8000 SERIES

PRECISION MULTIMETER

VERIFICATION AND ADJUSTMENT GUIDE

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Preparing For Calibration

Introduction

Verification and Adjustment of the 8000 series can be achieved using one of two methods:

1. Manual calibration via the front panel controls.
2. Automated closed-loop calibration using ProCal calibration software

In both instances the multimeter 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 ± 1ºC during the calibration. Deviations outside of this will affect the performance of the multimeter. Also note the temperature difference between the previous calibration and the current environment. If the difference is greater than 1 ºC the Tcal ± 3 ºC specifications should be used for verification purposes.

Calibration Interval Selection

The recommended calibration interval for the 8000 series is 1 Year / 365 Days. This depends upon the usage of the equipment and the required performance. If a higher level of performance is required, Transmille provide extended specifications for 90 and 180 day calibration intervals. Alternatively, if a lower performance is required, specifications for 2 Year intervals are also provided.

Calibration Uncertainties

During manufacture and calibration by Transmille, the multimeter is calibrated with low uncertainties, ensuring highly accurate measurements from new and after re-calibration by Transmille.

After re-calibration by Transmille, the user can use the Absolute Specifications that apply to their environment (Tcal ± 1 ºC or Tcal ± 3 ºC) to obtain the true specification of the instrument. Note that Transmille within the UK operate at 20 ºC, so a laboratory running at 22 or 23 ºC must use the Tcal ± 3 ºC specifications.

If re-calibrated by laboratory other than Transmille, 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 specifications, and the temperature coefficient for difference 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 calibration and repair services, Transmille USA offer calibration and repair services, and through our network of representatives and distributors we have a wide network of recommended laboratories to suit your calibration requirements.

Required Equipment

To calibrate the 8000 series multimeter the following equipment is required:

Equipment	Use	Recommended Models
High Accuracy Multifunction Calibrator	DC Voltage, AC Voltage, DC Current, AC Current, Resistance, Thermocouple	Transmille 4010 (for use as transfer standard), Fluke 5720A
Standard Resistors (if better uncertainties than offered by calibrator are required)	Resistance from 1 Ohm to 10M Ohm	Transmille 3000RS, Measurements International 9331R, Fluke 742A Resistance Standards
High Value Standard Resistors (100M Ohm to 1T Ohm)		Transmille 3000HR (10M Ohm – 100G Ohm), Measurements International 9155
Connection Leads	To make connections as required	Transmille 8000LEAD

To assist with calibration and achieve better uncertainties, the additional equipment is also recommended

Equipment	Use	Recommended Models
Voltage Reference (If better uncertainties than calibrator are required)	DC Voltage (10V and 1V Levels)	Transmille 3000ZR, Fluke 734A
Calibration Software	Automating the verification and adjustment of UUT	Transmille ProCal software
GPS Frequency Source / Off-Air Frequency Source	Frequency Measurement verification	Transmille 8600

Between these pieces of equipment, a full verification and calibration of an 8000 series multimeter can be performed

Overview of Calibration Procedure

The 8000 series has been designed using modern design philosophy, meaning that all adjustments (with the exception of frequency measurement) can be made directly through the front panel, or over the remote interfaces without the need to remove any casing of the instrument.

Depending upon the function and range, a valid calibration signal is input to the multimeter. Depending upon the input, the multimeter intelligently detects the correct factor to be adjusted, whether that be Zero, positive or negative full scale, or in the case of AC calibration, if a frequency spot point has been selected.

The calibration functions are locked via a user configurable lock code, meaning calibration functions do not require ‘keys’ or moving mechanical switches. A log of the date and range adjusted and stored permanently in the multimeters memory and can be accessed via the 8000 Setup Utility (available from Transmille).

Adjustment can be performed for a single range or frequency spot point, or for all ranges. This ensures a fast calibration even using manual methods. It is advised that this calibration guide is followed closely to avoid affecting the performance of the multimeter through incorrect adjustments.

Choosing Measurement Points

It is up to individual laboratories and customers’ requirements to decide on the measurements that will be issued on certificates. Transmille provide suggested measurement points based upon the ranges of the instrument to cover a wide variety of measurements while ensuring cost effective calibration. This list of measurement points is included later in this guide

Adjustment Points

To ensure that the instrument can be adjusted to provide the best performance, there are 3 adjustment points available for DC measurements, and up to 30 for AC ranges.

For DC functions (DC Voltage, Current and Resistance) the adjustment points are Zero, Positive Full Scale and Negative Full Scale.

For AC functions (AC Voltage and Current), the adjustment points are Full Scale Gain (1kHz), 20% of Full Scale (1kHz), and then frequency spot points at full scale at varying frequencies. During routine adjustments, only the Full Scale and 20%

adjustments will be required, unless corrections are required to the frequency response, at which point only the spot points that fall outside of specification are required.

The 8000 series can be adjusted at both nominal values (i.e. 1V on the 1V range), or non-nominal (i.e. 9.999867 kΩ on the 10 kΩ Range). These should be used appropriately for the input that is being applied for optimal adjustments to be performed. It is recommended that these values are no further than 5% from nominal (i.e. on the 10V range, 9.5V to 10.5V) for optimal performance across the range.

Calibration Mode

Entering Calibration Mode

To perform adjustments on the 8000 series multimeters, the calibration mode must be enabled through the entry of the calibration password. The following instructions must be followed to enter calibration mode from the front panel

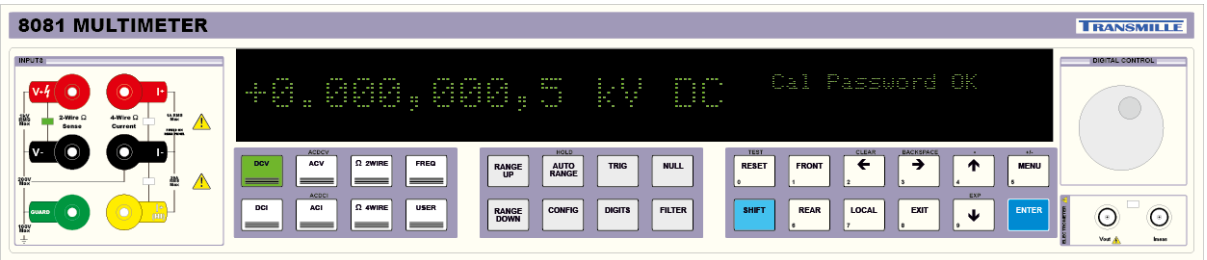
1. To access the calibration mode press RESET to return the multimeter to default condition, where the multimeter display will be as below

2. Press the MENU key, and scroll until > CALIBRATION MODE is displayed in the top segment of the secondary display as below

3. Pressing the MENU key again will move the >cursor and highlight > Enter Password. Pressing ENTER once more will provide a blinking _ cursor, where keys from the number pad can be entered. The default user password is **8081**.

4. Pressing ENTER after the calibration password has been entered into the screen will cause the multimeters to indicate if the password was correct or incorrect. If an incorrect password was entered the meter will display Incorrect Password and return to the password entry screen.

5. When the correct password is entered the multimeter will indicate Cal Password OK. The SHIFT key will also illuminate blue to indicate that calibration mode is active



6. The unit is now in calibration mode, where adjustments can be made to the instrument, and calibration factors reset to defaults.

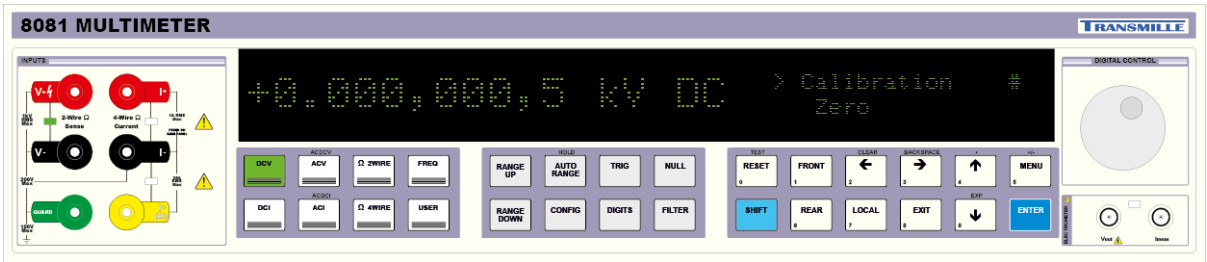
NOTE : BEFORE MAKING ADJUSTMENTS, PLEASE ENSURE THAT ADJUSTMENTS ARE REQUIRED. IT IS POSSIBLE TO MAKE A BACKUP OF CALIBRATION FACTORS VIA THE 8000 SETUP UTILITY WHICH IS AVAILABLE FREE OF CHARGE FROM TRANSMILLE

Changing Calibration Password

The calibration password of the multimeters can be changed by the user for security purposes to ensure that unauthorised adjustments are not performed.

To change the password, follow the steps below:

1. If calibration mode is not already enabled, follow instructions to enable calibration mode. Press MENU so that the > cursor is highlighting Calibration



on the secondary display

2. Using the direction keys or the digital control, navigate left so the secondary display indicates > Calibration Mode #
   Set Password

3. Pressing the ENTER key will move the selection to > Set Password

4. Pressing the ENTER key enable entry, highlighted by a flashing _ indicator. The new password can then be entered using the numerical keypad.

5. After entering the new password (4 characters), press the ENTER key. The unit will reset after a few seconds, after rebooting the new password is used to re-enter calibration mode as required

Reset Calibration Factors to Default

In some cases, where incorrect adjustments have been made it may be desirable to reset the units calibration factors back to default. This can be performed through the front panel, and will clear all calibration factors for the current range

NOTE: THIS WILL NOT RESTORE THE FACTORY CALIBRATION, THIS WILL RESTORE THE UNIT TO FACTORY DEFAULTS. IF THIS OPTION IS SELECTED THE RANGE MUST BE ADJUSTED

If the operator is certain that this option must be used, the following instructions can be followed:

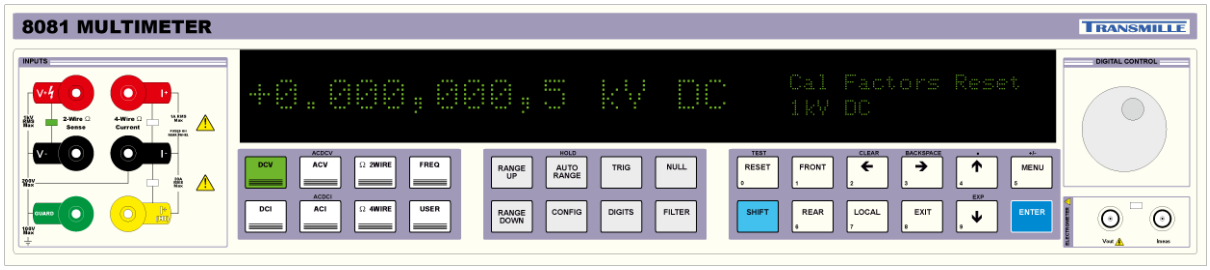
1. Press the MENU key, > Calibration will be displayed in the upper segment of the secondary display.

2. Press the ENTER key to move the > cursor to > ZERO

3. Using the directional arrows or the digital control, change the menu option to > Reset

WARNING : THE NEXT STEP WILL RESET THE CALIBRATION FACTORS FOR THE CURRENTLY SELECTED RANGE, ENSURE THAT PERFORMING A FACTORY RESET ON THE RANGE IS THE REQUESTED OPTION

4. Press ENTER, the multimeter will indicate that the calibration factor has been reset with a message on the secondary display, and then return to the calibration menu



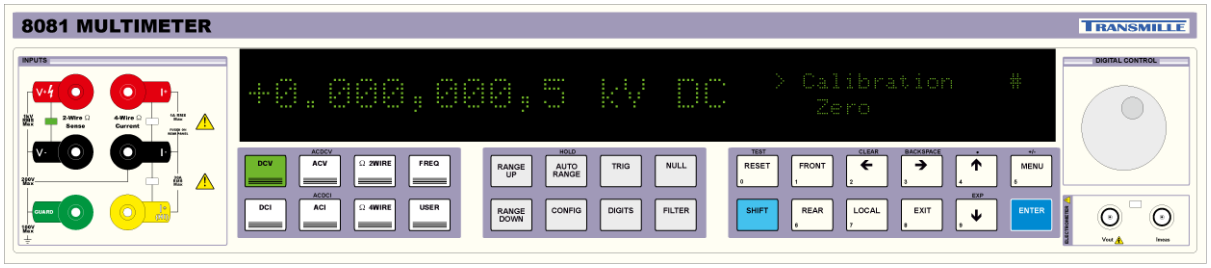
NOTE: ENSURE THAT THE RANGE IS RE-ADJUSTED AFTER PERFORMING A CALIBRATION FACTOR RESET

Exiting Calibration Mode

After completing adjustments, the Multimeter should be taken out of calibration mode.

If adjustments HAVE been performed, pressing the RESET button will exit calibration mode and return to the default setting. Alternatively, the instructions below will exit calibration mode in any function:

1. Press the MENU key, > Calibration will be displayed in the upper segment of the secondary display.

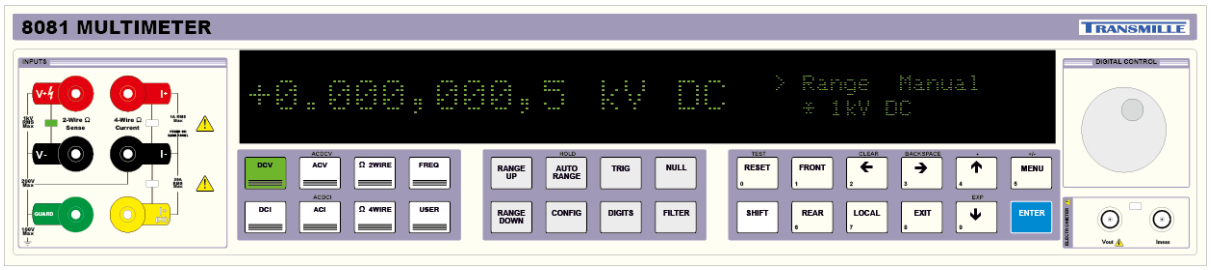


2. Using the directional arrows or the digital control, change the menu option to '> Calibration Mode'.

3. Press the ENTER key to move the > cursor to 'Set Password'.

4. Using the directional arrows or the digital control, change the menu option to > Exit Cal Mode.

5. Press ENTER , the SHIFT key will turn off indicating that the Multimeter is no longer in calibration mode.



Connections

DC Voltage

To perform verification and calibration of DC Voltage functions, it is important to ensure that leads that exhibit exceptional low thermal performance are used.

