Model 4610M

Advanced Multi Product Calibrator

Performance Verification & Calibration Manual

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TABLE OF CONTENTS

1. Introduction 7

1.1. Main Features 7
1.2. Accuracy and Functionality 7
1.3. True Multiproduct Calibration 7
1.4. Retro Fit Options 7
1.5. USB Interface 7
1.6. GPIB (IEEE488) Interface 8
1.7. Output Terminals 8

2. Calibration & Adjustments 10

2.1. Introduction 10
2.2. Equipment Required 10
2.3. Configuring for Measurements 11
2.4. Getting the best out of the calibrator. 11
2.4.1. Making Good Measurements 11
2.4.2. Thermally generated EMF voltage errors. 12
2.4.3. Lead/Connection Resistance 12
2.4.4. Power line and low frequency Pick up and noise 13
2.5. General 13
2.5.1. Electrical Safety Tests 13
2.5.2. Cleaning of the Fan Duct 13
2.5.3. Cleaning the external case 13
2.6. Calibration 14
2.6.1. Calibration Uncertainties 14
2.6.2. Beginning Calibration 15
2.6.3. DC Voltage 19
2.6.4. DC Current 25
2.6.5. AC Voltage 29
2.6.6. AC Current 33
2.6.7. 2 Wire Resistance (Passive) 35
2.6.8. 4 Wire Resistance (Passive) 37
2.6.9. Simulated Resistance 38
2.6.10. Passive Capacitance 41
2.6.11. Simulated Capacitance 42
2.6.12. Thermocouple Source 44
2.6.13. Thermocouple Measure 45
2.6.14. Thermocouple Cold Junction Measurement 46
2.6.15. Frequency Adjustment 47

3. Verification 48

3.1. DC Voltage 48
3.2. AC Voltage 50
3.3. DC Current 53
3.4. AC Current 54
3.5. 2 2 Wire Passive Resistance 57
3.6. 4 Wire Passive Resistance 59
3.7. Simulated Resistance - 4 Wire 61
3.8. Simulated Resistance - 2 Wire 63
3.9. Simulated Resistance - 2 Wire Compensated (Optional) 65
3.10. Passive Capacitance 67
3.11. Simulated Capacitance 68
3.12. Thermocouple Source 69
3.13. Thermocouple Measure 71
3.14. Thermocouple Cold Junction 72
3.15. Frequency Output 72

Figures 1 – LIST OF FIGURES

Figures 1 – Default Screen 15
Figures 2 – Main Menu (Calibration) 15
Figures 3 – Calibration Menu (Pasccode) 16
Figures 4 – Calibration Menu 17
Figures 5 – Calibration Menu (Backup Complete) 18
Figures 6 – Calibration Menu (1 of 2) 18
Figures 7 – Multimeter (DC Voltage, Zero Leads) 19
Figures 8 – DC Voltage Connections 20
Figures 9 – Calibration Menu (DC Voltage) 20
Figures 10 – DC Voltage (Zero Calibration Point Prompt) 21
Figures 11 – DC Voltage (Zero Calibration Point Prompt) 21
Figures 12 – Zero Calibration Point (Value Entered) 22
Figures 13 – Zero Calibration Point (adjusted) 22
Figures 14 – Zero Calibration Point (Calibration Factor Error) 23
Figures 15 – Multimeter (DC Current, Zero leads) 25
Figures 16 – DC Current Connections (≤ 1A) 26
Figures 17 – Calibration Menu (DC Current) 27
Figures 18 – DC Current (Zero Calibration Point) 27
Figures 19 – AC Voltage Connections 29
Figures 20 – Calibration Menu (AC Voltage) 30
Figures 21 – 4 Wire Zero at End Of Leads 35
Figures 22 – 2 Wire Passive Resistance - Values up to 100k Ohms 36
Figures 23 – 2 Wire Passive Resistance - Values above 100k Ohms 36
Figures 24 – 4 Wire Resistance Connection 37
Figures 25 – 4 Wire Zero at End Of Leads 38
Figures 26 – 4 Wire Simulated Resistance Connection - Values up to 100k Ohms 39
Figures 27 – 2 Wire Simulated Resistance Connection - Values above 100k Ohms 39
Figures 28 – 4 Wire Resistance Connection 41
Figures 29 – 4 Wire Resistance Connection 42
Figures 31 – Thermocouple Source Connection To Multimeter 44
Figures 32 – Thermocouple Measurement Connection 45
Figures 33 – Thermocouple Cold Junction Calibration 46
Figures 34 – Location of XTAL Adjust on Top Board 47
Figures 35 – 4 Wire Zero at End Of Leads 57
Figures 36 – 2 Wire Passive Resistance - Values below 100k Ohms 57
Figures 37 – 2 Wire Passive Resistance - Values above 100k Ohms 58
Figures 38 – 4 Wire Resistance Measurement Connection 59
Figures 39 – 4 Wire Lead Zero 61
Figures 40 – 4 Wire Resistance Connection 61

Figures 41 – 2 Wire Measurement for Resistance < 100 kOhms..... 63
Figures 42 – 2 Wire Measurement for Resistance above 100 kOhms..... 63
Figures 43 – Multimeter 2 Wire Zero to Terminals..... 65
Figures 44 – Measurement of 2 Wire Compensated Ohms Output 65

LIST OF TABLES

Table 1 – Table Terminal Description 9
Table 2 – Equipment Required for Verification/Adjustment 11
Table 3 – Calibration Menu (30 Minute Warmup Warning) 17
Table 4 – DC Voltage Adjustment Points 23
Table 5 – DC Current Adjustment Points 28
Table 6 – AC Voltage Adjustment Points 32
Table 7 – AC Current Adjustment Points & Frequencies 34
Table 8 – Simulated Resistance Adjustment Points 40
Table 9 – DC Voltage Verification Points 49
Table 10 – AC Voltage Verification Points 52
Table 11 – DC Current Verification Points 53
Table 12 – AC Current Verification Points 56
Table 13 – Passive 2 Wire Resistance Verification Points 58
Table 14 – Passive 4 Wire Resistance Verification Points 60
Table 15 – 4 Wire Simulated Resistance Verification Points 62
Table 16 – Wire Simulated Resistance Verification Points 64
Table 17 – 2 Wire Compensated Resistance Verification Points 66
Table 18 – Passive Capacitance Verification Points 67
Table 19 – Simulated Capacitance Verification Points 68
Table 20 – Thermocouple Source mV Out Verification 69
Table 21 – Thermocouple Source Verification Table 70
Table 22 – Thermocouple Measurement mV Verification 71
Table 23 – Thermocouple Measurement Verification Points 72
Table 24 – Frequency Output Verification Points 72

1. Introduction

The 4610M calibrator offers the most advanced and up to date means of calibration of a wide variety of electrical measuring instruments. The 4610M advanced multi product calibrator provides a fully functional, precision programmable calibration source.

1.1. Main Features

- AC/DC Volts to 1025 V
- AC/DC Current to 30 Amps
- AC/DC Current to 1500 Amps with EA002 50 turn clamp coil adapter (option)
- 2 and 4 wire passive resistance to 1 GΩ
- 2 wire, 2 wire compensated, and 4 wire simulated resistance
- Capacitance to 100 mF (passive and simulated modes)
- Frequency to 1 MHz
- Pulse width modulation / duty cycle
- RTD (PRT) simulation
- Thermocouple source simulation and measurement (°C & °F)
- USB Interface
- GPIB (IEEE488) Interface

1.2. Accuracy and Functionality

The 4610M integrates powerful calibration capabilities using built-in software.

1.3. True Multiproduct Calibration

From one instrument
Designed to provide an accurate cost-effective instrument for the calibration of multimeters, clamp meters, frequency meters, temperature meters, and capacitance meters.
Designed for use in the laboratory or portable onsite calibration, the 4610M calibrator is suitable for use in a standards laboratory. The 4610M boasts a fast-warm up time combined with connection to a PC/laptop (via a USB / GPIB interface) allowing for a fast return on investment and premium accuracy.

1.4. Retro Fit Options

Allows additional functions to be added.
Several internal retrofit options including oscilloscope and power allow the user to select the most cost-effective solution for the calibration work with the ability to add extra functions at a later date. External options include current coil adapter for the calibration of clamp meters.

1.5. USB Interface

All functions and outputs of the 4610M calibrator are fully programmable over the USB interface. Refer to the operation manual to connect and configure the interface.

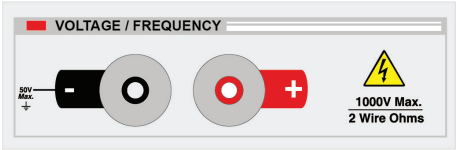
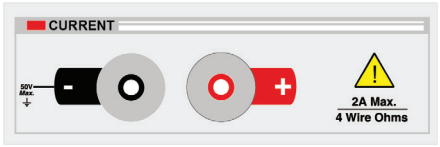
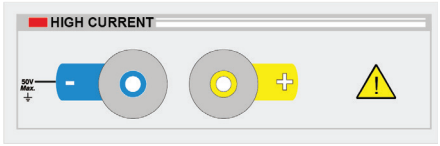
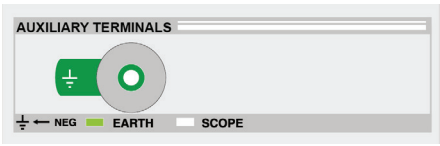
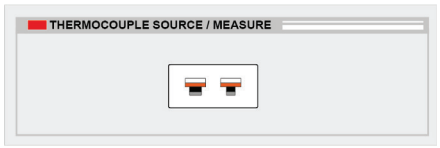
1.6. GPIB (IEEE488) Interface

All functions and outputs of the 4610M calibrator are fully programmable over the GPIB (IEEE488) interface. Refer to the operation manual to connect and configure the interface.

1.7. Output Terminals

The output terminal configuration is designed to match the majority of multimeter input connections, e.g. volts/ohms, low current and high current eliminating the need for lead changing during calibration. All outputs are isolated when not in use and an L.E.D. indicator shows the active output(s).

Table 1 – Table Terminal Description

Voltage / Frequency Output Terminals (Black & Red) Low thermal 4mm safety terminals used for all voltage outputs up to 1025V, for 2 wire / 4 wire resistance (both passive and simulated), capacitance and frequency (also optional inductance). *Note: the low 'black' terminal can be internally switched to line earth by a soft key function. When floating, the maximum voltage on this terminal with respect to ground should not exceed 50 Volts peak.*	
Current Output Terminals (≤ 2 Amps) (Black & Red) 4mm safety terminals for all current outputs up to 2 Amps, sense connection for 4 wire resistance (both passive and simulated) and compensated 2 wire simulated resistance. *Note: the low 'black' terminal can be internally switched to line earth by a soft key function. When floating, the maximum voltage on this terminal with respect to ground should not exceed 50 Volts peak.*	
High Current Output Terminals (Blue & Yellow) 4mm safety terminals for all currents above 2 Amps to 30 Amps. *Note: the low 'blue' terminal can be internally switched to line earth by a soft key function. When floating, the maximum voltage on this terminal with respect to ground should not exceed 50 Volts peak.*	
Earth Terminal (Green)	
Thermocouple Source / Measure *Thermocouple mini connector for simulation and measurement of thermocouples, example K & J types*	
WARNING: *Dangerous voltage or current may be present on these terminals.*	

2. Calibration & Adjustments

> *WARNING*
> *The information in this section is intended only for qualified personnel. The user must at all times be adequately protected from electric shock.*

2.1. Introduction

Transmille recommend that the 4610M calibrator should be calibrated at a 1-year calibration interval. The Verification procedure should be used if there is a need to verify the calibrator within that period. If higher levels of performance are required, Transmille provide extended specifications for different intervals. Alternatively, if a longer calibration interval is desirable specifications based on a 2 Year interval are available.

Transmille recommends that the instrument be returned to Transmille for calibration. Transmille use a software (ProCal) controlled calibration and verification process and supply a calibration certificate traceable to national standards. If you wish to calibrate or verify the 4610M at your own premises, use the following procedures for guidance.

2.2. Equipment Required

The equipment listed below is required to calibrate and verify the performance of the 4610M. If a specified instrument is not available, a suitable alternative may be used which has equal or better accuracies.

Equipment	Use	Recommended Models
High Accuracy Precision Multimeter	DC Voltage, AC Voltage, DC Current, AC Current Resistance	Transmille 8081 / 8104 Agilent / Keysight 3458A Opt. 002 Fluke 8508A
AC Meter (Optional)	AC Voltage, AC Current (with AC/DC Shunts)	Fluke 5790A/B
AC / DC Current Shunts (with corrections/calibration from DC to 30 kHz)	DC Current, AC Current	Transmille AC/DC Shunts Fluke A40B
LCR Bridge / Meter	Capacitance	Agilent / Keysight 4263B, Wayne Kerr B905

DC Voltage Source	Thermocouple Input	Transmille 3010A / 4010 Fluke 55xx Series Calibrator
Type K Thermocouple Lead and Calibrated Thermocouple Meter	Thermocouple Cold Junction Measurement	
Precision Frequency Counter	Frequency Output	Transmille 8700 Keysight 53200 Frequency Counter
Handheld Multimeter	Simulated Capacitance	Agilent U1252B

Table 2 – Equipment Required for Verification/Adjustment

Some multimeters do not offer current measurements up to 30A. In this case external current shunts will be required. Users are free to use their own shunts if they fall within the accuracies required for calibration. Alternatively, Transmille provide a series of AC/DC current shunts with accuracies suitable for performing calibration of the 4610M. For further information please visit www.transmille.com

2.3. Configuring for Measurements

Best practice should be applied for choice of test leads, environmental conditions as well as recommended warm up times of all the equipment.

Only skilled technicians should undertake the verification / calibration of the 4610M as consideration for such elements as thermals on leads and errors due to test lead resistance should be considered. Excessive errors due to connection issues can affect the measurements.

2.4. Getting the best out of the calibrator.

The 4610M is a highly accurate calibrator producing a very wide range of output signals. To make the best possible use of the range of outputs and to eliminate errors this section details some common sources of errors and offers some techniques to reduce them.

2.4.1. Making Good Measurements

Transmille provide free of charge online training via our website (www.transmille.com) as well as our YouTube channel (www.youtube.com/Transmille).

In these videos we demonstrate common errors in measurement technique in a visual format showing both the effects, as well as how to best mitigate these effects.

2.4.2. Thermally generated EMF voltage errors.

At every connection in a measuring system different metals come into contact with each other, each junction forms a thermocouple. The voltages generated at these junctions are called thermoelectric voltages and are dependent on the type of metals in contact and the difference in temperature.

This effect is used to measure temperature with thermocouples, however this effect will cause large errors in low voltage measurements, as thermocouple voltages for some metals can be in the millivolt region. Copper is best but many standard test plugs are made from nickel plated brass and should not be used.

Gold plated copper plugs are available for low level work. If the test lead has been in use on a high current range this will have made the plug warm, which will also increase the error.

2.4.3. Lead/Connection Resistance

When measuring resistance, it is important to ensure that the correct lead type and connections are used, as there are noticeable effects at both low and high values of resistance.
At low values of resistance, 4 wire connections should be used where possible, as well as ensuring that all connections are clean and free of contaminants. Leads and their connections can have up to 100mΩ of resistance, which can cause large errors in relation to the specification of both the calibrator as well as the Unit Under Test (UUT).

Leads should be zeroed (null) out by the user to ensure that the resistance of the leads used are not added to the indicated measurement by the UUT.

For high value resistance measurement, it is important to ensure that the insulation resistance of the leads used (the resistance between the conductor and the insulator) is suitably high. If the insulation resistance is not suitably high, the effect is equivalent to placing a resistor in parallel with the sourced resistor, reducing the resistance seen by the UUT.

An example of this is a set of leads with an insulation resistance of 10GΩ. The calibrator is used to source an output of 1GΩ. An error of 10% will be seen by the UUT, this is due to the resistance of the leads.

When High Resistance is being sourced low cost ‘ultra-flex’ leads should not be used, although these leads are very resilient to wear and tear in daily use, these leads are not suitable for precision measurements of high value resistance. Coaxial leads with high insulation resistance should be used, with insulation such as PTFE, and with screening to prevent power line and noise pickup.

2.4.4. Power line and low frequency Pick up and noise

These effects are most noticeable when using high resistance (100kΩ and above) and low current. All constant current sources have a very high output impedance which will pick up noise just like the high value resistance. To reduce pickup, use screened leads and try earthing the low side of the calibrator output.
For high value resistance it is essential that the cables insulation resistance will not affect the accuracy. Most PVC cables will only have insulation resistance of around 10GΩ; this will give an error of 1% on the 1GΩ output.

Low AC current is particularly difficult as the capacitance of screened leads will shunt some of the current away.

2.5. General

The 4610M calibrators maintenance requirements are listed below. Please note that the calibrator does not require any regular internal servicing.

- Electrical Safety Checks on Line power lead and case
- Cleaning of the Fan
- Cleaning the external case
- Calibration and operation verifications

2.5.1. Electrical Safety Tests

These can be carried out as frequently as required. Earth bond and insulation can be tested to a class 1 standard. Flash testing is not recommended due to the possibility of damage to internal components.

2.5.2. Cleaning of the Fan Duct



WARNING : Risk of Shock
Ensure calibrator is disconnected from line power before proceeding.

Fan ducts may be cleaned with brush and vacuum cleaner.

2.5.3. Cleaning the external case

Use a damp cloth with a mild water-based cleaner for the outside case and front panel. Do not use alcohol-based cleaners or solvents and do not spill or allow liquid to enter the case.

2.6. Calibration

The calibration of the 4610M calibrator can be carried out via the front panel controls and touchscreen, the calibration constants stored within the calibrator can then be adjusted.

The 4610M calibrator, can also be calibrated via the USB or GPIB (IEEE) interface. Calibration constants stored within the calibrator can be adjusted using the Transmille Virtual Front Panel software, ProCal software or by the calibration remote commands.

To prevent unauthorized use of this software, a password is required before access is granted. Adjustment can be completed without disassembly of the calibrator.

In both instances (manual or remote calibration) the calibrator should be switched on and allowed to warm up for the required period as stated in the operator's manual. Calibration should be performed in a stable environment where the temperature is stable to within ± 3ºC. Deviations outside of this will affect the performance of the calibrator as well as the measurement equipment. Also note the temperature difference between the previous calibration and the current environment. If the difference is greater than 5ºC extra allowances should be allowed for during verification stages due to the temperature difference.

2.6.1. Calibration Uncertainties

During manufacture and calibration by Transmille, the calibrator is calibrated with low uncertainties to ensure the best performance of the instrument.

After re-calibration by Transmille, the user can use the Absolute Specifications as published in the extended specifications (as long as the environment is within Tcal ± 5ºC). Note that Transmille within the UK operate at 20ºC, so from Transmille the Tcal is 20ºC.

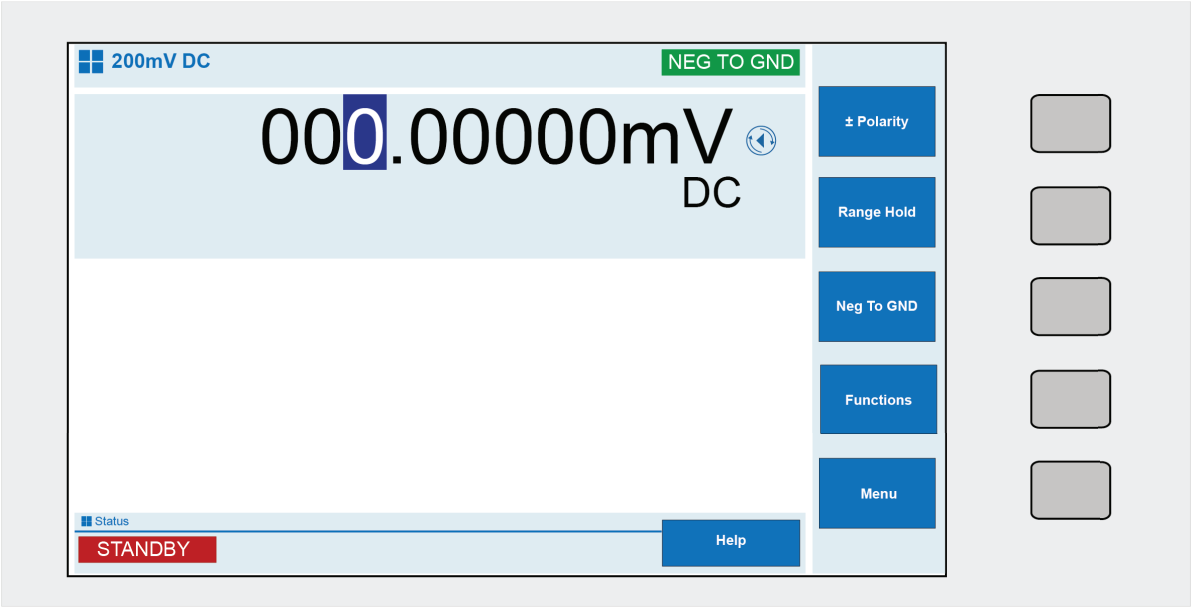
If re-calibrated by another laboratory, the calibration uncertainties will certainly differ. In this case, the specifications must be re-calculated, combining the uncertainty of measurement (the uncertainty listed on the calibration certificate), the relative specifications, and the temperature coefficient for different from calibration temperature (as required).

