# Z100 Quick Start Manual

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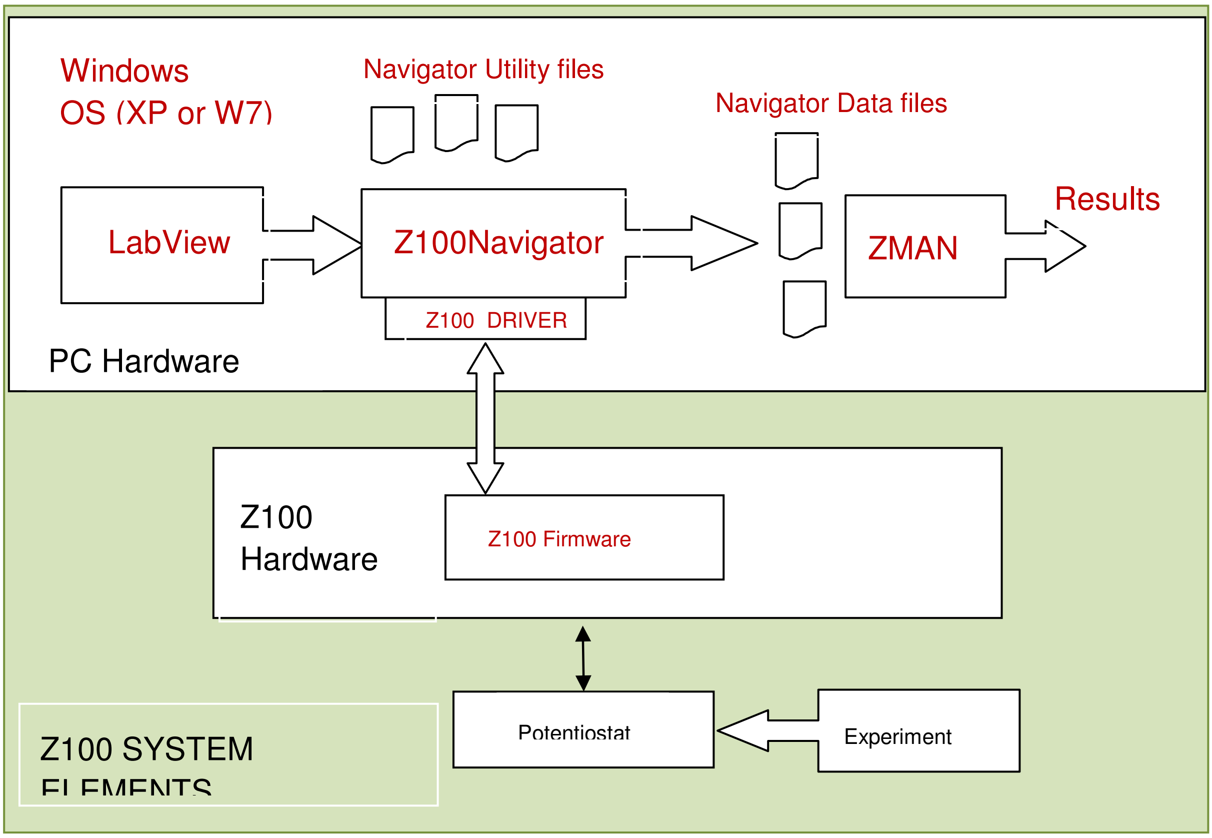
The Z100 EIS consists of a number of elements each of which needs to be present in order for the system to operate correctly. The installation procedure outlined below should result in a fully working system.  In the event that a problem occurs the diagram below may help in troubleshooting.




## System Elements:

**Potentiostat:** This will typically be an EDAQ EA163 Potentiostat.  A User supplied potentiostat can also be used but gains will need to be set manually.

**Z100 Hardware:** This is a microprocessor based unit that consists of waveform generator and two precision measuring channels for Voltage and Current so that Impedance can be calculated.

**Z100 Firmware:** This is the program internal to the Z100 Hardware that performs all the low level operations necessary to generate the required waveforms and perform the necessary measurements. This program also provides the communications between the Z100 Hardware and the PC hardware. This program will from time to time be upgraded to either correct errors or to enhance system performance.

**Z100 Driver:** This software routine provides the link between the Operating System and the Z100 Firmware.  It must be installed correctly in order for the Z100 Navigator application to communicate with the attached Z100 Hardware.

**Z100 Navigator:** This program controls and executes the measurements required by the user and stores the resulting data in files that are then accessible by the ZMAN display, analysis and modeling program. Z100 Navigator also uses data files related to its operation – such files may contain calibration, setup and Linearisation data.

**LabView:** A Run-time version of LabView is installed to support the Z100 Navigator program. This is not an operating version (License) of LabView and may only be used with the Z100 Navigator.

**ZMAN:** This program reads the Z100 Navigator data files and provides the means to display analyse and model the data.

**PC Hardware and Windows operating software:** This provides the hardware and software environment for Z100 Navigator and ZMAN

## System Installation

The following installation procedure should be used:

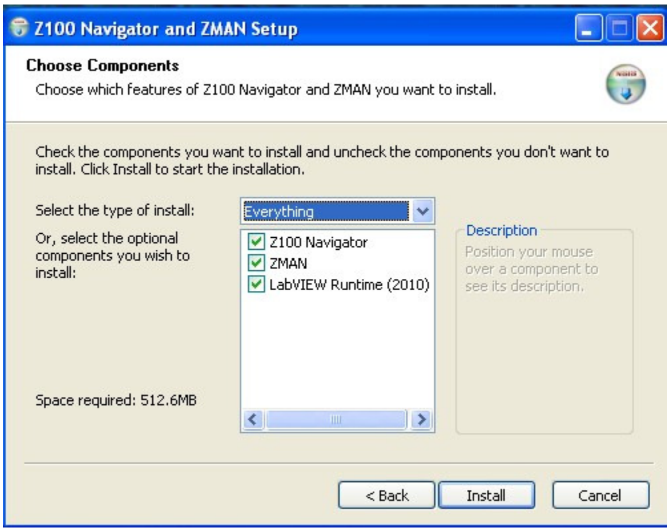
- Unpack the system and check that all items on the packing List are present. Locate the CD or Memory Stick containing the installation program.
- Install the software
- Connect the hardware and Run Z100 Navigator.
- Perform validation tests: Z100 Self Test, Test network

## Software Installation

Ensure your PC has sufficient disk space to install the Z100 material (at least 512.6 MB). Check that the system has an XP or later version of the Windows Operating system (32 Bit or 64 Bit system).