It is also essential to ensure that all connections are correctly nulled / zero'd. This is performed by zeroing the leads at the end which connects to the source. This ensures that any thermal effects of the leads used are not included in full scale gain adjustments.

A diagram showing correct zero connections is below, for both connections to a calibrator and to a voltage standard

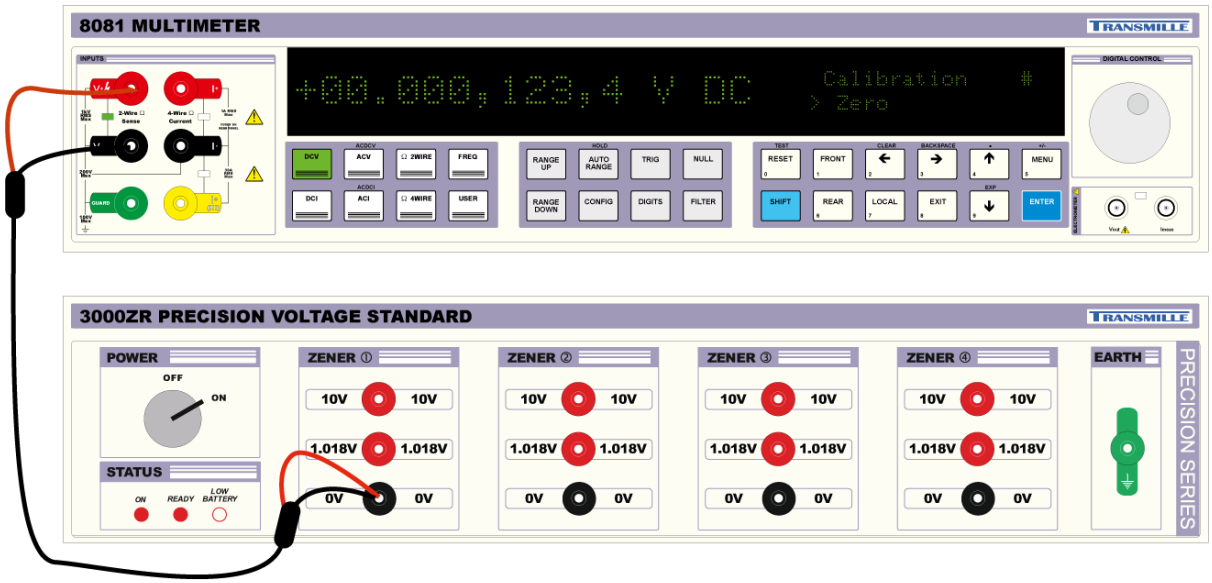


Figure 1 – DC Voltage Zero using Voltage Standard

Figure 2 – DC Voltage Zero using Calibrator

Connecting to the voltage source for verification and full scale gain calibration is then performed. Leads should be kept away from sources of heat and should be allowed to stabilise. Example connections are shown for both a calibrator and a voltage standard

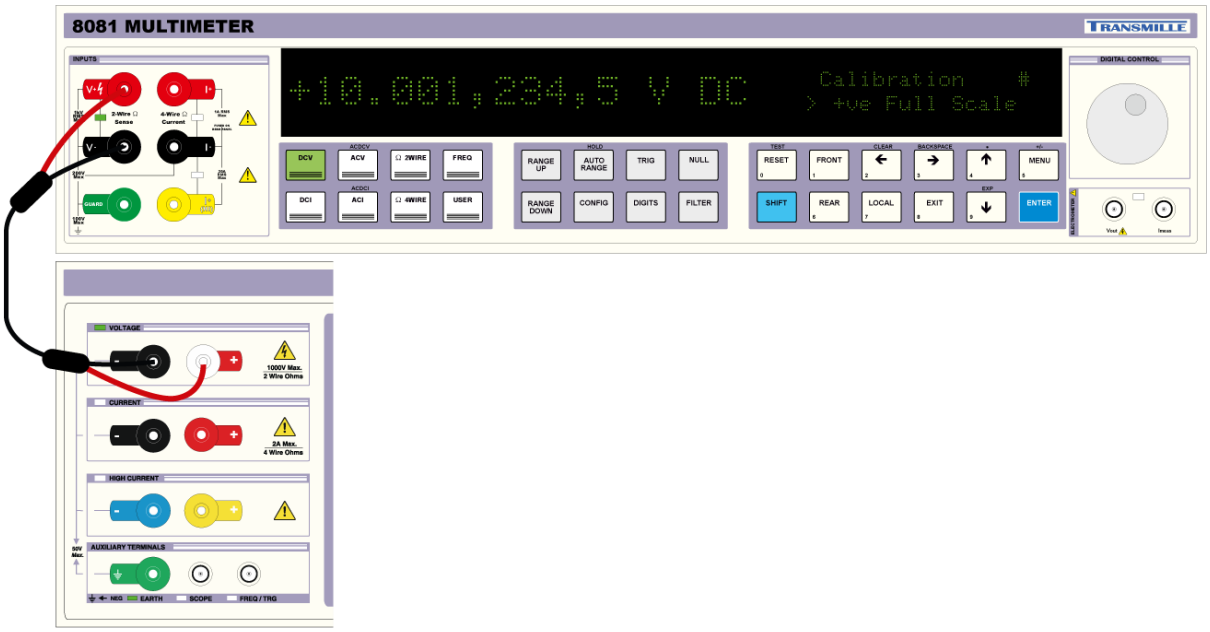


Figure 3 – DC Voltage Connection using Calibrator

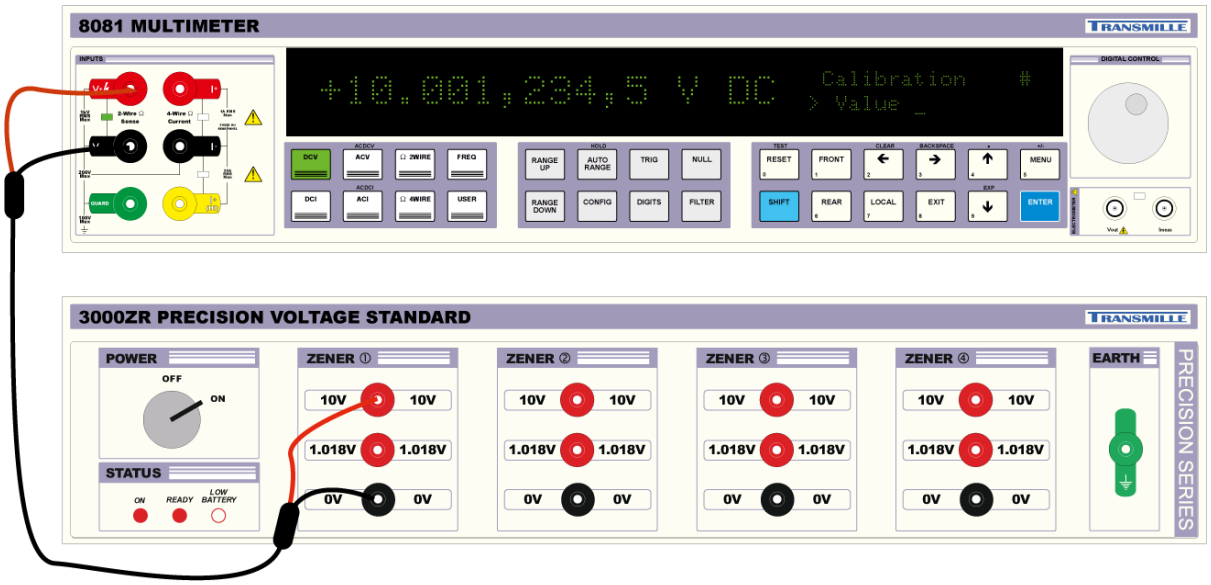


Figure 4 – DC Voltage Connection using Voltage Reference

DC Current (above 10uA)

Performing a zero on DC current should be performed by open circuiting the current leads. Some current sources do not truly disconnect the output terminals while in standby, causing zero measurements to have an offset due to these low currents. With open circuiting the leads this effect is avoided.

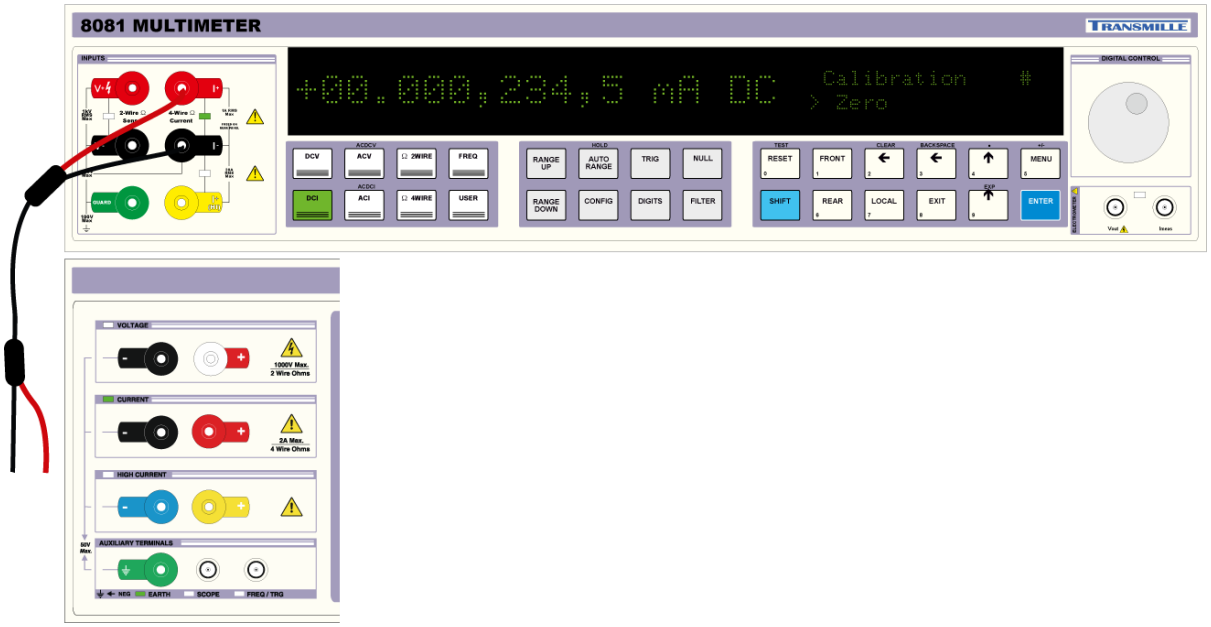


Figure 5 – DC Current Zero Connection

Care should be taken while connecting current sources to the Multimeter. It should be noted that the maximum current input for the low current terminals is 1A. If this limit is exceeded the protection fuses on the rear of the Multimeter will be damaged. In the case of damaged fuses spare fuses are included in the 8000 Operators Manual

Figure 6 – DC Current Connection (up to 1A)

The High Current terminals should be used for currents above 1A to 30A.

Figure 7 – DC Current Connection (from 1A to 30A)

AC Voltage

Connections for AC Voltage should be made using low capacitance leads with high insulation resistance. Any capacitive effects will affect the sourced voltage.

It is recommended that coaxial cable is NOT used.

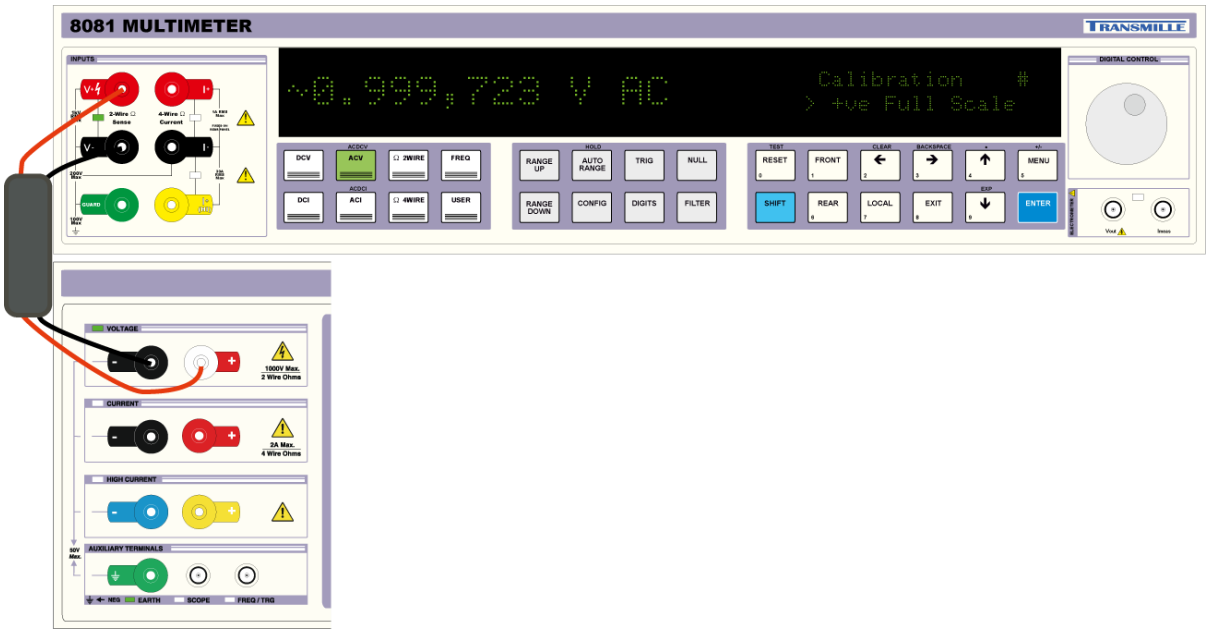


Figure 8 – AC Voltage Connection

AC Current

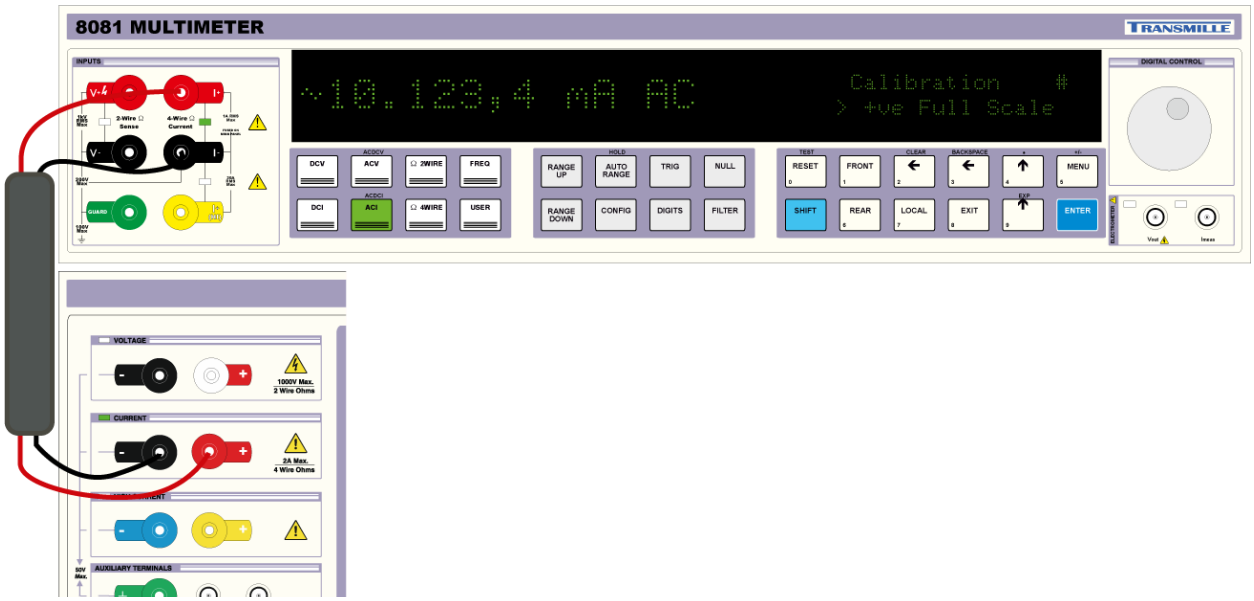


Figure 9 – AC Current Connection (up to 1A)

