TQG209A

Milliohmmeter Usage

TECHNICAL TRAINING

Start

TOYOTA

250717

INTRODUCTION

What Is a Milliohmmeter?

- A conventional DMM cannot measure the small resistance values that verify that electrical connections are clean and properly tightened.
- A milliohmmeter is a **PRECISION** instrument used to measure the resistance between each inter-phase winding connector (U–V, V–W, and W–U).

Reasons to Use a Milliohmmeter?

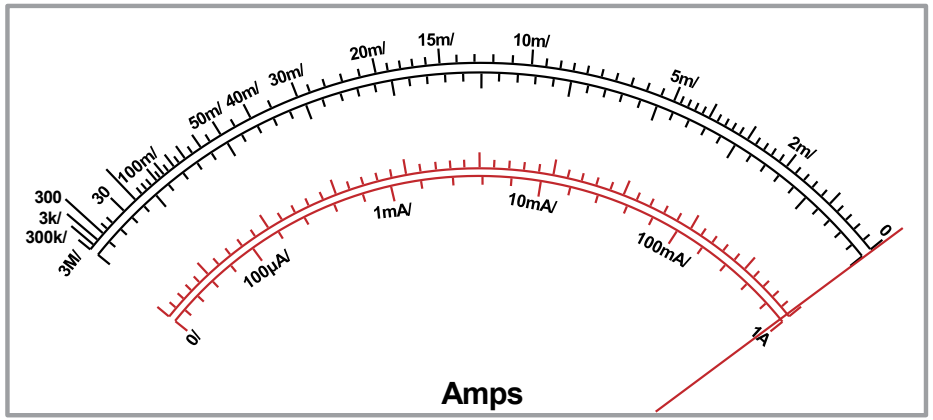
- Certain DTCs (such as P0A7A73) require that the continuity and integrity of wires, cables or windings be measured with an extremely accurate milliohmmeter (typically is less than 1 Ω). 1 mΩ = 1/1000th ohm.

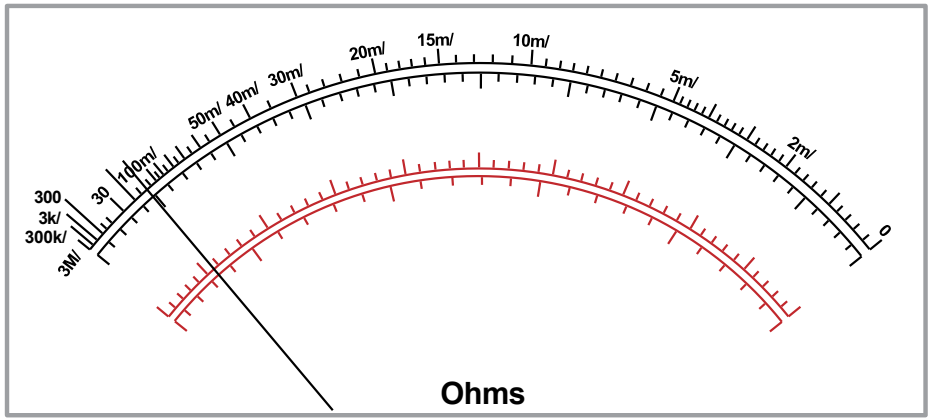
Milliohmmeter Precision

- If the motor/generator (MG) cable temperature is high, the resistance will vary significantly from the specification. So, be sure to measure the resistance at least 8 hours after READY OFF.
- Specifications are based on 68° F (20° C) temperature, and the Repair Manual includes a formula to correct the resistance for temperature. The Milliohm Meter Kit includes a temperature sensor with a compensation circuit. When the sensor is attached and 'TC' enabled, the meter can correct the readings to the specified temperature (e.g. 20° C default).

SAFETY

- Milliohmmeters (mΩ meters) use a potentially dangerous amount of current (amps) to measure very small amounts of resistance (ohms). Always follow all appropriate safety precautions and use the appropriate PPE. Refer to the meter's User Manual for specific cautions and warnings.





- Always use the Repair Manual to ensure that the proper pre-conditions are met (READY OFF, service plug removed etc.)
- Remember that when measuring inside the inverter, the capacitor(s) need time to dissipate electricity
- Also remember that while the components being tested will be 'de-energized', the HV battery assembly is always a live (energized) high voltage source & must be handled carefully

⚠	**Caution!**	The milliohmmeter is not intended for use on a live high voltage circuit as the protection circuitry is rated up to 70 V DC

- The meter's User Manual from the test equipment manufacturer is an excellent resource for understanding where imminently hazardous or potentially hazardous situations may result in death or serious injury to the operator. Make sure that you review the Danger, Warning & Caution information before using the test equipment.

