Newtons4th Ltd

BATT 470m-200-x

Current Shunt

User manual

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Chapter 1 Safety

Important safety Information

This manual contains important information that must be followed to ensure the safety of all operatives and both this instrument and any accessories attached.

General Safety Information

Use the product only as detailed in this manual. Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. Carefully read all instructions. Retain these instructions for future reference.

For correct and safe operation of this instrument, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The product is designed to be used by trained personnel only it is designed to comply with BSEN 61010-1 (Safety requirements for electrical equipment for measurement, control, and laboratory use)

Ensure that the supply voltage agrees with the rating of the instrument printed on the back panel before connecting the mains cord to the supply.

The cover(s) should not be removed to attempt repair, maintenance, or adjustment, as this instrument contains no user serviceable parts. All repairs, maintenance or adjustment should only be caried out by Newtons4th Ltd or our official distributor.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

When incorporating this equipment into a system, the safety of that system is the responsibility of the assembler of the system.

There are no user serviceable parts inside the instrument – do not attempt to open the instrument, refer service to the manufacturer or his appointed agent.

To avoid fire or personal injury

Ground the instrument. This instrument is grounded through the grounding terminal. To avoid electric shock, the grounding conductor **must** be connected to earth ground. Before making connections to the input or output terminals of the instrument, ensure that the instrument is properly grounded.

Connect and disconnect properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source. Use only insulated voltage probes, test leads, and accessories supplied with the product, or indicated by Newtons4th Ltd. to be suitable for the product.

Observe all terminal ratings. To avoid fire or shock hazard, observe all rating and markings on the instrument. Consult the specifications in this user manual for further ratings information before making connections to the product. Do not exceed the Measurement Category (CAT) rating and voltage or current rating of the lowest rated individual component of a product, probe, or accessory.
Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Do not operate with suspected failures. If you suspect that there is damage to this instrument, have it inspected by Newtons4th Ltd or our official distributor. Do not use the instrument if it is damaged or operates incorrectly. If in doubt about safety of the instrument, turn it off and disconnect the mains lead. Clearly mark the instrument to prevent its further operation. Before use, inspect voltage probes, test leads, and accessories for mechanical damage and replace when damaged. Do not use probes or test leads if they are damaged.

Do not operate in wet/damp conditions. Be aware that condensation may occur if a unit is moved from a cold to a warm environment.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry. Remove the input signals before you clean the product, only use a dry cloth for cleaning. Do not use chemicals or cleaning products on this instrument.

Provide a safe working environment. Always place the instrument in a location convenient for viewing and operating the switches.

Terms in the manual

These terms may appear in this manual:

WARNING. Warning statements identify conditions or practices that could result in injury or loss of life.

CAUTION. Caution statements identify conditions or practices that could result in damage to this product or other property.

INFORMATION. Information statements identify instructions or commands that may save time or provide extra functionality.

Terms on the product

These terms may appear on the product:
- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

Symbols on the product


When this symbol is marked on the product, be sure to consult the manual to find out the nature of the potential hazards and any actions which must be taken to avoid them.

The following symbol(s) may appear on the instrument.


Instrument GND

Conventions used to signify control keys, screen menu options and remote control commands are differentiated as shown below.

control keys	*ACQU*	denoted by *italicised font*
menu options	***bandwidth***	denoted by ***bold italicised font***
script commands	****CLS***	denoted by ***grey, bold italicised font***

Environmental compliance

This section provides information about the environmental impact of the product.

Product end-of-life handling
Observe the following guidelines when recycling an instrument or component:

Equipment recycling. Production of this equipment required the extraction and use of natural resources.

The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. To avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

This symbol indicates that this product complies with the applicable European Union requirements according to
Directives 2012/19/EU and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check with your local waste recycling facility.

Warranty

This product is guaranteed to be free from defects in materials and workmanship for a period of 36 months from the date of purchase.

In the unlikely event of any problem within this guarantee period, first contact Newtons4th Ltd. or your local representative, to give a description of the problem. Please have as much relevant information to hand as possible – particularly the serial number.

If the problem cannot be resolved directly then you will need to request an RMA number from the support section of our website. https://resources.newtons4th.com/ and return the unit. The unit will be repaired or replaced at the sole discretion of Newtons4th Ltd.

This guarantee is limited to the cost of the BATT470m itself and does not extend to any consequential damage or losses whatsoever including, but not limited to, any loss of earnings arising from a failure of the product or software.

In the event of any problem with the unit outside of the guarantee period, Newtons4th Ltd. offers a full repair service.

Please contact your local Distributor or the N4L office for further details of N4L's instrument repair and re-calibration service.

Chapter 2 Declaration of Conformity

Manufacturer: Newtons4th Ltd.
Address: 1 Bede Island Road
Leicester
LE2 7EA

We declare that the product:

Description: Electrochemical Impedance Spectroscopy Current Shunt
Model: BATT470m

Conforms to the EEC Directives:

2014/30/EU relating to electromagnetic compatibility:
EN 61326-1:2013
EN 55022 class A

2014/35/EU relating to Low Voltage Directive:
EN 61010-2-030:2010
EN 61010-1:2010

April 2023

Jigar Patel
(Senior Engineer Newtons4th Ltd.)

Chapter 3 Preface

This manual covers the Newtons4th Ltd BATT470m EIS shunt accessory.

Key Features

Wide frequency range DC & 10mHz to 1MHz

0.1˚/ kHz Phase Error

5 millidegree phase accuracy for low power factor applications

Up to 1Arms continuous current

Simple BNC safety connectors

Free Microsoft Windows Software for datalogging, graphs, Excel compatible output options, Microsoft, (Excel, Windows, Word, & C++) are trademarks of the Microsoft group of companies.

Chapter 4 Specifications

Model	BATT470m-200
Frequency Range	10mHz – 1MHz
Nominal Resistance	470mΩ ± 0.1%
Phase Error	0.1º / kHz
Impedance Measurement Range	1mΩ ~ 100kΩ
Shunt Nominal Inductance	< 1nH
Continuous Current	1Arms
Voltage Rating	200V DC
Input Connector	BNC*
Protection Rating	Up to 200V DC
Dimensions	187x187x67mm

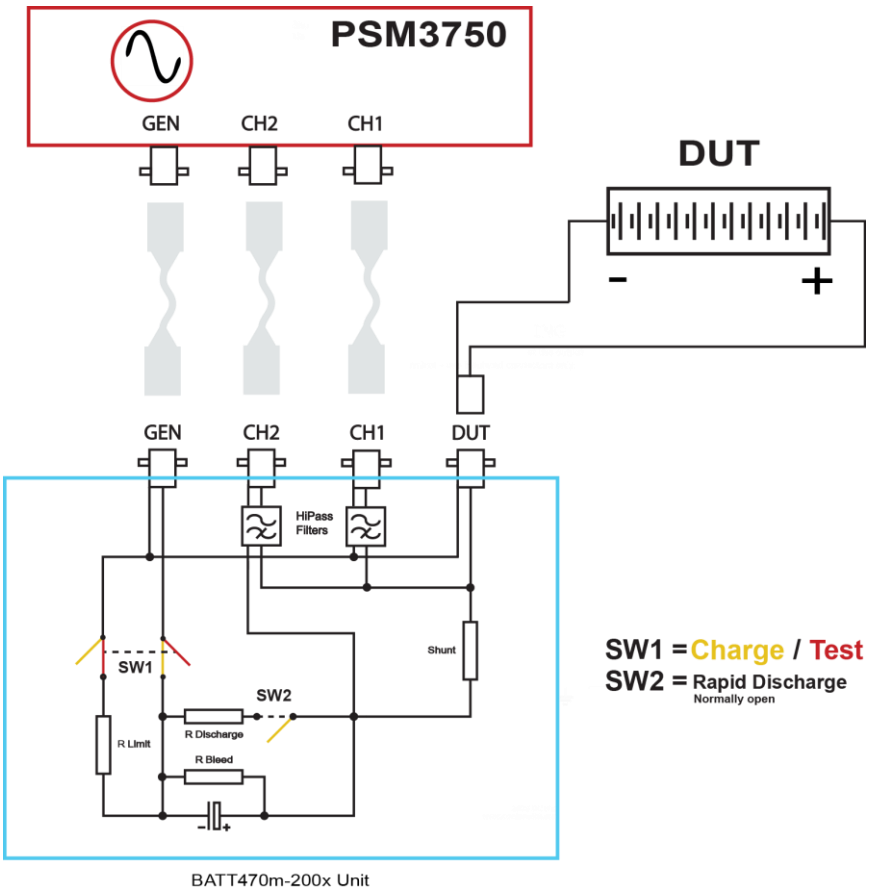
***GEN, CH1, CH2, & DUT:** Safety BNC – (Output is at line potential therefore safety BNC to BNC leads must be used for instrument connection)