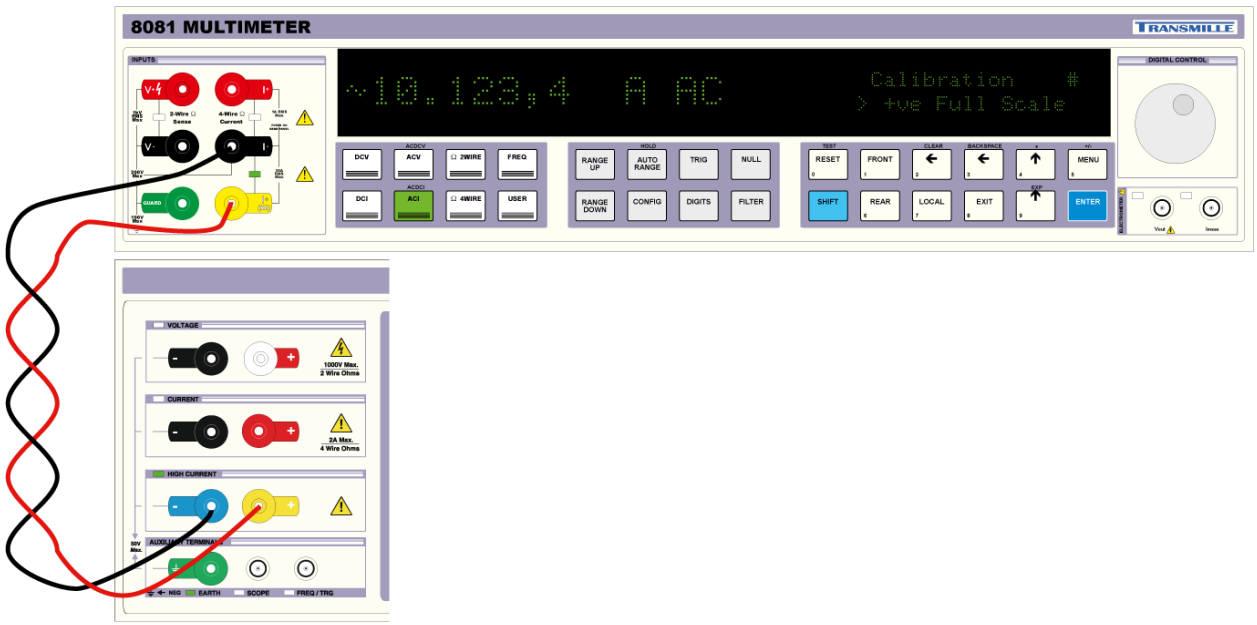


Figure 10 – AC Current Connection (from 1A to 30A)

Resistance (4 Wire Ohms)

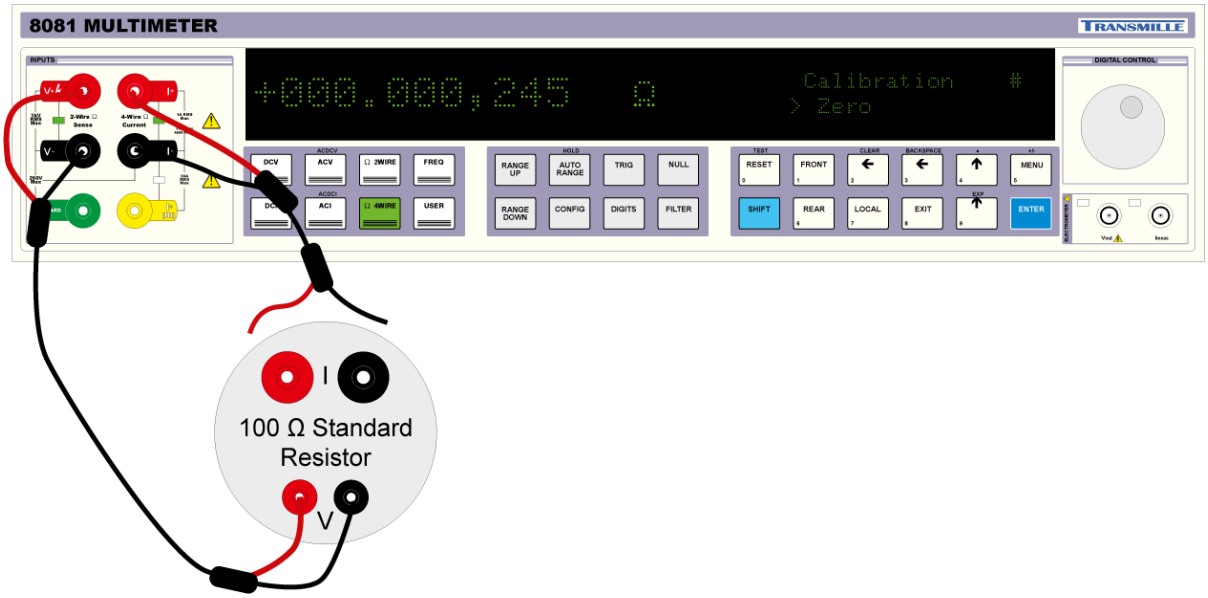


Figure 11 – 4 Wire Ohms Zero connection for a Standard Resistor

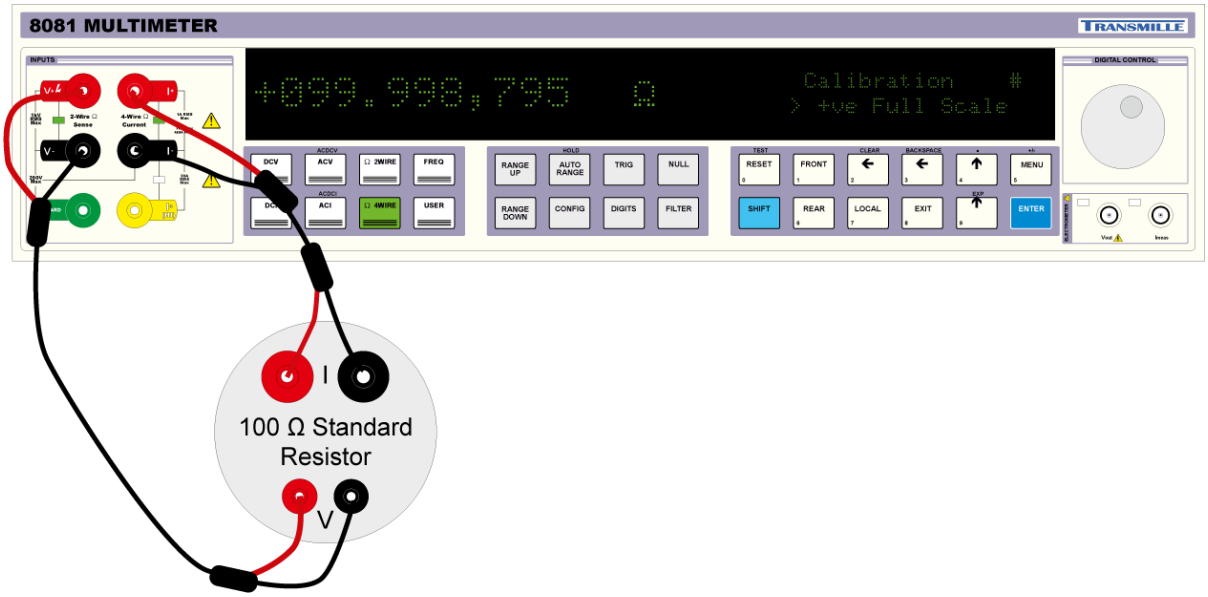


Figure 12 – 4 Wire Ohms connection for a Standard Resistor

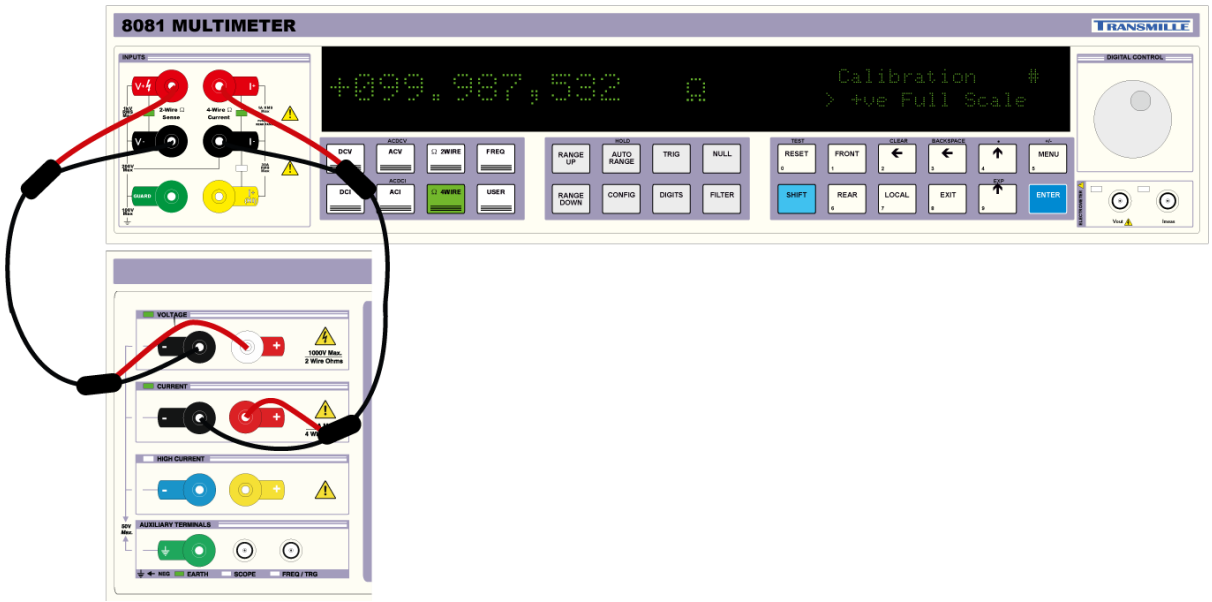


Figure 13 – 4 Wire Ohms connection for a Calibrator

Resistance (2 Wire Ohms)