MEASUREMENT UNITS & RANGES

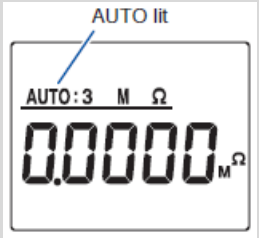
While it may be relatively easy to remember 'little m' is milliohm (mΩ) and 'big M' is Megohm (MΩ), some meters may auto-range to another scale. The Hioki RM3548 included in the Milliohm Meter Kit will auto-range but it is important to know the range indicators on the meter being used before determining if a component is within specification.

Units	Symbol	Description	Example
Micro-ohms	μΩ	ohms/1,000,000	165,000 μΩ is equivalent to 165 mΩ
milliohms	mΩ	ohms/1,000	39 mΩ is equivalent to 0.039 ohms
Ohms	Ω	–	–
kilohms	kΩ	Ohms * 1,000	21 kΩ is equivalent to 21,000 ohms
Megohms	MΩ	Ohms * 1 million	10 MΩ is equivalent to 10,000,000 ohms
Gigohms	GΩ	Ohms * 1,000 million	0.55 GΩ is equivalent to 550 MΩ

Hint!

Use the AUTO key to switch to the auto range. (The default setting is AUTO.)

Refer to the RM3548 User Manual if manual range settings are needed.

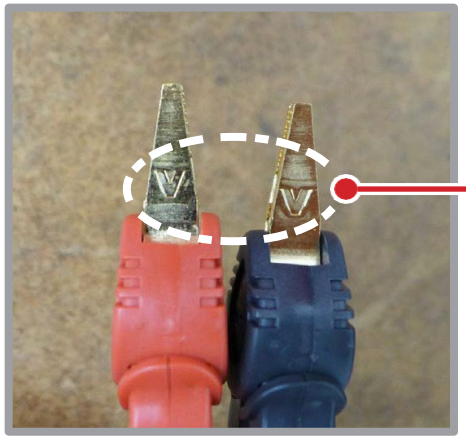


METER LEADS

A milliohmmeter is a tool that measures very small amounts of resistance, called milliohms. To do this, it sends a small amount of electricity through the object being measured and checks how much the electricity drops. This helps determine the resistance.

When measuring tiny resistances, using just two wires can cause mistakes. That's why good milliohmmeters use four wires. Two wires send the electricity (these are called **Source A** and **Source B**), and the other two wires measure the drop in electricity (these are called **Sense A** and **Sense B**).
In the Milliohm Meter Kit, the correct wires can be identified by looking for arrowheads on the plastic parts and a "V" on the metal parts of the Sense wires (as shown below).

- An arrowhead indented on the test lead jack and an arrowhead on the meter show the alignment marks to keep ‘Sense’ polarity correct.
- Since the jack can be installed backward, making sure that the jack is inserted as shown is important for reliable measurements.



“V” stamped into the ‘Sense’ side of the alligator clip jaws.

Hint!

- Although the Repair Manual may not specify a time period for milli-ohm testing, a best practice is to always use the same duration each time (e.g. 1 minute each & every time). Continue to test until the reading stabilizes. Note that if the test leads are not securely attached to the measurement target, relocate them more securely. For example, if the source terminal is secure but the sense terminal has a bad contact, an unstable reading may result.
- Zero adjustment is not required before starting measurement.

TEMPERATURE CORRECTION

Although you will likely use the Hioki RM3548 meter with the automatic temperature sensor compensation circuit enabled & the default set to 20° C, it is important to be aware of why temperature correction is needed.

- The resistance of the copper wire used in the MG windings changes with the temperature of the wire. When temperature goes up, resistance goes up. When the MG cable temperature is high, the resistance will vary from the specification. The repair manual recommends that measurements occur at least 8 hours after READY OFF.
- To make precise measurements of the very low resistance motor/generator windings all measurements must be temperature compensated. The resistance specifications in the Repair Manual are specified at 20° C (68° F), which is shown as R20.
- The formula for temperature compensation is:
  - R20 = Rt/{1+0.00393 X (T-20)} where **Rt** is the actual measurement recorded, **0.00393** is the correction factor for copper, **T** is the temperature of the windings in ° C and **20** is 20° C.
  - The ideal method would be to let the measurement target (MG windings) and the meter soak in the same 20° C (68° F) room for 8 hours.
  - The practical method is to use GTS+ data to measure the MG temperature and calculate R20.

Hint!

- Temperature compensation is very important when the temperature of a vehicle or component is much different from the shop's temperature. If you put the temperature sensor on a hot or cold surface, it might cause an error in the temperature correction.
- Also note that the operating range of the Hioki RM3548 is between 32°F to 104°F with a relative humidity of less than 80%.
- It is also important to keep the test leads & temperature sensor clean to ensure that your measurements will have the accuracy needed.