Any laboratory can offer a calibration service on Transmille products as there are no proprietary techniques or software required, however ensure that the offered uncertainties match your requirements for calibration.

Transmille in the UK can be contacted directly for Accredited and Traceable calibration and repair services, Transmille USA offer calibration and repair services, and throughout our worldwide network of representatives and distributors we have a network of recommended laboratories to suit your calibration requirements.

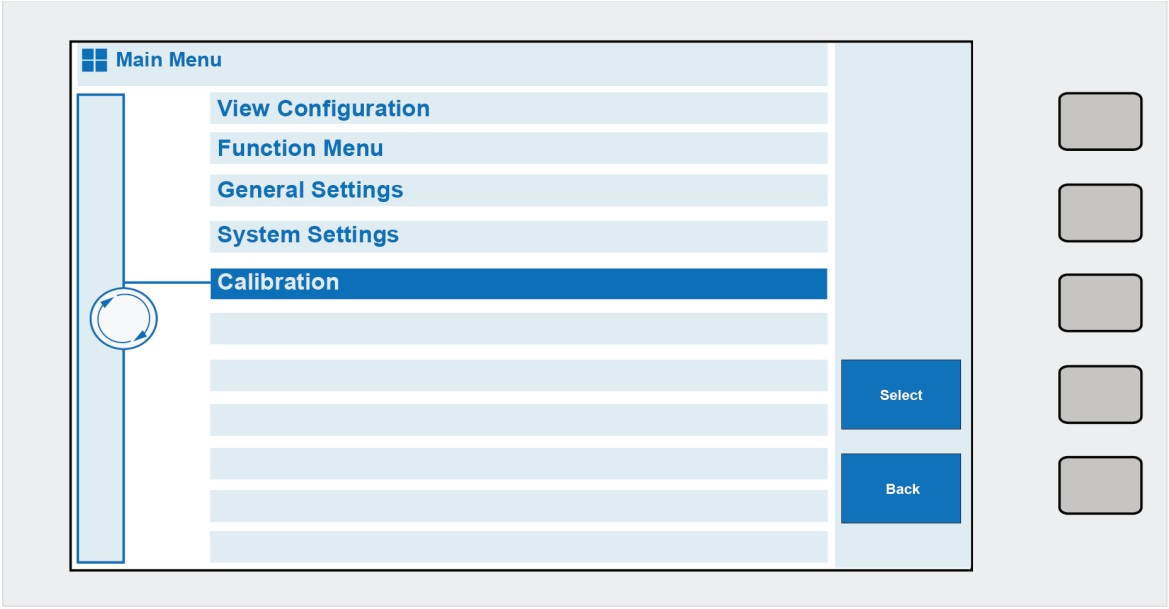
2.6.2. Beginning Calibration

To access the calibration menu from the front panel, proceed as follows:
Select the **Menu** key from the front screen.



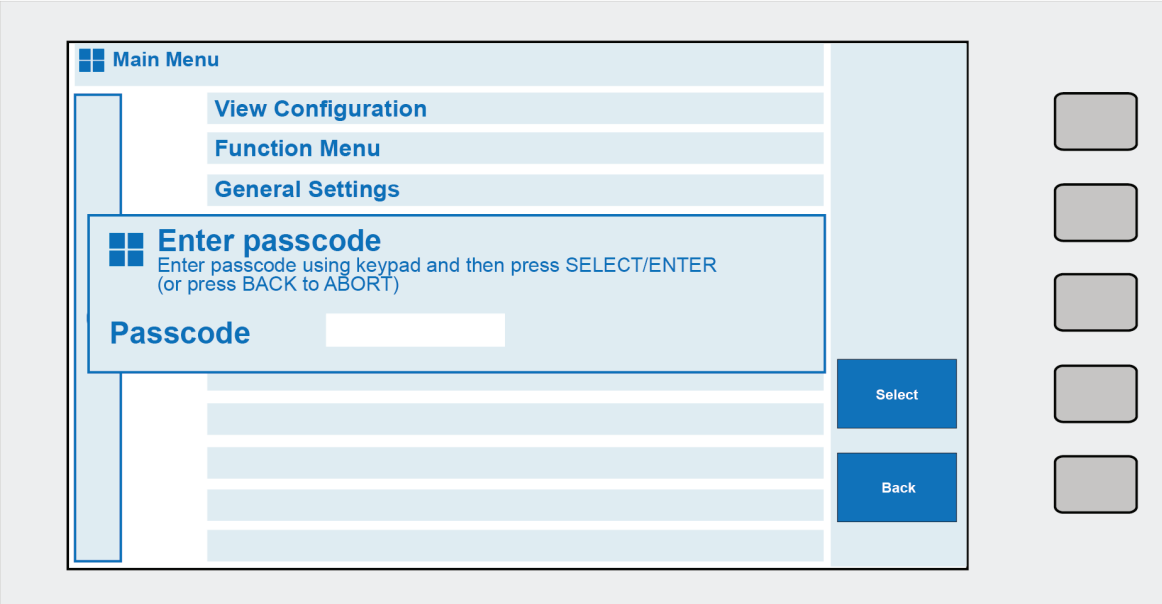
Figures 1 – Default Screen

To view the calibration (menu), use the digital control or touchscreen directly to highlight ‘Calibration’ on the main menu,



Figures 2 – Main Menu (Calibration)

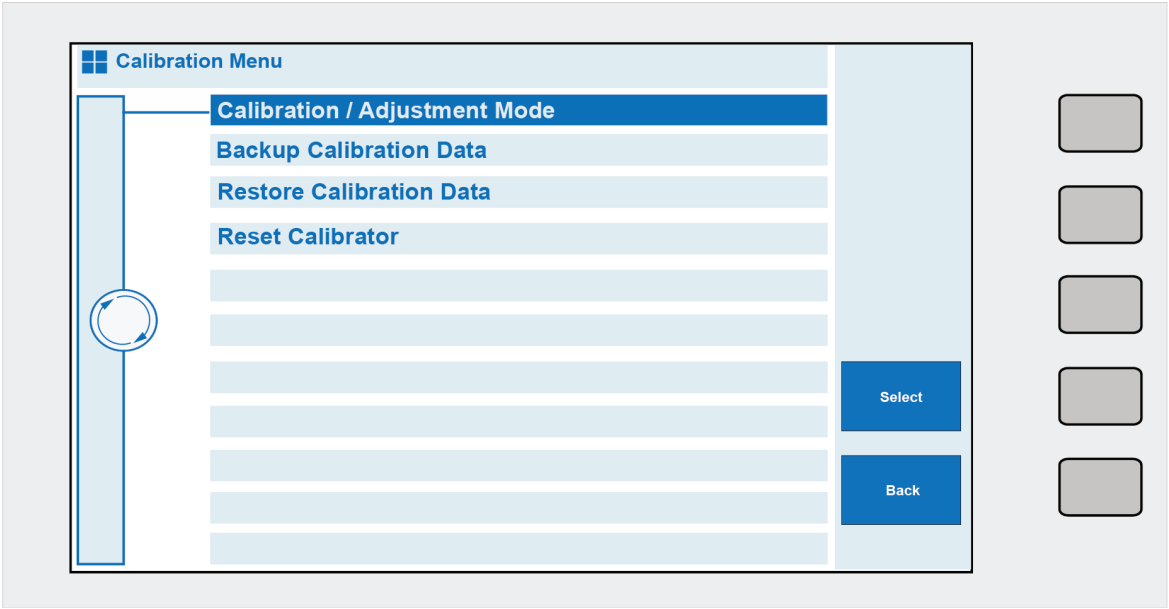
Touch **Select** or press the soft key adjacent to the function, the following screen displays.



Figures 3 – Calibration Menu (Passcode)

Follow the instructions on the screen to enter the passcode (default: 1234) at which point the following screen displays.

> ***Note:*** *If the passcode has previously been entered the passcode screen will not display, the instrument will display the selected menu, however when the instrument is returned to the 'Main Menu' the passcode will need to be entered again to access the 'Calibration' menu.*



Figures 4 – Calibration Menu

Touch **Select** or press the soft key adjacent to the function. If the calibrator has not been powered up continuously for at least 30 minutes, a warning will display asking the operator to confirm that they wish to continue with adjustments.

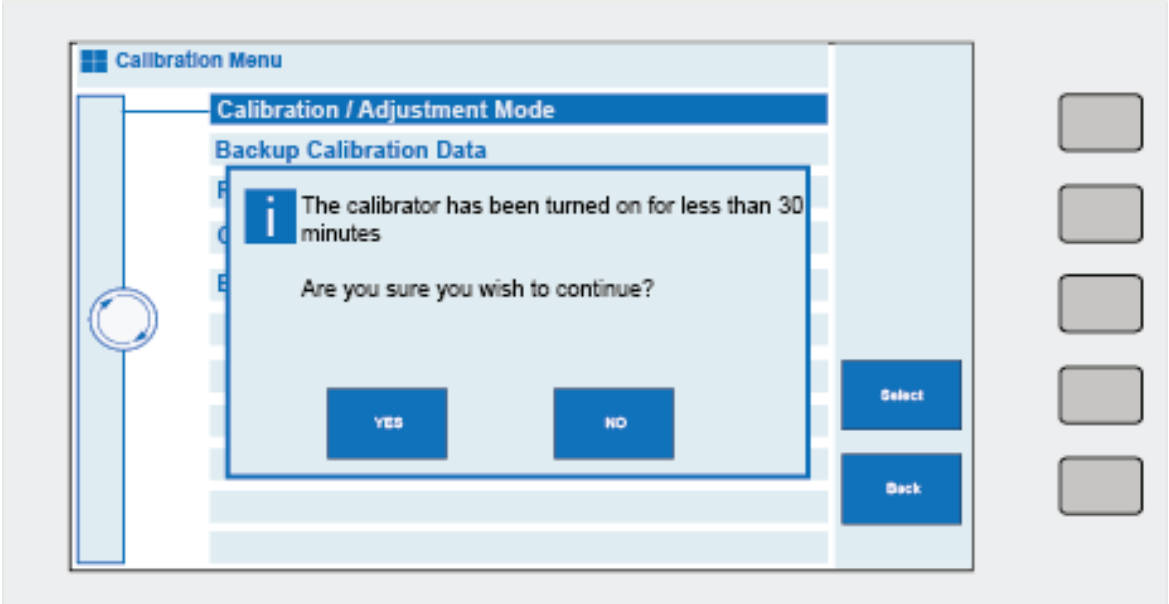
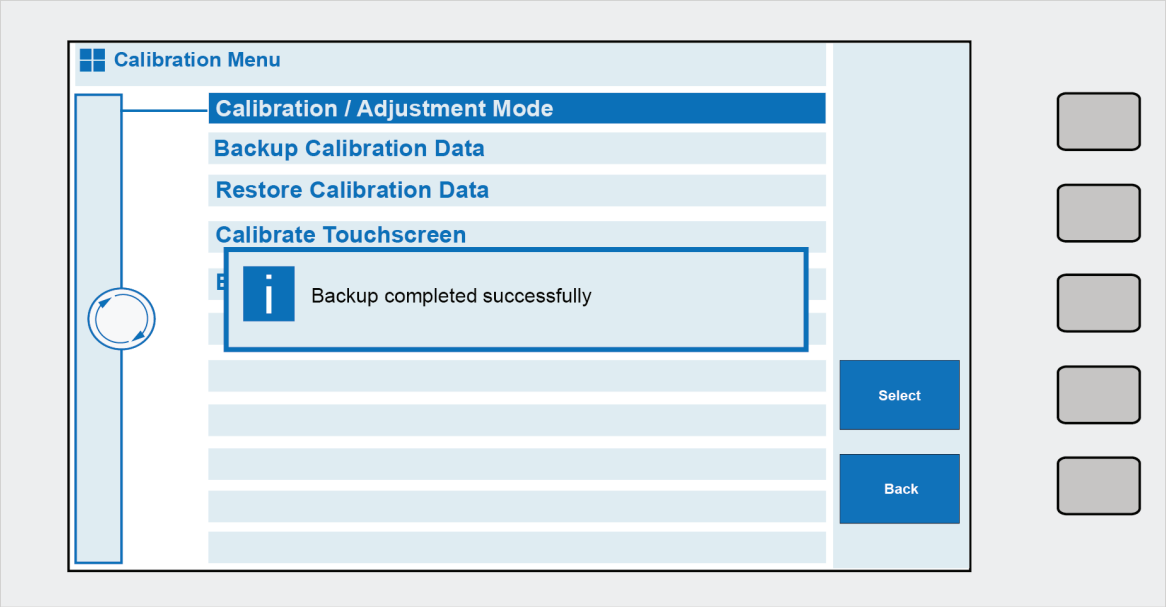


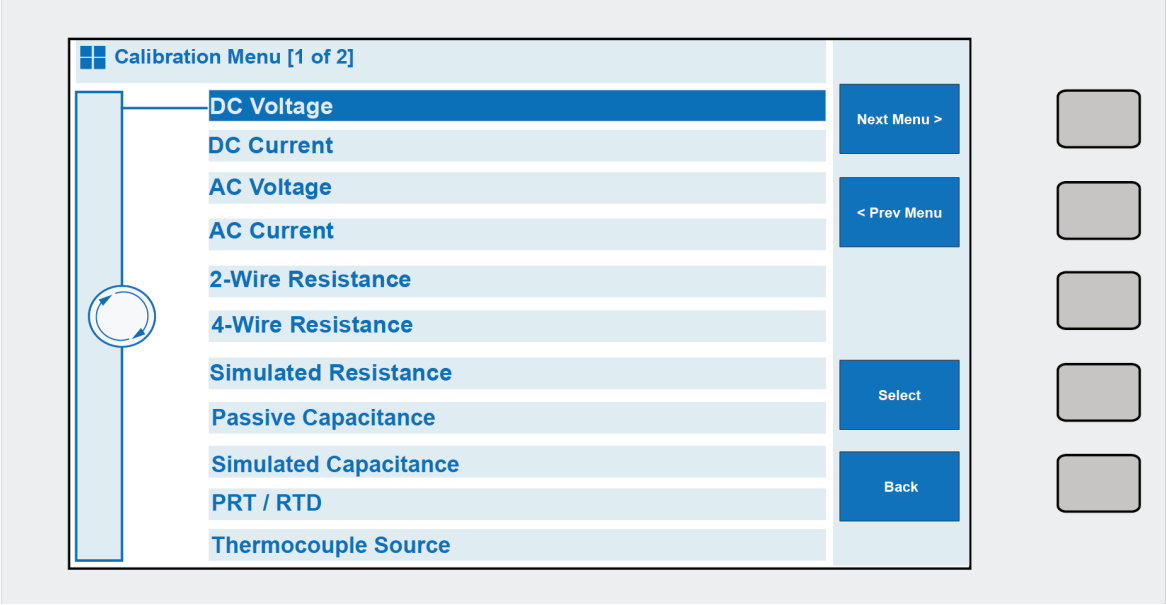
Table 3 – Calibration Menu (30 Minute Warmup Warning)

The calibrator begins the backup of the calibration data stored in the calibrator; upon completion the following screen is displayed:



Figures 5 – Calibration Menu (Backup Complete)

After a few seconds, the ‘Calibration Menu’ screen will display. At this time the BLUE shift key will illuminate to indcate that calibration mode is active.



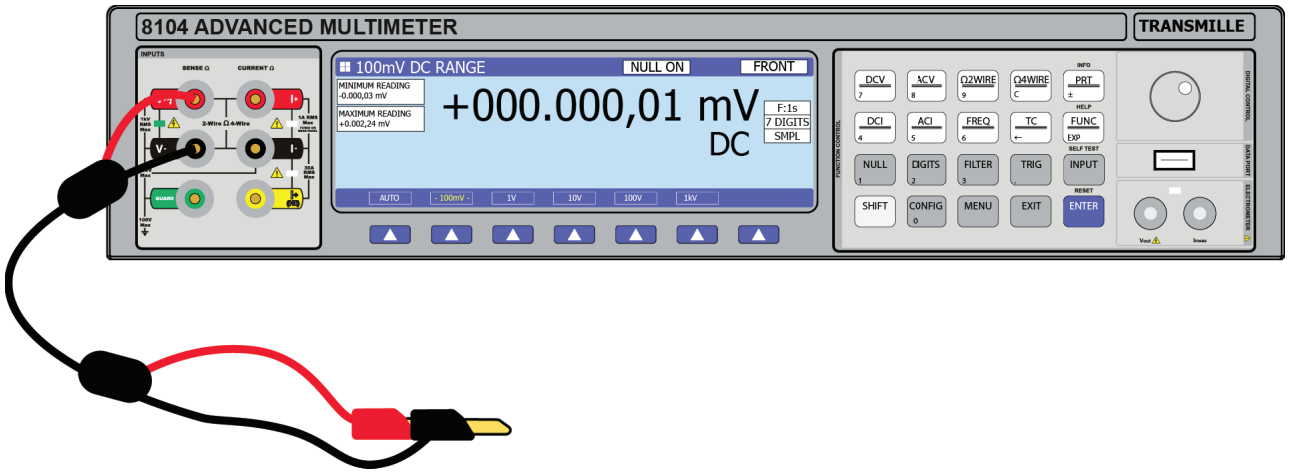
Figures 6 – Calibration Menu (1 of 2)

2.6.3. DC Voltage

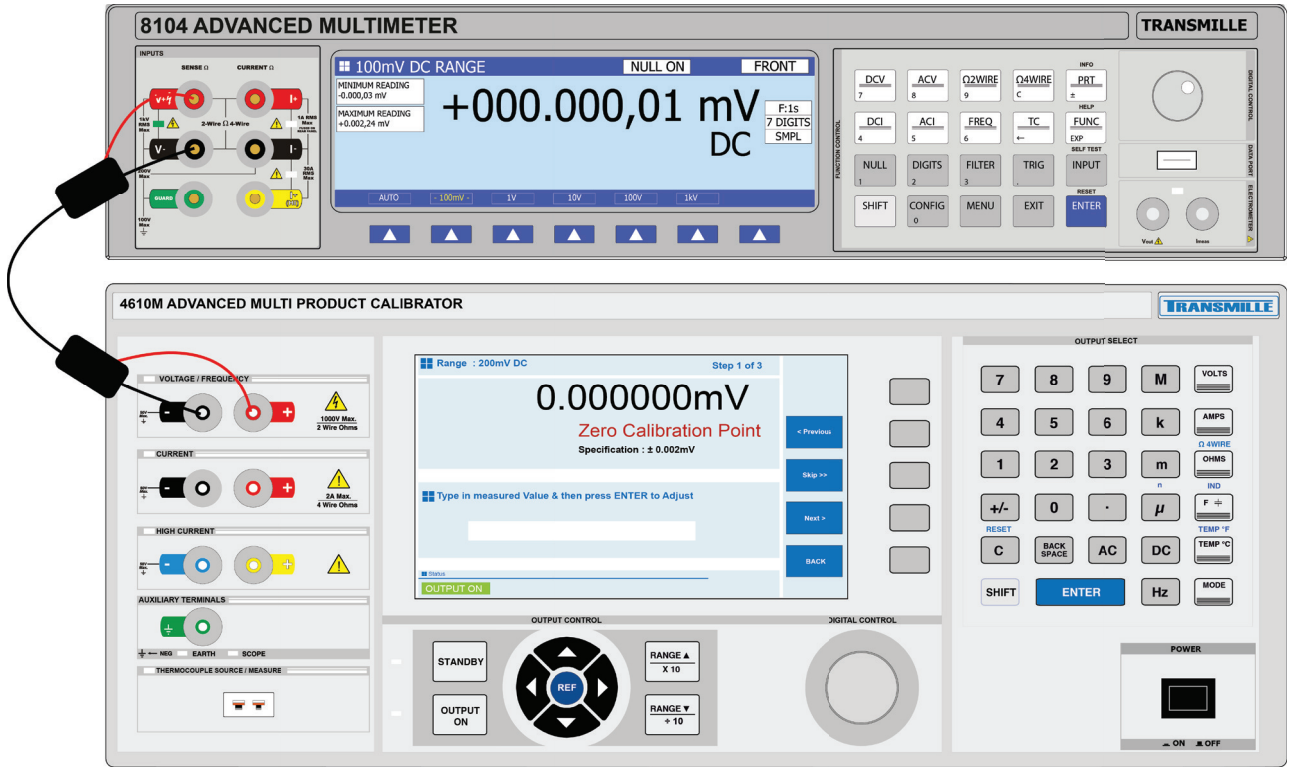
The DC Voltage function is measured using a precision multimeter to measure the output voltage from the calibrator. To speed up the verification of the calibrator while maintaining low uncertainties Transmille recommend characterizing the multimeter prior to use rather than using a precision voltage divider due to the added complexity.