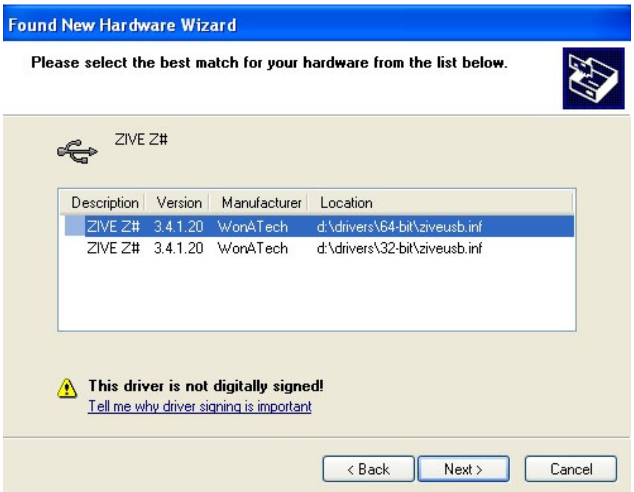
Insert your Installation. The Z100 Navigator and ZMAN Setup screen will be displayed. Carefully follow the instructions provided by the Setup program.


**Please note**: a number of different programs ( Labview, Z100 Navigator, ZMAN and Z100 Drivers (ZIVE Z#) will be installed during this process and some will take a few minutes to install. The setup program provides a choice of which programs you choose to install. For the first installation choose **Everything**




During the installation of the Z100 Drivers the following warning message will be displayed. It is safe to Continue with the installation.


During the installation of the Z100 driver you will be given a choice regarding the type of driver to install. Make sure you choose the appropriate driver to suit the operating system on your PC.

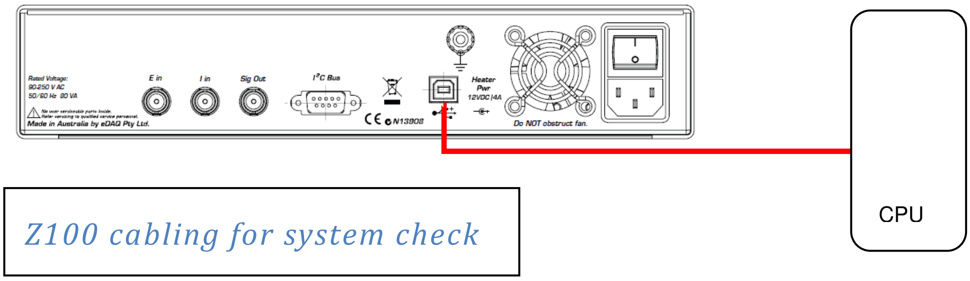



Continue the installation process until it is completed.

You are now ready install the Hardware and run the software.

## Hardware Installation

Connect the Z100 hardware unit as shown below:




*Z100 cabling for system check*

When your hardware has been connected as shown above apply power:

All indicator lights should come on momentarily and then go off except for the Green Power LED.

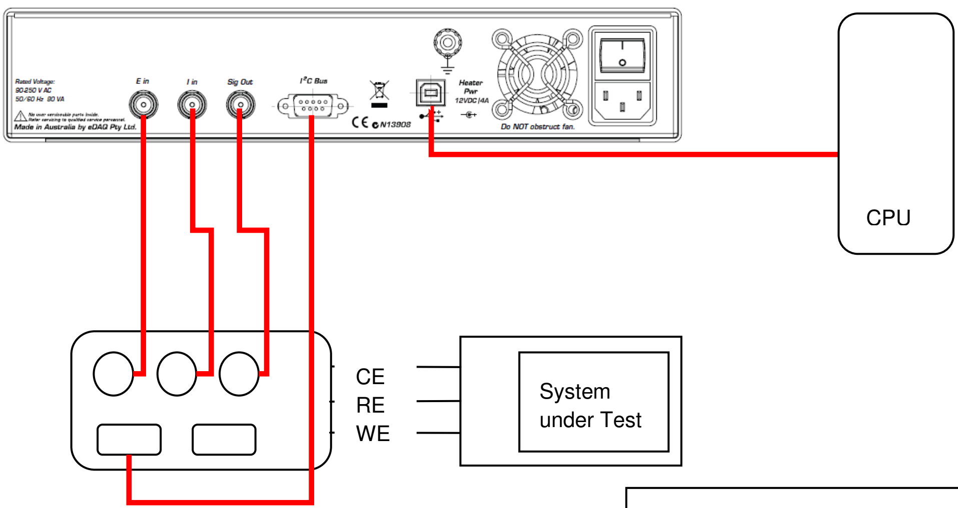
Initial Loop back tests can be run on this configuration without connecting a potentiostat.  However if you choose to connect the potentiostat at this stage then turn the Power Off and connect the potentiostat to the system as described below.

### Connecting a Potentiostat

**Advice:**  Whenever you need to change the hardware configuration, first save your results, exit the program and then switch off the hardware unit. **DO NOT CONNECT or DISCONNECT the POTENTIOSTAT while POWER IS ON**.