Chapter 5 Description

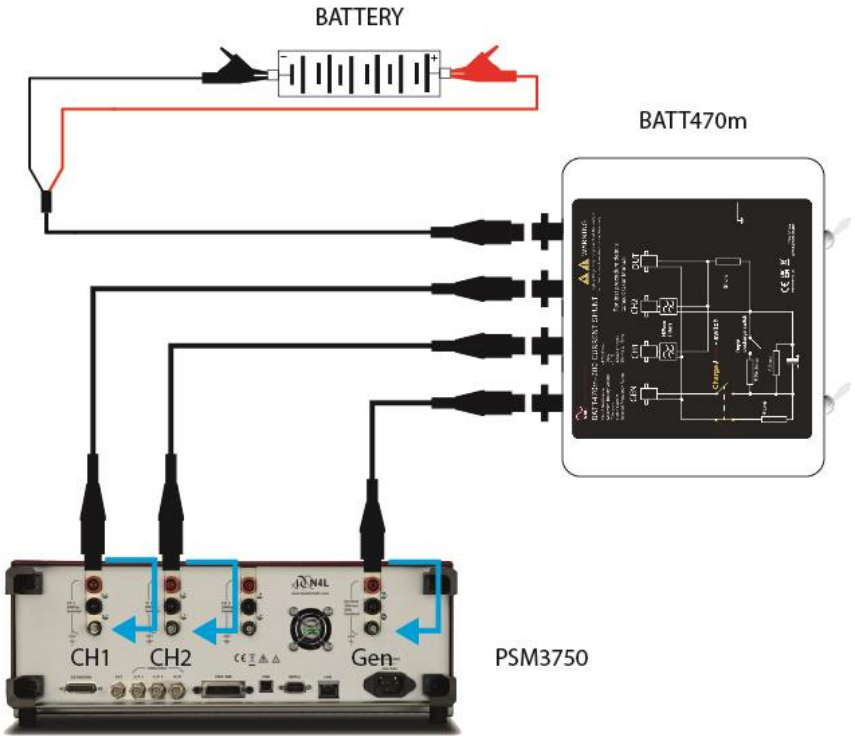
Electrochemical Impedance Spectroscopy or EIS has been in existence for some considerable time, however it is growing rapidly with the current worldwide emphasis on battery cell R&D, as well as preventative analysis of sealants, adhesive bond strength and composite repair techniques in the aeronautical fields.

N4L have developed an easy to use accessory for the PSM3750 Frequency Response Analyzer to enable accurate easily repeatable EIS analysis of battery / fuel cells and other electrochemical systems.

The BATT470m, coupled with the PSM3750 Frequency Response Analyzer facilitates impedance measurement of batteries/cells up to 200V DC. With a frequency range of 100mHz to 1MHz, equivalent circuit analysis as well as wideband impedance measurement. It is quick and simple to use, with our PSMComm2 software. The BATT470m incorporates a DC blocking capacitor and generator protection circuitry to protect the PSM3750 output generator. Channel 1 of the PSM3750 measures the voltage across the DUT and channel 2 measures the current through the DUT.



Chapter 6 Connecting the BATT470m to the PSM3750 & DUT



Using the supplied leads, connect the BATT470m, the DUT as shown above.

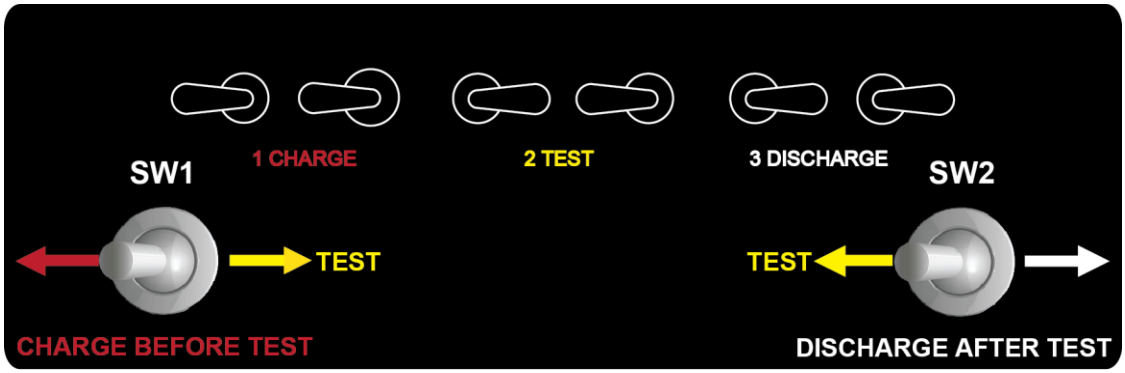
Channel 1 measures the voltage across the DUT and channel 2 the current through the battery by means of the 470mOhm shunt within the BATT470m.

CAUTION. Ensure only the supplied safety BNC leads are used on the PSM3750 and BATT470m to avoid undue wear and possible noisy connections.

Chapter 7 Test procedure

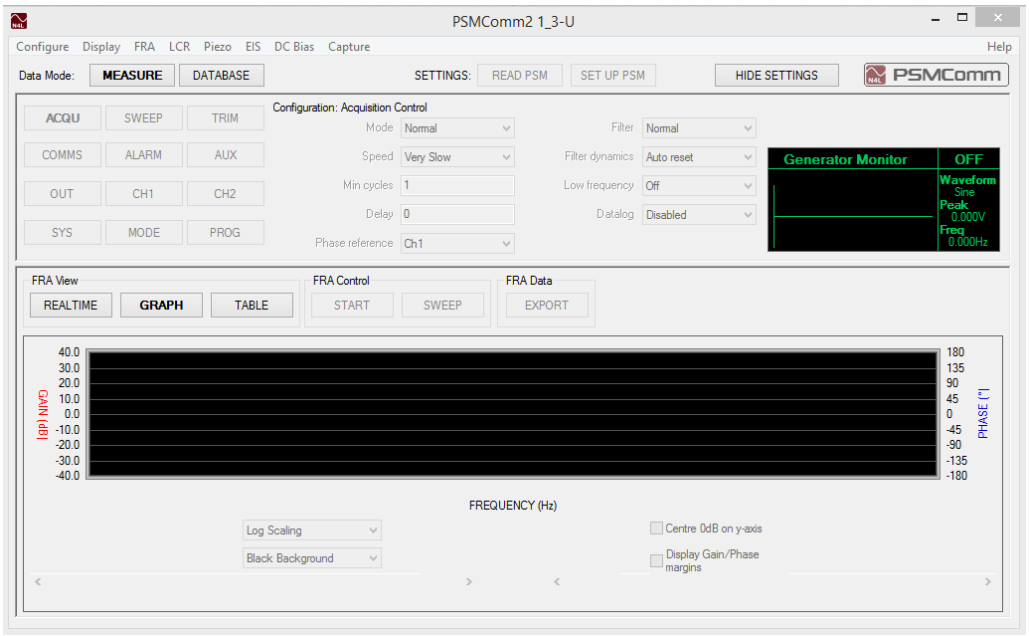
Setting up the PSMComm2 software

After ensuring that the BATT470m is connected correctly to the PSM3750, but before attaching the DUT, ensure that both switches are set correctly as shown below.

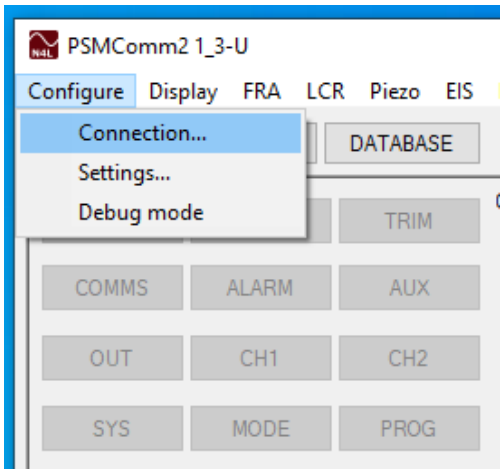


CAUTION. Failure to observe the correct position of the switches, could result in damage to the PSM3750, or the DUT.

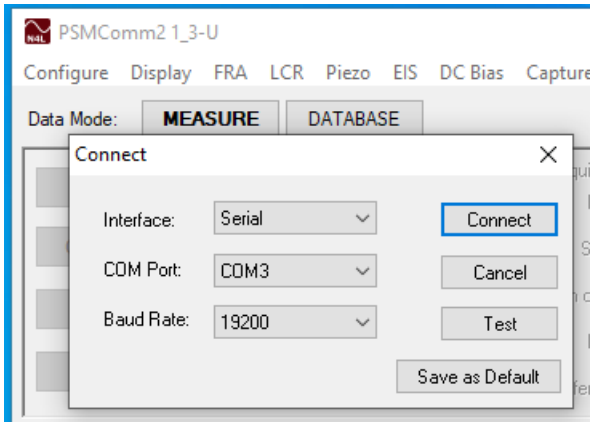
Load the PSMComm2 software and connect the PSM3750 to a PC via RS232/serial, USB, or LAN as appropriate. The first time you run this software on your PC if you haven't any other N4L software already installed and running, you will need an unlock code which can be obtained by sending an email to sales@newtons4th.com



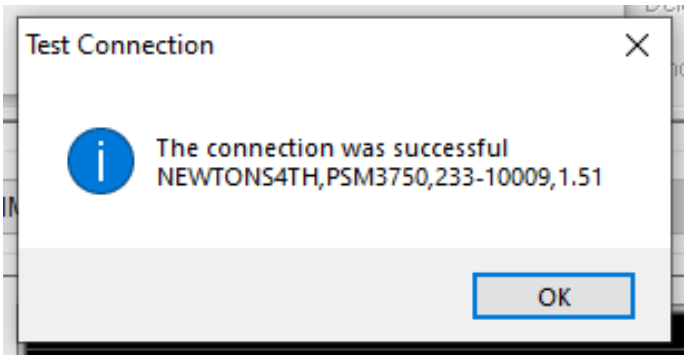
On loading you are presented with this screen layout



