ModuLab XM MTS

DUMMY CELL TEST

HTTP://WWW.AMETEKSI.COM/SUPPORT-CENTER/SOLARTRON-ANALYTICAL/USER-TESTS



Why Run a Dummy Cell Test?

Before beginning a dummy cell test, please ensure that the Solartron Analytical ModuLab XM MTS is connected and communicating with your PC. If you are unsure or need assistance with this, please refer to AMETEK®/ Solartron at: http://www.ameteksi.com/support-center/solartron-analytical/user-tests.

Additionally, it is imperative that the software and firmware corresponding to the Solartron Analytical ModuLab XM MTS, XM Studio MTS, be downloaded onto the connected PC. This can be found at: http://www.ameteksi.com/products/software/xm-studio-software.

When working with the Solartron Analytical ModuLab XM MTS, as with all Solartron Analytical equipment, it is important to perform a dummy cell test to ensure that the apparatus is working properly. Running a dummy cell test with known parameters and expected results can help to determine whether a ModuLab XM MTS that is supplying questionable data requires repair or calibration.

A properly working potentiostat/FRA that outputs questionable data can indicate any of the following:

- Faulty ethernet connection
- Noise interference (could be from power outlet, or from pumps, heaters, etc.)
- Bad connection to the experiment (i.e.-something may have disconnected mid-experiment)
- Broken or corroded cables
- AC voltage level is set too low
- Insufficient integration time during the experiment
- Measurements taken outside the specified range of the apparatus

Disqualifying the notion that the ModuLab XM MTS is responsible is a crucial step to determining the cause of erroneous data. Running a successful dummy cell test and obtaining experimental results that match expected results indicates that the potentiostat/FRA is working correctly under the software configuration.

The following is a guide which outlines the steps of performing two dummy cell experiments, “triangular sweep IV characterization” to test the MAT module that runs time domain (DC) tests, and impedance to test the FRA. Triangular sweep, along with an outlined experiment will be discussed first in this document, followed by an overview of impedance and steps for taking this measurement.

Background-Triangular Sweep I-V Characterization

Each Solartron Analytical ModuLab XM MTS includes a test cell labeled "12961 Dielectric Test Module" that may be used for AC test. In order to perform a DC test, the use of a standard resistor, 1.8kΩ in this example, is recommended (Figure 1).

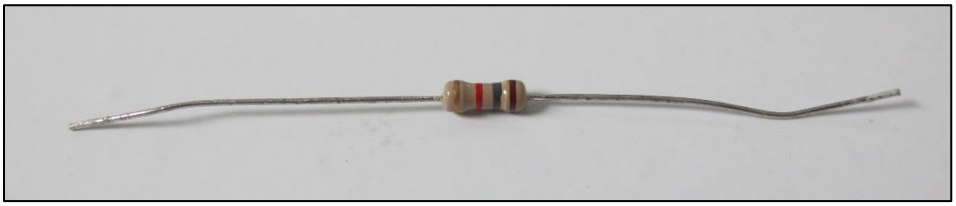


Figure 1

The dummy cell test can be performed with any predictable experiment. One of the easiest tests to evaluate equipment using DC circuits is triangular sweep. In triangular sweep, the potential is ramped across the dummy cell. When the potential reaches a set value, it is ramped in the opposite direction. During this time, the system measures voltage and current through the resistor and outputs the data. Typically, this experiment is run for several cycles (Figure 2).

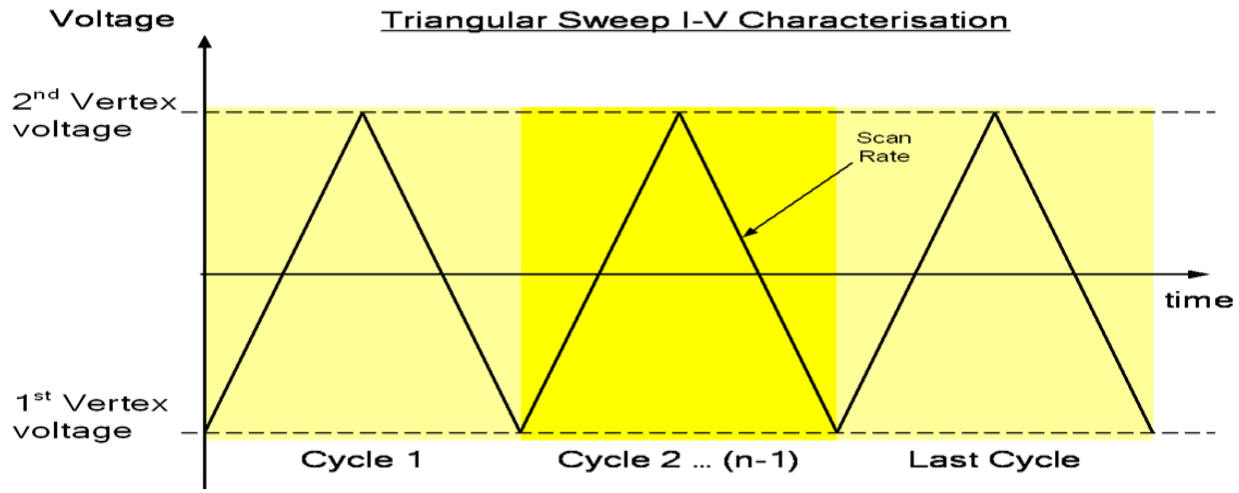


Figure 2

Triangular sweep is useful for a dummy cell test, due to the predictability of the cell behavior and ease of calculation. The following equation, also referred to as Ohm's Law, is used to approximate cell behavior, where V=potential, measured in volts; I=current, measured in amps; and R=resistance, measured in Ohms:

$$V=IR \qquad \textit{Eqn 1 (Ohm's Law)}$$

Experimental Setup-Physical Equipment-Cyclic Voltammetry

To set up a triangular sweep I-V characterization experiment in XM Studio, connect BNC cables between the Solartron Analytical ModuLab XM MTS and a standard resistor, 1.8kΩ in this example. One cable should connect from "Gen" to one end of the resistor, and the other cable should connect "I" to the opposite end of the resistor (Figure 3) using two BNC coaxial connector adaptors with alligator clips.

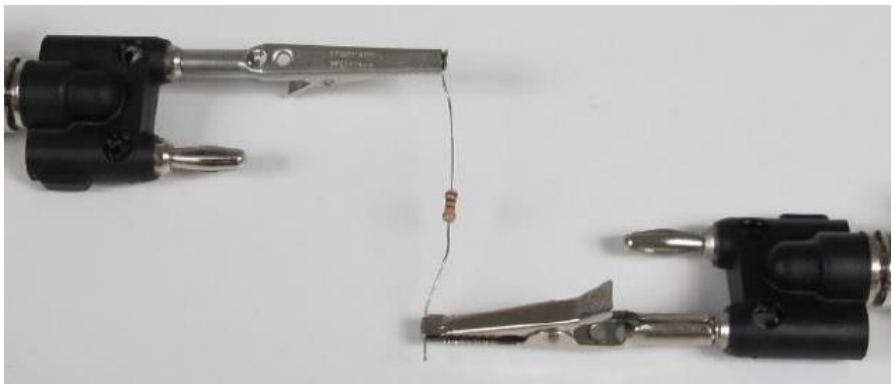


Figure 3

It should be noted that the alligator clip should be connected on the Pin side, not the ground side, of the BNC coaxial connector adaptors (Figure 4).