It is essential that the multimeter is zeroed correctly prior to performing measurements otherwise large errors can occur (refer to manufacturer's instructions).

Transmille advise that multimeter zeros should be performed by shorting the connecting leads from the multimeter at the point of connection to the calibrator rather than at the terminals of the multimeter as considerable errors can be caused due to thermal EMF in the leads/interconnections.



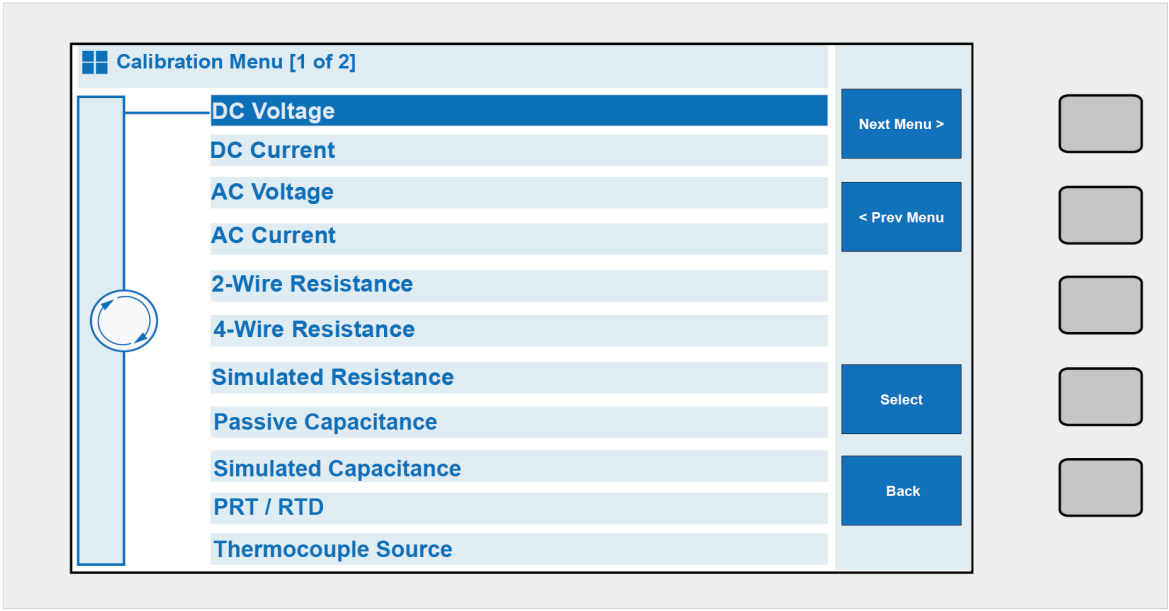
Figures 7 – Multimeter (DC Voltage, Zero Leads)



Figures 8 – DC Voltage Connections

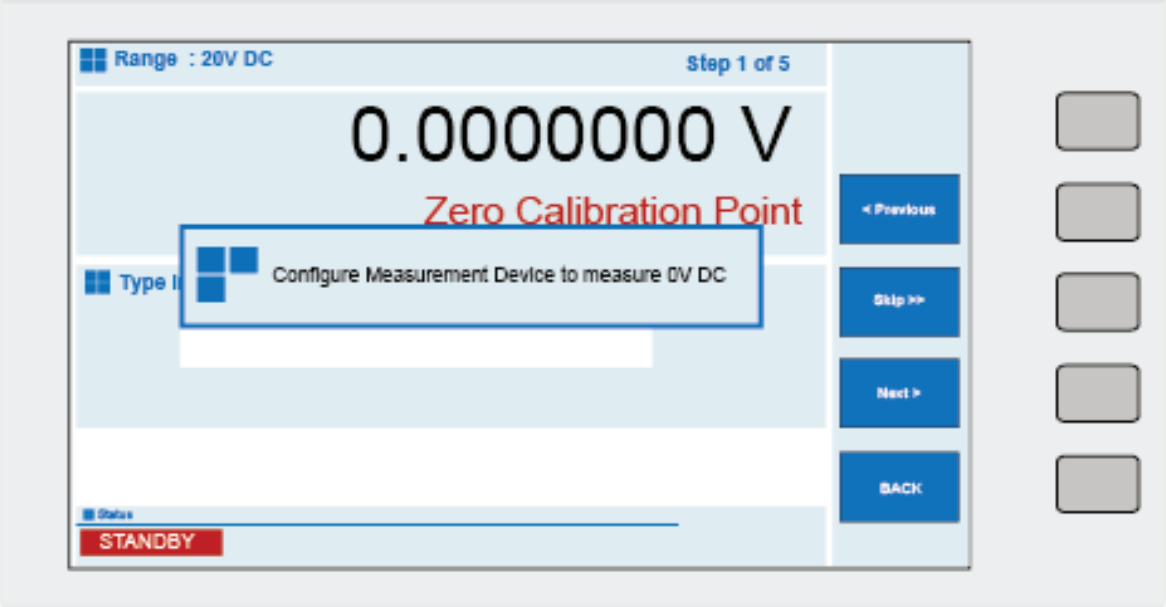
Connect the multimeter to the 4610M calibrator as shown above:

To view the DC Voltage calibration menu, use the digital control or touchscreen directly to highlight ‘DC Voltage’.



Figures 9 – Calibration Menu (DC Voltage)

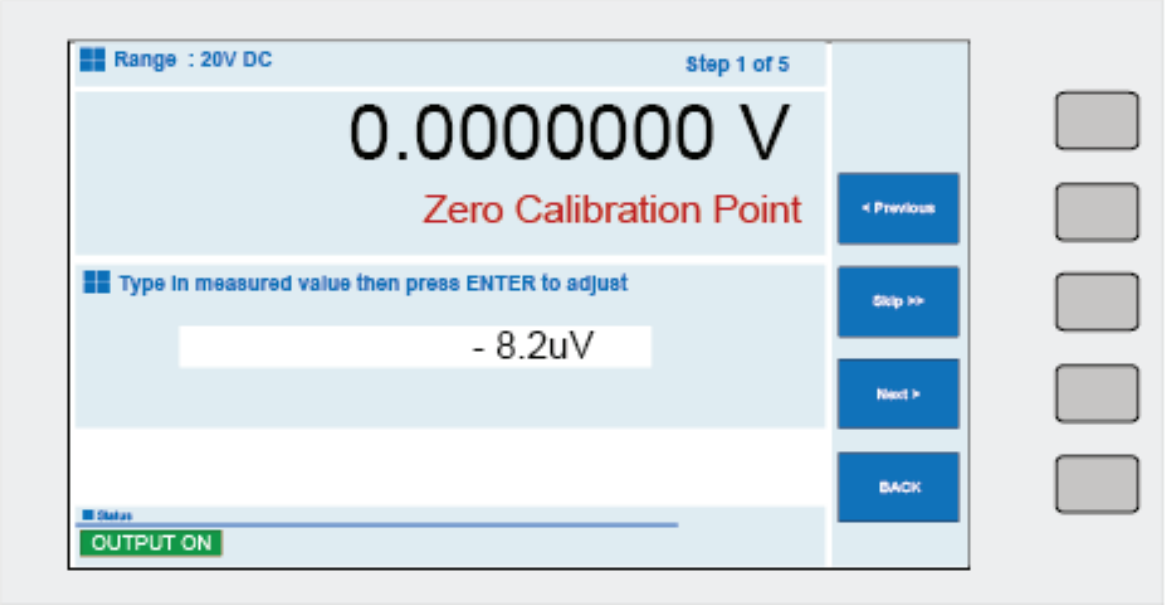
Touch ‘Select’ or press the soft key adjacent to the function, the DC Voltage calibration menu will display (Range 20V DC, step 1 of 5 – Zero Calibration Point).



Figures 10 – DC Voltage (Zero Calibration Point Prompt)

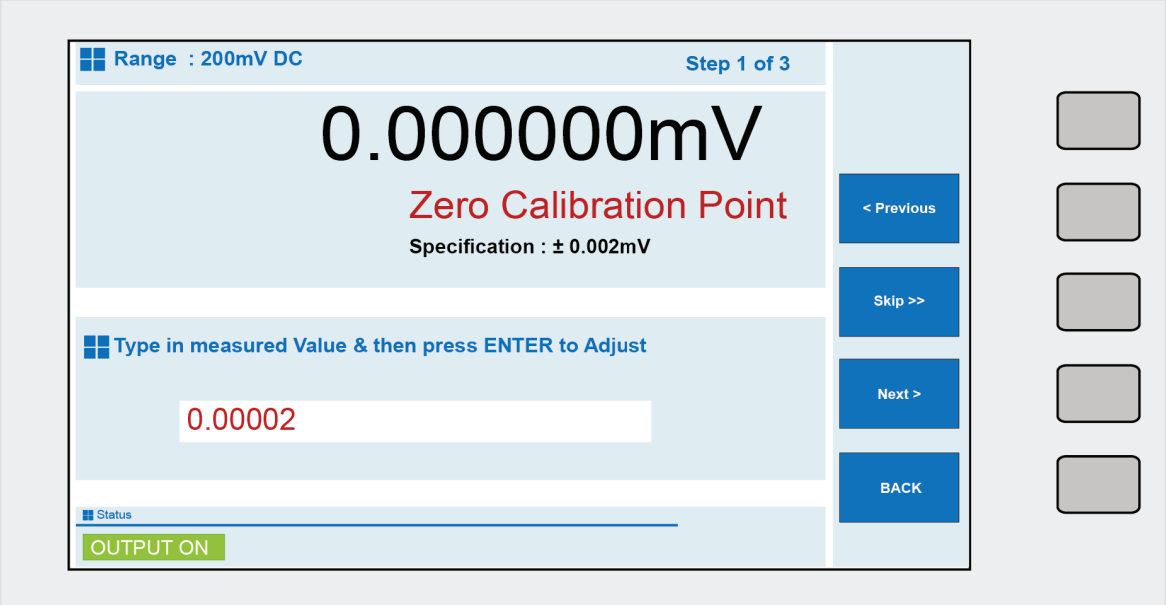
A connection help prompt will briefly display on the screen (2-3 seconds) to assist the operator in setting the measurement device to the correct function and range.

Press the OUTPUT ON key to turn the output of the calibrator on. Adjusments are not possible for souricng functions if the output is not on.



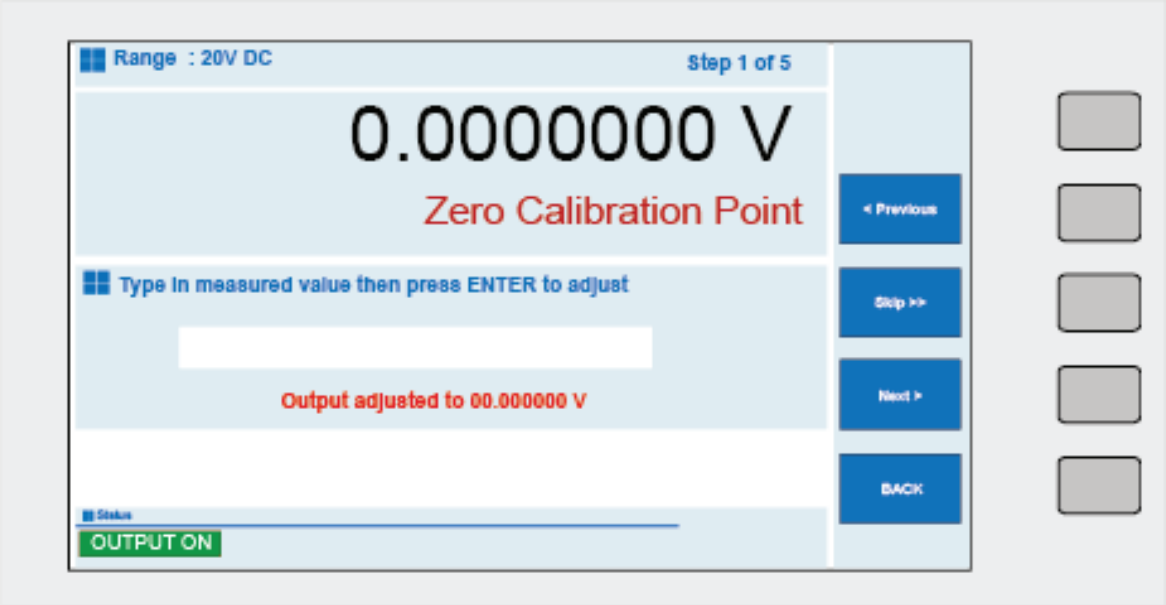
Figures 11 – DC Voltage (Zero Calibration Point Prompt)

Type in the value as measured on the multimeter and then press ENTER to adjust. Note that units are not required unless it simplies entry. If units are omitted then the units for the range (in this case V) will be automatically applied. If the range was 200mV, then an entry of 199 would be automatically converted to 199mV rather than 199V



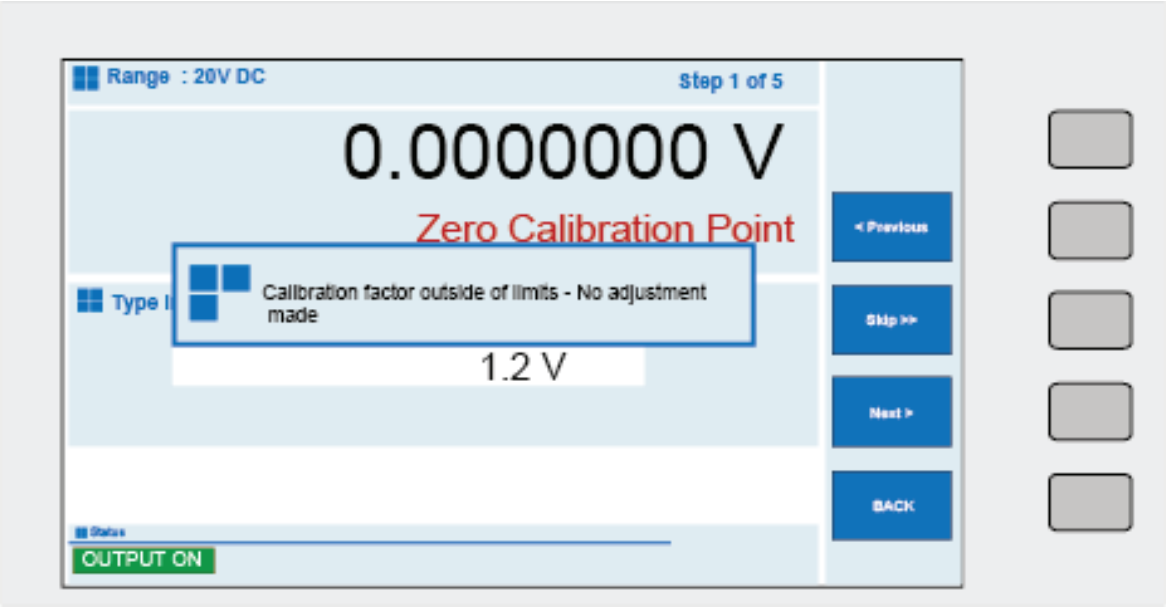
Figures 12 – Zero Calibration Point (Value Entered)

If the adjustment is successful then the entered value will disappear and the message ‘output adjusted to 00.00000V’ will be displayed on the screen underneath the value entry box



Figures 13 – Zero Calibration Point (adjusted)

If the calibrator detects that either too large a change from last calibration is being made, or the value is outside of acceptable limits for the output, then a message will displayed and no adjustment will be performed



Figures 14 – Zero Calibration Point (Calibration Factor Error)

Select 'Next >' to continue the DC Voltage calibration process, follow the on-screen instructions, the calibration points are list below:

Range	Zero	Positive	Negative	Positive Linearity	Negative Linearity
20V	0.000000V	19.000000V	-19.000000V	2.100000V	-2.100000V
200mV	0.00000mV	190.00000mV	-190.00000mV		
2V	0.0000000V	1.9000000V	-1.9000000V		
200V	5.00000V	190.00000V	-190.00000V		
1000V	50.0000V	1000.0000V	-1000.0000V		

Table 4 – DC Voltage Adjustment Points

Note that the Positive and Negative linearity are only performed on the 20V DC Range. This range is adjusted first as these calibration points affect all other DC Voltage ranges.

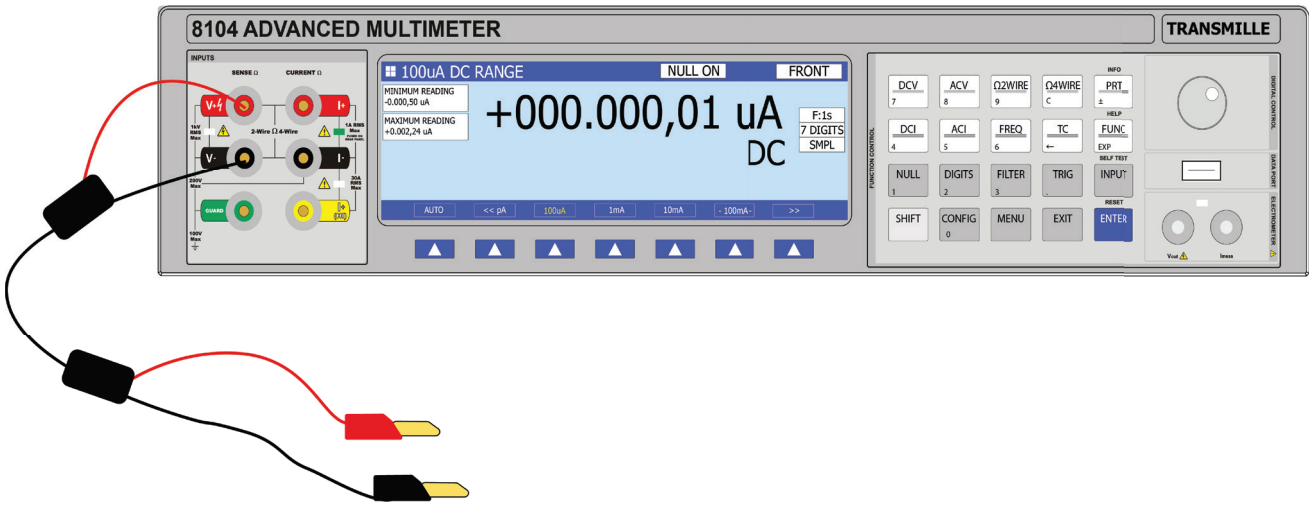
The calibration process can be halted at any time and selected points accessed by 'Next >' and '< Previous' keys, calibration points can also be skipped (not tested) using the 'Skip >>' key.

2.6.4. DC Current

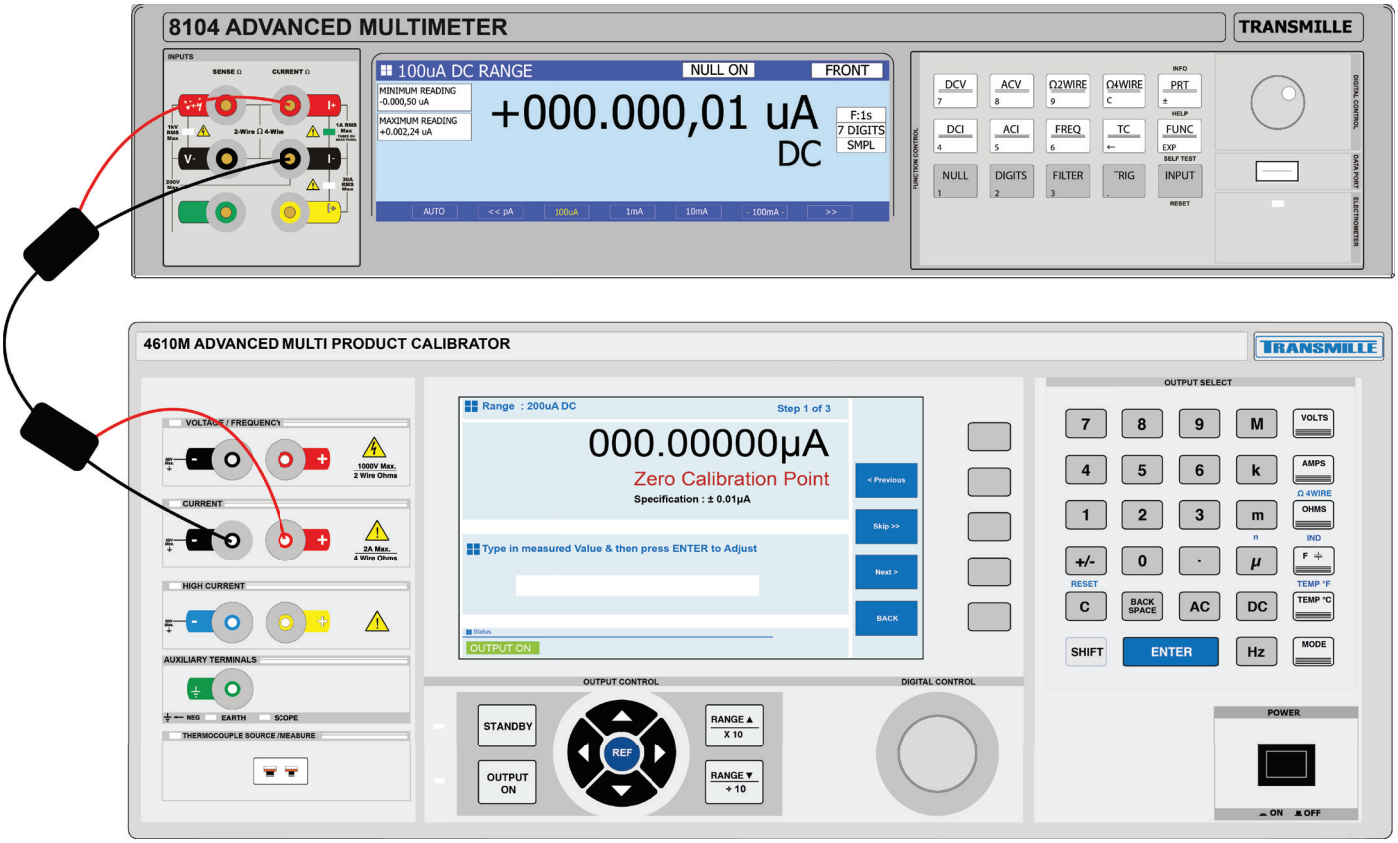
The DC Current function is measured using a precision multimeter to measure the output current from the calibrator. To speed up the verification of the calibrator while maintaining low uncertainties Transmille recommend characterizing the multimeter prior to use rather than using a precision current shunts due to the added complexity.