With the system powered down connect the external potentiostat as shown:

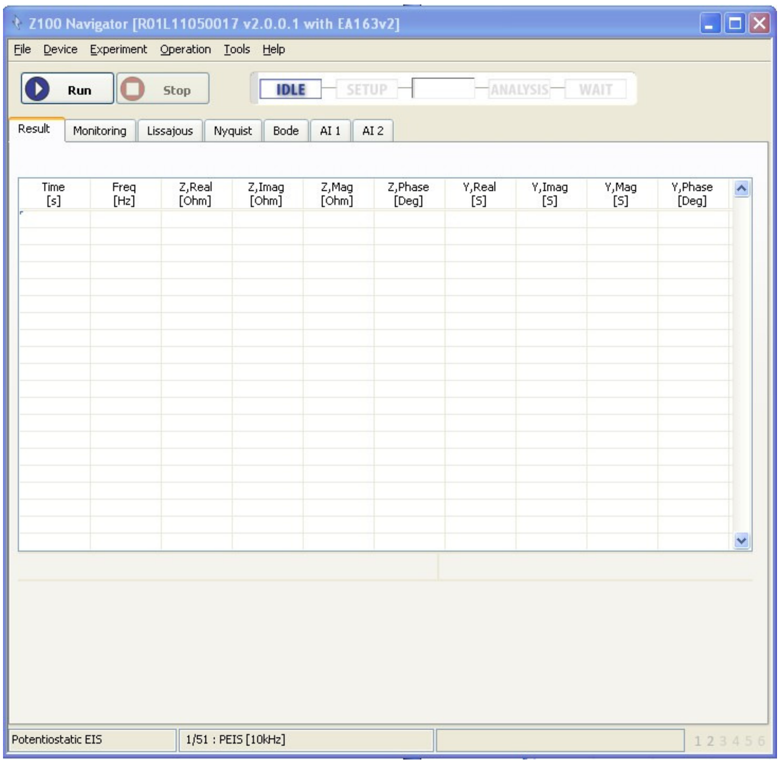
- Z100 Sig Out  > Potentiostat Ein
- Potentiostat I out > Z100 I in
- Potentiostat E Out > Z100 E in




Z100 cabling with EA163 POTENTIOSTAT

## Running Z 100 Navigator

Start the Z100 Navigator program. It may take a little longer to complete the startup phase if it needs to connect to the Potentiostat and complete its identification process. The startup screen shown below indicates that the system has identified its Hardware Unit serial Number, Firmware version and the successful installation and detection of the EA163 Potentiostat.




In order to complete the installation and Quick Start process three simple tests will be carried out described in the Validation tests below.

## Validation tests

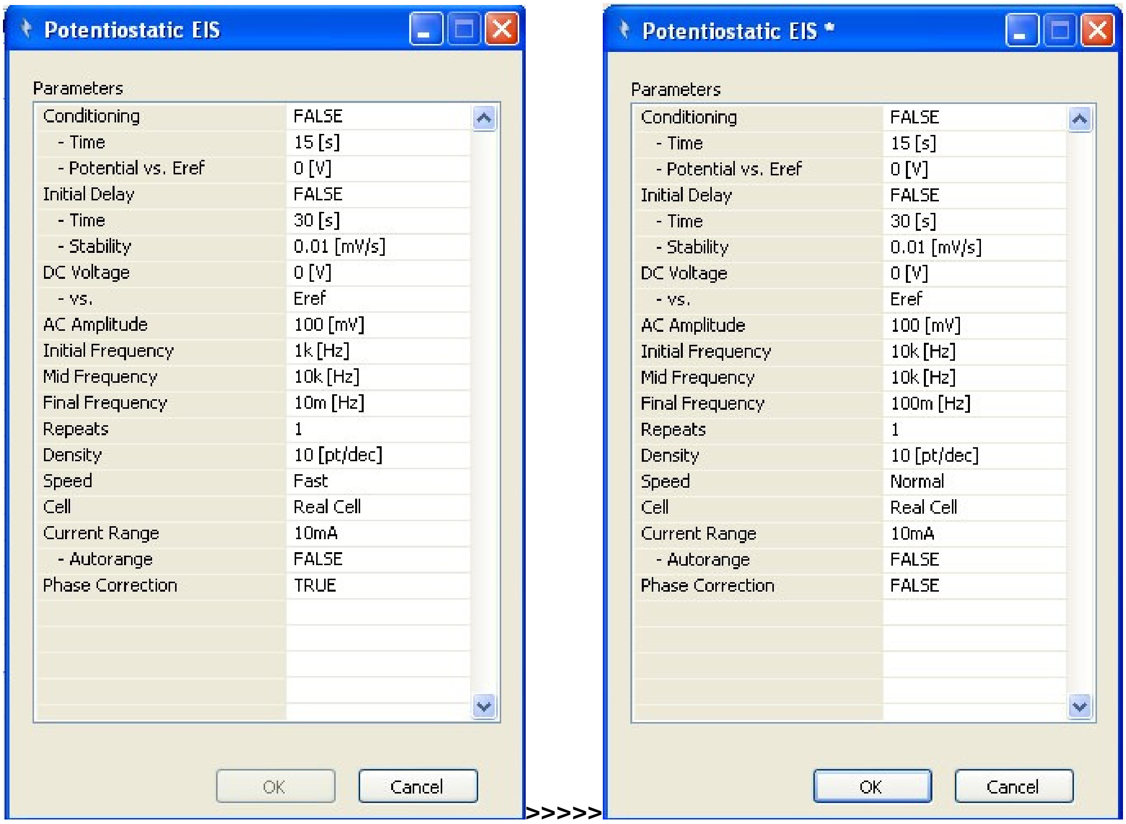
The following validation tests will be performed:

- Loop Back test: Checks operation of the Z100 Hardware without a potentiostat.
- Blank Run: Tests complete system including a potentiostat and a simple 5000 Ohm resistor.
- Simple Test network: using the Z100 Test Network card in simple configurations.

### Loop Back Test

The Z100 has an operating mode in which its output waveform is connected internally to its two input channels so that a Loop back test can be performed. This test provides the means to check all Z100 system operation without using the external potentiostat. To set up suitable Loop Back conditions:

- Select **Loopback** from the **Device menu**
- Select **Potentiostatic EIS** from the **Experiment Menu -** this will display a settings menu which should be checked before the Loopback test is run




Set the following as shown above:

- Initial Frequency = 10 KHz
- Mid Frequency = 10 KHz
- Final frequency = 100 mHz
- Phase Correction = FALSE

**All other settings remain unchanged**.

Close Potentiostatic EIS settings Menu.

