Calibration Instructions for
ALL-TEST PRO MOTOR GENIE® MCA™
Rev.1

1. Contents

1. Revision history

Revision	Date	Change description	Note
Rev. 1	01/02/24	Initial Release.	

2. Introduction

Instrument

The MOTOR GENIE® MCA™ are highly specialized test instruments for testing AC induction motors with squirrel-cage rotors or Permanent Magnet (PM) type motors and motor/generators used in hybrid and electric vehicles by using low voltage test signals for R, Z, Ψ and other patented proprietary parameters. In addition 500/1000V DC is used for Insulation Resistance testing.

The measuring technology is distinguished by "Static" and "Dynamic" testing, i.e. with the rotor fixed in position or manually rotated by hand during testing. All calibration testing is considered to be of the "Static" type. It is also important to point out that the ALL-TEST PRO® instruments measure R, Z, and Ψ in fundamentally different ways from the traditional bridge type as well as various more contemporary digital type LCR meters. This difference may have an impact on some test results, especially with nonlinear inductors or when a core material is added.

Summary of calibration parameters

	Instrument Test Mode
Resistance R	"SET" icon Manual Test R Ψ I/F Z
Phase Angle Ψ	"SET" icon Manual Test R Ψ I/F Z
Insulation R (MΩ)	"INS" icon

⚠️ **Important Note:**

- Please refer to the User Manuals, Chapter "Static Tests" for additional information on the instrument test modes, safety and general precautions!
- While phase angle ф is provided as an option in manual test menu, it is not used for calibration because phase angle is not used by the instrument for any diagnostic purpose.

Kelvin Test Leads

In the following sections, details of calibration tests are explained for each parameter using standard calibration test leads and accessories. Calibration test leads can be ordered directly from ALL-TEST Pro, LLC.

3. Resistance R

Instrument Specification Resistance Measurement:

Measurement Range	Absolute Accuracy	Max Resolution	Relative Accuracy (Phase to Phase)
0.01Ω - 0.1Ω	±(1% of the Range Full Scale +1 digit)	0.01mΩ - 1mΩ	±(1% of Measured Value +1 digit)
0.1Ω - 99.9Ω	±(1% of Measured Value +1 digit)	1mΩ - 0.1Ω	±(0.1% of Measured Value +1 digit)
100Ω - 500Ω	±(1.5% of Measured Value +1 digit)	1Ω	±(0.1% of Measured Value +1 digit)
501Ω - 999Ω	±(2.5% of Measured Value +1 digit)	1Ω	±(0.1% of Measured Value +1 digit)

Test Objects:

Resistance Standards of General Radio / IET Labs / Leeds & Northrup / Honeywell Rubicon
Accuracy specification ±0.02% or better

Suggested Test Values:

0.1 Ω, 1 Ω, 10 Ω, 100 Ω, 500 Ω, 900 Ω

Test Voltage:
Low voltage DC, dual polarity.

Test Leads / Connection:

An example is shown with ATP supplied custom version of Kelvin test leads **type A** terminated with 4mm banana plugs or use in combination with banana plug to open spade lug adaptors. (See Appendix A: Test Leads and Accessories, Figure 21)

Figure 1. Connection to Instrument with test leads type "A".

Figure 2. Example #1: Connection to Standard Resistor with Kelvin test leads type "A" and banana plug to open spade lug adaptors. (Note: Sense plugs marked with "S+"=HI and "S-"=LO)

Figure 3. Example #2: Connection to Standard Resistance with Kelvin test leads type "A"

Figure 4. Example #3: Connection to Standard Resistance with Kelvin test leads type "A"

Instrument Test Mode:

Select the "SET" icon in the instruments Main Menu and press OK to access the submenu. Now select "Manual Test R, L" and press OK. Follow the on-screen instructions to "Select Leads" pair (32) and then "Select Test" parameter R in this case. Press OK and then MENU to exit when done.

Resistance Test Result Limits:

Resistance Standard Nominal Value	100 mΩ	1 Ω	10 Ω	100 Ω	500 Ω	900 Ω
Max limit	102 mΩ	1.02 Ω	10.2 Ω	102 Ω	508 Ω	923 Ω
Min limit	98.9 mΩ	989 mΩ	9.89 Ω	98.4 Ω	492 Ω	877 Ω

4. Phase Angle Ψ (inductive)

Instrument Specification ϕ:

1 – 90°±(1°degree +one digit)

Test Objects:
Inductance Standards General Radio / IET Labs 1482 series air-cored or equivalent.

