

USER'S HANDBOOK

4910 and 4911

DC Voltage Reference Standards



USER'S HANDBOOK

for

THE DATRON 4910 and 4911 DC VOLTAGE REFERENCE STANDARDS

(for maintenance procedures
refer to the Servicing Handbook)

850254

Issue 1 (January 1990)

For any assistance contact your nearest Datron Sales and Service center.
Addresses can be found at the back of this handbook.

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 instrument serial number are available on request.

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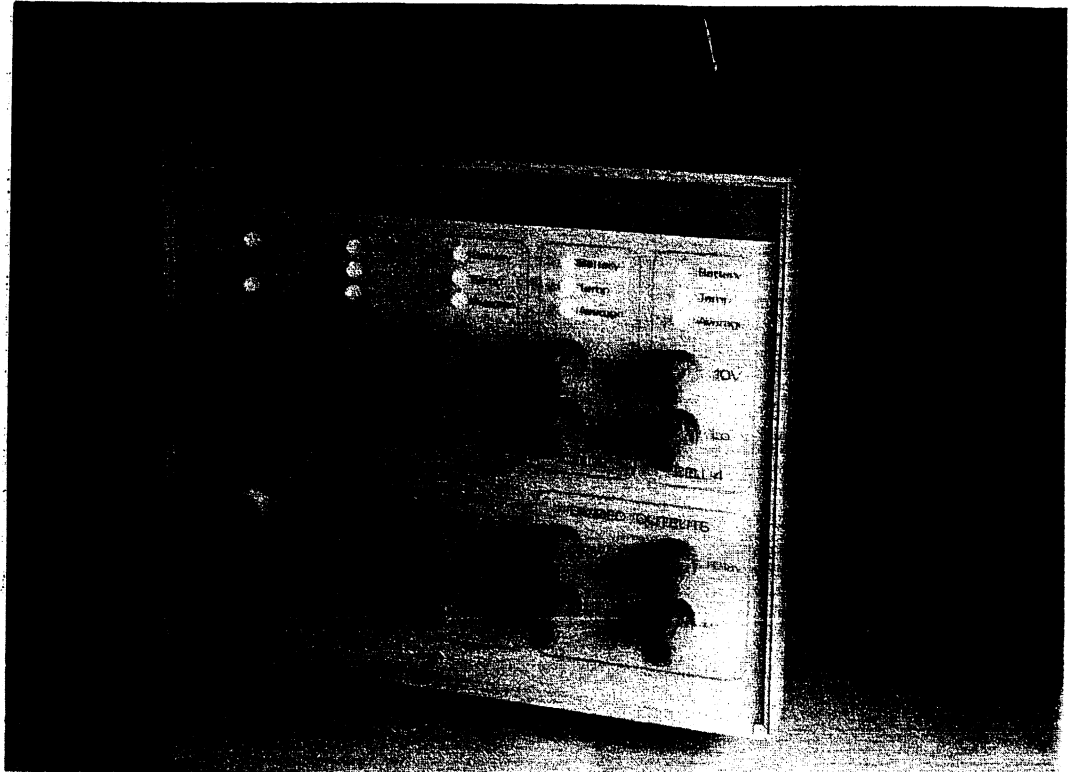
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SECTION 1 INTRODUCTION AND GENERAL DESCRIPTION



Introduction

The 4910 and 4911 are Electronic DC Voltage Reference Standards which feature four separate and highly stable 10V outputs. While their performance is comparable to that of saturated Weston standard cells, they eliminate most of the

drawbacks encountered in standard cell use and maintenance. In addition to replacing saturated Weston cells as a laboratory standard, the 4910 and 4911 can also be used as a readily transportable standard.

General Description

The 4910 and 4911 DC Voltage Standards are based on the latest zener-diode technology. Their four separate 10V outputs are fully independent, but can if required be averaged to provide a very low noise 10V output on separate front-panel terminals. The provision of both individual and average outputs enables direct inter-comparison between the cells at the output terminals, allowing excessive drift in any cell to be detected without the use of higher accuracy standards. The individual outputs are adjustable to within microvolts of one another, so that inter-comparison is possible to a very high level of accuracy.

In addition to its four individual cell outputs and its average 10V output, the 4910 also features 1V and 1.018V outputs, and a low-impedance 10V output with 4-wire sensing.

In their normal operating mode, the units can be powered from an ac line supply or from their internal batteries. Both models also feature a special low-power transit mode, which can be used during transportation or shipment of a unit to maintain its calibration. In transit mode, power can be derived from the unit's internal batteries, from an external DC supply, or from an AC line supply.

Accessories

The 4910 and 4911 DC Voltage Standards are supplied with the following accessories:

Description	Part Number
Power Cable	920012
Power Fuse	
1.6A 250V 32mm Fuse	920229
or	
3.0A 250V 32mm Fuse	920098
Terminal Link	920030
Terminal Link x 2 (4910 only)	450842
9-Way Female 'D' Connector	605195
15-Way Male 'D' Connector	604114
User's Handbook	850254
Servicing Handbook	850258

In addition, the following optional accessories are available for use with the 4910 and 4911:

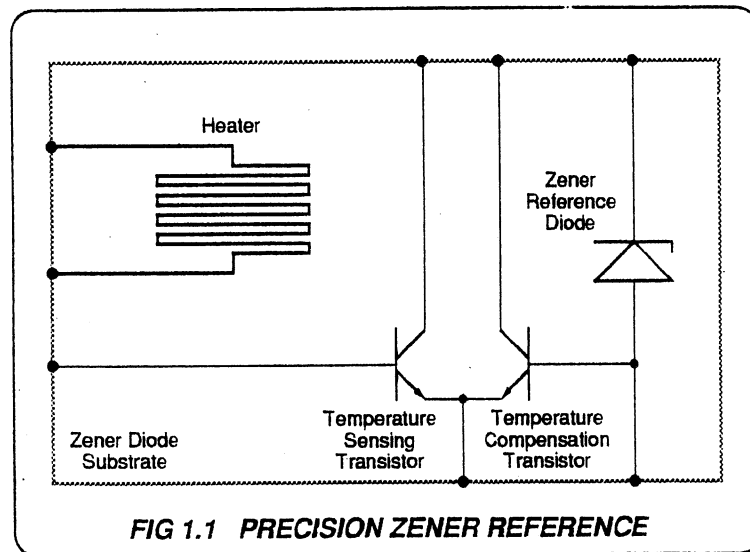
Description	Option Number	Part Number
Calibration and Hot Shipment	Option 10	-
Drift rate characterization derived from 90 days of pre-shipment measurements (must be ordered with Option 10)	Option 20	-
1.018V set to requested 6 decimal place value in the range 1.017000V to 1.019000V (must be ordered with Option 10). Not applicable to 4911.	Option 30	-
Ruggedized Transit Case	Option 40	440168
Soft Carrying Case and Terminal Protector Cover	Option 50	400959
Rack Mount Kit	Option 90	440161

Principles of Operation

The 4910/4911 DC Voltage Standard is based around precision zener-diode voltage references and pulse-width-modulation (PWM) voltage dividers. It is this solid-state circuitry which gives the unit its portability and ease of use.

To eliminate temperature coefficient (TC) problems, the reference zener-diodes are stabilized at a constant temperature, a few °C above the instrument's maximum ambient operating temperature. To facilitate temperature

control, the zener diodes have an on-chip temperature compensation transistor, a temperature sensing transistor and a substrate heating element — see Fig 1.1. These on-chip components allow the chip temperature to be stabilized to within approximately 1 m°C, and by providing direct control of the zener's substrate temperature they avoid the long warm-up times and high power consumptions of conventional temperature controlled "ovens".



The zener reference produces a highly stable output at around 7.2V, which is amplified to produce an accurate 10V output. Rather than using resistors to set the gain of the amplifier, (which would introduce unacceptable TC problems and provide no reliable and simple means of gain adjustment), the 4910/4911 uses a PWM voltage divider as the gain defining element — see Fig 1.2. Coarse gain is controlled by resistors R1 and R2 in a direct feedback path around amplifier A1.

However, precision control of the gain of A1 is provided by the PWM divider and the high DC gain amplifier A2. Because the PWM divider has a negligible TC and ageing coefficient, it automatically compensates for the TC and ageing of resistors R1 and R2. As a result the temperatures of R1 and R2 do not need to be controlled, as is the case for other solid state DC voltage references. In addition, the PWM divider can be controlled totally digitally, and therefore contains no adjustment potentiometers which could contribute to drift.

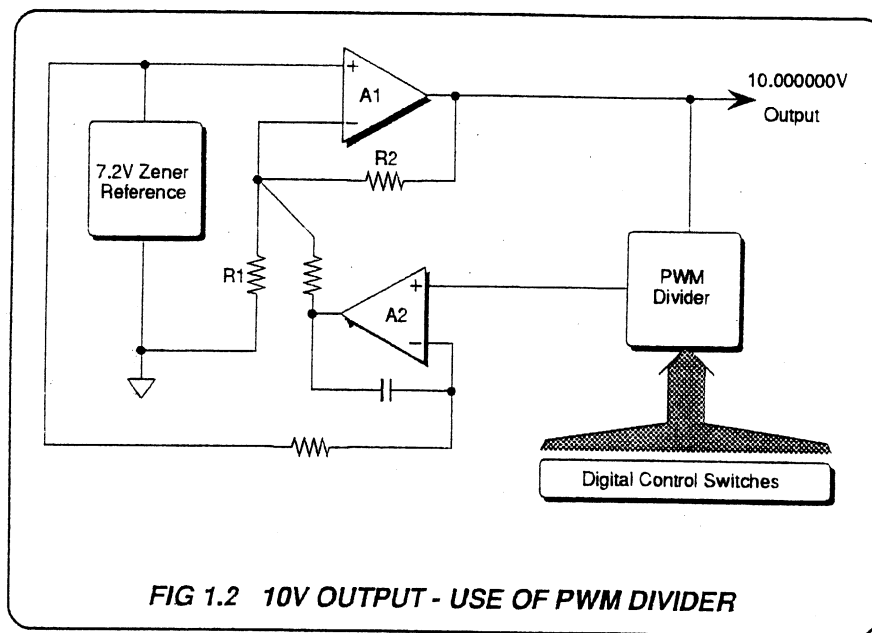


FIG 1.2 10V OUTPUT - USE OF PWM DIVIDER

Section 1 - Introduction and General Description

The 4910/4911 contains four individual 10V reference circuits each with its own pair of front-panel terminals. Totally separate power supplies for each of these reference circuits ensure that they are completely isolated from one another. However, internal shorting links are provided so

that individual 10V outputs can be connected together via 200Ω resistors to provide an average 10V output — see Fig 1.3. This average 10V output is provided unbuffered at front-panel terminals on both the 4910 and 4911.

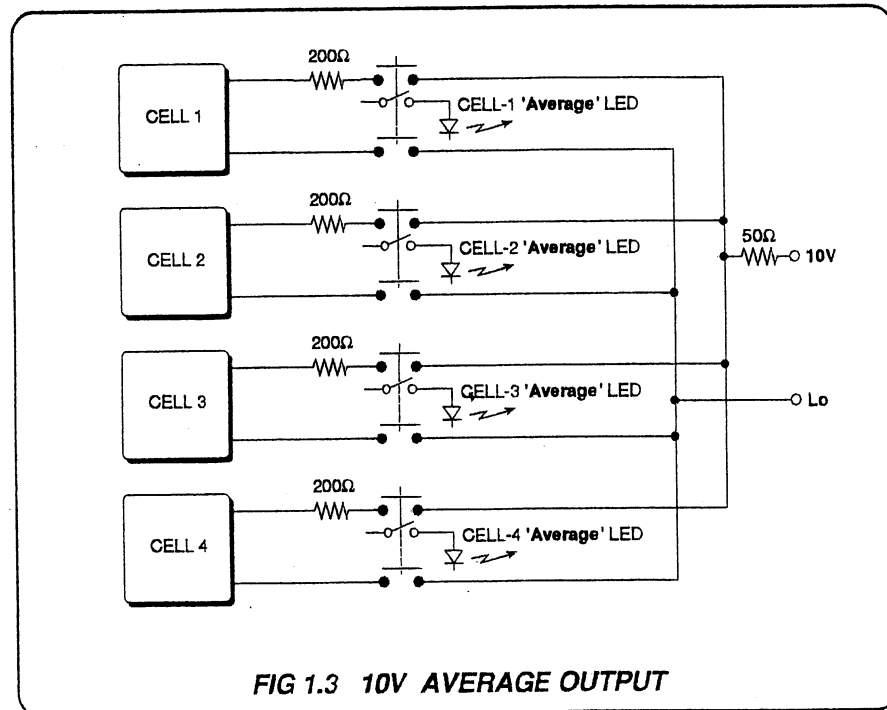
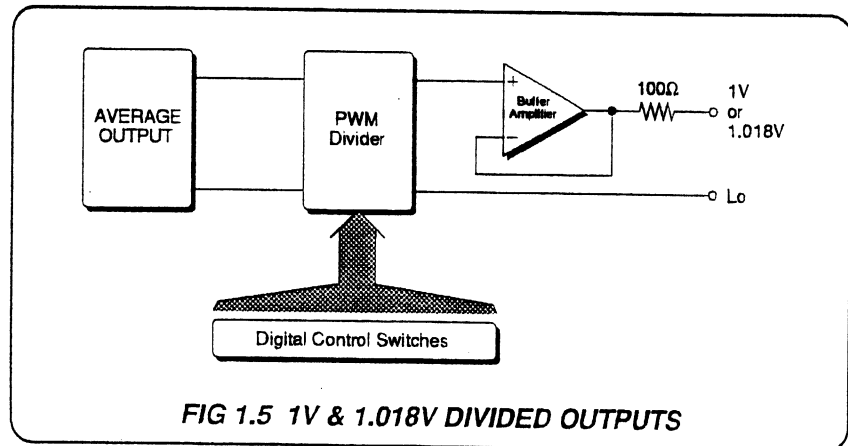
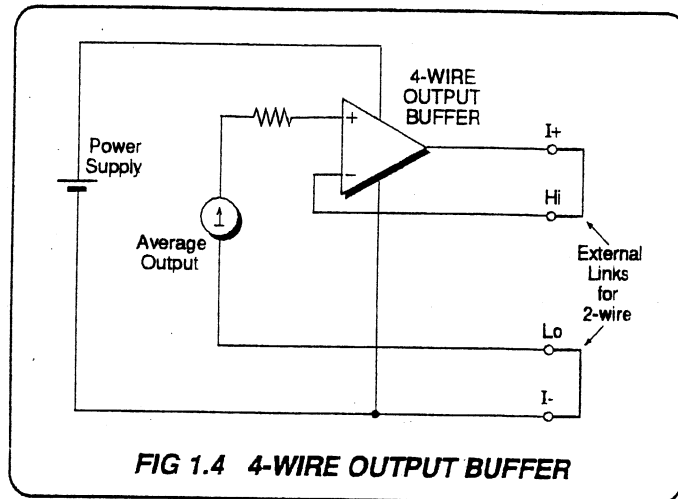


FIG 1.3 10V AVERAGE OUTPUT

On the 4910 the average 10V output is also fed to a buffer amplifier which provides a low impedance 10V output. This buffer amplifier has remote sensing on its high and low output terminals — see Fig 1.4.

In addition, the 4910 has two separate PWM dividers which divide down the average 10V output to provide 1.018V and 1V outputs — see Fig 1.5.



Operating Modes

The 4910/4911 has two basic operating modes — Normal mode and Transit mode. The Transit mode is provided so that the unit can be shipped by normal carrier methods, with all of its critical circuitry powered from its internal batteries, a low voltage external DC supply or an AC line supply.

A switch on the rear panel allows the unit to be switched from one mode to the other. (CAUTION - Read Section 3 before switching the unit from Normal to Transit mode.)

Normal Mode

In Normal mode all of the unit's internal circuitry is powered up and active. If its temperature in Transit mode has been stable in an ambient temperature of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$; then the unit will meet its full output specifications within four hours of being switched from Transit mode into Normal mode. If it has been subjected to extremes of temperature in transit, then a longer period will be required.

In Normal mode the 4910/4911 can be powered from a suitable AC line supply, or from its internal batteries, which will maintain a 4910 fully operational for a nominal period of 9 hours, and a 4911 fully operational for a nominal period of 17 hours.

In Normal mode, an external supply connected to the External DC socket will be isolated.

Transit Mode

In Transit mode only the zener reference module, zener diode temperature stabilization circuits and battery monitoring circuits remain powered up and active.

In this mode the 4910/4911 can be powered from its internal batteries, from an external 10V to 40V DC supply which is capable of delivering a current of at least 1A, or from a suitable AC line supply.

Assuming that the unit's batteries are initially fully charged and that the unit remains at its specified operating temperature of 25°C , the internal batteries will maintain the zener diode references at a constant temperature for a minimum period of 168 hours (7 days). At other temperatures within its lower operating range of 0°C to 25°C , this time will be reduced; for instance it is estimated that at 0°C , the reduced period will be 100 hours.

SECTION 2 INSTALLATION

This section contains information and instructions for unpacking and installing the Datron 4910 or 4911 DC Voltage Reference Standard. The layouts of the instruments' front and rear panels can be found in Section 3.

Unpacking and Inspection

Every care is taken in the choice of packing material to ensure that your equipment will reach you in perfect condition. If the equipment has been subject to mishandling in transit, this 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, front panel terminals etc. If damage is found, notify the carrier and your sales representative immediately.

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

Preparation for Operation - Cold Shipment (Option 10 not specified on ordering)

IMPORTANT: If the 4910/4911 was ordered with Option 10 (Calibration and Hot Shipment) it will have been despatched in Transit mode, with its internal batteries maintaining the zener references at constant

temperature. If this is the case DO NOT use the following installation procedure. Refer instead to the section titled "Preparation for Operation - Hot Shipment" on page 2-6 of this handbook.