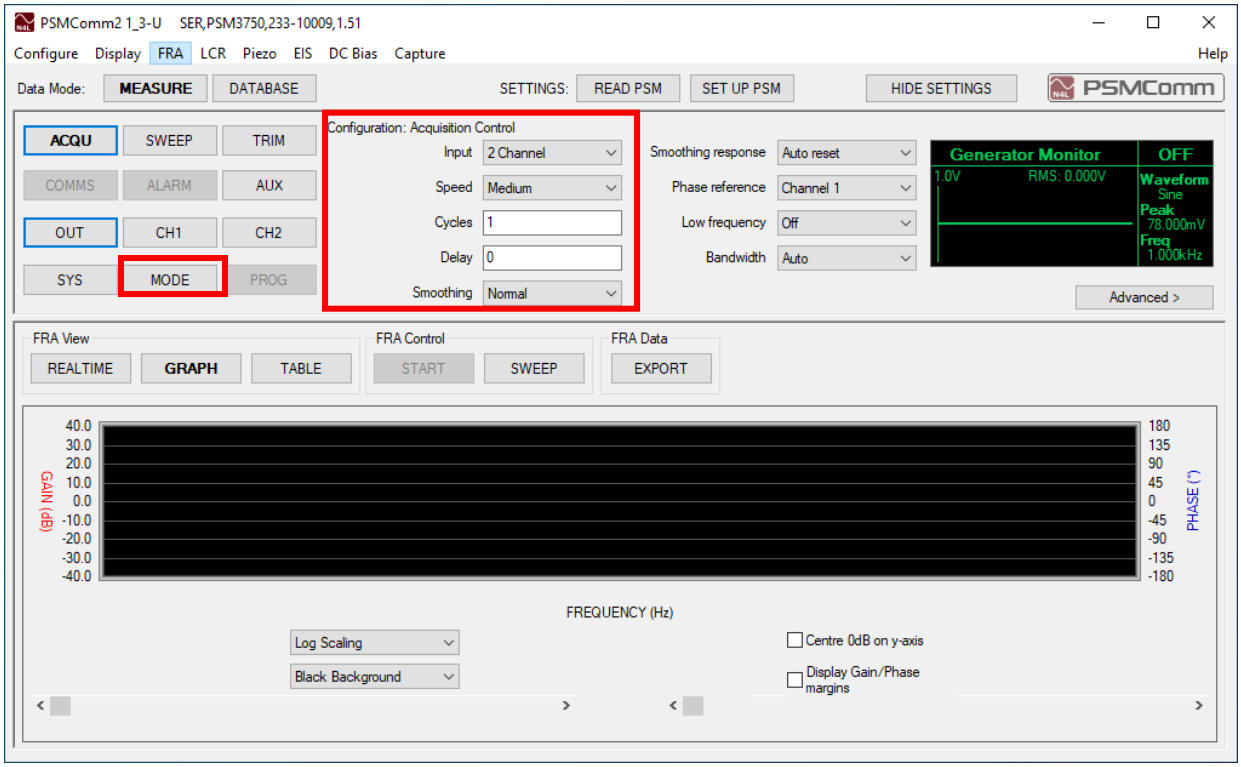
Click on Configure and click on connection. In this instance we are connecting using a serial RS232 connection[1]. However, USB or LAN can be used instead. Ensure whichever comms protocol is used that the PSM is set to the correct protocol via the ***comms*** menu on the front panel.



Click the connect button and once the connection is made, a window like this one below will appear. Click the ***OK*** button to dismiss this message box.

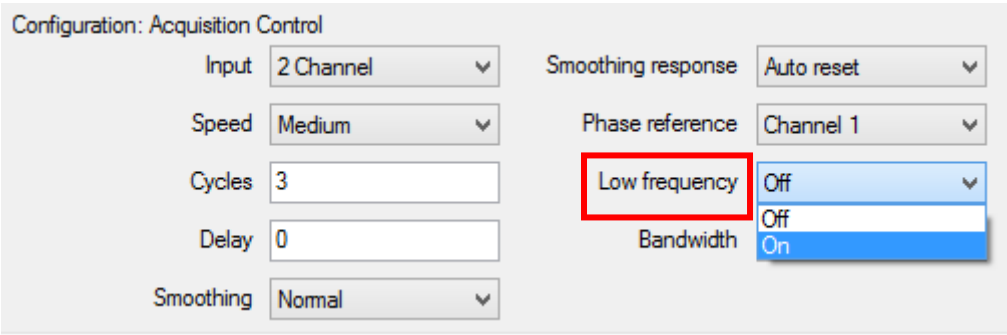


[1] We recommend the use of ATEN – UC232A serial to USB converter, which must be used with a Null modem cable.

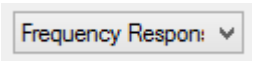


The default screen is the FRA view mode, see above, and the configuration is defaulted to Acquisition control.

In the Acquisition control sub window shown below, select ON from the Low Frequency drop down. Additionally in this section, it is advised to set the number of cycles to 3.[2]

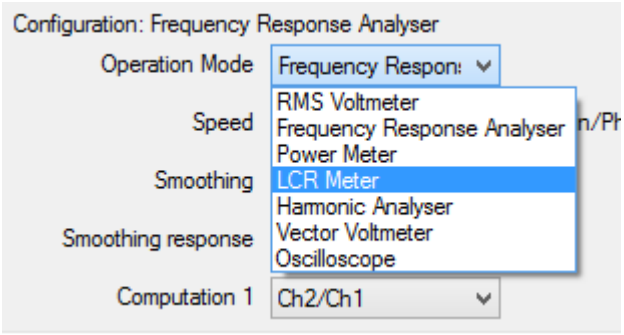


Click on the ***MODE*** button and the configuration section in the centre of the window will now display ***Operation Mode*** which will be defaulted to Frequency Response.
Click on the

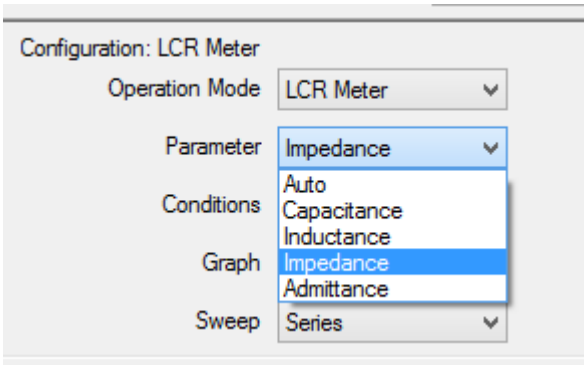


which will then drop down and allow the selection of LCR Meter as shown on the following page.

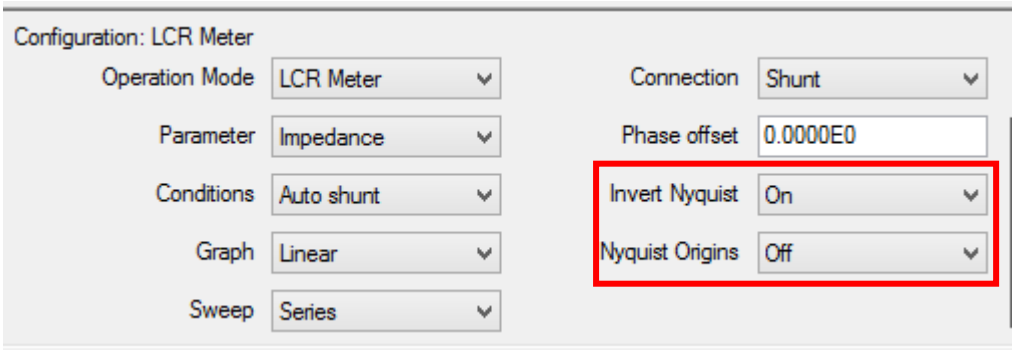
[2] 3 cycles measures each frequency point 3 times and averages the result, this will give a smoother final plot of the results. 3 is suggested as a good balance between the smoothing effect and the length of time each test takes overall.



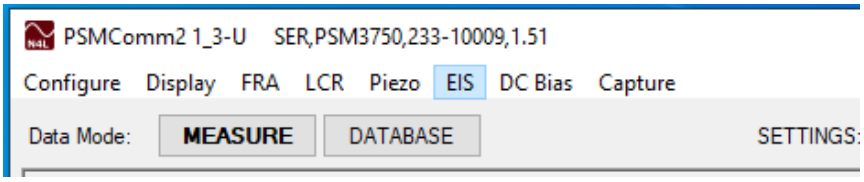
Now click on the Parameter dropdown and choose ***Impedance*** from the drop down menu.