It is essential that the multimeter is zeroed correctly prior to performing measurements otherwise large errors can occur (refer to manufacturer's instructions).

Transmille advise that multimeter zero's should be performed by open circuiting the connecting leads from the multimeter at the point of connection to the calibrator rather than at the terminals of the multimeter as considerable errors can be caused due to thermal EMF in the leads/interconnections.



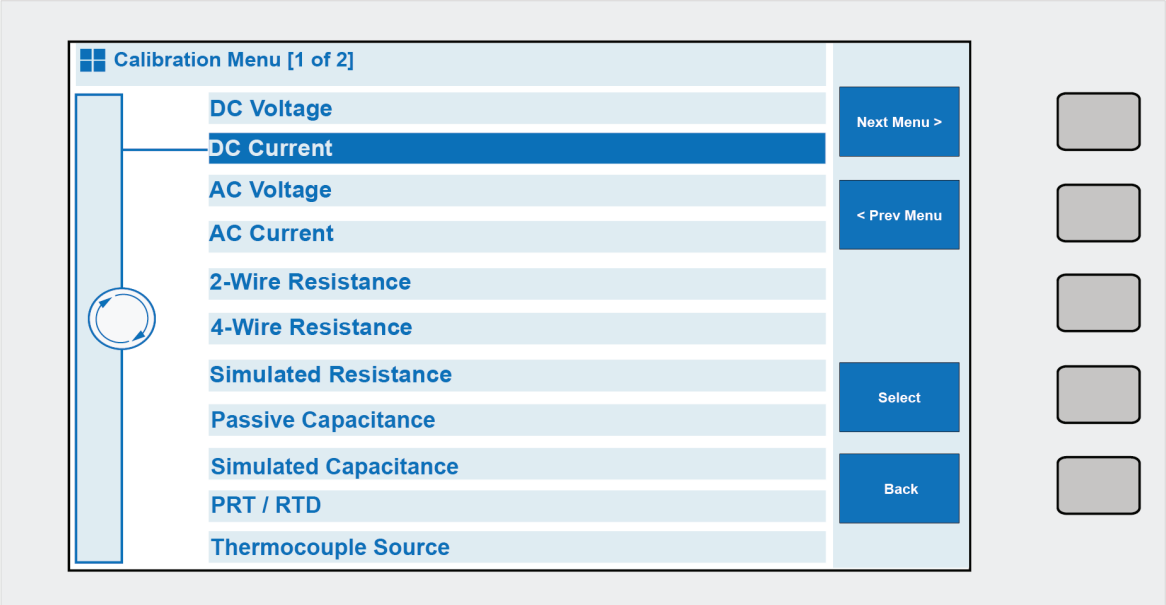
Figures 15 – Multimeter (DC Current, Zero leads)



Figures 16 – DC Current Connections (≤ 1A)

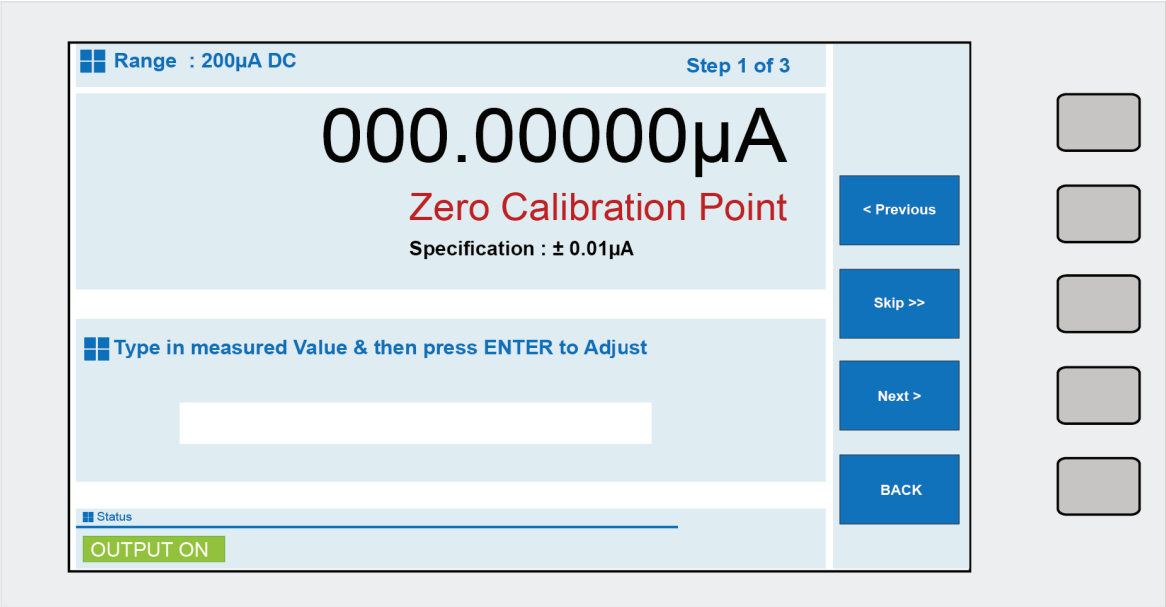
Connect the multimeter to the 4610M calibrator as shown above:

To view the DC Current calibration menu, use the digital control or touchscreen directly to highlight ‘DC Current’.



Figures 17 – Calibration Menu (DC Current)

Touch ‘Select’ or press the soft key adjacent to the function, the DC Current calibration menu will display (Range 200 µA DC, step 1 of 3 – Zero Calibration Point).



Figures 18 – DC Current (Zero Calibration Point)

Follow the sequence through as described above in section “2.6.3. DC Voltage” on page 19 for DC Voltage, the calibration points are list below:

Calibration Point	Zero	Positive	Negative
Range	Step 1 of 3	Step 2 of 3	Step 3 of 3
200µA	0.00000µA	190.00000µA	-190.00000µA
2mA	0.0000000mA	1.9000000mA	-1.9000000mA
20mA	0.000000mA	19.000000mA	-19.000000mA
200mA	0.00000mA	190.00000mA	-190.00000mA
2A *	0.0000000A	1.9000000A	-1.9000000mA
30A **	0.000000A	19.000000A	-19.000000A

Table 5 – DC Current Adjustment Points

* Change to high current terminals on multimeter
** Change to high current terminals on calibrator

The calibration process can be halted at any time and selected points accessed by ‘Next >’ and ‘< Previous’ keys, calibration points can also be skipped (not tested) using the ‘Skip >>’ key.

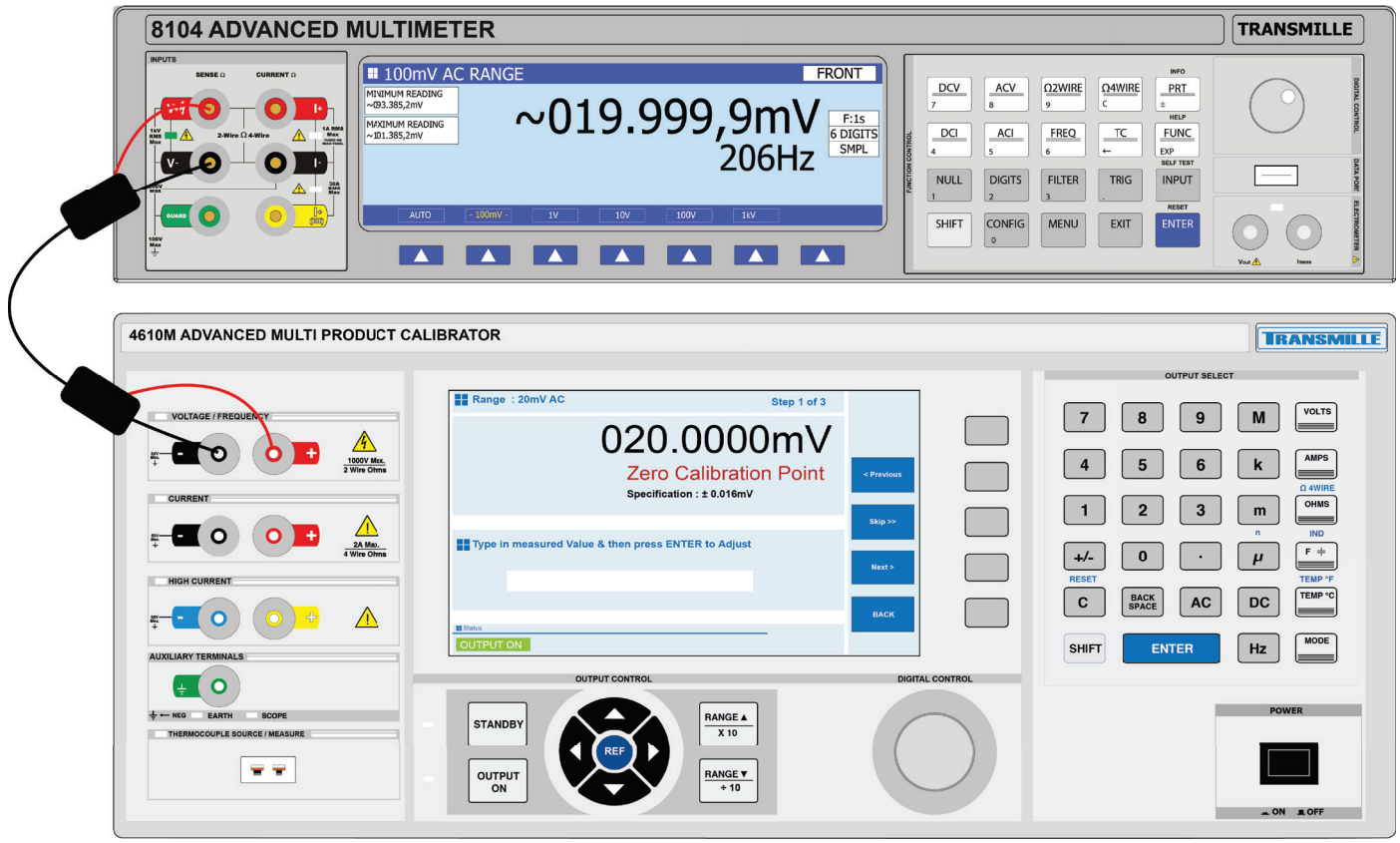
2.6.5. AC Voltage

The AC Voltage function is measured using a precision multimeter to measure the output voltage from the calibrator.

For reduced calibration uncertainty, a thermal transfer standard may be used however this requires a skilled technician to operate and increases the calibration time. Transmille advises the use of a characterized multimeter to minimize the time required to perform adjustments.

The process for adjusting AC ranges is different from DC parameters, in that there is a primary Full-Scale Gain and Zero point that is measured with a frequency of 1kHz, after which a frequency flatness calibration is performed at full scale.

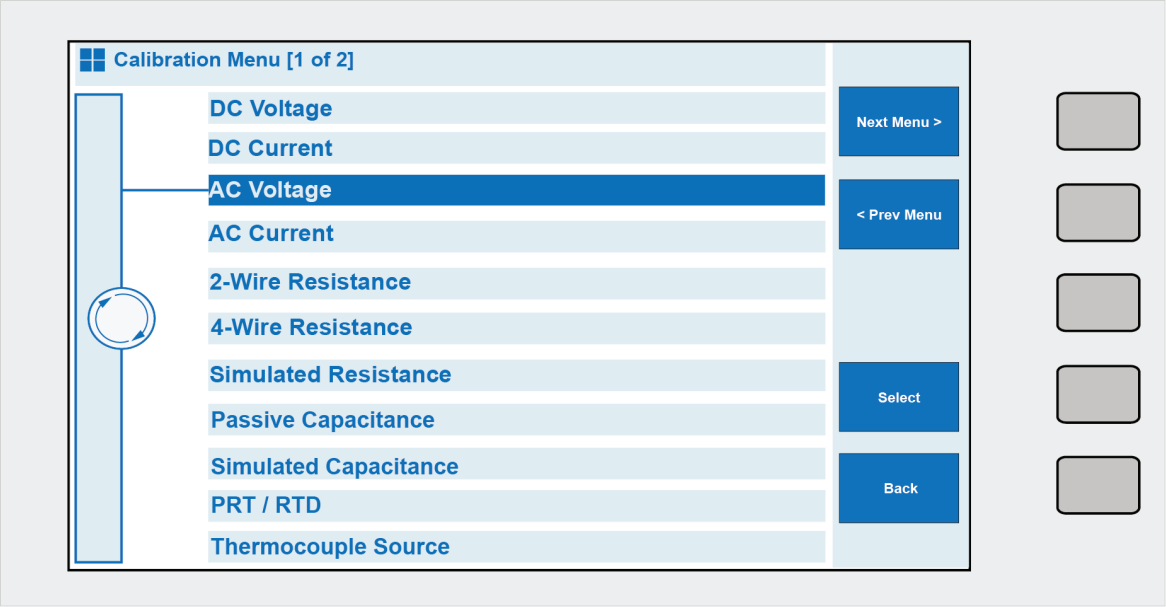
Connect the multimeter to the 4610M calibrator as shown below



Figures 19 – AC Voltage Connections

Some measurement devices may benefit from having their GUARD connection connected to the calibrator EARTH terminal depending on the grounding configuration in the measurement laboratory.

To view the AC Voltage calibration menu, use the digital control or touchscreen directly to highlight ‘AC Voltage’.



Figures 20 – Calibration Menu (AC Voltage)

The Calibrator will automatically enter the 20mV Range and select the Full Scale Point.

Configure the multimeter for the most appropriate range (and any settings required to measure 1kHz such as DC Coupling/Filters) and press Output On.

Enter the value measured by the Multimeter (units not required) and press ENTER. The Output of the calibrator will adjust. If required, re-type the measured value for a closer adjustment.

Click ‘Next >’ to move to the next calibration point, which is ~10% of scale (i.e. 21mV is the Zero calibration point for the 200mV AC Range).

Enter the value measured by the multimeter, followed by pressing the ENTER key.

Depending upon the range, the frequency flatness adjustment points that are available will vary, a list of all the frequency points can be found below.

Range	Output	Frequency
20mV	19mV	1kHz
	2.1mV	1kHz
	19mV	10Hz
	19mV	45Hz
	19mV	30kHz

	19mV	100kHz
	19mV	500kHz
200mV	190mV	1kHz
	21mV	1kHz
	190mV	10Hz
	190mV	45Hz
	190mV	30kHz
	190mV	100kHz
	190mV	500kHz
2V	1.9V	1kHz
	0.21V	1kHz
	1.9V	10Hz
	1.9V	45Hz
	1.9V	30kHz
	1.9V	500kHz
	1.9V	1MHz
	0.21V	1MHz (HF Low Value Correction - Only required after hardware repair/ replacement)
20V	19V	1kHz
	2.1V	1kHz
	19V	10Hz
	19V	45Hz
	19V	30kHz
	19V	100kHz
	19V	50kHz (HF Curve Calibration - Only required after hardware repair/ replacement)
200V	190V	1kHz
	21V	1kHz
	190V	10Hz
	190V	45Hz

	190V	30kHz
	190V	100kHz
1000V	700V	1kHz
	210V	1kHz
	700V	30Hz
	700V	45Hz
	700V	10kHz
	300V	20kHz

Table 6 – AC Voltage Adjustment Points

If an adjustment is performed at either Full Scale or Zero, the change will affect ALL frequencies as this is change in the overall gain rather than frequency flatness of the range.

In addition to the overall gain (Zero and Full Scale), for the 2V and 20V Ranges there are two additional calibration points which will only require adjustment in the event of a hardware repair or replacement.

As of UI Version 1.5.34 these adjustments are selections of correction factors rather than an absolute value.

The 2V, HF Low Value correction applies to values of less than 25% of scale, at frequencies above 100kHz.

There are 9 selectable corrections (1 through 9) to correct for variations in component values on the middle board.

The 20V, HF Curve correction applies to outputs between 30kHz and 100kHz at all output levels. The selection of curve is performed at 50kHz.

There are 28 selectable corrections (1 through 28) to correct for variations in component values on the middle board. These adjustments are fine adjustments, and there will be only small differences from one curve to the next. This is to allow for a wide variation in component values in the event of a hardware replacement without requiring a firmware update

2.6.6. AC Current

The AC Current output is calibrated / adjusted using a precision multimeter in combination with AC/DC Shunts. Due to the extended output frequency range and the wide range of current levels, multiple shunts are required. Alternatively, if a precision multimeter has been characterized at the specific measurement points this may be used to reduce lead changes and speed up the verification time.

The process for adjusting AC ranges is different from DC parameters, in that there is a primary Full Scale Gain and Zero point that is measured with a frequency of 1kHz, after which a frequency flatness calibration is performed at full scale.

The Calibrator will automatically enter the 200uA Range and select the Full Scale Point.

Configure the multimeter for the most appropriate range (and any settings required to measure 1kHz such as DC Coupling/Filters) and press Output On

Enter the value measured by the Multimeter (units not required) and press ENTER. The Output of the calibrator will adjust. If required, re-type the measured value for a closer adjustment.

Click ‘Next >’ to move to the next calibration point, which is the ‘Zero’ calibration point, which is 10% of scale (i.e. 21uA is the Zero calibration point for the 200uA AC Range).

Enter the value measured by the multimeter, followed by pressing the ENTER key.

Depending upon the range, the frequency flatness adjustment points that are available will vary, a list of all the frequency points can be found below.

Range	Output	Frequency
200uA	190uA	1kHz
	21uA	1kHz
	190uA	45Hz
	190uA	30kHz
2mA	1.9mA	1kHz
	0.21mA	1kHZ
	1.9mA	45Hz
	1.9mA	30kHz
20mA	19mA	1kHz
	1.9mA	1kHz
	19mA	45Hz
	19mA	30kHz
200mA	190mA	1kHz
	21mA	1kHz
	190mA	45Hz
	190mA	30kHz
2A	1.9A	1kHz
	0.21A	1kHz
	1.9A	45Hz
	1A	30kHz
30A	19A	1kHz
	2.1A	1kHz
	19A	45Hz
	10A	10kHz

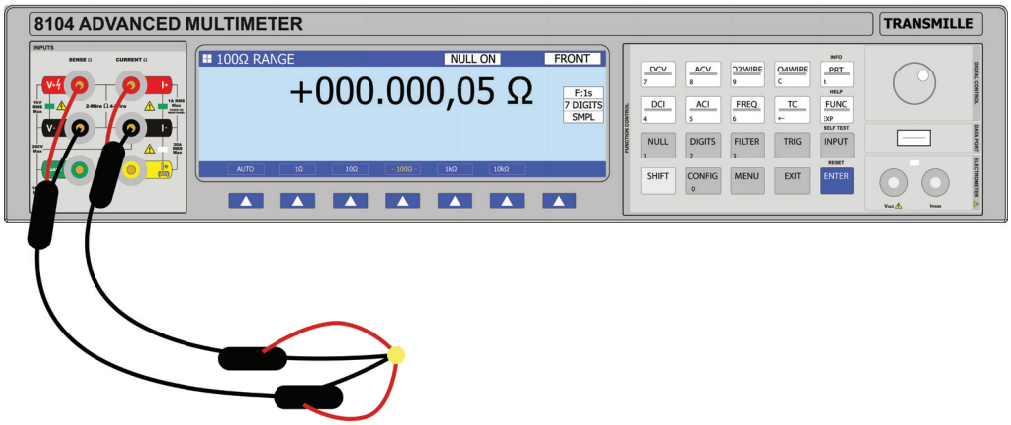
Table 7 – AC Current Adjustment Points & Frequencies

If an adjustment is performed at either Full Scale or Zero, the change will affect ALL frequencies as this is change in the overall gain rather than frequency flatness of the range.

