

# CReSIS Anechoic Chamber

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[chamber@ku.edu](mailto:chamber@ku.edu) • [chamber.ku.edu](http://chamber.ku.edu) • 785.864.2185

The CReSIS Anechoic Chamber is located at:

**The University of Kansas**

**M2SEC building**

**1536 W 15<sup>th</sup> St**

**Lawrence, KS 66045**

## Pattern Manual

# Antenna radiation pattern measurement

1. To open **EMQuest**, right click on the "EMQuest EMQ-100 Pattern Measurement Software" shortcut on the desktop, and then click on "Run as administrator".
2. Click on "File" – "New" to create a new parameter (.prm) file.
3. Using the drop-down menu on the right, select the type of measurement depending on you antenna under test or AUT (see Figure 1); in this example, choose "Lite Single-Axis Single-Polarization Pattern Measurement" under "Pattern Measurements, Scalar". A new menu tree will open under "**Test Information**".

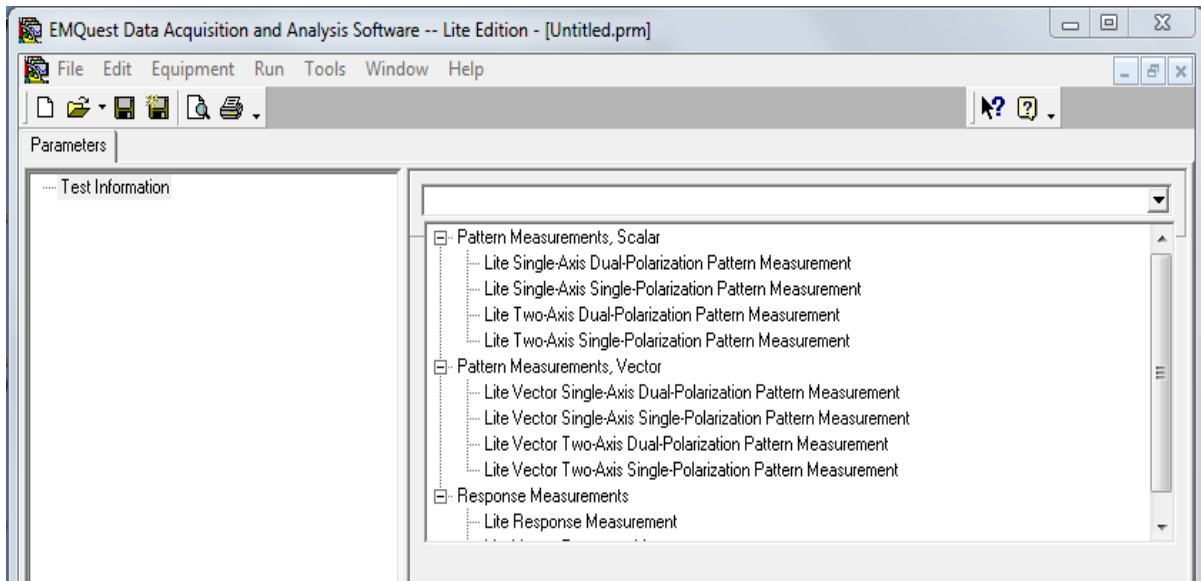


Figure 1. Select the type of measurement from the drop-down menu on the right.

4. Click on "**Operator/Comments**" and write your name in the **Operator** box. You may also use the **Comments** box to add additional notes (see Figure 2 below). It is recommended that you include the date and time of your measurement for future reference (you will need to go back to this page to add the end time once your measurement is complete).