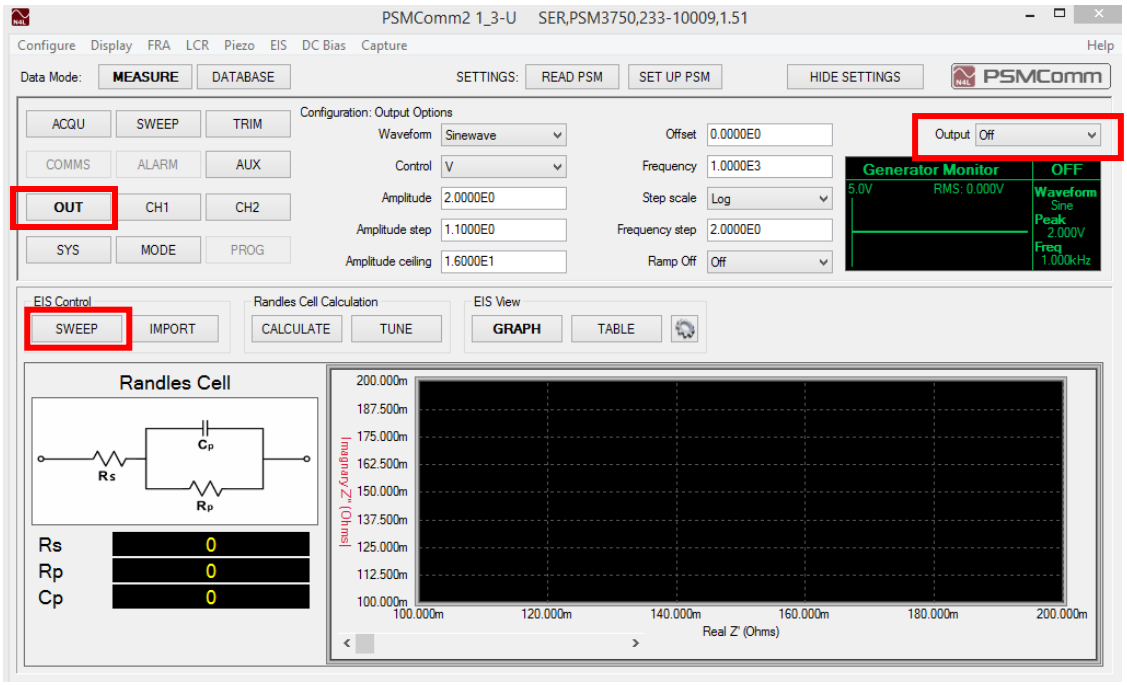


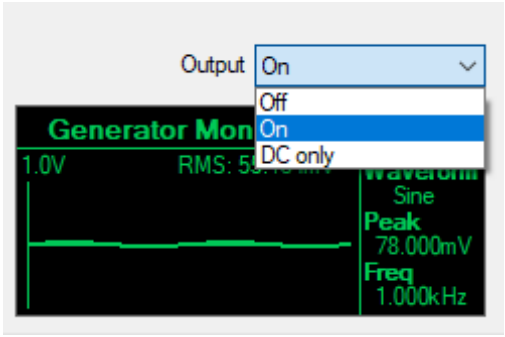
Once Impedance has been chosen, two Nyquist options will appear, as seen below. Leave these on the defaults shown.



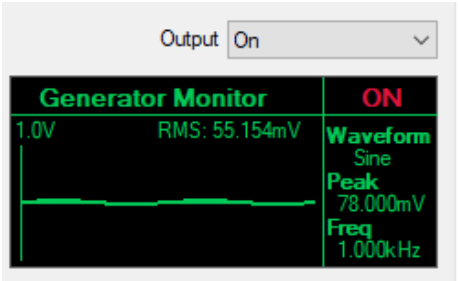
Click on the ***EIS*** menu, the lower half of the display will change to display the equivalent circuit / Randles Cell, also click on the ***OUT*** button and the output selection will be visible above the generator monitor screen.







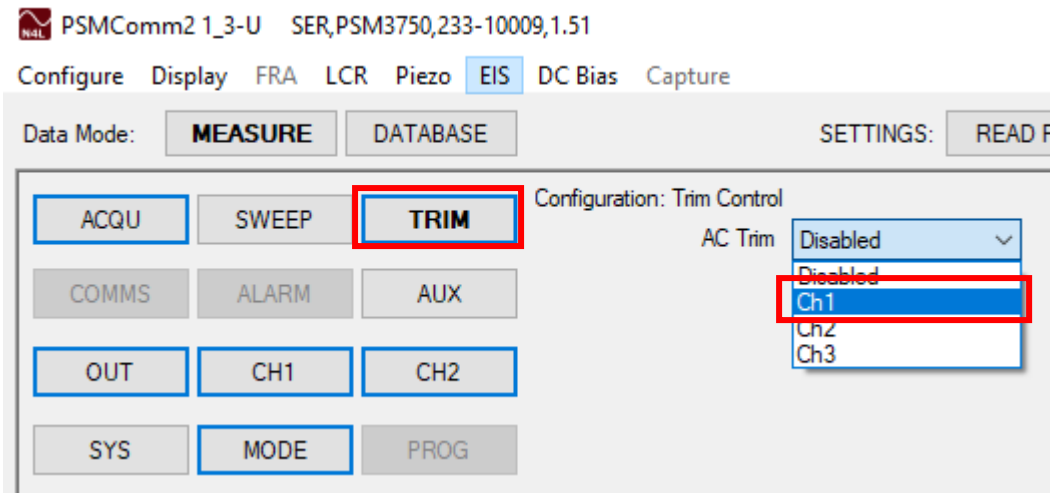
Click on the output dropdown just above the green Generator Monitor and select on. Now click on the ***SET UP PSM*** button, the display will change to show a sinusoid wave form.



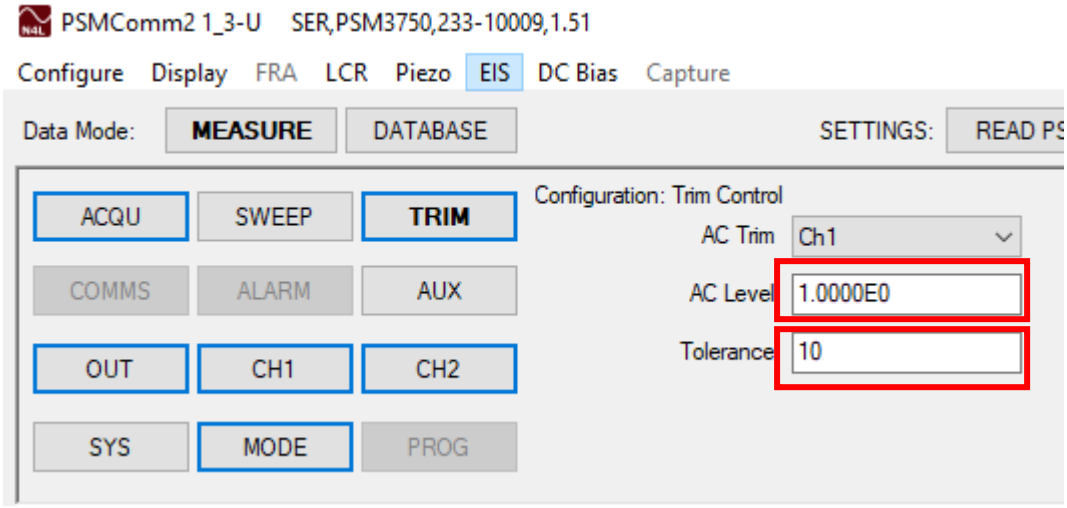
The amplitude should be set to approximately **78mV**, start at this voltage, and if required to obtain good results, you may increase the voltage up to a maximum of **1V** until you achieve a satisfactory sweep result without excessive noise. Only use as high a voltage as required to obtain a clean plot.

CAUTION. It is not advised to go beyond **1V** as you may damage the DUT.

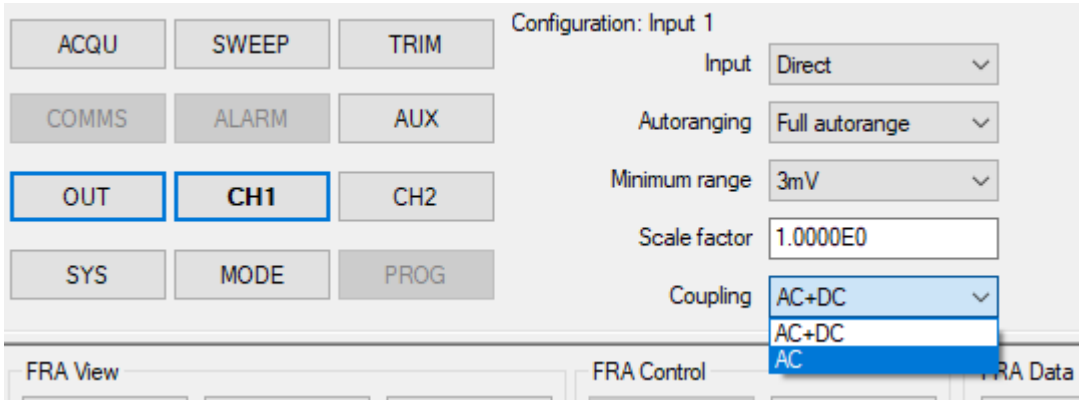
Once the generator voltage has been set, the AC Trim should also be enabled and set. When the Trim button is pressed a drop down menu will offer Disabled, Ch1, Ch2 and Ch3 if fitted.

