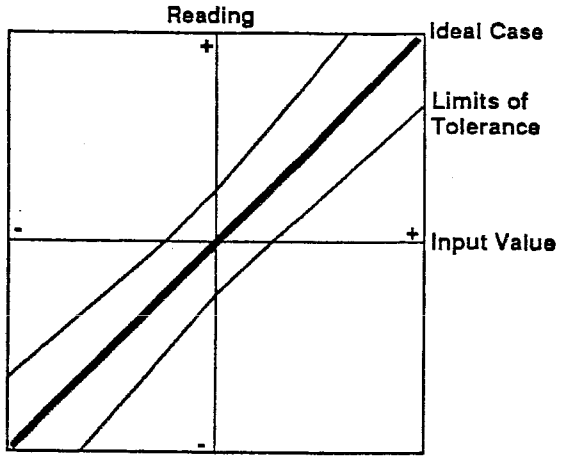
Thus the accuracy figures displayed for **90 dy** and **1 yr** are traceable to National Standards.

In verifying the instrument's specification on receipt of a 4708, users are able to display the 90-day limits to check against the instrument's specified traceable accuracy. After calibration, the '24 hour interval' limits should be used to verify against the same standards used for calibration.

Refer to Section 7, Specification Verification, for further information.

'Error' and 'Offset' Modes (Voltage and Current Only)

The specification of a high accuracy DMM (and of other electrical measuring equipment) relates its display readings to its input values. A perfectly calibrated DMM would have an exact 1:1 correspondence, and the specification lays down acceptable tolerances of deviation from this direct relationship. Plotted as a graph, the ideal case is a straight line at 45° through the origin. The tolerances, plotted on the graph, enclose an area on both sides of this line.



There are three major causes of deviation from the ideal case:

Zero offset - the line does not pass through the origin. Most DMMs have a front panel adjustment to correct this.

Gain Error - the slope of the line is not 45°

Linearity Error - the slope of the line varies. (A common variation is a "dog's leg" at zero).

Each of these elements could cause large enough deviations to place the instrument out of tolerance, sometimes a combination of elements being responsible.

The **"Error" and "Offset"** modes allow a user to deviate the output of the 4708 in specific ways, so as to identify directly the causes of excessive deviation.

Error key

The **Error key** is used to initiate Error mode. The 4708 terminal value can then be deviated from the **OUTPUT** display value, by known gain factors, as entered on the **MODE display.**

Error Mode Display

Pressing the Error key changes the MODE/FREQUENCY display from 'Frequency' readout to 'Error Mode' readout. The initial reading is always '0.0 ppm', indicating that the terminal value has not yet been deviated.

MODE/FREQUENCY ↑ ↓ Keys

The terminal value is changed, without altering the OUTPUT display, by pressing the ↑ ↓ keys beneath the MODE/FREQUENCY display. The gain compensation being applied is displayed as a percentage or ppm of the OUTPUT display value; with positive polarity for an increase of terminal value, and negative for a decrease.

The gain-compensation factor has a maximum possible resolution of ± 0.1ppm of Full Range (DCV).

Example of the use of "Error" mode

To measure the linearity of a DMM, a user needs to:

Remove any zero offset.
Detect and measure any inherent gain error ratio (usually from its response to a full range input).

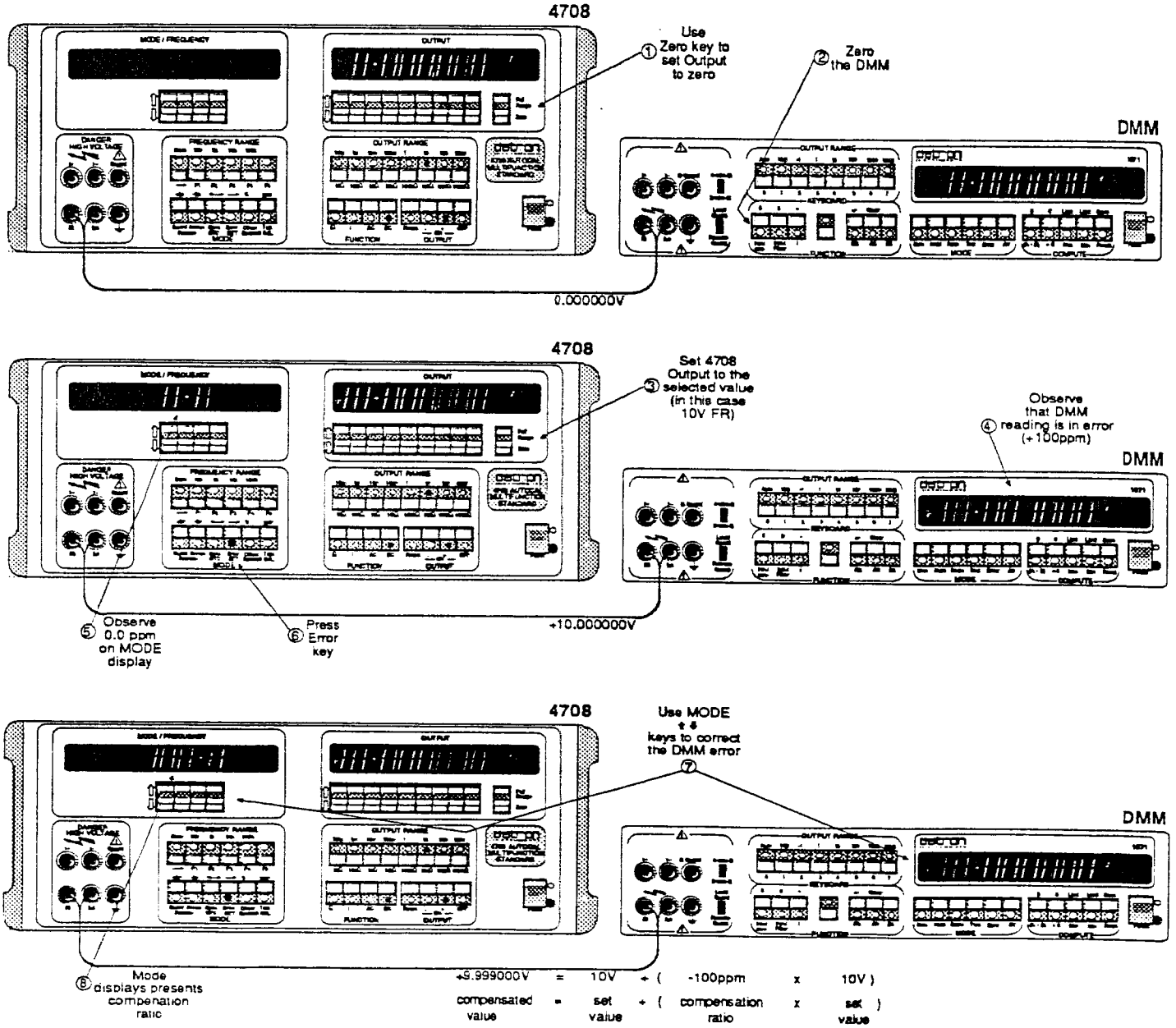
Calculate compensating deviations for each of the inputs for the linearity measurement, based on the measured ratio,

and

Compensate each input to the DMM so that the linearity errors may be measured.

In "Error" mode, once the gain error has been measured, the 4708 automatically calculates and applies the compensating deviation to all its outputs on that range and function; whilst displaying both the nominal (uncompensated) value of output and the compensation ratio. Only if the DMM response is linear, will each DMM reading agree with the corresponding 4708 OUTPUT display value.

In the following sequence a DMM is checked for linearity. For purposes of explanation, it is assumed that linearity is correct, but the DMM has a gain error of +100.0 ppm.



The 4708 output has now been compensated for the gain error of the DMM. All selected output values will be compensated in the same ratio on this range and function until either the ratio is changed or Error mode is selected. The **Mode** display presents the compensation ratio directly. Note that the compensation polarity is shown, not the error polarity, therefore the true output is the sum of both displayed values; in this case +10.000000V - 100ppm = +9.999000V.

The linearity of the DMM may now be checked by directly comparing its reading with the **OUTPUT** display settings.

e.g. at +5V on this range, both 4708 and DMM read +5.000000V, although the terminal voltages are +4.995000V.

Other linearity check values could be:

Nominal Check Point	4708 set Value	DMM Reading	Terminal Voltages
-0.5V	-0.500000V	-0.500000V	-0.499950V
+0.1V	+0.100000V	+0.100000V	+0.099990V
+0.01V	+0.010000V	+0.010000V	+0.009999V

Full Scale Limiting.

The **OUTPUT display** cannot be raised to a value which sets its overrange digit to greater than 1, and the **Error MODE display** cannot be raised about ±9.9999% (±999.9ppm).

Nevertheless, a combination of **OUTPUT display value** and **gain error** could result in an off-scale value. The 4708 prevents this by rejecting any demand for an error-corrected Output Voltage in excess of full scale. The user is informed by **Error** 5 message on the MODE display with no change to the **OUTPUT** display.

Deselection of Error Mode

Deselection clears the **MODE** display, turns the green **Error** LED **OFF** and restores the 4708 gain factor to unity. Normally the mode is deselected by repressing the **Error** key, but it is also turned off by changing **FUNCTION** or **RANGE**.

'Offset' Mode (DC Functions only)

Offset key

A device being checked against the 4708 (say a DMM) may have an inherent zero offset error. Nevertheless, a user may wish to perform other measurements before removing the offset error. The 4708 'Offset' Mode is used for this purpose.

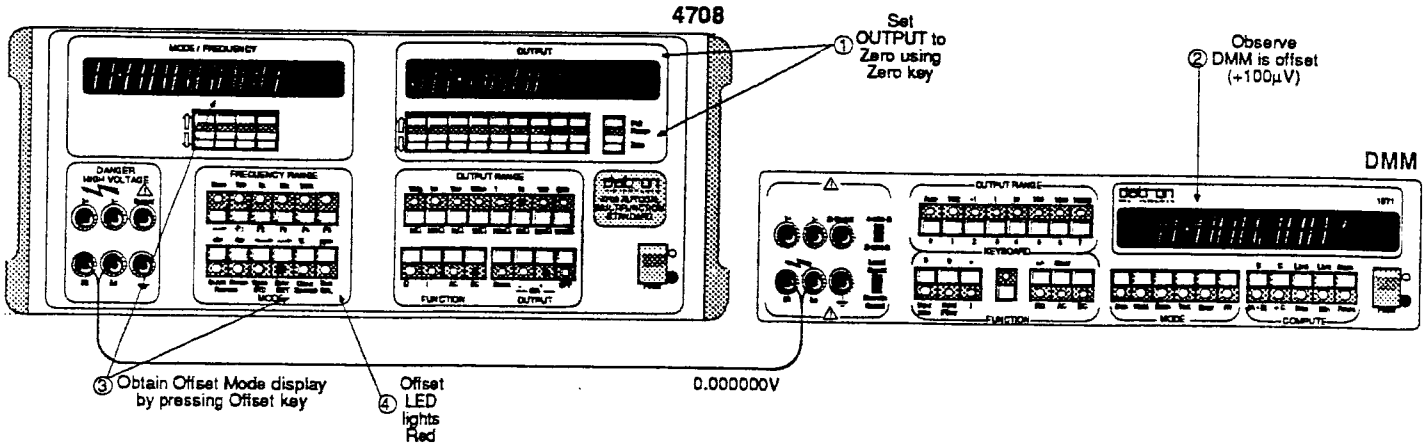
N.B. The **MODE** ↑ ↓ keys have an automatic action: If a key is held pressed, the display will increment or decrement continuously until the key is released.