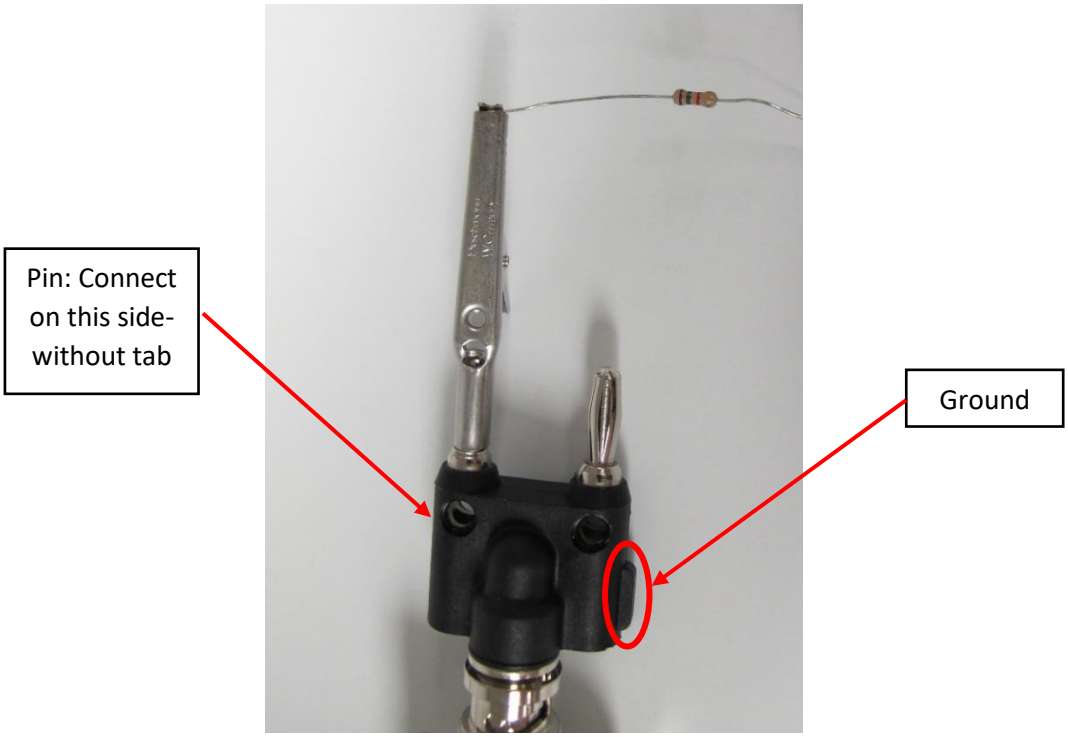


Figure 4

Experimental Setup & Run-Software-Triangular Sweep

Before beginning a new experiment, ensure that the ModuLab XM MTS is connected and communicating with the PC in use. For more information regarding connections and communications, please refer to the ModuLab XM MTS Connections/Communications document at http://ameteksi.com/support-center/solartron-analytical/user-tests.

Step 1: Select the "Project" Tab (Figure 5).

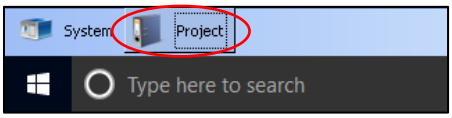


Figure 5

Step 2: Click "+ Project", "Experiment 1". A list of modules that are present should display highlighted in green (Figure 6).

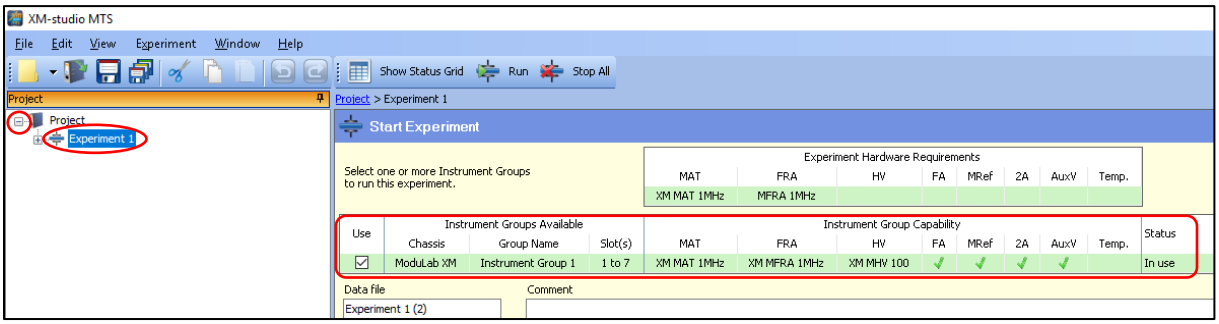


Figure 6

Step 3: Click "+ Experiment 1", then "Setup" (Figure 7). Select "Mat only" from the "Instrument configuration:" drop down box. **NOTE:** When choosing from the "Instrument configuration" dropdown menu, FRA will *not* be listed even if it really is present. The photo always shows the FRA to be present even if not fitted. For this triangular sweep test, the FRA is not used. The actual components used within the chassis for the selected "Instrument configuration" is reflected in the photo that displays on the right-hand portion of the software screen (Figure 7).

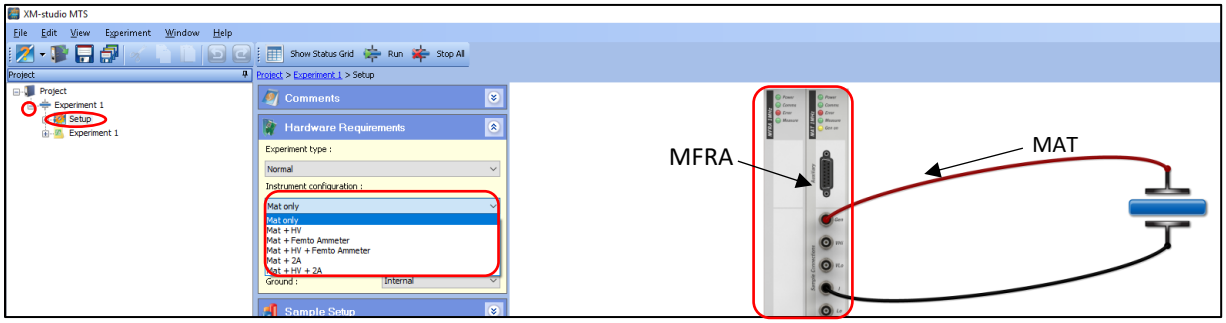


Figure 7

Step 4: Right click on “Setup”. Select “Add New”, then “Step” (Figure 8).

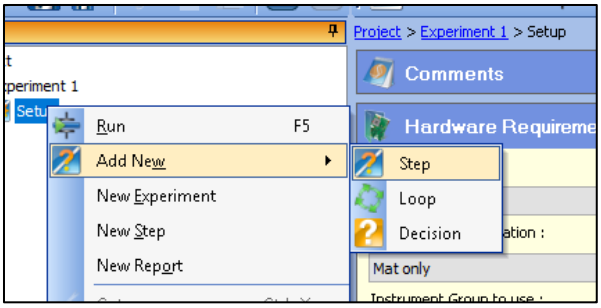


Figure 8

Step 5: The following menu will appear. Select “Voltage Waveforms (DC)” (Figure 9).

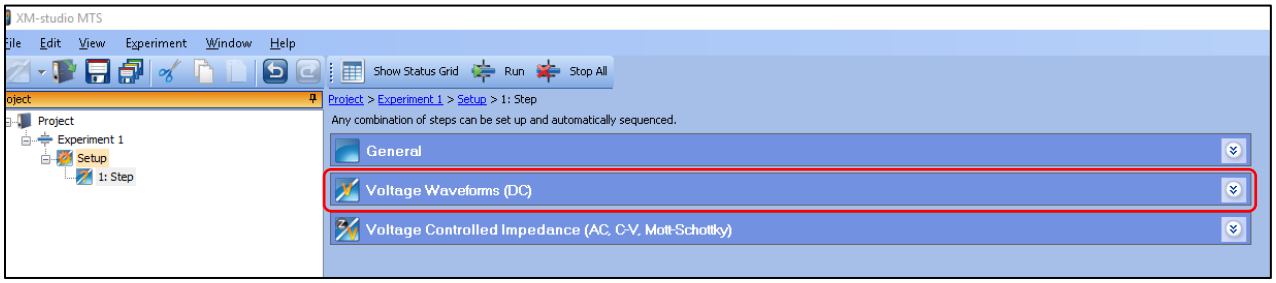


Figure 9

Step 6: A selection of experiments will open. Select “Triangular Sweep I-V Characterization” (Figure 10).

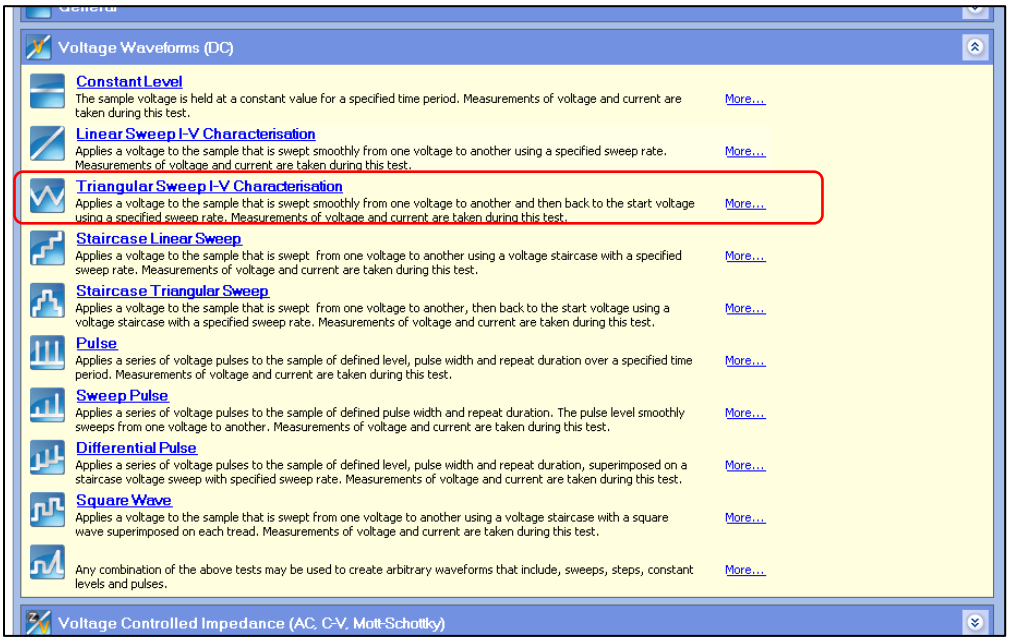


Figure 10

Step 7: The following screen will appear outlining a cyclic voltammetry experiment (Figure 11).