Line Voltage Selection and Fuse Rating

The 4910/4911 can operate from 50Hz or 60Hz line supplies in the ranges 100/120/220/240 volts $\pm 10\%$. A recessed **POWER INPUT** plug, **POWER FUSE** and **LINE VOLTAGE SELECTOR** are contained in an integral module on the 4910/4911's rear panel. A transparent cover on the module allows the fuse rating and line voltage selector to be visually inspected.

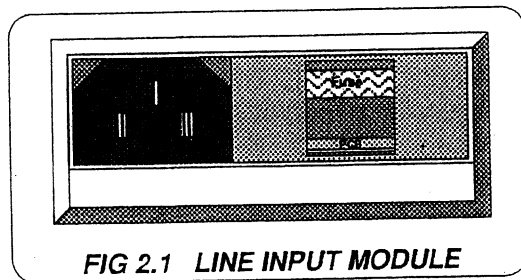


FIG 2.1 LINE INPUT MODULE

Fuse and Line Voltage Check

Check that the fuse rating, and the line voltage indicated in the cut-out below the power fuse, are appropriate for your line supply. (NOTE: to inspect the fuse rating you may have to remove the fuse by sliding the module's transparent cover to the left and pulling on the fuse extractor.)

Fuse Rating

The appropriate fuse rating is as follows:-

Supplies in the range 198V to 264V

- a 1.6A, 250V, T-type fuse

Supplies in the range 90 to 132V

- a 3.0A, 250V, T-type fuse

If the fuse rating is incorrect for your line supply voltage, replace it with an appropriately rated T-type fuse.

MAKE SURE THAT ONLY FUSES WITH THE REQUIRED CURRENT RATING AND OF THE SPECIFIED TYPE ARE INSERTED AS REPLACEMENTS.

AVOID THE USE OF REPAIRED FUSES, AND NEVER SHORT-CIRCUIT THE FUSE HOLDER CONTACTS. SUCH PRACTICES WILL RENDER THE UNIT'S WARRANTY VOID.

To Reselect the Operating Voltage:

If the indicated line voltage is inappropriate for your line supply, carry out the following procedure:-

1. **FIRST** ensure that the **POWER CABLE** is removed.
2. Slide the protective window to the left to reveal the fuse and voltage selector pc board.
3. Draw the fuse extractor to the left, and remove the fuse.
4. Remove the voltage selector pc board (NOTE: a hole is provided in the board to assist in its removal) and rotate it until the appropriate line voltage appears on the left-hand side of the upper surface.
5. Re-insert the selector pc board firmly into its slot in the module. The selected line voltage should be visible in the cutout below the fuse.
6. Move the fuse extractor to the right-hand position.
7. Insert the appropriate **POWER FUSE**.
8. Slide the protective window to the right.

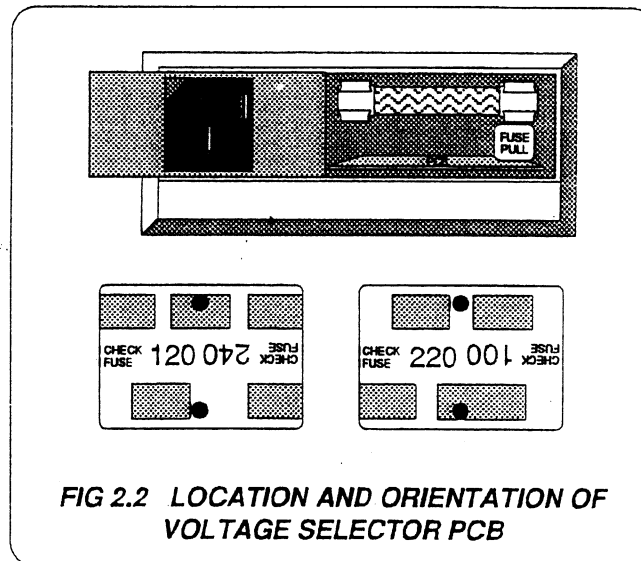


FIG 2.2 LOCATION AND ORIENTATION OF VOLTAGE SELECTOR PCB

(Preparation for Operation - Cold Shipment: continued overleaf)

Internal Battery Connection

The 4910/4911 contains internal batteries which power the unit when it is not operating from a line supply or an external DC input. If Option 10 (Calibration and Hot Shipment) was NOT specified on ordering the 4910/4911, the unit will be shipped with its internal batteries disconnected.

To Connect the Internal Battery Pack

Before connecting the unit to a line supply or external DC power source, carry out the following procedure:-

1. Ensure that the rear-panel **BATTERY MODE** switch is switched to N (Normal) position.
2. Remove the two screws situated towards the rear of the unit's top cover and remove the top cover.
3. Detach the battery connecting plug (P102) from its retaining clip on the outside of the *Line Input Unit* (position 'B' in Fig. 2.3) and insert it into its socket (J102) on the rear of the *Battery Pack* (position 'A' in Fig. 2.3).
4. Check that the four **Battery** LEDs situated above the **CELL** outputs, and the **Battery Supply** LED situated above the **AVERAGE** output, are continuously lit GREEN or are flashing between RED and GREEN. If any of these LEDs are continuously RED, flashing RED, or permanently OFF the unit probably has a fault, in which case you should refer to the 4910/4911 Servicing Handbook or contact your local service center.
5. Leave the unit to warm up for 5 minutes.
6. Press the **HEATER RESET** pushbutton which is recessed into the rear panel of the unit.
7. Check that all of the **Temp** LEDs on the unit's front panel are lit GREEN. (If any of the **Temp** LEDs is not lit GREEN immediately after pressing the **HEATER RESET** pushbutton, the unit probably has a fault, in which case consult the 4910/4911 Servicing Handbook or your local service center.)
8. Replace the unit's top cover and the two top cover retaining screws.

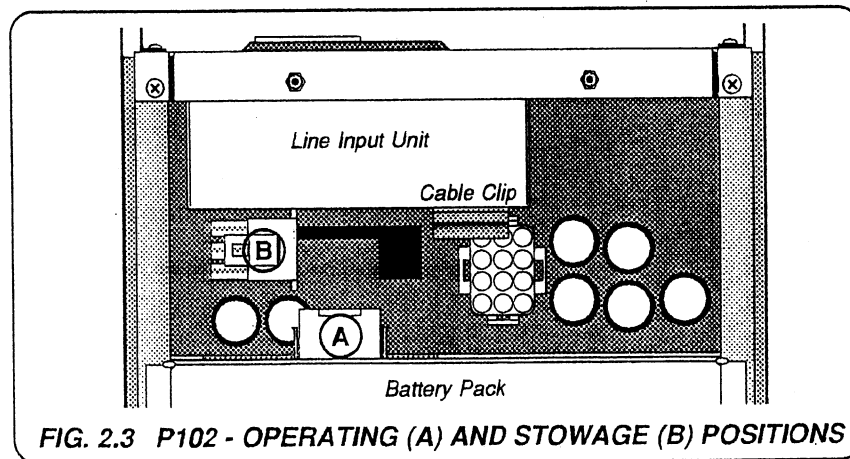


FIG. 2.3 P102 - OPERATING (A) AND STOWAGE (B) POSITIONS

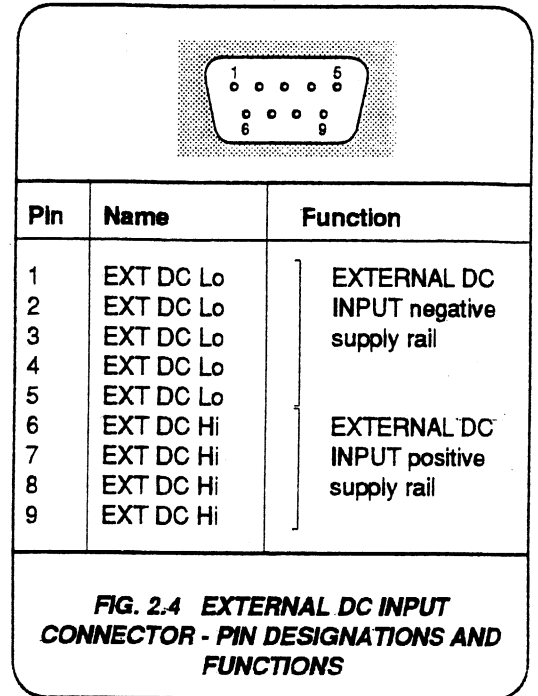
AC Line Supply Connection

The detachable AC POWER CABLE comprises two metres of 3-core PVC sheathed cable permanently moulded to a fully-shrouded 3-pin cable socket. It fits into the receptacle in the POWER INPUT module on the unit's rear panel, and should be pushed firmly home. The power cable should be connected to a grounded line supply outlet. When connecting the cable to a suitable line plug, connect the Brown lead to Line, Blue lead to Neutral, and Green/Yellow lead to Ground. DO NOT operate the unit from an ungrounded line supply, and NEVER disconnect the ground lead in the power cable's line plug.

DC Power Connection

The 4910/4911 has a 10 to 40V EXTERNAL DC INPUT which can be used to power the unit while it is in Transit mode. This input is situated on a rear-panel mounted 9-way 'D' connector, for which the pin designations are shown in Fig 2.4. When an external DC supply (of the correct polarity and within the 10V to 40V limits) is applied to the unit, an LED alongside the connector glows GREEN.

The EXTERNAL DC INPUT is protected against reversed polarity and overcurrent conditions. Overcurrent protection is provided by a replaceable 1.6A fuse which is located in a rear-panel mounted fuse holder — see Fig 3.3 on page 3-6 of this manual.



Calibration

Calibrate the unit by performing the calibration procedure detailed in Section 5 of this manual, or send it to a National Standards Laboratory for calibration.

Preparation for Operation - Hot Shipment

(Option 10 specified on ordering)

IMPORTANT: If the 4910/4911 was ordered without Option 10 (Calibration and Hot Shipment) DO NOT use the following installation procedure.

Refer instead to the section titled "Preparation for Operation - Cold Shipment" on page 2-2 of this handbook.

Immediate Checks

Immediately after unpacking a 4910/4911 which was ordered with Option 10 (Calibration and Hot Shipment) carry out the following procedure:

1. Check that the calibration seals are not broken.
2. Move the 4910/4911 to a stable environment which meets the environmental specifications detailed in Section 4 of this manual.
3. Check the unit's front panel LEDs to ensure that they are in the following condition. (NOTE: because the front-panel LEDs are strobed in Transit mode to conserve battery power, an individual LED must be observed for at least 30 seconds to determine its true condition.) :-

Cell 1, 2, 3 and 4 **Battery** LEDs:

flashing GREEN or flashing RED and GREEN (see NOTE below).

Cell 1, 2, 3 and 4 **Temp** LEDs:

flashing GREEN.

If any of these LEDs is in a condition other than the ones listed above, the unit may have been in Transit mode for longer than seven days, or may have been subjected to extremes of temperature. Contact Datron Instruments or your supplier.

NOTE:

If any of the Cell 1, 2, 3 and 4 Battery LEDs is flashing RED and GREEN it indicates that the unit's internal batteries require recharging. There should be as little delay as possible before carrying out the remainder of the installation procedure and connecting the unit to an AC line supply or external DC supply if it is to remain in Transit mode, or to an AC line supply if it is to be switched to Normal mode.

Line Voltage Selection and Fuse Rating

The 4910/4911 can operate from 50Hz or 60Hz line supplies in the ranges 100/120/220/240 volts $\pm 10\%$. A recessed **POWER INPUT** plug, **POWER FUSE** and **LINE VOLTAGE SELECTOR** are contained in an integral module on the 4910/4911's rear panel. A transparent cover on the module allows the fuse rating and line voltage selector to be visually inspected.

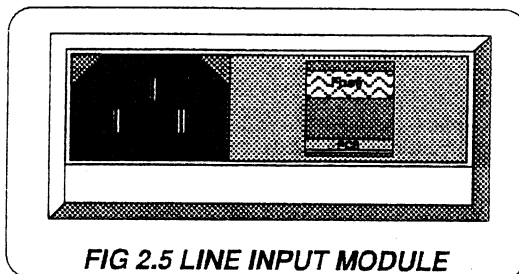


FIG 2.5 LINE INPUT MODULE

Fuse and Line Voltage Check

Check that the fuse rating, and the line voltage indicated in the cut-out below the power fuse, are appropriate for your line supply. (NOTE: to inspect the fuse rating you may have to remove the fuse by sliding the module's transparent cover to the left and pulling on the fuse extractor.)

Fuse Rating

The appropriate fuse rating is as follows:-

Supplies in the range 198V to 264V

- a 1.6A, 250V, T-type fuse

Supplies in the range 90V to 132V

- a 3.0A, 250V, T-type fuse

If the fuse rating is incorrect for your line supply voltage, replace it with an appropriately rated T-type fuse.

MAKE SURE THAT ONLY FUSES WITH THE REQUIRED CURRENT RATING AND OF THE SPECIFIED TYPE ARE INSERTED AS REPLACEMENTS.

AVOID THE USE OF REPAIRED FUSES, AND NEVER SHORT-CIRCUIT THE FUSE HOLDER CONTACTS. SUCH PRACTICES WILL RENDER THE UNIT'S WARRANTY VOID.

Section 2 - Installation - Hot Shipment

To Reselect the Operating Voltage:

If the indicated line voltage is inappropriate for your line supply, carry out the following procedure:

1. **FIRST** ensure that the **POWER CABLE** is removed.
2. Slide the protective window to the left to reveal the fuse and voltage selector pc board.
3. Draw the fuse extractor to the left, and remove the fuse.
4. Remove the voltage selector pc board (NOTE: a hole is provided in the board to assist in its removal) and rotate it until the appropriate line voltage appears on the left-hand side of the upper surface.
5. Re-insert the selector pc board firmly into its slot in the module. The selected line voltage should be visible in the cutout below the fuse.
6. Move the fuse extractor to the right-hand position.
7. Insert the appropriate **POWER FUSE**.
8. Slide the protective window to the right.

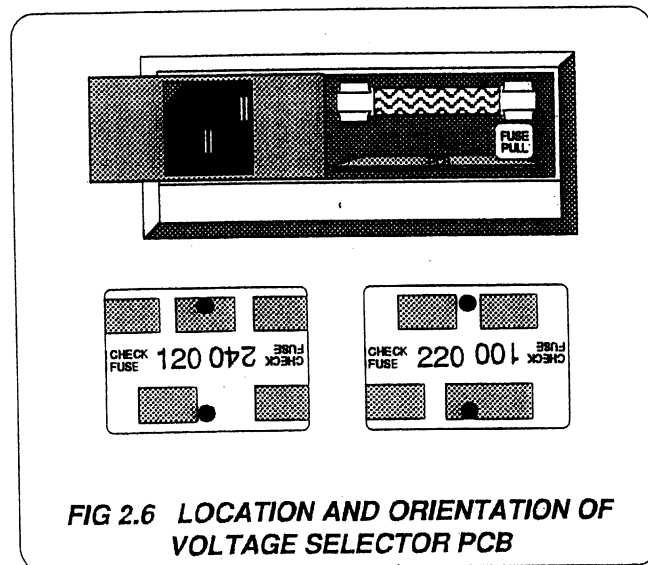


FIG 2.6 LOCATION AND ORIENTATION OF VOLTAGE SELECTOR PCB

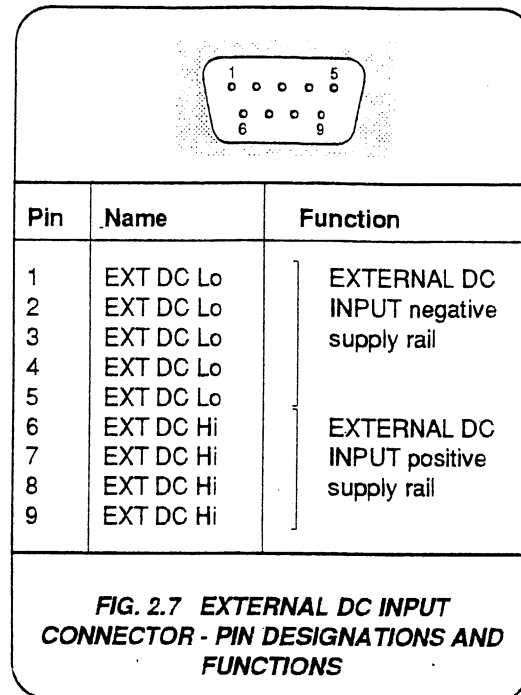
AC Line Supply Connection

The detachable AC POWER CABLE comprises two metres of 3-core PVC sheathed cable permanently moulded to a fully-shrouded 3-pin cable socket. It fits into the receptacle in the POWER INPUT module on the unit's rear panel, and should be pushed firmly home. The power cable should be connected to a grounded line supply outlet. When connecting the cable to a suitable line plug, connect the Brown lead to Line, Blue lead to Neutral, and Green/Yellow lead to Ground. DO NOT operate the unit from an ungrounded line supply, and NEVER disconnect the ground lead in the power cable's line plug.

DC Power Connection

The 4910/4911 has a 10 to 40V EXTERNAL DC INPUT which can be used to power the unit while it is in Transit mode. This input is situated on a rear-panel mounted 9-way 'D' connector, for which the pin designations are shown in Fig 2.7. When an external DC supply (of the correct polarity and within the 10V to 40V limits) is applied to the unit, an LED alongside the connector glows GREEN.

The EXTERNAL DC INPUT is protected against reversed polarity and overcurrent conditions. Overcurrent protection is provided by a replaceable 1.6A fuse which is located in a rear-panel mounted fuse holder — see Fig 3.3 on page 3-6 of this handbook.



Specification Verification

Carry out the Calibration Confidence-check procedure detailed in Section 5 of this handbook.

Section 2 - Installation - Hot Shipment

Mounting

Bench Mounting

The 4910/4911 is fitted with plastic feet, which allow the unit to stand on a flat surface.