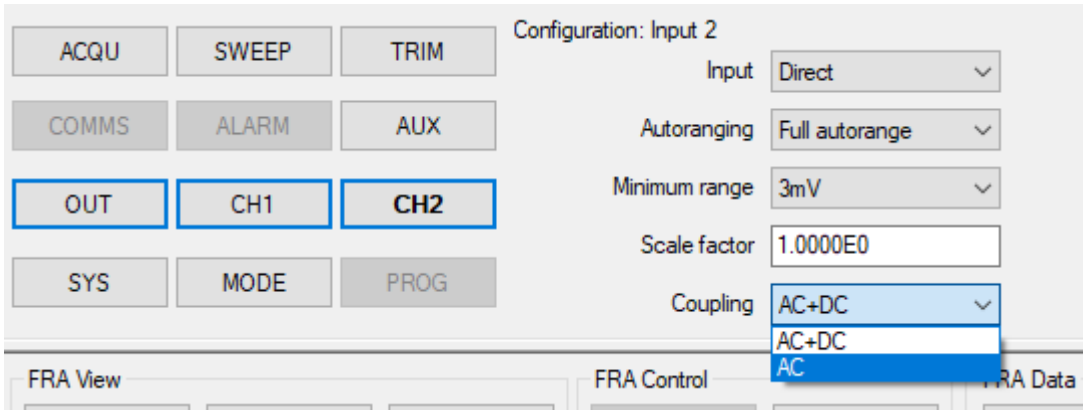


Once Ch1 has been selected, the trim level should be set to the same value as that the generator is set to. For the tolerance try in the range 5-10%

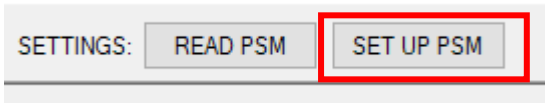


The final setting before running the sweep is to set both Ch1 and Ch2 to AC coupling only, the default is AC+DC, this must be changed for both channels to enable only the AC signal from the generator to be measured on the inputs.



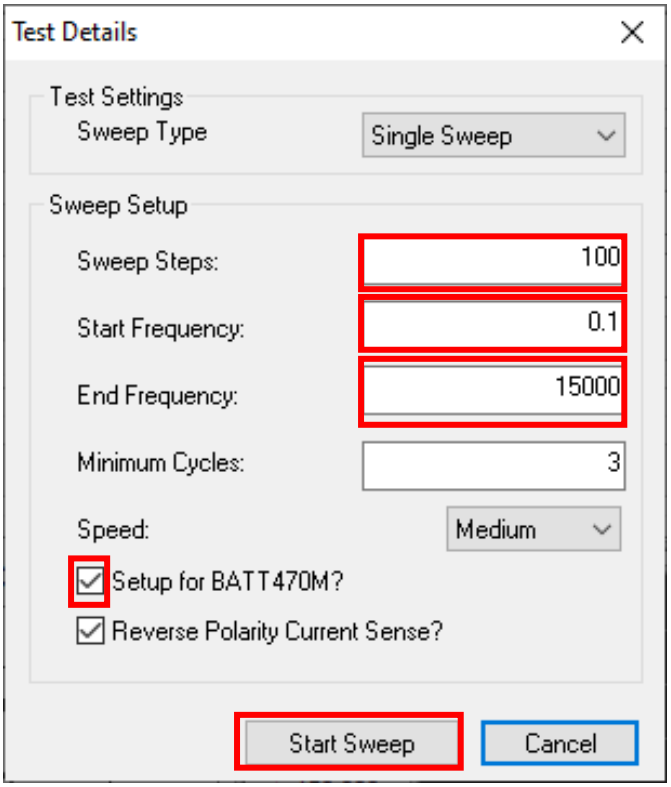


Now that all the settings have been adjusted, click the SET UP PSM button to ensure that all the settings are transferred to the instrument.



Setting the Sweep parameters

Click on the SWEEP button to display the SWEEP dialog window as shown below.

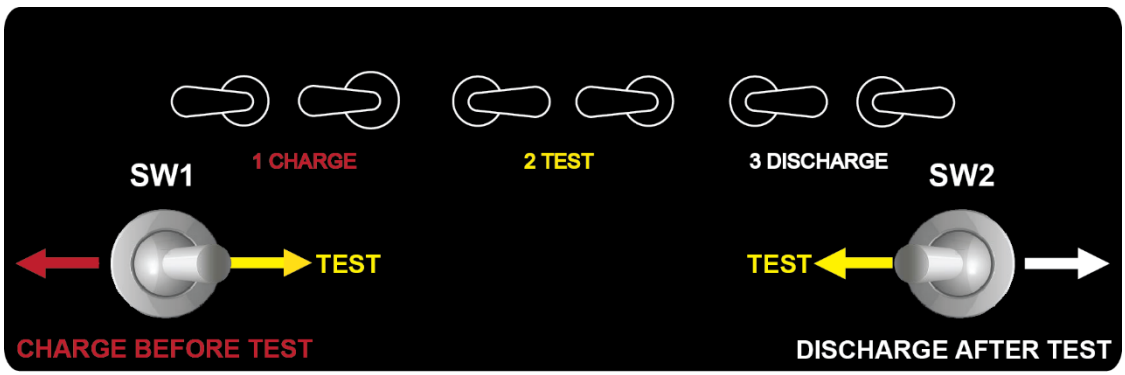


For this example, set the values as shown above.
The frequency range is set from 100mHz to 15kHz, the minimum cycles had already been set in the ACQU menu previously.

Lastly check the “Setup for BATT470m? check box.

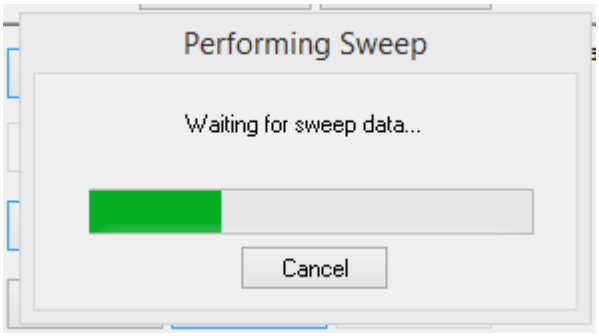
INFORMATION. The bandwidth shown in this example is only a suggested starting point and may be necessary to change either or both the start and end frequencies to achieve a satisfactory plot for the cell under test.

Now set SW1 & SW2 to the TEST position as shown below, then click Start Sweep

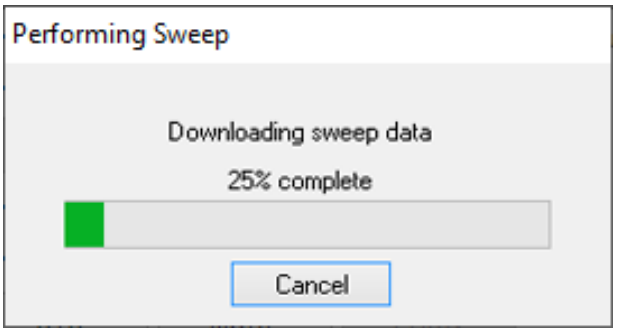


Running the test sweep

To initiate the sweep, click the sweep button.

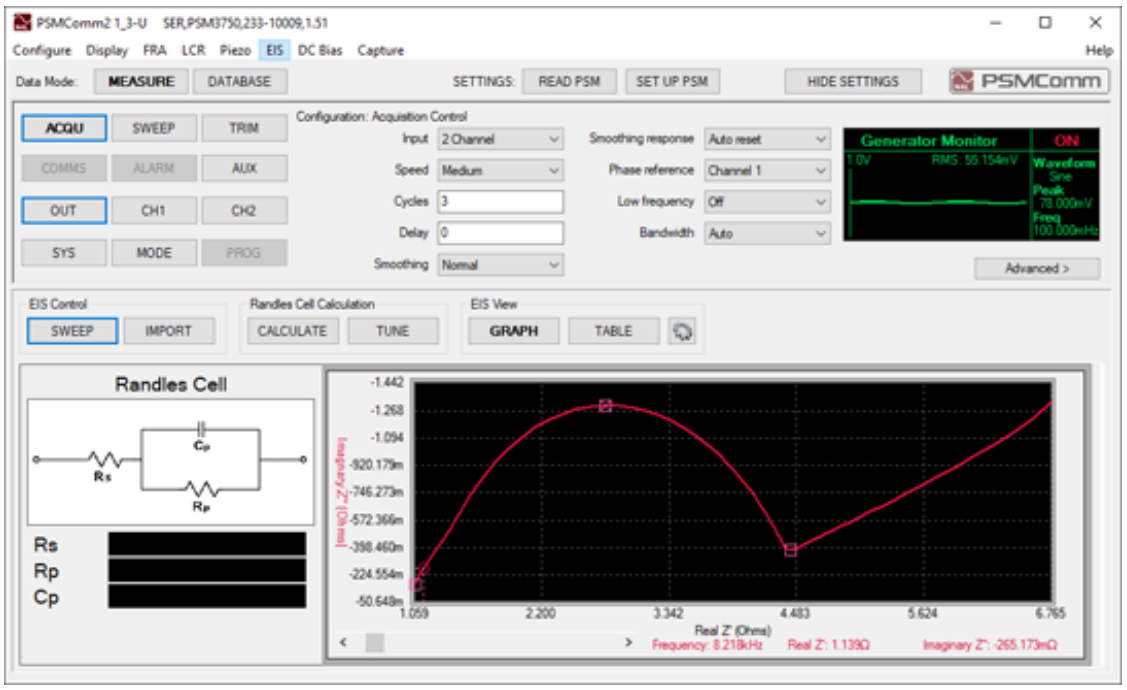


Depending on the start and end frequencies set for the sweep parameters and the number of cycles which in turn governs the length of time between each frequency measurement point, this dialog box will appear on the screen for a variable length of time from a few minutes to more than one hour as the sweep is performed.

