

Application Note

Connection of the 1865 and 1865 Plus Megohmmeter to the 1865-11 Resistivity Test Cell

The following items are necessary to connect the 1865-11 Resistivity Test Cell to the 1865 and 1865 Plus Megohmmeter. Use the listed cable assembly or the provided cable assembly rather than miscellaneous adapters to permit proper correction of cable and lessen related error and system leakage. Use only the fixture that corresponds to the test instrument.

1. 1865-11 Test Cell
2. 1689-7003-00 BNC to Banana Adapter (Pomona 4684)

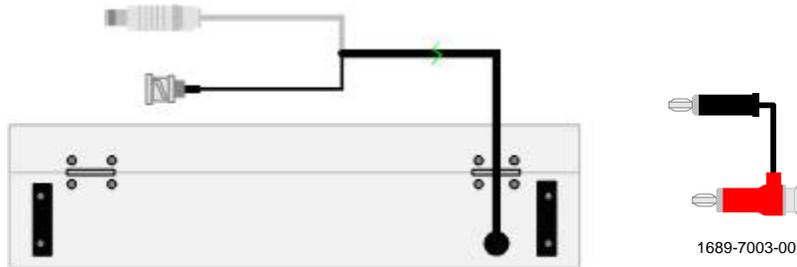


Figure 1: Rear View of 1865-11 Test Cell

The Resistivity Cell Fixture reads resistance only and with unique formulas it will convert resistance into Surface Resistivity and Volume Resistivity. Measuring resistance through the fixture is theoretically the same concept as measuring without the fixture. Volume Resistance is the **Resistance** through the chosen material where as Surface Resistance is the **Resistance** on the surface of the chosen material. This Resistivity Fixture will allow a stable and accurate measurement despite external radiation/ leakages.

How to Connect the Fixture

Make connections carefully as illustrated in Figure 2. It is important to follow these directions exactly to avoid improper measuring techniques and damage to the test fixture. Proper knowledge of material and fixture allows the DUT to be measured accurately while taking into account correct polarity. **To connect the fixture to an 1865 Megohmmeter:**

1. First remove any DUT/Cables from the 1865 instrument and 1865-11 fixture.
2. Carefully insert the 1865-11 BNC Male into the 1689-7003-00 adapter.
3. Insert the adapter into the (-) banana jack on the 1865 instrument.
4. Insert its pigtail banana plug into the **GUARD** banana jack on the 1865 instrument.
5. Insert the 1865-11 banana plug into the banana jack labeled (+) on the 1865 instrument.
6. For accurate measurements perform a zero each time the voltage is changed

Figure 2 illustrates the connection of the 1865-11 Test Cell to an 1865 Megohmmeter.

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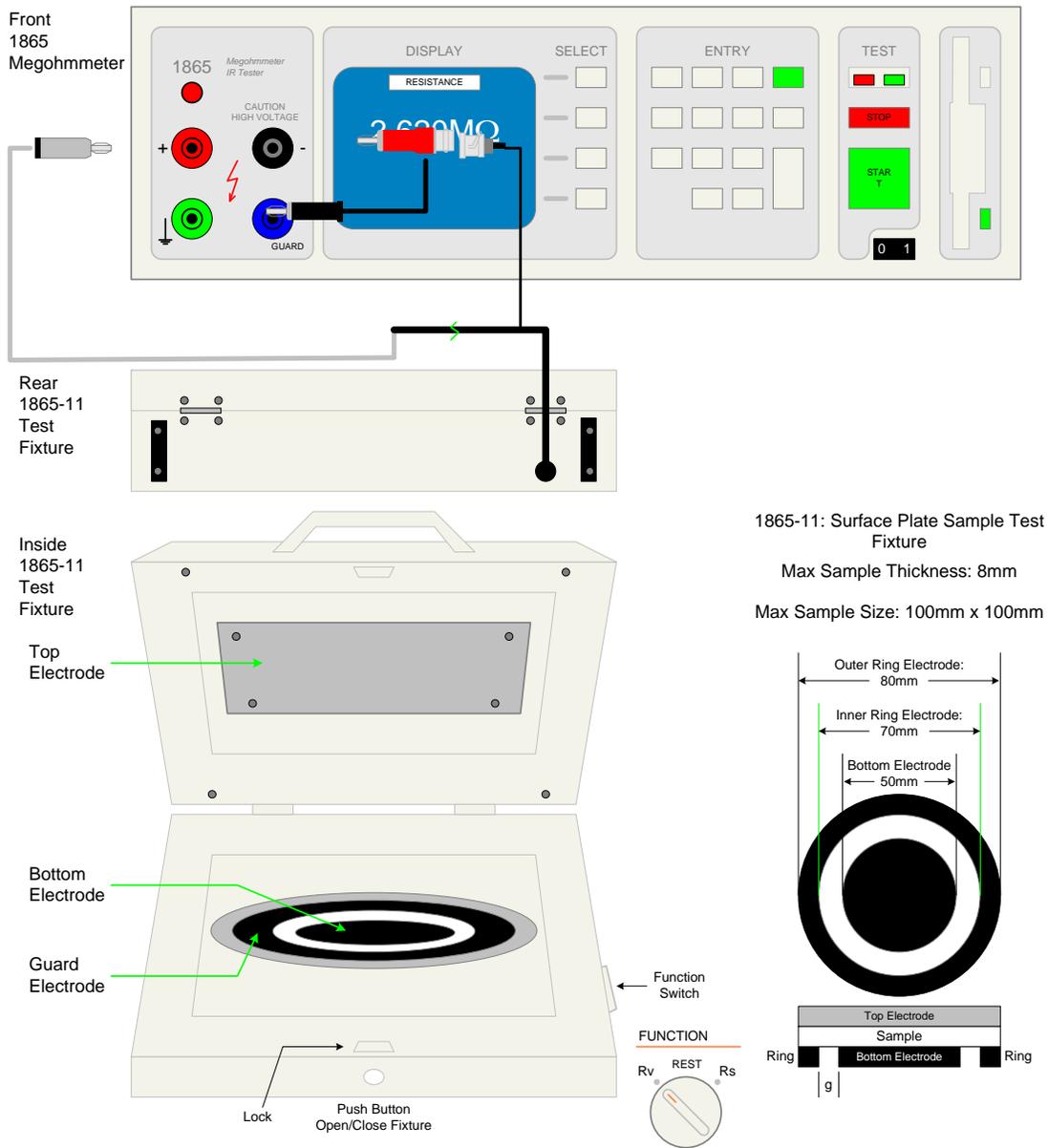