Rack Mounting

Option 90 permits the 4910/4911 to be mounted in a standard 19-inch rack. The rack mounting kit will accommodate a single 4910/4911, or two 4910/4911s mounted alongside one another. For details of how to assemble the rack mounting kit refer to Fig 2.8.

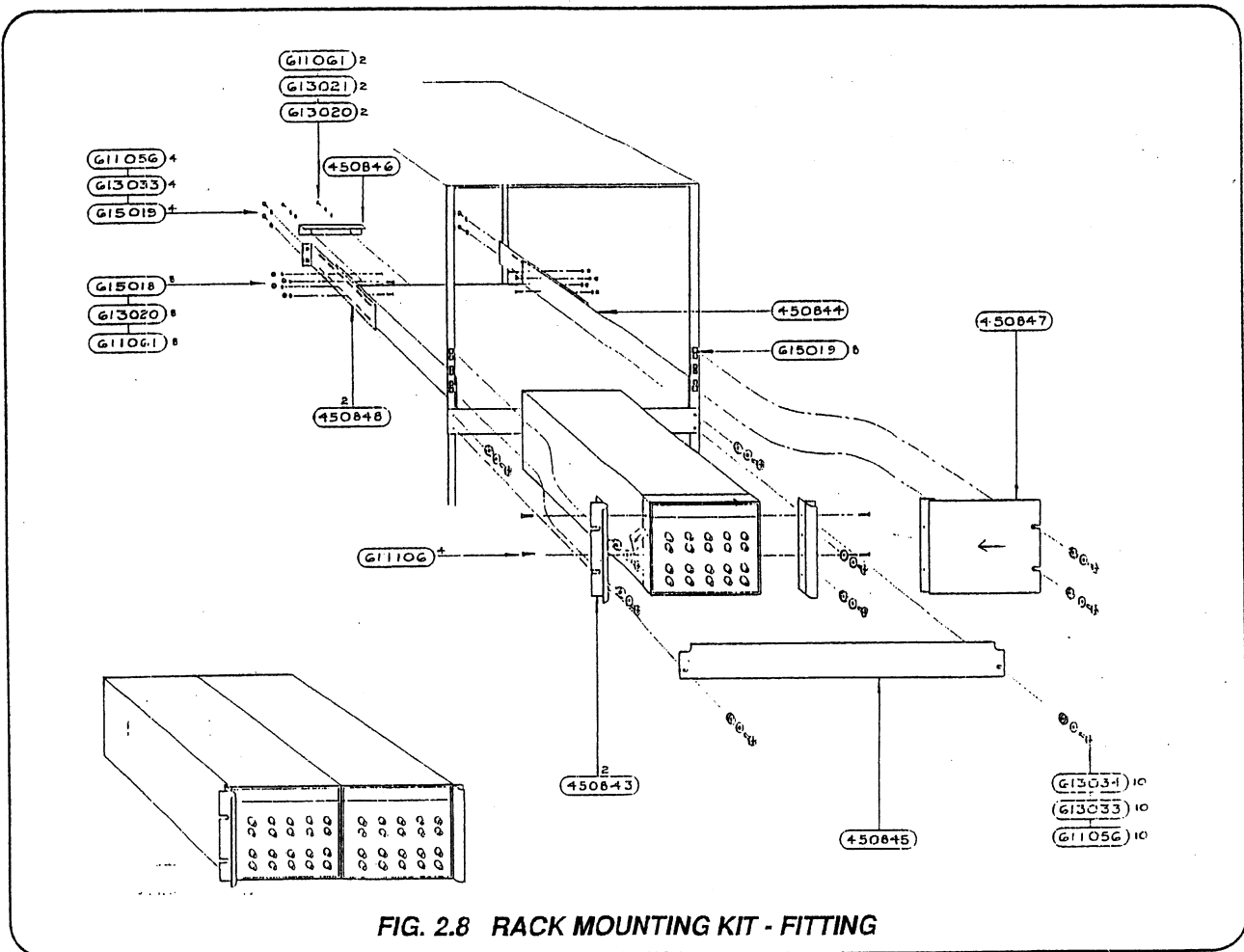


FIG. 2.8 RACK MOUNTING KIT - FITTING

Section 2 - Installation

RACK MOUNTING KIT - PARTS LIST

 DATRON INSTRUMENTS LTD PARTS LIST 16-Nov-89 DESC: KIT RACK MOUNT 4910 DRG NO: LP440161-1 REV: 0 PAGE NO: 1

DESIG	PART NO	DESCRIPTION	PRINC MANUF	MANUF PART NUMBER	CLASS	UM	QUANTITY	CHANGES
	450843-1	RACK EAR/HANDLE 4U 4910		SEE DRG			EA 2	
	450844-1	RACK MOUNTING TRAY 4910		SEE DRG			EA 1	
	450845-1	BLANKING PLATE 1U 4910		SEE DRG			EA 1	
	450846-1	BRACKET REAR CLAMP 4910		SEE DRG			EA 2	
	450847-1	BLANKING PLATE HALF RACK 4910		SEE DRG			EA 1	
	450848-1	BRACKET REAR SUPPORT 4910		SEE DRG			EA 2	
	611056	SCREW M6 X 16 POZIPAN ST.CR.PL					EA 14	
	611061	SCREW M4 X 12 POZIPAN SZP					EA 12	
	611106	SCREW 8-32 X 5/8 POZICSK SZP					EA 4	
	613020	WASHER M4 SZP					EA 12	
	613021	WASHER M4 INT. SHAKP.					EA 4	
	613033	WASHER M6 SZP	SCHROFF	21100-104			EA 14	
	613034	WASHER M6 PLASTIC BLK.	SCHROFF	21100-015			EA 10	
	615018	NUT NYLOCK M4 SZP					EA 8	
	615019	NUT CAGE M6 SZP	SCHROFF	21100-004			EA 12	

End

SECTION 3 USING THE 4910/4911

4910 Front Panel Features

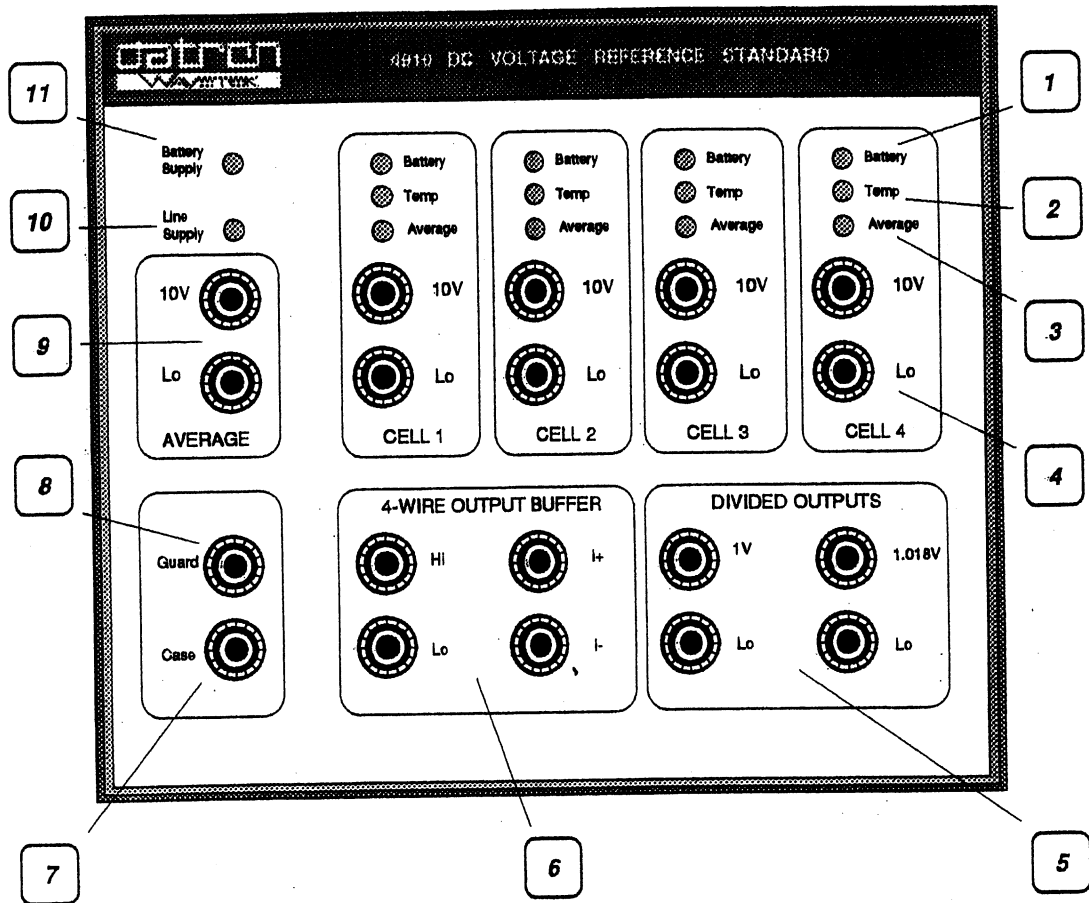


FIG. 3.1

Features

1. **Battery LEDs**

Each LED indicates the operational status of the battery which powers the cell's analog circuitry:

Continuous GREEN: the battery is OK.
Alternate RED and GREEN: the battery needs recharging.
Alternate RED and OFF: the battery urgently needs recharging.
Continuous RED or OFF: failure conditions.

2. **Temp LEDs**

Each LED indicates the temperature stability of the cell's zener reference diode:

Continuous GREEN: the correct zener temperature has been maintained.
Continuous RED: correct temperature control has at some time been lost.

3. **Average LEDs**

Each LED indicates whether the cell is coupled to the AVERAGE output:

Continuous GREEN: the cell is coupled to the AVERAGE output.
Continuous RED: the cell is not coupled to the AVERAGE output.

4. **10V CELL Outputs**

Provide high stability 10V outputs.

5. **DIVIDED OUTPUTS**

Provide 1V and 1.018V outputs.

6. **4-WIRE OUTPUT BUFFER**

Provides a very low impedance 10V output with 4-wire sensing capability.
Can deliver output currents as high as 15mA.

7. **Case Terminal**

Connects to the unit's exposed metalwork.

NOTE: It must not be used as a 'Safety Ground' terminal.

8. **Guard Terminal**

Connects to a guard screen between the primary and secondary windings of the line input transformer.
Connect this terminal to the source of common-mode noise in the system.

9. **10V AVERAGE Output**

Provides a low-noise 10V output derived from one or more of the CELL outputs.

10. **Line Supply LED**

Lights GREEN when the unit is connected to an ac line supply.

11. **Battery Supply LED**

Indicates the operational status of the battery which powers the unit's digital, 4-WIRE OUTPUT BUFFER and DIVIDED OUTPUTS circuitry:

Continuous GREEN: the battery is OK.
Alternate RED and GREEN: the battery needs recharging.
Alternate RED and OFF: the battery urgently needs recharging.
Continuous OFF: the instrument is in Transit mode, or a failure has occurred.
Continuous RED: a failure has occurred in Normal mode.

4911 Front Panel Features

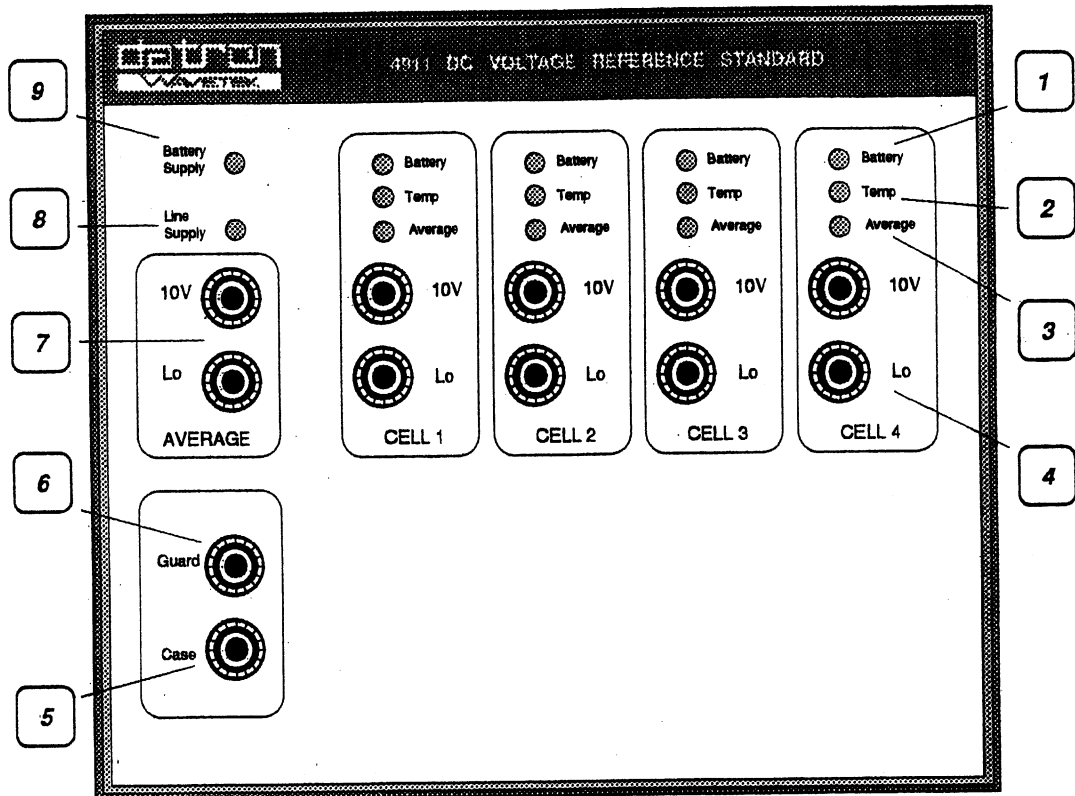


FIG. 3.2

Features

1. **Battery LEDs**
Each LED indicates the operational status of the battery which powers the cell's analog circuitry:
Continuous GREEN: the battery is OK.
Alternate RED and GREEN: the battery needs recharging.
Alternate RED and OFF: the battery urgently needs recharging.
Continuous RED or OFF: failure conditions.
2. **Temp LEDs**
Each LED indicates the temperature stability of the cell's zener reference diode:
Continuous GREEN: the correct zener temperature has been maintained.
Continuous RED: correct temperature control has at some time been lost.
3. **Average LEDs**
Each LED indicates whether the cell is coupled to the AVERAGE output:
Continuous GREEN: the cell is coupled to the AVERAGE output.
Continuous RED: the cell is not coupled to the AVERAGE output.
4. **10V CELL Outputs**
Provide high stability 10V outputs.
5. **Case Terminal**
Connects to the unit's exposed metalwork.
NOTE: It must not be used as a 'Safety Ground' terminal.
6. **Guard Terminal**
Connects to a guard screen between the primary and secondary windings of the line input transformer.
Connect this terminal to the source of common-mode noise in the system.
7. **10V AVERAGE Output**
Provides a low-noise 10V output derived from one or more of the CELL outputs.
8. **Line Supply LED**
Lights GREEN when the unit is connected to an ac line supply.
9. **Battery Supply LED**
Indicates the operational status of the battery which powers the unit's digital circuitry:
Continuous GREEN: the battery is OK.
Alternate RED and GREEN: the battery needs recharging.
Alternate RED and OFF: the battery urgently needs recharging.
Continuous OFF: the instrument is in Transit mode, or a failure has occurred.
Continuous RED: a failure has occurred in Normal mode.

4910/4911 Rear Panel Features

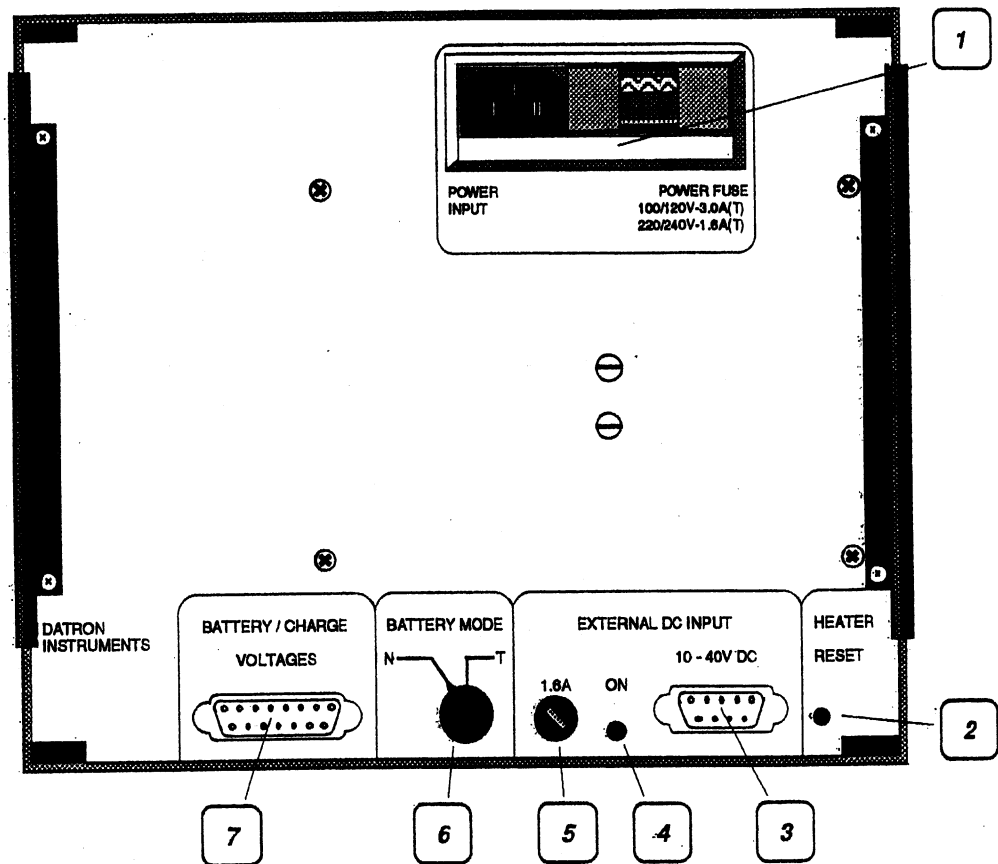


FIG. 3.3

Features

1. **Power Input Module**
*Receives the Line Power Input Cable.
The module also contains a power fuse and voltage-selector PCB behind the sliding panel
The fuse and selected line voltage can be inspected through the transparent window.*
2. **HEATER RESET**
*Press to reset the front-panel Temp LEDs from RED to GREEN.
(Note: this switch is recessed behind the rear panel and should normally be covered by a calibration seal).*
3. **J601**
9-way 'D' connector used to input a 10V to 40V; 1A DC supply to power the unit in Transit mode.
4. **EXTERNAL DC INPUT LED**
Lights GREEN when an external DC supply of the correct polarity, and within the 10V to 40V limits, is applied to J601.
5. **1.6A Fuse**
Protects the EXTERNAL DC INPUT against overcurrent conditions.
6. **BATTERY MODE Switch**
Used to switch the unit between Normal mode and Transit mode.
7. **J103**
15-way 'D' connector used to monitor the terminal voltages of the unit's internal batteries.