2.6.7. 2 Wire Resistance (Passive)

The 4610M features passive resistance outputs, the calibrated output of each range is displayed on the screen of the calibrator when used, and as such cannot be adjusted to read an exact value. For resistance outputs less than 100kOhms, parallel up 4 Wire resistance leads from a precision multimeter and connect to the Voltage / Frequency terminals

Enter that a Null/Zero is performed on the multimeter with all 4 wires shorted at the point of connection to the calibrator as per the diagram below. Incorrectly Zeroing the multimeter can generate errors in excess of the specification of the instrument.

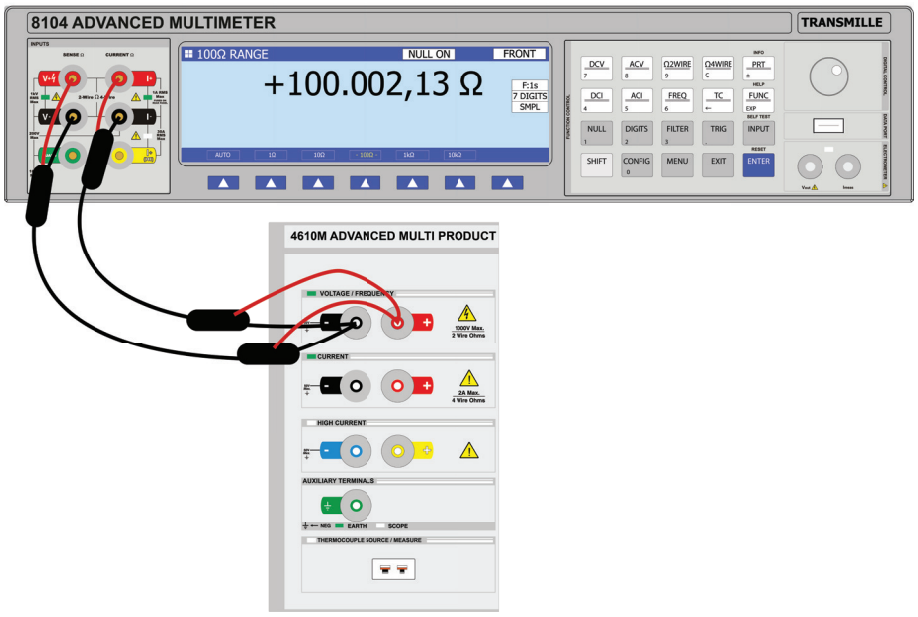


Figures 21 – 4 Wire Zero at End Of Leads

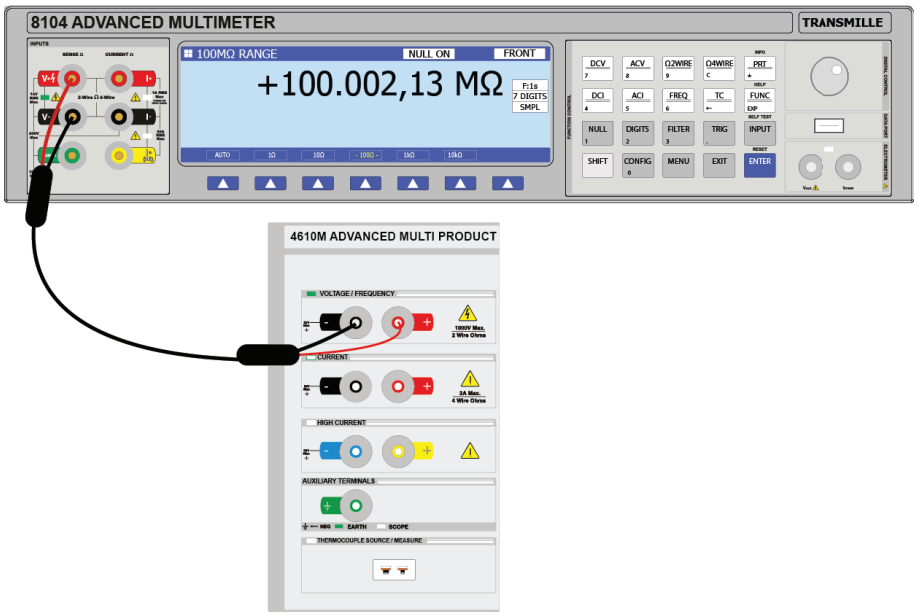
Enter 2 Wire Resistance (Passive) and the 0 Ohm output will automatically be set. Type in the indicating measurement from the multimeter and press ENTER. The calibrator will update the displayed value for the range.

Click ‘Next >’ to proceed to the next Resistance Range.

When measuring the 1 MOhm range and above, change the multimeter to 2 Wire Resistance Measurement and continue to perform measurements.



Figures 22 – 2 Wire Passive Resistance - Values up to 100k Ohms

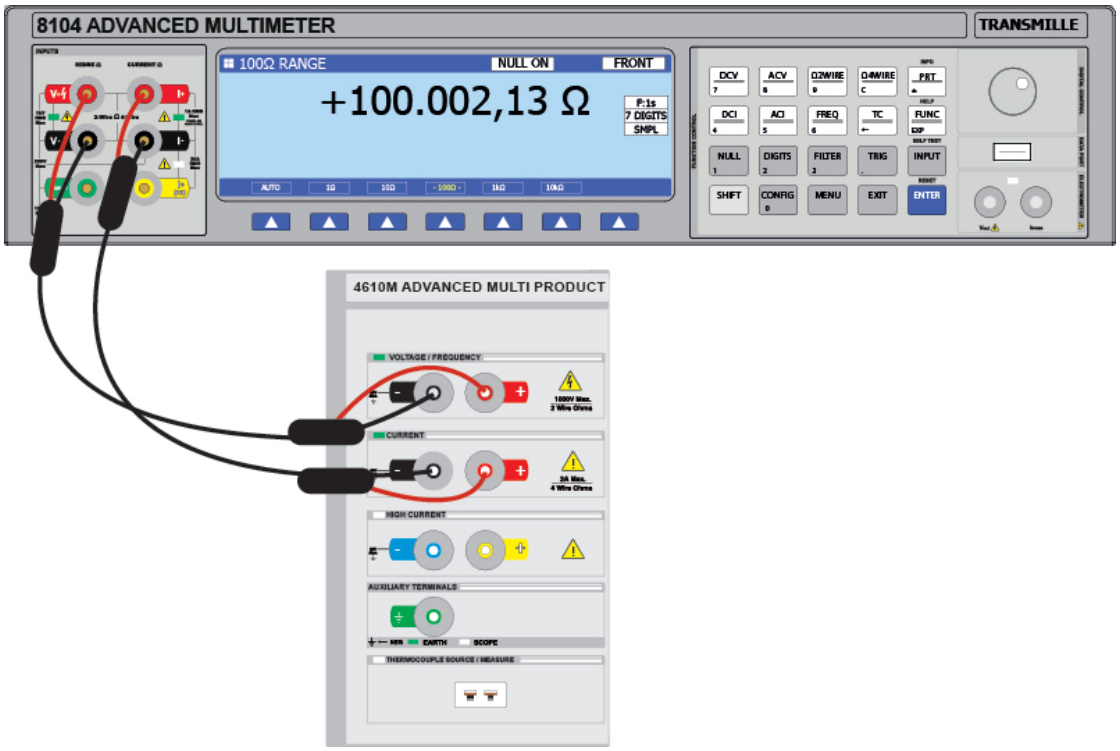


Figures 23 – 2 Wire Passive Resistance - Values above 100k Ohms

2.6.8. 4 Wire Resistance (Passive)

The 4610M Features passive resistance outputs, the calibrated output of each range is displayed on the screen of the calibrator when used, and as such cannot be adjusted to read an exact value.

Connect the precision multimeter to the Voltage and Low Current terminals and configure 4 Wire Resistance Measurement on the multimeter.



Figures 24 – 4 Wire Resistance Connection

Enter 4 Wire Resistance (Passive) and the 0 Ohm output will automatically be set. Zero the Multimeter to the 0 Ohm output of the calibrator to remove any offsets in the internal connections to the resistance section

Click ‘Next >’ to proceed to the next Resistance Range.

Enter the measured value from the multimeter and press ENTER. The calibrator will update the displayed value.

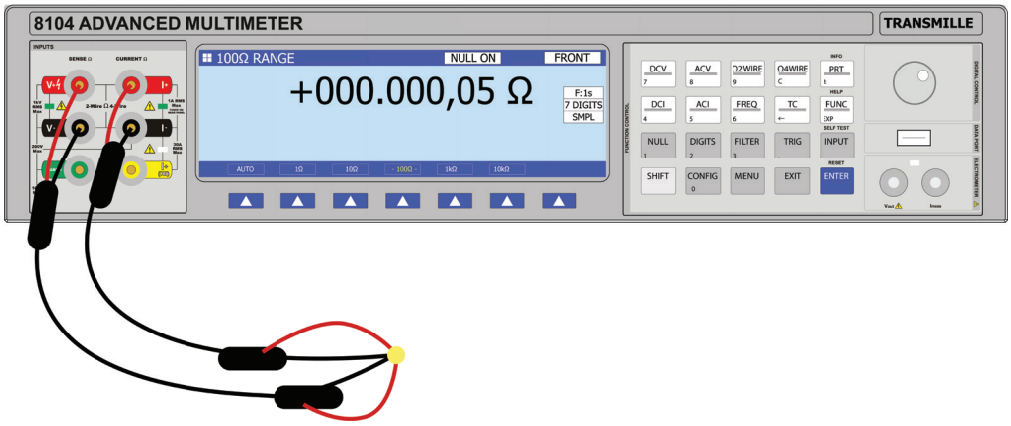
Continue until all resistances have been adjusted as required.

2.6.9. Simulated Resistance

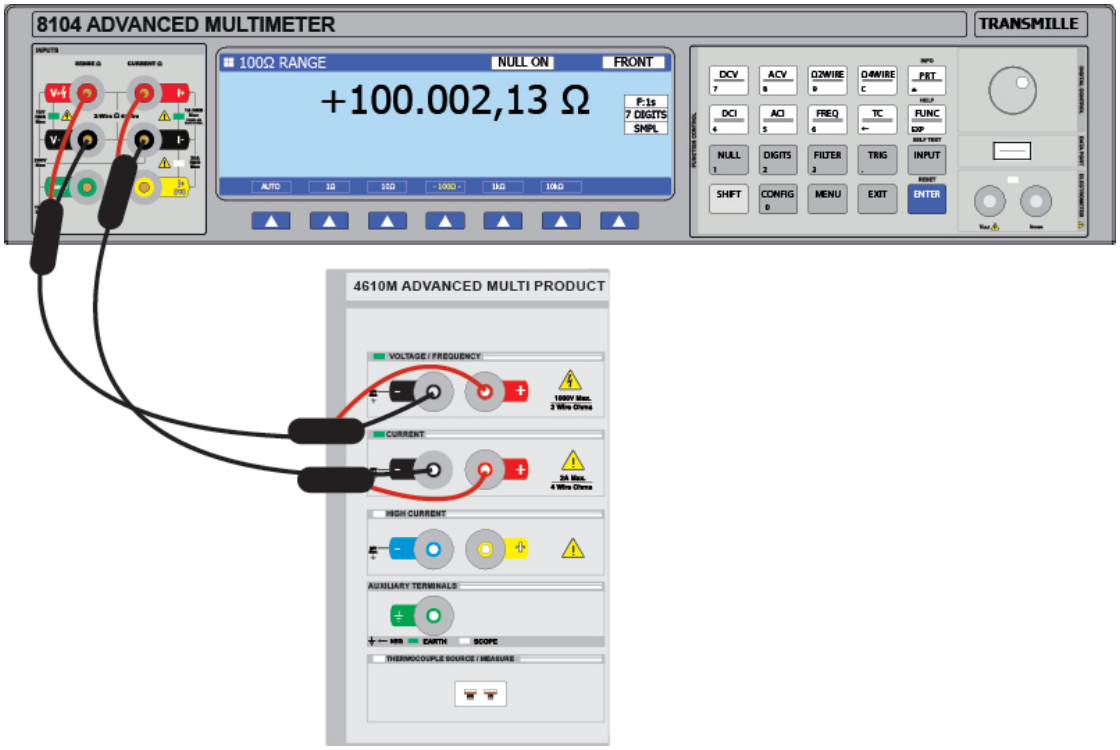
The 4610M features fully variable simulated resistance, capable of generating values from 0 Ohms to 1 GOhm

Values from 0 Ohm to 100kOhm are measured and adjusted as 4 Wire Resistance, and values from 100 kOhm to 1 GOhm are measured and adjusted as 2 Wire Resistance. No separate adjustment is required for each of the output modes (2 Wire, 4 Wire and 2 Wire Compensated)

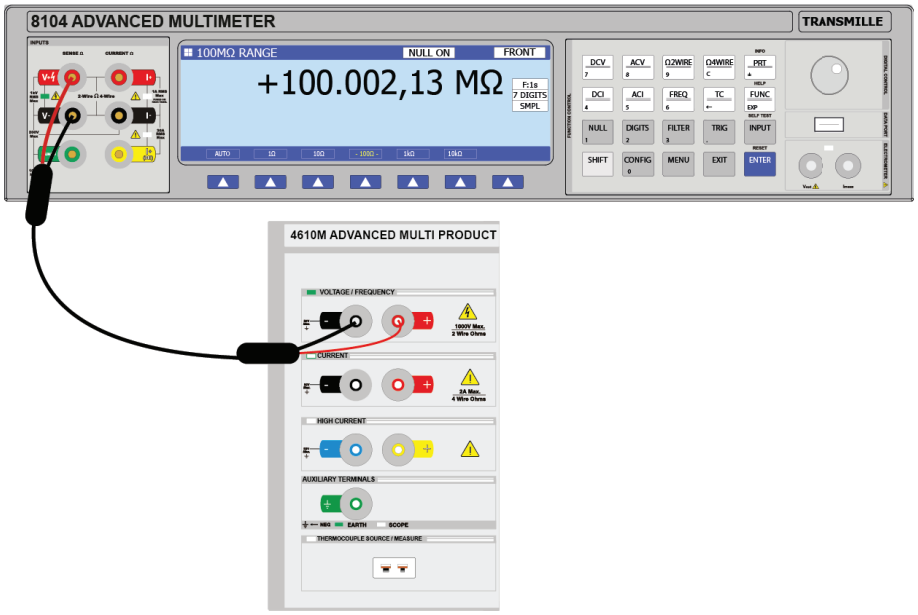
The precision multimeter should have a Zero/Null performed with all wires shorted together prior to connection to the calibrator. Incorrectly performing a Null can cause errors in excess of the specification.



Figures 25 – 4 Wire Zero at End Of Leads



Figures 26 – 4 Wire Simulated Resistance Connection - Values up to 100k Ohms



Figures 27 – 2 Wire Simulated Resistance Connection - Values above 100k Ohms

Each simulated resistance range has a ‘Zero’ and ‘Full Scale’ calibration adjustment point.

A table of adjustment points is listed as follows

Range	Zero	Full Scale	Measurement Method
10 Ohms	0 Ohms	10 Ohm	4 Wire
33 Ohm	10 Ohm	30 Ohm	4 Wire
100 Ohm	33 Ohm	100 Ohm	4 Wire
330 Ohm	100 Ohm	300 Ohm	4 Wire
1 kOhm	330 Ohm	1 kOhm	4 Wire
3.3 kOhm	1 kOhm	3 kOhm	4 Wire
10 kOhm	3.3 kOhm	10 kOhm	4 Wire
33 kOhm	10 kOhm	30 kOhm	4 Wire
100 kOhm	33 kOhm	100 kOhm	4 Wire
330 kOhm	100 kOhm	300 kOhm	2 Wire
1 MOhm	330 kOhm	1 MOhm	2 Wire
3.3 MOhm	1 MOhm	3 MOhm	2 Wire
10 MOhm	3.3 MOhm	10 MOhm	2 Wire
33 MOhm	10 MOhm	3 MOhm	2 Wire
100 MOhm	33 MOhm	100 MOhm	2 Wire
330 MOhm	100 MOhm	300 MOhm	2 Wire
1 GOhm	0.4 GOhm	1 GOhm	2 Wire

Table 8 – Simulated Resistance Adjustment Points

In addition, there are two adjustments (one for ‘1’ ranges, the other for ‘3’ ranges) for low current offset (to compensate for devices that measure with a significantly lower current than others) which are performed on the 100 Ohm and 330 Ohm Ranges.

These adjustments only need to be performed if a hardware repair or change has been performed.

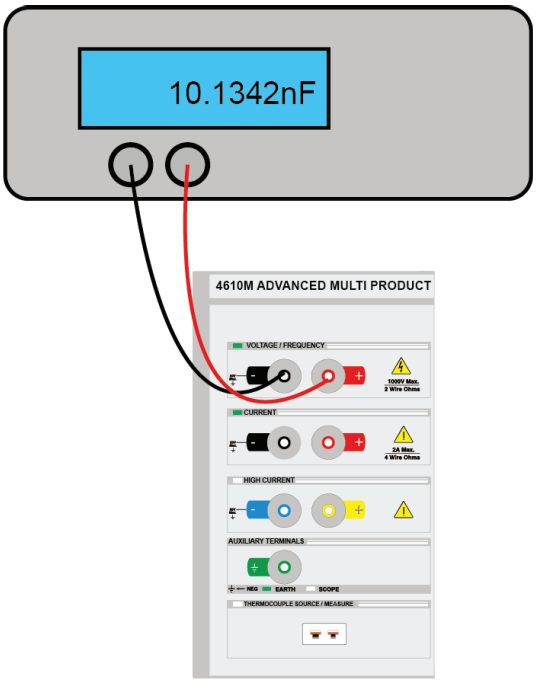
To perform these measurements, set the precision meter to the nominal range (i.e. the 100 Ohm range for measurement of the 100 Ohm output) and take a note of the reading. Then increase the range on the multimeter (hence measuring with 1 1/10th of the current typically) and then calculate the difference between these two readings. Enter the difference using the keyboard and the calibrator will adjust the output accordingly.

Note that performing the Low Current Offset adjustments will affect the calibration of the other ranges, so if a hardware replacement/repair has been performed it is advised to perform these adjustments first.

2.6.10. Passive Capacitance

The 4610M Features passive capacitance outputs, the calibrated output of each range is displayed on the screen of the calibrator when used, and as such cannot be adjusted to read an exact value.

Select ‘Passive Capacitance’ from the Menu and connect the LCR meter to the Voltage/Frequency terminals as in the connection diagram.



Figures 28 – 4 Wire Resistance Connection

Ensure that the LCR bridge has the Null/Zero procedure performed with the leads disconnected from the Calibrator and set a measurement frequency of 1kHz.

For measurements below 1uF use Cp on the LCR Meter, for measurements above use Cs measurement modes.

Enter the measured value from the LCR Meter and press ENTER. The calibrator will update the displayed value.

Continue until all capacitance ranges have been adjusted as required.

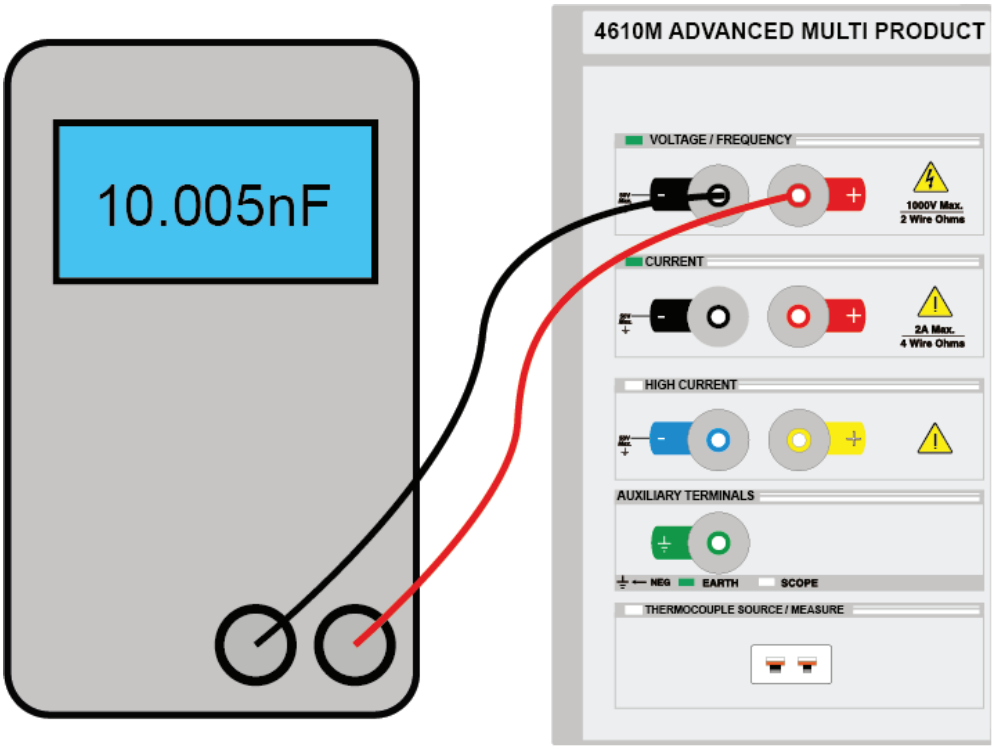
2.6.11. Simulated Capacitance

The 4610M features simulated capacitance output from 1nF to 100mF. The output uses a capacitance divider circuit for values from 1nF to 10uF, and a capacitance multiplier from 10uF to 100mF.