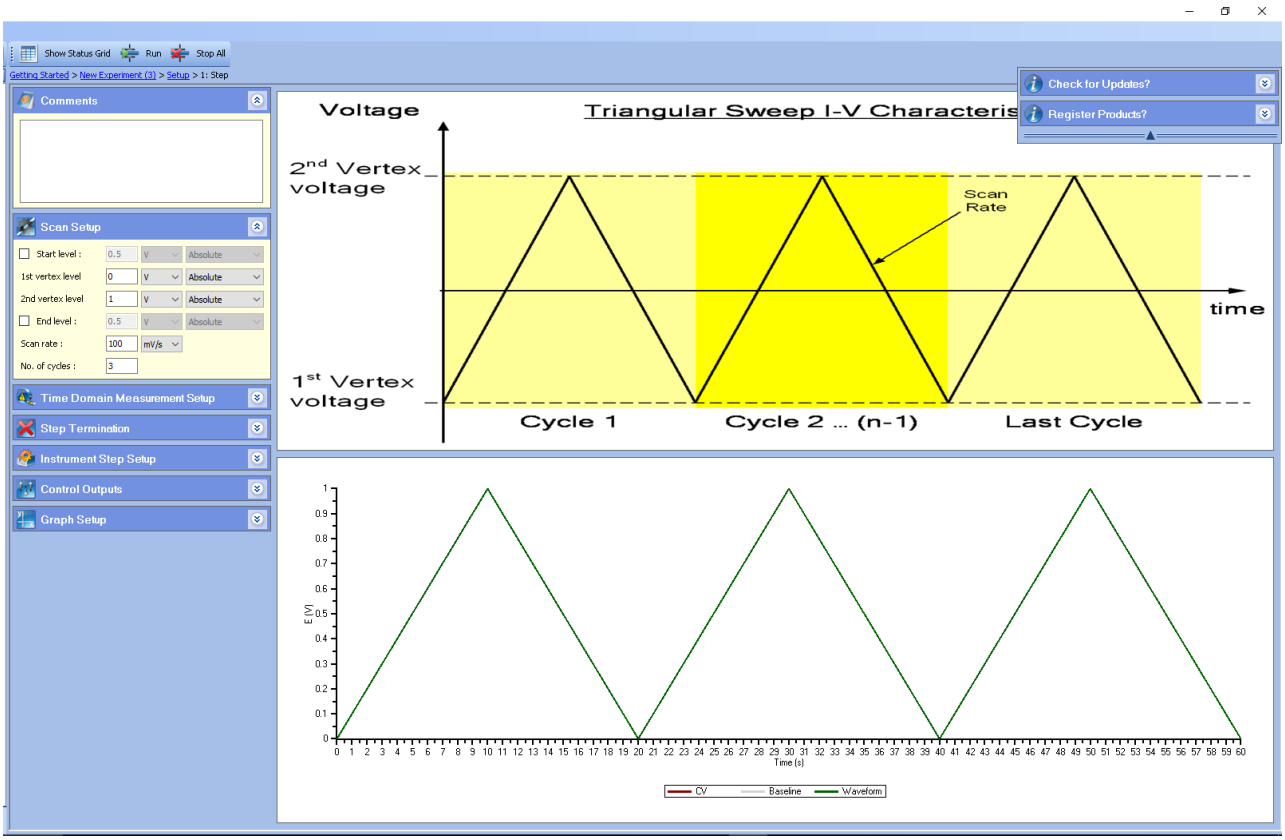


Figure 11

Step 8: Under "Scan Setup", leave the default parameters in place (Figure 12).

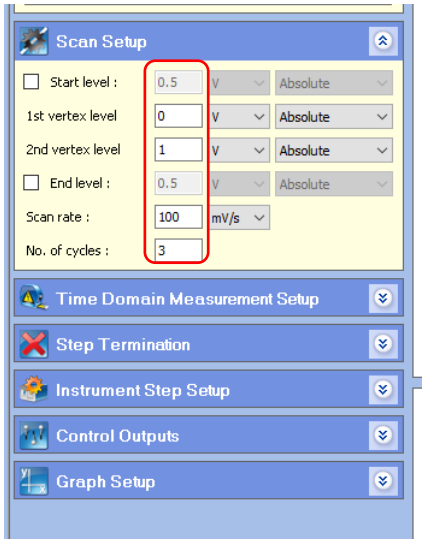


Figure 12

Step 9: Select “Run” (Figure 13).

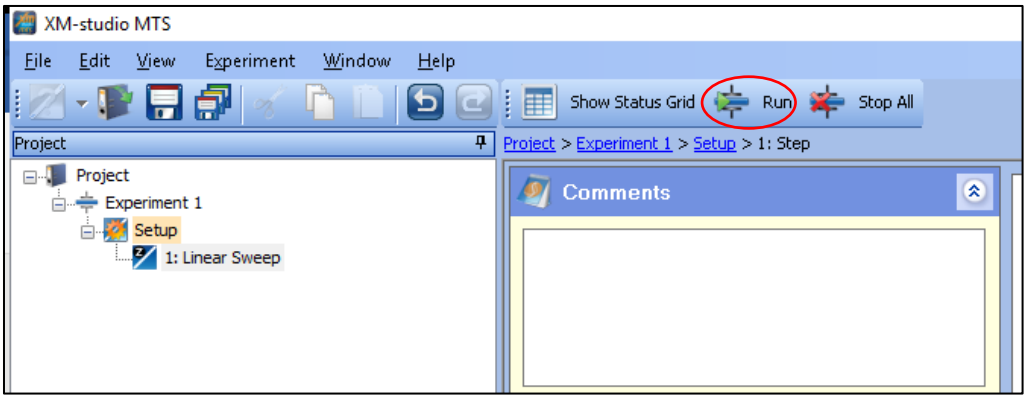


Figure 13

Step 10: A screen like that shown in Figure 14 will display which shows the connection setup.

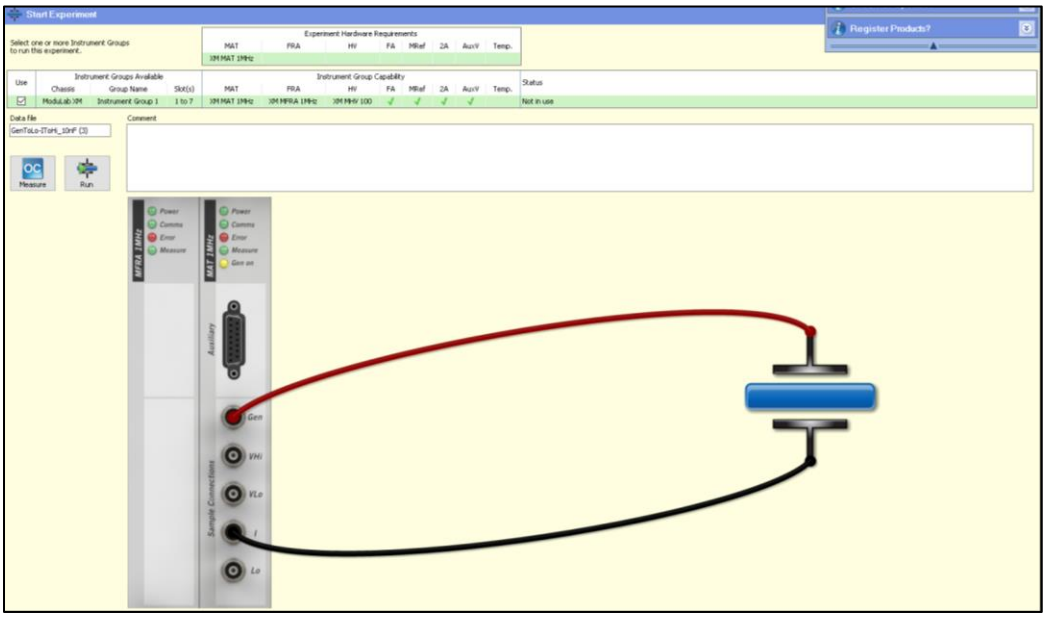


Figure 14

Step 11: Using the default axes I versus current density, the screen will automatically show progress with a default graph as the experiment runs (Figure 15).