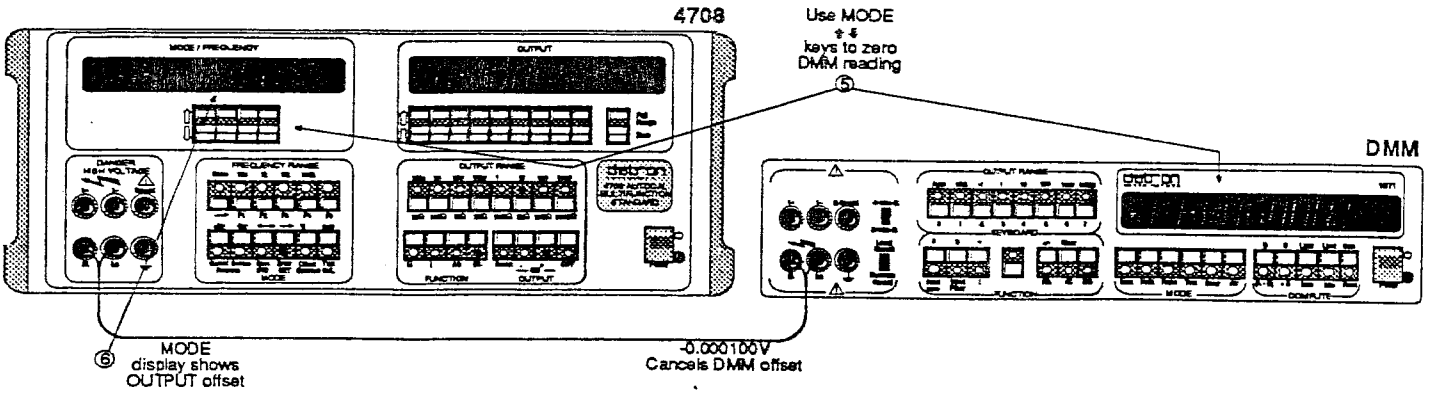
The value of output at the 4708 terminals is now the **sum** of the **OUTPUT display value** and the **MODE display offset value.**

The following example generates an offset of -100μV on the 10V range of a DMM, for all set values (unless the 4708 would be driven off-scale).

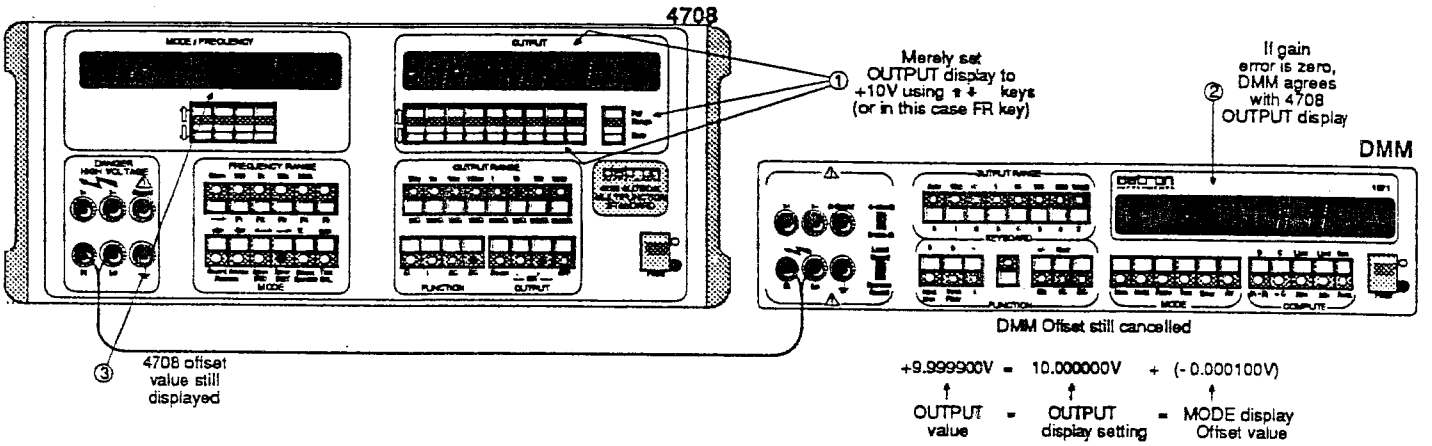
Connect the DMM to the 4708, both set to 10V range, ensuring that 4708 **Error** and **Offset** LEDs are **UNLIT.**

Note that the negative polarity of the Offset value shown on the MODE display indicates that the Output voltage is more negative than the value on the OUTPUT display, i.e. the 4708 offset polarity is displayed, not the polarity of the DMM offset error.





Now the DMM gain error may be measured



Full Scale Limiting.

The 4708 will reject any combination of set value and zero offset which would result in an off-scale output.

e.g. if - 19.999950V is set together with -100µV offset, the user is requesting an offscale output of -20.000050V and the combination is invalid. The 4708 causes **Error 5** to appear on the **MODE** display as a signal to the user, and continues to output its previous (valid) value.

The **OUTPUT display** cannot be set to a value greater than Full Scale. The **Offset MODE display** cannot be set to a value greater than the Offset span for the Range in use.

i.e. 100µV and 1mV Ranges: <200µV
Other Ranges: <2% of Full Range value

Deselection of Offset Mode

This clears the **MODE** display, turns the red **Offset** LED **OFF** and reduces the 4708 offset to zero. Normally the mode is deselected by repressing the **Offset** key, but it is also turned off by changing **FUNCTION** or **RANGE.**

Combining Offset and Error Modes (DC Functions only)

By combining Offset and Error modes it is possible to carry out a rapid analysis of a measuring instrument's linearity (e.g. for a DMM or A-D converter) without the need to correct its zero offset and gain errors.

This is done by using **Offset Mode** to compensate the 4708 output for the DMMs zero offset, and then using **Error Mode** to compensate for the DMM's gain error with the offset compensation still present.

In this condition, any residual deviations in DMM readings from the 4708 **OUTPUT** display settings represent non-linearities which would still be present if the DMM were corrected for offset and gain errors.

This facility also permits a user to quantify the linear response of the instrument to its input values in the form $y = mx + c$

in which y = instrument reading
x = input value
m = gain ratio
c = zero offset value

e.g. for a DMM on its 10V range:

if $y = 9.999956x - 0.000084$,

then the DMM needs a gain compensation of +4.4ppm and a zero offset compensation of +84μV

These compensation figures can be read directly from the 4708 MODE display, during the following procedure.

Combination procedure (See Note below)

1. Use Offset-mode to compensate for input offset error and record the 4708 MODE display value at operation 6 ➡ (γ) on page 4-15.

2. With Offset LED still lit, press Error key. Use Error mode to compensate for the instrument's gain error and record the 4708 MODE display value (ppm or %) at operation 8 ➡ (μ) on page 4-13.

3. Use suitable values of **OUTPUT display** setting to check the linearity of the instrument under test. If the instrument has perfect linear response, then its readings will agree with those of the 4708 **OUTPUT** display and its linear transfer function is:

either: Instrument reading

$$= \left[1 - \frac{\mu\,(\text{in ppm})}{10^6}\right] \times \text{Input value} - \gamma \equiv y = mx + c$$

or:

$$= \left[1 - \frac{\mu\,(\text{in \%})}{100}\right] \times \text{Input value} - \gamma \equiv y = mx + c$$

4. Deselect in reverse sequence.

NOTE: For these equations to be varied, the procedure must follow the above sequence. Therefore the 4708 has been designed to inhibit any other sequence.

i.e. Offset mode cannot be selected or deselected when the Error LED is lit, and the Offset key operates in its secondary function of '%'.

Test Key

Tests available

There are two stages of 'Test' mode. The first stage, Safety and Memory checks, cannot be omitted from any 'Test' sequence.

Safety and Memory Checks

On first pressing the Test key, the 4708 carries out three checks:

1. Operation of the Safety trip, buzzer and reset circuitry.
2. Calibration Memory integrity.
3. Over-voltage check. (High voltage when not in HV state).

Messages appear on the **MODE** display, and completion is signalled by the **Test** LED going **OFF**. The second stage Display and Key checks may be omitted by pressing any key **other than Test.**

Display and Key Checks

If the **Test** Key is repressed before pressing any other Key, a visual sequence tests the front panel:

1. Gas discharge displays.
2. Key LEDs.
3. Key contacts (user-selected).

The 4708 remains in the key-contact mode until the Zero Key is pressed or test is deselected. It may then be used normally.

N.B. 1. At any time during the second stage, the Test sequence may be aborted by pressing Test Key again.

2. During self-test the instrument reset facility is not available.

Test Sequence

The Front or Rear panel terminals are not energized during Test sequence.

Safety and Memory Checks

1. Initial Conditions

Ensure that **OUTPUT OFF** LED is lit, **Error** and **Spec** LEDs are unlit. Check that **Test** LED is unlit.

2. Press Test Key:

Test LED lights as the checks begin.

3. Safety Trip Check

The 4708 tests the safety trip circuits. The **SAFEtY** message appears on the **MODE** display and the buzzer will sound continuously when the trips have operated, and the **Reset LED** flashes.

4. Reset Check

The program ensures that user tests the Reset action.

Press **Reset** Key:

The **SAFEtY** message is replaced by the **running** message and the buzzer stops sounding. Relay operation can be heard during the automatic checks which follow.

5. Calibration Memory Check

This is a sum-check of the Non-volatile RAM. If the check fails, the Message **FAIL 6** appears, otherwise no message.

6. Over-Voltage Checks

The 4708 automatically tests the over-voltage detector threshold levels in Low Voltage state.

If the check fails, the message **Fail 2** appears, otherwise **PASS** message indicates both tests completed successfully.

7. The Test LED goes OFF.

The following table summarizes the MODE display messages:

Message	Reason
SAFEtY running	First stage of 'test' operative
PASS	No failure discovered.
FAIL 6 only	Parity error in Calibration Memory Check.
FAIL 2 only	High voltage can be present in Low Voltage state.

Any combination of these two **FAIL** messages can appear in sequence, replacing the **running** message.

8. To terminate Test before the Display and Key checks, press any key **other than Test: 4708 returns to prior conditions.**

Display and Key Checks

Visual Check Sequence

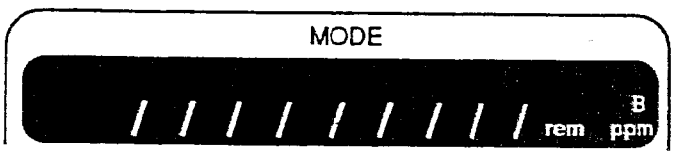
Read this Note before pressing **Test** Key to start.

NOTE: After pressing Test Key, the Visual Check sequence commences. During this sequence observe that:

(a) No display segments or blocks are missing or incomplete.
(b) Segments and blocks do not appear spuriously.
(c) Inter-digit and inter-segment 'streaming' does not occur.
(d) All LEDs are lit in their correct sequence.
(e) LEDs are not lit spuriously.