Due to the nature of the high values of capacitance that are generated by the instrument typical measurement techniques are non-traceable.

Two methods of verification are recommended by Transmille, with the secondary offering lower uncertainties but with a more complex configuration and extended set up time with requiring extra equipment.

The first method is to use a verified handheld meter such as an Agilent/Keysight U1252B or Fluke 287 which has been verified against a calibrator which has been verified using the second method. Ensure that the meter is Nulled with the measurement leads connected, but open circuit and not connected to the calibrator as significant capacitance (50-80pF) can be caused by interconnecting leads.



Figures 29 – 4 Wire Resistance Connection

Figures 30 –

The secondary method requires a known DC current (supplied from a reference calibrator such as a second Transmille 4610M or a Fluke 5700A) and an oscilloscope that has been verified on both timebase and amplitude.

The capacitance can be verified by calculating the increase in DC voltage over time, knowing the

charging current, the time that the charging current was present for and the increase in voltage across this time.

The Low Value capacitance has two points of adjustment for each range, whereas the high value capacitance has a single point of adjustment for each range which is performed at 10% of scale.

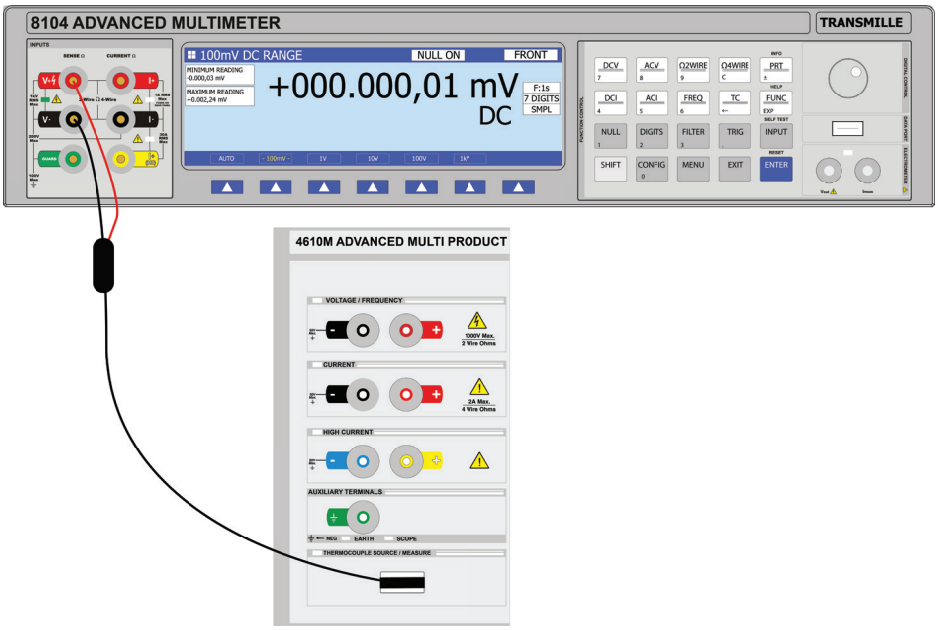
2.6.12. Thermocouple Source

The 4610M Features an integrated thermocouple output which utilizes a buffered precision divider on the normal DC Voltage output. As Thermocouples are extremely sensitive it is critical that the Zero output is measured with utmost care.

The thermocouple output can be measured as DC Voltage, with calibration points at 0mV, +100mV and -100mV

A Precision Multimeter and a Copper/Copper Mini-TC Plug is required to connect the multimeter to the Thermocouple Socket.

Select Thermocouple Source from the Calibration menu and prepare the multimeter to measure DC Voltage on the 100mV DC Range.



Figures 31 – Thermocouple Source Connection To Multimeter

It is essential that a Zero/Null is performed at the end of the leads from the multimeter to avoid introducing errors that are in excess of the specification of the calibrator.

Plug the Copper/Copper Mini-TC Plug into the Copper/Copper TC Socket on the front panel of the calibrator and enter the measured output in terms of mV, followed by the ‘ENTER’ key. The calibrator will adjust the output

Click ‘Next >’ to proceed to the Positive Full-Scale calibration point and enter the measured output and click ‘ENTER’

Proceed with the on-screen instructions

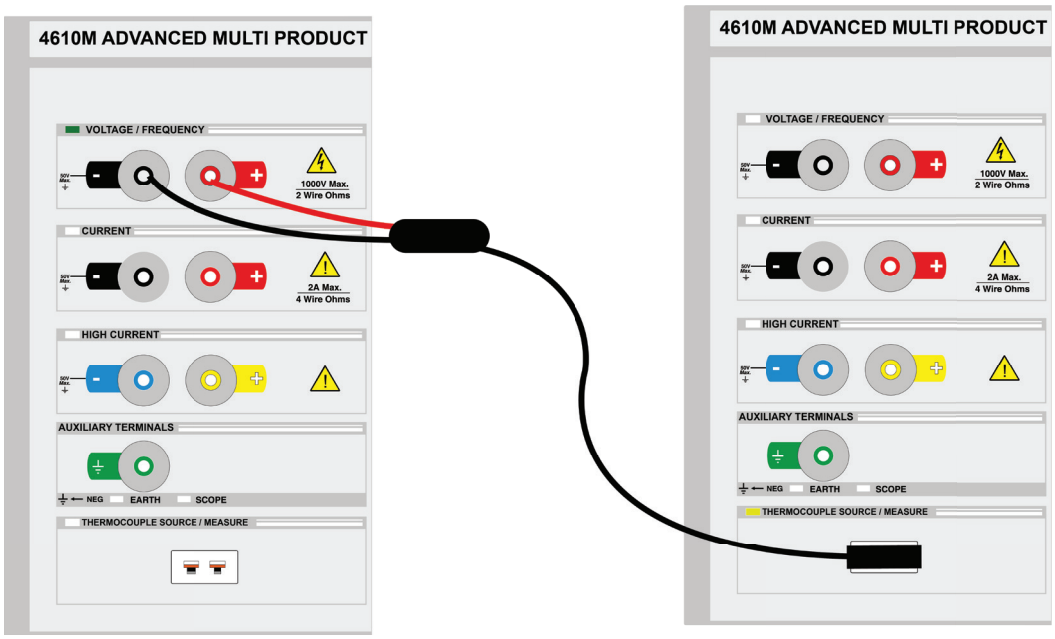
2.6.13. Thermocouple Measure

The 4610M features an integrated thermocouple input which utilizes a precision x100 amplifier to increase the measured input at the closes point of connection to the socket.

The thermocouple measurement function is verified by applying DC Voltage to the thermocouple input from a precision source such as a second 4610M or a Fluke 57xx

A Copper/Cooper Mini-TC Plug is required to connect to the TC socket – using a non-neutral thermocouple can cause large errors in excess of the specification of the instrument.

Select Thermocouple Measure from the Calibration Menu and prepare the calibrated source to output DC Voltage. Connect the Neutral Copper/Cooper Mini-TC Plug to both the Thermocouple socket on the front panel of the calibrator and to the voltage output terminals of the calibrated source.



Figures 32 – Thermocouple Measurement Connection

Apply 0mV from the calibrated source and allow the measurement to stabilize, then press the ‘ENTER’ key on the calibrator. The Calibrator will update the measured value on the screen and then continue to update the measurement periodically.

Click ‘Next >’ and follow the on-screen instructions.

2.6.14. Thermocouple Cold Junction Measurement

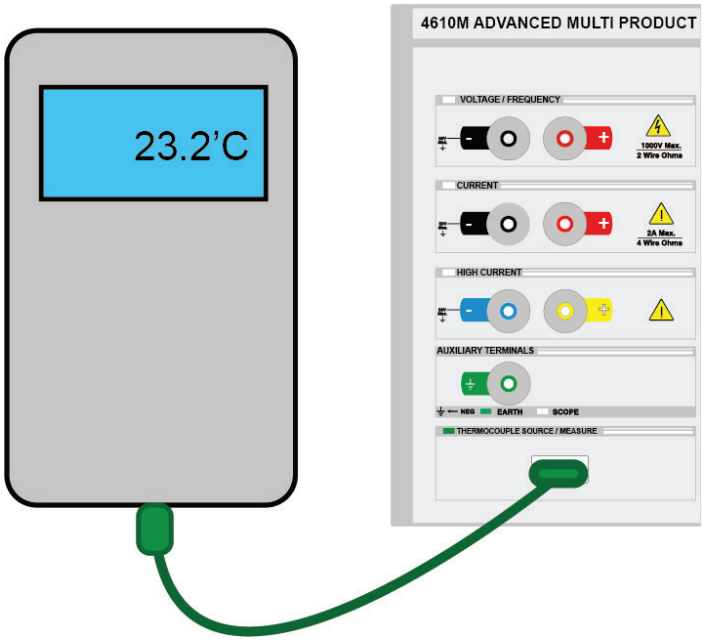
The 4610M Thermocouple function includes an integrated cold junction temperature sensor which allows the calibrator to measure the temperature at the Thermocouple Socket.

The temperature at the thermocouple socket may be slightly different from the ambient temperature due to heat generating components within the calibrator.

To verify the thermocouple cold junction measurement, connect a calibrated thermocouple meter with a Type K cable to the Thermocouple Output.

Care must be taken to ensure that the Type K cable is of good quality and thermally stable to the ambient temperature, and that the thermocouple meter is in a stable environment without any drafts blowing across it.

Set the thermocouple meter to Type K and ensure that the internal cold junction is enabled.



Figures 33 – Thermocouple Cold Junction Calibration

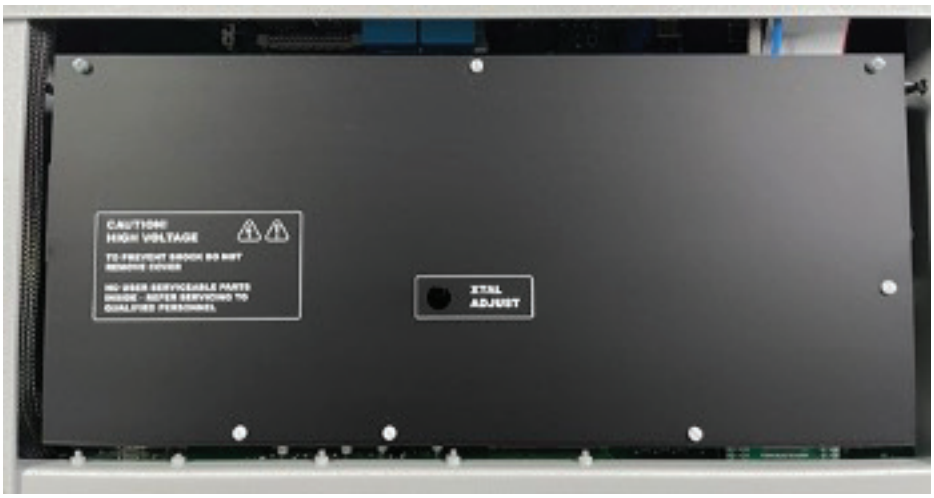
Enter the measured reading error (The calibrator has set 23'C, Type K) and the cold junction will be adjusted to correct the error.

Alternatively, knowing the ambient temperature (using a calibrated PRT probe) and with the Type K thermocouple table, the correct output in mV can be calculated by knowing the difference between the Ambient temperature and 23'C as set by the calibrator. The calculated output temperature can then be entered via the front panel.

2.6.15. Frequency Adjustment

The frequency output of the 4610M is generated by one precision oscillator.

To adjust the frequency output, removal of the top case is required. For instructions, refer to the maintenance manual on how to remove the case



Figures 34 – Location of XTAL Adjust on Top Board

The oscillator can be adjusted by aligning a small screwdriver through the hole labeled XTAL adjust in the top board cover.

To adjust, make very small adjustments to the small adjustment point in each oscillator with a frequency measurement standard connected.

Note – It is very rare for the frequency output to require adjustment. Please make sure that the calibrator is fully warmed up before making measurements to avoid unnecessary disassembly.

3. Verification

The calibrator requires routine verification to confirm that outputs are within specification. Transmille recommends that verification is performed on an annual basis but depending upon the users requirements this can either be shortened or extended.

Note : Verification can be performed without removal of any covers or screws

The following instructions and tables provide performance verification to Transmille's published specification and recommended test points.

3.1. DC Voltage

Connect the Calibrator to a precision multimeter using High Quality, Low Thermal cables and perform a DMM Null/Zero procedure prior to connecting the leads to the Voltage/Frequency output terminals

Controlling the calibrator via the front panel or through software, continue through the below test points.

Range	Output	Low Limit	High Limit	Optional
200mV Range	0mV	-0.002mV	0.002mV	
	190mV	189.9952mV	190.0048mV	
	-190mV	-190.0048mV	-189.9952mV	
2V Range	0.22V	0.2199955V	0.2200045V	
	1.9V	1.8999804V	1.90000196V	
	-1.9V	-1.90000196	-1.8999804V	
20V Range	2.2V	2.1999584V	2.2000416V	
	19V	18.999824V	19.000176V	
	-19V	-19.000176V	-18.999824V	
	20V	19.999816V	20.000184V	X
	18V	17.999832V	18.000168V	X
	17V	16.99984V	17.00016V	X
	16V	15.999848V	16.000152V	X
	15V	14.999856V	15.000144V	X
	14V	13.999864V	14.000136V	X
	13V	12.999872V	13.000128V	X
	12V	11.99988V	12.00012V	X
	11V	10.999888V	11.000112V	X

	10V	9.999896V	10.000104V	X
	9V	8.999904V	9.000096V	X
	8V	7.999912V	8.000088V	X
	7V	6.99992V	7.00008V	X
	6V	5.999928V	6.000072V	X
	5V	4.999936V	5.000064V	X
	4V	3.999944V	4.000056V	X
	3V	2.999952V	3.000048V	X
	2.1V	2.0999592V	2.1000408V	X
	-2.1V	-2.1000408V	-2.0999592V	X
	-3V	-3.000048V	-2.999952V	X
	-4V	-4.000056V	-3.999944V	X
	-5V	-5.000064V	-4.999936V	X
	-6V	-6.000072V	-5.999928V	X
	-7V	-7.00008V	-6.99992V	X
	-8V	-8.000088V	-7.999912V	X
	-9V	-9.000096V	-8.999904V	X
	10V	-10.000104V	-9.999896V	X
	-11V	-11.000112V	-10.999888V	X
	-12V	-12.00012V	-11.99988V	X
	-13V	-13.000128V	-12.999872V	X
	-14V	-14.000136V	-13.999864V	X
	-15V	-15.000144V	-14.999856V	X
	-16V	-16.000152V	-15.999848V	X
	-17V	-17.00016V	-16.99984V	X
	-18V	-18.000168V	-17.999832V	X
	-20V	-20.000184V	-19.999816V	X
200V Range	22V	21.999536V	22.000464V	
	100V	99.9986V	100.0014V	X
	190V	189.9975V	190.0025V	
	-190V	-190.0025V	-189.9975V	
1kV Range	220V	219.9954V	220.0046V	
	500V	499.992V	500.008V	X
	1000V	999.986V	1000.014V	
	-1000V	-1000.014V	-999.986V	

Table 9 – DC Voltage Verification Points

3.2. AC Voltage

Connect the calibrator to a precision multimeter using low capacitance cables. It is important to note that at high voltage/high frequency levels the capacitance of the cables will become significant and possible exceed the specification of the calibrator.

As thermals are not significant in AC Voltage measurements it is recommended to use separated cables rather than coaxial cables.

Controlling the calibrator via the front panel or through software, continue through the below test points.

Range	Output	Frequency	Minimum	Maximum	Optional
20mV	2mV	10Hz	1.9884mV	2.0116mV	X
	2mV	1kHz	1.9896mV	2.0104mV	
	2mV	20kHz	1.9896mV	2.0104mV	X
	2mV	50kHz	1.9876mV	2.0124mV	X
	2mV	100kHz	1.981mV	2.019mV	X
	2mV	500kHz	1.934mV	2.066mV	
	10mV	1kHz	9.9882mV	10.0118mV	X
	19mV	10Hz	18.9858mV	19.0142mV	
	19mV	45Hz	18.9858mV	19.0142mV	
	19mV	1kHz	18.9866mV	19.0134mV	
	19mV	20kHz	18.9866mV	19.0134mV	
	19mV	30kHz	18.9672mV	19.0328mV	
	19mV	100kHz	18.9215mV	19.0785mV	
	19mV	500kHz	18.798mV	19.202mV	
200mV	21mV	10Hz	20.9821mV	21.0179mV	X
	21mV	1kHz	20.9866mV	21.0134mV	
	21mV	10kHz	20.9812mV	21.0192mV	X
	21mV	20kHz	20.9812mV	21.0192mV	X
	21mV	50kHz	20.9632mV	21.0368mV	X
	21mV	100kHz	20.939mV	21.061mV	X
	21mV	500kHz	20.887mV	21.113mV	
	100mV	1kHz	99.974mV	100.026mV	X
	190mV	10Hz	189.9348mV	190.0652mV	
	190mV	45Hz	189.9596mV	190.0404mV	
	190mV	1kHz	189.9596mV	190.0404mV	
	190mV	20kHz	189.9470mV	190.0530mV	
	190mV	30kHz	189.8280mV	190.1720mV	

	190mV	50kHz	189.8280mV	190.1720mV	
	190mV	100kHz	189.77mV	190.23mV	
	190mV	500kHz	189.38mV	190.62mV	
2V	0.21V	10Hz	0.2099208V	0.2100792V	X
	0.21V	1kHz	0.209938V	0.210062V	
	0.21V	20kHz	0.209908V	0.210092V	X
	0.21V	50kHz	0.2098135V	0.2101865V	X
	0.21V	100kHz	0.2096935V	0.2103065V	X
	0.21V	500kHz	0.209175V	0.210825V	X
	0.21V	1MHz	0.20892V	0.21080V	
	1V	1kHz	0.99978V	1.00022V	X
	1.9V	10Hz	1.89938V	1.90062V	
	1.9V	45Hz	1.8996V	1.9004V	
	1.9V	1kHz	1.8996V	1.9004V	
	1.9V	20kHz	1.89957V	1.90043V	
	1.9V	30kHz	1.898715V	1.901285V	
	1.9V	50kHz	1.898715V	1.901285V	
	1.9V	100kHz	1.898595V	1.901405V	
	1.9V	500kHz	1.89485V	1.90505V	
	1.9V	1MHz	1.89385V	1.90615V	
20V	2.1V	10Hz	2.0989V	2.1011V	X
	2.1V	1kHz	2.099422V	2.100578V	
	2.1V	20kHz	2.099218V	2.100782V	X
	2.1V	50kHz	2.098765V	2.101235V	X
	2.1V	100kHz	2.098125V	2.101875V	
	10V	1kHz	9.998V	10.002V	X
	19V	10Hz	18.99215V	19.00785V	
	19V	45Hz	18.99638V	19.00362V	
	19V	1kHz	18.9964V	19.0036V	
	19V	20kHz	18.9955V	19.0045V	
	19V	30kHz	18.99285V	19.00715V	
	19V	50kHz	18.99285V	19.00715V	
	19V	100kHz	18.98545V	19.01455V	
200V	21V	10Hz	20.9866V	21.0134V	X
	21V	45Hz	20.9942V	21.0058V	X
	21V	1kHz	20.9942V	21.0058V	
	21V	20kHz	20.99225V	21.00775V	X
	21V	50kHz	20.99165V	21.00835V	X

	21V	100kHz	20.9782V	21.0218V	
	100V	1kHz	99.9792V	100.0208V	X
	190V	10Hz	189.919V	190.081V	
	190V	45Hz	189.9621V	190.0379V	
	190V	1kHz	189.9621V	190.0379V	
	190V	20kHz	189.95V	190.05V	
	190V	30kHz	189.9325V	190.0675V	
	190V	50kHz	189.9325V	190.0675V	
	190V	100kHz	189.843V	190.157V	
1000V	210V	30Hz	209.859V	210.141V	X
	210V	45Hz	209.9416V	210.0584V	X
	210V	1kHz	209.9416V	210.0584V	
	210V	10kHz	209.925V	210.075V	X
	210V	20kHz	209.925V	210.075V	
	750V	30Hz	749.535V	750.465V	
	750V	45Hz	749.812V	750.188V	
	750V	1kHz	749.812V	750.188V	
	750V	5kHz	749.763V	750.237V	X
	750V	10kHz	749.763V	750.237V	
	1000V	45Hz	999.752V	1000.248V	X
	1000V	1kHz	999.752V	1000.248V	
	1000V	5kHz	999.688V	1000.312V	X
	1000V	7kHz	999.688V	1000.312V	X
	1000V	10kHz	999.688V	1000.312V	X

Table 10 – AC Voltage Verification Points

3.3. DC Current

Depending upon the accuracy of the multimeter being used, DC Current can either be measured directly or will require the use of current shunts.