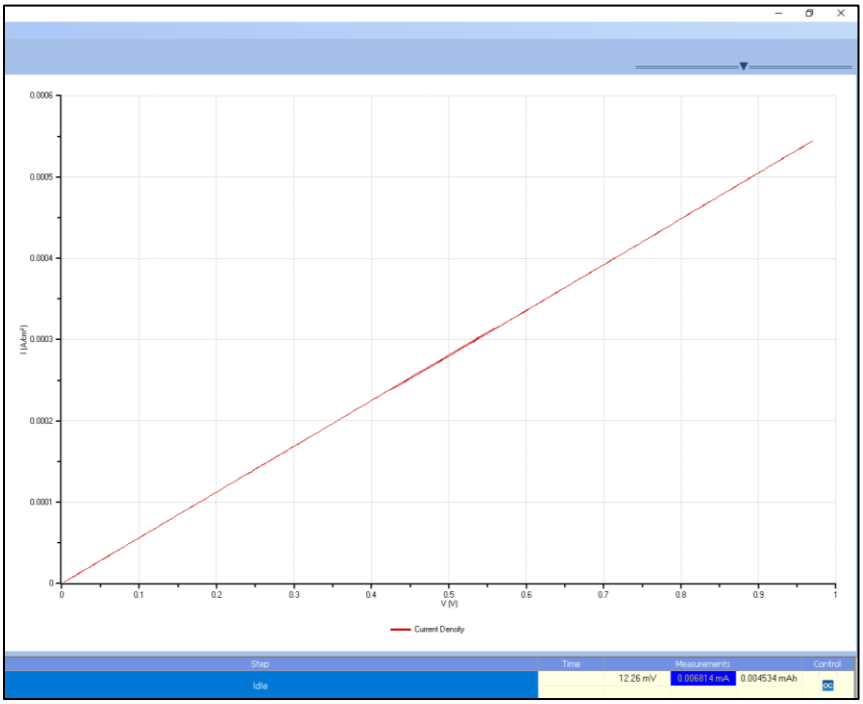


Figure 15

Step 12: Use the drop-down box in the "Axes" section to change the axes to "V vs. I" and select "Refresh". Figure 16.

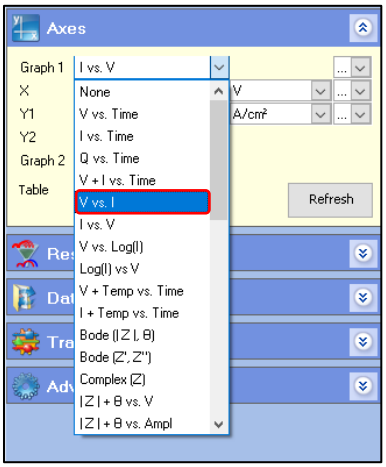


Figure 16

Evaluating Data

Step 13: Select the "Fitting" tab (Figure 17).

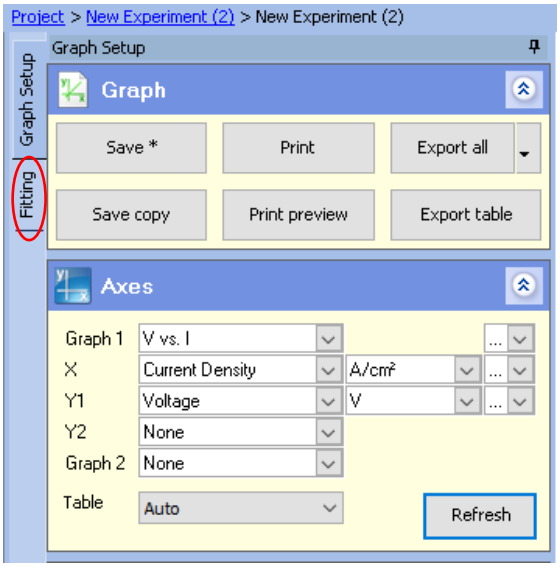


Figure 17

Step 14: From the drop-down box, select "Line", then click "Run" to obtain the line of best fit (Figure 18).

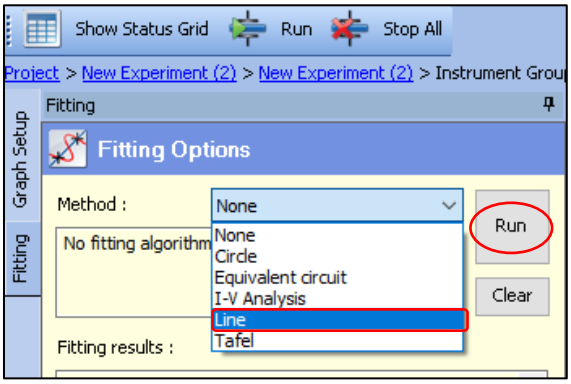


Figure 18

Step 15: The line of best fit will appear on the graph (Figure 19), and line fitting results will be displayed numerically (Figure 20).

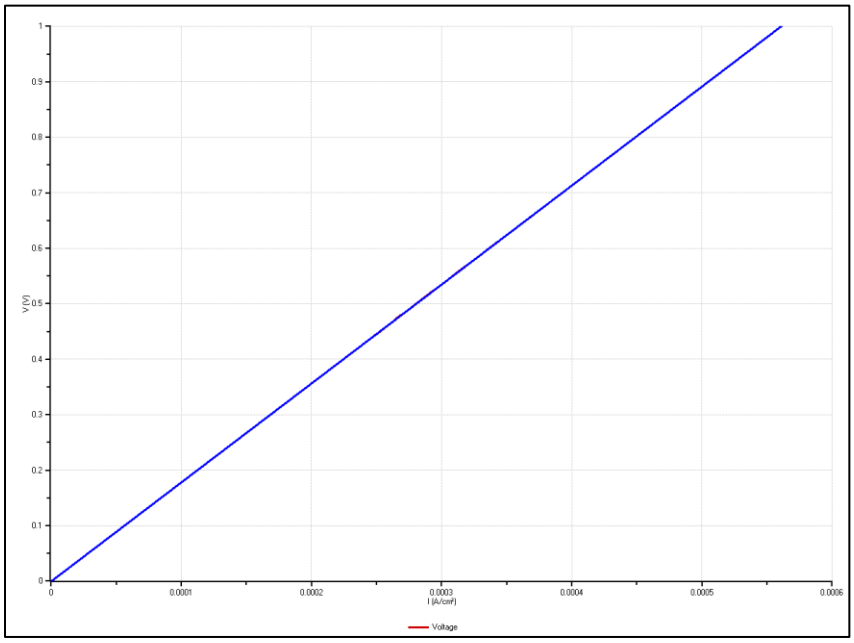


Figure 19

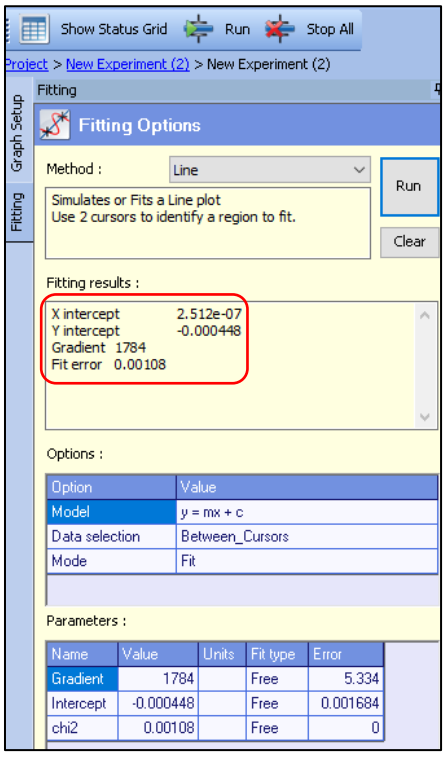


Figure 20

Step 16: As the resistor being tested is valued at 1.8kΩ, it is expected that this will be the value obtained from the experimental results. The gradient listed from the fitting results indicates the approximate value of the resistor, 1,784 Ω, or roughly 1.8 kΩ.

Because the data from the experiment matches the expected/calculated results, as shown below, it can be inferred that the equipment is in good working order. In this case, other causes for misinformation should be explored.

Background-Impedance

Each Solartron Analytical ModuLab XM MTS includes a test cell labeled “12961 Dielectric Test Module”. The test module contains a known resistor capacitor circuit as shown below (Figure 21).

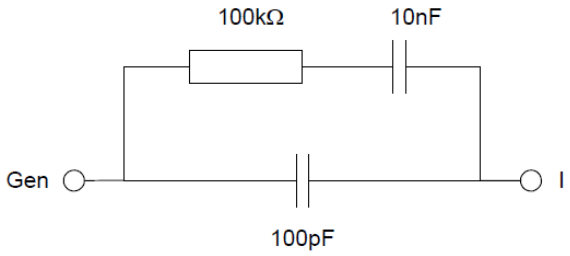


Figure 21

The dummy cell test can be performed using voltage controlled impedance. This is labeled “Constant Level” in the XM-Studio software that accompanies the ModuLab XM MTS. In a constant level impedance test, the AC potential is constant across the dummy cell. During this time, the system measures AC current passing through the module and displays measurement results (Figure 22).

