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APPLICATION NOTE

Connection of the 1864 Megohmmeter to the 1864-11 Resistivity Test Cell

The following items are necessary to connect the 1864-11 Resistivity Test Cell to the 1864 Megohmmeter. Use the listed cable assembly or the provide 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. 1864-11 Test Cell
2. 1689-7003-00 BNC adapter

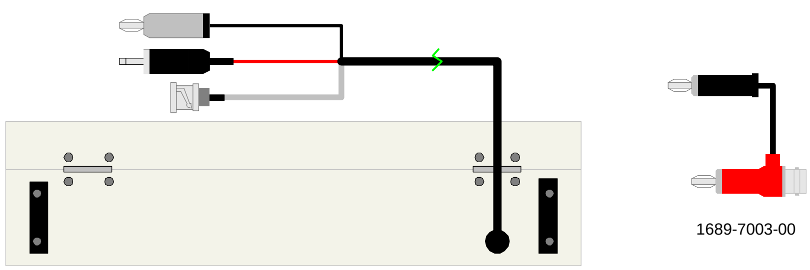

Figure 1: Rear View of 1864-11 Test Cell

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 1864 Megohmmeter:**

1. First remove any DUT/Cables from the 1864 instrument and 1864-11 fixture.
2. Carefully insert the 1864-11 BNC Male into the 1689-7003-00 adapter.
3. Insert the adapter into the **(+)** banana jack on the 1864 instrument.
4. Insert its pigtail banana plug into the **GUARD** banana jack on the 1864 instrument.

5. Insert the 1864-11 banana plug into the banana jack labeled **(-)** on the 1864 instrument**.**
6. For accurate measurements perform a zero each time the voltage is changed and each time the Rs/Rv switch setting on the fixture is changed. Refer to Figure 2.

Figure 2 illustrates the connection of the 1864-11 Test Cell to an 1864 Megohmmeter.