- **Hint: Choosing Initial Frequency:** When initially selecting operating frequencies for an experiment start by selecting a restricted range (e.g. from 10Hz to 10,000Hz) that you are confident will produce a representative output. This will result in faster experiment execution. Slow frequencies and multiple points per decade frequency such as 10mHz take 100 seconds for every point! Once correct operation is established the range can be extended to the limits and resolution required by your experiment.
- **Hint: Choosing Frequencies:** The system allows the selection of an **Initial**, **Middle** and **Final** Frequency. Typically start from a high frequency and end with a Low frequency. **Final** and **Middle** can have the same value if it is required to make a single unidirectional scan.
- **Hint: System settings:** Typically an experiment will consist of a number of runs or scans so the system remembers its settings from run to run. If it is required to start a new set of experiments make sure you review and set all parameters correctly for your new experiment.
- **Hint: Choosing AC Amplitude.** As a general comment – the higher the AC amplitude used the better the Signal to Noise ratio. When dealing with passive components relatively high AC amplitude (e.g. 1000mV) can be chosen. However when dealing with electrochemical

systems the applied AC amplitude will be limed to less than 200mV so as not to cause unintended electrochemical effects.

- **Hint: Choosing Current range.** The best Potentiostat frequency response is achieved at higher current amplitudes. At currents below 1mA the Potentiostat frequency response of the potentiostat will be degraded and should be tested prior to commencing experiments. 10mA range is a useful range to start experiments.
- **AutoRange:** When selected the system will choose an appropriate gain range for the frequency being measured. The impedance of a network typically increases as the frequency is decreased and a lower current range can be used.

**Run** can now be initiated to start the EIS measurement cycle.

The system will now commence operation and the system performs a number of measurements to determine the appropriate internal gain levels that should be used for subsequent measurements, each time producing an audible alarm when an unsuccessful trial measurement is made.

Once the system finds appropriate settings it will commence testing and generate results in the **Result** window one line at the time – starting with the **Initial Frequency** and ending with the **Final Frequency.**

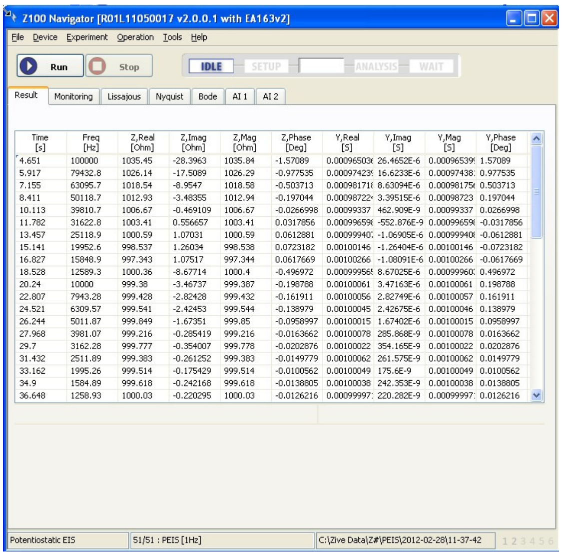
Measurement progress can be followed by choosing one of the following Display tags:

- **Result:** displays all the numerical impedance values measured and computed at each frequency.
- **Monitoring:** will show the applied voltage and the output current useful for detecting noisy or distorted signals.
- **Lissajous:** displays an X-Y display of applied voltage and output current. Highlights phase shift.
- **Nyquist plot:** Plots Real Z vs Imaginary Z values
- **Bode Plot:** Amplitude and Phase vs Frequency

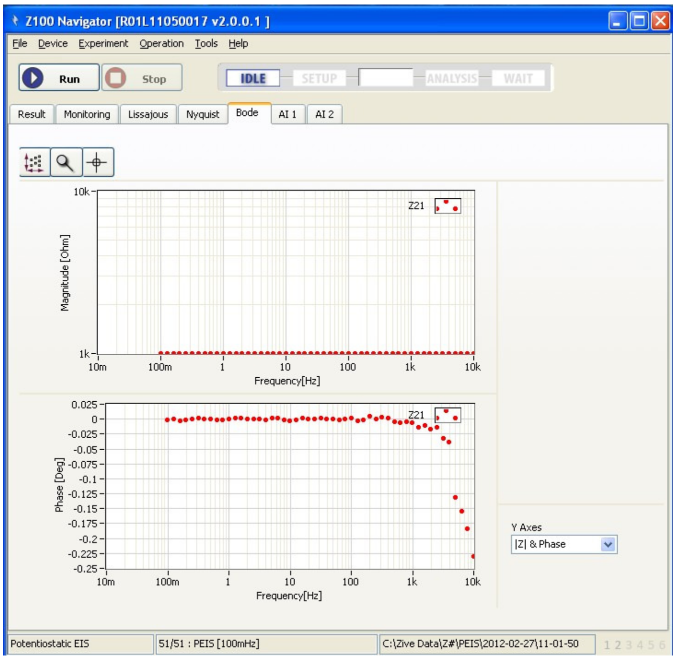
These display modes can be selected during the measurement cycle to check on progress**.**

Measurement progress can be followed by choosing one of the Display tags:

**Typical results**




| Time [s] | Freq [Hz] | Z,Real [Ohm] | Z,Imag [Ohm] | Z,Mag [Ohm] | Z,Phase [Deg] | Y,Real [S] | Y,Imag [S] | Y,Mag [S] | Y,Phase [Deg] |
|---|---|---|---|---|---|---|---|---|---|
| 4.651 | 100000 | 1035.45 | -28.3963 | 1035.84 | -1.57089 | 0.00096503 | 26.4652E-6 | 0.00096539 | 1.57089 |
| 5.917 | 79432.8 | 1026.14 | -17.5089 | 1026.29 | -0.977535 | 0.00097423 | 16.6233E-6 | 0.00097438 | 0.977535 |
| 7.155 | 63095.7 | 1018.54 | -8.9547 | 1018.58 | -0.503713 | 0.00098171 | 8.63094E-6 | 0.00098175 | 0.503713 |
| 8.411 | 50118.7 | 1012.93 | -3.48355 | 1012.94 | -0.197044 | 0.00098722 | 3.39515E-6 | 0.00098723 | 0.197044 |
| 10.113 | 39810.7 | 1006.67 | -0.469109 | 1006.67 | -0.0266998 | 0.00099337 | 462.909E-9 | 0.00099337 | 0.0266998 |
| 11.782 | 31622.8 | 1003.41 | 0.556657 | 1003.41 | 0.0317856 | 0.00099659 | -552.876E-9 | 0.00099659 | -0.0317856 |
| 13.457 | 25118.9 | 1000.59 | 1.07031 | 1000.59 | 0.0612881 | 0.00099940 | -1.06905E-6 | 0.00099940 | -0.0612881 |
| 15.141 | 19952.6 | 998.537 | 1.26034 | 998.538 | 0.0723182 | 0.00100146 | -1.26404E-6 | 0.00100146 | -0.0723182 |
| 16.827 | 15848.9 | 997.343 | 1.07517 | 997.344 | 0.0617669 | 0.00100266 | -1.08091E-6 | 0.00100266 | -0.0617669 |
| 18.528 | 12589.3 | 1000.36 | -8.67714 | 1000.4 | -0.496972 | 0.00099956 | 8.67025E-6 | 0.00099960 | 0.496972 |
| 20.24 | 10000 | 999.38 | -3.46737 | 999.387 | -0.198788 | 0.00100061 | 3.47163E-6 | 0.00100061 | 0.198788 |
| 22.807 | 7943.28 | 999.428 | -2.82428 | 999.432 | -0.161911 | 0.00100056 | 2.82749E-6 | 0.00100057 | 0.161911 |
| 24.521 | 6309.57 | 999.541 | -2.42453 | 999.544 | -0.138979 | 0.00100045 | 2.42675E-6 | 0.00100046 | 0.138979 |
| 26.244 | 5011.87 | 999.849 | -1.67351 | 999.85 | -0.0958997 | 0.00100015 | 1.67402E-6 | 0.00100015 | 0.0958997 |
| 27.968 | 3981.07 | 999.216 | -0.285419 | 999.216 | -0.0163662 | 0.00100078 | 285.868E-9 | 0.00100078 | 0.0163662 |
| 29.7 | 3162.28 | 999.777 | -0.354007 | 999.778 | -0.0202876 | 0.00100022 | 354.165E-9 | 0.00100022 | 0.0202876 |
| 31.432 | 2511.89 | 999.383 | -0.261252 | 999.383 | -0.0149779 | 0.00100062 | 261.575E-9 | 0.00100062 | 0.0149779 |
| 33.162 | 1995.26 | 999.514 | -0.175429 | 999.514 | -0.0100562 | 0.00100049 | 175.6E-9 | 0.00100049 | 0.0100562 |
| 34.9 | 1584.89 | 999.618 | -0.242168 | 999.618 | -0.0138805 | 0.00100038 | 242.353E-9 | 0.00100038 | 0.0138805 |
| 36.648 | 1258.93 | 1000.03 | -0.220295 | 1000.03 | -0.0126216 | 0.00099997 | 220.282E-9 | 0.00099997 | 0.0126216 |




- **AI 1 & AI 2**: These selections display the current and voltage AC and DC values. In addition, Time & Frequency Domain plots (power spectrum) are displayed as well as the signal to noise ratio achieved. A higher “Signal In Noise and Distortion” (SINAD) value and a lower Total Harmonic Distortion and Noise (%THD+N) indicate better measurements.

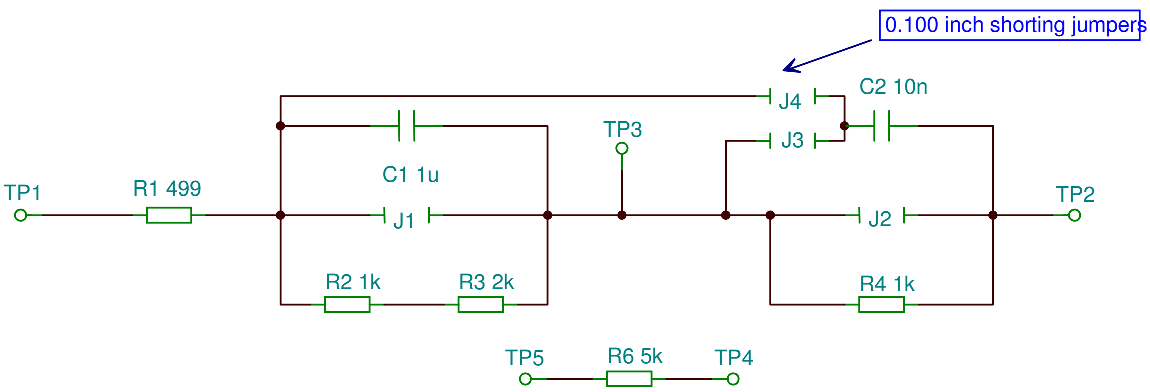
This completes the initial Loopback tests. It confirms that the system is performing correctly. Disable the loop back test in the **Device** menu.

The next step will connect a Potentiostat and perform a test on a sample cell using the Z100 Test Network.

## Z100 Test Network

The system is provided with a test network whose circuit is shown below. The Test Network can be used to test the operation of the system and to provide a predictable and reproducible test environment.

The test network circuit is provided with a number of shorting links that allow different circuits to be configured. Some typical configurations are detailed below.




- **Blank Test:** In this configuration only the isolated 5000 Ohm Resistor (R6) is used to measure the system performance. It provides a useful indication of the overall frequency response of the Z100/Potentiostat system. The file so generated can be used to perform minor phase corrections that occur at high frequencies.

- **Simple Model** – 1 timing element: In this configuration the network between TP1 and TP3 is used and Jumper J1 and J4 are removed.
- **Complex Model** – 2 timing elements: In this configuration total network between TP1 and TP2 is used and the Jumpers are configured as follows: J1 OUT; J2 OUT; J3 OUT; J4 IN.