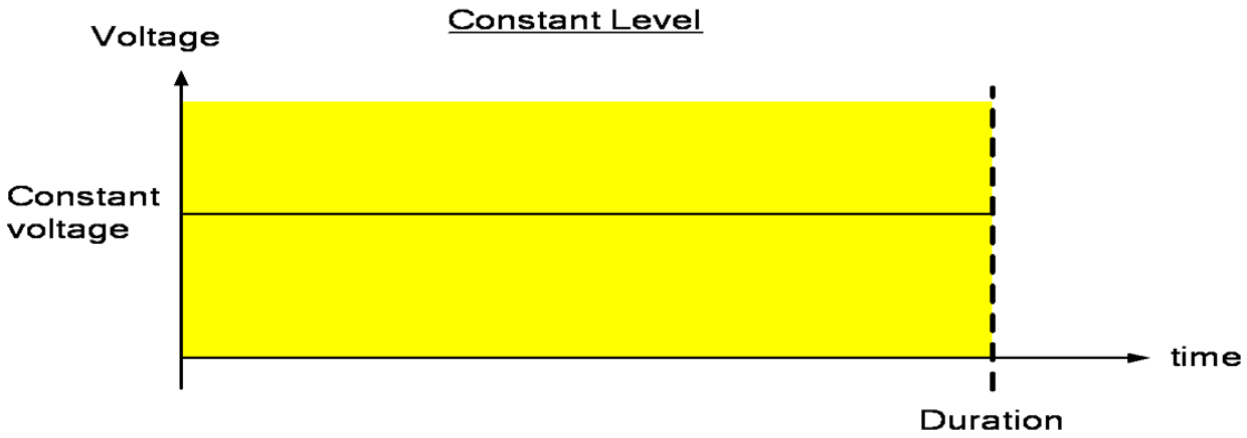


Figure 22

A constant level impedance test is useful for this dummy cell test due to the predictability of the cell behavior and ease of calculation. The following equation is used to approximate cell behavior, where V=potential, measured in volts; I=current, measured in amps; and Z=impedance, measured in Ohms:

$$Z=V/I \qquad \textit{Eqn 2}$$

Experimental Setup-Physical Equipment-Impedance

To set up a constant level impedance test in XM Studio, connect BNC cables between the Solartron Analytical ModuLab XM MTS and the 12961 Dielectric Reference Module. One cable should connect from “Gen” to one side of the “TEST” circuit, and the other cable should connect “I” to the other side of the “TEST” circuit of the cell (Figure 23).

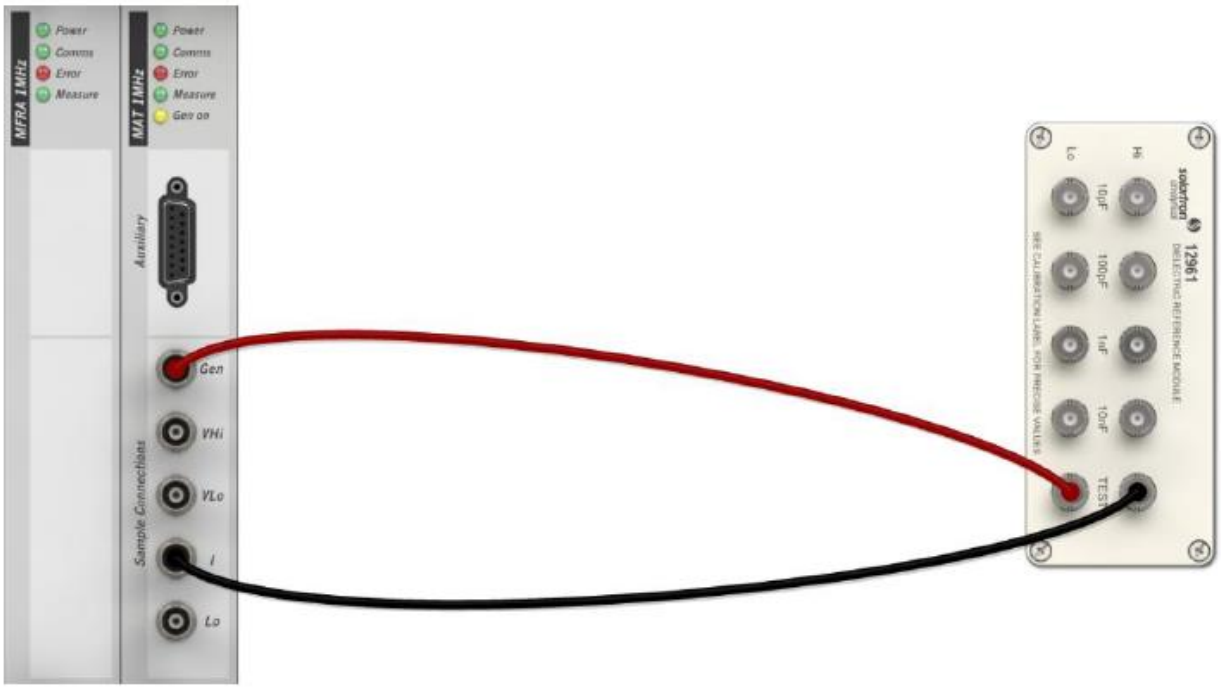


Figure 23

The potential that is selected within the software will be applied to the circuitry within the test module (Figure 24). The resulting current will be plotted against the voltage.

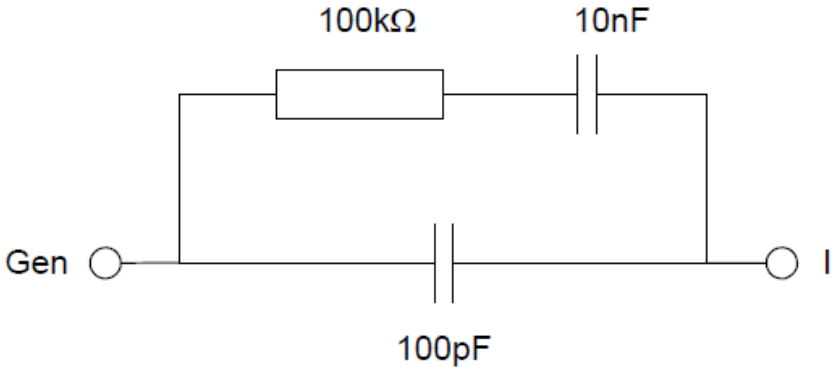


Figure 24

Experimental Setup & Run-Software-Impedance

Step 1: Follow steps 1-4 from the "Experimental Setup & Run-Software-Triangular Sweep" section of this document.

Step 2: The following menu will appear. Select "Voltage Controlled Impedance (AC, C-V, Mott-Schottky)" (Figure 25).

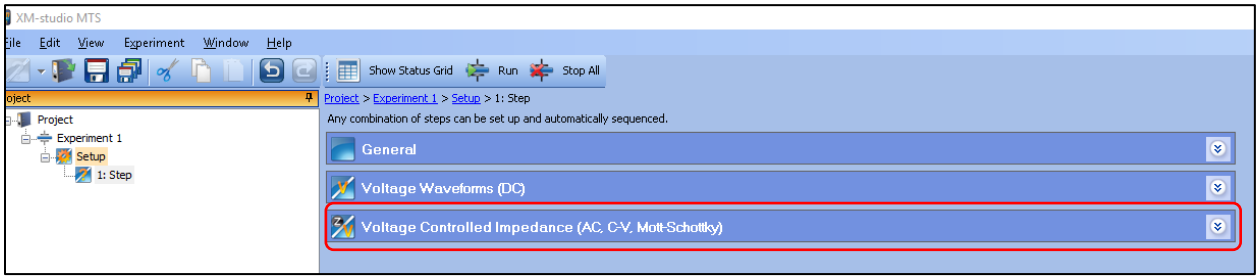


Figure 25

Step 3: A selection of experiments will open. Select "Constant Level" (Figure 26).