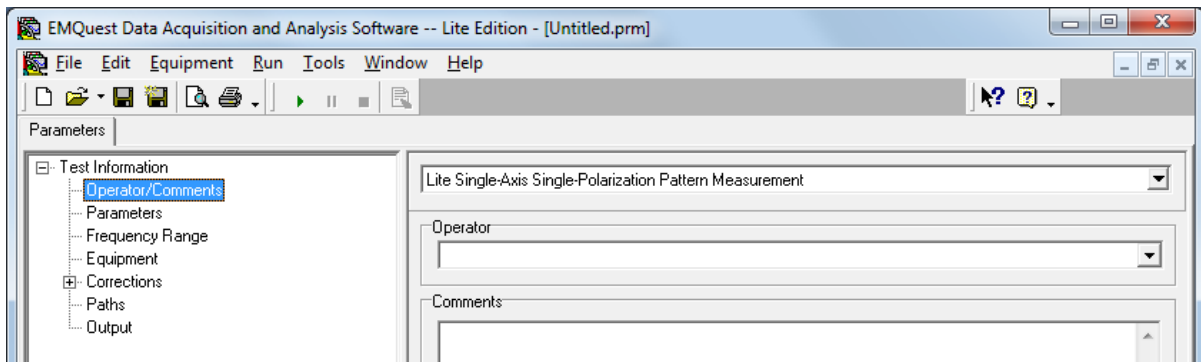
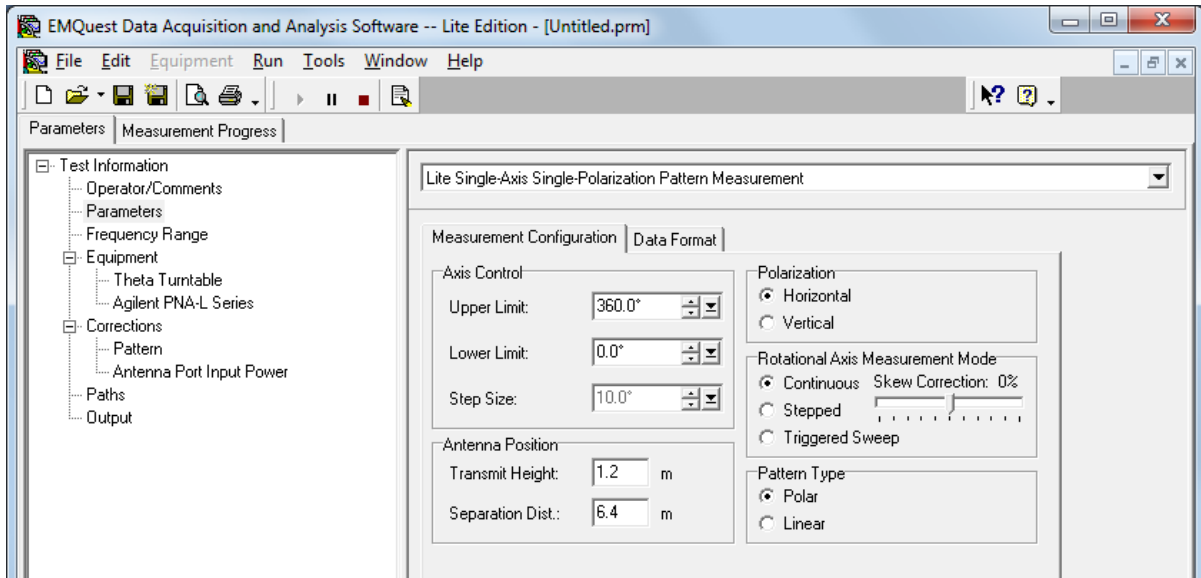


Figure 2. Operator/Comments tab (STEP 4).

5. Select the “**Parameters**” pane, which is used to enter most of the required test parameters specific to this test. On the “Measurement Configuration” tab, enter the upper and lower limits for the axis control, as well as the angular step (this will determine both the angular span and the discrete angular points of your pattern measurement). On the right-hand side of the same tab, select the “Polarization” of the receive antenna (AUT), the “Rotational Axis Measurement Mode” (the “stepped” mode gives the best possible results) and the pattern acquisition mode (the polar mode must be used with the rotational positioner available in the chamber). Include the height of the antenna as well as the separation distance between transmit and receive antennas. These can be measured with the aid of the laser distance measurer available in the tool drawer.



**Figure 3. Parameters setup - Measurement configuration (STEP 5).**

The “Data Format” tab is used to enter the settings related to data acquisition and processing modes. The “Receiver Mode” can be set as absolute (power levels recorded in dBm) or relative (receive channels are measured relative to their reference signal). The “Data Acquisition Mode” controls how the data is displayed during the actual measurement. For example, selecting “Max Marker” will display the instantaneous measured data with maximum transmission coefficient or  $S_{21}$  over the frequency range of interest (see the **EMQuest** help for additional information). The “Close Pattern” option in the “Optimizations” box can be used to obtain a closed surface for polar plots. Check the “S parameters” option in the “Network Analyzer Ports” box so that the pattern will be taken from the  $S_{21}$  data as the positioner rotates. In this case, the “Receiver mode” is set to “Relative” as  $S_{21}$  is a relative quantity. Leave the “Record Actual Axis Position” box unchecked.