1. Press **Test** key - Test LED lights
   - All other LEDs unlit
   - Displays cleared momentarily.

   then:
2. **MODE** Display
   (a) Initial presentation:

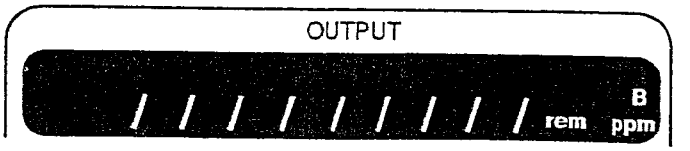


Nine segments and legends are presented.
(b) Progressively, all seven-segment digits and legends are displayed segment by segment.

N.B. Commas are presented in the MODE display sequence.

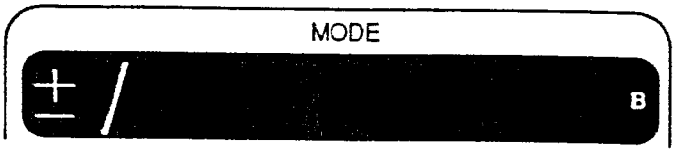
(c) **MODE** display cleared.

3. **OUTPUT** display
   (a) Initial presentation:

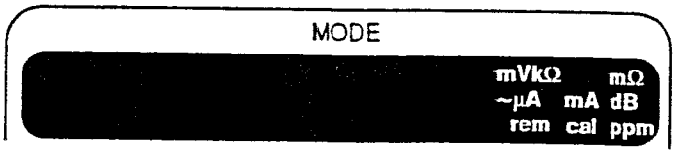


Nine segments and legends are presented.
(b) Progressively, all seven-segment digits and legends are displayed segment by segment.
(c) Final presentation: Nine commas are displayed on **OUTPUT** display then all 18 commas are displayed on **OUTPUT** and **MODE** displays.
(d) **OUTPUT** and **MODE** displays cleared.

4. MODE Display
   (a) Initial presentation:



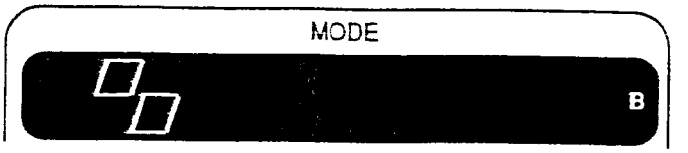
Polarity signs and overrange digit displayed.
(b) Progressively, seven-segment digits are presented digit by digit.
(c) Final presentation.



First, then second blocks of legends are displayed.
(d) MODE display cleared.

5. **OUTPUT** display digits are presented next, in the same order as for the **MODE display.**

6. **LED** Check sequence commences:
   (a) **Test** LED stays on, and other key LEDs are lit in Left to Right sequence starting at 100μ key and ending at **OFF.**
   (b) **MODE** display.



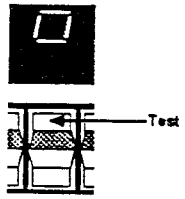
Symbol shown indicates that the keys are ready to be checked.

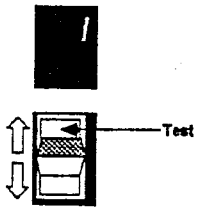
7. Key Checks

N.B. The Zero key should not be pressed until it is desired to terminate the Test Sequence.

(a) ↑ ↓ Keys

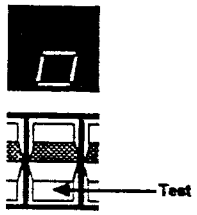
Each ↑ key should light the upper half of the digit immediately above it.

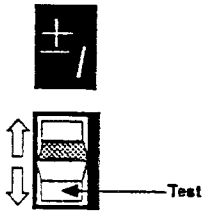




OUTPUT Display overrange digit ↑ key.

Each ↓ key should light the lower half of the digit immediately above it.





OUTPUT Display overrange digit ↓ key.

(b) **FREQUENCY RANGE, MODE, OUTPUT RANGE, FUNCTION** and **OUTPUT** keys should cause their LEDs to light, except:

(i) **Reset** key, which is inoperative,
and (ii) **Test** key, which aborts the test.

In these tests the key-press operates a latch so that the display or LED remains lit until another key is pressed. Only one key-press at a time is recognized.

(c) **To Terminate the Test Sequence:**

Press Zero key to check its operation.
- 4708 reverts to initial conditions.
- Test LED goes OFF

(d) Operate 4708 normally.

Warnings and Messages

High Pitch Audible Warning

(a) Sounds at approx 5 pulses per second during the 3 second delay between selection of OUTPUT ON and the High Voltage being connected to the terminals, when the OUTPUT TERMINAL VOLTAGE WILL EXCEED 110V DC or 75V RMS AC.
(b) Sounds at approx 1 second intervals with OUTPUT ON in **High Voltage State.**
(c) Sounds for 1 second with blank **FREQUENCY** display when frequency auto-ranges up or down.
(d) Sounds continuously when SAFEtY message is present on **MODE** display during self test.

Low Pitch Audible Warning

(a) Sounds when any message is displayed on the **MODE/FREQUENCY** display (except recalled messages).
(b) Sounds when any invalid bus command is received.

FREQUENCY/MODE display

Error 1	- Spec Mode: [%]	- Tolerance exceeds 100%.
	:[+Lim, -Lim]	- The selected limit is off-scale.
Error 2	- Calibrate Mode	- OUTPUT OFF.
Error 3	- Calibrate Mode	- Incorrect FUNCTION, OUTPUT or FREQUENCY RANGE for this calibration mode.
Error 4	- Calibrate Mode	- Correction out of limits.
Error 5	- Offset or Error Mode	- Temporary message. The selected deviation would exceed the full scale value. **Activation has been prevented.**
Error 6	- Calibrate Mode (Resistance)	- The resistance value selected exceeds the calibration value.
Error 7	- 100V and 1000V Ranges	- Temporary message. The selected Voltage and Frequency exceeds the 4708 internal constraints. **Activation has been prevented.**
Error 8	- Selection error	- Temporary message. The operation requested by the user is not possible in present machine configuration.
Error 9	- Option not fitted	- Temporary message. The requested range or function option is not fitted.
Error EF	- External frequency	- The external frequency is not present, machine will perform out of specification.
Error OL	- Voltage Ranges	- The output has been current-limited by an overload. (If in 100V or 1000V range, OUTPUT is automatically switched OFF).
	- Current Ranges	- The terminal voltage has been **compliance-limited** to 3V. (Load impedance too high).

FAIL 1	- Excessive internal temperature.
FAIL 2	- Over-voltage
FAIL 3	- Control data corrupted
FAIL 4	- Precision divider fault
FAIL 5	- Safety circuits tripped
FAIL 6	- Calibration memory sumcheck non-parity
FAIL 7	- 400V power supply fault - this 'trip' may reset itself if no hardware fault exists and the Fail message is temporary.
FAIL 8	- 38V power supply fault
FAIL 9	- 15V in-guard power supply fault
FAIL 10	- Model 4600 communication fault

SAFEtY	- Test Mode	- Safety circuits tested by tripping: Press **Reset** key to continue test.
running	- Test Mode	- Indicates test in progress.
PASS	- Test Mode	- **FAIL 6** did not occur during test of calibration memory parity, and **FAIL 2** did not occur during test of over-voltage thresholds.

Recalled Messages

ISS XX.XX - Firmware issue number (selected by pressing **Error** then **-Lim**).
Addr XX - IEEE 488 Bus address as set on Address switch (selected by pressing **Error** then **+Lim**).

Processor 'Busy' (Keyboard Unreceptive)

The 4708 will not respond to commands while legend '**B**' is present on the MODE and OUTPUT displays except to override during safety delay.

KEY LEDs

Basic Indications:

Lit	- The labelled facility is selected and active.
Unlit	- The labelled facility is not selected.
Lit Green (Spec and Error only)	- Other **MODE** keys' facilities are reassigned to the secondary modes printed ABOVE their keys, as directed by the arrows.
Lit Green (Store only)	- **FREQUENCY RANGE** keys are reassigned to select **F1-F5** memory stores.

Warnings with Function DC or AC Selected:

OUTPUT RANGE 100V or **1000V** LED flashing

- A voltage in excess of **110V DC** or **75V RMS AC** has been selected (**OUTPUT ON** or **OFF**).

ON LED flashing while in **Low Voltage State** with **OUTPUT ON**

- An attempt to select output in excess of **110V DC** or **75V RMS AC** has been prevented.
- Repressing **OUTPUT ON** key will switch the **HIGH VOLTAGE ON.**

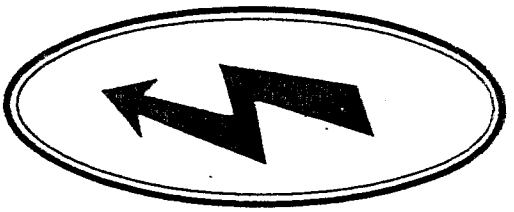
DANGER

HIGH VOLTAGE

THIS INSTRUMENT IS CAPABLE OF DELIVERING

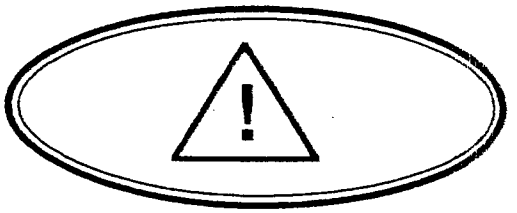
A LETHAL ELECTRIC SHOCK !

when connected to a high voltage source



FRONT or REAR terminals carry the Full Input Voltage

THIS CAN KILL !



Guard terminal is sensitive to over-voltage

It can damage your instrument !

Unless **you** are **sure** that it is **safe** to do so,

DO NOT TOUCH

the **I+ I- Hi** or **Lo leads** and **terminals**

DANGER

SECTION 5 SYSTEMS APPLICATION VIA THE IEEE 488 INTERFACE

Introduction

Section 5 gives the information necessary to put the 4708 into operation on the IEEE 488 bus. As some operators will be first time users of the bus, the text is pitched at an introductory level. For more detailed information, refer to the standard specification, which appears in the publication ANSI/IEEE Std. 488-1978.

Section Contents

The section is divided so as to group certain types of information together. These divisions are:

Interface Capability - the permitted options which have been implemented in the 4708.

Typical System - a brief view of a typical process using the 4708 to check a DMM calibration.

Using the 4708 in a System - implications of bus operation.

Programming Instructions - how the 4708 facilities have been transferred into remote commands.

Programming of Operational Functions - more detail about the codes which control 4708 operation.

Programming of Bus Transmissions - how to program the 4708 to obtain specific types of readout.

Service Request - why the 4708 needs the controller's attention and how it gets it.

Activation of Commands - what the 4708 does with the commands it receives.

Operational Sequence Guidelines - a little general help with programming sequences.

INTERFACE CAPABILITY

IEEE Standard 488

The 4708 conforms to the Standard specification IEEE 488-1978 - 'IEEE Standard Digital Interface for Programmable Instrumentation'.

It can be connected to the IEEE 488 Interface Bus and set into programmed communication with other bus-connected devices under the direction of a system controller.

Programming Options

The instrument can be programmed via the IEEE Interface, to:

(1) Change its operational state (Range, Function, Frequency, Mode, Output, etc.)
(2) Transmit its own status data to other devices on the bus.
(3) Request service from the system controller.