Applicable Test Values:

1 mH, 10 mH, 100 mH, 200 mH

Test Frequency / Voltage:

"Auto frequency" selection by AT7, as one off 400, 200, 100 or 50 Hz @ 1VRMS

Test Leads / Connection:

Use ATP supplied custom version of Kelvin test leads **type B** (red and blue) terminated with 4mm banana plugs. (See Appendix A, Figure 20)

Figure 5. Connection to Instrument with test leads type "B".

Figure 6. Connection to Standard Inductor with test leads type "B".

Since there are no explicit Standards for Phase Angle, (inductive or capacitive), we have to use existing standards available for inductance in order to calibrate "inductive" phase angle (where current lags voltage). General Radio / IET Labs 1482 series air-cored inductance standards (or equivalent of other makes) are examples of applicable inductor types and can essentially be considered as an ideally linear circuit element. But due to the normal design choices of inductance standards, testing phase angle at 100 Hz only will result in typically low values for φ across the range of inductors.

To overcome or ease this limitation we will use the manual single phase test mode of the AT7™ which can be found by selecting the "MAN" icon in the main menu. The idea is to utilize the "Auto Frequency Selection" feature of the AT7™ to cover a larger range of phase angle values by letting AT7™ selecting the "optimal" test frequency of the used ones for each inductance based on the impedance value at 100Hz. (The frequencies used are 50, 100, 200 and 400Hz.)

It follows from the above discussion that the phase angle of each inductor must be calculated individually for each specimen and test frequency used. To calculate the nominal phase angle for a given standard inductor we can use the well-known textbook formula for phase angle:

φ=arctan (ωL/R) (1)

Where L and R should be taken directly from the standard inductors individual calibration certificate. (Note: L is stated at more than one frequency, usually 100, 200, 400 and 1000 Hz)

Note: The instruments measure the actual time difference between the voltage and the lagging current in order to obtain the phase angle in degrees unit.

Instrument Test Mode:

Select the "SET" icon in the instruments Main Menu and press OK to access the submenu. Now select "Manual Test R, L" and press OK. Follow the on-screen instructions to "Select Leads" pair (32) and then "Select Test" parameter **φ** .
(Note: φ tests are performed on multiple set of frequencies 50, 100, 200, 400 Hz)

Press OK and then MENU to exit when done.

The "φ Typical Value" stated in the "φ Test Result Limits" table below are based on current 1482 series product data sheet specification and are given as approximate values for guidance only. Nominal values of phase angle φ for each specific standard inductor used must be calculated at typical "Auto Frequency" as indicated below before any testing!

φ Test Result Limits (To be determined by equation labeled (1) φ=arctan (ωL/R))

General Radio 1482 series inductors	1mH	10mH	100mH	200mH
φ Typical Value φ Calculated Value	≈71.5° 400Hz	≈56.9° 200Hz	≈37.8° 100Hz	≈49.1° 100Hz
Max limit	72.5°	57.9°	38.8°	50.1°
Min limit	70.5°	55.9°	37.8°	48.1°

5. Insulation Resistance MΩ

Instrument Specification

0 – 999 MΩ @1000V,   0 – 999 MΩ @500V

1 – 100 MΩ ±3% , all other values ±5%

Test Objects:

Resistance Standards General Radio / IET Labs SRA series or equivalent. (SRL series ≥10MΩ OK)
Voltage rating of resistor must be ≥ 1000 V

Test Values:

1 MΩ, 10 MΩ, 100 MΩ, 450 MΩ and 900 MΩ. For 900 MΩ, please see note below.

Test Voltages:

500V and/or 1000V

Test Leads / Connection:

Use ATP supplied custom version of Kelvin test leads **type B** (blue) terminated with 4mm
banana plug and safety test lead (yellow) with banana adapter. See

Figure 21 and Figure .

Figure 74. Connection to Instrument with blue test lead type "B" and yellow safety test lead.