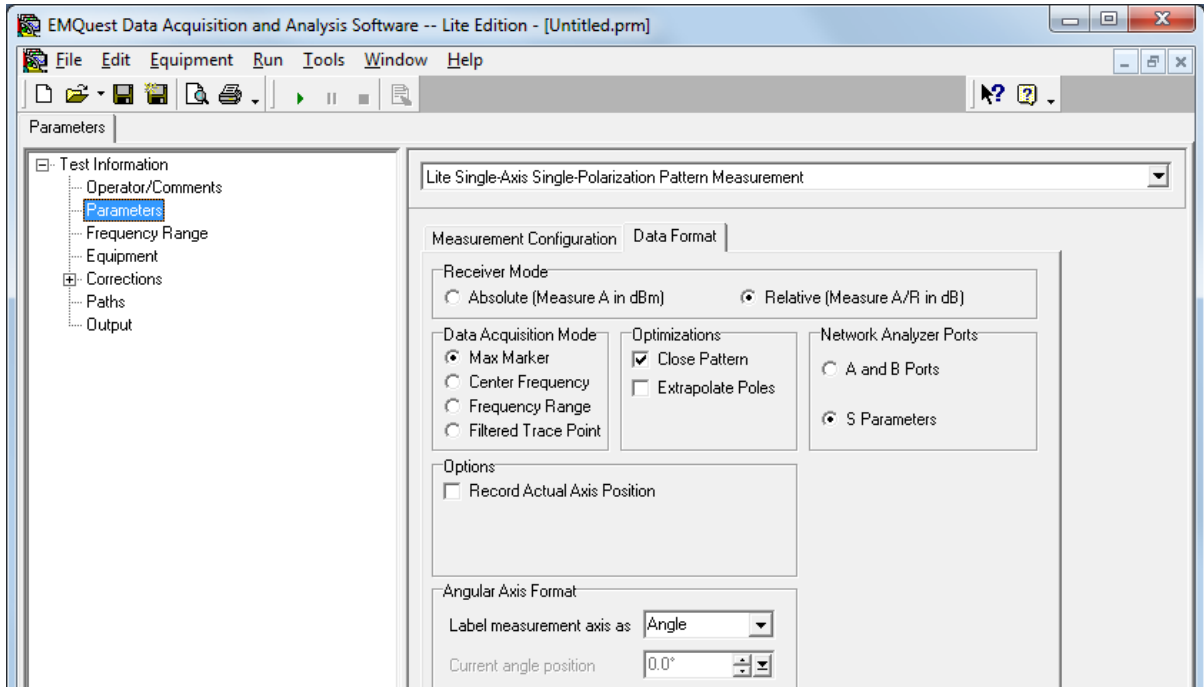


Figure 4. Parameters pane (STEP 6).

6. In the **"Frequency Range"** pane, select "Linear frequency" which is the default format. Check the "User Defined" option in the frequency "Range Control" box and then enter the start and stop frequencies (in MHz), according to your AUT, under "Frequency Range". This will automatically adjust the center and span settings.

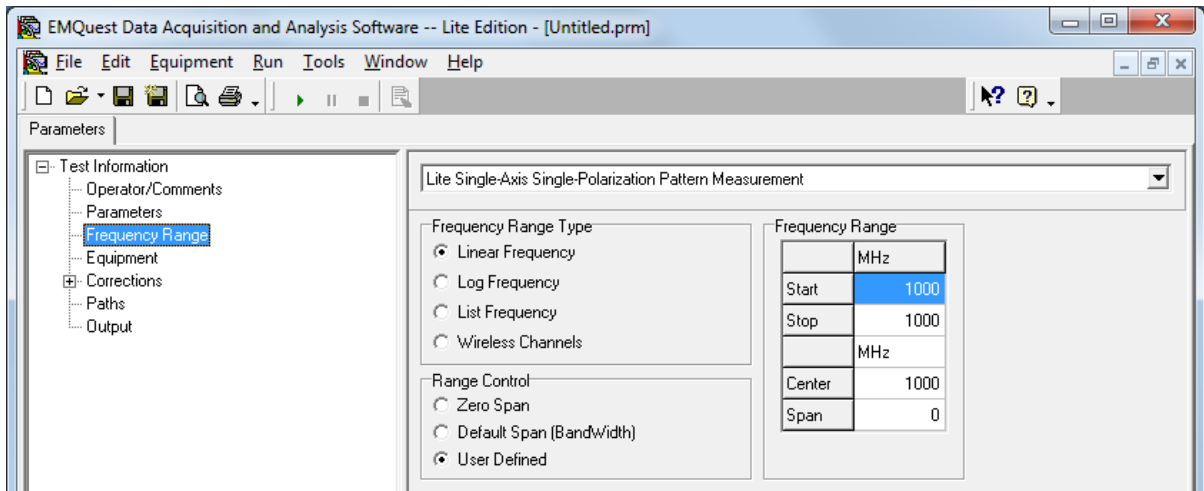


Figure 5. "Frequency range" pane (STEP 6).