Setting Up the 4910/4911

IMPORTANT:

If the 4910/4911 has just been shipped to you, carry out the installation procedure detailed in Section 2 of this manual before using the unit.

NOTE that the installation procedure is different depending on whether the 4910/4911 has been shipped "Hot" or "Cold".

If shipped "Hot", some of the 4910/4911's internal circuitry will have remained active during shipment, deriving its power from the unit's internal batteries.

If the unit has been shipped "Cold", its batteries will have been internally disconnected, and must be reconnected before operating the unit.

A "Cold-shipped" unit will have all of its front panel LEDs permanently extinguished.

A "Hot-shipped" unit can be recognised by the fact that its front panel LEDs will illuminate momentarily at approximately 3-second intervals.

Safety

The 4910/4911 is designed to be Class 1 equipment as defined in IEC Publication 348, and to meet the requirements of UL-1244 concerning safety.

Protection is provided by a direct connection via the **POWER CABLE** from ground to exposed metal parts and internal ground screens of the unit.

The line connection must only be inserted in a socket outlet which is provided with a protective ground contact, and continuity must be assured between the socket and the **POWER INPUT** module on the rear panel of the instrument.

WARNING:

WHEN THE UNIT IS OPERATED FROM AN AC LINE SUPPLY, 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.

OPERATING MODES

Normal Operating Mode

In Normal mode all of the unit's internal circuitry is powered up and active. If its temperature in Transit mode has been stable in an ambient temperature of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$; then the unit will meet its full output specifications within four hours of being switched from Transit mode into Normal mode. If it has been subjected to extremes of temperature in transit, then a longer period will be required.

In Normal mode the unit may be powered either from a suitable AC line supply or from its internal batteries. (It will not operate from the 10V to 40V EXTERNAL DC INPUT in Normal mode.) If the line supply fails, the internal batteries will automatically maintain the unit fully operational.

The internal batteries will keep a 4910 fully operational for a period of 9 hours, and a 4911 fully operational for a period of 17 hours, before the batteries require re-charging. The 4910/4911 may also be deliberately operated for these periods without an AC line input in situations where complete isolation from the AC line supply is required (for example, where ground-loops in the measurement system might be a problem).

10V Cell Outputs

Provided that a cell's Average LED is lit RED, then the output from that cell is completely isolated from all of the other 4910/4911 outputs. As a result, CELL outputs which have their Average LEDs lit RED can be connected in series to obtain total output voltages of 20, 30 or 40V.

Average Output

Each of the 4910/4911's CELL outputs may be resistively coupled to the AVERAGE output. Assuming that no current is drawn from the AVERAGE output, the voltage which appears at its terminals is the arithmetic mean of the CELL output voltages which are coupled to it. Because of the averaging process, random effects such as noise are reduced at the AVERAGE output by a factor of \sqrt{n} , where n is the number of CELL outputs coupled to the AVERAGE output. It should also be noted that the output resistance of the AVERAGE output also depends on the number of CELL outputs coupled to it. This output resistance is governed by the equation:-

$$\text{Output Resistance} = \frac{200}{n} + 50 \text{ ohms}$$

If a CELL output is coupled to the AVERAGE output, its Average LED is lit GREEN. It is recommended that when using the AVERAGE output all external loads are disconnected from the individual CELL outputs that are coupled to it.

Average Switching

The 4910/4911 is shipped from Datron Instruments with all four of its CELL outputs coupled in to the AVERAGE output. In this condition each of the four CELL Lo terminals is internally linked to the AVERAGE Lo terminal, and each of the four CELL 10V outputs is internally linked via a resistor to the AVERAGE 10V terminal.

If you wish to isolate a CELL output from the AVERAGE output, carry out the following procedure:-

To Isolate a CELL Output from the AVERAGE Output

1. Remove all external connections from the front-panel terminals.
2. Remove the two screws situated towards the rear of the unit's top cover. Remove the top cover.
3. For the cell that you wish to isolate, undo each of the six link-retaining screws by two turns - see Fig 3.4.
4. Rotate the two links from position A to position B as shown in Fig 3.4.
5. Tighten down the six link-retaining screws to secure the links in their new positions ensuring that the washers remain on top of the links.
6. Move the two AVERAGE IN/OUT slide switches to the OUT position (refer to the IN/OUT legend printed on the left of the internal cover).
7. Replace the unit's top cover and the two top-cover retaining screws.
8. Ensure that the front-panel Average LED for the appropriate cell is lit RED. (NOTE: If the Average LED is lit ORANGE, check that the AVERAGE IN/OUT switches beneath BOTH of the cell's links have been moved to the OUT position - refer to the IN/OUT legend printed on the left of the internal cover).

If you wish to reintroduce a CELL output into the AVERAGE output, carry out the following procedure:-

To Reconnect a CELL Output to the AVERAGE Output

1. Remove all external connections from the front-panel terminals.
2. Remove the two screws situated towards the rear of the unit's top cover. Remove the top cover.
3. Move the two AVERAGE IN/OUT slide switches to the IN position (refer to the IN/OUT legend printed on the left of the internal cover).
4. For the cell that you wish to reconnect, undo each of the six link-retaining screws by two turns - see Fig 3.4.
5. Rotate the two links from position B to position A as shown in Fig 3.4.
6. Tighten down the six link-retaining screws to secure the links in their new positions ensuring that the washers remain on top of the links.
7. Replace the unit's top cover and the two top-cover retaining screws.
8. Ensure that the front-panel Average LED for the appropriate cell is lit GREEN. (NOTE: If the Average LED is lit ORANGE, check that the AVERAGE IN/OUT switches beneath BOTH of the cell's links have been moved to the IN position.)

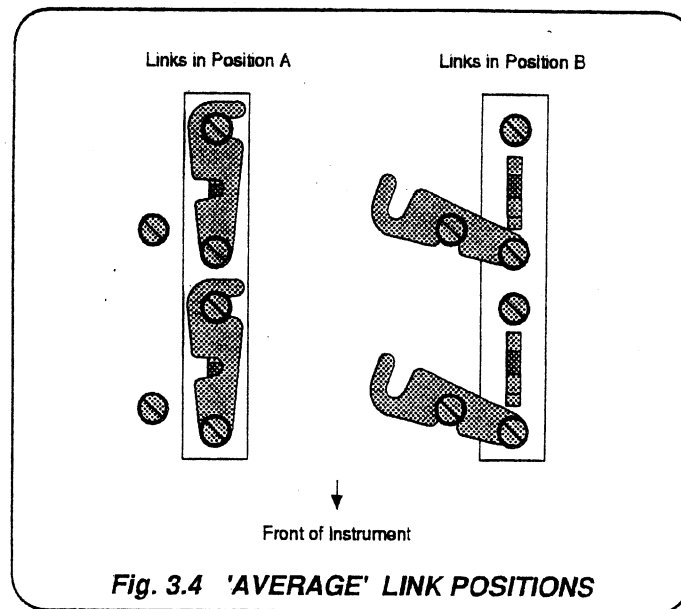


Fig. 3.4 'AVERAGE' LINK POSITIONS

4-Wire Output Buffer (4910 only)

The **4-WIRE OUTPUT BUFFER** provides a very low impedance ($<100\ \mu\Omega$) 10V output which is derived from the **AVERAGE** output. It can source output currents as high as 15 mA, and incorporates separate power and sense terminals so that external equipment — such as a resistive divider — can be driven with negligible error caused by lead resistance.

The **4-WIRE OUTPUT BUFFER's** **Lo**, **Hi**, **I-** and **I+** terminals should be connected to an external load as illustrated in Fig 3.5.

If a divider is used to make comparisons with other outputs from the same 4910, care should be taken to account for the effects of the currents flowing in the divider - refer to Appendix D.

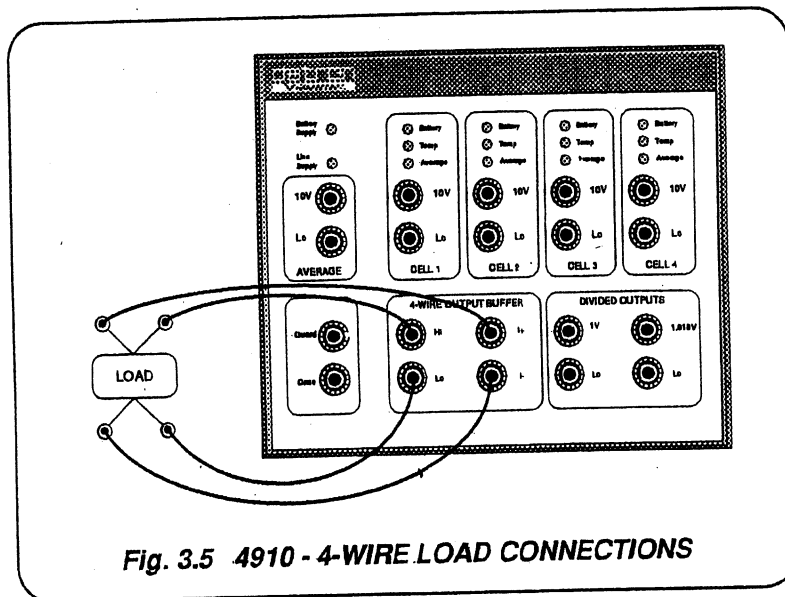


Fig. 3.5 4910 - 4-WIRE LOAD CONNECTIONS

NOTES:

- 1) In order for the **4-WIRE OUTPUT BUFFER** to be operational, at least one **CELL** output must be internally coupled to the **AVERAGE** output.
- 2) If the **AVERAGE** output, or any of the **CELL** outputs that are connected to it, is loaded to such an extent that the voltage at the

AVERAGE output falls, then the output from the **4-WIRE OUTPUT BUFFER** will also be affected. When using the **4-WIRE OUTPUT BUFFER**, it is therefore recommended that all external loads are disconnected from the **AVERAGE** output and from the individual **CELL** outputs that are coupled to it.

Divided Outputs (4910 only)

The **DIVIDED OUTPUTS** provide buffered output voltages of 1V and 1.018V which are derived from the 10V **AVERAGE** output.

NOTES:

- 1) In order for the 1V and 1.018V **DIVIDED OUTPUTS** to be operational, at least one **CELL** output must be internally coupled to the **AVERAGE** output, and the external shorting links provided with the unit must be connected between the **Hi** and **I+** terminals, and between the **Lo** and **I-** terminals of the **4-WIRE OUTPUT BUFFER**. Also, current must not be drawn from the 4-wire output.
- 2) If the **AVERAGE** output, or any of the **CELL** outputs that are connected to it, is loaded to such an extent that the voltage at the **AVERAGE** output falls, then the output from the **DIVIDED OUTPUTS** will also be affected. When using the **DIVIDED OUTPUTS**, therefore, it is essential that all external loads are disconnected from the **AVERAGE** output, from individual **CELL** outputs that are coupled to it, and from the **4-WIRE OUTPUT BUFFER**.

Battery LEDs and Battery Supply LED

Each cell of the 4910/4911 has a **Battery LED** to indicate the operational status of the internal battery which powers the analog circuitry within the cell. In addition, the 4910/4911 has a **Battery Supply LED** which indicates the operational status of a separate battery which powers the unit's digital circuitry, and in the case of the 4910 only, the **4-WIRE OUTPUT BUFFER** and the **DIVIDED OUTPUTS**. Possible combinations of LED colours are given below, with the indicated battery condition and any required action:

- 1) Continuous RED:
Battery overcharging. Refer to the 4910/4911 Servicing Handbook or your local service center.
- 2) Continuous GREEN:
Battery OK. No action required.
- 3) Alternating RED/GREEN:
Battery OK but requires recharging.

Reconnect an AC line supply as soon as possible.

- 4) Alternating RED/OFF:
Battery is approaching deep discharge point. Ensure that the associated **Temp LED** is lit GREEN and reconnect an AC line supply as soon as possible. If the associated **Temp LED** is RED the instrument may require recalibration as detailed in Section 5 of this handbook.
- 5) Continuously OFF:
Battery has reached its deep discharge point and has been automatically disconnected. Recharge and re-certify.

NOTE:

The output specifications detailed in Section 4 of this handbook are valid only if the **Battery LED** for a particular **CELL** and the **Battery Supply LED** for the unit are in conditions 2 or 3.

Temp LEDs

Each cell of the 4910/4911 has a **Temp LED** which indicates whether or not temperature control of the cell's zener reference diode has been maintained. If a particular cell's **Temp LED** is lit **GREEN** it indicates that correct control of that cell's zener diode temperature has been maintained. If a cell's **Temp LED** is lit **RED** it means that control of the cell's zener diode temperature has, at some time, been lost.

If any of the **Temp LEDs** is lit **RED**, carry out the following procedure:-

To Reset the Temp LEDs

1. Check that all the unit's **Battery LEDs** are lit **GREEN**. (If any of these LEDs is in a condition other than **GREEN** refer to the table in the **Battery LEDs** section above for corrective action.)
2. Wait for 5 minutes.
3. Press the **HEATER RESET** pushbutton which is recessed into the rear panel of the unit.
4. Check that all of the **Temp LEDs** on the unit's front panel are lit **GREEN**. (If any of the **Temp LEDs** is not lit **GREEN** immediately after pressing the **HEATER RESET** pushbutton the unit probably has a fault, in which case consult the 4910/4911 Servicing Handbook or your local service center.)
5. Check the unit's calibration using the procedure detailed in Sect. 5 of this handbook.

Line Supply LED

The 4910/4911 has a single **Line Supply LED** which indicates whether the unit is operating from an AC line input. This LED is lit **GREEN** if the unit is operating from an AC line supply, and is **OFF** when the unit is not operating from an AC line supply.

Guard Terminal

The 4910/4911's **Guard** terminal is connected to a guard screen between the primary and secondary windings of the unit's line input transformer. Its purpose is to provide a means of eliminating common-mode noise problems in external measurement systems, in which case the **Guard** terminal of the 4910/4911 should be connected to the source of common mode noise in the measurement system. If the 4910/4911 is being operated from an AC line supply, it is usually sufficient to connect its **Guard** terminal to its **Case** terminal.

Case Terminal

The 4910/4911's **Case** terminal is connected directly to the front-panel metalwork of the unit. When the unit is operated from a suitably grounded AC line supply the **Case** terminal is connected (via the unit's metalwork) to AC power ground. **THE CASE TERMINAL MUST NOT BE REGARDED AS A SAFETY GROUND TERMINAL.**

Battery/Charge Voltages

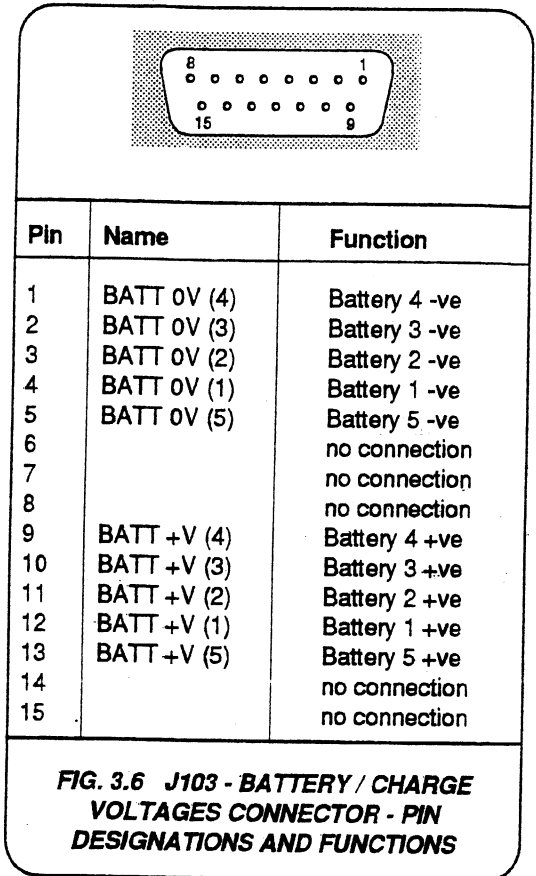
The rear panel **BATTERY/CHARGE VOLTAGE** connector allows the terminal voltages of the 4910/4911's internal batteries to be monitored. Pin designations for this 15-way 'D' connector are illustrated in Fig 3.6.

When the 4910/4911 is operating in Normal mode from an AC line supply, the battery charging voltage for all of the internal batteries should be in the range 19.96V to 20.50V at 25°.

(For the battery charging voltage at other temperatures, refer to Appendix C.)

If the unit is operated with its AC line supply disconnected, the battery voltages available at the **BATTERY/CHARGE VOLTAGE** connector can be used to monitor the discharge of the internal batteries. In order to ensure that the integrity of the unit's calibration is maintained, none of the batteries should be allowed to discharge beyond a terminal voltage of 16V.