## Running a "Blank" Sample

This test requires a potentiostat (EDAQ EA163) to be connected to the Z100 Hardware.

The purpose in running a "blank" sample is to establish correct system operation and to provide an optional phase correction file that removes minor phase shifts introduced by the system at higher frequencies. The blank sample used is typically a relatively low value resistor which is assumed to have zero phase shift within the 100kHz system bandwidth.

**Connect the potentiostat** to the 5000 Ohm test resistor on the Z100 Test Network with the RE, and AE connected together at one end of the resistor and the WE at the other

**Launch the Z 100 Navigator**. Before starting operations ensure that the Loopback test in the Device menu is disabled and the Potentiostatic EIS experiment is selected as indicated at the bottom of the Startup screen. Note that it takes a little longer to complete its startup phase because it needs to connect to the external potentiometer and complete its identification process. The startup screen indicates that the system has identified a potentiostat in this case an EA163.

The potentiostat Green On-Line LED should be On and the Overload LED should be OFF.

## Procedure

1. Use the Z100 Test network 5kOhm Resistor.
2. Open parameter dialog by selecting **Experiment >> Potentiostatic EIS…** in the main menu.

   Please make sure that **Real Cell** is selected,

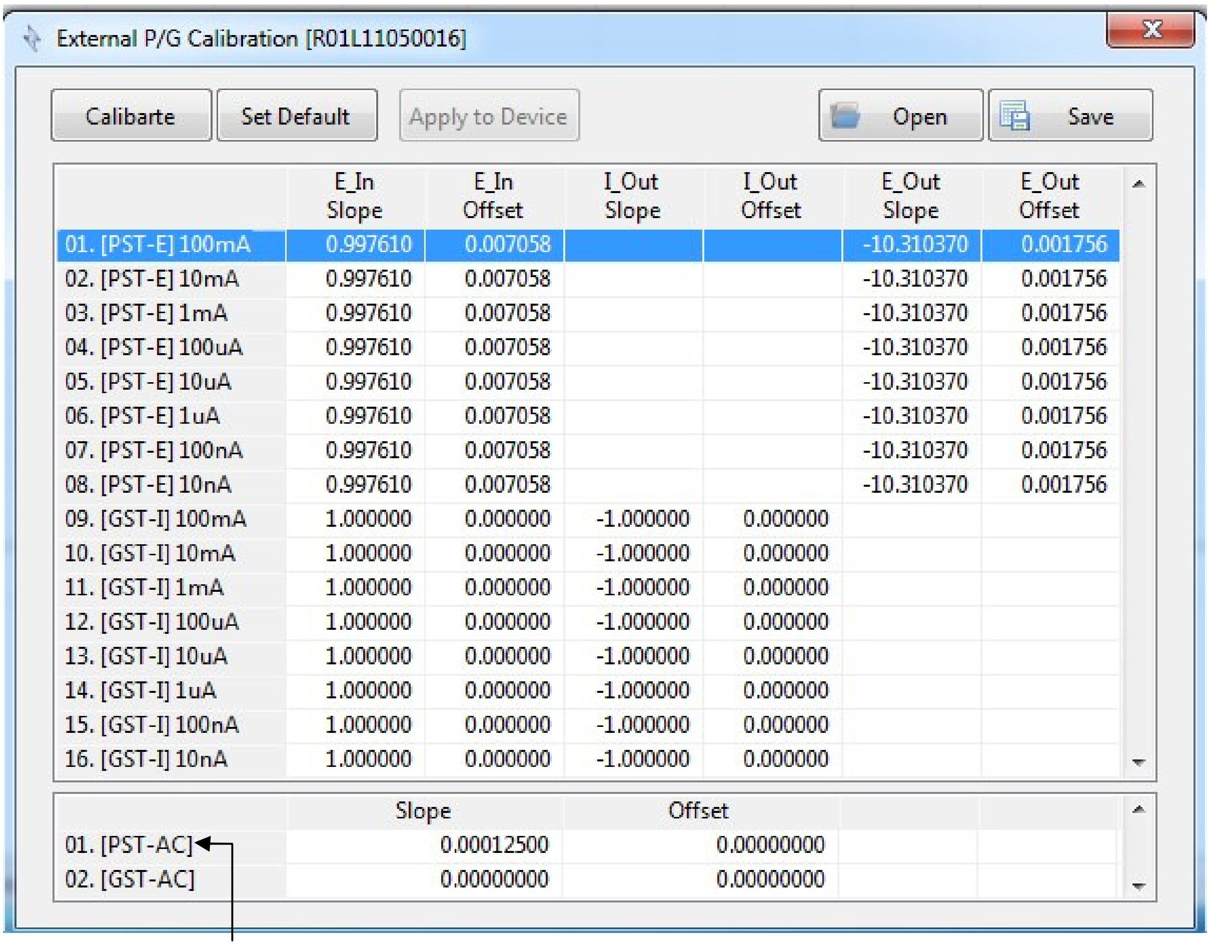
   Phase Correction = FALSE

   Adjust Scan from 100kHz to 1Hz with 10 steps per decade.