7. Click on **"Equipment"** and select the test equipment that is interfaced with **EMQuest**, i.e. the "Theta Turntable" **positioner** for azimuth rotation and the "Agilent PNA-L Series" network **analyzer**, as shown in Figure 6 below.

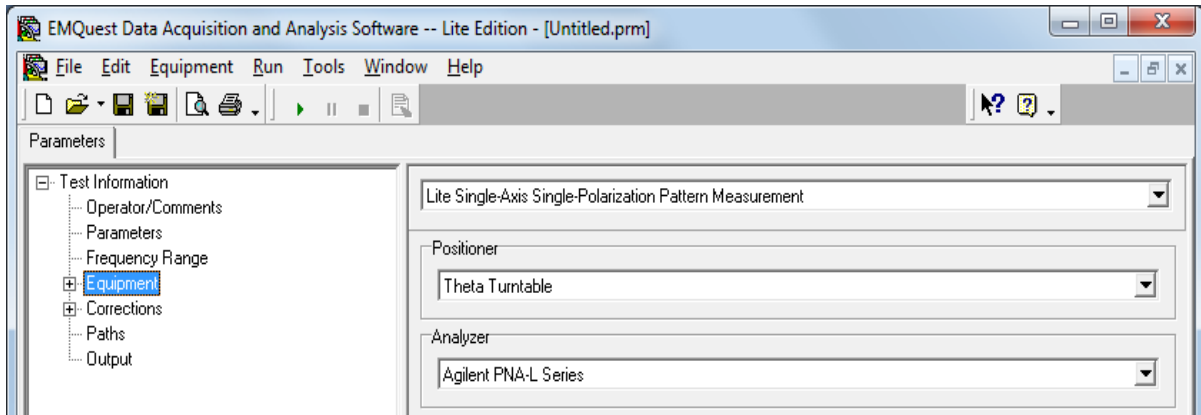


Figure 6. Equipment pane: positioner and analyzer (STEP 7).

8. Click on “**Theta Turntable**” to set up both the turntable speed and the angular step. The speed can be adjusted to faster values, depending on how steady the AUT is mounted on the positioner (Speed 1 being the slowest and Speed 5 the fastest). If you are not sure what speed to use, select Speed 1 in your first experiment. The "Positioner Settling Time" is used to delay data acquisition (in ms) after positioner motion to prevent any vibration due to movement (in this example, this may be left to 0 ms). The "Position Offset" box may be used to apply a fixed offset from the position. Do not change the default "Trigger Settings".