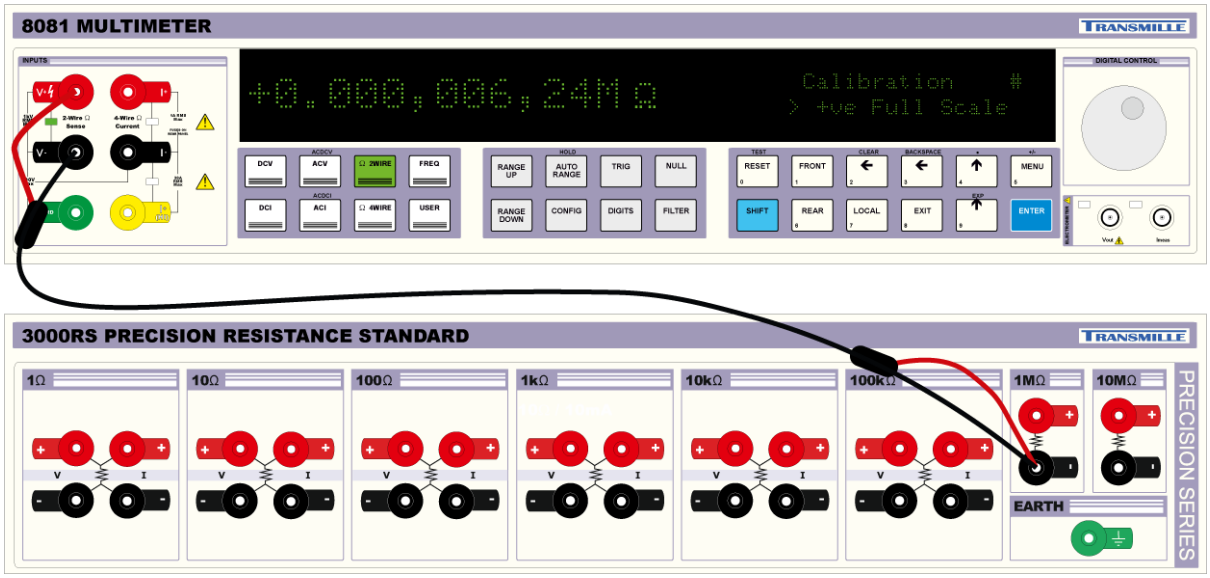


Figure 14 – 2 Wire Ohms Zero connection using resistance Standard

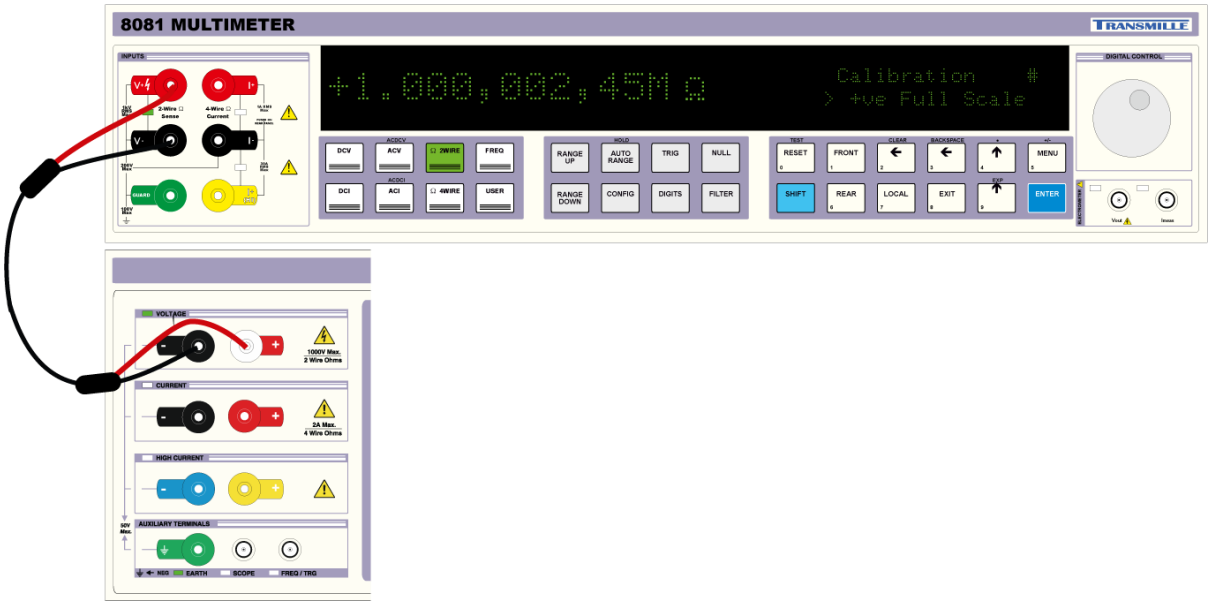


Figure 15 – 2 Wire Ohms connection using calibrator

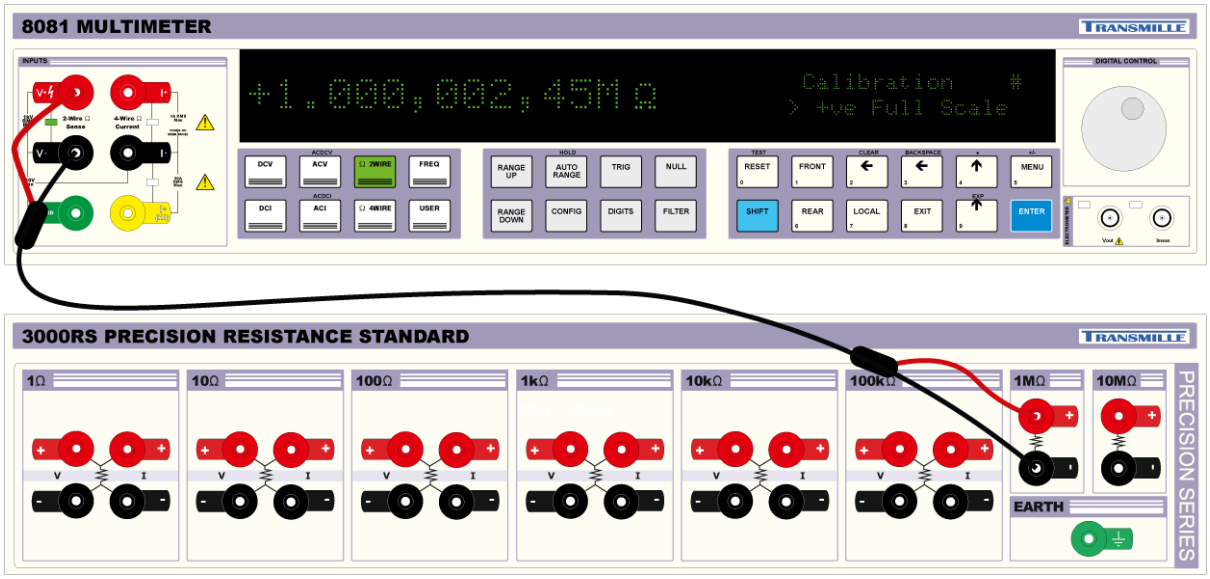


Figure 16 – 2 Wire Ohms connection using resistance standard

DC Current (Below 10uA)

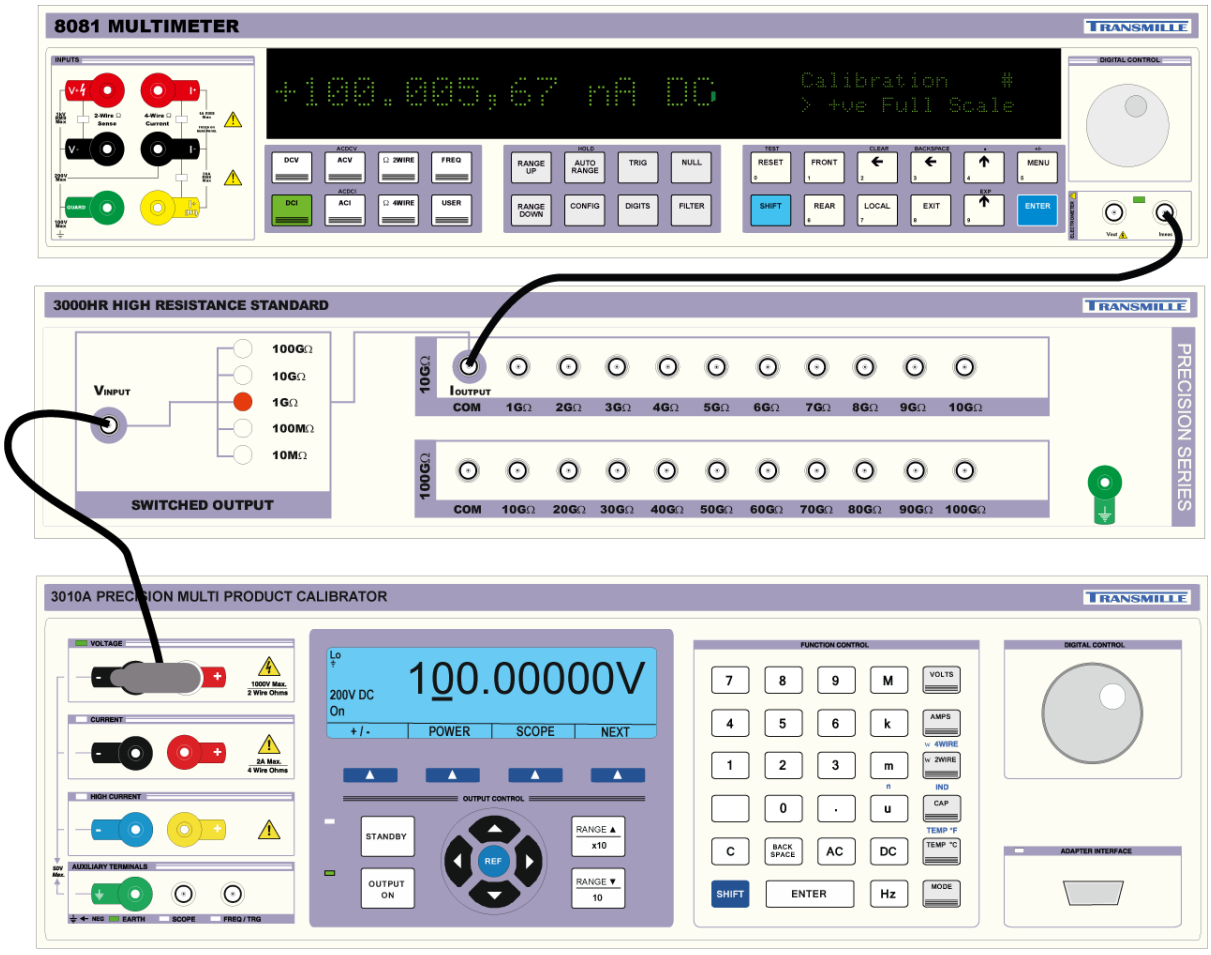


Figure 17 – Connection for DC Current below 10uA

Electrometer Voltage Output

Figure 18 – Connection for Electrometer Voltage Output measurement

Resistance (Electrometer Function)

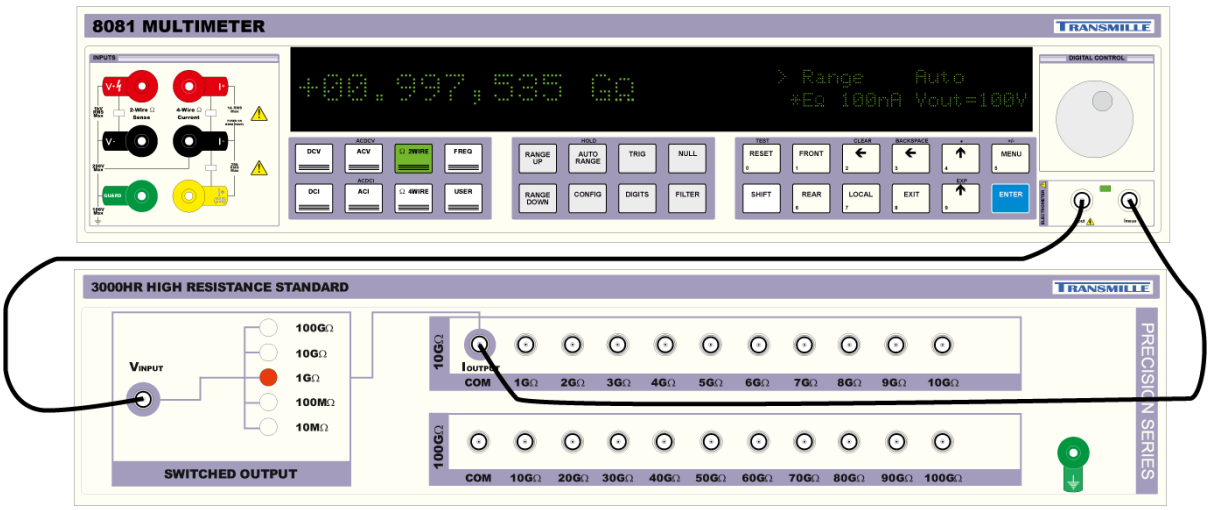


Figure 19 – Connection for Electrometer Resistance Measurement using 3000HR

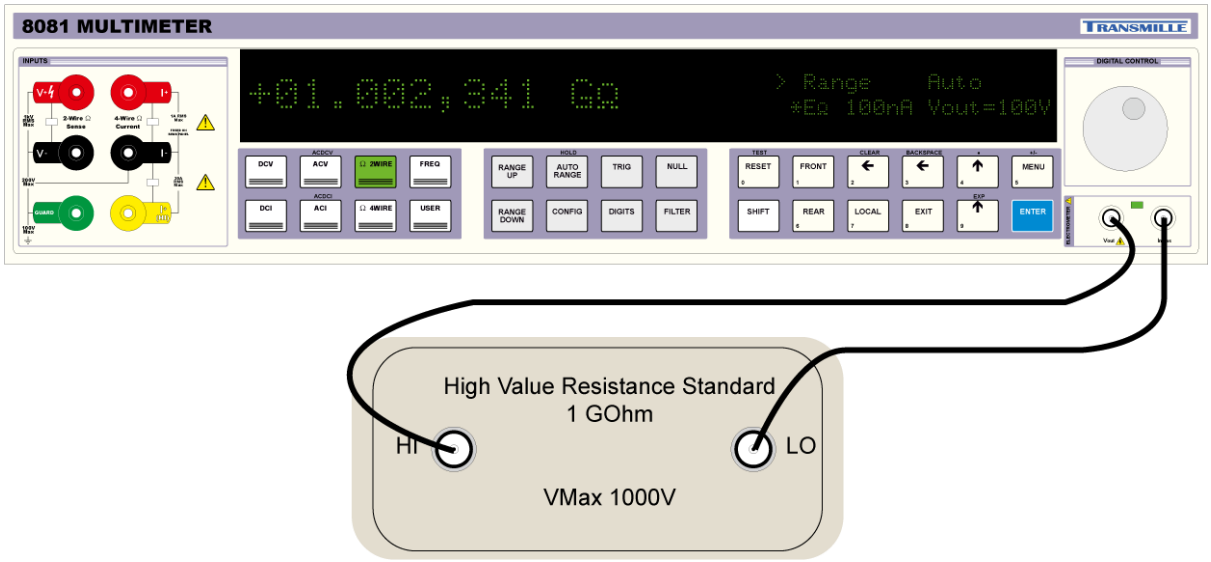


Figure 20 – Connection for electrometer resistance measurement using Standard Resistor

Adjustment Procedure Overview

Performing Nominal Adjustments (DC Values)

Adjusting the multimeter through the front panel to nominal inputs for DC measurements is performed through the calibration menu.

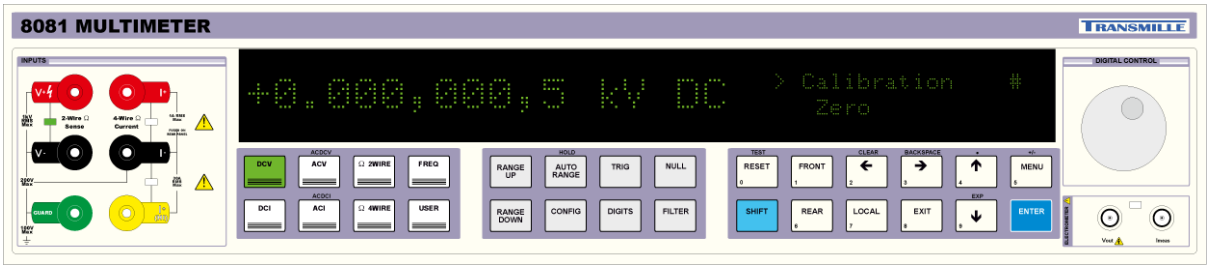
For a DC range the 3 adjustment points are as follow;

1. Zero
2. Positive Full Scale
3. Negative Full Scale

In normal operation, only the Zero and Positive Full Scale will require adjustments. During normal operation the multimeter adjusts the stored offset for zero during nulling operations.