NOTE: The **BATTERY/CHARGE VOLTAGE** outputs have an output resistance of 10k Ω . This should be taken into account if measurements are being made with a low input impedance voltmeter.



Normal/Transit Mode Switching

The rear panel **BATTERY MODE** switch allows the 4910/4911 to be switched between its Normal operating mode and its Transit mode. The Transit mode is a special low-power mode that is used to prolong the unit's battery back-up time during periods when an AC line supply is not available - for example, during shipment of the unit from one place to another.

If you wish to put the instrument into its Transit mode carry out the following procedure:-

To Switch from Normal Mode to Transit Mode

1. Ensure that the unit has been operated in Normal mode from an AC line supply for at least 48 hours. (This will ensure that the internal batteries are fully charged.)
2. Disconnect all external loads from the unit's front panel terminals.
3. Turn off the AC line supply and disconnect the AC power cable.
4. Leave the unit for 15 minutes.
5. Check that all of the **Battery LEDs** and the **Battery Supply LED** on the unit's front panel are lit **GREEN**. (If any of these LEDs is alternating between **RED** and **GREEN** or between **RED** and **OFF**, then the unit probably has a fault, in which case refer to the 4910/4911 Service Handbook or your local service center.)
6. Switch the rear panel **BATTERY MODE** switch from the **N (Normal)** position to the **T (Transit)** position.
7. Check that all the **Battery LEDs** are flashing **GREEN** at approximately 3 second intervals.

Transit Operating Mode

The 4910/4911 is in its Transit operating mode when the rear-panel **BATTERY MODE** switch is set to the **T (Transit)** position. In this mode, all of the 4910/4911's front panel outputs are inoperative. The only internal circuits that remain powered up are the zener reference module, the zener diode temperature control circuits and the battery monitoring circuits.

In Transit mode the unit may be powered from its internal batteries, from an AC line supply, or from a low-voltage external DC supply. The internal batteries will keep a 4910 or 4911 operational in Transit mode for a period of 168 hours (7 days) at 25°C. In this mode the front-panel **Battery**, **Temp** and **Average** LEDs are strobed approximately three times per second to conserve battery power. (NOTE: because the front-panel LEDs are strobed, an individual LED must be observed for at least 30 seconds to determine its true condition.)

Battery LEDs

In Transit mode the front-panel **Battery** LEDs indicate the operational status of the unit's internal battery pack. (It should be noted that the five separate internal batteries are connected in parallel during Transit mode. As a result, all four **Battery** LEDs effectively indicate the operational status of the same composite battery pack.) Possible combinations of LED colours are given below, with the indicated battery condition and any required action:

- 1) **Flashing GREEN**
Battery pack OK. No action required.

- 2) **Flashing RED/GREEN**
Battery pack OK but requires recharging. Connect the unit to an AC line supply, or connect it to a 10 to 40V external DC supply via the rear-panel **EXTERNAL DC INPUT**, as soon as possible (See NOTE below).

- 3) **Flashing RED/OFF**
 - a. With AC line supply disconnected:
The battery pack is approaching its deep discharge point. Ensure that all the front-panel **Temp** LEDs are flashing **GREEN** and then connect the unit to an AC line supply via the **POWER INPUT** module, or to a 10V to 40V external DC supply via the rear-panel **EXTERNAL DC INPUT**, as soon as possible (See NOTE below).

- b. With AC line supply connected:
The flashing **RED/OFF** combination can also indicate overcharging. Disconnect the AC line supply

If any of the front panel **Temp** LEDs is flashing **RED**, the unit's calibration should be checked as detailed in Section 5 of this handbook.

- 4) **Continuous OFF**
The battery pack has reached its deep discharge point and has been automatically disconnected. Recharge and re-certify.

NOTE:

When connected, the external 10V to 40V DC supply takes over from the battery in supplying the unit with power. It does not recharge the unit's internal batteries. To recharge the batteries, the unit must be connected to an AC line supply.

Temp LEDs

Apart from the fact that the **Temp LEDs** are strobed, their function in Transit mode is exactly the same as that in Normal mode. i.e. they are lit **GREEN** if correct temperature control of the associated cell's zener diode has been maintained, and **RED** if at any time temperature control has been lost.

In Transit mode, if any of the **Temp LEDs** is flashing **RED**, switch the unit into Normal mode and carry out the procedure to reset the **Temp LEDs** as detailed in the section titled "Temp LEDs" on page 3-14 of this handbook.

Battery Supply LED

The front-panel **Battery Supply LED** is always **OFF** when in Transit mode.

Line Supply LED

In Transit mode the **Line Supply LED** operates in the same way as it does in Normal mode i.e. it is lit **GREEN** if the unit is operating from an AC line supply, and is **OFF** when the unit is not operating from an AC line supply.

Transit/Normal Mode Switching

To switch the 4910/4911 into Normal mode carry out the following procedure:-

To Switch from Transit Mode to Normal Mode

1. Connect the 4910/4911 to a suitable AC line supply, unless it is intended that the unit continues to be operated from its internal batteries.
2. Check that all the front-panel **Battery LEDs** are flashing **GREEN** (if any of the front-panel LEDs is in a condition other than flashing **GREEN**, it is essential that the unit is connected to an AC line supply before switching it to the Normal mode).
3. Switch the rear-panel **BATTERY MODE** switch from the **T** (Transit) position to the **N** (Normal) position.
4. Check that the front-panel **Battery** and **Temp LEDs**, and the **Battery Supply LED** are lit **GREEN** (if any of the **Temp LEDs** is lit **RED**, the unit may require recalibration as detailed in Section 5 of this handbook).

SECTION 4 SPECIFICATIONS

POWER SUPPLY	<p>Line Voltage: 100V, 120V, 220V, 240V \pm 10% (Selectable on Rear Panel).</p> <p>Line frequency: 47Hz to 63Hz. Power: < 50VA</p> <p>External DC Input: 10V to 40V at a current of up to 1A (Operative only in Transit mode)</p>
BATTERY BACKUP	<p>Transit Mode: 168 hour (7 days) at 25°C ambient falling to 100 hours (4 days) at 0°C ambient.</p> <p>Normal Mode: 4910: 9 hours at 25°C ambient. 4911: 17 hours at 25°C ambient.</p> <p>Battery Type: 15 x 6V 2A-H sealed lead-acid batteries. In Transit mode these form 5 parallel banks, each of 3 in series.</p> <p>Battery Capacity: 10A-H total at 18V. Energy 648kJ.</p>
BATTERY CHARGING	<p>To ensure full capacity and hence achieve full backup time in Normal or Transit mode, the 4910/11 must be charged by the instrument operating in Normal mode for a continuous period of 48 hours.</p>
MECHANICAL	<p>Height: 182mm (7.17ins) including feet; 177mm (7ins) without feet. Width: 214mm (8.43ins). Overall depth: 591mm (23.27ins), which includes 20mm (0.79ins) of extended terminals. Weight: 20kg (44lbs).</p>
TEMPERATURE	<p>Operating: 0°C to 40°C. Storage: -40°C to 50°C.</p>
HUMIDITY	<p>Operating: 0°C to 30°C : < 95% RH; 30°C to 40 : < 75% RH. (Non-condensing)</p>
ALTITUDE	<p>Operating: -250m to 3050m (-820 to 10,000 feet).</p>
SHOCK AND VIBRATION	<p>Meets the requirements of: MIL-T-28800C, Type III, Class 5, Style E equipment.</p>
SAFETY	<p>Meets the requirements of: UL 1244; ANSI C39.5 Draft 5; IEC-348; BS-4743; VDE-0411-1973.</p>

(Continued Overleaf)

SPECIFICATIONS (Contd.)

- RFI EMISSION** Meets the requirements of the following specifications for both conducted and radiated RFI:
MIL-STD-461B, Class B, RE02; FCC Rules, Part 15, Sub-part J, Limit B;
VDE-871, Limit B; BS-6527, Limit B.
- RFI SUSCEPTIBILITY** Meets the requirements of the following specifications for RFI susceptibility:
MIL-STD-461B, Class B, RS03; MIL-T-2880C Section 3.5.5.2.2 (Power Supply Transients); MIL-T-2880C Section 3.5.5.2.3 (Power Supply Interruption); Proposed IEC 801-4 (Burst/Showering Arcs).
- TERMINAL PROTECTION** All terminals on the 4910/4911 are protected against the application of external current sources provided that the current which flows into or out of the 4910/4911's terminals is externally limited to 25 mA or less. Each Hi terminal is clamped, with respect to its Lo, at +11V and -1V, but any signal whose slew rate exceeds 1kV/ μ s **must not** be applied.
- Any CELL output that is not coupled to the AVERAGE output is isolated from all other terminals on the unit by an isolation impedance of $>10M\Omega$ and $<1nF$.
- The isolation impedance between the 4910/4911 **Guard** terminal and ground (the unit's exposed metalwork or **Case** terminal) is $>10G\Omega$ and $<10nF$.

OUTPUT SPECIFICATIONS

	10V AVERAGE	10V CELL	10V 4-WIRE BUFFER*	1.018V*	1V*
STABILITY ($\pm 1^\circ\text{C}$), ppm					
30 days	0.3	0.3	0.3	0.6	0.6
90 days	0.8	1.0	1.0	1.5	1.5
1 year	1.0	1.5	1.5	2.0	2.0
TC ($0^\circ\text{C} - 50^\circ\text{C}$), ppm/ $^\circ\text{C}$	0.05	0.05	0.06	0.10	0.12
NOISE, 0.01Hz- 2Hz, ppm RMS	0.02	0.04	0.03	0.10	0.10
OUTPUT RESISTANCE	100 Ω	100 Ω	<100 $\mu\Omega$	100 Ω	100 Ω
CURRENT DRIVE	-	-	15mA*	-	-
SETTING RESOLUTION, $\pm\text{ppm}$	-	<0.1	-	<0.2	<0.2

* Not applicable to 4911

LINE REGULATION: <0.01ppm for all power supply conditions

OUTPUT SHORT-CIRCUIT DURATION: Indefinite

SECTION 5 SPECIFICATION VERIFICATION AND CALIBRATION

Introduction

Confidence in the performance of reference standards such as the 4910/4911 DC Voltage Standard can only be established by extensive long term monitoring. The majority of calibration laboratories would not, for example, accept the manufacturer's data-sheet stability figure for such a standard until they had measured the unit's stability for themselves over a period of several months. Although many calibration laboratories will carry out this monitoring for themselves by comparing the unit against their own primary standards, others will prefer to periodically send the unit to a National Standards Laboratory in order to acquire the necessary calibration data.

Despite the fact that most users will want to evaluate a unit's stability for themselves, every 4910/4911 is subjected to a rigorous program of burn-in and monitoring before being shipped from Datron Instruments. The zener reference modules, which contain all the components that are critical to the 4910/4911's stability, are subjected to a high-temperature burn-in lasting one week. They are then temperature cycled to evaluate their temperature coefficient (TC), evaluated for output noise, and monitored for a period of 6 months to determine their long-term stability. Only modules which meet stringent TC, noise level and stability requirements are subsequently built in to 4910/4911s. Complete units are then subjected to a 1-week burn-in period, and their stability is monitored for a minimum period of three months before shipment.

Units ordered with Option 10 (Calibration and Hot Shipment) are traceably calibrated by Datron Instruments, and are shipped in their low-power battery-backed Transit mode so that their calibration is maintained during shipment to their destination. If Option 20 is specified at the same time as Option 10, drift coefficients are supplied which allow the user to predict the values of the 10V CELL outputs for a period of up to one year after pre-shipment calibration. If Option 30 (4910 only) is specified on ordering, Datron Instruments will traceably calibrate the unit's 1.018V output to a specified 6-decimal place value in the range 1.017000 to 1.019000V.

Units ordered without Option 10 are traceably calibrated before shipment, but are shipped 'cold', with their internal batteries disconnected. As a result, the pre-shipment calibration is not guaranteed on arrival of the unit at its destination. It should be noted, however, that even after cold shipment, the 4910/4911 returns to a condition extremely close to its initial calibration once it is re-powered and allowed to stabilize. As a result, it may only be necessary to check the calibration of a cold-shipped unit when it is received, rather than assuming that full recalibration is necessary.

Calibration Confidence-check

Irrespective of whether a 4910/4911 has been shipped 'hot' (with Option 10) or 'cold' (without Option 10), it should be checked according to the following procedure after it is received from the manufacturer or supplier. This procedure can also be used to periodically check, with a high degree of confidence, that the unit is functioning correctly.

IMPORTANT!

If these checks are being performed on a 4910/4911 that has been shipped 'cold', the unit should be prepared for use as detailed in Section 2 of this handbook and allowed to stabilise for a period of 24 hours before the checks are carried out.

Equipment Requirements

MODEL NUMBER	EQUIPMENT REQUIRED
4910	Null Detector: Sensitivity < 1 μ V Noise < 200 nV pk-pk Input Impedance > 1M Ω (For example:- Keithley 155) Callibrator: Datron 4708 calibrator or similar
4911	Null Detector: Sensitivity < 1 μ V Noise < 200 nV pk-pk Input Impedance > 1M Ω (For example:- Keithley 155)

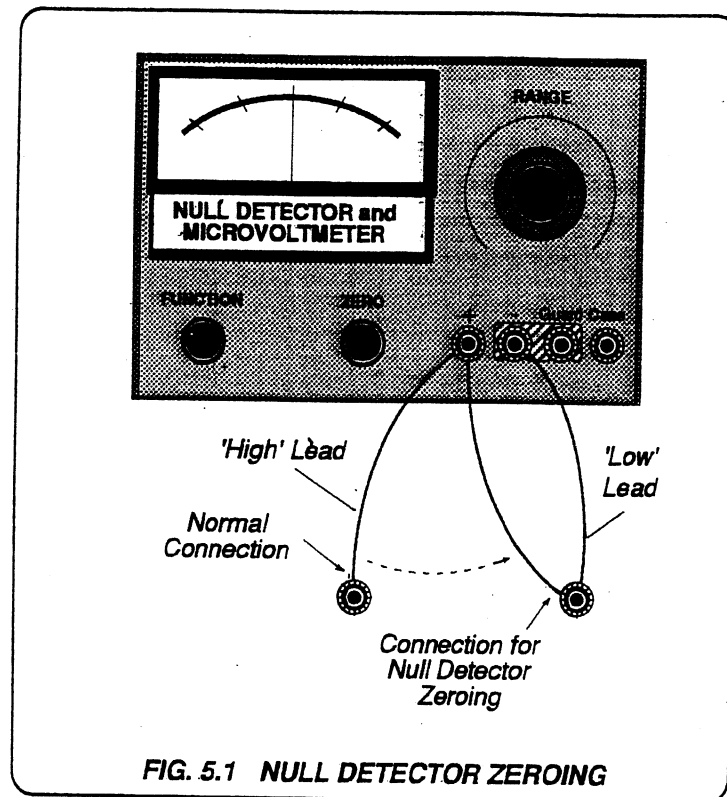
Interconnecting Leads

In order to minimize thermal emfs in external measurement circuits, the leads used to connect the 4910/4911 to other pieces of equipment should be made of high-purity copper and should be terminated in crimped on, gold-flashed copper terminal connectors. Wherever possible the leads should be made from fully-screened twisted-pair cable with the screen connected as shown in the following figures.

Null Detector Zeroing

Before each step in the following procedure which requires the use of the null detector, the detector should be zeroed as follows:-

1. Select the appropriate null detector range.
2. Transfer the far end of the null detector's 'high' lead to the terminal which the far end of its 'low' lead is connected to — see Fig 5.1.
3. With the null detector set to 'measure', zero the null detector using its zero control.
4. Return the far end of the null detector's 'high' lead to the terminal which it was previously connected to.



Calibration Confidence-check Procedure

1. Ensure that the unit is connected to a suitable AC line supply, and is switched into Normal mode. (To switch the unit from Transit mode to Normal mode refer to Section 3 of this handbook).
2. Ensure that all four of the 4910/4911's CELL outputs are coupled into the AVERAGE output - i.e. that all four of the Average LEDs are lit GREEN. (If any of the CELL outputs is not coupled into the AVERAGE output — i.e. its Average LED is lit RED — couple it to the AVERAGE output as detailed in Section 3 of this handbook.)
3. Connect the Guard terminal to the Case terminal with the link provided.
4. For the 4910 only, connect the 4-Wire Output Buffer Hi terminal to the I+ terminal, and the 4-Wire Output Buffer Lo terminal to the I- terminal with the links provided.
5. Connect the null detector to the 4910/4911 as shown in Fig 5.2.
6. Use the null detector to measure the difference between the 4910/4911's CELL output and its AVERAGE output. (Provided that the difference is small enough, it should be measured on the null detector's 10 μ V or 1 μ V range with the null detector zeroed to better than $\pm 0.1\mu$ V.) Note the measured value on the 4910/4911 Calibration Confidence-check Report Sheet — See appendix A.
7. Repeat steps 5 and 6 to measure the differences between the CELL-2, CELL-3 and CELL-4 outputs and the AVERAGE output.