   Set AC Amplitude to 100mV

   Set Speed to Normal

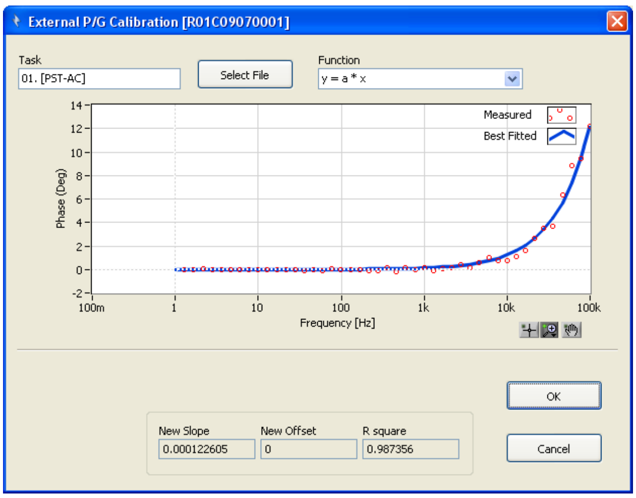
   Current Range to 10mA
3. **Run** the experiment.
4. In the Bode plot the phase shift and magnitude is plotted. A phase shift indicates that there is a time delay between the current path and excitation voltage path. This time delay tends to be constant (with this simple resistor) over frequency and its effect is more pronounced at high frequencies. There are many cumulative factors that cause this phase shift: time delay of control loop, time delay of current measuring circuit, signal conditioning path and the input cable. With the EA163 the uncompensated phase shift at 100 kHz should be less than 20º and is less than 1º at frequencies less than 10 kHz. The Phase corrected phase shift will be less than 0.5º.
5. When finished, save the calibration data by selecting **File >> Save as Binary Format…**,
6. Select **Tools >> Calibrate External P/G…** The External P/G Calibration window will appear.



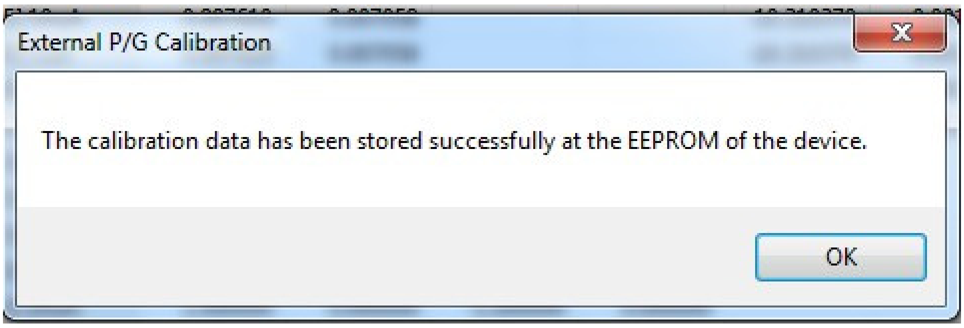

| | E_In Slope | E_In Offset | I_Out Slope | I_Out Offset | E_Out Slope | E_Out Offset |
|---|---|---|---|---|---|---|
| 01. [PST-E] 100mA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 02. [PST-E] 10mA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 03. [PST-E] 1mA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 04. [PST-E] 100uA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 05. [PST-E] 10uA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 06. [PST-E] 1uA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 07. [PST-E] 100nA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 08. [PST-E] 10nA | 0.997610 | 0.007058 | | | -10.310370 | 0.001756 |
| 09. [GST-I] 100mA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |
| 10. [GST-I] 10mA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |
| 11. [GST-I] 1mA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |
| 12. [GST-I] 100uA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |
| 13. [GST-I] 10uA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |
| 14. [GST-I] 1uA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |
| 15. [GST-I] 100nA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |
| 16. [GST-I] 10nA | 1.000000 | 0.000000 | -1.000000 | 0.000000 | | |

| | Slope | Offset |
|---|---|---|
| 01. [PST-AC] | 0.00012500 | 0.00000000 |
| 02. [GST-AC] | 0.00000000 | 0.00000000 |

7. Select **01. [PST-AC]** item from lower table and the following window will be displayed.
8. Open the saved calibration file by clicking "Select File" button and choosing the calibration file you have just recorded. Select **y = a * x** item from the **function** list. Linear regression is executed automatically and you can see the result. The plot shows good linearity. This means there is a good linear relationship between phase and frequency. Please note it the data is displayed as a log-log plot. Return to **External P/G Calibration** dialog by clicking the OK button.

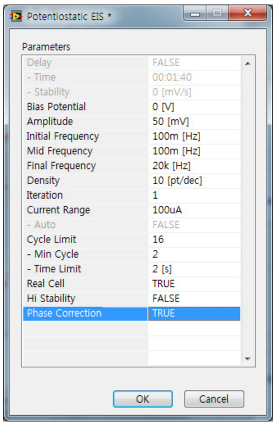


The “**Apply to Device**” button is now enabled, click this button and the calibration data will be written to the EEPROM and once this is done – a message should indicate the completion of this process- close the dialog.




The Phase correction file you have written to the EEPROM is stored in the hardware and, if enabled, each time an experiment is performed the Phase correction procedure is applied to the data. Normally this phase correction file can be used for any experiment that uses the same physical cable and instrumentation configuration.

9. To apply Phase correction to an experiment, run a PEIS experiment, but this time set **Phase Correction** = True in Experiment Parameter dialog.




## Removing Phase correction

In some circumstances it may be necessary to remove the Phase correction. This can be done without removing the phase correction data by disabling the **Phase Correction** item in the experiment menu.

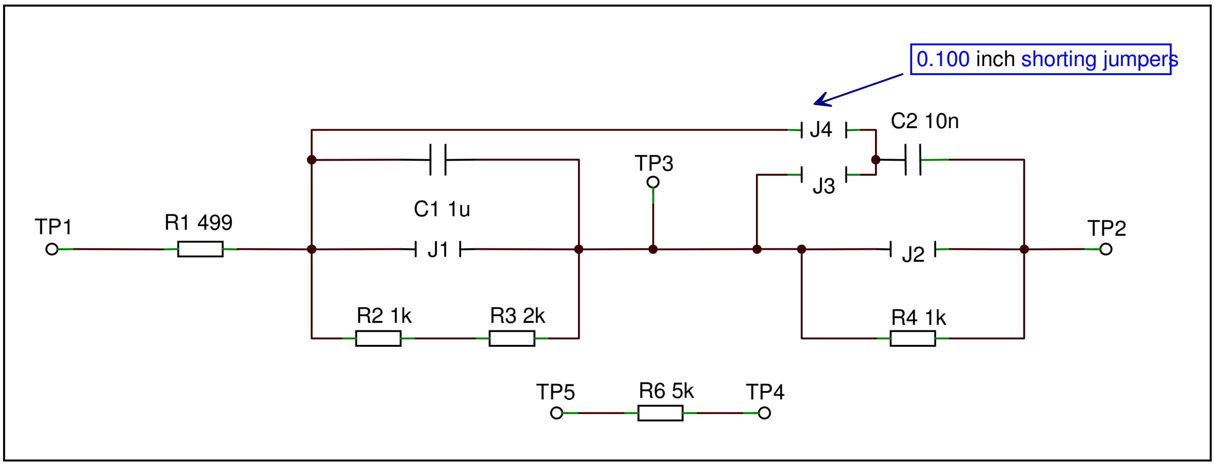
To permanently remove phase correction and return the system to its basic measuring mode:

1 Choose **Tools** > **Calibrate ext P/G**

2 Choose **Set Default** to remove phase correction stored in the Z100 hardware unit.

## Running a simple model

This simple experiment will include one timing element: In this configuration the network between TP1 and TP3 is used and Jumper J1 and J4/J3 is removed, J2 is fitted.