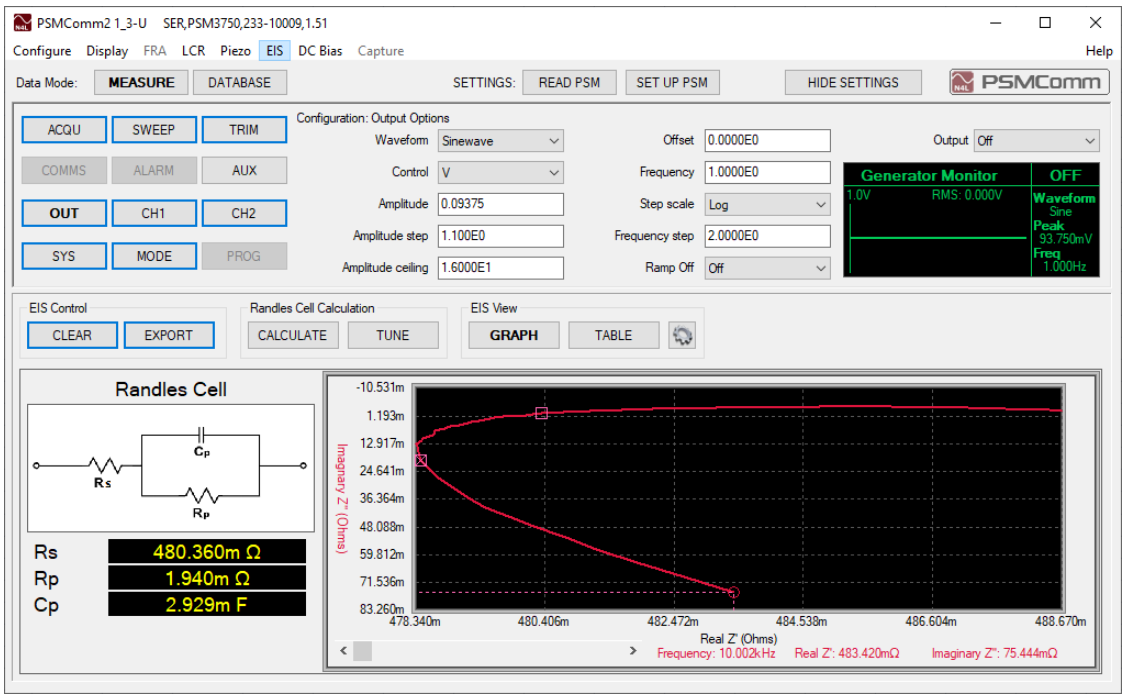


Once the sweep is complete the display changes to show that the data is being downloaded.

Once the data has finished downloading, the pop up message widow clears and the results are shown as seen in the screenshot below.
The result below is from an alkaline primary cell which exhibits the “typical Nyquist” plot shape with the Warburg impedance clearly evident as the approx. 45° line on the right hand side.



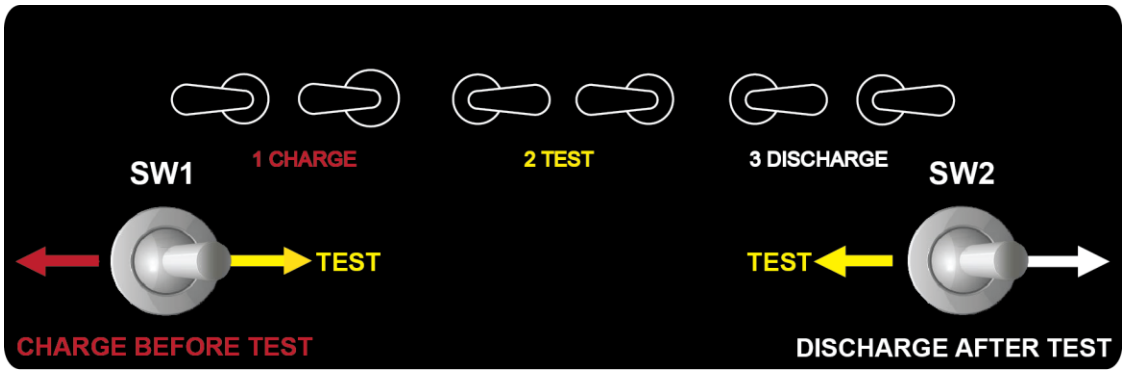
However, a plot from a Lithium-ion secondary cell shows a different, but typical form for that type of cell.



End of test

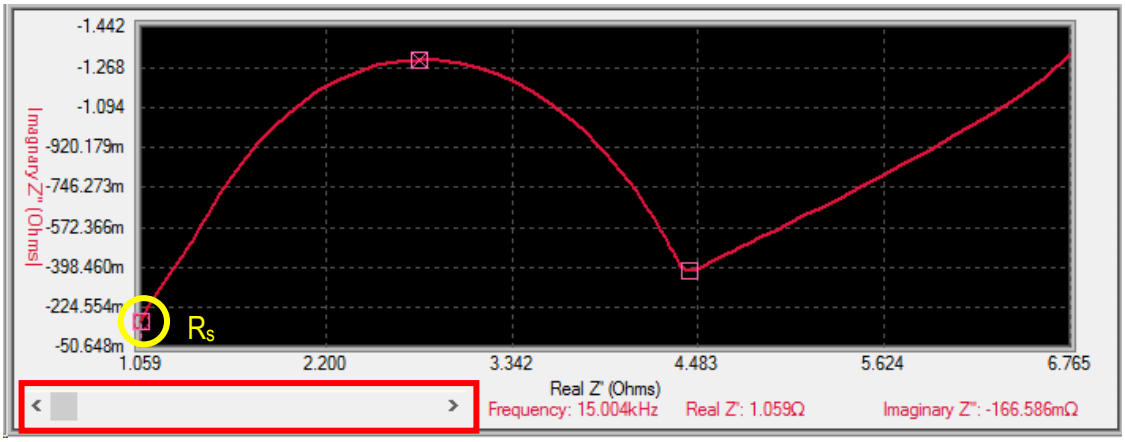
At the end of a sweep test, if no more sweeps are to be run then SW2 can be toggled, to "DISCHARGE AFTER TEST" to safely discharge the capacitance in the BATT470m.

Alternatively, if another test is to be run then there is no harm in leaving SW2 in the Test position until all testing is concluded.



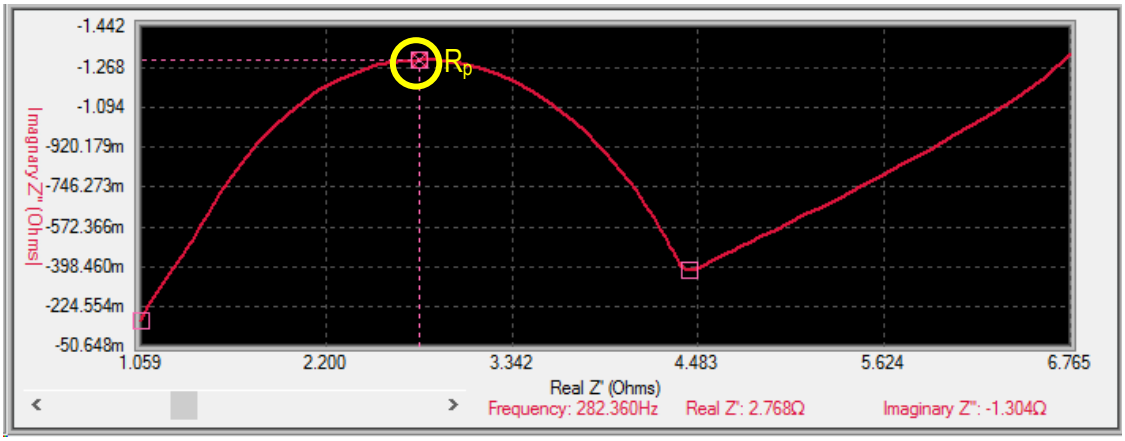
CAUTION. SW2 is to be used at the end of a test session to discharge the capacitors, if set to fast discharge at any other time, the capacitors will not charge and the PSM3750 could be damaged.