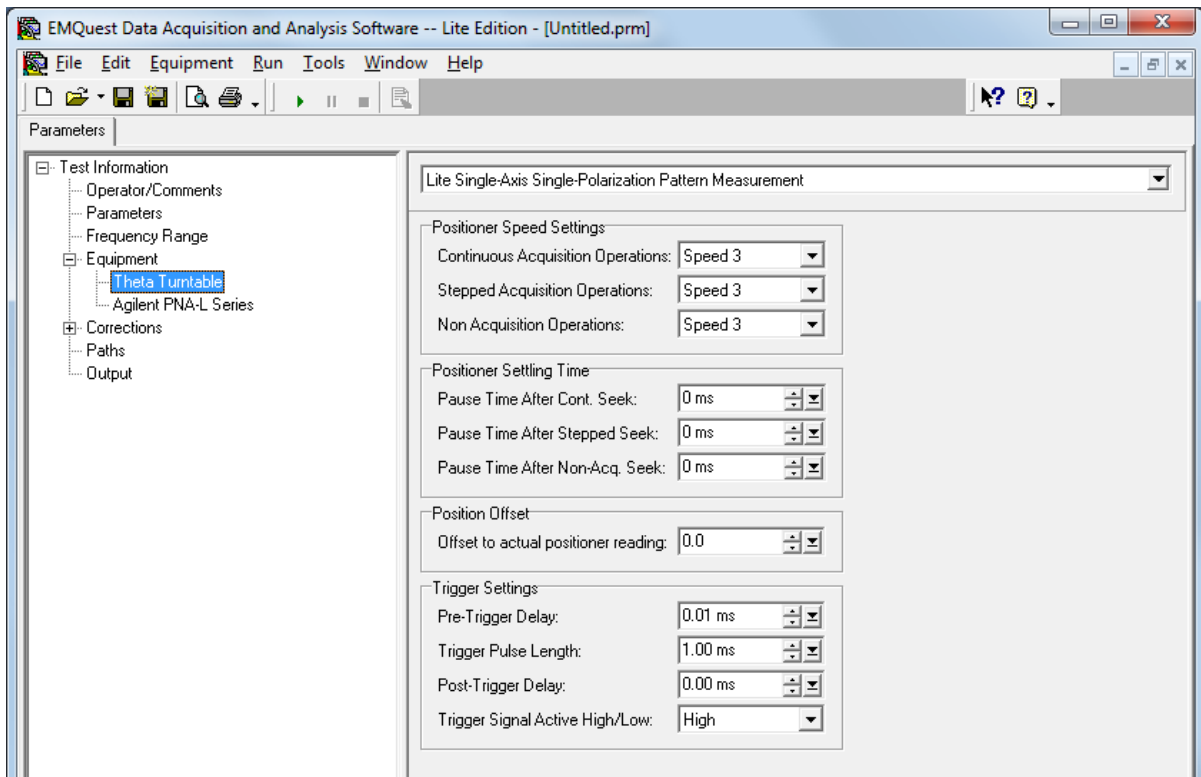


Figure 7. Settings for the theta turntable (STEP 8).

9. Go to the "Agilent PNA-L Series" pane. The NA calibration and other parameters can be specified here. Make sure all settings match those shown in Figure 8 below. Under "Trace Information", you may smooth the measured data using the two functions given there. However, these are normally not needed in pattern measurements if the setup is done properly. The value in "Points Per Trace" sets the number of frequency points that will be taken within the frequency range selected in STEP 6. The measurement "Output Power" level can be used to select the source power level; this can be adjusted in a second measurement if the noise level is unacceptable. This control should be used with caution to prevent overloading the inputs, and it is recommended to keep the output power level below 15 dBm.

For high frequency measurements (beyond 3 GHz), the measured data might not have enough signal-to-noise ratio even if the output power of the NA is set to maximum. In this case, you may insert a preamplifier (Agilent 87405C 0.1 - 18 GHz available in the cabinet under the spectrum analyzer) in the measurement loop. It is recommended that you include a directional coupler (Agilent 87300B 1 - 20 GHz available in the cabinet under the spectrum analyzer) before the preamplifier to protect the NA.

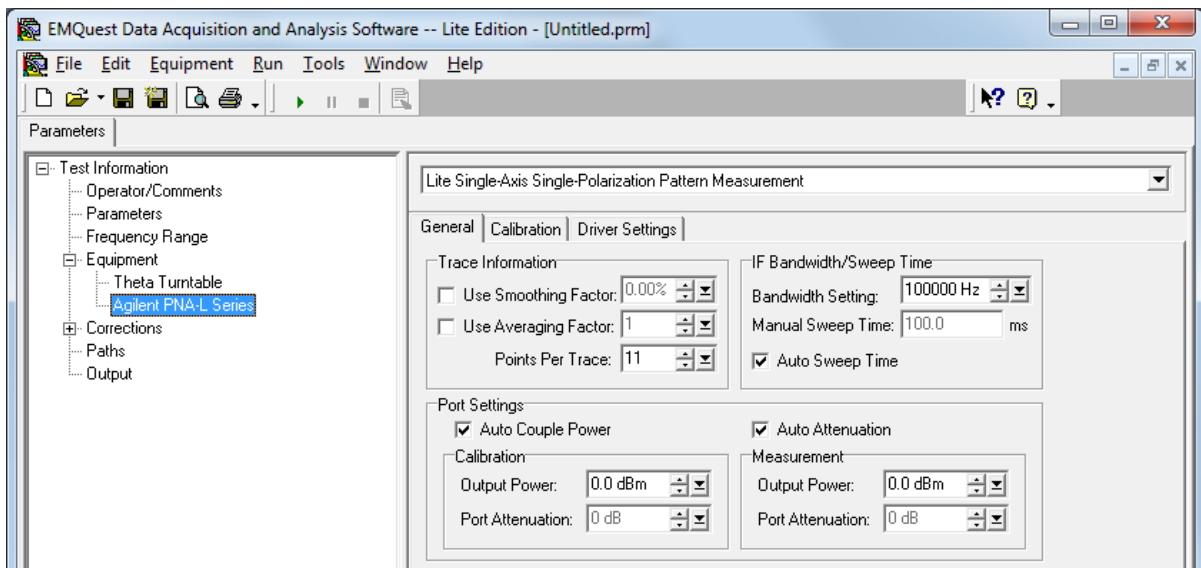


Figure 8. Network analyzer settings.