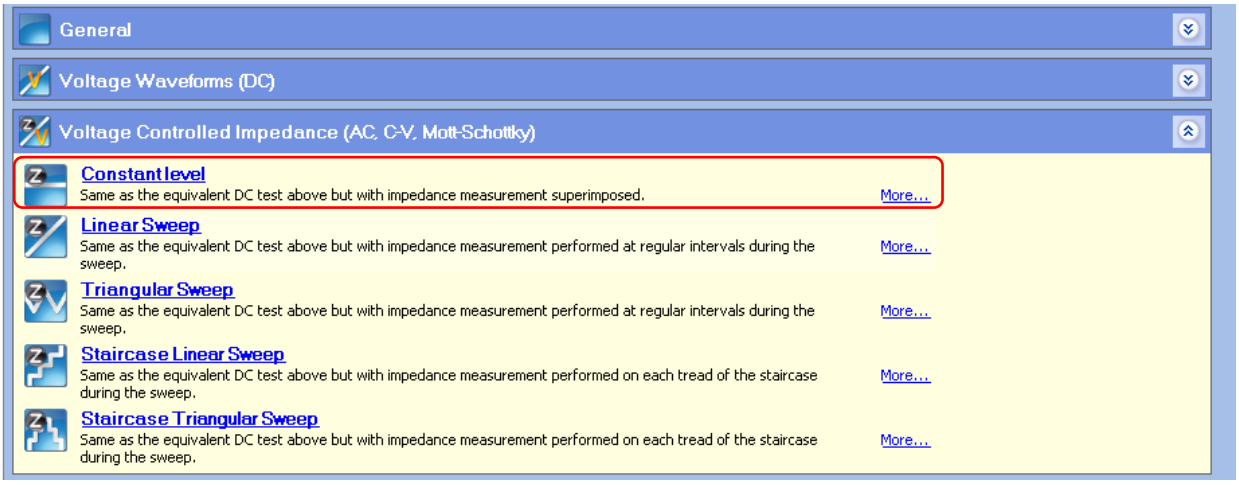


Figure 26

Step 4: The following screen will appear outlining a constant level impedance experiment (Figure 27).

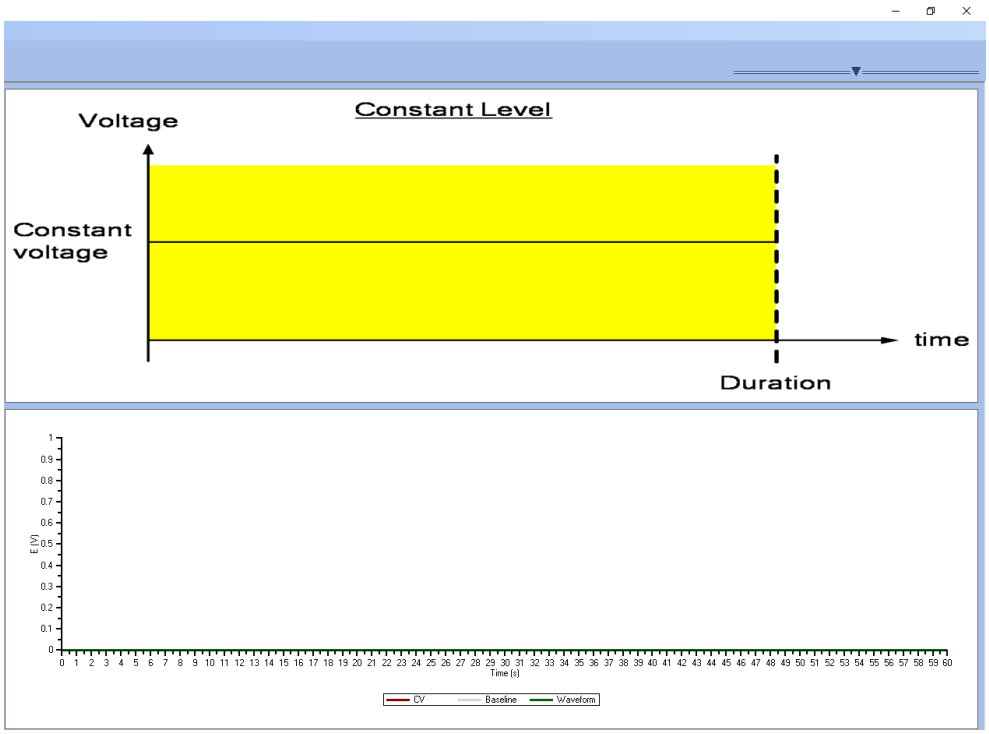


Figure 27

Step 5: Under "Scan Setup" Leave the DC level at 0V, and leave as "absolute", as this cell has no open circuit potential. Leave the default parameters in place and press "Run" (Figure 28).

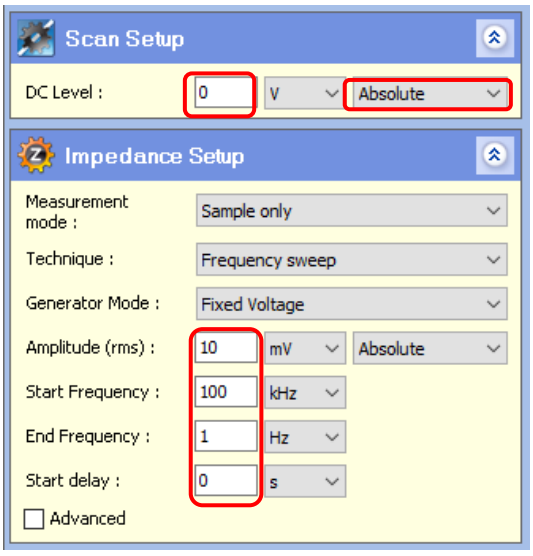


Figure 28

Step 6: Select “Run” (Figure 29).

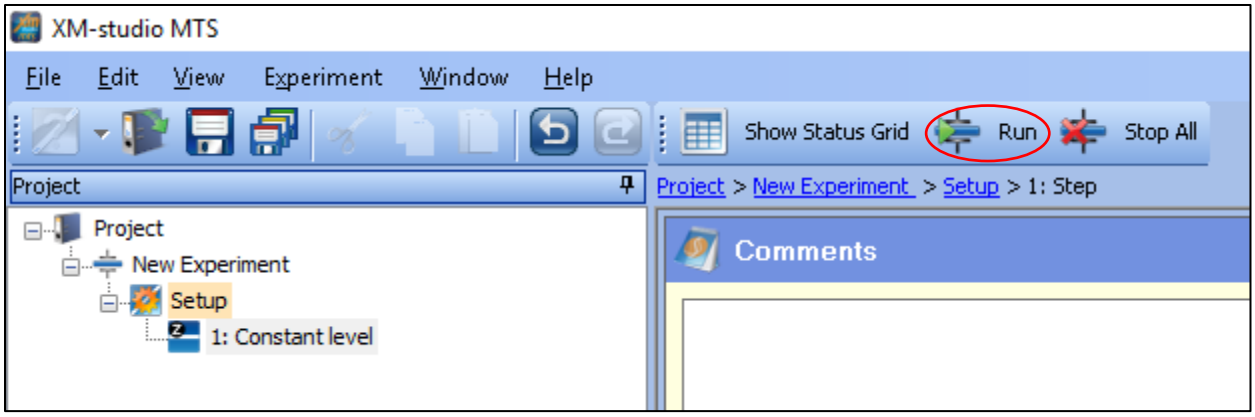


Figure 29

Step 7: A screen like that shown in Figure 30 will display which shows the connection setup.