Figure 85. Connection to ≥ 1MΩ Standard Resistor with blue test lead type "B" and yellow safety lead with open banana plug adaptor. (Note: GND connection not used)

Instrument Test Mode:

Select the "INS" icon in the Main Menu and press OK. Ignore instructions in the message screen instead connect the Test Leads according to Figure 8 above and then press OK:

--- will be displayed indicating an empty start value for MΩ. Select the desired test voltage by pressing the Right Arrow key ▷ which will toggle between the two available selections, 500V or 1kV.

Press "TEST" key ▽ until the MΩ value becomes stable then release for auto-hold of value and check it against table below. (>500MΩ will be displayed if connection is open). Press "MENU" key to exit when done.

⚠ **WARNING: Risk of electric shock!** ⚠ **Pressing the TEST key will output the selected test voltage 500V or 1000V on the yellow output port and illuminate the orange status LED.**

MΩ Test Result Limits:

Nominal Test value	1 MΩ	10 MΩ	100 MΩ	450 MΩ	900 MΩ
Max limit	1.03 MΩ	10.3 MΩ	103 MΩ	472.5 MΩ	945 MΩ
Min limit	0.97 MΩ	9.7 MΩ	97 MΩ	427.5 MΩ	855 MΩ

6. Calibration Adjustment.

a. Calibration Adjustment Overview (Factory and Custom Calibration)

Calibration adjustment functionality allows compensation of initial tolerances of all hardware components which affect the measurements.

Calibration adjustment includes 3 steps listed according to priority level:

1) Voltage measurement adjustment

2) Resistance measurement adjustment

3) Insulation measurement adjustment

These steps should be done sequentially Voltage first, then Resistance and Insulation as the last one. Each step can be done independently but any change on the upper level can affect the lower level readings. At the end of the adjustment process the calibration information is saved in non-volatile memory. There are two sections of calibration adjustments: Factory Calibration Memory and Custom Calibration Memory.

Factory Calibration: Every unit will be calibrated through the manufacturing process and this initial calibration will be stored as Factory Calibration.

Custom Calibration: Through the service period units shall be checked and recalibrated. Any qualified Calibration laboratory can perform the Calibration Adjustment process using this Calibration manual. This subsequent Calibration Adjustment Data will be stored as Custom Calibration in separate non-volatile memory.

At any point in time unit calibration can be reversed to Factory Calibration.

b. Calibration Adjustment Equipment.

The Calibration Adjustment process requires standard test objects and additional equipment:

1) Computer with USB Port. With Installed software and drivers:
    a. Any Serial / COM port communication Software. Such us Windows HyperTerminal, or any other Software which will be able to communicate through the standard COM port.
    b. FTDI D2XX Direct Drivers and Virtual COM Port (VCP) drivers for FT234 USB to serial chip. These drivers can be obtained from FTDI website: http://www.ftdichip.com/Drivers/D2XX.htm
    Note: Most of the Windows computers will be able to install and activate the

FTDI drivers automatically when you plug in the USB cable to the Unit for the first time.

2) USB 2.0 Type A Male to Type B Male cable. Commonly used with printers.
3) Test Leads and Accessories as shown in Appendix A.
4) A Laboratory Voltage Calibrator with minimum Voltage Source requirements:
   a. Voltage: 0 to 100 mV, Resolution 0.01 mV, Accuracy 0.02% Rdg + 2 LSD, Load 1mA.
   b. Voltage: 0.1 V to 10 V, Resolution 0.01 V, Accuracy 0.02% Rdg + 2 LSD, Load 1mA.
5) Laboratory Resistance Standards of General Radio / IET Labs / Leeds & Northrup / Honeywell Rubicon with accuracy specification of ±0.02% or better.
   Test Load Values needed for Calibration: 1Ω, 5Ω, 10Ω, 25Ω, 50Ω, 100Ω, 300Ω, 700Ω.
6) High Voltage Resistance Standards with voltage rating of ≥ 1000 V.
   General Radio / IET Labs SRA Series or equivalent.
   Test Load Values needed for Calibration: 10MΩ, 100MΩ, 700MΩ.

c.   Computer COM port Serial Communication Setup.