Capability Codes

To conform to the standard specification, it is not essential for a compatible device to encompass the full range of bus capabilities.

The IEEE 488 document describes and codes each of the standard bus features, so that manufacturers can provide brief coded descriptions of their own interfaces' overall capability. A code string is often printed on the product itself.

The codes which apply to the 4708 are given in Table 5.1, together with short descriptions. They also appear on the rear of the instrument next to the interface connector.

Appendix C of the IEEE 488 document contains a fuller description of each code.

Code	Interface Function
SH1	Source Handshake Capability
AH1	Acceptor Handshake Capability
T6	Talker (basic talker, serial poll, unaddressed to talk if addressed to listen)
TEØ	No Address Extension Talker Mode
L4	Listener (basic listener, unaddressed to listen if addressed to talk)
LEØ	No Address Extension Listener Mode
SR1	Service Request Capability
RL2	Remote/Local Capability (without Local Lockout)
PPØ	No Parallel Poll Capability
DC1	Device Clear Capability
DTØ	No Device Trigger Capability
CØ	No Controller Capability
E1	Open-Collector Drivers

Table 5.1 IEEE Interface Capability

Bus Addresses

When an IEEE 488 system comprises several instruments, a unique 'Address' should be assigned to each to enable the controller to communicate with them individually.

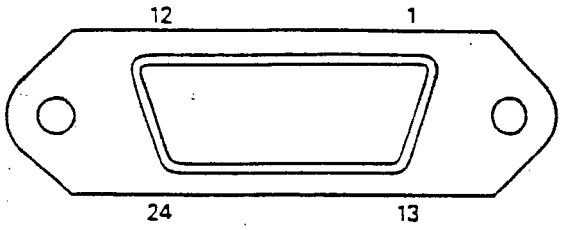
One address is sufficient for a Datron instrument, as the controller can add information to it to define either 'talk' or 'listen'.

Interconnections

Instruments fitted with an IEEE 488 interface normally communicate through a set of interconnecting cables, specified in the IEEE 488-1978 Standard document.

The 4708 interface connector, J27, is fitted on its rear panel. It receives the specified connector, whose pin designations are also standardised and shown in Fig. 5.1 and Table 5.2.

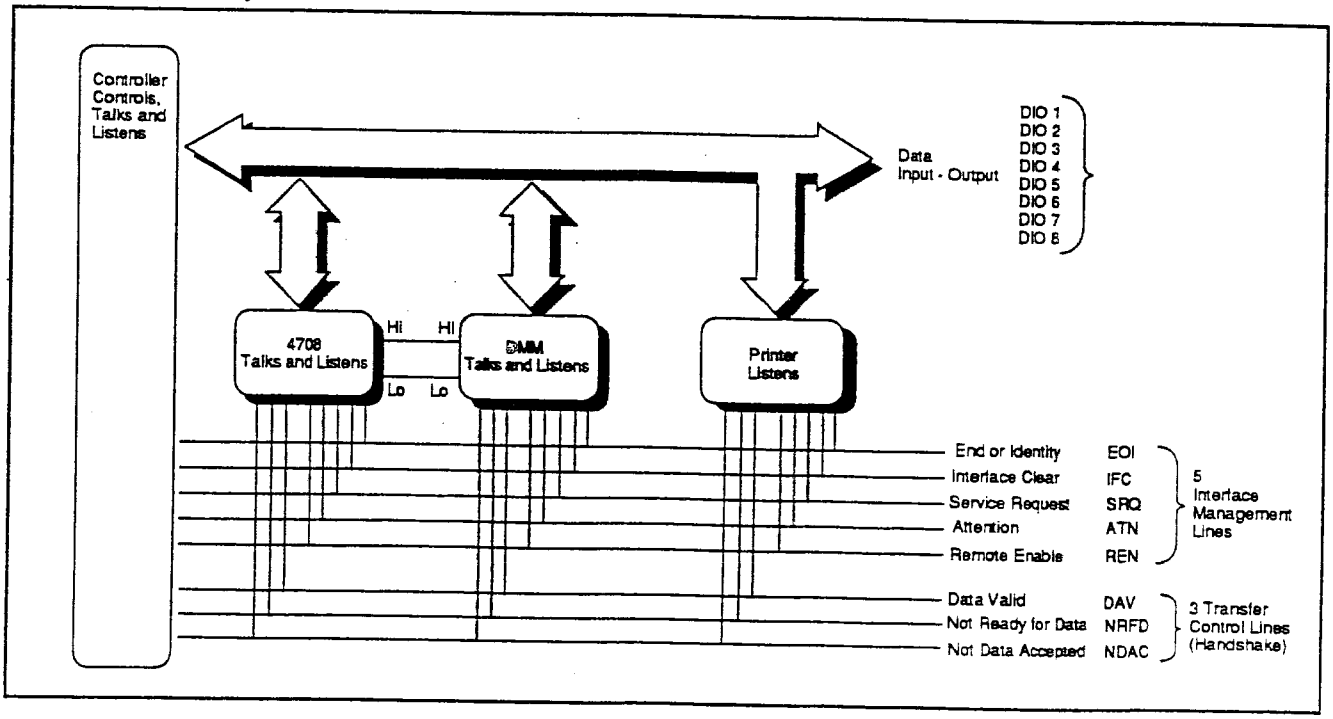
Fig. 5.1 J27 Pin Layout



J27 Pin No.	Name	Description
1	DIO 1	Data Input Output Line 1
2	DIO 2	Data Input Output Line 2
3	DIO 3	Data Input Output Line 3
4	DIO 4	Data Input Output Line 4
5	EOI	End or Identify
6	DAV	Data Valid
7	NRFD	Not ready for Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Screening on cable (connected to Safety Ground)
13	DIO 5	Data Input Output Line 5
14	DIO 6	Data Input Output Line 6
15	DIO 7	Data Input Output Line 7
16	DIO 8	Data Input Output Line 8
17	REN	Remote Enable
18	GND 6	Gnd wire of twisted pair with DAV
19	GND 7	Gnd wire of twisted pair with NRFD
20	GND 8	Gnd wire of twisted pair with NDAC
21	GND 9	Gnd wire of twisted pair with IFC
22	GND 10	Gnd wire of twisted pair with SRQ
23	GND 11	Gnd wire of twisted pair with ATN
24	GND	4708 Logic Ground (Internally connected to 4708 Safety Ground)

Table 5.2 IEEE 488-1978 Connector - Pin Designations

Fig 5.2. Typical System



Typical System

A typical system is shown in Fig. 5.2. The system is directed by a controlling device able to:

(a) 'Control' (Issue commands)
(b) 'Listen' (Receive data)
and (c) 'Talk' (Transmit data)

EXAMPLE OF A SYSTEM IN OPERATION

In the system example (Fig. 5.2) the programme task could be to check the DMM calibration against the 4708, and print out the results. The following is a typical squence of events:

(1) The controller needs to instruct the 4708 to set its output to a calibration point for the DMM. These commands must not be received by the DMM or the printer and so the controller sends the general bus message **'Unlisten'**. When sending general messages, the controller makes all bus devices interpret any DIO-line data as configuration or data-flow commands, by holding the ATN line true.

(2) The controller then sends the 4708 listen address to force it to receive, followed by 4708 configuration commands (including the **Output Disable** message, to prevent the DMM receiving an inappropriate analog input). The instructions are passed along the **DIO** (data input-output) lines as coded messages (bytes). The code is used in **ASCII** (American Std. Code for Information Interchange).

(3) Although the 4708 accepts the instructions as they are passed, their implementation takes a short time. The controller would perform other tasks during this period. In the example, it would pass configuring commands to the DMM, after 'Unlisten' and the DMM listen address have been sent.

(4) The DMM also needs time to settle into stable operation, so the controller performs other tasks while waiting, such as configuring the printer.

(5) The controller next generates 'Unlisten', addresses the 4708 as listener, and reconfigures its Analog Output On by an **Output Enable** message. If the 4708 has executed its previous instructions, it sets OUTPUT ON immediately, otherwise the OUTPUT is set ON as soon as they have been executed. In either case, the instrument sends a message back to the controller via the **SRQ** (Service Request) management line, if programmed to do so.

(6) As the SRQ facility is available to all bus devices (Wired-OR function), the controller needs to discover which one sent the 'SRQ'. It therefore asks all devices one by one (**'serial poll'**), finds out that the 4708 is the SRQ source and that its OUTPUT is ON.

(7) It next addresses the DMM as a listener, and sends the **GET** message (Group Execute Trigger) via the DIO lines to initiate the reading. After a short delay for measurement, the DMM prepares output data and SRQ's the controller when it is ready for transfer.

(8) The controller identifies the DMM by a serial poll. Finding that the reading is available, it sends the DMM's talk address, and printer's listen address, to activate both devices.

(9) The controller sets the ATN line false, thus releasing both devices to start the transfer. The DMM sends its data, byte by byte, via the DIO lines to the printer. This data must be in a form acceptable to the printer, and to ensure orderly transfer, each byte is transferred by **'Handshake'**, using the three Transfer-Control lines.

(10) Usually the controller is also listening to this data transfer to determine when it is complete. As an aid to the controller and printer, the DMM can send another message with the last byte to be transferred (EOI-end or identify, using another bus management line).

(11) The sequence is complete, and the controller can start again at another calibration point.

The controller holds the **REN** line true when taking remote control. It can send an addressed command **GTL**, or some controllers can set REN false, to permit temporary manual control of a device. The **IFC** line is used at the discretion of the controller, to clear any activity off the bus.

Sequences such as this are often assembled into programs to check DMMs at many calibration points; changing functions, ranges and output levels as designed by the user. The program would also include 'display' messages to complete the printout in a recognizable form for the user's convenience. Programs must also cater for FAIL and ERROR SRQs.

Note that many of the individual steps detailed above will be transparent to the programmer. The level of transparency will be dependent on the controller. Refer to the relevant documentation for further information.

With a Datron Autocal DMM, other sequences can cause the DMM errors to be reduced until they are within specification, using its 'calibrate' mode.

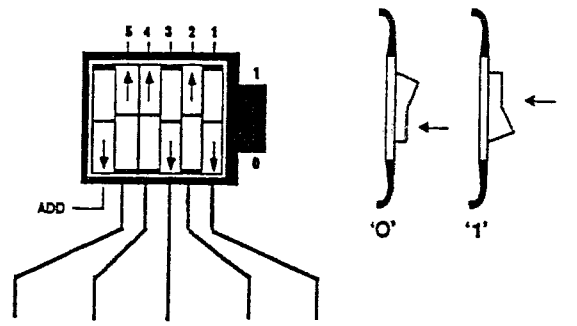
Using the 4708 in a System

ADDRESSING THE 4708

Bus Address

The instrument address is set manually using a six-way miniature switch near the interface connector on the rear panel. Five of the switches are used to set any address in the range 00 to 30, using a binary code.

e.g. Switch setting ; ADD 11010 = ADDRESS 26



A5	A4	A3	A2	A1	Decimal Code	
0	0	0	0	0	00	
0	0	0	0	1	01	
0	0	0	1	0	02	
0	0	0	1	1	03	
0	0	1	0	0	04	
0	0	1	0	1	05	
0	0	1	1	0	06	
0	0	1	1	1	07	
0	1	0	0	0	08	
0	1	0	0	1	09	
0	1	0	1	0	10	
0	1	0	1	1	11	
0	1	1	0	0	12	
0	1	1	0	1	13	
0	1	1	1	0	14	
0	1	1	1	1	15	
1	0	0	0	0	16	
1	0	0	0	1	17	
1	0	0	1	0	18	
1	0	0	1	1	19	
1	0	1	0	0	20	
1	0	1	0	1	21	
1	0	1	1	0	22	
1	0	1	1	1	23	
1	1	0	0	0	24	
1	1	0	0	1	25	
1	1	0	1	0	26	(e.g. above)
1	1	0	1	1	27	
1	1	1	0	0	28	
1	1	1	0	1	29	
1	1	1	1	0	30	

Table 5.3 Address Selection

'ADD'

The sixth switch is provided for possible future variants. In the 4708, the position of the ADD switch is immaterial, as the normal bus addresses can be selected at either setting.