TEMPERATURE CORRECTION

Initial Setting

The automatic Temperature Correction (TC) function on the Hioki RM3548 meter should be set to compensate for thermal effects. Once this function is set, it will remain active with future use.

The characters “TC” on the display above circled in green, indicate that the Temperature Correction function “TC” has been set & is currently active.

The values that are ‘pre-populated’ in the display respectively represent

- a reference temperature of 20° C
- a temperature coefficient of 3930 at reference temperature.

These values are the same as the formula for R20 given in the Repair Manual.

To get to this screen & enable automatic temperature correction, **quickly** press the TC/ΔT button (shown below).

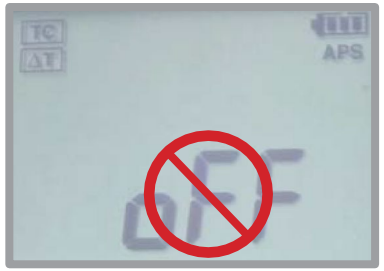
The display will then toggle between three positions (TC, ΔT & off).

Once TC select is active, the 1st zero in the main display 020.0 will begin to flash.

Use the > or < to scroll so that the last zero of 3930 on the last row of the display flashes.

Press enter to store the values into the meter's memory.

Temperature Correction function TC has been set & is now complete (image above).



When set to off, both TC & ΔT functions are disabled (image above).

EXAMPLE MEASUREMENTS

Hioki meter Set-up

Temp. Sensor terminal

Attached Z2002 Temperature Sensor shown below

Power key - press 1 sec

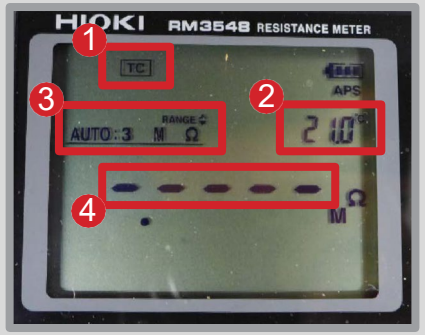
Display active *

*If the display is inactive after pressing & holding the Power key for 1 second, replace the fuse. Although the kit comes with a spare fuse, a best practice is to immediately purchase a new fuse if the spare was used so that a replacement is on-hand. RM3548 User Manual Reference: F2AH250 V - a fast-blow ceramic type.

**Refer to the RM3548 User Manual if manual range settings are needed.

Ready to Measure

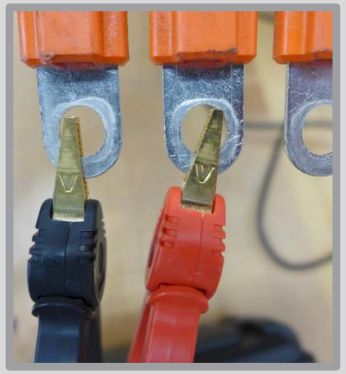
1. Top left side display shows that the Temperature Correction (TC) is active (note, default value is ON & set to 20° C).



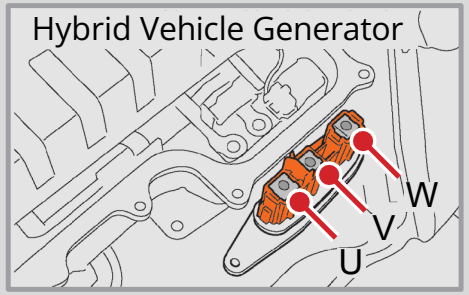
2. Temperature shown on the right side of the display shows the shop temperature at 21.0° C.
3. Although the range shows 3MΩ, 'AUTO is ON & the meter will automatically range to the appropriate range (mΩ) when measuring**.
4. When the leads are connected, the characters "----" will be replaced with an actual resistance measurement.

Hint! If your selection of key-stroke moves the display away from a ready to measure condition, simply press ESC to go back.

EXAMPLE MEASUREMENTS (cont.)

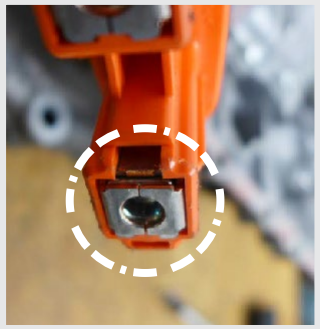


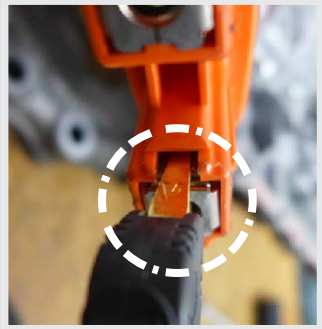
Following Standard Operating Procedures, like measuring exposed terminals the same way every time, gives consistent results when using a precise milliohmmeter. Measuring between Phase U & Phase V terminals shown above.