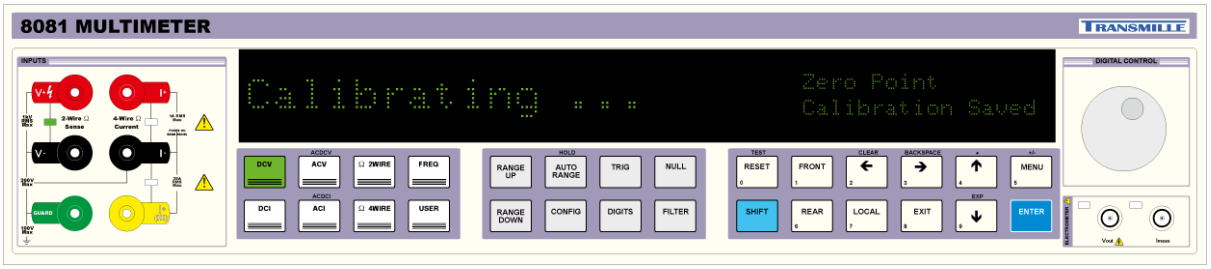
To access each of these adjustments, after ensuring the multimeters is in calibration mode (indicated by a permanently illuminated SHIFT key) follow the instructions below:

1. Select the required Range, confirm that the indicated reading requires adjustment and press the MENU key. When in calibration mode this will default to displaying the calibration menu on the secondary display



2. Pressing either ENTER or the downwards directional arrow will move the > cursor to the second line of the secondary display. From here the required function can be selected. As default, the first selection will be the Zero point.

3. Pressing the ENTER key will perform a Zero calibration. The multimeter will only perform a Zero if the correct input is detected. If the adjustment is successful, the secondary display will update to indicate that the Zero calibration has been performed successfully.



If an incorrect input is detected the secondary display will update to indicate an error and then return to the calibration menu

4. After performing the Zero calibration, the Positive Full Scale calibration is the next adjustment point. Apply the full scale input for the range (i.e. 10V for the 10V range) to the input of the multimeter, and using the directional arrows or the digital control, move the > cursor to > +ve Full Scale

5. Pressing the ENTER key will initiate the calibration sequence if a valid full scale input is detected

   If an invalid input is detected, the secondary screen will indicate an error message and return to the calibration menu without making an adjustment

6. If the adjustment is successful, the secondary screen will display a success message, followed by returning to the calibration menu

7. Calibration of the range is now complete, unless adjustment of the Negative Full Scale is required. If so, repeat the above procedure with the > −ve Full Scale menu selected using the directional arrows or digital control

Performing Nominal adjustments (A.C. Values)

Adjusting the multimeter through the front panel to nominal inputs in AC functions is performed through the calibration menu.

For an AC range the 2 main adjustment points are as follow;

1. Full Scale, 1kHz
2. 20% Full Scale, 1kHz

In normal operation, only the Full Scale 1kHz and 20% Scale 1kHz points would typically require adjustment. However if improved performance is required from the 8000 series a wide range of Spot frequency adjustments are available which vary range by range. For full details on the available spot points for each range, please refer to the Appendix where a list of all adjustment points are available. Adjusting these points corrects the frequency curve of the measurement circuit for measurements around the frequency. Using these points the frequency measurement characteristics of the Multimeter can be corrected to ensure AC flatness across the range.

An adjustment to the Full scale 1kHz and 20% Full Scale points will have an effect on all measurements across the range by adjusting the overall gain of the measurement, however adjusting individual spot frequencies does not affect frequencies or measurements on the same range.

To access each of these adjustments, after ensuring the Multimeter is in calibration mode (indicated by a permanently illuminated SHIFT key) follow the instructions below:

1. Select the required Range (1V AC in this example), confirm that the indicated reading requires adjustment and press the MENU key. When in calibration mode this will default to displaying the calibration menu on the secondary display

2. Pressing either ENTER or the downwards directional arrow will move the > cursor to the second line of the secondary display. From here the required function can be select. As default, the first selection will be the 20% Full Scale Using the direction arrows or the digital control, move the menu selection to +ve Full Scale, followed by pressing the ENTER key. The multimeter will indicate that an adjustment is taking place. If successful the multimeter will also indicate that a successful adjustment has been performed.

   If an incorrect input is detected the secondary display will update to indicate an error and then return to the calibration menu. There are two possible indicated errors in AC Function. The first is the detection of an invalid calibration frequency, in which case the below message will be displayed :

   The second is the detection of a non-full scale input voltage, which is

displayed as below :

3. After performing the Full Scale 1kHz calibration the 20% Full Scale calibration should be performed. Using the directional arrows or digital control, move the secondary display > cursor to 20% FS

4. Pressing the ENTER key will initiate the calibration if a valid signal has been detected. The 20% FS adjustment can only be performed at 1kHz

   If the adjustment is successful, the secondary screen will display a success message, followed by returning to the calibration menu.

5. The process of adjusting the Full Scale 1kHz and 20% FS may need to be repeated more than once as each adjustment will have an effect upon the other.
6. After this procedure has been completed, the individual spot points can be adjusted through the same procedure as for the full scale by varying the input frequency. A full list of frequency points is available in the Appendix of this guide

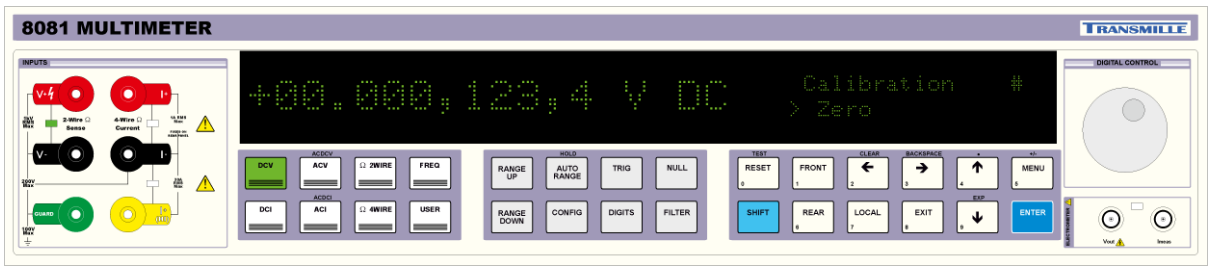
Performing Non-Nominal adjustments (DC, A.C. and Resistance)

During calibration against standards or a characterised calibrator it is unlikely that the sourced value will be an exact nominal value.

To assist with calibration, the 8000 has the ability for the value of the standard to be entered through the front panel or over the remote interface and will adjust to the exact value of the standard entered.

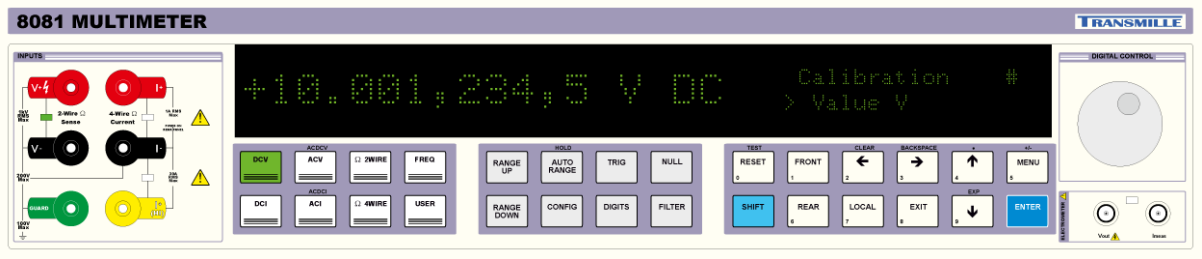
To adjust the 8000 series to a non-nominal value, follow the following steps :

1. Select the required Range (10V DC in this example), confirm that the indicated reading requires adjustment and press the MENU key. When in calibration mode this will default to displaying the calibration menu on the secondary display

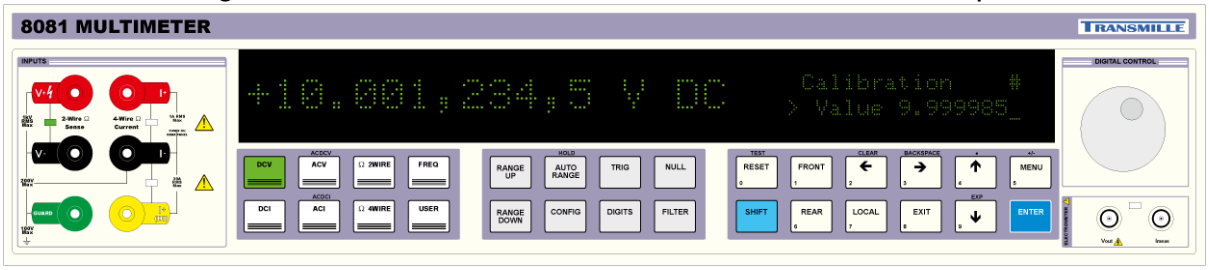


2. Pressing either ENTER or the downwards directional arrow will move the > cursor to the second line of the secondary display. From here the required function can be selected. As default, the first selection will be > Zero

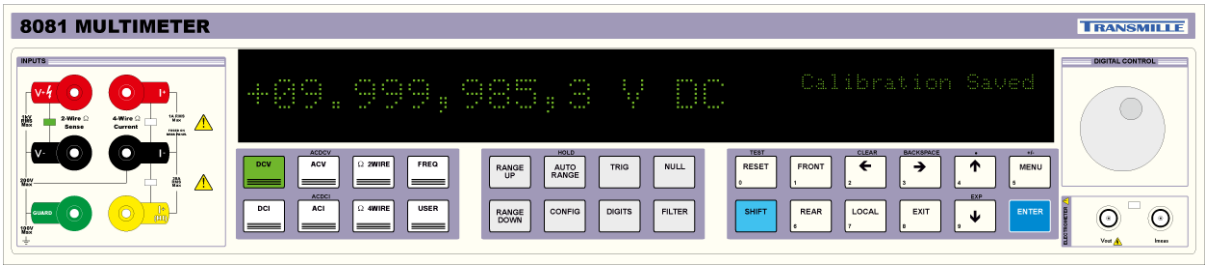
3. Using the direction arrows or the digital control, move the menu selection to > Value V



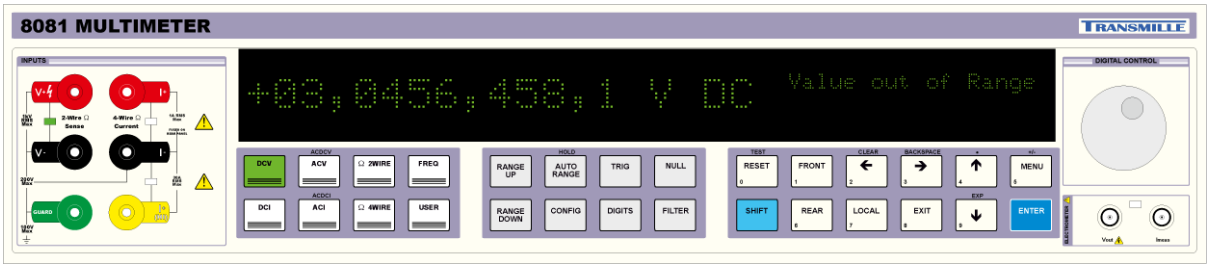
4. Pressing the ENTER key will place the multimeter into value entry mode, where the characterised value can be entered. The _ cursor will start flashing indicating that numerical values can be entered from the front panel.



5. Pressing the ENTER key once more will start the adjustment process. After a successful adjustment has been performed the multimeter will indicate success on the secondary display and then return to the calibration menu.



6. If the multimeter detects that the entered value is not detected at the input an error message will be displayed and the multimeter will return to the calibration menu.



Adjustment of Ranges

D.C. Voltage

WARNING: During these tests the voltage source will output up to 1000V during the adjustment procedure.

To avoid electric shock while performing steps of the following procedure please observe the following warnings:

If using non touch safe leads, ensure that any exposed elements of the lead are not touched when the output of the voltage source is active

Make sure that leads used are rated for the output voltage and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Press the DCV Key, the Multimeter will enter auto range.
3. Press the DIGITS key, and select 7
4. Press the FILTER key, change filter speed to 4s
5. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
6. Connect the calibrator to the Multimeter as illustrated on page 12

Adjustment Points

The available adjustment points for the DC Voltage functions of the 8000 multimeter are listed in the following table

It is possible to adjust a single range, or all ranges. A change to one range will not affect another, i.e. adjustments on the 1V range do not affect measurements on the 100mV or 10V range.

Multimeter Range	Adjustment Point	Nominal Value
100mV	Zero	Zero
	Positive Full Scale	+ 100mV
	Negative Full Scale *	- 100mV
1V	Zero	Zero
	Positive Full Scale	+ 1V
	Negative Full Scale *	- 1V
10V	Zero	Zero
	Positive Full Scale	+ 10V
	Negative Full Scale *	- 10V
100V	Zero	Zero
	Positive Full Scale	+ 100V
	Negative Full Scale *	- 100V
1kV	Zero	Zero
	Positive Full Scale	+ 1000V
	Negative Full Scale *	- 1000V
* Adjustment point available, but not required during routine adjustments		

Table 1 – DC Voltage Adjustment Points

Zero Point Adjustment

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys. Note that if the Multimeter is left in Auto Range the 100mV range will automatically be selected
2. If using a calibrator, set zero output and set the output to on
3. If using a voltage reference / standard, short the connection leads from the Multimeter together at the point of connection to the voltage standard as described in the connections section of this manual.
4. Allow the measurement to stabilise on the Multimeter
5. Press the MENU key so that the calibration menu is active on the secondary display
6. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
7. Press the ENTER key once more, the Multimeter will perform a Zero calibration adjustment
8. The zero point calibration for the current range is now complete, repeat steps 1 through 7 for remaining ranges that require adjustment

Positive Full Scale Adjustment – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. If using a calibrator, set the required output (in this example 10V)
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero

6. Using the directional arrow keys or the digital control to select > +ve Full Scale
7. Press the ENTER key to trigger calibration
8. The Positive Full Scale adjustment has now been completed. Repeat steps 1 through 7 for remaining ranges that require adjustment

Full Scale Adjustment – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. If using a calibrator, set the required output (in this example 10V). If the calibrator has been characterized, make a note of the characterized output. (i.e. 9.999985 Volts)
3. If using a voltage standard / reference, make a note of the certified output value (i.e. 9.999985 Volts)
4. Allow the measurement to stabilise on the Multimeter
5. Press the MENU key so that the calibration menu is active on the secondary display
6. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
7. Using the directional arrow keys or the digital control to select > Value V
8. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
9. Press the ENTER key to trigger calibration, the secondary display will indicate that the calibration has been completed successfully
10. The Multimeter has now been adjusted to the characterized / certified value of the input. Repeat steps 1 to 9 for other ranges that require adjustment.

Negative Full Scale Adjustment

NOTE : Negative Full Scale adjustment is not required during routine adjustment. The inherent characteristics of 8000 series mean that only Positive Full Scale adjustments are normally required. An adjustment to the Positive Full Scale automatically corrects for Negative inputs during normal calibration.

It is possible that adjusting this factor separately can decrease the performance of the 8000 series.