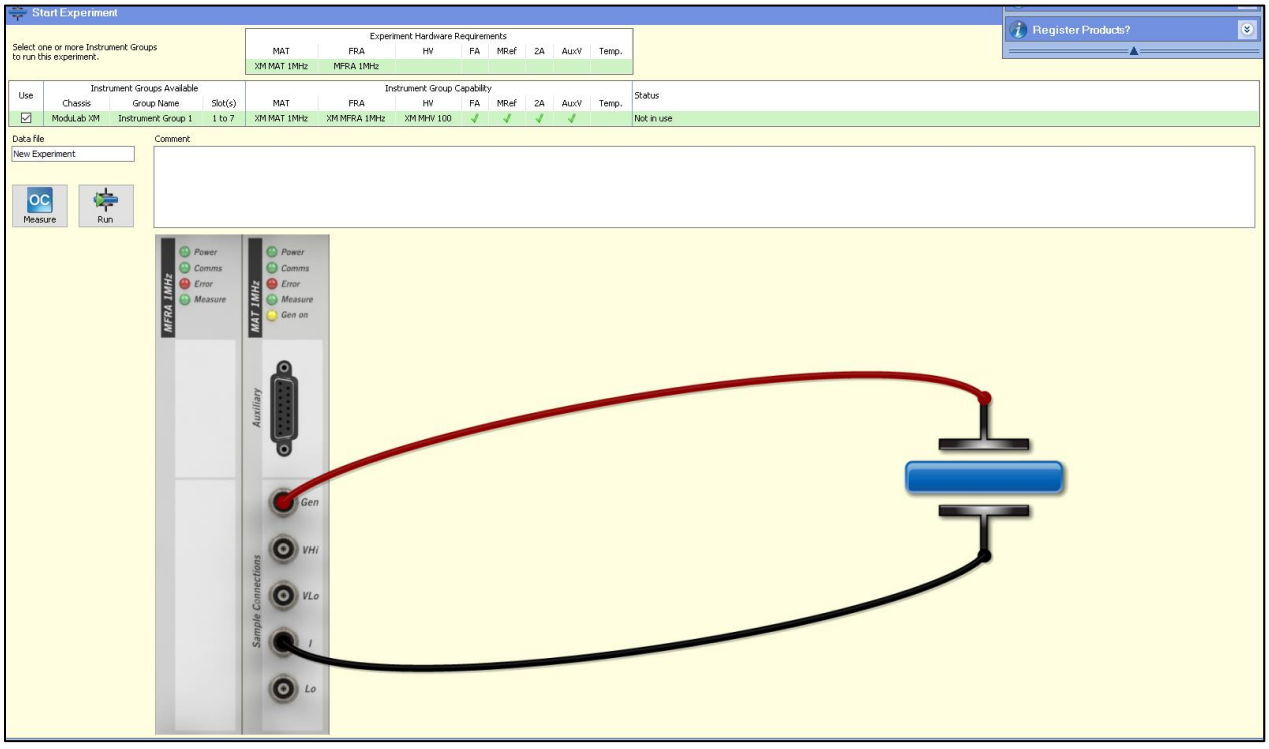


Figure 30

Step 8: The screen will automatically show progress with a default graph as the experiment runs. The Axes should be adjusted beneath the "Axes" tab using the drop-down box for each parameter. For this impedance experiment, it is beneficial to select a Bode graph with the parameters outlined below (Figure 31).

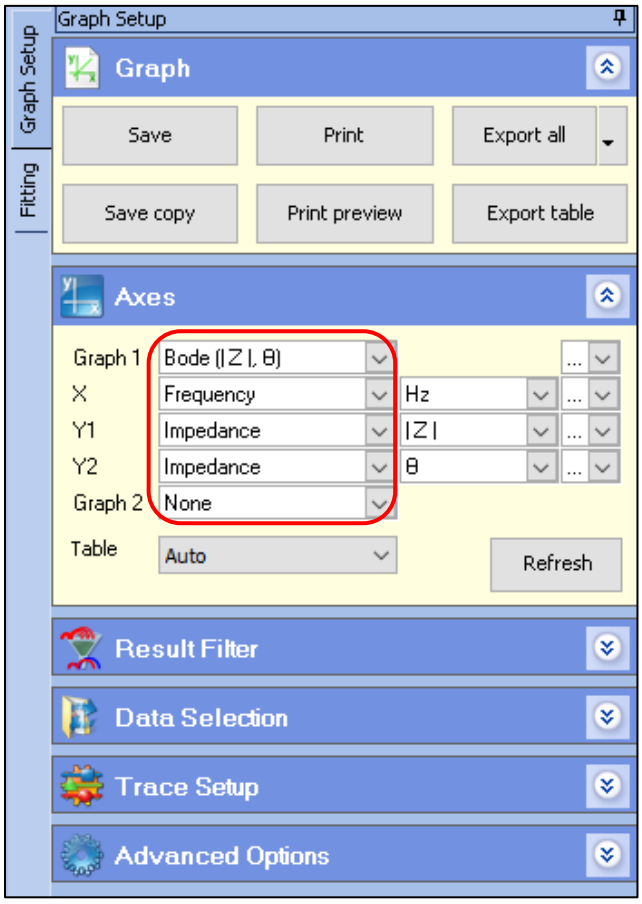


Figure 31

Evaluating Data

Step 9: The data presented in the Bode diagram (Figure 32) can be compared to the outlined circuit in Figure 24 to verify the functionality of the ModuLab XM MTS. The Bode diagram shows two areas with a negative one slope which indicate the presence of two capacitors. The Bode diagram also shows a region with a slope of zero, which indicates the presence of a resistor. Additionally, the phase angle diagram shows two peaks near -90, which indicate the presence of capacitors, along with a dip near zero, which indicates the presence of a resistor. As the module's schematic consists of two capacitors and one resistor, the experimental results verify that the Modulab XM MTS is in good working order.

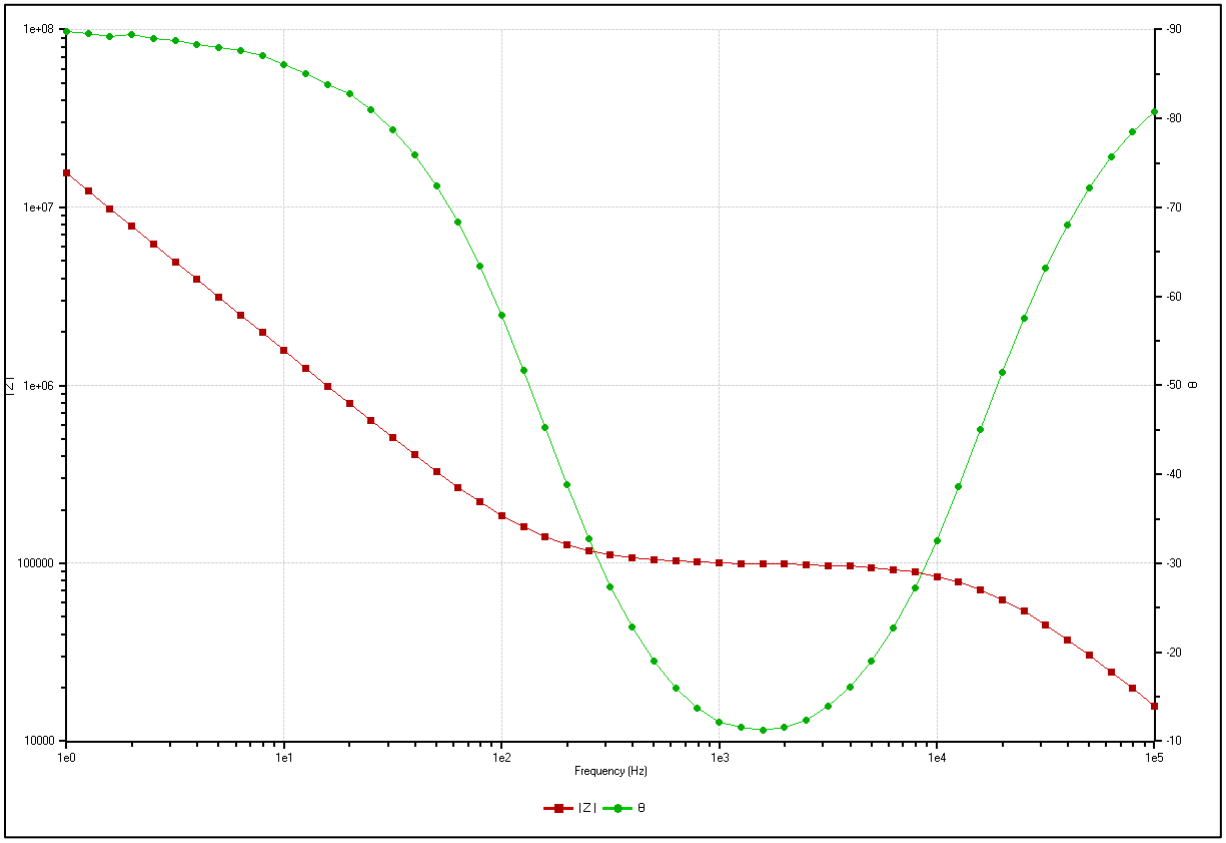


Figure 32

Step 10: Data from the experiment can also be verified by performing an equivalent circuit fit. Begin by selecting the "Fitting" tab (Figure 33).

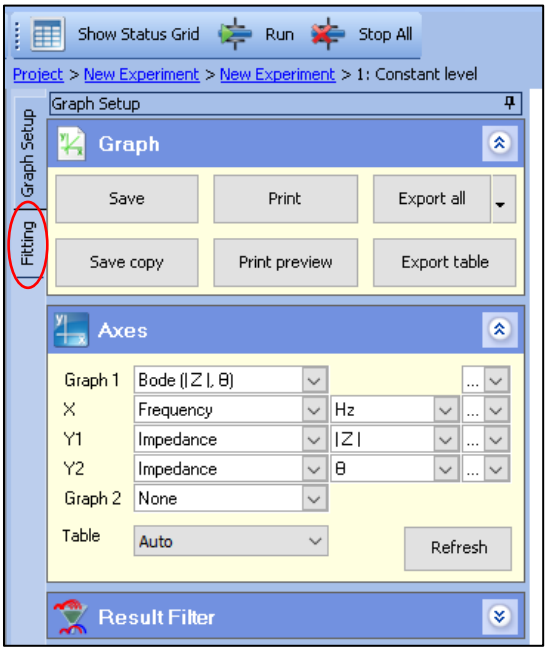


Figure 33

Step 11: From the drop-down box, select "Equivalent circuit" (Figure 34).