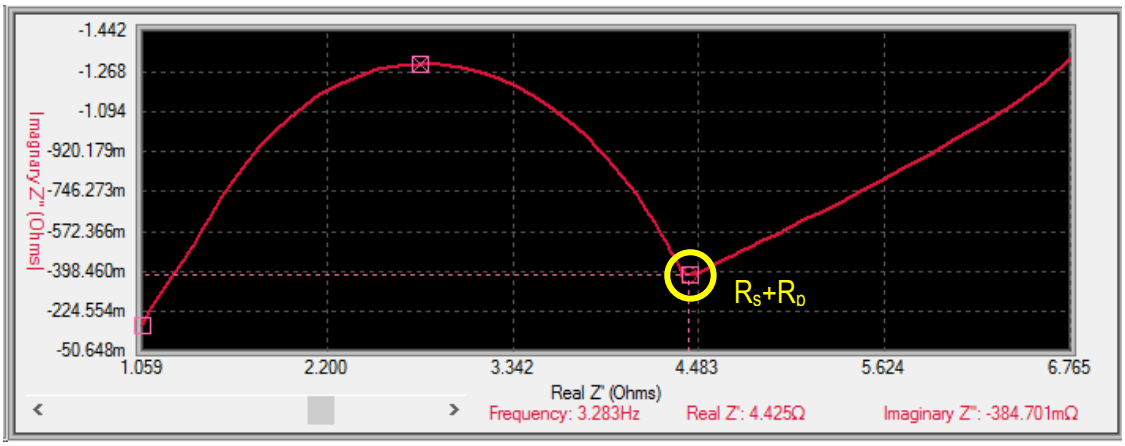
Interpreting the results



By moving the slider, highlighted in red, the cursor will follow the locus with the frequency, while Real Z, & Imaginary Z figures are updated beneath the graph accordingly.
In the start position above, the cursor is on the co-ordinates that represent Rs (Series resistance)

The co-ordinate highlighted by the yellow circle below, is the graphical representation of Rp (Parallel resistance)





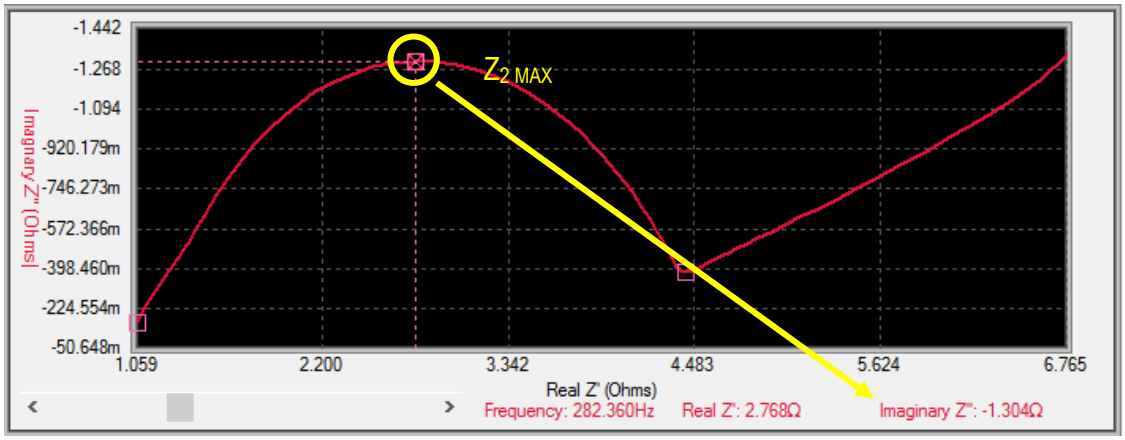
At the low frequency end of the plot, the highlighted point represents the sum of Rs and Rp

In the above example Rs= 1.059Ω

Rs+Rp=4.425Ω

∴ Rp=(Rs+Rp)-Rs
= 4.425Ω – 1.059Ω
= 3.366Ω
This calculated value is out by 0.002Ω compared to the values calculated by PSMComm2 because the Z values are dependent on accurate positioning of the cursor slider control.

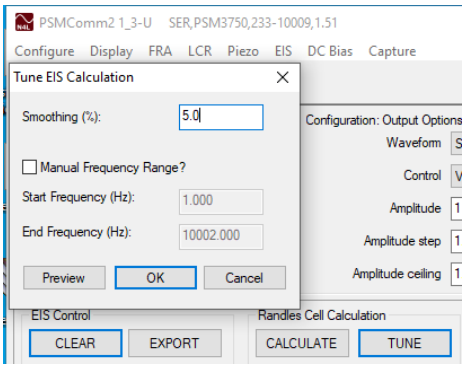
Cp= 1/2π x f x $Z_{2\,MAX}$ where $Z_{2\,MAX}$ is the imaginary impedance at the maximum point on the curve



Cp = 1/2π x f x $Z_{2\,MAX}$
= 1/6.28318 x 282.360 x 1.304
= 432.254 µF
Again, due to the difference between manual determination of the highest point on the curve and the software calculated result there is a 0.344pF difference.

Should the curve not fit the data as expected the Tune function can be used to adjust the fit of the data to the curve.

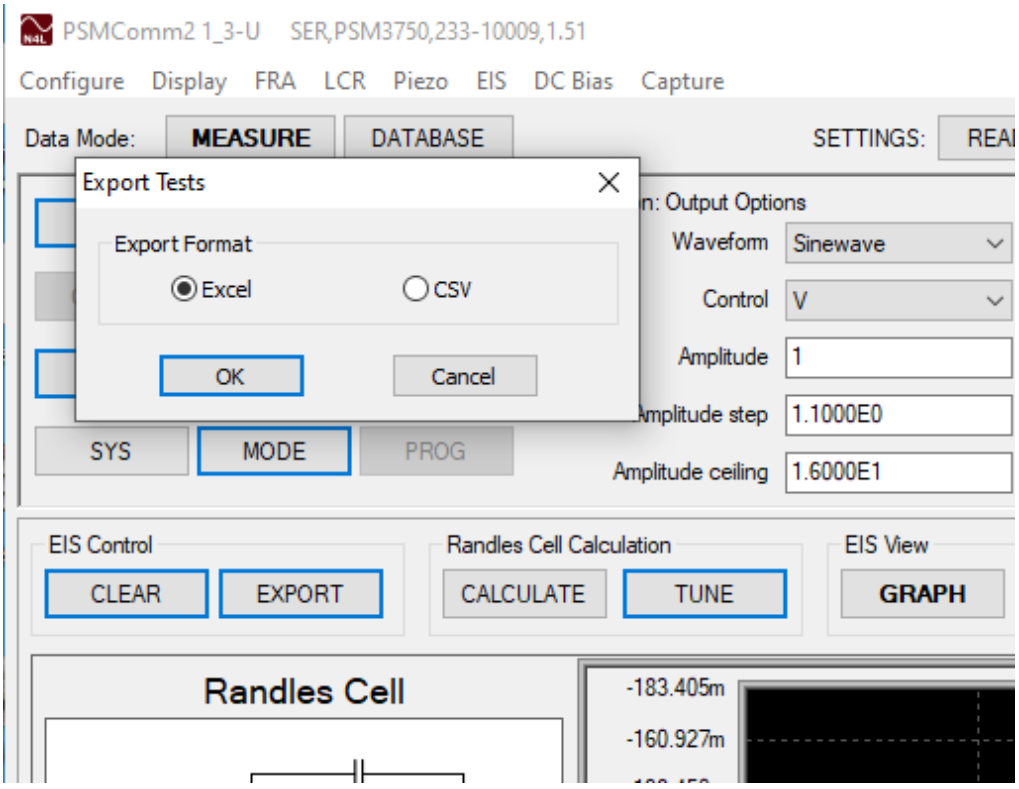
Adjusting the fit of the plot

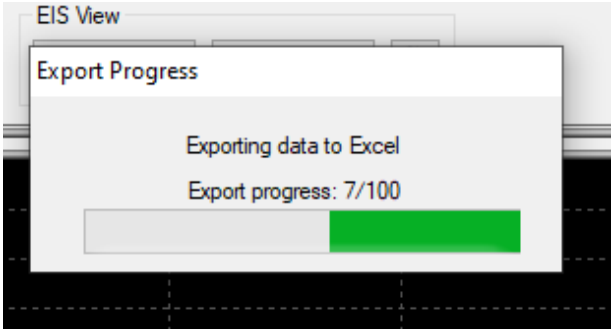


Clicking the Tune key brings up the dialog box shown to the left, the percentage smoothing and the start and end points of the curve can be adjusted for a better fit.

Exporting the results

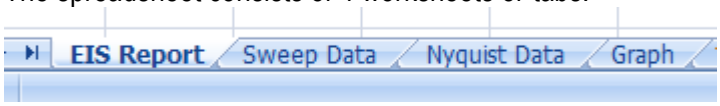
The data from the sweep can be exported as either an Excel file or a CSV file by clicking on the Export button, just above the Randles Cell diagram.





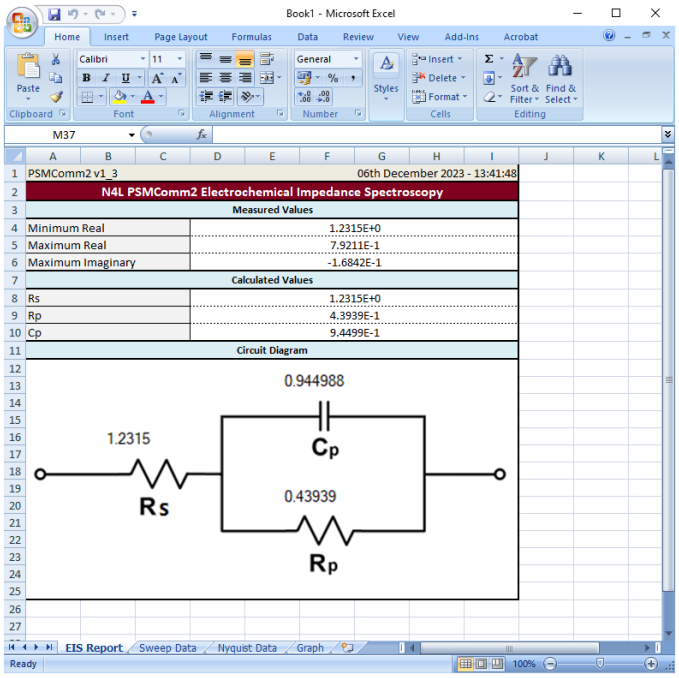
Once complete, Excel will open, and the results are displayed in the spreadsheet as shown below.