Adjusting the negative full scale follows exactly the same procedure as the positive full scale with exception of input (which will be negative in polarity) and that the –ve Full Scale menu item will be selected

A.C. Voltage

WARNING: During these tests the voltage source will output up to 1000V during the adjustment procedure.

To avoid electric shock while performing steps of the following procedure please observe the following warnings:

If using non touch safe leads, ensure that any exposed elements of the lead are not touched when the output of the voltage source is active

Make sure that leads used are rated for the output voltage and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Press the ACV Key, the Multimeter will enter auto range.
3. Press the DIGITS key, and select 6
4. Press the FILTER key, change filter speed to 2s
5. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
6. Connect the calibrator to the Multimeter as illustrated on page 16

Adjustment Points

The available adjustment points for the AC Voltage functions of the 8000 multimeter are listed in the following table

It is possible to adjust a single range, or all ranges. A change to one range will not affect another, i.e. adjustments on the 1V range do not affect measurements on the 100mV or 10V range.

Multimeter Range	Adjustment Point	Nominal Value	Frequency
100mV	20% Full Scale	20mV	1kHz
	Full Scale	100mV	1kHz
1V	20% Full Scale	0.2V	1kHz
	Full Scale	1V	1kHz
10V	20% Full Scale	2V	1kHz
	Full Scale	10V	1kHz
100V	20% Full Scale	20V	1kHz
	Full Scale	100V	1kHz
1kV	20% Full Scale	200V	1kHz
	Full Scale	1000V OR 700V	1kHz

Table 2 – AC Voltage Gain Correction Points

In addition to the main gain correction, each range has a variety of frequency correction points. Under routine verification and adjustment these points do not need to be adjusted. If a frequency ‘band’ (i.e. from 30kHz to 50kHz) is found to be outside of specification, only the spot points within that band need to be adjusted. In this example those points would be 30 kHz, 35 kHz, 40 kHz and 50 kHz.

These corrections are configured at production, and will not normally need adjustment.

Frequency corrections are carried out at either Full Scale, or a nominal value that is within 10% of full scale for best performance.

Frequency
10Hz
23Hz
40Hz
56Hz
106Hz
206Hz
1kHz
2kHz
10kHz
20kHz
30kHz
35kHz
40kHz
50kHz
60kHz
75kHz
80kHz
100kHz
200kHz
400kHz
500kHz
750kHz
1MHz

Table 3 – AC Frequency Correction Points

Full Scale Adjustment (1 kHz) – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Set the calibrator to the correct output, with a frequency of 1 kHz. Refer to Table 2 for adjustment points
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display

5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Full Scale
7. Press the ENTER key to trigger calibration
8. The multimeter will display a success screen, indicating the frequency point that has been adjusted (in this case 1 kHz)
9. The Positive Full Scale adjustment has now been completed. Repeat steps 1 through 7 for remaining ranges that require adjustment

20% Full Scale (1kHz) Adjustment

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys. Note that if the Multimeter is left in Auto Range the 100mV range will automatically be selected.
2. Configure the voltage source for the appropriate nominal value (i.e. 200mV) at 1 kHz and press output on.
3. Allow the measurement to stabilise on the Multimeter.
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to > 20% FS
6. Press the ENTER key once more, the Multimeter will perform an adjustment at 20% Full Scale.

NOTE : When adjusting the main correction factor on AC ranges it may be necessary to repeat the Full Scale and 20% full scale adjustments more than once. Ensure that both points at within specification prior to proceeding

Full Scale Adjustment – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. If using a calibrator, set the required output (in this example 10V). If the calibrator has been characterized, make a note of the characterized output. (i.e. 9.999985 Volts)
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Value V
7. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
8. Press the ENTER key to trigger calibration, the secondary display will indicate that the calibration has been completed successfully

9. The Multimeter has now been adjusted to the characterized / certified value of the input. Repeat steps 1 to 9 for other ranges that require adjustment.

Full Scale Adjustment (Frequency Correction) – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Set the calibrator to the required output, referring both to the nominal value required (i.e. 10V) as well as a valid frequency correction point as listed in Table 3 – The 8000 multimeter automatically determines the correct frequency for the adjustment
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Full Scale
7. Press the ENTER key to trigger calibration
8. The multimeter will display a success screen, indicating the frequency point that has been adjusted
9. Repeat steps 2 – 8 for any other additional frequency points that require adjustment

Full Scale Adjustment (Frequency Correction) – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Set the calibrator to the required output, referring both to the nominal value required (i.e. 10V) as well as a valid frequency correction point as listed in Table 3 – The 8000 multimeter automatically determines the correct frequency for the adjustment. Retain the characterized value of the output for use later in the adjustment procedure.
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Value V
7. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
8. Press the ENTER key to trigger calibration
9. The multimeter will display a success screen, indicating the frequency point that has been adjusted
10. Repeat steps 2 – 9 for any other additional frequency points that require adjustment

DC Current (Above 10uA)

WARNING: During these tests the current source will output currents of up to 30A

Make sure that leads used are rated for the output current and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Press the DCI Key, the Multimeter will enter auto range.
3. Press the DIGITS key, and select 7
4. Press the FILTER key, change filter speed to 4s
5. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
6. Connect the calibrator to the Multimeter as illustrated on page

Adjustment Points

The available adjustment points for the DC Current function of the 8000 multimeter are listed in the following table

It is possible to adjust a single range, or all ranges. A change to one range will not affect another, i.e. adjustments on the 1mA range do not affect measurements on the 100uA or 10mA ranges.

Multimeter Range	Adjustment Point	Nominal Value
100uA	Zero	Zero
	Positive Full Scale	+ 100uA
	Negative Full Scale *	- 100uA
1mA	Zero	Zero
	Positive Full Scale	+ 1mA
	Negative Full Scale *	- 1mA
10mA	Zero	Zero
	Positive Full Scale	+ 10mA
	Negative Full Scale *	- 10mA
100mA	Zero	Zero
	Positive Full Scale	+ 100mA
	Negative Full Scale *	- 100mA
1A	Zero	Zero
	Positive Full Scale	+ 1A
	Negative Full Scale *	- 1A
10A	Zero	Zero
	Positive Full Scale	+ 10A
	Negative Full Scale *	- 10A
30A	Zero	Zero
	Positive Full Scale	+ 30A
	Negative Full Scale *	- 30A
* Adjustment point available, but not required during routine adjustments		

Table 4 – DC Current Adjustment Points

Zero Point Adjustment

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys. Note that if the Multimeter is left in Auto Range the 100mA range will automatically be selected
2. Connect leads to perform current zero as described in Figure 5 on page 14
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Press the ENTER key once more, the Multimeter will perform a Zero calibration adjustment
7. The zero point calibration for the current range is now complete, repeat steps 1 through 7 for remaining ranges that require adjustment

Positive Full Scale Adjustment – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Set the calibrator output to the nominal positive full scale point as listed in Table 4

3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > +ve Full Scale
7. Press the ENTER key to trigger calibration
8. The Positive Full Scale adjustment has now been completed. Repeat steps 1 through 7 for remaining ranges that require adjustment

Full Scale Adjustment – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. If using a calibrator, set the required output as in Table 4 on Page 35. Make a note of the characterized output. (i.e. 9.999985 mA)
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Value mA
7. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
8. Press the ENTER key to trigger calibration, the secondary display will indicate that the calibration has been completed successfully
9. The Multimeter has now been adjusted to the characterized / certified value of the input. Repeat steps 1 to 8 for other ranges that require adjustment.

Negative Full Scale Adjustment

NOTE : Negative Full Scale adjustment is not required during routine adjustment. The inherent characteristics of 8000 series mean that only Positive Full Scale adjustments are normally required. An adjustment to the Positive Full Scale automatically corrects for Negative inputs during normal calibration.

It is possible that adjusting this factor separately can decrease the performance of the 8000 series.

Adjusting the negative full scale follows exactly the same procedure as the positive full scale with exception of input (which will be negative in polarity) and that the –ve Full Scale menu item will be selected

A.C. Current

WARNING: During these tests the current source will output up to 30A

Make sure that leads used are rated for the output current and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Press the ACI Key, the Multimeter will enter auto range.
3. Press the DIGITS key, and select 6
4. Press the FILTER key, change filter speed to 2s
5. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
6. Connect the calibrator to the Multimeter as illustrated on page 16

Adjustment Points

The available adjustment points for the AC Current functions of the 8000 multimeter are listed in the following table

It is possible to adjust a single range, or all ranges. A change to one range will not affect another, i.e. adjustments on the 1V range do not affect measurements on the 100mV or 10V range.

Multimeter Range	Adjustment Point	Nominal Value	Frequency
100uA	20% Full Scale	20uA	1 kHz
	Full Scale	100uA	1 kHz
1mA	20% Full Scale	0.2mA	1 kHz
	Full Scale	1mA	1 kHz
10mA	20% Full Scale	2mA	1 kHz
	Full Scale	10mA	1 kHz
100mA	20% Full Scale	20mA	1 kHz
	Full Scale	100mA	1 kHz
1A	20% Full Scale	0.2A	1 kHz
	Full Scale	1A	1 kHz
10A	20% Full Scale	2A	1 kHz
	Full Scale	10A	1 kHz
30A	20% Full Scale	2A	1 kHz
	Full Scale	30A	1 kHz
* Adjustment point available, but not required during routine adjustments			

Table 5 – AC Current Gain Correction Points

In addition to the main gain correction, each range has a variety of frequency correction points. Under routine verification and adjustment these points do not need to be adjusted. If a frequency 'band' (i.e. from 10Hz to 40Hz) is found to be outside of specification, only the spot points within that band need to be adjusted. In this example those points would be 10 Hz, 23 Hz and 40 Hz.

These corrections are configured at production, and will not normally need adjustment.

Frequency corrections are carried out at either Full Scale, or a nominal value that is within 10% of full scale for best performance.

Frequency
10Hz
23Hz
40Hz
56Hz
106Hz
206Hz
1kHz
2kHz
10kHz

Table 6 – AC Current Frequency Correction Points

Full Scale Adjustment (1 kHz) – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Set the calibrator to the correct output, with a frequency of 1 kHz. Refer to Table 2 for adjustment points
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Full Scale
7. Press the ENTER key to trigger calibration
8. The multimeter will display a success screen, indicating the frequency point that has been adjusted (in this case 1 kHz)
9. The Positive Full Scale adjustment has now been completed. Repeat steps 1 through 7 for remaining ranges that require adjustment

20% Full Scale (1kHz) Adjustment

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys. Note that if the Multimeter is left in Auto Range the 100mV range will automatically be selected.

2. Configure the voltage source for the appropriate nominal value (i.e. 100mA) at 1 kHz and press output on.
3. Allow the measurement to stabilise on the Multimeter.
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to > 20% FS
6. Press the ENTER key once more, the Multimeter will perform an adjustment at 20% Full Scale.

NOTE : When adjusting the main correction factor on AC ranges it may be necessary to repeat the Full Scale and 20% full scale adjustments more than once. Ensure that both points at within specification prior to proceeding

Full Scale Adjustment – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. If using a calibrator, set the required output (in this example 10mA). Make a note of the characterized output. (i.e. 9.999985 mA)
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Value mA
7. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
8. Press the ENTER key to trigger calibration, the secondary display will indicate that the calibration has been completed successfully
9. The Multimeter has now been adjusted to the characterized / certified value of the input. Repeat steps 1 to 8 for other ranges that require adjustment.

Full Scale Adjustment (Frequency Correction) – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Set the calibrator to the required output, referring both to the nominal value required (i.e. 10mA) as well as a valid frequency correction point as listed in Table 6 – The 8000 multimeter automatically determines the correct frequency for the adjustment
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero

6. Using the directional arrow keys or the digital control to select > Full Scale
7. Press the ENTER key to trigger calibration
8. The multimeter will display a success screen, indicating the frequency point that has been adjusted
9. Repeat steps 2 – 8 for any other additional frequency points that require adjustment

Full Scale Adjustment (Frequency Correction) – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Set the calibrator to the required output, referring both to the nominal value required (i.e. 10mA) as well as a valid frequency correction point as listed in Table 6 – The 8000 multimeter automatically determines the correct frequency for the adjustment. Retain the characterized value of the output for use later in the adjustment procedure.
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Value mA
7. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
8. Press the ENTER key to trigger calibration
9. The multimeter will display a success screen, indicating the frequency point that has been adjusted
10. Repeat steps 2 – 9 for any other additional frequency points that require adjustment

Resistance (up to 10 MOhms)

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Press the Ω 4Wire Key / Ω 2Wire Key, the Multimeter will enter auto range.
3. Press the DIGITS key, and select 7
4. Press the FILTER key, change filter speed to 4s
5. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
6. Connect the calibrator to the Multimeter as illustrated on page 12

Adjustment Points

The available adjustment points for the Resistance functions of the 8000 multimeter are listed in the following table

It is possible to adjust a single range, or all ranges. A change to one range will not affect another, i.e. adjustments on the 10 Ohm range do not affect measurements on the 100 Ohm range

Multimeter Range	Adjustment Point	Nominal Value
1 Ohm	Zero	0 Ω
	Full Scale	1 Ω
10 Ohm	Zero	0 Ω
	Full Scale	10 Ω
100 Ohm Low I	Zero	0 Ω
	Full Scale	100 Ω
100 Ohm	Zero	0 Ω
	Full Scale	100 Ω
1 kOhm Low I	Zero	0 Ω
	Full Scale	1 kΩ
1 kOhm	Zero	0 Ω
	Full Scale	1 kΩ
10 kOhm Low I	Zero	0 Ω
	Full Scale	10 kΩ
10 kOhm	Zero	0 Ω
	Full Scale	10 kΩ
100 kOhm	Zero	0 Ω
	Full Scale	100 kΩ
1 MOhm	Zero	0 Ω
	Full Scale	1 MΩ
10 MOhm	Zero	0 Ω
	Full Scale	10 MΩ
* Adjustment point available, but not required during routine adjustments		

Table 7 – Resistance Adjustment Points

Note : 2 Wire Calibration is only required for 1 MOhm and 10 MOhm values

Zero Point Adjustment

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys. Note that if the Multimeter is left in Auto Range the 100k Ohm range will be selected if in 4 wire mode, the 10 MOhm range will be selected if in 2 Wire resistance mode
2. If using a calibrator, set zero output and set the output to on (4 wire only)
3. If using a standard resistor, perform the zero connection as described in
4. Allow the measurement to stabilise on the Multimeter
5. Press the MENU key so that the calibration menu is active on the secondary display
6. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
7. Press the ENTER key once more, the Multimeter will perform a Zero calibration adjustment
8. The zero point calibration for the current range is now complete, repeat steps 1 through 7 for remaining ranges that require adjustment

Positive Full Scale Adjustment – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. If using a calibrator, set the required output (in this example 10V)
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Full Scale
7. Press the ENTER key to trigger calibration
8. The Positive Full Scale adjustment has now been completed. Repeat steps 1 through 7 for remaining ranges that require adjustment

Full Scale Adjustment – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. If using a calibrator, set the required output (in this example 10 Ω). If the calibrator has been characterized, make a note of the characterized output. (i.e. 9.999985 Ohms)
3. If using a voltage standard / reference, make a note of the certified output value (i.e. 9.999985 Ohms)
4. Allow the measurement to stabilise on the Multimeter
5. Press the MENU key so that the calibration menu is active on the secondary display

6. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
7. Using the directional arrow keys or the digital control to select > Value Ω
8. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
9. Press the ENTER key to trigger calibration, the secondary display will indicate that the calibration has been completed successfully
10. The Multimeter has now been adjusted to the characterized / certified value of the input. Repeat steps 1 to 9 for other ranges that require adjustment.