Connect the calibrator to the measuring device using the appropriate leads, note that for currents above 1A the leads should be of suitable gauge.

Test the unit at each of the below test points.

Range	Output	Minimum	Maximum
200uA	0uA	-0.01uA	0.01uA
	190uA	199.971uA	200.029uA
	-190uA	-200.029uA	-199.971uA
2mA	0.21mA	0.209955mA	0.210045mA
	1.9mA	1.899875mA	1.900125mA
	-1.9mA	-1.900125mA	-1.899875mA
20mA	2.1mA	2.099695mA	2.100305mA
	19mA	19.9988mA	20.0012mA
	-19mA	-20.0012mA	-19.9988mA
200mA	21mA	20.997mA	21.003mA
	190mA	189.9885mA	190.0115mA
	-190mA	-200.012mA	-189.9885mA
2A	0.21A	0.2099427A	0.2100573A
	1.9A	1.899723A	1.900277A
	-1.9A	-1.900277A	-1.899723A
30A	2.1A	2.09907A	2.10093A
	10A	9.9967A	10.0033A
	20A	19.9937A	20.0063A
	30A	29.9786A	30.0214A
	-30A	-30.0214A	-29.9786A

Table 11 – DC Current Verification Points

3.4. AC Current

If using a characterized multimeter, AC current can be measured directly without the need for AC Current Shunts, however typically a set of AC/DC Current shunts will be required.

Ensure that loading effects of the multimeter across the AC Shunt are compensated for. For information on how to do this, refer to the operating manual for the shunts.

Connect the calibrator to the measuring device using coaxial leads for current up to 200mA, and non-coaxial leads for currents above. Make sure that any leads used are rated for the currents that are to be sourced by the calibrator.

Test the unit at each of the below test points.

Range	Output	Frequency	Minimum	Maximum	Optional
200uA	25uA	10Hz	24.85uA	25.15uA	
	25uA	45Hz	24.875uA	25.125uA	X
	25uA	1kHz	24.875uA	25.125uA	
	25uA	5kHz	24.55uA	25.45uA	X
	25uA	10kHz	24.55uA	25.45uA	X
	25uA	30kHz	24.2uA	25.8uA	
	100uA	1kHz	99.8uA	100.2uA	X
	190uA	10Hz	189.52uA	190.48uA	
	190uA	45Hz	189.71uA	190.29uA	
	190uA	1kHz	189.71uA	190.29uA	
	190uA	5kHz	188.2uA	191.8uA	
	190uA	10kHz	188.2uA	191.8uA	
	190uA	20kHz	186.6uA	193.4uA	
	190uA	30kHz	186.6uA	193.4uA	
2mA	0.21mA	10Hz	0.209585mA	0.210415mA	
	0.21mA	45Hz	0.20964mA	0.21036mA	X
	0.21mA	1kHz	0.20964mA	0.21036mA	
	0.21mA	5kHz	0.2086mA	0.2114mA	X
	0.21mA	10kHz	0.2086mA	0.2114mA	X
	0.21mA	30kHz	0.2073mA	0.2127mA	
	1mA	1kHz	0.9988mA	1.0012mA	X
	1.9mA	10Hz	1.897mA	1.903mA	
	1.9mA	45Hz	1.8979mA	1.9021mA	
	1.9mA	1kHz	1.8979mA	1.9021mA	
	1.9mA	5kHz	1.8902mA	1.9098mA	
	1.9mA	10kHz	1.8902mA	1.9098mA	
	1.9mA	20kHz	1.8804mA	1.9196mA	
	1.9mA	30kHz	1.8804mA	1.9196mA	

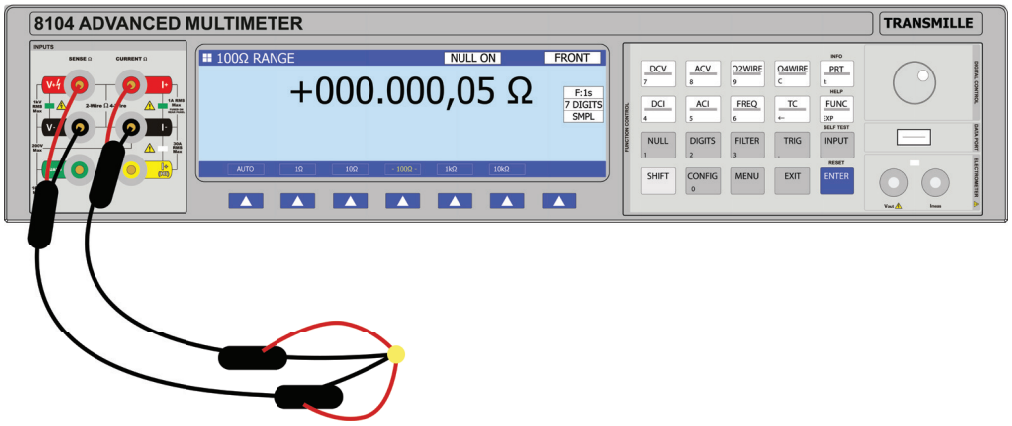
20mA	2.1mA	10Hz	2.0954mA	2.1046mA	X
	2.1mA	45Hz	2.0977mA	2.1023mA	X
	2.1mA	1kHz	2.0977mA	2.1023mA	
	2.1mA	5kHz	2.0917mA	2.1083mA	X
	2.1mA	10kHz	2.0892mA	2.1108mA	X
	2.1mA	30kHz	2.0855mA	2.1145mA	
	10mA	1kHz	9.9945mA	10.0055mA	X
	19mA	10Hz	18.9667mA	19.0333mA	
	19mA	45Hz	18.9809mA	19.0191mA	
	19mA	1kHz	18.9909mA	19.0091mA	
	19mA	5kHz	18.9495mA	19.0505mA	
	19mA	10kHz	18.9495mA	19.0505mA	
	19mA	20kHz	18.901mA	19.099mA	
	19mA	30kHz	18.901mA	19.099mA	
200mA	21mA	10Hz	20.9485mA	21.0515mA	X
	21mA	45Hz	20.9836mA	21.0164mA	X
	21mA	1kHz	20.9836mA	21.0164mA	
	21mA	5kHz	20.897mA	21.103mA	X
	21mA	10kHz	20.855mA	21.145mA	X
	21mA	30kHz	20.653mA	21.347mA	
	100mA	1kHz	99.952mA	100.048mA	X
	190mA	10Hz	189.695mA	190.305mA	
	190mA	45Hz	189.916mA	190.084mA	
	190mA	1kHz	189.916mA	190.084mA	
	190mA	5kHz	189.39mA	190.61mA	
	190mA	10kHz	189.01mA	190.99mA	
	190mA	20kHz	188.5mA	191.5mA	
	190mA	30kHz	188.5mA	191.5mA	
2A	0.21A	10Hz	0.209506A	0.210494A	X
	0.21A	45Hz	0.209795A	0.210205A	X
	0.21A	1kHz	0.209795A	0.210205A	
	0.21A	5kHz	0.2088A	0.2112A	X
	0.21A	10kHz	0.2077A	0.2123A	X
	0.21A	30kHz	0.1998A	0.2202A	
	1A	1kHz	0.9995A	1.0005A	X
	1A	10kHz	0.993A	1.007A	X
	1A	20kHz	0.97A	1.03A	X
	1A	30kHz	0.97A	1.03A	
	1.9A	10Hz	1.8971A	1.9029A	
	1.9A	45Hz	1.899A	1.901A	
	1.9A	1kHz	1.899A	1.901A	
	1.9A	5kHz	1.892A	1.908A	
	1.9A	10kHz	1.8876A	1.9124A	
30A	2.1A	10Hz	2.0951A	2.1049A	X

	2.1A	45Hz	2.0953A	2.1047A	X
	2.1A	1kHz	2.0953A	2.1047A	
	2.1A	5kHz	2.0834A	2.1166A	
	2.1A	10kHz	2.032A	2.168A	
	10A	10Hz	9.984A	10.016A	X
	10A	45Hz	9.985A	10.015A	X
	10A	1kHz	9.985A	10.015A	X
	10A	10kHz	9.936A	10.064A	X
	20A	10Hz	19.97A	20.03A	
	20A	45Hz	19.972A	20.028A	
	20A	1kHz	19.972A	20.028A	
	20A	5kHz	19.876A	20.124A	
	30A	30Hz	29.937A	30.063A	X
	30A	1kHz	29.906A	30.094A	X
	30A	5kHz	29.816A	30.184A	X

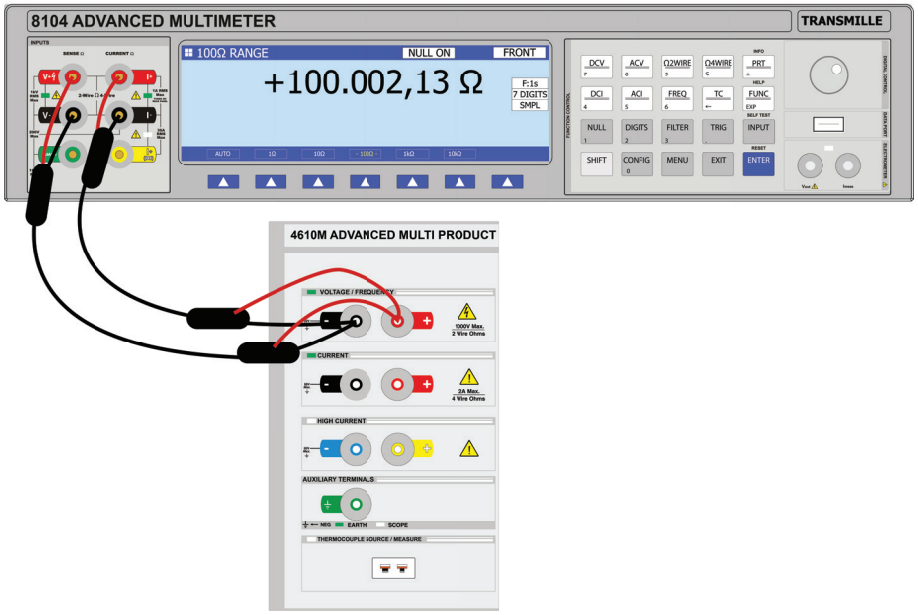
Table 12 – AC Current Verification Points

3.5.2 2 Wire Passive Resistance

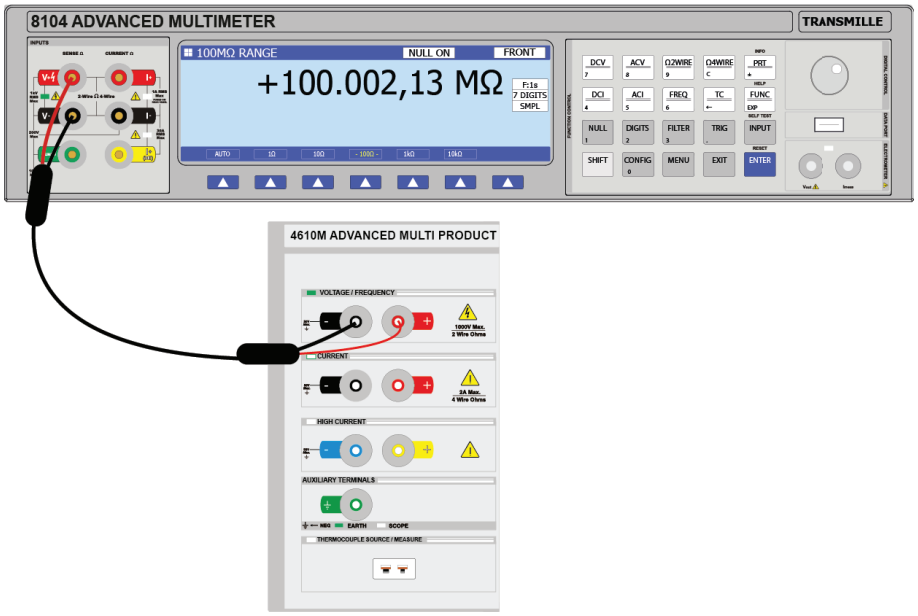
Using a precision multimeter, connect the sense and current leads together and stack the leads together. Perform a Zero/Null operation on the multimeter and then connect the leads to the Voltage / Frequency terminals.



Figures 35 – 4 Wire Zero at End Of Leads



Figures 36 – 2 Wire Passive Resistance - Values below 100k Ohms



Figures 37 – 2 Wire Passive Resistance - Values above 100k Ohms

The specifications are applied relative to the currently displayed value rather than the nominal for the range and must include the floor value.

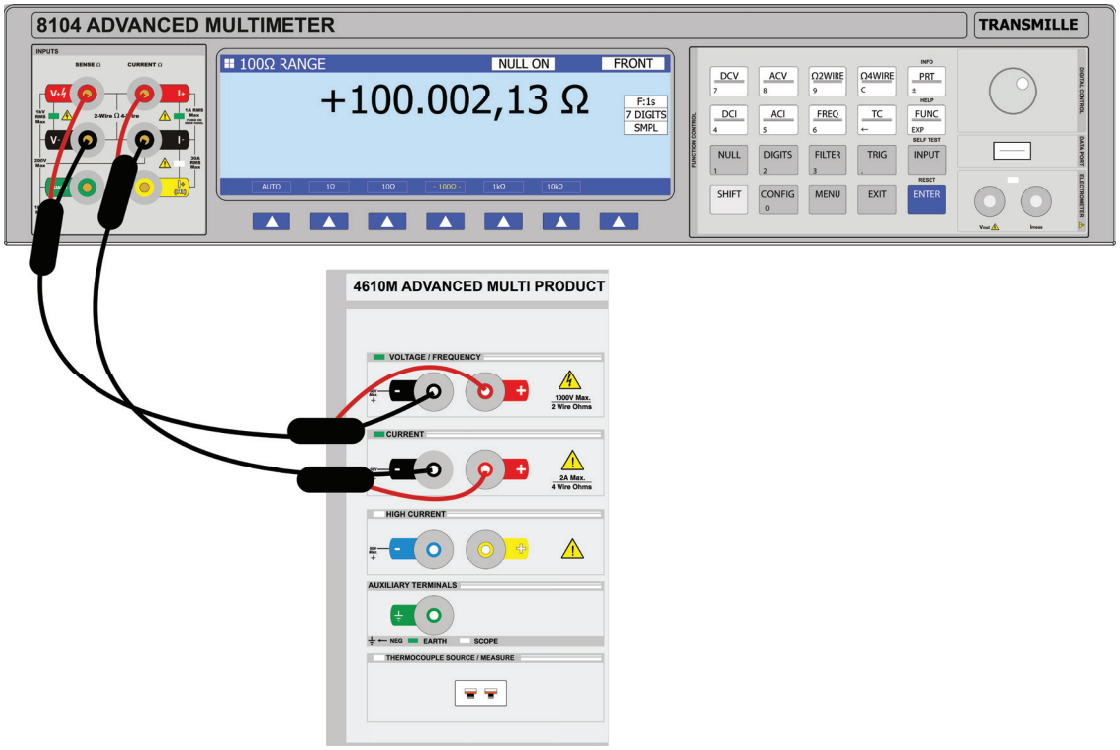
Measure each resistance range and calculate the tolerance based upon the displayed value.

Range	Output	Minimum	Maximum
0Ω	~200mΩ	-40mΩ	40mΩ
0.1Ω	~300mΩ	60mΩ	140mΩ
1Ω	1.0Ω	0.96Ω	1.04Ω
10Ω	10.0Ω	9.9598Ω	10.0402Ω
100Ω	100Ω	99.9582Ω	100.0418Ω
1kΩ	1.0kΩ	0.999942kΩ	1.000058kΩ
10kΩ	10.00kΩ	9.99987kΩ	10.00013kΩ
100kΩ	100kΩ	99.9977kΩ	100.0023kΩ
1MΩ	1MΩ	0.99997MΩ	1.00003MΩ
10MΩ	10.0MΩ	9.999MΩ	10.001MΩ
100MΩ	100MΩ	99.818MΩ	100.182MΩ
1GΩ	1GΩ	0.99GΩ	1.01GΩ

Table 13 – Passive 2 Wire Resistance Verification Points

3.6.4 Wire Passive Resistance

Using a precision multimeter, connect the sense and current leads as a 4 Wire connection to the front panel terminals of the calibrator.



Figures 38 – 4 Wire Resistance Measurement Connection

All displayed values are relative to the 0 Ohm output of the 4 Wire resistance range. Ensure that the multimeter zero is performed when the Multimeter is connected to the calibrator, and the 0 Ohm 4 Wire Resistance output is set.

The specifications are applied relative to the currently displayed value rather than the nominal for the range and must include the floor value.

Measure each resistance range and calculate the tolerance based upon the displayed value.

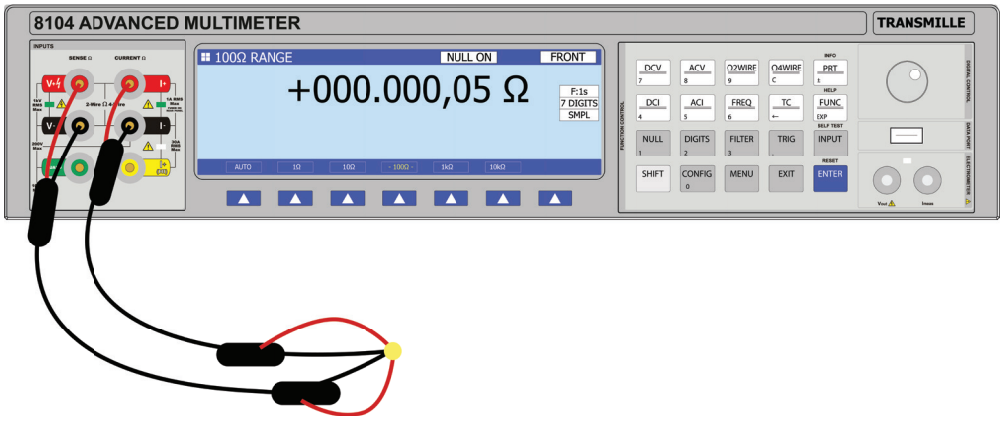
Range	Output	Minimum	Maximum
100mΩ	100mΩ	95mΩ	105mΩ
1Ω	1Ω	0.995Ω	1.005Ω
10Ω	10Ω	9.9948Ω	10.0052Ω
100Ω	100Ω	99.9932Ω	100.0068Ω
1kΩ	1kΩ	0.999977kΩ	1.000023kΩ
10kΩ	10kΩ	9.99987kΩ	10.00013kΩ
100kΩ	100kΩ	99.9977kΩ	100.0023kΩ
1MΩ	1MΩ	0.99997MΩ	1.00003MΩ
10MΩ	10MΩ	9.999MΩ	10.001MΩ
100MΩ	100MΩ	99.818MΩ	100.182MΩ

Table 14 – Passive 4 Wire Resistance Verification Points

3.7. Simulated Resistance - 4 Wire

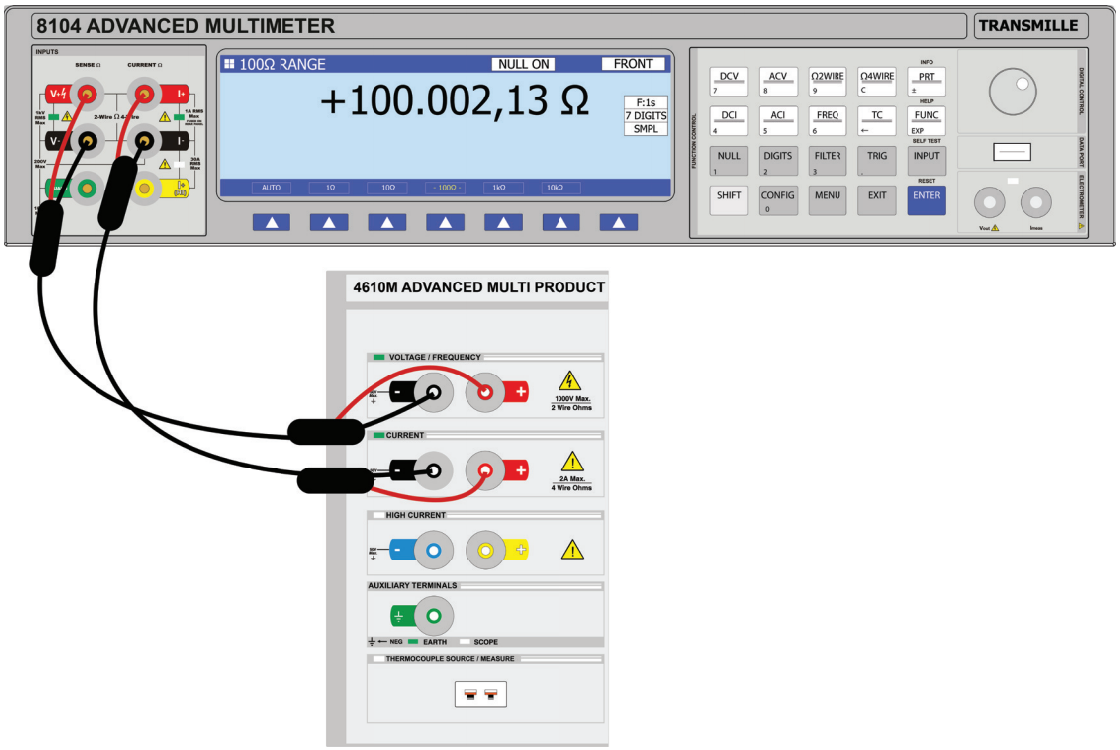
Using a precision multimeter, configure to perform 4 Wire Resistance Measurements.