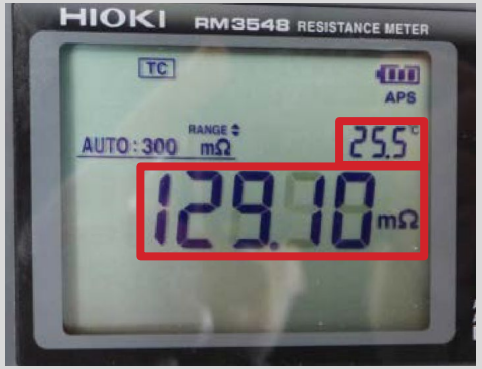
When measuring terminals covered by an orange colored plastic shield, there might be limited access and the milliohmmeter clips may not fully contact the terminals.*

Only one of the four corners of the terminal provides access for consistently clipping on the milliohmmeter leads (as shown below).





*If the readings are not stable, installing bolts in the terminals may be an alternative.

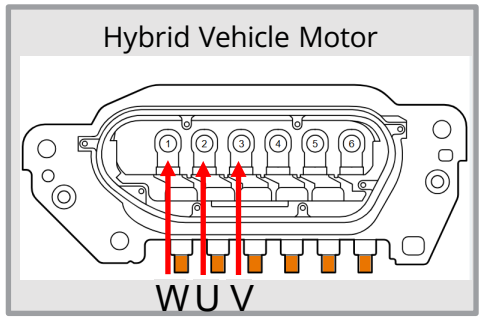


In the example above, the display shows;

- a measured value of 129.1 mΩ between Phase U & Phase V terminals on this component,
- that the current ambient temperature in this shop is 25.5 °C
- that the Temperature Correction (TC) function is active & that the meter has selecting a 300 mΩ range with it's 'AUTO' function

EXAMPLE 1 – 2024 PRIUS MOTOR (MG2)

Temperature compensated measurements were taken at MG2 terminals of the motor cable:



Tester connection	Meter Reading	Spec.
W to U	**62.0 mΩ**	55.1 to 62.3 mΩ
U to V	**62.1 mΩ**	55.1 to 62.6 mΩ
V to W	**62.3 mΩ**	55.3 to 62.7 mΩ

Difference	Calculated Δ	Specified Condition
62.0 (W to U) – **62.1** (U to V)	**-0.1 mΩ Pass**	-1.4 to 1.2 mΩ
62.1(U to V) – **62.3** (V to W)	**-0.2 mΩ Pass**	-1.5 to 1.2 mΩ
62.3 (V to W) – **62.0** (W to U)	**0.3 mΩ Pass**	-1.1 to 1.6 mΩ

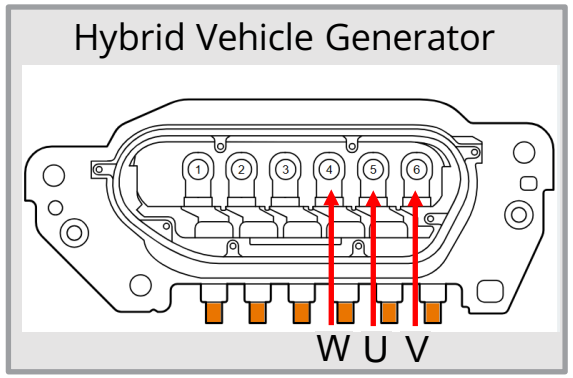
In the example above, this vehicle passes for both Specification as well as for difference calculation between phases of MG2.

Hint!

- You can find an interphase short by pushing the vehicle in neutral with the ignition off. The short makes the motor hard to turn, so the vehicle will be hard to push or you might feel a shake in the driveline.
- Disconnecting the inverter with converter assembly helps test only the motor when pushing the vehicle. If the vehicle stops shaking, the problem is in the inverter with converter assembly. If the shaking continues, the problem is in the transaxle.

EXAMPLE 2 – 2024 PRIUS GENERATOR (MG1)

Temperature compensated measurements were taken at MG1 terminals of the motor cable:



Tester connection	Meter Reading	Spec.
W to U	**46.3 mΩ**	41.5 to 47.9 mΩ
U to V	**44.7 mΩ**	41.6 to 48.0 mΩ
V to W	**46.8 mΩ**	41.8 to 48.1mΩ

Difference	Calculated Δ	Specified Condition
46.3 (W to U) - **44.7** (U to V)	**1.6 mΩ Fail**	-1.2 to 1.0 mΩ
44.7 (U to V) - **46.8** (V to W)	**-2.1 mΩ Fail**	-1.2 to 0.9 mΩ
46.8 (V to W) - **46.3** (W to U)	**0.5 mΩ Pass**	-0.8 to 1.3 mΩ

In the example above, although this vehicle has passed Specification it does not pass for difference calculation between phases of MG1.