In the "Calibration" tab, make sure the settings are those shown in Figure 9 as no calibration is needed for magnitude pattern measurement as it is a relative power measurement. You can edit the "Driver settings" in the corresponding tab, or you can revert to the pre-configured settings shown in Figure 10Figure 9 below by right-clicking on the tab itself.

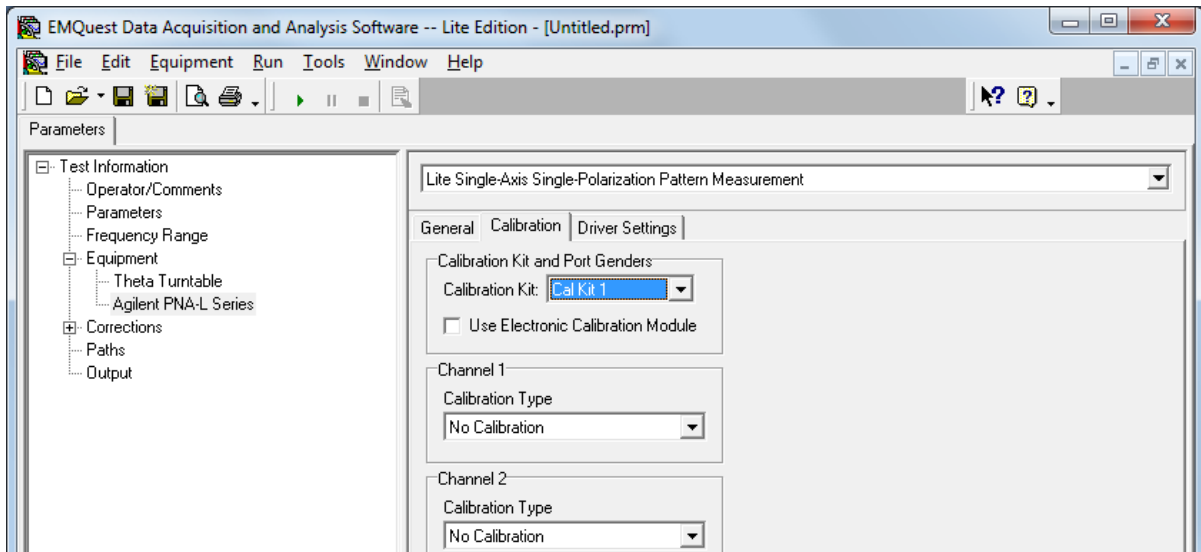


Figure 9. Agilent PNA-L Series calibration tab.