The calibration Adjustment process can only be controlled through Serial Port Communication. Follow these steps in order to establish the communication:

1) Connect the Unit to computer using USB cable.
2) Wait until the computer establishes the connection. If this is the first connection you might need to wait until the computer installs the appropriate drivers automatically or install FTDI drivers manually.
   Successful connection can be checked using Device Manager. See picture below

The COM port number can be different. Every time you connect the unit to the computer the COM port number will be reassigned. If you have multiple COM port connections it might be useful to connect and disconnect the USB cable with Device Manager window open so you can identify the COM port assigned to the Unit.

3) Open your Serial Port communication Software and establish the connection using Serial port configuration settings listed below:
    - Port: COMxx   (COM port number assigned to the Unit. see above)
    - Baud Rate: 115200
    - Data bits: 8
    - Stop Bits: 1
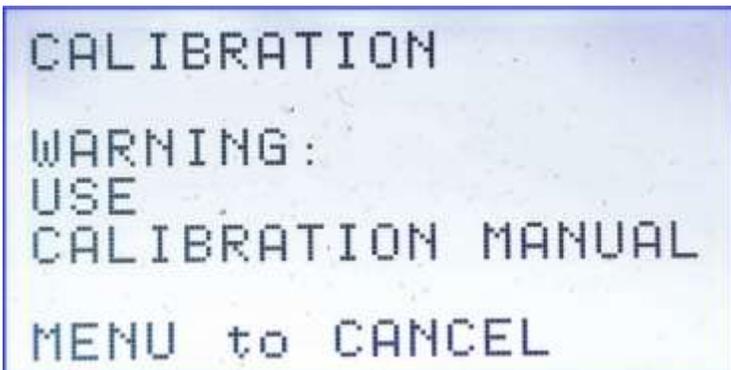   - Parity: None
    - Flow control: None

4) Select Instrument Calibration Mode:

    Select the "SET" icon in the instruments Main Menu and press OK to access the submenu.

Figure 96. SET menu screen.

Select "CALIBRATION" and press OK.

Figure 107. Calibration Mode active screen.

5) At the same time the unit will send welcoming calibration strings/menu to the Computer and the Serial communication Software should show the message (below)

CALIBRATION MENU:
V – VOLTAGE
R - RESISTANCE
I - INSULATION
S - STATUS
C - CALIBRATION RESTORE to FACTORY
E - EXIT

Note: All communication messages coming from the Unit to Computer will be shown using this BOLD ITALIC FONT

Starting from this point all communications for the calibration adjustment process should be driven by the commands sent from the computer through Serial port communication.

Every Text Message line from the Unit is terminated with "line feed" (0x0A hex) symbol.

All commands from the computer to the Unit are One-Symbol commands. Upper or Lower case symbols can be used to send the command. Available commands for each particular mode will be prompted by the unit response. In case of Main Calibration Menu (above) the available commands are "V", "R", "I", "S", "C", "E".

d.   Main Calibration Menu Commands.

| Command Symbol	Function
V	Start calibration adjustment of the Voltage measurement input.
R	Start calibration adjustment of the Resistance / Current measurement input
I	Start calibration adjustment for High Voltage Insulation measurement input.
S	Show Calibration Status
C	Restore Factory Calibration adjustment settings
E	Exit Calibration mode

e. Voltage Measurement Calibration

From Main calibration menu send [**V**] command (press V) to start voltage calibration process. The Unit will respond with message below:

* VOLTAGE
*　　　　Connect BLUE to Negative(-), RED & BLACK to Positive(+) Volts Source
Press '1'