Figure 2: Connection of an 1865-11 Test Cell to an 1865 Megohmmeter

Application Note

Performing a Zero

A zero should be performed each time the voltage is changed or during initial setup, to minimize errors in the measurement due to leakage in the 1865-11 Fixture and cables.

Make sure the 1865-11 is connected to the 1865+ per Figure 2.

Open the fixture and set the switch to the Rv.

On the 1865+ go to the utilities menu and select zero. When prompted press the start button and verify the zero process completes without an error.

This completes the zero process.

Theory of Operation

WARNING

Do not open the fixture while voltage is present at its output. Any material that holds charge may be hazardous until completely discharged.

There are two methods of reading resistance yet each is used very differently. The first and most commonly used method for reading high resistance (megohm range) is the constant voltage method. In this method voltage is applied in series with the resistor (or this case an insulator) and a current meter. This will allow a known high voltage to pass through the resistor while the current meter detects the amount of current (electrons) that passes through the barrier (A.K.A resistor or insulator). Using Ohm's Law for resistance $R = V/I$ the resistance of the insulation can be calculated or in today's world measured.

The second method commonly used is a conductivity test. The conductivity test applies a known measured current through the resistor and measures the voltage drop across the resistance. This method has been used at a high resistance $<10^{14}$ but the risk of danger is greater due to the higher current being applied and the voltage resulting from the resistance. This method of high resistance measurement greater than a gigohm can be very costly when it comes to equipment. Ohm's Law for resistance again applies here.

The measurement accuracy of both methods is affected by the surrounding electromagnetic environment (radiation). When measuring high resistance charging of the insulation is required to offset radiation effects. This occurs naturally when an object with a high concentration of electrons is moved near an object with no or a diminutive amount of electrons (or vice versa). Any slight electron change can result in noisy readings or wrong readings. One method to avoid noise is to use a Guard, Shield, or Insulation.

Application Note

Surface Resistivity

Surface **Resistance** (also known as sheet resistance) is defined as the electrical resistance between two points or electrodes on one side of a material. This resistance is calculated using the simplified version of Ohm's law.

$R_s = V/I_s$ where:

R_s = Surface Resistance

I_s = Surface Current

V = Applied Voltage

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Surface **Resistivity** is defined as the electrical resistance between two points or electrodes on one side of a material with respect to the area of a “flat” annulus. In other words the megohmmeter reads the current that skids or travels on the surface of the material with respect to a distance. The surface resistivity can be calculated in two ways, hard or easy. The hard way means substituting the 1865-11 test cell dimensions into formulas for Current Density and Surface Current Density. Pull out the old Calculus and Physics books and convert these formulas for a circular electrode configuration.