DC Current (Below 10uA)

Method of generating Low Currents

To accurately generate low current, rather than relying upon the calibrators output Transmille suggest using a standard resistor and high voltage source to accurately generate low value currents.

The advantages of this method are a much lower noise current source that is fully traceable (DC voltage from the voltage source and resistance of the high value resistor)

To calculate the voltage required, obtain the value of the standard resistor, and then determine the current required using the following equation

V = I x R

For example,

V = 0.000,000,1 A x 1,000,000,000 Ohms

V = 100nA x 1GOhm

V = 100V

The multimeter is then placed on the low side of the resistor and calibrator (connected between the negative terminal of the calibrator and the resistor) and the current passed through the multimeter.

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Press the DCI Key, the Multimeter will enter auto range.

3. Press RANGE DOWN until the electrometer indicator lights (10uA Range)
4. Press the DIGITS key, and select 7
5. Press the FILTER key, change filter speed to 4s
6. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
7. Connect the calibrator to the Multimeter as illustrated in Figure 17 on Page 20

Adjustment Points

The available adjustment points for the Electrometer Current function of the 8000 multimeter are listed in the following table

It is possible to adjust a single range, or all ranges. A change to one range will not affect another, i.e. adjustments on the 100nA range do not affect measurements on the 1uA or 10nA ranges.

Multimeter Range	Adjustment Point	Nominal Value
10nA	Zero	Zero
	Positive Full Scale	+ 10nA
	Negative Full Scale *	- 10nA
100nA	Zero	Zero
	Positive Full Scale	+ 100nA
	Negative Full Scale *	- 100nA
1uA	Zero	Zero
	Positive Full Scale	+ 1uA
	Negative Full Scale *	- 1uA
10uA	Zero	Zero
	Positive Full Scale	+ 10uA
	Negative Full Scale *	- 10uA
* Adjustment point available, but not required during routine adjustments		

Table 8 – Electrometer Current Adjustment Points

Zero Point Adjustment

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Connect leads to perform current zero as described in Figure 5 on page 14
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Press the ENTER key once more, the Multimeter will perform a Zero calibration adjustment
7. The zero point calibration for the current range is now complete, repeat steps 1 through 6 for remaining ranges that require adjustment

Positive Full Scale Adjustment – Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Using a standard resistor of suitable value, and a DC voltage source, calculate the voltage required to generate a current flow of the required value as in Table 8 using the example on page 43 to calculate the required resistor and voltage
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > +ve Full Scale
7. Press the ENTER key to trigger calibration
8. The Positive Full Scale adjustment has now been completed. Repeat steps 1 through 7 for remaining ranges that require adjustment

Full Scale Adjustment – Non-Nominal Value

1. Ensure the Multimeter is set to the required range using the RANGE UP and RANGE DOWN keys.
2. Using a standard resistor of suitable value, and a DC voltage source, calculate the voltage required to generate a current flow of the required value as in Table 8 using the example on page 43 to calculate the required resistor and voltage. Make a note of the calculated current
3. Allow the measurement to stabilise on the Multimeter
4. Press the MENU key so that the calibration menu is active on the secondary display
5. Press the down directional arrow, or press the ENTER key to move the > cursor to Zero
6. Using the directional arrow keys or the digital control to select > Value nA
7. Pressing the ENTER key will cause the _ indicator to flash, indicating that entry mode is active. Enter the characterized / certified value of the input source using the numerical keys
8. Press the ENTER key to trigger calibration, the secondary display will indicate that the calibration has been completed successfully
9. The Multimeter has now been adjusted to the characterized / certified value of the input. Repeat steps 1 to 8 for other ranges that require adjustment.

Negative Full Scale Adjustment

NOTE : Negative Full Scale adjustment is not required during routine adjustment. The inherent characteristics of 8000 series mean that only Positive Full Scale adjustments are normally required. An adjustment to the Positive Full Scale automatically corrects for Negative inputs during normal calibration.

It is possible that adjusting this factor separately can decrease the performance of the 8000 series.

Adjusting the negative full scale follows exactly the same procedure as the positive full scale with exception of input (which will be negative in polarity) and that the –ve Full Scale menu item will be selected

Electrometer Voltage Output

NOTE : The 8000 Multimeter is capable of OUTPUTTING voltages of up to 300V.

Ensure safety precautions are taken to avoid receiving electric shocks by only using appropriate leads and connections while performing these measurements

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Connect the multimeter for measurements as described as in Figure 18 on Page 21
3. Press the 2 Wire Key, the Multimeter will enter auto range.
4. Press RANGE UP until the electrometer indicator lights
5. Select the required voltage for measurements using the LEFT and RIGHT arrow keys, followed by the ENTER key.

Adjustment Points

The following adjustment points are available on the 8000 multimeter.

Note that an adjustment of the 300V Full Scale Gain will have an effect on all values, and as such should be adjusted first prior to performing other steps

Multimeter Range	Adjustment Point	Nominal Value
10V	Full Scale	10V
50V	Full Scale	50V
100V	Full Scale	100V
150V	Full Scale	150V
200V	Full Scale	200V
250V	Full Scale	250V
300V	Full Scale	300V

Table 9 – Electrometer Voltage Output Calibration

Full Scale Gain Adjustment

1. Connect the multimeter for measurements as described as in Figure 18 on Page 21
2. Press 2Wire Ohms
3. Press Range Up until the secondary display shows ‘Test Voltage’
4. Select 300V using the arrow keys
5. Press ENTER
6. After the multimeter has set, press the MENU Key
7. Press the right arrow until > Elect. Output Cal is displayed
8. Press ENTER
9. Enter the value indicated by the reference multimeter
10. Press the Enter Key
11. Confirm that the output has been adjusted
12. Press DCV to exit electrometer mode

Voltage Output Characterisation

Rather than adjust the output at other points, the multimeter stores the actual output for use in resistance calculations. If the outputs require adjustment the following procedure should be followed.

A list of available adjustment points is included in Table 8

1. Connect the multimeter for measurements as described as in Figure 18 on Page 21
2. Press 2Wire Ohms
3. Press Range Up until the secondary display shows ‘Test Voltage’
4. Select the required ranges using the arrow keys
5. Press ENTER
6. After the multimeter has set, press the MENU Key
7. Press the right arrow until > Elect. Measured is displayed
8. Press Enter
9. Enter the value indicated by the reference multimeter
10. Press the Enter Key
11. Confirm that the value has been stored
12. Repeat steps 4 – 11 for all required ranges

Verification of Ranges

In this section the procedure for verification of ranges is described. These procedures are mutually exclusive (for example, if required only the DC voltage portion can be verified) however we would advise that all ranges are verified at the user determined calibration interval. Transmille recommend that a recalibration / verification is performed every 12 months for optimal performance.

The recommended verification points for the 8081 multimeter are listed below, as well as the calculated tolerance to 1 year specifications based upon TCal ± 3 specifications. These specifications apply if the unit is re-calibrated by Transmille within the UK and include both the tolerance of the 8081 as well as the uncertainty of calibration.

When calibrated by another laboratory new absolute accuracies will apply as the uncertainty of calibration will be different than that of Transmille. In this case a new specification must be calculated. This can improve or degrade the specifications depending upon the uncertainty of calibration.

DC Voltage

WARNING: During these tests the voltage source will output up to 1000V during the adjustment procedure.

To avoid electric shock while performing steps of the following procedure please observe the following warnings:

If using non touch safe leads, ensure that any exposed elements of the lead are not touched when the output of the voltage source is active

Make sure that leads used are rated for the output voltage and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Press the DCV Key, the Multimeter will enter auto range.
2. Press the DIGITS key, and select 7
3. Press the FILTER key, change filter speed to 4s
4. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
5. Connect the calibrator to the Multimeter as illustrated on page 12

Verification Points

The points listed in Table 10 provide the recommended test points and tolerance for 8081.

Range	Test Value	Tolerance
100mV Range	0mV	± 0.0002 mV
100mV Range	100 mV	± 0.0011 mV
100mV Range	-100 mV	± 0.0011 mV
1V Range	0 V	± 0.0000006 V
1V Range	1 V	± 0.0000070 V
1V Range	-1 V	± 0.0000070 V
10V Range	0 V	± 0.000006 V
10V Range	10 V	± 0.000074 V
10V Range	-10 V	± 0.000074 V
100V Range	0 V	± 0.0001 V
100V Range	100 V	± 0.0010 V
100V Range	-100 V	± 0.0010 V
1kV Range	0kV	± 0.0000012 kV
1kV Range	1 kV	± 0.0000107 kV
1kV Range	-1 kV	± 0.0000107 kV

Table 10 – DC Voltage Verification Points

After performing verification of the Full scale and Zero values, a linearity check should be performed.

Range	Test Value	Tolerance
10V	9 V	± 0.0000672 V
	8 V	± 0.0000604 V
	7 V	± 0.0000536 V
	6 V	± 0.0000468 V
	5 V	± 0.00004 V
	4 V	± 0.0000332 V
	3 V	± 0.0000264 V
	2 V	± 0.0000196 V
	1 V	± 0.0000128 V
	-1 V	± 0.0000128 V
	-2 V	± 0.0000196 V
	-3 V	± 0.0000264 V
	-4 V	± 0.0000332 V
	-5 V	± 0.00004 V
	-6 V	± 0.0000468 V
	-7 V	± 0.0000536 V
	-8 V	± 0.0000604 V
	-9 V	± 0.0000672 V

Table 11 – DC Voltage Linearity Verification

A.C. Voltage

WARNING: During these tests the voltage source will output up to 1000V during the adjustment procedure.

To avoid electric shock while performing steps of the following procedure please observe the following warnings:

If using non touch safe leads, ensure that any exposed elements of the lead are not touched when the output of the voltage source is active

Make sure that leads used are rated for the output voltage and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Press the ACV Key, the Multimeter will enter auto range.
2. Press the DIGITS key, and select 6
3. Press the FILTER key, change filter speed to 2s
4. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
5. Connect the calibrator to the Multimeter as illustrated on page 16

Verification Points

The points listed in Table 12 provide the recommended test points and tolerance for 8081.

Range	Test Voltage	Frequency (Hz)	Tolerance
100mV AC	20 mV	1000	± 0.014 mV
	100 mV	10	± 0.095 mV
	100 mV	40	± 0.039 mV
	100 mV	56	± 0.039 mV
	100 mV	106	± 0.039 mV
	100 mV	206	± 0.038 mV
	100 mV	1000	± 0.038 mV
	100 mV	10000	± 0.05 mV
	100 mV	20000	± 0.05 mV
	100 mV	50000	± 0.14 mV
	100 mV	100000	± 0.14 mV
1V AC	0.2 V	1000	± 0.0001 V
	1 V	10	± 0.00075 V
	1 V	40	± 0.00036 V
	1 V	56	± 0.00036 V
	1 V	106	± 0.00036 V
	1 V	206	± 0.00026 V

	1 V	1000	± 0.00026 V
	1 V	10000	± 0.0005 V
	1 V	20000	± 0.0005 V
	1 V	50000	± 0.0014 V
	1 V	100000	± 0.0014 V
	1 V	400000	± 0.0406 V
	1 V	1000000	± 0.0406 V
10V AC	2 V	1000	± 0.001 V
	10 V	10	± 0.0075 V
	10 V	40	± 0.0036 V
	10 V	56	± 0.0036 V
	10 V	106	± 0.0036 V
	10 V	206	± 0.0026 V
	10 V	1000	± 0.0026 V
	10 V	2000	± 0.0026 V
	10 V	5000	± 0.005 V
	10 V	10000	± 0.005 V
	10 V	20000	± 0.005 V
	10 V	50000	± 0.014 V
	10 V	75000	± 0.014 V
	10 V	100000	± 0.014 V
100V AC	20 V	1000	± 0.013 V
	100 V	10	± 0.095 V
	100 V	23	± 0.095 V
	100 V	40	± 0.039 V
	100 V	56	± 0.039 V
	100 V	106	± 0.039 V
	100 V	206	± 0.037 V
	100 V	1000	± 0.037 V
	100 V	2000	± 0.037 V
	100 V	5000	± 0.06 V
	100 V	10000	± 0.06 V
	100 V	20000	± 0.06 V
1kV AC	0.2 kV	1000	± 0.00013 kV
	0.7 kV	40	± 0.0003 kV
	0.7 kV	56	± 0.0003 kV
	0.7 kV	106	± 0.0003 kV
	0.7 kV	206	± 0.00028 kV
	0.7 kV	1000	± 0.00028 kV
	0.7 kV	2000	± 0.00028 kV
	0.7 kV	5000	± 0.00045 kV
	0.7 kV	10000	± 0.00045 kV
	1 kV	40	± 0.00039 kV
	1 kV	56	± 0.00039 kV
	1 kV	1000	± 0.00037 kV
	1 kV	10000	± 0.0006 kV

Table 12 – AC Voltage Verification Points

DC Current (Above 10uA)

WARNING: During these tests the current source will output currents of up to 30A

Make sure that leads used are rated for the output current and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 8
2. Press the DCI Key, the Multimeter will enter auto range.
3. Press the DIGITS key, and select 7
4. Press the FILTER key, change filter speed to 4s
5. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
6. Connect the calibrator to the Multimeter as illustrated on page