Addresses 0-30

With an address selected in the range 0 to 30 the instrument may be controlled manually, or remotely as part of a system on the Bus. The address selected must be the same as that used in the controller program to activate the 4708.

N.B. The selected address can be temporarily displayed on the front panel when in manual control, by touching **Error** and then **Guard**.

Remote Operation

When the 4708 is operating under the direction of the controller, the legend **rem** appears on the mode display, and all front panel controls are disabled except **Power**.

On entering, any earlier (manual) selection of **Error** mode is cancelled. During remote operation, the facilities of **Error** mode are excluded, as they can easily be programmed into the controller. Spec mode is also cancelled, but 'Spec' information can be obtained by bus command. There is no **Spec** mode display on the front panel during remote operation.

The 4708 power-up sequence is performed as for manual operation. After power-up, and on recovery from a power failure, the 4708 generates an **SRQ** and prepares an **'RQS Status Byte'** for transmission to the controller as a response to its subsequent **serial poll.**

Calibration Enable

A **'Calibration Enable'** command via the bus is required to set the instrument into its Remote Calibration mode (the **CALIBRATION ENABLE** keyswitch on the rear panel must already be set at **ENABLE**). Selection of any address 0-30 inhibits **manual** calibration from the front panel. In **remote**, calibration may be initiated with any address in range 0 - 30 selected.

Address 31 (Illegal bus address)

This address configures manual operation only, inhibiting remote facilities. Address 31 **must** be selected (with CAL key set to ENABLE), for manual calibration to be carried out.

Temporary Transfer to Local Operation (GTL)

The 4708 can be programmed to switch into **'Local'** operation (Command GTL), permitting a user to take manual control from the front panel. The system controller regains **'Remote'** control by sending the following overriding commands:

LAD with REN True

The controller addresses the 4708 as a listener with the **Remote Enable** management line true (Low). This returns the 4708 from local to remote control. Any commands which had been sent during the period under local control will then be executed.

SDC

Specific **'Device Clear'** commands are sent over the bus, returning the 4708 to a predetermined state (described later in this section).

Programming Instructions

Programming Strings

From the example given earlier in this section it is evident that the 4708 requires an address code followed by a series of device-dependent messages or commands to alter its configuration.

A series of these commands can be sent together as a '**program string**', each programming instruction being position-dependent.

Each string will contain at least one programming instruction (detailed later in this section), but the 4708 must receive the string '**terminator**' before it can activate any instructions. The required terminator for the 4708 is either the ASCII character '=' or EOI asserted coincident with the line feed character (decimal 1Ø).

R4F301 =

e.g. programming instructions — **string terminator**

To assist in eliminating incorrect programming instructions, the 4708 checks for errors in the string, and generates a service request (**SRQ**) if a syntax error occurs or if an option is called for but not fitted. To ensure that the programming string does not set up a prohibited state, it also checks the whole string for validity. If it finds any errors in this phase, the whole command string is ignored.

For Example:

With the 4708 set in 10mV Range, a string is received which contains an unacceptable command to switch Sense connection ('S' command). The user needs to set up a completely new, valid string: so the whole string is discarded.

Device-dependent commands

To give maximum scope for system programming, the bus operation of the 4708 differs in detail from manual operation, which is organised for ease of front panel use. Some functions of the 4708 firmware are deleted for bus operation, as they are easily programmed into the system controller; and extra functions have been made available to take advantage of the controller's added computing power.

The following Alphabetic codes are used to establish the required functioning of the 4708 as a calibration source:

Full Range/Zero:	A
Safety Delay Override:	D
Output ON/OFF:	O
Function DCV, ACV, DCI, ACI, Ω:	F
Output Range in all Functions:	R
Output Value:	M
Frequency:	H
Spot Frequencies:	T
Sense:	S
Guard:	G
'Calibrate' trigger:	C
Calibration Mode Enable:	W

The following Alphabetic codes are used to select and configure the messages to be passed by the 4708 via the IEEE Bus:

User memory	I
Output string terminators:	K
Notation of output values:	L
Specification tolerances (relative: per unit):	P
Specification tolerances (absolute limits):	U
Recall/Verify (relative):	V
Service request origination:	Q
Diagnostic information:	X

Table 5.4 lists the range of device-dependent command codes available.

Fig. 5.3 summarises the way that front panel functions are transferred to system operation.

CONTROL	CODE	DESCRIPTION
Full Range/Zero	A0	Zero) But not in Autorange
	A1	+Full Range) (i.e. not if R0 set)
	A2	-Full Range)
Calibration Mode	C0	"CAL" (Calibration Trigger)
	C1	"SET"
	C3	"±0" (in DC) see
		"Precal" (in AC) Section 8
	C4	DC Coarse Linearity
	C5	DC Linearity
Safety Delay	D0	Safety delay Active
	D1	Safety dealy Over-Ridden
Function	F0	V (DC Voltage)
	F1	V~ (AC Voltage)
	F2	A (DC Current)
	F3	A~ (AC Current)
	F4	R (Resistance)
Guard	G0	Local Guard
	G1	Remote Guard
Frequency	H****	Numeric value of frequency
Memory (users Aide-Memoire)	I	Store next 16 ASCII Characters
Output String Terminators	K0	Cr followed by Lf with EOI
	K1	Cr followed by Lf
	K2	Cr with EOI
	K3	Cr
	K4	Lf with EOI
	K5	Lf
	K6	EOI with last character
	K7	No terminator
Value Notation	L0	Scientific with legends
	L1	Scientific with no legends
	L2	Engineering with legends
	L3	Engineering with no legends
Main Register Value	M±***	Numeric value of 'Output' display
Output	O0	Output OFF
	O1	Output ON
Specification Tolerance	P0	24 hours
	P1	90 days
	P2	1 year
Service Request	Q0	SRQ on all specified states
	Q1	SRQ on Overload and Fail only
	Q2	No SRQs
Output Range	R0	Autorange
	R1	100µ —
	R2	1m 10Ω
	R3	10m 100Ω
	R4	100m 1kΩ
	R5	1 10kΩ
	R6	10 100kΩ
	R7	100 1MΩ
	R8	1000 10MΩ
	R9	— 100MΩ
Sense	S0	Local Sense
	S1	Remote sense
Spot Frequencies	T0	Cancel Spot Frequency
	T1	SF1
	T2	SF2
	T3	SF3
	T4	SF4
	T5	SF5
Specification Tolerance (Absolute Limits of Uncertainty)	U0	24 hours)
	U1	90 days) Output low limit to bus
	U2	1 year)
	U3	24 hours)
	U4	90 days) Output high limit to bus
	U5	1 year)
Recall/Verify	V0	'OUTPUT' Value
	V1	'Frequency Setting'
	V2	4708 Status
	V3	Software Status (Part No/Issue)
	V4	F1)
	V5	F2)
	V6	F3) Recall 'Stored' frequency issue
	V7	F4)
	V8	F5)
Calibration	W0	Calibration Mode Disable
	W1	Calibration Mode Enable
Diagnostic (The callstore values relate to the function set at the time) Refer to Calibration and Servicing Handbook for description of correct process	X0	Zero Cal Store
	X1	Gain Cal Store
	X2	STD Cal Gain Factor
	X3	Zero offset)
	X4	Gain Offset) Factory
	X5	Linearity (not AC)) corrections
	X6	Reference Divider Setting
	X7	Not Used
	X8	User Message Recall

Table 5.4 4708 IEEE 488 Command Codes

CONTROL	CODE	DESCRIPTION
Full Range/Zero	**A0**	Zero) But not in Autorange
	A1	+Full Range) (i.e. not if R0 set)
	A2	-Full Range)
Calibration Mode	**C0**	"CAL" (Calibration Trigger)
	C1	"SET"
	C3	"±0" (In DC) **see**
		"Precal" (In AC) **Section 8**
	C4	DC Coarse Linearity
	C5	DC Linearity
Safety Delay	**D0**	Safety delay Active
	D1	Safety delay Over-Ridden
Function	**F0**	V (DC Voltage)
	F1	V~ (AC Voltage)
	F2	A (DC Current)
	F3	A~ (AC Current)
	F4	R (Resistance)
Guard	**G0**	Local Guard
	G1	Remote Guard
Frequency	**H******	Numeric value of frequency
Memory (users Aide-Memoire)	**I**	Store next 16 ASCII Characters
Output String Terminators	**K0**	Cr followed by Lf with EOI
	K1	Cr followed by Lf
	K2	Cr with EOI
	K3	Cr
	K4	Lf with EOI
	K5	Lf
	K6	EOI with last character
	K7	No terminator
Value Notation	**L0**	Scientific with legends
	L1	Scientific with no legends
	L2	Engineering with legends
	L3	Engineering with no legends
Main Register Value	**M±*****	Numeric value of 'Output' display
Output	**O0**	Output OFF
	O1	Output ON
Specification Tolerance	**P0**	24 hours
	P1	90 days
	P2	1 year
Service Request	**Q0**	SRQ on all specified states
	Q1	SRQ on Overload and Fail only
	Q2	No SRQs
Output Range	**R0**	Autorange
	R1	100µ —
	R2	1m 10Ω
	R3	10m 100Ω
	R4	100m 1kΩ
	R5	1 10kΩ
	R6	10 100kΩ
	R7	100 1MΩ
	R8	1000 10MΩ
	R9	— 100MΩ
Sense	**S0**	Local Sense
	S1	Remote sense
Spot Frequencies	**T0**	Cancel Spot Frequency
	T1	SF1
	T2	SF2
	T3	SF3
	T4	SF4
	T5	SF5
Specification Tolerance (Absolute Limits of Uncertainty)	**U0**	24 hours)
	U1	90 days) Output low limit to bus
	U2	1 year)
	U3	24 hours)
	U4	90 days) Output high limit to bus
	U5	1 year)
Recall/Verify	**V0**	'OUTPUT' Value
	V1	'Frequency Setting'
	V2	4708 Status
	V3	Software Status (Part No/Issue)
	V4	F1)
	V5	F2)
	V6	F3) Recall 'Stored' frequency issue
	V7	F4)
	V8	F5)
Calibration	**W0**	Calibration Mode Disable
	W1	Calibration Mode Enable
Diagnostic (The calistore values relate to the function set at the time) Refer to Calibration and Servicing Handbook for description of correct process	**X0**	Zero Cal Store
	X1	Gain Cal Store
	X2	STD Cal Gain Factor
	X3	Zero offset)
	X4	Gain Offset) Factory
	X5	Linearity (not AC)) corrections
	X6	Reference Divider Setting
	X7	Not Used
	X8	User Message Recall