The easy way is finding the area of two different circles and subtracting them. The space between two concentric objects is known as the annulus. This resistivity is calculated using the modified version of Ohm’s law where $\rho_s = R_s \times L \times W$ for a quadrilateral or in the case of the QuadTech Resistivity Test Cell, an annulus.

$$\rho_s = (R_s \times A) \Omega \cdot \text{cm}^2, \text{ where } A = \pi (a^2 - b^2) \text{ and } a > b.$$
$$a = 3.5 \text{ cm radii for the outer electrode}$$
$$b = 2.5 \text{ cm radii for the inner electrode}$$

Supplementing values into the equation it gives a constant value of 18.84955 cm^2 . Therefore, if the measuring device reads $2.20 \text{ M}\Omega$ for the R_s value, multiply that value by 18.84955 cm^2 .

$$\rho_s = R_s \times A = 2.20 \text{ M}\Omega \times 18.84955 \text{ cm}^2 = 41.46901 \text{ M}\Omega \cdot \text{cm}^2$$

According to the ASTM D257 – 99 (2005) standard, the formula for Surface Resistivity of a circular electrode is:

$$\rho_s = R_s \times P/g (\Omega) \text{ where: } P = \pi (D_o)$$
$$D_o = (D1+D2)/2$$
$$D1 = \text{diameter of inner electrode}$$
$$D2 = \text{diameter of outer electrode}$$
$$g = \text{is the distance between them}$$

Note: g can be factored out only if the thickness of the sample is much smaller than g .
i.e.: $t \ll g \sim < 8\text{mm}$. 8mm is the max thickness of the QuadTech Resistivity Test Cell.

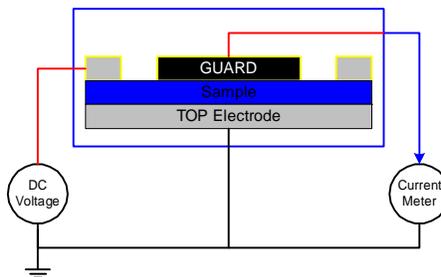


Figure 3: Surface Resistance

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Volume Resistivity

Volume **Resistance** is defined as the electrical resistance between opposite faces of an insulating material. This resistance is calculated using the simplified version of Ohm's law.

$R_v = V/I_v$ where:
 R_v = Volume Resistance
 I_v = Volume Current
 V = Applied Voltage

Volume **Resistivity** is defined as the electrical resistance through a specific volume on one side of a material to the opposite side. In other words the measured resistance is multiplied by the cross sectional area and divided by the trajectory path the current must travel. This resistivity is calculated using the modified version of Ohm's law where $\rho = [R_v \times L \times W]/t$ for a quadrilateral electrode or in the case of the QuadTech Resistivity Cell, a cylinder.

$\rho = [R_v \times A]/t$ ($\Omega \cdot \text{cm}$) where: $A = \pi (b^2)$ or $\pi (D1^2)/4$
 $b = 2.5$ cm radii for the inner electrode
 $D1 = 5$ cm diameter of inner electrode
 $t =$ thickness of sample; needs to be $\ll 8$ mm

Supplementing values into the equation it gives a constant value of 19.634554cm^2 . Therefore, if the measuring device reads $20.20 \text{M}\Omega$ for the R_v value and the sample has a thickness of 3.3mm (0.33cm), then multiply that value by 19.634554cm^2 .

$\rho = [R_v \times A]/t = [20.20 \text{M}\Omega \times 19.634554 \text{cm}^2]/.33 \text{cm} = 1.201872 \text{G}\Omega \cdot \text{cm}$

According to the ASTM D257 – 99 (2005) standard, the formula for Volume Resistivity of a circular electrode is:

$\rho = [R_v \times A]/t$ ($\Omega\text{-cm}$) where: $A = [\pi (D1+g)^2]/4$
 $D1 =$ diameter of inner electrode
 $D2 =$ diameter of outer electrode
 $g =$ is the distance between inner & outer electrode

Note: g can be factored out only if the thickness of the sample is much smaller than g .
i.e.: $t \ll g \sim < 8 \text{mm}$. 8mm is the maximum thickness of the QuadTech Resistivity Cell.

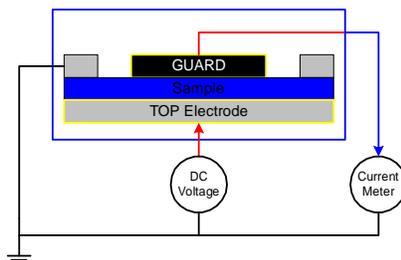


Figure 4: Volume Resistance

Application Note

Cleaning the Resistivity Test Fixture

Before touching any of the electrodes disconnect all wires from the measuring device. Clean the remote test fixture only if the previously tested material left some type of remnant or residue on any of the electrodes. Do not remove the rubber conductor unless it comes out by itself where it would then need to be cleaned and replaced as is.

For removal of dirt and wax use warm clean water first with a lint free cloth, if residue is still visible use mild detergent diluted in water to wipe down residue. If all else fails use isopropyl alcohol on a Q-tip to soften and remove dirt from selected areas on the electrodes. Do not douse the electrodes with isopropyl alcohol – use only a small amount on a Q-tip. Dry thoroughly with a lint free cloth before using.



Figure 5: 1865 Plus Megohmmeter and 1865-11 Test Cell