Test Leads Connection to the Unit
Use Blue and Red Kelvin test leads type "A" and Blue Kelvin test lead type "B":
  – plug type "**A**" **BLUE** test lead into **BLACK** input socket(1)
  – plug type "**A**" **RED** test lead into **RED** input socket(3)
 – plug type "**B**" **BLUE** test lead into **BLUE** input socket(2)
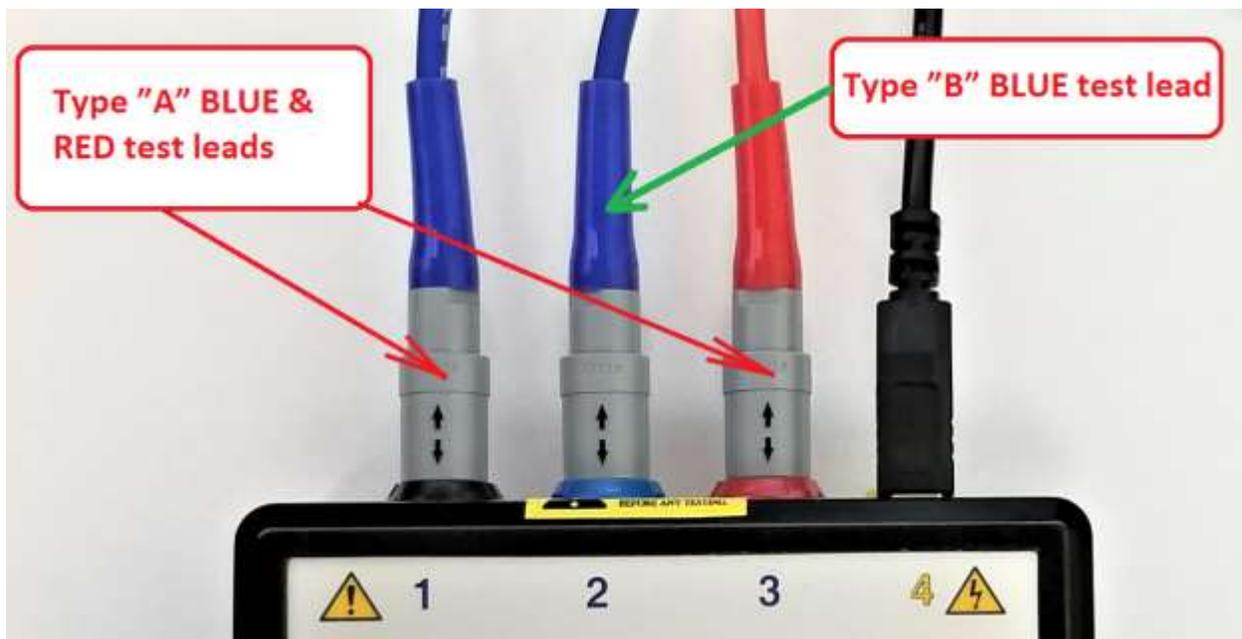
Figure 118. Voltage Calibration Mode Test Leads connection to the Unit.

Connection to the Voltage Source

– connect type "**B**" **BLUE** test lead to **Negative** Voltage source output.

– connect Sense plugs marked with white "S+" "S-" of the type "**A**" **BLUE** and **RED** test lead to **Positive** Voltage source output.

Note: Use additional plugs (wires) to provide 2 connections to **Positive** Voltage source output.
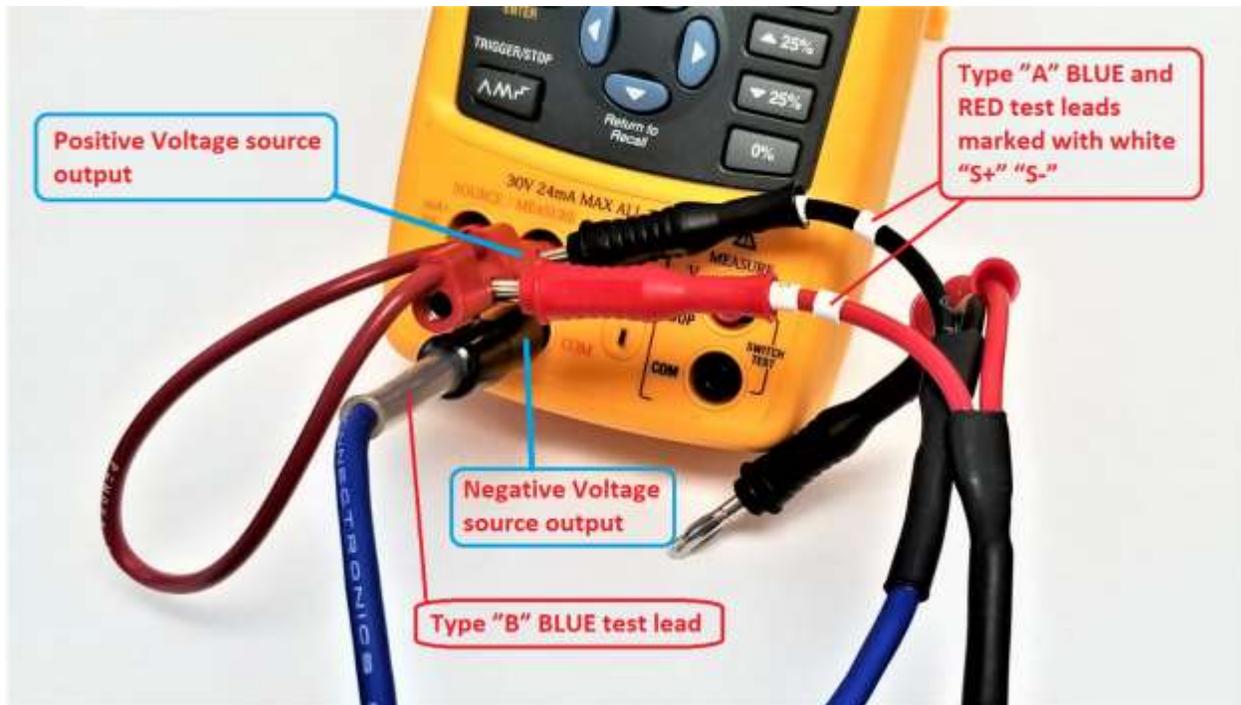
Figure 129. Voltage Calibration Mode Test Leads connection to a Voltage Source .