Table 5.4 4708 IEEE 488 Command Codes

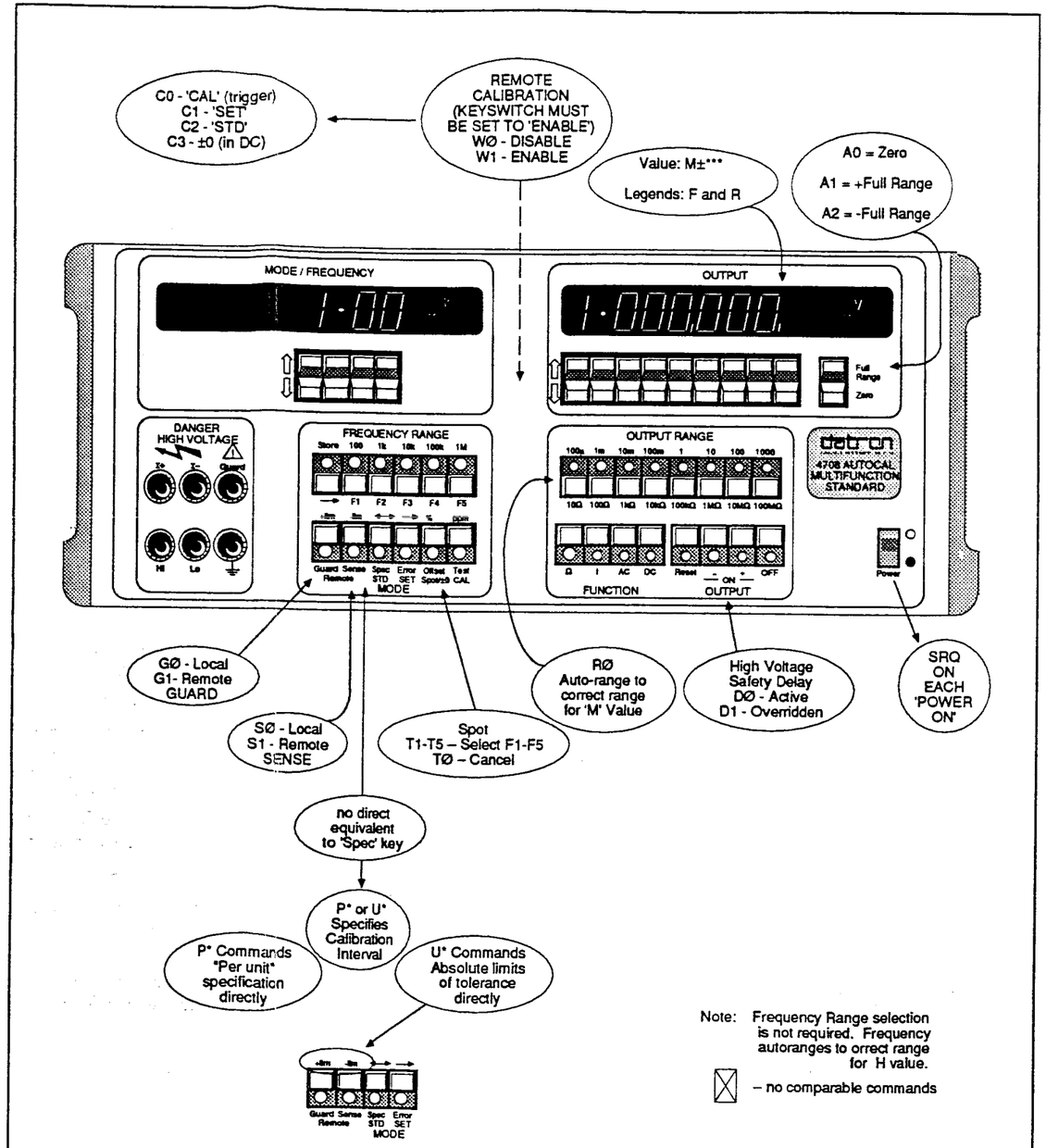
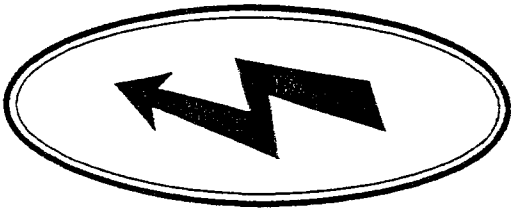


Figure 5.3 Transfer of Front Panel Controls to System Operations

DANGER
HIGH VOLTAGE



FRONT or REAR terminals
carry the Full Input Voltage
THIS CAN KILL !

READ THIS: For manual operation, the 4708 High Voltage Interlocks ensure that users employ deliberate actions before voltages in excess of 100V DC or 75V RMS are generated at the output terminals.

In system applications, the same interlocks require the same deliberate commands to be received from the system controller. (But see Safety Delay Override command D1 in the text).

In manual operation the user who is exposed to danger from high voltage also has direct control of the 4708 output, but it is not possible to give the same degree of built-in protection to exposed users when the instrument is under remote programming, so it is ESSENTIAL that WHENEVER THE 4708 IS BEING USED IN A SYSTEM TO GENERATE VOLTAGES IN EXCESS OF 75V, THERE MUST BE NO ACCESS TO THE 4708 FRONT PANEL OR REAR PANEL OUTPUT TERMINALS.

Unless **you** are **sure** that it is **safe** to do so,
DO NOT TOUCH
the **I+ I- Hi** or **Lo leads** and **terminals**

DANGER

Programming of Operational Functions

OUTPUT ON/OFF

The analog OUTPUT is switched off by command **0Ø** (output disable), and switched on to the selected value by **01**. The amplitude and frequency of the output are derived from the **'M'** code and **'H'** code data used to set the **'Main'** (OUTPUT display), and **'Auxiliary'** (MODE/FREQUENCY display) registers.

Safety Delay

The High Voltage Safety delay (3 seconds) is normally active (**DØ**). It can be overridden by the command **D1**, but the use of this command sets up potentially dangerous situations. **DØ** is enforced by any Function or Range change (including Autorange changes).

WARNING:

DO NOT USE D1 UNLESS IT IS ESSENTIAL FOR HIGH SPEED OPERATION. TAKE SAFETY PRECAUTIONS TO PROTECT PERSONNEL IN THE VICINITY.

Function

FØ (DC voltage), **F1** (AC voltage), **F2** (DC Current), **F3** (AC Current) and **F4** (Resistance) configure the instrument to the required function.

Output Range

R1 through to R9 configure the 4708 to specific ranges as shown earlier in Table 5.4. **RØ** puts the instrument in auto-range function, allowing the output value to be specified as a number without setting the actual range. Ranging down occurs at 20% of range, i.e. Full Scale value of next lower range. Ranging up occurs at Full Scale. In autorange, commands AØ, A1 and A2 are invalid.

Output Display Value (Main Register)

In remote programming, the incremental ↑ ↓ method of setting the output value is not used. Instead, Code M±*** is used to set the output value explicitly, either in numeric, scientific or engineering notation (see examples below). If the resolution is too high, the value is truncated to the correct resolution and the controller is informed by SRQ and RQS Status byte (see RQS status byte formats later in this section).

High Voltage Outputs

The change from Low to High voltage state is controlled by the same interlocks which govern the manual changeover (Refer to Section 4, page 4-7). To effect the changeover, the command string:

'M (followed by voltage) 01 ='

should be used if OUTPUT is already on and a range change is not involved. If a range change is programmed to set the output into high voltage state (for instance in **RØ**) the **'01'** should be sent as a separate string.

If the M code alone is attempted (**M***...=) with OUTPUT already enabled (**01**), the new value is set in the Main Register (OUTPUT display); but the output voltage will not ramp to high voltage state until the enabling string **'01 ='** is received.

If the attempt had been made with OUTPUT disabled (**0Ø**), the **01** would be required in any case.

It should also be remembered that the output circuitry needs time to settle to its final value, especially if a range-change is incurred. Delays should be included in the controller program to allow for this.

During these processes, the front panel warnings of flashing LEDs and pulsing tones operate as for manual operation. **Nevertheless, access to the front panel should be restricted because the high speed of programming in the IEEE interface adds to the safety hazard.**

Examples of valid M codes:

Required Output Value	Function	Range	M Code	Output Display
-153V	FØ	R7	M-153	-153.000,0V
+1.621257V	FØ	R5	M+1.6212574	+1.621,2574V
1.621257V RMS	F1	R5	M1621257E-6	1.621,257V ~
1.621257V RMS	F1	RØ	M1621.257E-03	1.621,257V ~ (Autorange to R5 = 1V)
0.002563 RMS	F3	RØ	M.002563	2.56300mA ~ (Autorange to R3 = 10mA)

Output Resolution

The output resolution conforms to the following number of digits:

Range		100µ 10	1m 100	10m 1k	100m 10k	1 100k	10 1m	100 10m	1000 100m	DCV, ACV DCI, ACI Ω
Range Code		R1	R2	R3	R4	R5	R6	R7	R8	
Functions:										
DC Voltage	FØ	4.5	5.5	6.5	7.5	7.5	7.5	7.5	7.5	
AC Voltage	F1	-	4.5	5.5	6.5	6.5	6.5	6.5	6.5	
DC Current	F2	6.5	6.5	6.5	6.5	6.5	-	-	-	
AC Current	F3	6.5	6.5	6.5	6.5	6.5	-	-	-	
Resistance and Local Sense	F4)) SØ)	4.5	5.5	6.5	7.5	7.5	7.5	7.5	7.5	
Resistance and Remote Sense	F4)) S1)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	

Frequency Display Value (Auxiliary Register)

In remote programming, the incremental (↑↓) method of setting the frequency is not used. Instead, each auxiliary register value is input explicitly by Code **H****** in numeric, scientific or engineering notation.

The manual frequency 'Store' memories cannot be set via the bus, although their contents can be read using 'V' codes.

Frequency Resolution

Frequency is resolved to three significant digits (1% to 100ppm accuracy). On the display this occupies four digit spaces, to accommodate the decimal point. If the significance is greater than three digits, the value is truncated and the controller is informed by SRQ Status byte (see SRQ status byte formats later in this section).

Frequency and Voltage Constraints

On 100V and 1000V output ranges, the 4708 will refuse any command for an output which exceeds the limits defined on page 3-7. The controller is informed by **'Error 7'** SRQ status byte (see SRQ status byte formats later in this section).

Spot Frequency Selection

Codes **T1-T5** select the spot frequencies stored in SF1-SF5 non-volatile memories. Sixty unique memory locations exist. Thirty five are allocated to the seven AC Voltage output ranges and twenty five to the five AC Current ranges: five for each range. The value of the frequency called up by any T command is therefore dependent on the preselected **F** and **R** codes. With spot active, sending a new R code selects the corresponding spot frequency in the new range. A new F code, sent to change function, cancels the T command: the 4708 frequency reverts to 1kHz.