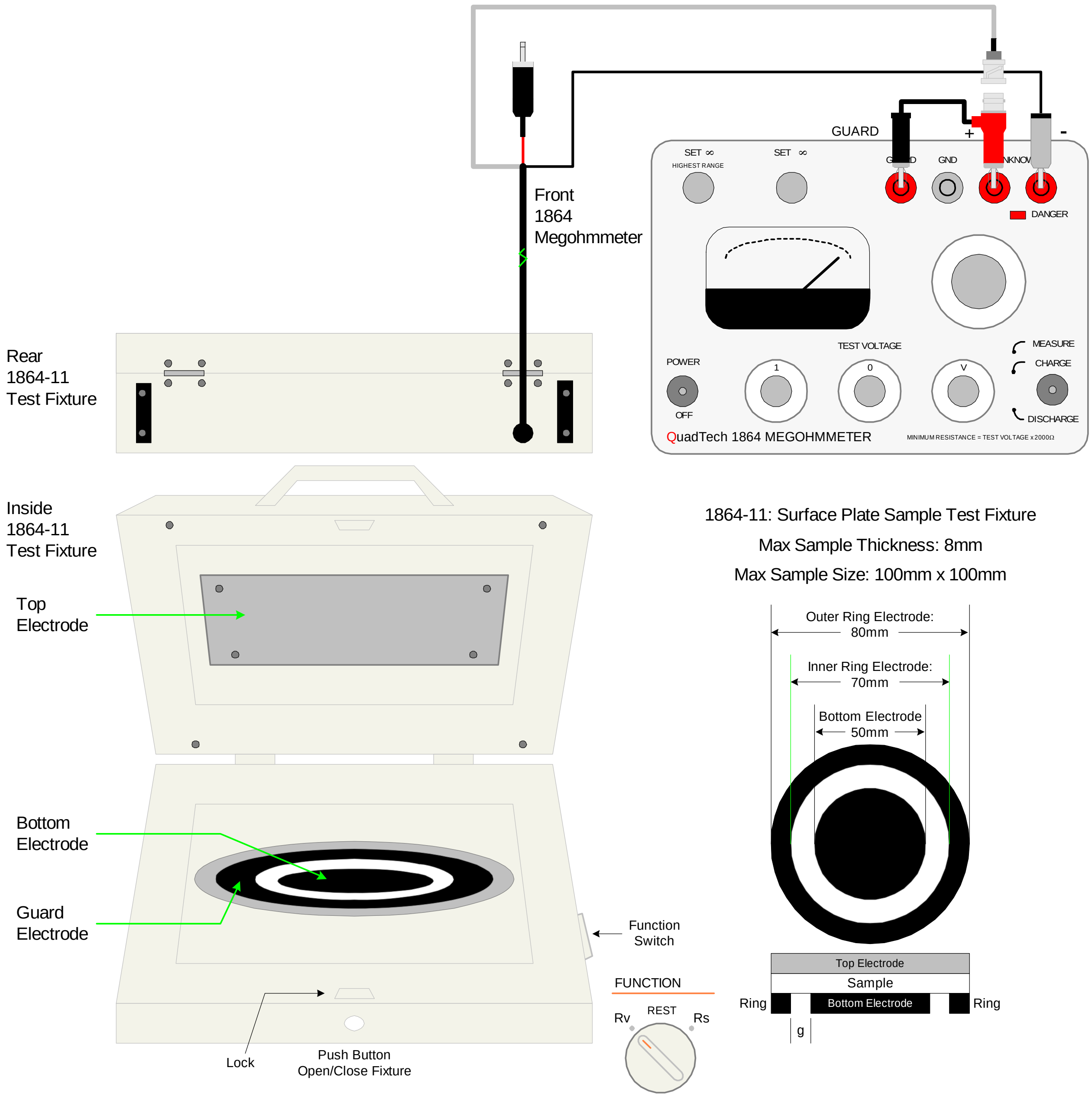

Figure 2: Connection of an 1864-11 Test Cell to an 1864 Megohmmeter

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Theory of Operation

WARNING
To minimize electric shock hazard use the test cell interlock to prevent the operator from opening 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 both are used very differently. The first and most commonly used method for reading high resistance (mega-ohm 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 giga-ohm 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 vise 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.

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.

Rs = V/Is where:	Rs = Surface Resistance
	Is = 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 1864-11 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 is 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 $\rho s = Rs \times L \times W$ for a quadrilateral or in the case of the IET Labs Resistivity Test Cell, an annulus.

$\rho s = Rs \times A\ (\Omega)$ where:
$A = \pi (a^2 - b^2)$ and $a > b$.
a = 3.5 cm radii for the outer electrode
b = 2.5 cm radii for the inner electrode

Supplementing values into the equation it gives a constant value of 18.84955. Therefore, if the measuring device reads 2.20 MΩ for the Rs value then multiply that value by 18.84955.

$\rho s = Rs \times A = 2.20\ M\Omega \times 18.84955\ cm = 41.46901\ M\Omega$

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

$\rho s = Rs \times P/g\ (\Omega)$ where:
$P = \pi (D_o)$
$D_o = (D1+D2)/2$
D1= diameter of inner electrode
D2= diameter of outer electrode
g = 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<<g ~ <8mm. 8mm is the max thickness of the IET Labs Resistivity Test Cell.

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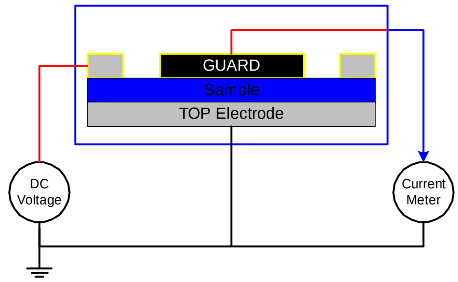

Figure 3: Surface Resistance

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.

Rv = V/Iv where: Rv = Volume Resistance
Iv = 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 ρ = [Rv x L x W]/t for a quadrilateral electrode or in the case of the IET Labs Resistivity Cell, a cylinder.

ρ = [Rv x A]/t (Ω-cm) where: Av = π (b^2)/t or π ($D1^2$)/4t
b = 2.5 cm radii for the inner electrode
D1 = 5 cm diameter of inner electrode
t = thickness of sample; needs to be << 8mm

Supplementing values into the equation it gives a constant value of 19.634554cm^2/t (cm). Therefore, if the measuring device reads 20.20 MΩ for the Rv value and the sample has a thickness of 3mm (.33cm) then multiply that value by 19.634554cm^2/t.

ρ = [Rv x A]/t = [20.20 MΩ x 19.634554]/.33cm = 1.201872TΩ-cm

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

ρ = [Rv x A]/t (Ω-cm) where: A = [π $(D1+g)^2$]/4
D1= diameter of inner electrode
D2= diameter of outer electrode
g = is the distance between inner & outer electrode

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Note: g can be factored out only if the thickness of the sample is much smaller than g.
i.e.: t<<g ~ <8mm. 8mm is the maximum thickness of the IET Labs Resistivity Cell.

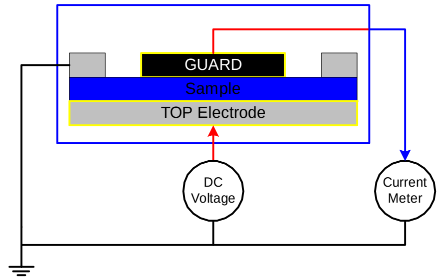

Figure 4: Volume Resistance

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: 1864 Megohmmeter and 1864-11 Test Cell

For complete product specifications on the 1864 Megohmmeter and Test Cell or any of IET Labs's products, visit us at http://www.ietlabs.com/ all us at 1-800-899-8438 mail your questions to sales@ietlabs.com The information presented in this application note is subject to change and is intended for general information only.