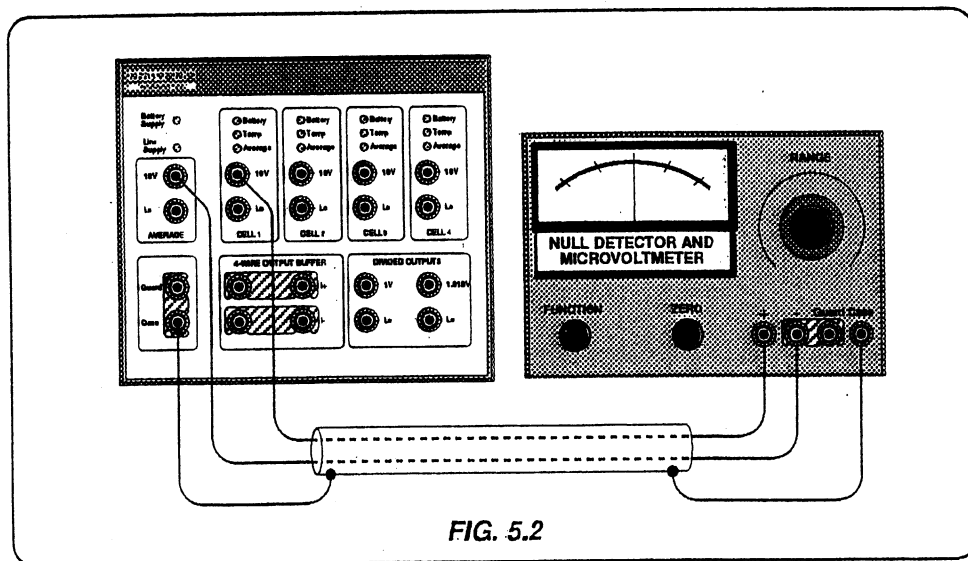


FIG. 5.2

The following checks should be carried out on the 4910 only.

8. Connect the null detector to the 4910 as shown in Fig 5.3.
9. Use the null detector to measure the difference between the 4910's 4-WIRE OUTPUT BUFFER output and its AVERAGE output. (Provided that the

difference is small enough, it should be measured on the null detector's $10\mu\text{V}$ or $1\mu\text{V}$ range with the null detector zeroed to better than $\pm 0.1\mu\text{V}$.) Note the measured value on the 4910/4911 Calibration Confidence-check Report Sheet.

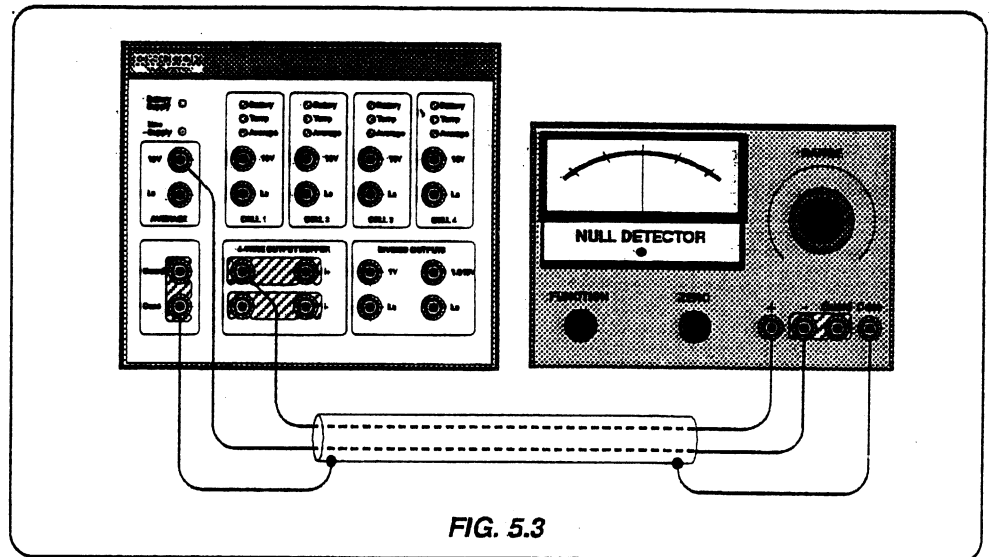


FIG. 5.3

Section 5 - Calibration

If a Datron 4708 or similar calibrator is available, carry out the following steps.

10. Connect the null detector to the 4910 and the 4708 calibrator as shown in Fig 5.4.
11. Set the output of the 4708 calibrator to 10.000000V on its 10V DC range and select remote guard and local sense.
12. Use the calibrator's 'Error' mode to deviate its output until a null is achieved between the output of the calibrator and the AVERAGE output of the 4910, on the null detector's 10 μ V range.

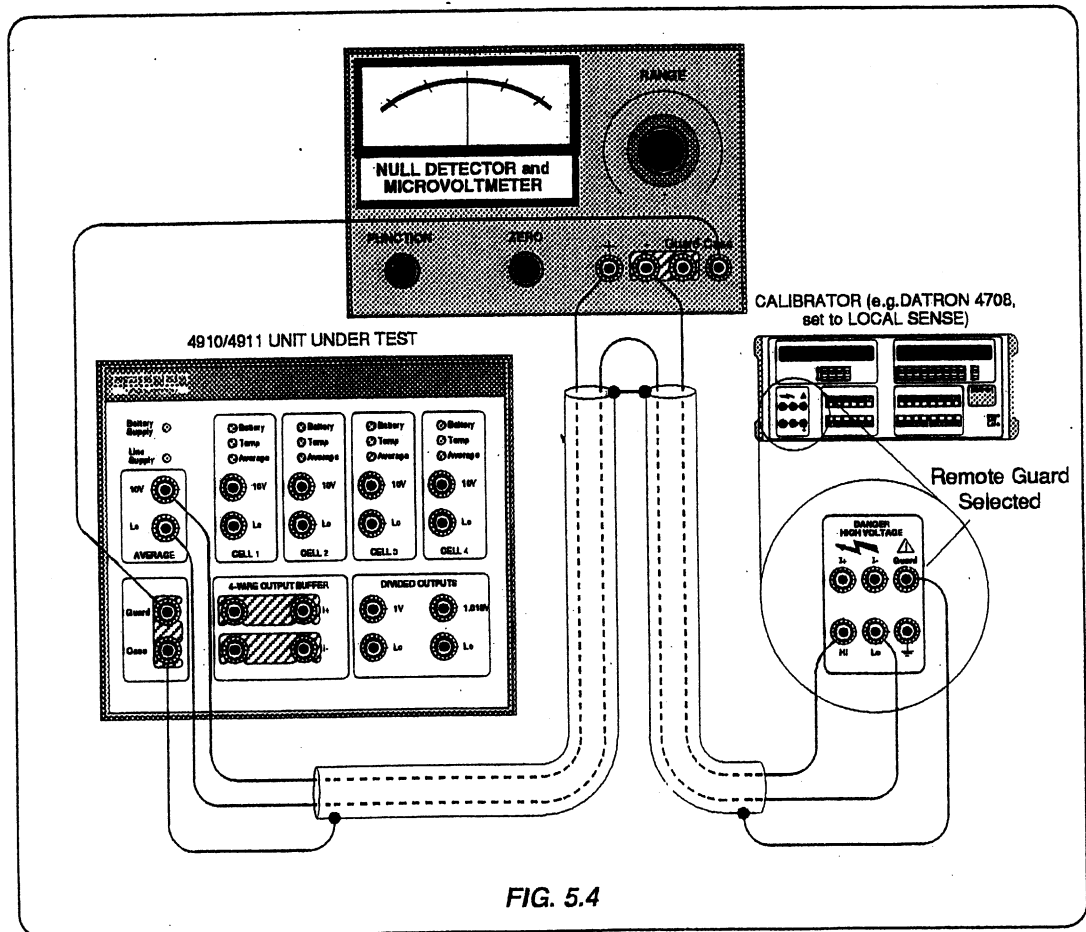
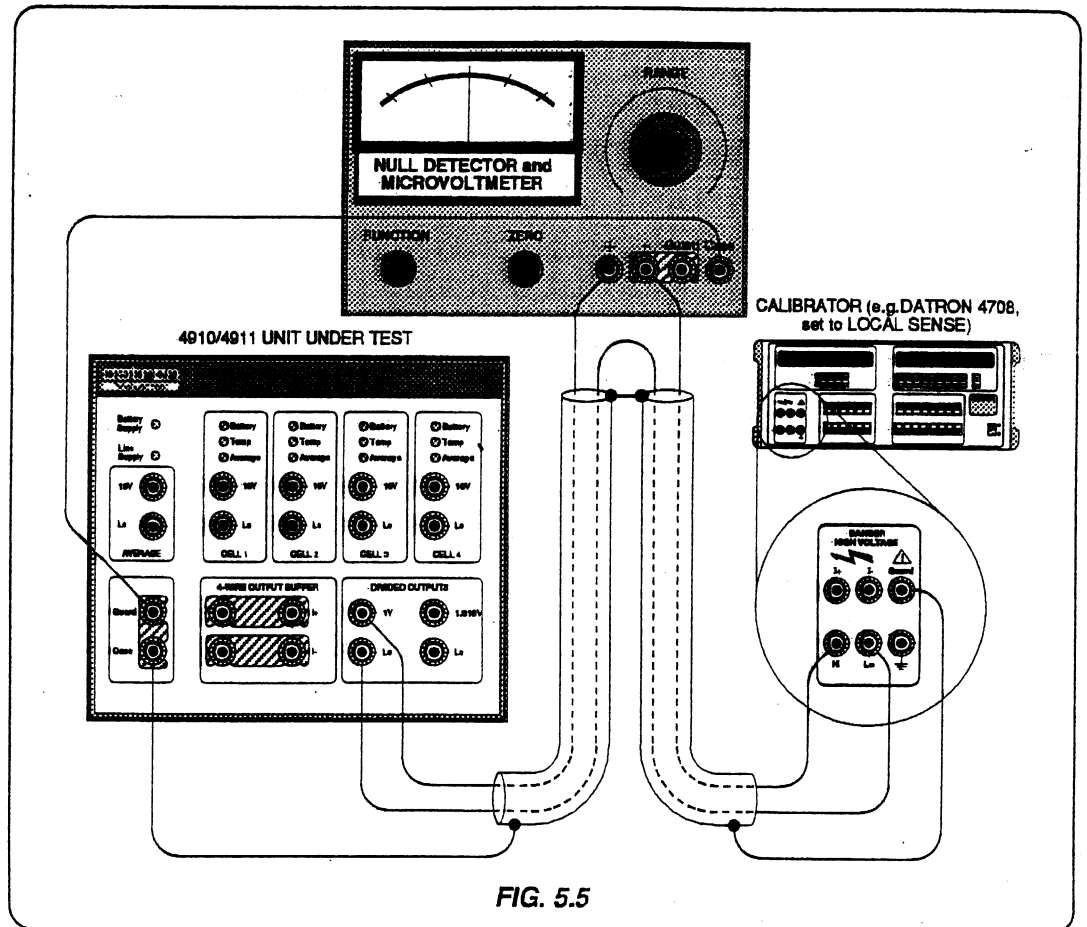


FIG. 5.4

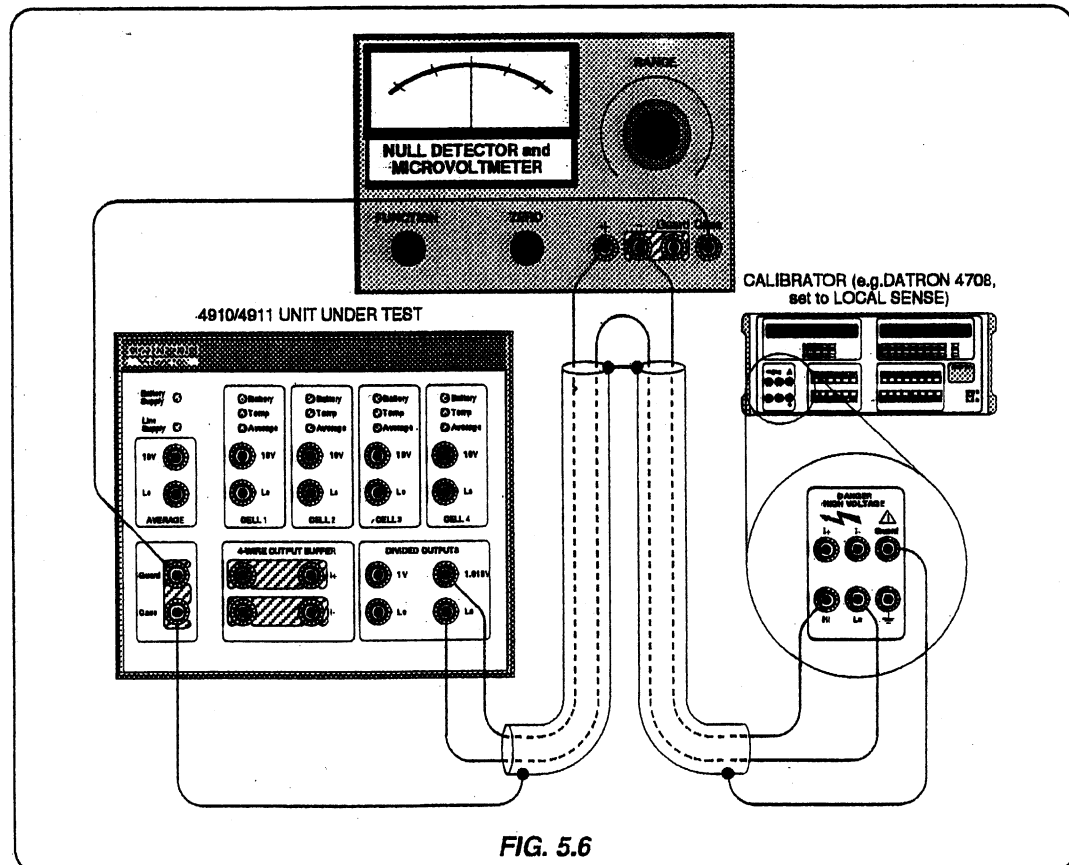
Note: It is possible that some advanced users may wish to measure the divided outputs by comparison with the 10V AVERAGE output, using a high quality divider. This is permissible, providing that the effects of the divider current are determined. A suitable method is suggested in Appendix D.

13. Connect the null detector to the 4910 and the 4708 calibrator as shown in Fig 5.5.
14. Set the output of the 4708 calibrator to 1.000000V on its 10V range.
15. Use the null detector to measure the difference between the 4910's 1V DIVIDED OUTPUT and the 4708 calibrator output. (Provided that the difference is small enough, it should be measured on the null detector's 10 μ V or 1 μ V range with the null detector zeroed to better than $\pm 0.1\mu$ V.) Note the measured value on the 4910/4911 Calibration Confidence-check Report Sheet.



Section 5 - Calibration

16. Connect the null detector to the 4910 and the 4708 calibrator as shown in Fig 5.6.
17. Set the 4708 calibrator output to 1.018000V on its 10V range.
18. Use the null detector to measure the difference between the 4910's 1.018V DIVIDED OUTPUT and the 4708 calibrator output. (Provided that the difference is small enough, it should be measured on the null detector's 10 μ V or 1 μ V range with the null detector zeroed to better than $\pm 0.1\mu$ V.) Note the measured value on the 4910/4911 Calibration Confidence-check Report Sheet.
19. If the unit has just been received from Datron Instruments or a local sales office, check the recorded figures against the validity tolerance figures as calculated on the 4910/4911 Calibration Confidence-check Report Sheet. Otherwise, check the recorded null detector measured values against previous 4910/4911 Calibration Confidence-check Report Sheets for the unit.



Calibration

Introduction

The 4910/4911 DC Voltage Standard should be calibrated by direct comparison against a second 4910/4911, which has been certified by a National Standards Laboratory. Using this method, the only additional piece of equipment required to check or adjust the calibration of the unit is a high-sensitivity null detector. If it is required to check or re-calibrate a 4910/4911 against other standards, such as saturated Weston cells, refer to Datron Instruments for relevant information.

The calibration procedure may be carried out with the unit under test (UUT) and the certified 4910/4911 powered from a suitable AC line supply unless local AC line supplies are poor — in which case it may be advantageous to operate both units from their internal batteries.

Because the 1V and 1.018V DIVIDED OUTPUTS are derived from the 4910/4911's four individual CELL outputs, it is essential that the CELL outputs are calibrated before the DIVIDED OUTPUTS as detailed in the calibration procedure given below.

IMPORTANT!

If the following calibration procedure is being performed on a 4910/4911 that was NOT ordered with Option 10 (Calibration and Hot Shipment), the unit should be prepared for use as detailed in the section titled 'Preparation for Operation - Cold Shipment' on page 2-2 of this handbook and allowed to stabilize for a period of 24 hours before the calibration procedure is carried out.

Equipment Requirements

MODEL NUMBER	EQUIPMENT REQUIRED
4910 or 4911	Null Detector: Sensitivity < 1 μ V Noise < 200 nV pk-pk Input Impedance > 1M Ω (For example:- Keithley 155)

Adjustment of Unit Under Test Outputs

All reference voltage scaling within the 4910/4911 DC Voltage Standard is performed by precision pulse-width modulation (PWM) voltage dividers rather than resistive dividers. As a result calibration adjustments are made entirely digitally, without the use of potentiometers or similar 'analog' controls. To adjust its division ratio, each PWM divider is provided with a set of rotary switches. These switches operate in a similar way to the 'decade' switches found on many pieces of laboratory equipment, except that they operate to a hexadecimal base rather than to a decimal base. In practice, since they are used only to increment or decrement the outputs and not to set the output to an absolute value, the fact that they operate to a hexadecimal base is of little consequence. NOTE: In order to increment an output, the appropriate switch should be rotated in an anti-clockwise direction. In order to decrement an output, the appropriate switch should be rotated in a clockwise direction.

In common with most decade switching, when incrementing an output by one switch step it may be necessary to turn an individual rotary switch from its maximum setting to its minimum setting and to increase the next most significant rotary switch by one step. Similarly, when decrementing an output, it may be necessary to turn a switch from its minimum setting to its maximum setting and to then decrease the next most significant switch by one step. The layout of the rotary switches, after removal of the unit's top cover, is illustrated in Fig 5.7. Note that the left-hand set of switches, which control the 1V and 1.018V DIVIDED OUTPUTS are not present in a 4911.

Interconnecting Leads

In order to minimize thermal emfs in external measurement circuits, the leads used to connect the 4910/4911 to other pieces of equipment should be made of high-purity copper and should be terminated in crimped on, gold-flashed copper terminal connectors. Wherever possible the leads should be made from fully-screened twisted-pair cable with the screen connected as shown in the relevant figures.