Confirm connection to Voltage Source by sending [**1**] command (press "1").

The Unit will respond requesting first Voltage as shown below:

Apply 0.40000 V, Press '1'

Set the Voltage Calibrator to the voltage shown and send [**1**] (press "1")

Unit will request next voltage. Set the Voltage Calibrator to the voltage indicated and press 1. Continue with the voltages displayed until you are prompted to Store Calibration

Example of the voltage calibration dialog:

Apply 0.40000 V, press '1'
Apply 1.50000 V, press '1'
Apply 0.40000 V, press '1'

Apply 1.50000 V, press '1'
Apply 0.19000 V, press '1'
Apply 0.67000 V, press '1'
Apply 0.09000 V, press '1'
Apply 0.32000 V, press '1'
Apply 0.04000 V, press '1'
Apply 0.14400 V, press '1'
Apply 0.01900 V, press '1'
Apply 0.06800 V, press '1'
Apply 0.00900 V, press '1'
Apply 0.03200 V, press '1'
Apply 0.00440 V, press '1'
Apply 0.01580 V, press '1'
Apply 0.00220 V, press '1'
Apply 0.00780 V, press '1'
Store Cal? (Y/N)

To save Voltage Calibration settings select Yes (send [**Y**] command / press Y)

This will be confirmed by

New Cal Stored

To cancel calibration - send [**N**] command (press N).

This will be confirmed by

- CANCELLED

Upon selecting (Y/N) the unit will return to the Main Calibration Menu will allowing you to start another calibration selection.

NOTE: At any Voltage calibration step the unit can report a calibration error by sending a message:

K-ERR-REMEASURE

Then the unit will request the calibration point value to remeasure. Check the connections and requested value before continuing.

f.   Resistance Measurement Calibration

From Main Calibration Menu

CALIBRATION MENU:
     V - VOLTAGE

> *R - RESISTANCE*
> *I - INSULATION*
> *S - STATUS*
> *C - CALIBRATION RESTORE to FACTORY*
> *E - EXIT*

Send [**R**] command (press R) to enter Resistance Calibration Mode. The Unit will respond with message below:

* RESISTANCE
*   Connect BLUE & RED to Resistance Standard
Press '1'

Connect Blue and Red type "A" test lead to (1Ω) Resistance Standard as instructed in paragraph **2.Resistance.** - Then press 1.

The Unit will respond with:

Set 1.00 Ohm, press '1
'

Connect to 1Ω Resistance Standard as instructed and press 1.

Continue as instructed with all the Resistance Standards.