The spreadsheet consists of 4 worksheets or tabs.

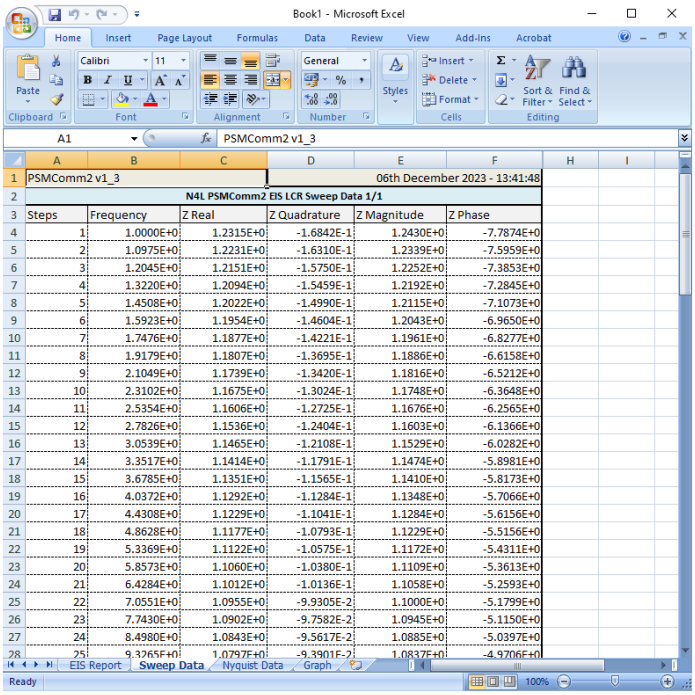


Consisting of the EIS Report, Sweep Data, Nyquist Data and the Graph or Bode Plot

EIS Report



Sweep data.



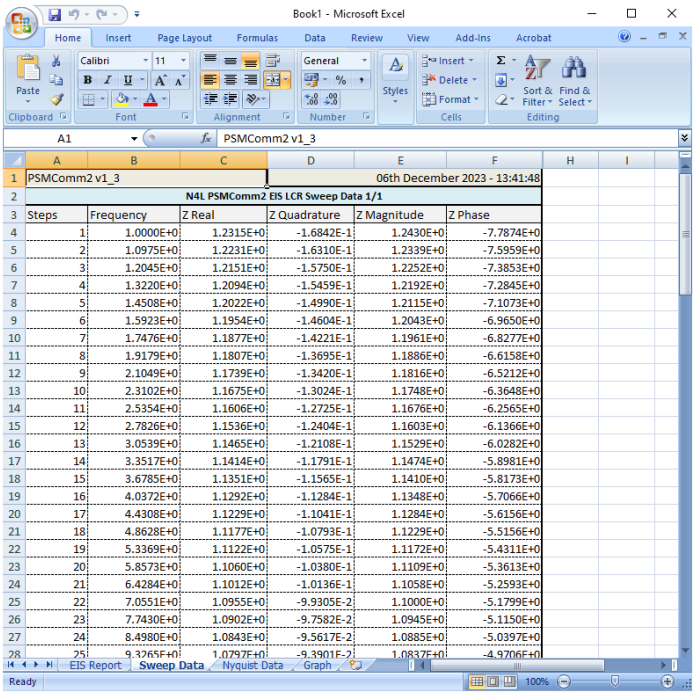
Book1 - Microsoft Excel

	A	B	C	D	E	F
1	PSMComm2 v1_3				06th December 2023 - 13:41:48	
2	N4L PSMComm2 EIS LCR Sweep Data 1/1					
3	Steps	Frequency	Z Real	Z Quadrature	Z Magnitude	Z Phase
4	1	1.0000E+0	1.2315E+0	-1.6842E-1	1.2430E+0	-7.7874E+0
5	2	1.0975E+0	1.2231E+0	-1.6310E-1	1.2339E+0	-7.5959E+0
6	3	1.2045E+0	1.2151E+0	-1.5750E-1	1.2252E+0	-7.3853E+0
7	4	1.3220E+0	1.2094E+0	-1.5459E-1	1.2192E+0	-7.2845E+0
8	5	1.4508E+0	1.2022E+0	-1.4990E-1	1.2115E+0	-7.1073E+0
9	6	1.5923E+0	1.1954E+0	-1.4604E-1	1.2043E+0	-6.9650E+0
10	7	1.7476E+0	1.1877E+0	-1.4221E-1	1.1961E+0	-6.8277E+0
11	8	1.9179E+0	1.1807E+0	-1.3695E-1	1.1886E+0	-6.6158E+0
12	9	2.1049E+0	1.1739E+0	-1.3420E-1	1.1816E+0	-6.5212E+0
13	10	2.3102E+0	1.1675E+0	-1.3024E-1	1.1748E+0	-6.3648E+0
14	11	2.5354E+0	1.1606E+0	-1.2725E-1	1.1676E+0	-6.2565E+0
15	12	2.7826E+0	1.1536E+0	-1.2404E-1	1.1603E+0	-6.1366E+0
16	13	3.0539E+0	1.1465E+0	-1.2108E-1	1.1529E+0	-6.0282E+0
17	14	3.3517E+0	1.1414E+0	-1.1791E-1	1.1474E+0	-5.8981E+0
18	15	3.6785E+0	1.1351E+0	-1.1565E-1	1.1410E+0	-5.8173E+0
19	16	4.0372E+0	1.1292E+0	-1.1284E-1	1.1348E+0	-5.7066E+0
20	17	4.4308E+0	1.1229E+0	-1.1041E-1	1.1284E+0	-5.6156E+0
21	18	4.8628E+0	1.1177E+0	-1.0793E-1	1.1229E+0	-5.5156E+0
22	19	5.3369E+0	1.1122E+0	-1.0575E-1	1.1172E+0	-5.4311E+0
23	20	5.8573E+0	1.1060E+0	-1.0380E-1	1.1109E+0	-5.3613E+0
24	21	6.4284E+0	1.1012E+0	-1.0136E-1	1.1058E+0	-5.2593E+0
25	22	7.0551E+0	1.0955E+0	-9.9305E-2	1.1000E+0	-5.1799E+0
26	23	7.7430E+0	1.0902E+0	-9.7582E-2	1.0945E+0	-5.1150E+0
27	24	8.4980E+0	1.0843E+0	-9.5617E-2	1.0885E+0	-5.0397E+0
28	25	9.3265E+0	1.0797E+0	-9.3901E-2	1.0837E+0	-4.9706E+0

EIS Report | Sweep Data | Nyquist Data | Graph

Ready

Nyquist data.



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27	24	8.4980E+0	1.0843E+0	-9.5617E-2	1.0885E+0	-5.0397E+0
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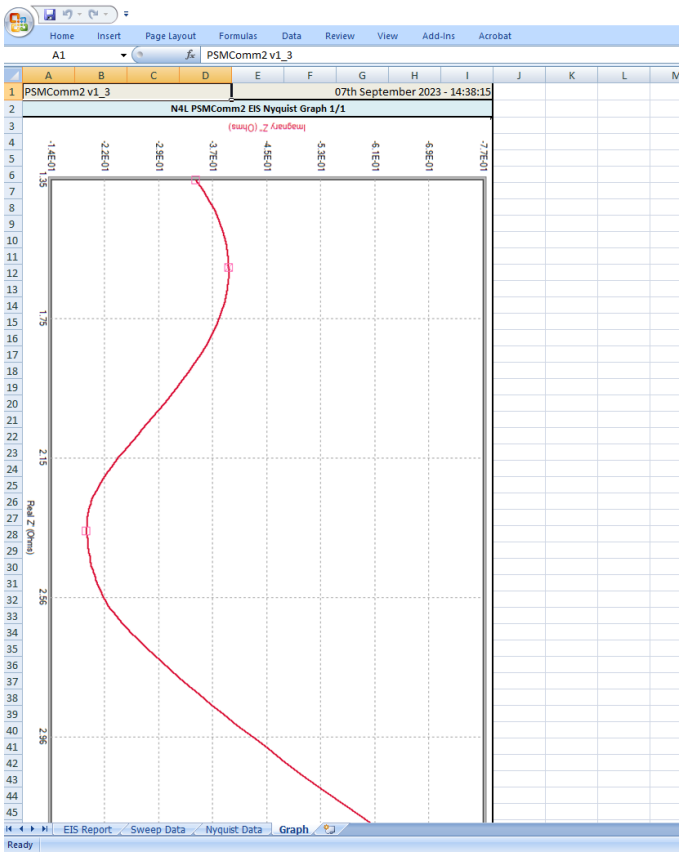
EIS Report | Sweep Data | Nyquist Data | Graph

Ready

Graph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PSMComm2 v1_3
07th September 2023 - 14:38:15
N4L PSMComm2 EIS Nyquist Graph 1/1
Imagnary Z' (Ohms)
-1.4E-01
-2.2E-01
-2.9E-01
-3.7E-01
-4.5E-01
-5.3E-01
-6.1E-01
-6.9E-01
-7.7E-01
1.35
1.75
2.15
2.56
2.96
Real Z (Ohms)
EIS Report
Sweep Data
Nyquist Data
Graph
Ready