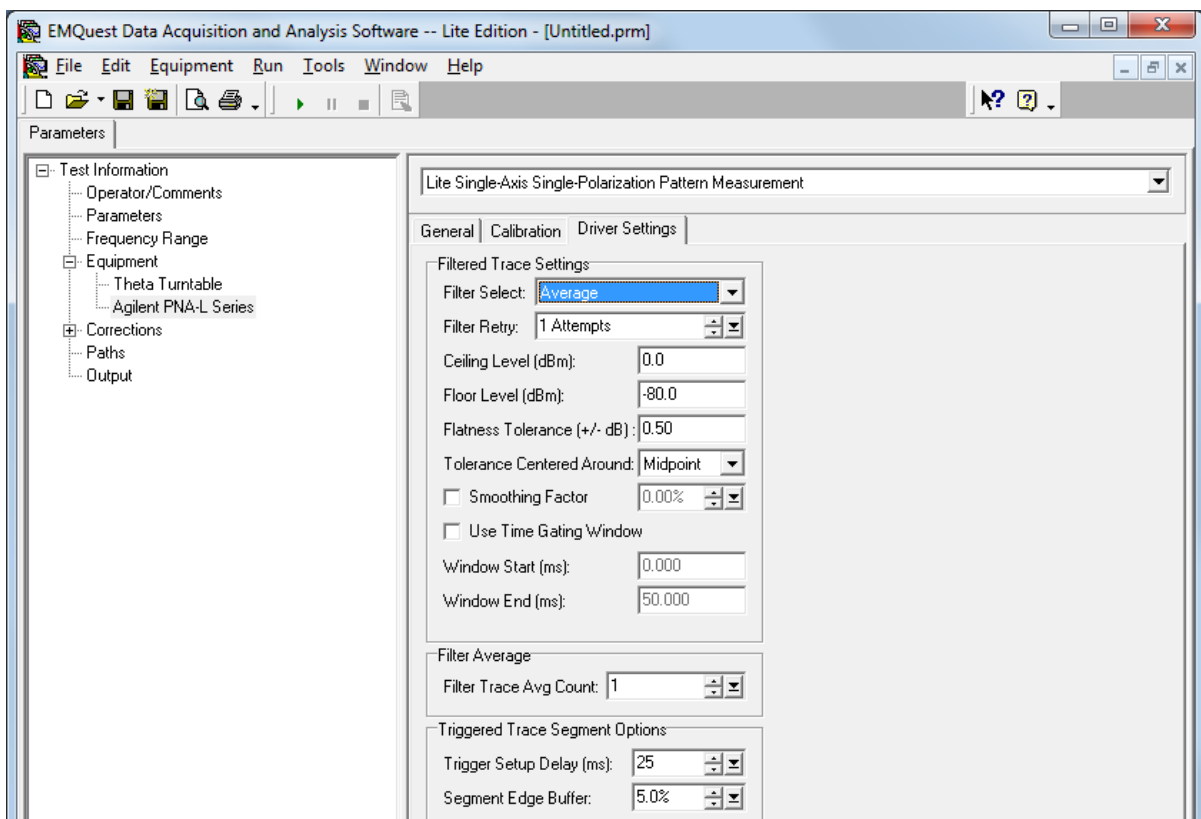
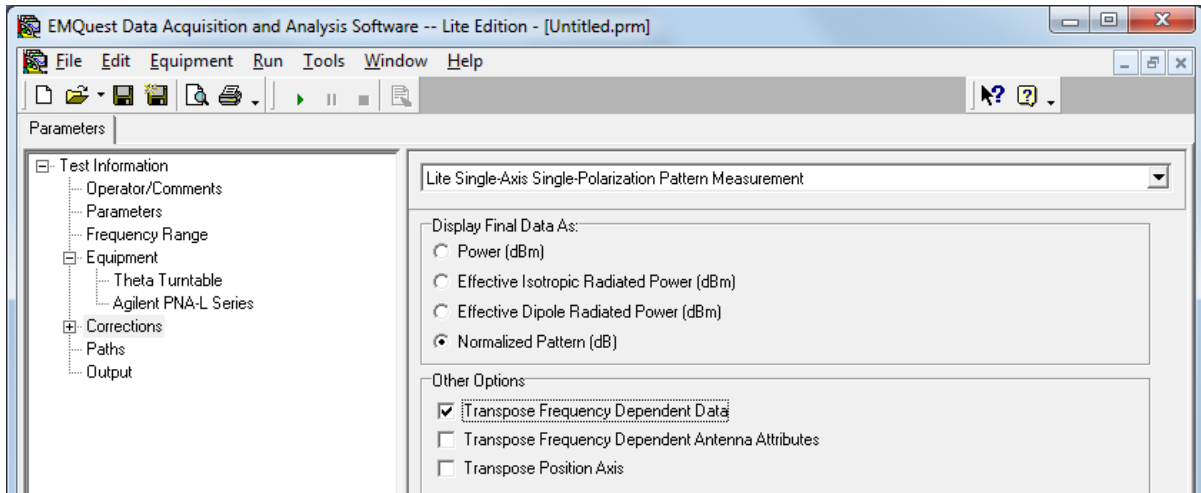


Figure 10. Agilent PNA-L Series driver settings tab.

10. Select the "**Corrections**" pane to enter any corrections that you want applied to measured data Under "Display Final Data As" you may select the format of the results: P (dBm), EIRP (dBm), or Normalized Pattern (dB). "Other options" allow additional formatting. If the "Frequency Range"

option was selected in the "Data Acquisition Mode" (see STEP 5), the "Transpose Frequency Dependent Data" option will produce pattern plots for each frequency.



**Figure 11. Corrections pane.**

The "Corrections" list box in each tree element (see Figure 12) shows a list of response file names for frequency dependent corrections, where a "+" or "-" sign in front of the file name indicates that the corresponding data will be either added or subtracted from the results. The buttons on the right can be used to edit this list. The "Constant" box can be used to enter a single constant correction to all data points. These frequency dependent corrections are useful for estimating the absolute gain of the AUT as a function of frequency using the gain comparison method:

$$G_{AUT} = G_{ref} - 20 \log_{10}(|S_{21}|_o) + 20 \log_{10}(|S_{21}|),$$

where  $G_{AUT}$  is the absolute gain of the AUT in dBi;  $G_{ref}$  is the absolute gain of the reference antenna (standard gain antenna) in dBi;  $|S_{21}|_o$  is the magnitude of the  $S_{21}$  measured between the reference antenna and an arbitrary receive antenna; and  $|S_{21}|$  is the magnitude of the  $S_{21}$  measured between the AUT and an arbitrary receive antenna. Here, the receive antenna used does not have to have a known gain, but it is recommended that the antenna's operating range covers the frequency range of interest for minimizing transmission loss.