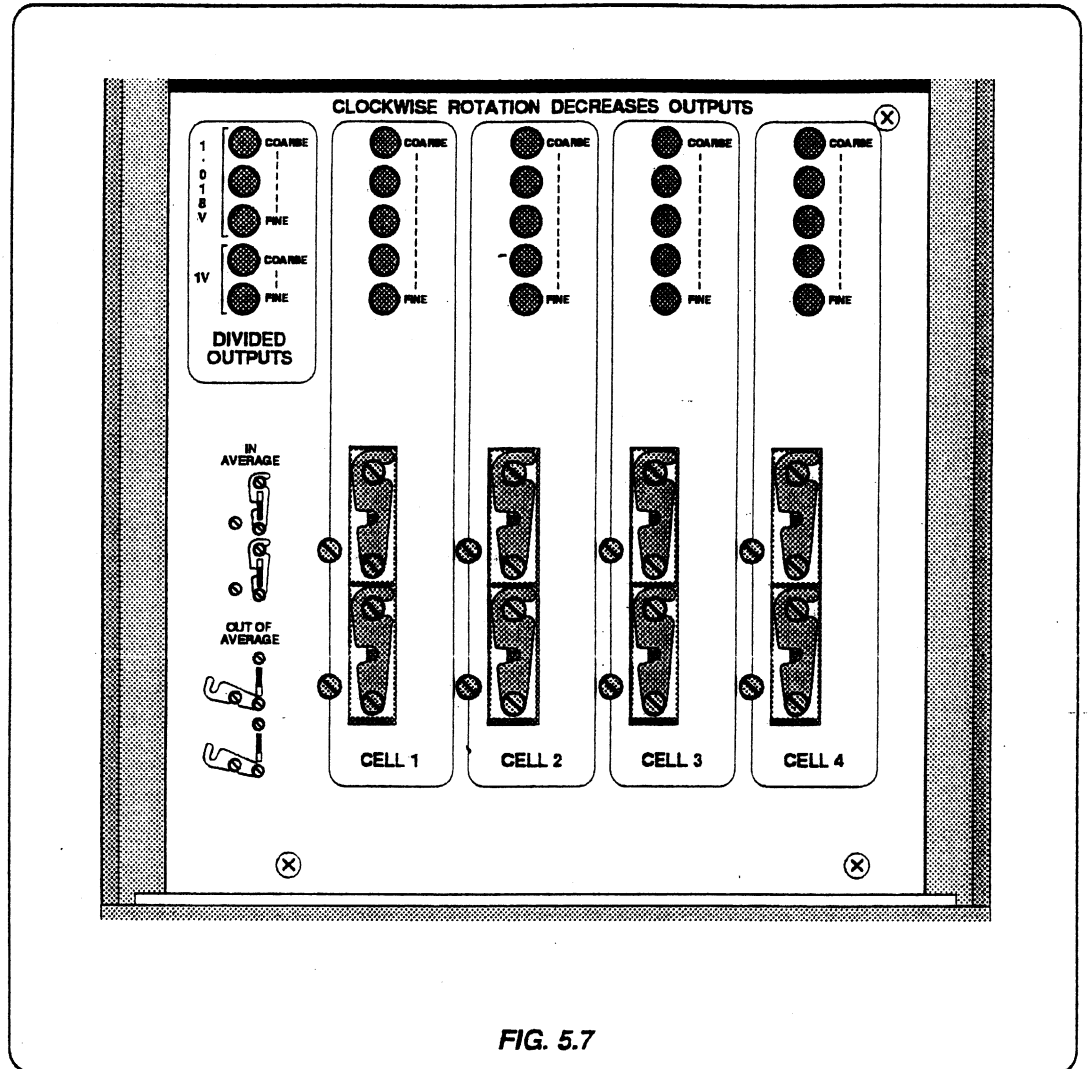
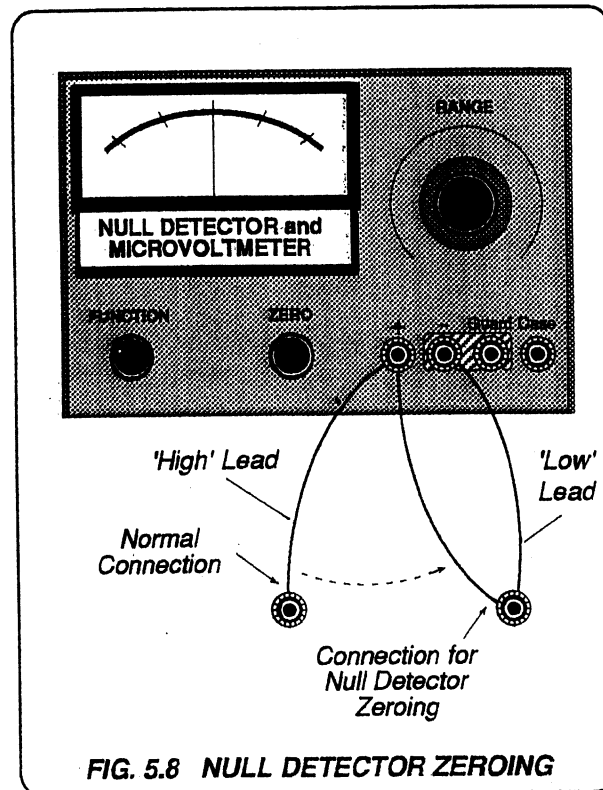


FIG. 5.7

Null Detector Zeroing

Before each step in the following procedure which requires the use of the null detector, the detector should be zeroed as follows:-

1. Select the appropriate null detector range.
2. Transfer the far end of the null detector's 'high' lead to the terminal which the far end of its 'low' lead is connected to — see Fig 5.8.
3. With the null detector set to 'measure', zero the null detector using its zero control.
4. Return the far end of the null detector's 'high' lead to the terminal which it was previously connected to.



Calibration Procedure

IMPORTANT: If it is required only to check the calibration of the 4910/4911, and not to adjust the outputs, omit those steps in the following procedure which are highlighted in *italic* type.

1. *Remove the two screws towards the rear of the unit's top cover and remove the top cover.*
2. Ensure that the unit has been switched into Normal mode for a period of at least 4 hours. (To switch the unit from Transit mode to Normal mode refer to Section 3 of this handbook).
3. Ensure that all four of the 4910/4911's CELL outputs are coupled into the AVERAGE output - i.e. that all four of the Average LEDs are lit GREEN. (If any of the CELL outputs is not coupled into the AVERAGE output — i.e. its Average LED is lit RED — couple it to the AVERAGE output as detailed in Section 3 of this handbook.)
4. Carry out the Calibration Confidence-check procedure, detailed on page 5-2 of this handbook, on the certified 4910/4911.

Section 5 - Calibration

5. Connect the null detector to the certified 4910/4911 and the UUT as illustrated in Fig 5.9.
6. Use the null detector to measure the difference between the UUT's CELL output and the certified 4910/4911's AVERAGE output. (Provided that the difference is small enough, it should be measured on the null detector's 10 μ V or 1 μ V range with the null detector zeroed to better than $\pm 0.1\mu$ V.) Note the measured value on the 4910/4911 Calibration Report Sheet — See appendix B.
7. Adjust the appropriate CELL output of the UUT to bring the null detector reading to zero $\pm 1\mu$ V.
8. Note the final null detector reading on the 4910/4911 Calibration Report Sheet.
9. Repeat steps 5 to 8 for the CELL-2, CELL-3 and CELL-4 outputs of the UUT.

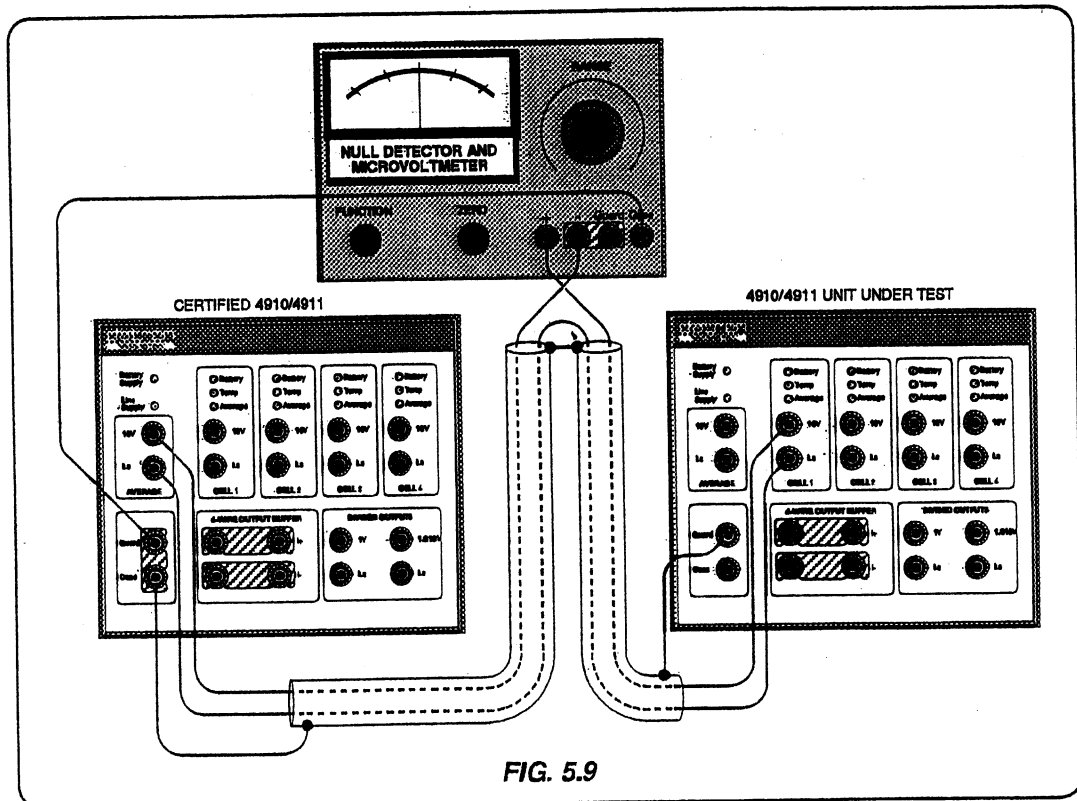


FIG. 5.9

10. Connect the null detector to the certified 4910/4911 and the UUT as shown in Fig 5.10.
11. Use the null detector to measure the difference between the UUT's AVERAGE output and the certified 4910/4911 AVERAGE output. (Provided that the

difference is small enough, it should be measured on the null detector's $10\mu\text{V}$ or $1\mu\text{V}$ range with the null detector zeroed to better than $\pm 0.1\mu\text{V}$.) Note the measured value on the 4910/4911 Calibration Report Sheet.

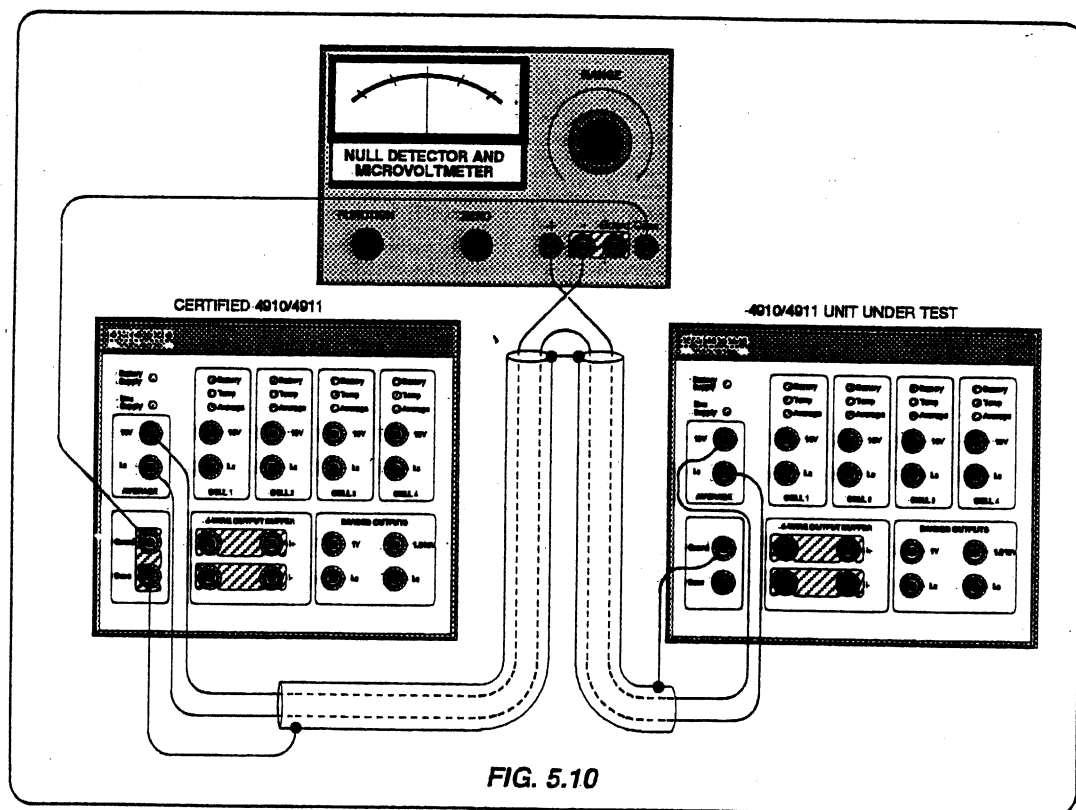
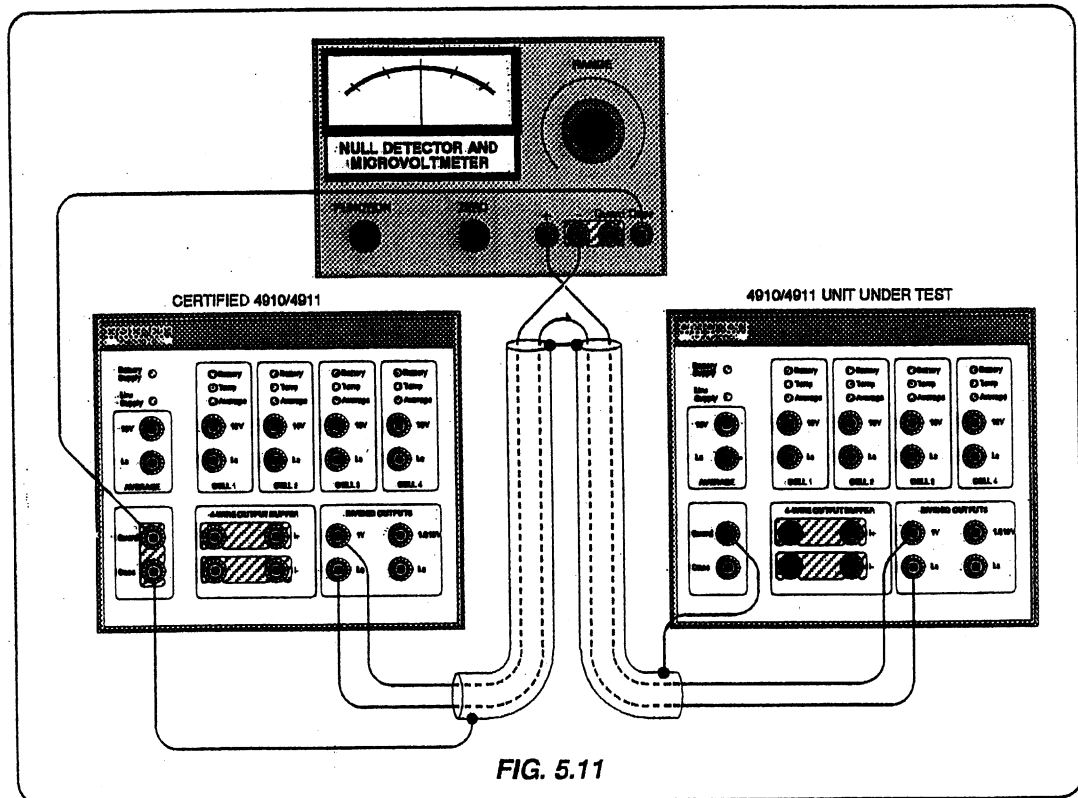


FIG. 5.10

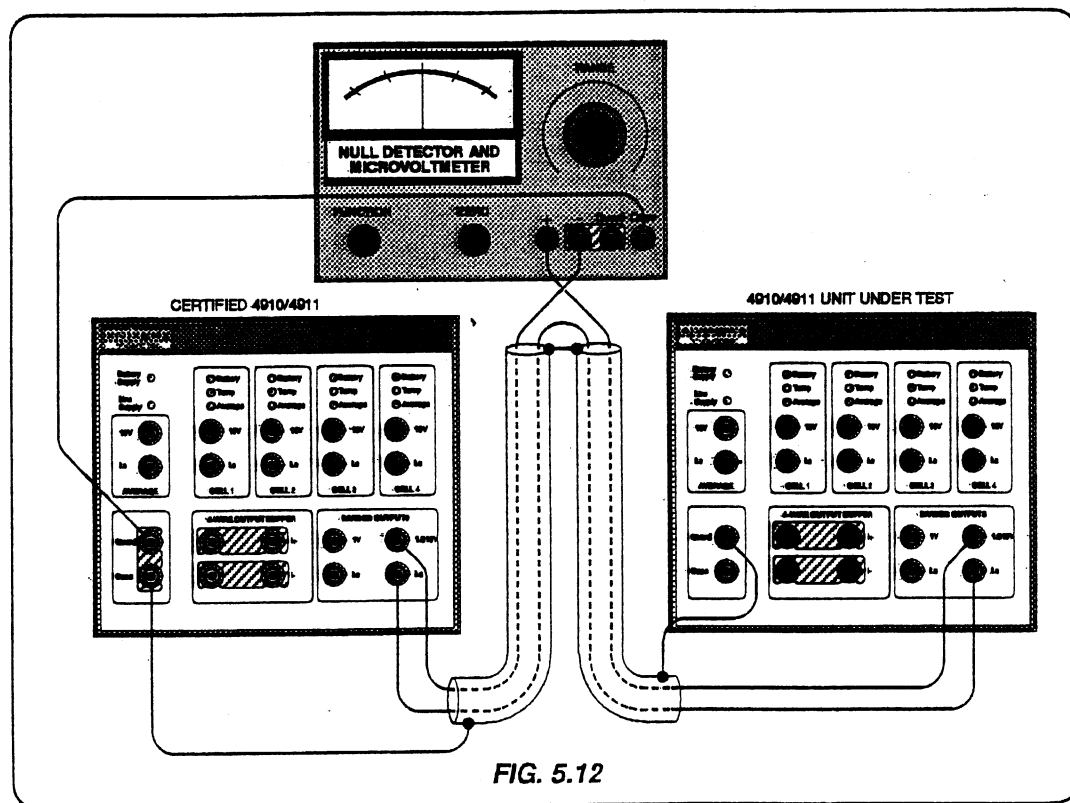
Section 5 - Calibration

The following calibration steps apply to the 4910 only.