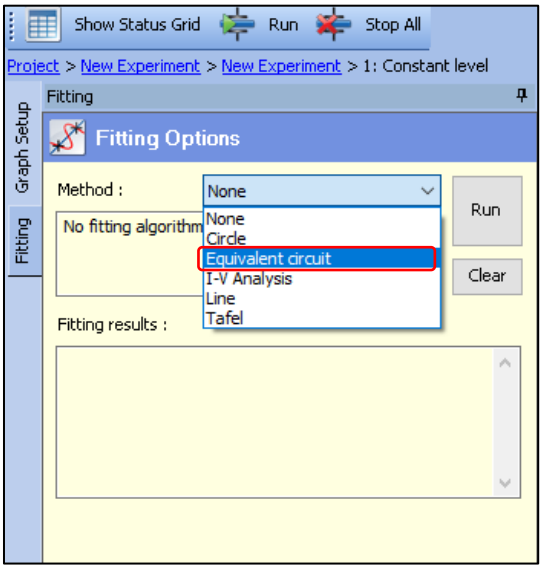


Figure 34

Step 12: Using the menu highlighted in Figure 35, select each portion of the circuit tested and place it in the equivalent ciruit builder.

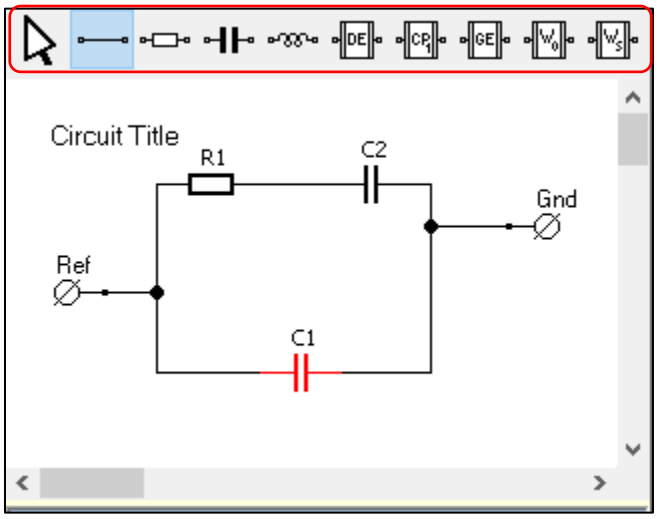
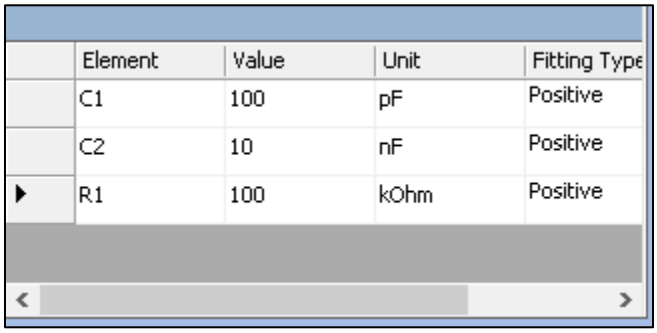


Figure 35

Step 13: Input the anticipated values from the circuit tested. The values from the test module are shown in Figure 36.



Element	Value	Unit	Fitting Type
C1	100	pF	Positive
C2	10	nF	Positive
R1	100	kOhm	Positive

Figure 36

Step 14: Select “Run”. The fitting results will be displayed as shown in Figure 37 below. These should be an approximate match to the values input in step 13. The line of best fit will also display as shown in Figure 38. This should closely match the original experimental graph from Figure 32. If the line of best fit and the given values of the testing results nearly equal those from the test box, it can be inferred that the ModuLab XM MTS is in good working order.

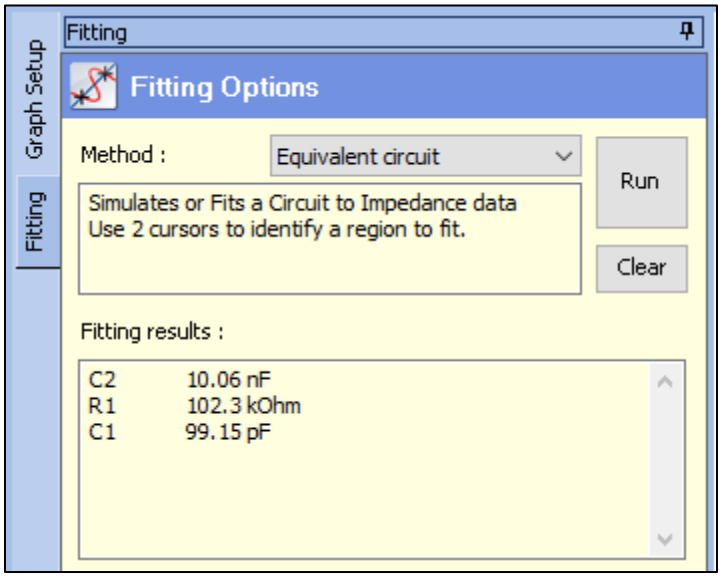


Figure 37

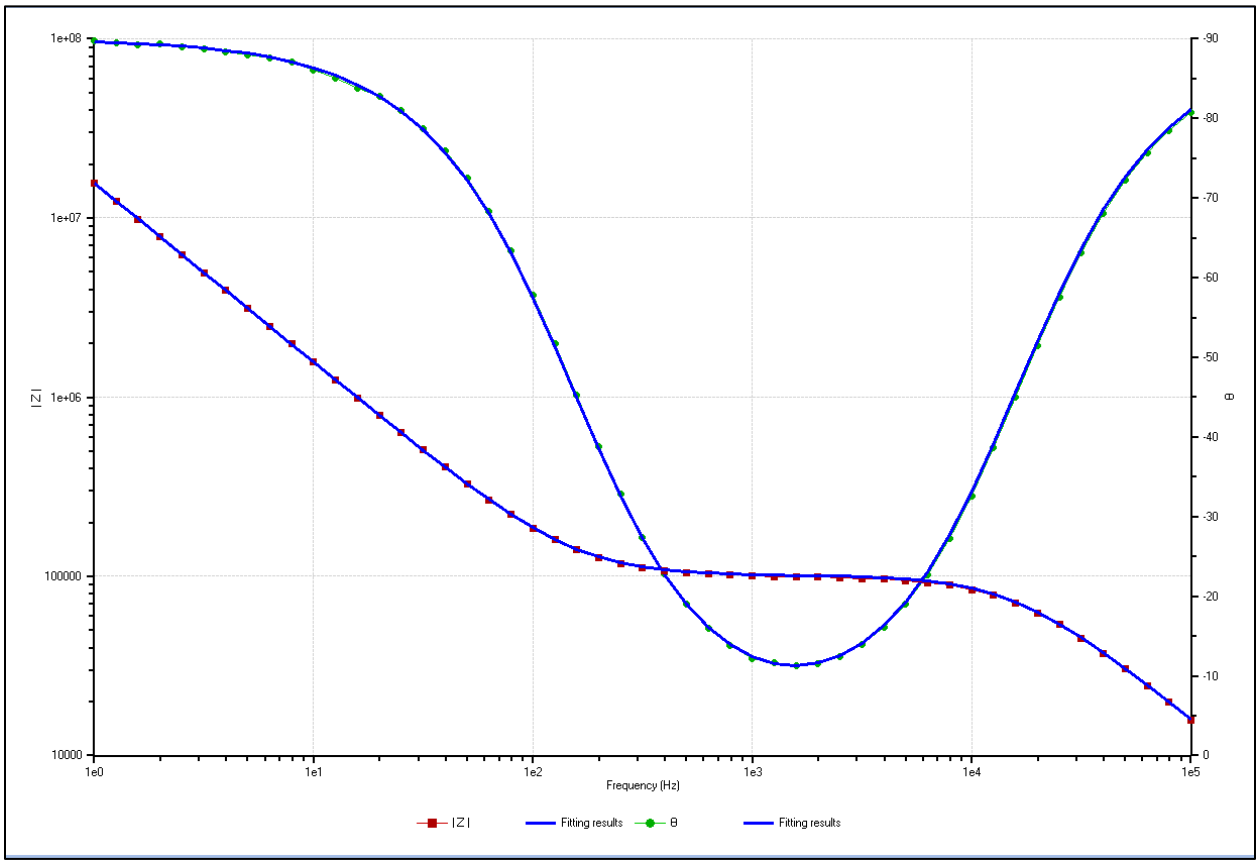

1e+08
1e+07
1e+06
100000
10000
|Z|
1e0
1e1
1e2
1e3
1e4
1e5
Frequency (Hz)
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
θ
|Z|
Fitting results
θ
Fitting results

Figure 38

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