The controller is able to command an uncalibrated spot. The 'uncalibrated' message is displayed as in manual operation, the 4708 frequency remaining as previously set. But in addition, the 4708 generates an SRQ to notify the controller. Code **TØ** cancels any earlier spot frequency selection: the 4708 frequency reverts to 1kHz.

N.B. The Spot Frequency facility is included to provide separate, ultra-accurately calibrated points in the 4708 output spectrum. Therefore, frequencies set into the 'spot frequency' memories can only be changed during the Autocal routine (See Section 8).

Guard and Sense

These are configured into Local or Remote by **G** or **S** codes respectively:

- **GØ** - Local Guard
- **G1** - Remote Guard
- **SØ** - Local Sense (forced when F2 or F3 has been commanded and when F0, R1, R2, R3 and R4 or F1, R2, R3 and R4 have been commanded). Programs for 2-wire resistance in F4.
- **S1** - Remote Sense (available only when F0 or F1 have been selected together with R5, R6, R7 and R8 or when F4 has been selected in all ranges). Programs for 4-wire resistance in F4.

These bus commands are subject to the constraints of the 4708 firmware. The instrument will reject and ignore invalid commands, such as **Remote Sense** when in **100mV** range.

Calibration Enable and Calibrate (W and C codes)

These are available for automatic calibration of the 4708, under remote control via the IEEE bus. Refer to the Calibration and Servicing Handbook.

WØ	-	Calibration disable	
W1	-	Calibration enable (only if CALIBRATION ENABLE keyswitch set to ENABLE).	
CØ	-	Calibration Trigger - equivalent to CAL key	) Refer to Section 8.
C1	-	As SET key	)
C2	-	As STD key	)
C3	-	As ±0 key (in DC)	)

Programming of Bus Transmissions

Output String Formation

The 4708 can be commanded to output 'internal' information to the system via the IEEE-488 bus, by sending one of the specified 'recall' messages.

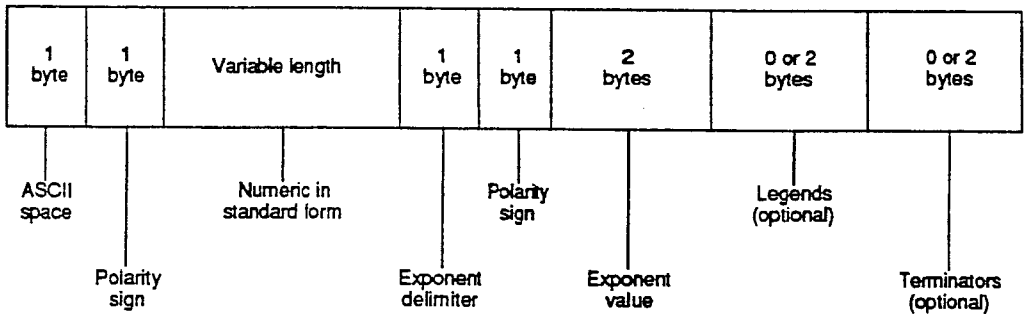
Only one recall command should be included in a terminated string.

As well as the information it contains, the string needs to be formatted correctly for acceptance by the system. Many variations of format are available; these can be programmed for the type of system in use.

The length and construction of the string both depend upon the type of information to be transmitted, and thus upon the codes used to program the 4708. The purpose of this explanation is to describe the effects of these codes on the output string format.

Figure 5.4 illustrates the construction of a typical string, such as the 4708 output value. Notice that numerical data is reduced to a standard form, and scaled by means of an exponent in base 10. All device dependent messages use the ASCII code.

Figure 5.4 Breakdown of a typical Output String
(This is a general example - two specific 4708 examples appears on page 5-12)



ASCII 'Space'
A format character to denote the beginning of an output string - not present for recall command X8.

Polarity Sign
Replaced by an ASCII space in AC Functions. For DC functions, the appropriate polarity sign is presented.

Numeric sub-string
Length depends on the resolution of the information to be transmitted, and form depends on the notation programmed by 'L' code.

Exponent delimiter 'E'
Signifies that the numeric has finished and the next three bytes form the exponent.

Exponent Value
The first of the three bytes is always '+' or '-'. Because the value is never greater than 9, the second byte is always 0, and the third is a single decimal digit.

Legends
Inclusion is optional, but if they are programmed in, two bytes are always present. The characters are appropriate to the programmed state of the 4708.

Terminators
Two terminating characters are available, as programmed by 'K' code. The EOI bus management line can optionally be programmed for simultaneous transmission with the last byte of the string.

Format Codes

The following pages list and describe the programming codes which determine the formation of the output string. The codes on this page select specific types of ASCII strings for retrieval.

Recall/Verify (code V)

By sending a V code the controller interrogates the 4708 to obtain information about its present status. Unless otherwise stated, the output strings are formatted as programmed by K and L codes. The V codes are as follows:

VØ - The present **Output** value
V1 - The present **Frequency** setting
V2 - The present **functional status.**

The response to V2 is a standard ASCII string: **(space R*F*O*G*S*W*Q*D*L*K terminator).** The functions are represented by the same numerics as for programming. In addition, the Output Range is identified by a lower case 'r' if the 4708 is programmed in autorange.

V3 - Software status

The software status is the part number and issue number of the internal program. This is formatted as follows, in response to command code V3:

(space 890077 - numeric terminator)

Part No. Issue No.

(This status report is also available manually by pressing Error key then Lim-. The firmware issue number is presented on the MODE display).

V4-V8- 'Stored' Frequencies

Codes V4 to V8 recall each of the five frequencies held in volatile memory locations F1 to F5. These can only be set or selected manually. (Refer to pages 3-7 and 3-8).

The range of legends transmitted by the 4708 is listed under 'String Formatting Commands (K and L Codes)'.

I-code (Aide Memoire)

This allows the user to identify a specific calibrator with a designator up to 16 characters in length, stored in non-volatile memory. The 4708 must first be placed in the CAL mode by turning the CAL key to ENABLE and sending the W1 command. Sending the I command will store the subsequent 16 character string in memory. This string can be recalled using the X8 command.

N.B. The I-command and the W1 command must not be sent in the same string.

Specification Tolerance (Per unit - P codes)

The P commands give access to Spec mode over the bus, also setting the calibration interval:

PØ - 24 hour; P1 - 90 day; P2 - 1 year

On being commanded by P code, the 4708 calculates the Output Uncertainty of its current state (as a 'per unit' fraction of the output value) and generates an output string formatted by K and L codes. Legends are transmitted as pu (per unit).

Absolute Limits of Tolerance

In this case, the U commands cause the 4708 to calculate the high or low limit of uncertainty of its output value against the nominated calibration interval.

UØ - Low limit 24 hour
U1 - Low limit 90 day
U2 - Low limit 1 year
U3 - High limit 24 hour
U4 - High limit 90 day
U5 - High limit 1 year

On being commanded, the calculated value is output by the 4708 in an output string formatted by K and L codes.

Diagnostic Information

The X commands recall the contents of certain non-volatile calibration memory locations. The values recalled are calibration constants stored at the most recent Autocalibration. They are used in the computations which establish the 4708 output level, as corrections for long-term drift in the analog circuitry.

XØ - Zero Cal. Store
X1 - Gain Cal. Store in DC, LF gain + HF calibration in AC
X2 - 'STD' calibration gain factor
X3 - Zero offset)
X4 - Gain error) factory established
X5 - Linearity (not AC))
X6 - Reference Divider setting
X7 - Not used in 4708
X8 - Recall message which was memorised earlier by the operator using Code I.

Activating the Recall Transmission

The 4708 assembles the appropriate output string in its output registers in response to the V, P, U or X command. It can subsequently be released onto the bus by addressing the 4708 as a talker.

String Formatting Commands (K and L Codes)

The output string can be formatted and terminated to adapt to user's requirements. Scientific or Engineering notation can be programmed, with or without descriptive legends. Two examples are given below.

Codes L0 to L3 configure the output string notation:

LØ - Scientific notation with legends
L1 - Scientific notation, no legends
L2 - Engineering notation with legends
L3 - Engineering notation, no legends

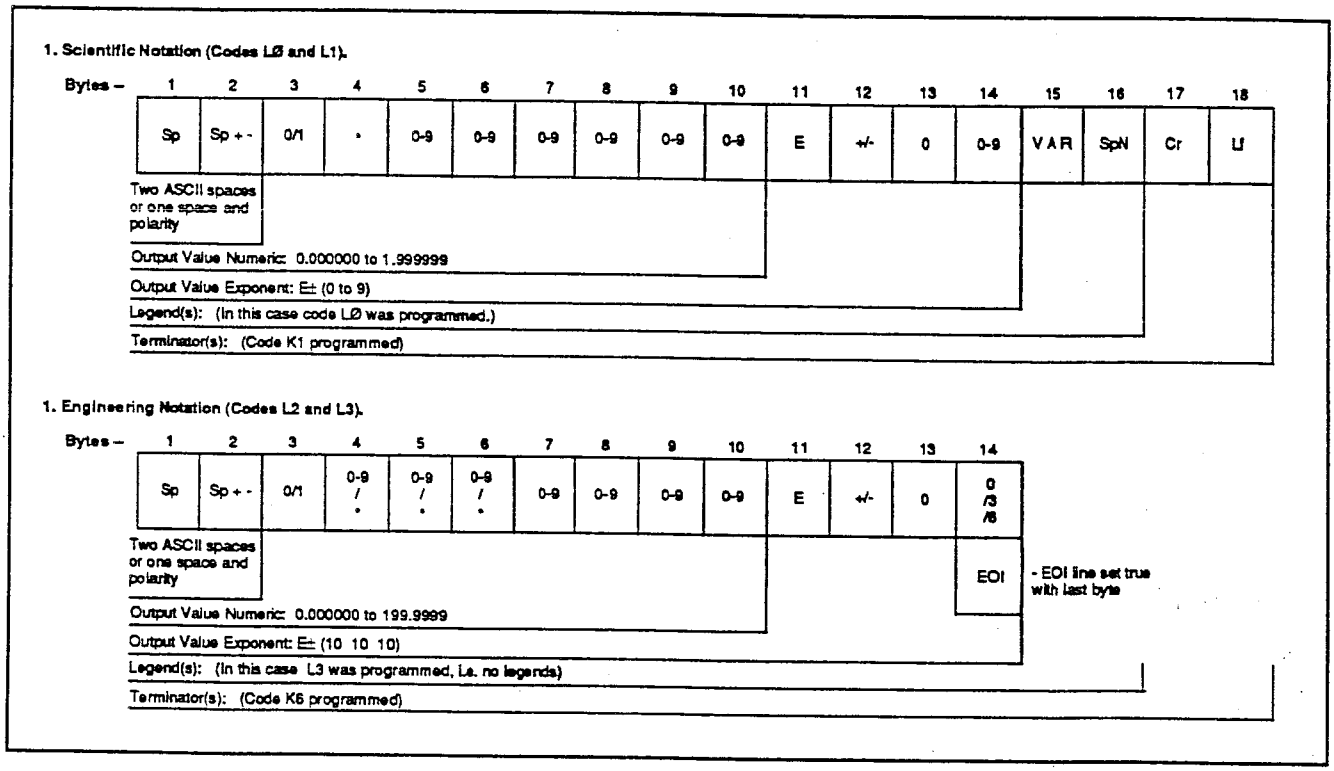
Two sorts of terminator are available:

a. One or two bytes can be added to the end of the string. These contain either Carriage Return (Cr) or Line Feed (Lf); or both in the order: Cr followed by Lf.

b. The EOI bus management line can be programmed to set true simultaneously with the last byte of the string. EOI can be used even if both Cr and Lf are suppressed.