Perform a Zero/Null on the multimeter by shorting all leads together at the point of connection to the calibrator to remove any offsets from the measurement system.



Figures 39 – 4 Wire Lead Zero

Connect the multimeter to the calibrator to measure 4 Wire resistance and measure the output at the following points.



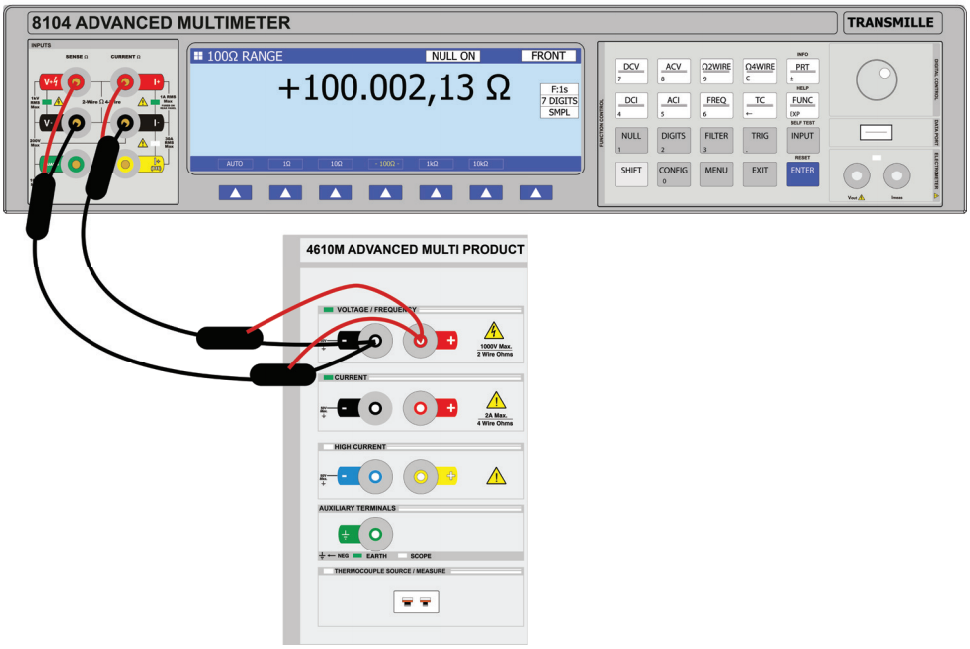
Figures 40 – 4 Wire Resistance Connection

Range	Output	Minimum	Maximum	Optional
10Ω	0Ω	-0.006Ω	0.006Ω	
	1Ω	0.9938Ω	1.0062Ω	
	10Ω	9.9925Ω	10.0075Ω	
33Ω	10.1Ω	10.0961Ω	10.1039Ω	
	33Ω	32.994Ω	33.006Ω	
100Ω	33.1Ω	33.0884Ω	33.1116Ω	
	100Ω	99.983Ω	100.017Ω	
330Ω	100.1Ω	100.079Ω	100.121Ω	
	330Ω	329.9721Ω	330.0279Ω	
1kΩ	0.33kΩ	0.3299575kΩ	0.3300425kΩ	
	0.5kΩ	0.499949kΩ	0.500051kΩ	X
	1kΩ	0.999924kΩ	1.000076kΩ	
3.3kΩ	1.1kΩ	0.999874kΩ	1.000126kΩ	
	3.3kΩ	3.299742kΩ	3.300258kΩ	
10kΩ	3.3kΩ	3.299582kΩ	3.300418kΩ	
	4kΩ	3.99954kΩ	4.00046kΩ	X
	5kΩ	4.99948kΩ	5.00052kΩ	X
	6kΩ	5.99942kΩ	6.00058kΩ	X
	7kΩ	6.99936kΩ	7.00064kΩ	X
	8kΩ	7.9993kΩ	8.0007kΩ	X
	9kΩ	8.99924kΩ	9.00076kΩ	X
	10kΩ	9.99918kΩ	10.00082kΩ	
33kΩ	10.1kΩ	9.9988kΩ	10.0012kΩ	
	33kΩ	32.9974kΩ	33.0026kΩ	
100kΩ	33kΩ	32.9958kΩ	33.0042kΩ	
	100kΩ	99.9918kΩ	100.0082kΩ	

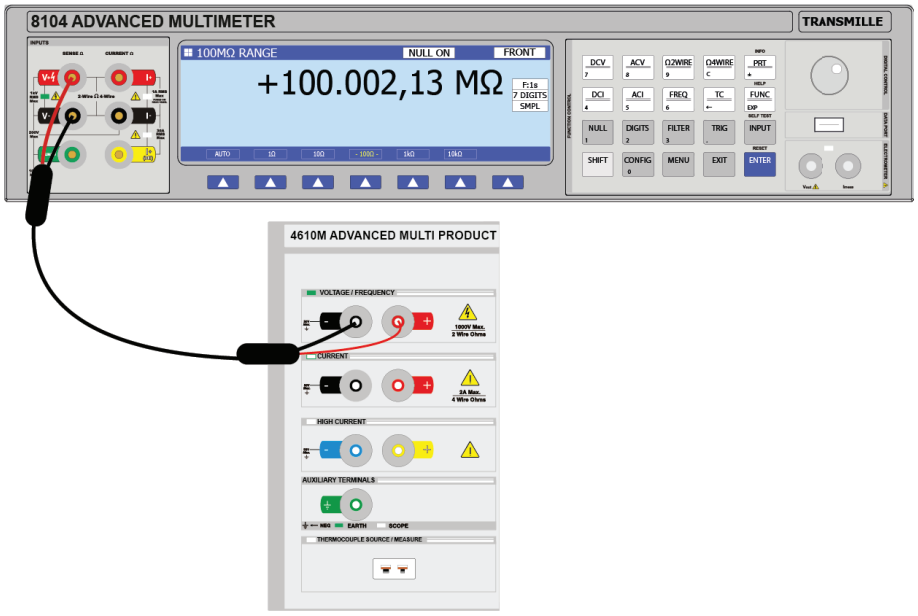
Table 15 – 4 Wire Simulated Resistance Verification Points

3.8. Simulated Resistance - 2 Wire

Using a precision multimeter, configure to perform 2 Wire Resistance Measurements. Ensure that a Null is performed prior to taking measurements



Figures 41 – 2 Wire Measurement for Resistance < 100 kOhms



Figures 42 – 2 Wire Measurement for Resistance above 100 kOhms

Note – The 2 Wire specifications apply relative to the 0 Output of the calibrator. Ensure that the multimeter has a Zero/Null performed while connected to the output of the calibrator while outputting 0 Ohms on the 2 Wire Simulated Output

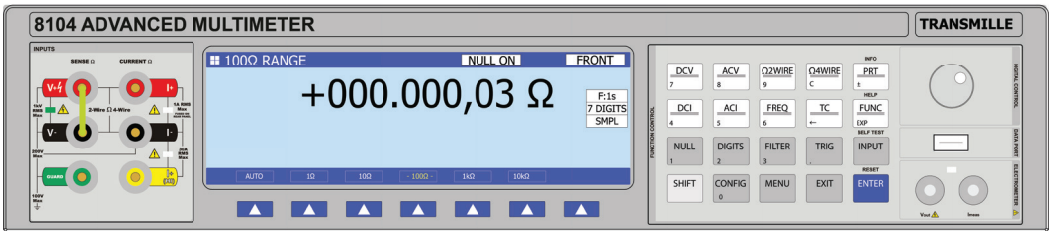
Range	Output	Minimum	Maximum
330kR	100kR	99.9878kR	100.0122kR
	330kR	329.974kR	330.026kR
1MR	0.33MR	0.329958MR	0.330042MR
	1MR	0.999891MR	1.000109MR
3.3MR	1MR	0.99965MR	1.00035MR
	3.3MR	3.29919MR	3.30081MR
10MR	3.3MR	3.2989MR	3.3011MR
	10MR	9.9972MR	10.0028MR
33MR	10MR	9.977MR	10.023MR
	33MR	32.9586MR	33.0414MR
100MR	33MR	32.9255MR	33.0745MR
	100MR	99.825MR	100.175MR
330MR	100MR	99.75MR	100.25MR
	330MR	329.359MR	330.641MR
1GR	0.33GR	0.3259GR	0.3341GR
	1GR	0.9892GR	1.0108GR

Table 16 – Wire Simulated Resistance Verification Points

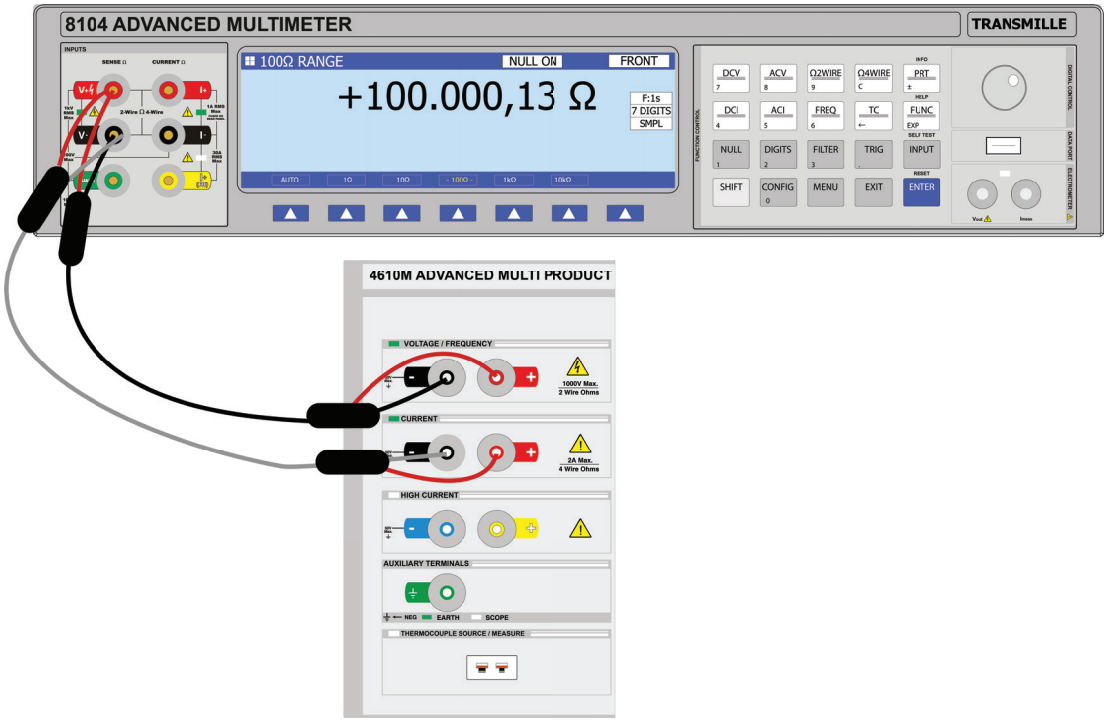
3.9. Simulated Resistance - 2 Wire Compensated (Optional)

To verify that 2 Wire Compensated Resistance operates within specifications, optionally perform the following measurements.

Ensure that a multimeter Zero is performed at the terminals as compensated ohms provides a corrected output at the point of connection to the terminals, not at the end of the leads.



Figures 43 – Multimeter 2 Wire Zero to Terminals



Figures 44 – Measurement of 2 Wire Compensated Ohms Output

Range	Output	Minimum	Maximum
10 R Range	0R	-0.006R	0.006R
10 R Range	10R	9.9925R	10.0075R
33 R Range	33R	32.994R	33.006R
100 R Range	100R	99.983R	100.017R
330 R Range	330R	329.9671R	330.0329R
1kR Range	1kR	0.999919kR	1.000081kR
3.3kR Range	3.3kR	3.299742kR	3.300258kR
10kR Range	10kR	9.99918kR	10.00082kR
33kR Range	33kR	32.9974kR	33.0026kR
100kR Range	100kR	99.9918kR	100.0082kR

Table 17 – 2 Wire Compensated Resistance Verification Points

3.10. Passive Capacitance

Using an LCR meter, configure to perform measurements with a frequency of 1kHz. All passive outputs of the 4610M are measured with a 1kHz frequency. Measuring at a different frequency is possible but it must then be noted that this was the Calibration Frequency.

Perform a Zero/Null of the LCR meter with the leads disconnected from the calibrator, but open circuited.

The specifications are applied relative to the currently displayed value rather than the nominal for the range and must include the floor value.

Connect the LCR Meter to the Voltage/Frequency terminals of the calibrator and calculate the tolerance based upon the displayed value.

Range	Output	Minimum	Maximum
1nF	1nF	0.9775nF	1.0225nF
2nF	2.0nF	1.975nF	2.025nF
5nF	5nF	4.9675nF	5.0325nF
10nF	10nF	9.955nF	10.045nF
100nF	100nF	99.73nF	100.27nF
1uF	1uF	0.996uF	1.004uF
10uF	10uF	9.94uF	10.06uF

Table 18 – Passive Capacitance Verification Points

3.11. Simulated Capacitance

Verifying the simulated capacitance requires two different techniques, one technique for capacitance measurements up to 10uF and the second for capacitance up to 100mF.

Either use a pre-characterized handheld multimeter or using a known DC current source and an oscilloscope. Further instructions are available from Transmille upon request.

Ensure that the handheld meter that the meter has had a Zero/Null process performed prior to performing measurements to avoid offsets from the meter being introduced into the verification.

Measure at the points detailed in the table below.

Range	Output	Minimum	Maximum
10nF	1nF	0.985nF	1.015nF
	10nF	9.945nF	10.055nF
100nF	11nF	10.9395nF	11.0605nF
	100nF	99.45nF	100.55nF
1uF	0.2uF	0.199uF	0.201uF
	0.95uF	0.9452uF	0.9548uF
10uF	2uF	1.99uF	2.01uF
	9.5uF	9.4525uF	9.5475uF
100uF	10uF	9.925uF	10.075uF
	95uF	94.2875uF	95.7125uF
1mF	0.1mF	0.09925mF	0.10075mF
	0.95mF	0.9429mF	0.9571mF
10mF	1mF	0.9925mF	1.0075mF
	9.5mF	9.4287mF	9.5713mF
100mF	10mF	9.86mF	10.14mF
	40mF	39.44mF	40.56mF

Table 19 – Simulated Capacitance Verification Points

3.12. Thermocouple Source

Verifying the thermocouple source requires a multimeter and a neutral Copper/Copper Mini TC-Plug

The primary verification consists of confirming the divider ratio at 0mV, +100mV and -100mV, as the thermocouple table is contained within the firmware and does not change with time.

To measure the output, set the Thermocouple to 1mV'C type and set the Cold Junction to manual and 0'C

Check the measurement in mV as measured with the multimeter against the table of points below.

Output	Minimum	Maximum
0°C	-0.002mV	0.002mV
100°C	99.990mV	100.010mV
-100°C	-100.010mV	-99.990mV

Table 20 – Thermocouple Source mV Out Verification

For additional verification, the internal thermocouple conversation table can be verified at the points below, however it is not required at every verification.

Range	Output	Minimum	Maximum
K type	-200 °C	-200.35 °C	-199.65 °C
	-140 °C	-140.35 °C	-139.65 °C
	-100 °C	-100.35 °C	-99.65 °C
	0 °C	-0.25 °C	0.25 °C
	100 °C	99.75 °C	100.25 °C
	200 °C	199.7 °C	200.3 °C
	500 °C	499.7 °C	500.3 °C
	1000 °C	999.7 °C	1000.3 °C
	1370 °C	1369.6 °C	1370.4 °C
J type	-210 °C	-210.3 °C	-209.7 °C
	-100 °C	-100.3 °C	-99.7 °C
	0 °C	-0.2 °C	0.2 °C
	100 °C	99.8 °C	100.2 °C
	400 °C	399.8 °C	400.2 °C
	1000 °C	999.75 °C	1000.25 °C
	1200 °C	1199.75 °C	1200.25 °C

T type	400 °C	399.89 °C	400.11 °C
R type	1760 °C	1759.49 °C	1760.51 °C
S type	1760 °C	1759.49 °C	1760.51 °C
N type	1300 °C	1299.76 °C	1300.24 °C
B type	1000 °C	999.46 °C	1000.54 °C
E type	350 °C	349.91 °C	350.09 °C
L type	900 °C	899.66 °C	900.34 °C
U type	600 °C	599.7 °C	600.3 °C
C type	2316 °C	2315.32 °C	2316.68 °C

Table 21 – Thermocouple Source Verification Table

3.13. Thermocouple Measure

Verifying the thermocouple measurement function requires a DC Voltage source and a neutral Copper/Copper Mini TC-Plug

Set the calibrator to Thermocouple Measurement mode, and set the Thermocouple Type to 1mV/'C. Set the Cold Junction to Manual Compensation and to 0'C

Set the Voltage Source to DC Voltage and connect to the thermocouple socket on the front of the calibrator.

Output	Minimum	Maximum
0mV	-0.002°C	0.002°C
100mV	99.990°C	100.010°C
-100mV	-100.010°C	-99.990°C

Table 22 – Thermocouple Measurement mV Verification

If required, the other thermocouple types can be verified using the below test points, however the voltage to thermocouple conversion tables are constant within firmware.

Range	Output	Minimum	Maximum
K type	-200 °C	-200.35 °C	-199.65 °C
	-140 °C	-140.35 °C	-139.65 °C
	-100 °C	-100.35 °C	-99.65 °C
	0 °C	-0.25 °C	0.25 °C
	100 °C	99.75 °C	100.25 °C
	200 °C	199.7 °C	200.3 °C
	500 °C	499.7 °C	500.3 °C
	1000 °C	999.7 °C	1000.3 °C
	1370 °C	1369.6 °C	1370.4 °C
J type	-210 °C	-210.3 °C	-209.7 °C
	-100 °C	-100.3 °C	-99.7 °C
	0 °C	-0.2 °C	0.2 °C
	100 °C	99.8 °C	100.2 °C
	400 °C	399.8 °C	400.2 °C
	1000 °C	999.75 °C	1000.25 °C
	1200 °C	1199.75 °C	1200.25 °C
T type	400 °C	399.89 °C	400.11 °C

R type	1760 °C	1759.49 °C	1760.51 °C
S type	1760 °C	1759.49 °C	1760.51 °C
N type	1300 °C	1299.76 °C	1300.24 °C
B type	1000 °C	999.46 °C	1000.54 °C
E type	350 °C	349.91 °C	350.09 °C
L type	900 °C	899.66 °C	900.34 °C
U type	600 °C	599.7 °C	600.3 °C
C type	2316 °C	2315.32 °C	2316.68 °C

Table 23 – Thermocouple Measurement Verification Points

3.14. Thermocouple Cold Junction

Set the Calibrator to Thermocouple Measurement Mode, Type K and set the Cold Junction measurement to automatic.

Connect a Calibrated Thermocouple meter with a Type K Cable, and set Type K. Compare the measured reading to the set reading and note the error.

The tolerance is 0.2°C

3.15. Frequency Output

Set the calibrator to the 2V AC Range and set the desired frequency.

Measuring using the frequency measurement standard while connected to the voltage output terminals and verify the below test points.

Note - for lower frequencies it is advised to ensure that HF reject (or equivalent) is enabled on the frequency counter and a longer gate time (10s for 10Hz & 100Hz measurements, 1s above) is used.

Range	Output Level	Output Frequency	Minimum	Maximum
2V	1V	10Hz	9.99999Hz	10.000001Hz
	1V	100Hz	99.9999Hz	100.00001Hz
	1V	1kHz	0.999999kHz	1.000001kHz
	1V	10kHz	9.99999kHz	10.00001kHz
	1V	100kHz	99.9999kHz	100.0001kHz
	1V	1MHz	0.999999MHz	1.000001MHz

Table 24 – Frequency Output Verification Points