Set 5.00 Ohm, press '1'
Set 10.00 Ohm, press '1'
Set 25.00 Ohm, press '1'
Set 50.00 Ohm, press '1'
Set 100.00 Ohm, press '1'
Set 300.00 Ohm, press '1'
Set 700.00 Ohm, press '1'
Store Cal? (Y/N)

Select Yes (send [**Y**] command / press Y) to Store Calibration or N to Cancel resistance calibration.
The Unit will respond with:

New Cal Stored

To cancel calibration - send [**N**] command (press N).
This will be confirmed by

 - CANCELLED

NOTE: At any Resistance calibration step the unit can report a calibration error by sending a message:

K-ERR-REMEASURE

Then the unit will request the calibration point value to remeasure. Check the connections and requested value before continuing.

g.   Insulation Measurement Calibration

WARNING: Risk of electric shock!   Starting CALIBRATION will output the test voltage 1000V on the yellow output port and illuminate the orange status LED.
Warning message will be sent to the serial port for each calibration value tested:

*** ! HIGH VOLTAGE WARNING ! 1000 VOLTS WILL BE APPLIED TO THE TEST LEADS!

Start Insulation Measurement Calibration from Main Calibration Menu

CALIBRATION MENU:
         V - VOLTAGE
         R - RESISTANCE
         I - INSULATION
         S - STATUS
         C - CALIBRATION RESTORE to FACTORY
         E - EXIT

Send [I] command (press I) to enter Insulation Resistance Calibration Mode. The Unit will respond with message below:

* INSULATION
*   Connect BLUE & YELLOW to MOhm Resistance Standards
Press '1'

As Instructed in paragraph **7.Insulation Resistance MΩ** :
Use ATP supplied custom version of Kelvin test leads **type B** (blue) terminated with 4mm banana plug and safety test lead (yellow) with banana adapter. - Then press 1.

Continue as instructed with all the Resistance Standards:

*** ! HIGH VOLTAGE WARNING ! - 1000V WILL BE APPLIED to TEST LEADS !
Set 10.00 MOhm, Press '1'
*** ! HIGH VOLTAGE WARNING ! - 1000V WILL BE APPLIED to TEST LEADS !

Set 100.00 MOhm, Press '1'
*** ! HIGH VOLTAGE WARNING ! - 1000V WILL BE APPLIED to TEST LEADS !
Set 700.00 MOhm, Press '1'

Select Yes (send [**Y**] command / press Y) to Store Calibration or Cancel Insulation Resistance calibration.
The Unit will respond with:

New Cal Stored

To cancel calibration - send [**N**] command (press N).
This will be confirmed by

- CANCELLED

Upon selecting (Y/N) the unit will return to the Main Calibration Menu will allowing you to start another calibration selection.

NOTE: At any Insulation Resistance calibration step the unit can report a calibration error by sending a message:

K-ERR-REMEASURE

Then the unit will request the calibration point value to remeasure. Check the connections and requested value before continuing.

h.   Calibration Status, Restore Factory Calibration and Exit Commands

From Main Calibration Menu

CALIBRATION MENU:
*   V - VOLTAGE*
*   R - RESISTANCE*
*   I - INSULATION*
*   S - STATUS*
*   C - CALIBRATION RESTORE to FACTORY*
*   E – EXIT*

1) For Calibration status check:

Send [**S**] command (press S) to show Calibration Status. The Unit will respond with one of the messages below:

CALIBRATION STATUS - DEFAULT
CALIBRATION STATUS - FACTORY
CALIBRATION STATUS - CUSTOM

DEFAULT status: The unit was never calibrated.

FACTORY status: The unit was calibrated during manufacturing process.

CUSTOM status: The unit was calibrated at the third party calibration facility.

2) To Restore Factory Calibration:

Send [**C**] command (press C). The Unit will respond with the message below:

*** *CALIBRATION RESTORE to FACTORY - Please Confirm Y/N*

Select Yes (send [**Y**] command / press Y) to Restore Calibration to Factory values.
The Unit will respond with:

- DONE
CALIBRATION STATUS - FACTORY

To cancel - send [**N**] command (press N).
This will be confirmed by

- CANCELLED
CALIBRATION STATUS - CUSTOM

3) To Exit Calibration mode

At any calibration stage and mode send [**E**] command (press E), or press [MENU] button on the Unit keypad

The Unit will respond with the message below:

Cal. Exit

Calibration Mode will be turned OFF, the Unit will return to Main Menu. All consequent measurement values will be adjusted to the saved calibration parameters.

7. Appendix A: Test Leads and Accessories

Figure20. Kelvin Test Leads type "A".

Figure 21. Kelvin Test Leads type "B".

Figure 22. Yellow safety test lead (1m) and safety plug to open banana plug adaptor.

Figure 23. Red test lead, L=8"(20cm) and banana plug to open spade lug adaptors.

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