The 4708 can also be programmed to transmit strings without terminators. To accommodate these variations, the system programmer uses the K codes:

KØ	-	No suppression (**Cr, Lf** and **EOI** all present as terminators)
K1	-	Suppress EOI (Terminator **Cr** followed by **Lf**)
K2	-	Suppress Lf (Terminator **Cr** with EOI)
K3	-	Suppress Lf and EOI (Terminator Cr)
K4	-	Suppress Cr (Terminator **Lf** with EOI)
K5	-	Suppress Cr and EOI (Terminator **Lf**)
K6	-	Suppress Cr and Lf (Terminator **EOI** with last character)
K7	-	Suppress Cr, Lf and EOI (**No terminators**)



Descriptive Legends

The following Legends will be fitted into the string after the exponent, if programmed by codes LØ or L2:

Recall	Function	Legend	Meaning
VØ) UØ-U5	F0	V	DC Volts
VØ) UØ-U5	F1	V	AC Volts
VØ) UØ-U5	F2	A	DC Amps
VØ) UØ-U5	F3	A	AC Amps
VØ) UØ-U5	F4	R	Resistance
PØ-P2		pu	per unit
Frequency		Hz	frequency

the 4708 can asynchronously request service from the controller by putting the SRQ line true (low).

SRQ is always generated by the action of switching the 4708 power ON, as the power-up default mode is QØ.

A user can program the 4708 to generate SRQs (or not) using command code Q:

Code	QØ	-	SRQ on any of the states in Table 5.5
	Q1	-	SRQ on overload and any FAIL state in Table 5.5 (but not in Error states).
	Q2	-	No SRQs generated

Serial Poll and RQS Status Byte

If programmed for SRQ response, the bus controller will pause in its operation to attend to the service request. It first conducts a serial or parallel poll to determine which device initiated the SRQ. The 4708 does not react to parallel poll, but only to serial poll, during which each device is addressed in turn. The instrument responds to its serial poll address by releasing a prepared 'RQS Status Byte' onto the bus. The RQS Request Bit (bit B7 of its status byte) is asserted only if the 4708 has generated the SRQ. This validates the remainder of the byte, which describes the causal condition by the state codes listed in Table 5.5.

RQS Status Byte Composition

bit **b8**: Indicates a syntax or option error when true.

bit **b7**: The RQS request bit, when true, confirms that the 4708 was the SRQ originator. The RQS status byte is not valid unless bit b7 is true.

bit **b6 true**: Each combination of bits b5-b1 represents a single state as listed in Table 5.5.

bit **b6 false**: Bits b5-b1 each represent separate functional states within the 4708 and rthe RQS byte represents several states as listed in Table 5.5.

Example with bit b6 false:

RQS status byte 01000001 represents:

0 - No option or Syntax error
1 - This instrument originated the SRQ
0 - The following bits each represent separate states
0 - This bit is not used in the 4708
0 - No High Voltage warning
0 - Auxiliary register not at limit
0 - Main register not at limit
1 - Output is ON

The RQS status byte should not be confused with other status messages (e.g. 'calibrator' or 'software' status, described earlier under 'Recall/Verify') which are called up by the system controller's program.

DIO Line Transmissions

Providing QØ or Q1 has been selected; when the 4708 has a message to transmit over the DIO lines, it sets the SRQ line true the subsequent serial poll. On receiving the status byte, the controller can address any device required to receive the data as a listener, and address the 4708 as a talker. Then the message is sent via DIO lines to the programmed listener(s).

Fail Messages

The 4708 needs to react quickly to internally-generated FAIL messages and is programmed to take rapid protective action. A fault condition may generate a train of such internal messages, which occur too quickly for some controllers to detect.

Such a train may be terminated by a FAIL 5 message, which is detected by the controller. Thus the receipt of FAIL 5 by a controller should be taken as a final default condition, and not as indicating the origin of the fault. The FAIL 5 message can be cleared, if the 4708 has recovered, by pressing the **Reset** key on the instrument front panel. As FAIL 5 is related to safety, it cannot be reset by remote control.

Activation of Commands

User of Terminator

The 4708 activates single or multiple commands, only on receipt of the recognised terminator. This is either the ASCII character '=' or EOI coincident with the LF characters.

Commands or command strings may be received while the instrument is in Local control, but will not be activated even if a terminator is present, until the instrument is set to Remote control. The two 'Clear' messages (DCL and SDC) will be activated even when in Local control.

Multiple Commands

Activation Sequence

The input buffer has a capacity of 128 characters. Commands in a multiple string may be entered in any order, provided correct character syntax is observed. They are extracted from the buffer in received sequence and stored by alpha character into command stores. Any existing commands in the store are overwritten and lost.

When a string terminator is received, the commands in the store are validated. Validation ensures that the proposed instrument state (consisting of those changes programmed and those current states not reprogrammed) is valid. Any error results in the string being ignored and a syntax error generated.

Table 5.5 Status Byte Coding – Lists the possible RQS status bytes which may be transmitted by the 4708. The information in the byte is valid only if bit 7 (request bit) is true.

Legend: 1 = True, 0 = False, X = either 1 or 0

bits b8	b7	b6	b5	b4	b3	b2	b1	
1	1	X	X	X	X	X	X	Syntax error
X	1	X	X	X	X	X	X	RQS Request-for-service bit
Combination Status Messages								
X	1	0	X	X	X	X	1	Output ON
X	1	0	X	X	X	1	X	Main Register limit reached
X	1	0	X	X	1	X	X	Auxiliary Register limit reached
X	1	0	X	1	X	X	X	High Voltage Warning
Individual Status Messages								
X	1	1	0	0	0	0	0	Recall message available
X	1	1	0	0	0	0	1	Error 1 Specification not displayable
X	1	1	0	0	0	1	0	Error 2 CAL mode: Output not ON
X	1	1	0	0	0	1	1	Error 3 CAL mode: Incorrect Range/Function
X	1	1	0	0	1	0	0	Error 4 CAL mode: Insufficient store span
X	1	1	0	0	1	0	1	Error 5 Error or Offset mode: Overscale output requested
X	1	1	0	0	1	1	0	Error 6 CAL mode: Resistance selected exceeds val. value
X	1	1	0	0	1	1	1	Error 7 AC Functions: Output has been limited by internal frequency constraints
X	1	1	0	1	0	0	0	Error 8 General selection error
X	1	1	0	1	0	0	1	Error 9 Option not fitted
X	1	1	1	0	0	0	0	Fail 0 Fault condition rectified
X	1	1	1	0	0	0	1	Fail 1 Over-temperature
X	1	1	1	0	0	1	0	Fail 2 Over-voltage
X	1	1	1	0	0	1	1	Fail 3 Control data corrupted
X	1	1	1	0	1	0	0	Fail 4 Precision divider fault
X	1	1	1	0	1	0	1	Fail 5 Safety alarm
X	1	1	1	0	1	1	0	Fail 6 Cal. store sum check non-parity
X	1	1	1	0	1	1	1	Fail 7 400V power supply fault (automatically resets if temporary)
X	1	1	1	1	0	0	0	Fail 8 3V power supply fault
X	1	1	1	1	0	0	1	Fail 9 15V In-guard power supply fault
X	1	1	1	1	0	1	0	Fail 10 Model 4600 communication fault
X	1	1	1	1	0	1	1	Reset. Instrument reset to power-up state
X	1	1	1	1	1	0	0	Error EF External frequency no present
X	1	1	1	1	1	0	1	Spot Frequency not calibrated
X	1	1	1	1	1	1	0	Overload - Current or Voltage limit
X	1	1	1	1	1	1	1	Power-on

Notes: ***(1) Power-up condition:***
DØ FØ GØ KØ LØ MØ OØ QØ RØ(1V) SØ TØ WØ
Device clear condition as power-up but K = and L = continue unchanged
(2) Program string terminator: '=' activates preceding string.

New commands are executed in this sequence:

K	Output terminator format
L	Output notation
Q	SRQ Mode
W	Remote Calibration Enable
I	User Message Input
OØ	OUTPUT OFF
G	Guard
D	Safety Delay override
F	Function
R	Range
M	Main Register Value (Output)
A	Full Range/Zero
S	Sense
H	Auxiliary Register Value (Frequency)
T	Spot Frequency
O1	OUTPUT ON
C	Calibrate Mode
P	Specification tolerance
U	Specification limits
V	Recall/Verify
X	Diagnostic information

A programmer may elect to change the sequence by inserting terminators between commands, but the basic constraints of the 4708 will still be imposed. For example, if the function is changed as a single command (e.g. **F3=**) the main program firmware will set **Output OFF** as a result, and it must then be re-programmed ON by the user.

Succession of Multiple Commands

If the input buffer is not full, new commands are accepted to await their turn for processing, and are extracted string by string. The input system design makes it extremely unlikely that the buffer will overflow, unless the 4708 is in Local Control and the command input is excessive. If this does cause the buffer to fill up, the 4708 places a hold on the IEEE bus handshake sequence. The command **IFC** can be used to release the hold, followed by **DCL** to clear the 4708 input buffer; but as a general principle, this situation should be avoided by suitable reprogramming.

Input Errors

Some unwanted commands are ignored. Others enter the input buffer and are rejected later.

'Read' commands

Before addressing the 4708 as a talker, it is essential that it has been programmed by a **P, U, V** or **X** command. Otherwise it will have no data to transmit.

Universal commands

LLO (Local Lockout) - ignored, no capability.

PPU (Parallel Poll Unconfigure) - ignored, no capability for parallel poll.

SPE (Serial Poll Enable) - sets the 4708 to serial poll state, which when addressed responds with the RQS status byte. This byte contains the condition of the request-service bit (bit 7). If the 4708 is requesting service; bit 7 will be true, the other bits describing the service required.

SPD (Serial Poll Disable) - returns the instrument to serial poll idle state.

Addressed commands

PPC (Parallel Poll Configure) - ignored, no capability.

GET (Group Execute Trigger) - ignored, no capability.

TCT (Take Control) - ignored, no capability.

GTL (Go To Local) - instrument returns to Manual Control. The controller regains remote control by addressing the 4708 as a listener with REN line true.

Clear Commands (DCL and SDC)

When the 4708 receives either of the two 'Clear' messages, (**DCL** is universal and **SDC** is addressed to a selected device) it will default to the predetermined state defined below. During the time taken to default, the IEEE interface handshake is held. These commands are effective even in 'Local' control.

A?	Not Active (see M code)
FØ	DC Volts
RØ	Autorange 1V default
MØ	Where value is zero
TØ	Cancel Spot Frequency
H (value)	Where value is 1kHz
GØ	Local guard
SØ	Local sense
OØ	OUTPUT OFF state
QØ	SRQ on all specified states
DØ	Safety delay active
WØ	Calibration disabled
C?	Not active - disabled by W0
P?	Not active
U?	Not active
V?	Not active
X?	Not active
K*	Unchanged
L*	Unchanged

The frequency values held in 'Store' volatile memory locations F1-F5 are reset to the default state described on page 3-8.