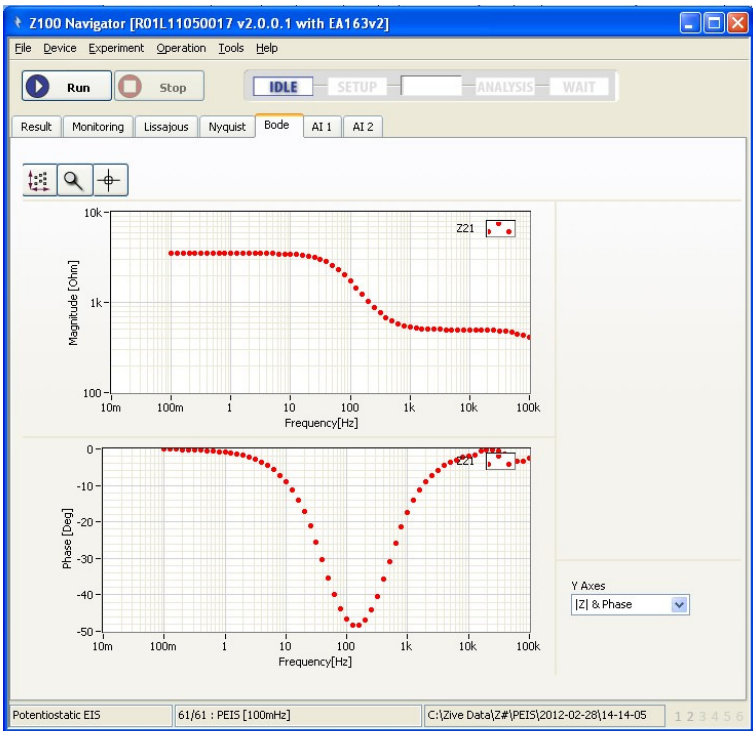



A quick circuit evaluation indicates that at low frequencies the total impedance should trend towards 3500 Ohms and at high frequencies it should trend towards 499 Ohms.

## Procedure

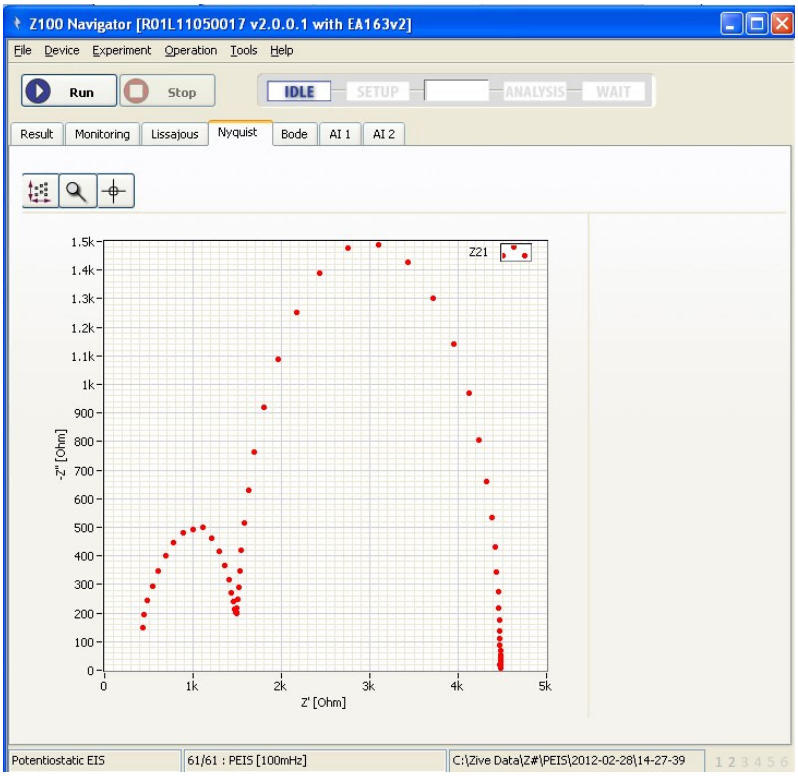
1. Use the Z100 Test network configured as shown above
2. Connect the potentiostat to the Z100 Test Network with the RE, and AE connected together on TP1 and the WE (green) to TP3.
3. Run Z100 Navigator.
4. Open parameter dialog by selecting **Experiment >> Potentiostatic EIS…** in the main menu.
   Please make sure that **Real Cell** is selected
   Phase Correction = FALSE.
   Adjust Scan from 100 kHz to 100 mHz with 10 steps per decade.
   Set AC Amplitude to 100mV
   Set Speed to Normal
   Current Range to10mA
5. **Run** the experiment.
6. When finished, save the data by selecting **File >> Save as Binary Format…**

   The Bode Diagram for this simple network is shown below




## More Complex Model

Contains 2 timing elements: In this configuration total network between TP1 and TP2 is used and the Jumpers are configured as follows: J1 OUT; J2 OUT; J3 IN; J4 OUT.
Same settings as used in Simple Model. The Nyquist diagram clearly shows two energy elements.



## Next Step

Once you have successfully recorded data from an experiment the next step is to analyse the data using ZMAN the Z100 Analysis and Modeling software