12. Connect the null detector to the certified 4910 and the UUT as shown in Fig 5.11.
13. Use the null detector to measure the difference between the 1V DIVIDED OUTPUT of the UUT and the 1V DIVIDED OUTPUT of the certified 4910. (Provided that the difference is small enough, it should be measured on the null detector's 10 μ V or 1 μ V range with the null detector zeroed to better than $\pm 0.1\mu$ V.) Note the measured value on the 4910/4911 Calibration Report Sheet.
14. Adjust the 1V DIVIDED OUTPUT of the UUT to bring the null detector reading to zero $\pm 0.5\mu$ V.
15. Note the final null detector reading on the 4910/4911 Calibration Report Sheet.

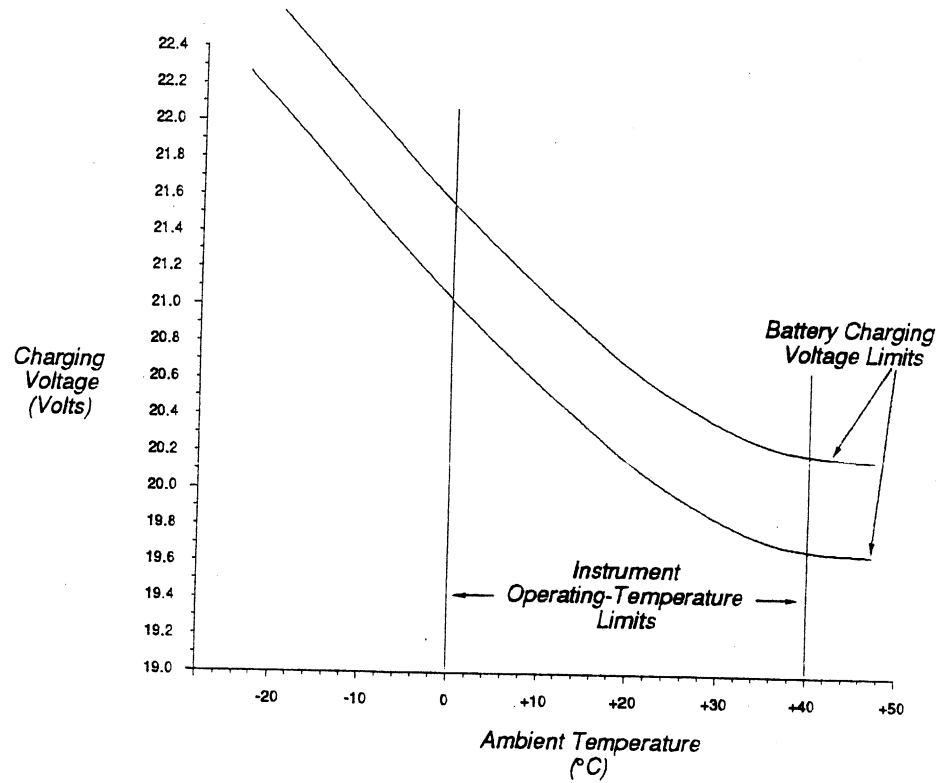


16. Connect the null detector to the certified 4910 and the UUT as shown in Fig 5.12.
17. Use the null detector to measure the difference between the 1.018V DIVIDED OUTPUT of the UUT and the 1.018V DIVIDED OUTPUT of the certified 4910. (Provided that the difference is small enough, it should be measured on the null detector's 10 μ V or 1 μ V range with the null detector zeroed to better than $\pm 0.1\mu$ V.) Note the measured value on the 4910/4911 Calibration Report Sheet.
18. Adjust the 1.018V DIVIDED OUTPUT of the UUT to bring the null detector reading to zero $\pm 0.5\mu$ V.
19. Note the final null detector reading on the 4910/4911 Calibration Report Sheet.



APPENDIX C

Battery Charging Voltage Limits



APPENDIX D 4910 - Measurement of Divided Outputs Alternative Method using a High Quality Divider

Introduction

As a general recommendation, measurement of the divided outputs of the 4910 should be carried out using potentiometric methods, against a separate standard source (as described in Section 5 pages 5-7/16/17). Nevertheless, where a high-quality divider is in general use within a standards and calibration system, it is permissible to check the Divided Outputs against the 4-Wire Output Buffer, under certain conditions.

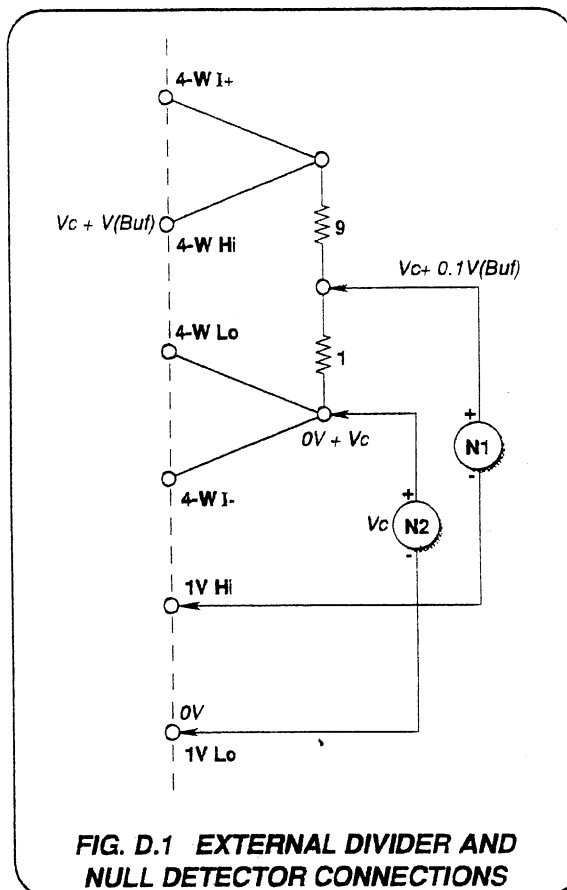
Precautions must be taken to ensure that any common mode voltages generated by the external divider current (total shown overleaf as V_c) are eliminated from the measurement.

Providing the buffer output voltage is known (it is measured in the Calibration Confidence-check - page 5-5) this can be done by taking two readings using a Null Detector - Microvoltmeter, and using the readings to calculate the Divided Output magnitude.

A measurement circuit is given overleaf which shows the relevant connections. The two readings N_1 and N_2 can be taken separately with the same Null Detector, and the calculations to obtain the 1V divided output are also given.

The 1.018V Divided Output can be measured using the same technique, but using an external divider of 10 : 1.018 instead of 10 : 1.

Alternative Method of using a High Quality Divider to Measure the 4910 Divided Outputs



In the following, the external divider is assumed to be perfect. In fact its uncertainty must be taken into account. The voltage between 1VHi and 1VLo is to be found, so 1VLo potential is taken to be 0V:

$$1VHi = 0V + Vc + 0.1[V(Buf)] - N1$$

but: total common-mode voltage (Vc) = $N2$

$$\text{so: } 1VHi = N2 - N1 + 0.1[V(Buf)]$$

$V(Buf)$ has been measured earlier; $N1$ and $N2$ readings are taken as part of this measurement.

$$1VHi \text{ error} = N1 - N2$$

DATRON INSTRUMENTS FAILURE REPORT.

Please complete all sections and return with your instrument.

Company:.....
Division: Department/Mail Stop
User, Name: Telephone Ext
Serial number:.....
Datron Return Authorisation number Date of failure

Brief description of fault:
.....
.....
.....

Is the fault: Permanent Intermittent
If intermittent under what conditions does the fault re-appear
.....
.....

Is the instrument normally enclosed in a rack? Yes No
Approximate ambient temperature

TERMS AND CONDITIONS OF SALE

1. GENERAL

The acceptance of a quotation, of any goods supplied, advice given or service rendered includes the acceptance of the following terms and conditions and no variation of or addition to the same shall be binding upon us unless expressly agreed in writing by us. Any order shall be subject to our written acceptance.

2. QUOTATION

Unless previously withdrawn our quotation is open to acceptance in writing within the period stated or where no period is stated within thirty (30) days after its date. We reserve the right to correct any errors or omissions in our quotation. Unless otherwise stated all quotations are firm and fixed. The prices quoted are based on manufacture of the quantity and type ordered and are subject to revision when interruptions, engineering changes or changes in quantity are caused or requested by the customer.

3. LIABILITY FOR DELAY

Any delivery times quoted are from the date of our written acceptance of any order and on receipt of all information and drawings to enable us to put the work in hand. Where delivery is to take place by instalments each such instalment shall constitute a separate contract. We will use our best endeavours to complete delivery of the goods or services in the period stated but accept no liability in damages or otherwise for failure to do so for any cause whatsoever. In all cases of delay the delivery time shall be extended by reasonable period having regard to the cause of delay.

4. PAYMENT

Payment shall be made net cash within thirty (30) days of delivery or in accordance with the payment terms set out in the quotation. Unless specifically stated to the contrary payment shall be in pounds sterling. In the event of any payment to us being overdue we may without prejudice to any other right suspend delivery to you or terminate the contract and/or charge you simple interest on overdue amounts at the rate of 2.5% above the ruling Bank of England Minimum Lending Rate. No payment to us shall in any circumstance be offset against any sum owing by us to you whether in respect of the present transaction or otherwise.

5. INSPECTION & TEST

All goods are fully inspected at our works and where practicable subjected to our standard tests before despatch. If tests are required to be witnessed by your representative notice of this must be given at the time of placing the order and notice of readiness will then be given to you seven (7) days in advance of such tests being carried out. In the event of any delay on your part in attending such tests or in carrying out inspection by you after seven (7) days notice of readiness the tests will proceed in your absence and shall be deemed to have been made in your presence and the inspection deemed to have been made by you. In any event you shall be required promptly after witnessing a test or receiving test results of witnessed or unwitnessed tests to notify us in writing of any claimed defects in the goods or of any respect in which it is claimed that the goods do not conform with the contract. Before you become entitled to reject any goods we are to be given reasonable time and opportunity to rectify them. You assume the responsibility that the goods stipulated by you are sufficient and suitable for your purpose and take all steps to ensure that the goods will be safe and without risk to health when properly used. Any additional certification demanded may incur extra cost for which a special quotation will be issued.

6. DELIVERY AND PACKING

All shipments are, unless otherwise specifically provided, Ex-works which is the address given on the invoice. An additional charge will be made for carriage and insurance as necessary with the provision that all shipments shall be insured and this insurance expense shall be paid by the purchaser. Where special domestic or export packing is specified a charge will be made to cover the extra expense involved.

7. DAMAGE IN TRANSIT

Claims for damage in transit or loss in delivery of the goods will only be considered if the carriers and ourselves receive notice of such damage within seven (7) days of delivery or in the event of loss of goods in transit within fourteen (14) days of consignment.

8. TRANSFER OF PROPERTY & RISK

Title and property of the goods shall pass when full payment has been received of all sums due to us whether in respect of the present transaction or not. The risk in the goods shall be deemed to have passed on delivery.

9. WARRANTY

We agree to correct, either by repair, or at our election, by replacement, any defects of material or workmanship which develop within the warranty period specified in the sales literature or quotation after delivery to the original purchaser. All items claimed defective must be promptly returned to us carriage paid unless otherwise arranged and will be returned to you free of charge. Unless otherwise agreed no warranty is made concerning components or accessories not manufactured by us. We will be released from all obligations under warranty in the event of repairs or modifications made by persons other than our own authorised service personnel unless such repairs are made with our prior written consent.

10. PATENTS

We will indemnify you against any claim of infringement of Letters Patent, Registered Design, Trade Mark or Copyright (published at the date of the contract) by the use or sale of any goods supplied or service rendered by us to you and against all costs and damages which you may incur and for which you may become liable in any action for such infringement. Provided always that this indemnity shall not apply to any infringement which is due to our having followed a design or instruction furnished or given by you or to the use of such goods or service in association or combination with any other article, material or service not supplied by us. This indemnity is conditional on your giving to us the earliest possible notice in writing of any claim being made or action threatened or brought against you and on your permitting us at our own expense to conduct litigation that may ensue and all negotiations for a settlement of the claim or action. You on your part warrant that any design or instruction furnished or given by you shall not cause us to infringe any Letter Patent, Registered Design, Trade Mark or Copyright in the execution of your order.

11. DOCUMENTATION

All drawings, plans, designs, software specifications, manuals and technical documents and information supplied by us for your use or information shall remain at all times our exclusive property and must not be copied, reproduced, transmitted or communicated to a third party without our prior written consent.

12. FRUSTRATION

If any contract or any part of it shall become impossible of performance or otherwise frustrated we shall be entitled to a fair and reasonable proportion of the price in respect of the work done up to the date thereof. For this purpose any monies previously paid by you shall be retained against the sum due to us under this provision. We may dispose of the goods as we think fit due allowance being made to you for the net proceeds thereof.

13. BANKRUPTCY

If the purchaser shall become bankrupt or insolvent, or being a Limited Company commence to be wound up or suffer a Receiver to be appointed, we shall be at liberty to treat the contract as terminated and be relieved of further obligations. This shall be without prejudice to our right to claim for damages for breach of contract.

14. LEGAL INTERPRETATION

Any contract will be deemed to be made in England and shall be governed and construed for all purposes and in all respects in accordance with English Law and only the Courts of England shall have jurisdiction.



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TME Systems Pte Ltd 21 Moonstone Lane, No. 06-01, Singapore 1232	268 4608	786 37545	288 5935
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APPENDIX B

4910/4911 Calibration Report Sheet

Unit Under Test Type Number (4910 or 4911):

Unit Under Test Serial Number:

Certified Unit Type Number (4910 or 4911):

Certified Unit Serial Number:

Null Detector Type Number:

Null Detector Serial Number:

Null Detector Accuracy:

Ambient Temperature:

Checked by:

Company/Department:

Date:

Procedure Step Number	Measurement	Absolute Value of Certified Unit Output	Uncertainty of Certified Unit Output	Null Detector Reading Before UUT Adjustment	Uncertainty of Null Detector Reading	Absolute Value of UUT Output Before Adjustment	Uncertainty of UUT Output Before Adjustment	Null Detector Reading After UUT Adjustment	Uncertainty of Null Detector Reading	Absolute Value of UUT Output After Adjustment	Uncertainty of UUT Output After Adjustment
		(V_c) V	(U_c) $\pm\mu V$	(V_n) μV	(U_n) $\pm\mu V$	$(V_t=V_c+V_n)$ V	$(U_t=U_c+U_n)$ $\pm\mu V$	(V_n') μV	(U_n') $\pm\mu V$	$(V_t'=V_c+V_n')$ V	$(U_t'=U_c+U_n')$ $\pm\mu V$
6a/8a	CELL-1 10V										
6b/8b	CELL-2 10V										
6c/8c	CELL-3 10V										
6d/8d	CELL-4 10V										
11	AVERAGE 10V										
13/15*	1V DIVIDED OUTPUT										
17/19*	1.018V DIVIDED OUTPUT										

* Not applicable to model 4911

APPENDIX A

4910/4911 Calibration Confidence-check Report Sheet

Unit Under Test Type Number (4910 or 4911):

Unit Under Test Serial Number:

Null Detector Type Number:

Null Detector Serial Number:

Null Detector Accuracy:

Calibrator Type Number (if used):

Calibrator Serial Number (if used):

Ambient Temperature:

Checked by:

Company/Department:

Date:

Procedure Step Number	Measurement	Calibration and Drift Tolerance $\pm\mu V$ (Ud)	TC Tolerance $\pm\mu V$ (Utc)	Null Detector Measurement Tolerance $\pm\mu V$ (Um)	Validity Tolerance $\pm\mu V$ $\pm(Ud+Utc+Um)$	Null Detector Measured Value μV
6a	AVERAGE 10V to CELL-1 10V	10	$ (23 - T) \times 0.5 =$	= A		= E
6b	AVERAGE 10V to CELL-2 10V	10	$ (23 - T) \times 0.5 =$	= B		= F
6c	AVERAGE 10V to CELL-3 10V	10	$ (23 - T) \times 0.5 =$	= C		= G
6d	AVERAGE 10V to CELL-4 10V	10	$ (23 - T) \times 0.5 =$	= D		= H
Totals for four cells (4910 only)					$7\mu V + A + B + C + D =$	$E + F + G + H =$
Totals for four cells (4911 only)					$A + B + C + D =$	$E + F + G + H =$

9*	AVERAGE 10V TO 4-WIRE OUTPUT BUFFER Hi	10	$ (23 - T) \times 0.1 =$			
15*	4708 calibrator output to 1V DIVIDED OUTPUT	0.8	$ (23 - T) \times 0.07 =$			
18*	4708 calibrator output to 1.018V DIVIDED OUTPUT	0.8	$ (23 - T) \times 0.05 =$			

* Not applicable to 4911