Verification Points

Range	Test Value	Tolerance
USE LOW CURRENT TERMINALS		
100uA Range	0 uA	± 0.0004 uA
	100 uA	± 0.0018 uA
	-100 uA	± 0.0018 uA
1mA Range	0 mA	± 0.000004 mA
	1 mA	± 0.000018 mA
	-1 mA	± 0.000018 mA
10mA Range	0 mA	± 0.00004 mA
	10 mA	± 0.0002 mA
	-10 mA	± 0.0002 mA
100mA Range	0 mA	± 0.0006 mA
	100 mA	± 0.0053 mA
	-100 mA	± 0.0053 mA
1A Range	0 A	± 0.000013 A
	1 A	± 0.000247 A
	-1 A	± 0.000247 A
CHANGE TO HIGH CURRENT TERMINALS		
10A Range	0 A	± 0.00035 A
	10 A	± 0.00596 A
	-10 A	± 0.00596 A
30A Range	0 A	± 0.00435 A
	30 A	± 0.02727 A
	-30 A	± 0.02727 A

Table 13 – DC Current Verification Points

A.C. Current

WARNING: During these tests the current source will output up to 30A

Make sure that leads used are rated for the output current and in good condition, with no damaged insulation

Configuring the Multimeter for measurements

1. Press the ACI Key, the Multimeter will enter auto range.
2. Press the DIGITS key, and select 6
3. Press the FILTER key, change filter speed to 2s
4. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
5. Connect the calibrator to the Multimeter as illustrated on page 16

Verification Points

Range	Test Value	Frequency (Hz)	Tolerance
USE LOW CURRENT TERMINALS			
100uA Range	25 uA	1000	± 0.0245 uA
	100 uA	10	± 0.105 uA
	100 uA	40	± 0.062 uA
	100 uA	56	± 0.062 uA
	100 uA	106	± 0.062 uA
	100 uA	206	± 0.062 uA
	100 uA	1000	± 0.062 uA
	100 uA	10000	± 0.15 uA
1mA Range	0.2 mA	1000	± 0.00022 mA
	1 mA	10	± 0.00105 mA
	1 mA	40	± 0.00062 mA
	1 mA	56	± 0.00062 mA
	1 mA	106	± 0.00062 mA
	1 mA	206	± 0.00062 mA
	1 mA	1000	± 0.00062 mA
	1 mA	2000	± 0.0015 mA
	1 mA	5000	± 0.0015 mA
	1 mA	10000	± 0.0015 mA
10mA Range	2 mA	1000	± 0.0022 mA
	10 mA	10	± 0.0105 mA
	10 mA	40	± 0.0062 mA

	10 mA	56	± 0.0062 mA
	10 mA	106	± 0.0062 mA
	10 mA	206	± 0.0062 mA
	10 mA	1000	± 0.0062 mA
	10 mA	10000	± 0.015 mA
100mA Range	20 mA	1000	± 0.022 mA
	100 mA	10	± 0.105 mA
	100 mA	40	± 0.062 mA
	100 mA	56	± 0.062 mA
	100 mA	106	± 0.062 mA
	100 mA	206	± 0.062 mA
	100 mA	1000	± 0.062 mA
	100 mA	10000	± 0.15 mA
1A Range	0.2 A	1000	± 0.00029 A
	1 A	10	± 0.0013 A
	1 A	40	± 0.00085 A
	1 A	56	± 0.00085 A
	1 A	106	± 0.00085 A
	1 A	206	± 0.00085 A
	1 A	1000	± 0.00085 A
	1 A	10000	± 0.0018 A
CONNECT TO HIGH CURRENT TERMINALS			
10A Range	2 A	1000	± 0.0044 A
	10 A	10	± 0.02 A
	10 A	40	± 0.015 A
	10 A	56	± 0.015 A
	10 A	106	± 0.015 A
	10 A	206	± 0.015 A
	10 A	1000	± 0.015 A
30A Range	30 A	10	± 0.06 A
	30 A	40	± 0.045 A
	30 A	56	± 0.045 A
	30 A	106	± 0.045 A
	30 A	206	± 0.045 A
	30 A	1000	± 0.045 A

Table 14 – AC Current Verification Points

Resistance (up to 10 MOhms)

Configuring the Multimeter for measurements

1. Press the Ω 4Wire Key / Ω 2Wire Key, the Multimeter will enter auto range.
2. Press the DIGITS key, and select 7

3. Press the FILTER key, change filter speed to 4s
4. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
5. Connect the calibrator to the Multimeter as illustrated on page 12

Verification Points

NOTE : The tolerances below are based upon nominal value resistance (i.e. 100 ohms)

If values are deviating more than 10 ppm from Nominal the tolerance should be re-calculated.

A zero should be performed prior to making measurements on resistance functions as shown in Figure 11 on Page 17. Appropriate leads and connectors should be used to minimise the resistance of connections for optimal performance.

Figure 12 and Figure 13 on Page 18 should be referred to for correct connections for nominal values for 4 Wire Connections

Range	Test Value	Tolerance
1 Ohm	1 Ω	± 0.0000295 Ω
10 Ohm	10 Ω	± 0.000188 Ω
100 Ohm	100 Ω	± 0.00151 Ω
100 Ohm Lo	100 Ω	± 0.00227 Ω
1k Ohm	1 kΩ	± 0.0000133 kΩ
1k Ohm Lo	1 kΩ	± 0.0000171 kΩ
10k Ohm	10 kΩ	± 0.000157 kΩ
10k Ohm Lo	10 kΩ	± 0.000194 kΩ
100k Ohm	100 kΩ	± 0.00165 kΩ

Table 15 – 4 Wire Resistance Verification Points

Prior to performing measurements on 2 Wire resistance functions it is important that lead resistance in interconnecting leads is removed. The resistance in interconnecting leads has the potential to be in the order of hundreds of milliohms which will affect measurements if not correctly compensated for.

Figure 14 on Page 19 should be referred to for correct Null procedure and connection. Note that leads are shorted at the point of connection with the standard resistor, not at the terminals of the 8000 unit. This short should be performed as close as possible to the resistance source to eliminate as many errors as possible.

Figure 15 and Figure 16 on Page 19 should be used as reference for correct connections for 2 Wire Ohms measurements

100k Ohm	100 kΩ	± 0.00165 kΩ
1M Ohm	1 MΩ	± 0.0000202 MΩ

10M Ohm	10 MΩ	± 0.000319 MΩ

Table 16 – 2 Wire Resistance Verification Points

DC Current (Below 10uA)

Method of generating Low Currents

To accurately generate low current, rather than relying upon the calibrators output Transmille suggest using a standard resistor and high voltage source to accurately generate low value currents.

The advantages of this method are a much lower noise current source that is fully traceable (DC voltage from the voltage source and resistance of the high value resistor)

To calculate the voltage required, obtain the value of the standard resistor, and then determine the current required using the following equation

V = I x R

For example,

V = 0.000,000,1 A x 1,000,000,000 Ohms

V = 100nA x 1GOhm

V = 100V

The multimeter is then placed on the low side of the resistor and calibrator (connected between the negative terminal of the calibrator and the resistor) and the current passed through the multimeter.

Configuring the Multimeter for measurements

1. Press the DCI Key, the Multimeter will enter auto range.
2. Press RANGE DOWN until the electrometer indicator lights (10uA Range)
3. Press the DIGITS key, and select 7
4. Press the FILTER key, change filter speed to 4s
5. Select the required range using the RANGE UP or RANGE DOWN keys. For best performance the required range should be selected manually.
6. Connect the calibrator to the Multimeter as illustrated in Figure 17 on Page 20

Verification Points

Range	Test Value	Tolerance

10nA	10 nA	± 0.15228 nA
	-10 nA	± 0.15228 nA
100nA	100 nA	± 0.3121 nA
	-100 nA	± 0.3121 nA
1uA	1 uA	± 0.000356 uA
	-1 uA	± 0.000356 uA
10uA	10 uA	± 0.0006 uA
	-10 uA	± 0.0006 uA

Table 17 – DC Current (Below 10uA) Verification Points

Electrometer Voltage Output

NOTE : The 8000 Multimeter is capable of OUTPUTTING voltages of up to 300V.

Ensure safety precautions are taken to avoid receiving electric shocks by only using appropriate leads and connections while performing these measurements

Configuring the Multimeter for measurements

1. Enter Calibration Mode as described on Page 7
2. Connect the multimeter for measurements as described as in Figure 18 on Page 21
3. Press the 2 Wire Key, the Multimeter will enter auto range.
4. Press RANGE UP until the electrometer indicator lights
5. Select the required voltage for measurements using the LEFT and RIGHT arrow keys, followed by the ENTER key.

Verification Points

The verification points are the error of measurement compared to the stored value for the voltage setting. This output can be seen when in Calibration Mode by using the LEFT and RIGHT keys to move the menu to > Vout = . The value stored here is then compared with the true output, and then measurement voltage increased / decreased to the next test point

The table below lists tolerances based upon the nominal output value, not the actual output value.

Output	Nominal Value	Tolerance
10V	10 V	± 0.00075 V
50V	50 V	± 0.00375 V
100V	100 V	± 0.0075 V
150V	150 V	± 0.01125 V
200V	200 V	± 0.015 V
250V	250 V	± 0.01875 V
300V	300 V	± 0.0225 V

Table 18 – Electrometer Output Voltage Verification Points

Electrometer Resistance Measurements

NOTE : The 8000 Multimeter is capable of OUTPUTTING voltages of up to 300V.

Ensure safety precautions are taken to avoid receiving electric shocks by only using appropriate leads and connections while performing these measurements

NOTE : Ensure that the resistors used for the next section are rated for the applied test values. If not, damage may occur to the resistors.

If no resistors are available the test voltage may be lowered however the tolerances will no longer apply.

Configuring the Multimeter for measurements

1. Connect the multimeter for measurements as described as in Figure 19 and Figure 20 on Page 21
2. Press the 2 Wire Key, the Multimeter will enter auto range.
3. Press RANGE UP until the electrometer indicator lights
4. Select the required voltage for measurements (100V recommended) using the LEFT and RIGHT arrow keys, followed by the ENTER key.

Verification Points

Range	Test Voltage	Test Value	Tolerance
100 MOhm	100 V	100 MΩ	± 0.0416 MΩ
1 GOhm	100 V	1 GΩ	± 0.00181 GΩ
10 GOhm	100 V	10 GΩ	± 0.23 GΩ
100 GOhm	100 V	100 GΩ	± 2.3 GΩ
1 TOhm	100 V	1 TΩ	± 0.023 TΩ

Table 19 – Electrometer Resistance Measurement Verification Points

Frequency Measurement

Configuring the Multimeter for measurements

1. Press the ACV Key, the Multimeter will enter auto range.
2. Select the most appropriate range depending upon the amplitude of the frequency source (1V or 10V recommended)

3. Press the FREQ Key
4. Connect the calibrator to the Multimeter for AC Voltage measurements as illustrated on page 16

Verification Points

The Frequency measurement function is a sub function of the AC Voltage and Current Ranges.

Range	Frequency	Tolerance
100 Hz	100 Hz	0.1 Hz
1 kHz	1 kHz	0.0001 kHz
10 kHz	10 kHz	0.0001 kHz
100 kHz	100 kHz	0.0003 kHz
1 MHz	1 MHz	0.0000021 MHz

Table 20 – Frequency Measurement Verification Points

Optional Verification Ranges

The following ranges are sub functions of other ranges featured in the 8000 series. The thermocouple function is a sub function of DC Voltage (measuring voltage with the 100mV range and using internal conversion to temperature) and the PRT function is a sub range of 4 Wire Resistance Low Current mode.

If the previously verified ranges are within specification it can be assumed that these ranges are in specification as there is no difference in hardware or measurement.

It is important to note that if custom PRT coefficients have been loaded into the 8000 series unit the appropriate resistance must be sourced for these coefficients, or the coefficients returned to default.

Thermocouple

Configuring the Multimeter for measurements

1. Connect the calibrator to the Multimeter as illustrated on page 12 for DC Voltage measurements
2. Ensure that an accurate Zero / Null has been performed on the 100mV DC Range
3. Press the SHIFT key, followed by the DC Voltage key. Thermocouple mode has now been selected.
4. Select the required Thermocouple Type using the LEFT and RIGHT arrow keys
5. Press Enter

6. Select ‘Man CJc’, enter 0’C
7. Proceed with measurements

Verification Points

For best accuracy the required thermocouple mV are sourced as DC voltage from the reference calibrator rather than using a thermocouple source mode. This also avoids any errors in the calibrators thermocouple conversion.

The thermocouple conversion table within the 8000 series is based upon ITS 90, and as such appropriate thermocouple tables should be used to determine calibrator output in mV

Thermocouple Type	Test Value	Tolerance
K Type	-140 °C	0.08 °C
	-50 °C	0.08 °C
	0 °C	0.08 °C
	100 °C	0.08 °C
	200 °C	0.08 °C
	500 °C	0.08 °C
	700 °C	0.08 °C
	1000 °C	0.08 °C
	1340 °C	0.08 °C
J Type	-180 °C	0.08 °C
	400 °C	0.08 °C
	750 °C	0.08 °C
T Type	0 °C	0.08 °C
	400 °C	0.08 °C
R Type	-50 °C	0.25 °C
	1700 °C	0.15 °C

Table 21 – Thermocouple Verification Points

Glossary of Terms Used

Throughout this calibration manual, many technical terms have been used. To avoid repeating terms, a glossary of these terms has been included for convenience

Null / Zero

By Null or Zero, the desired outcome is any offsets external to the measurement system are removed. This includes offsets such as thermal voltages (EMF), lead resistance etc.

It is important that external sources of error are removed from the multimeter as when performing verification and adjustment of accurate instrumentation 1uV of thermals on the 100mV range will cause measurements to have a 10ppm error.

Correct Null / Zero technique is to zero the measurement system as a whole, i.e. all leads, relays and other components that connect the multimeter to the source.

Performing a null using a short at the terminals of the multimeter is not removing and effects introduced by leads or external equipment, meaning these effects will be re-introduced as soon as leads are re-connected.

Examples of correct zero technique can be found in the following figures :

Thermals

Thermals are the term used for Electromotive Force (EMF) generated when two dissimilar metals are joined. At each connection between two dissimilar metals a voltage will be generated depending upon the different metals and the temperature difference.

This can cause errors in excess of 2uV / degree C, which at the 1V level relates to a 2ppm error.

Transmille have free of charge training material available from our website at www.transmille.com and from our ‘Making Good Measurements’ video series which is available free of charge from www.youtube.com/Transmille

Transmille use premium materials throughout the design of the 8000 multimeter, down to the use of gold flashed copper terminals for the front and rear panel connections. However introducing a low quality (i.e. Nickel plated Brass) lead will introduce external errors which will affect the performance of the 8000 series.

For this purpose Transmille can provide a precision lead set designed for use with the 8000 series to remove these sources of error. Further details are available from www.transmille.com