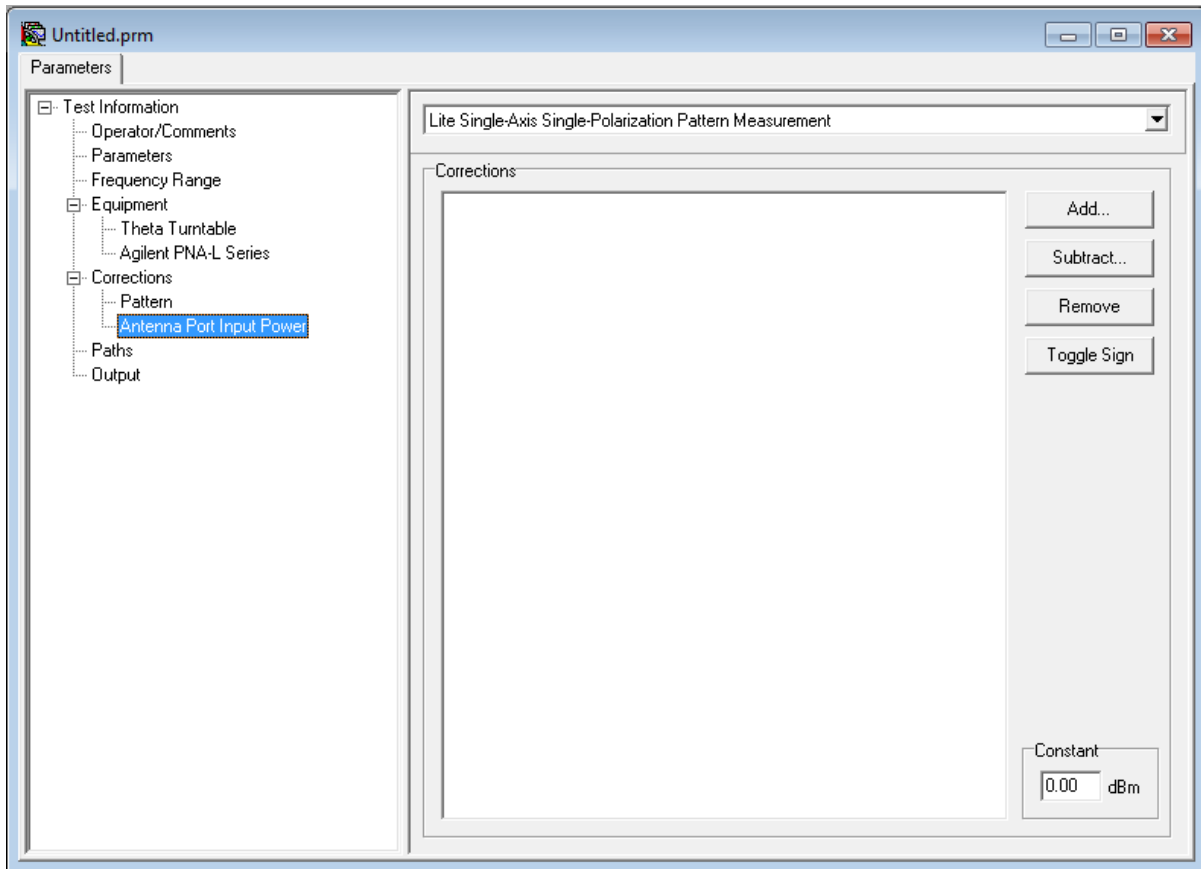


Figure 12. Corrections list box and options.

11. Once all parameters have been set and you are ready to start your measurement, make sure that all cables and equipment are properly connected, that the chamber door is closed, and press the "Run" button. A measurement progress window will show the current status of the test (Figure 13 and Figure 14). The status of the positioners may be monitored through the webcam installed in the chamber. This camera can be controlled by the computer on the left. It is important to make sure that the positioner does not become stuck during the pattern measurement. If this happens during data acquisition, stop the measurement process immediately to avoid any damage to the positioners as they are expensive and time-consuming to repair.

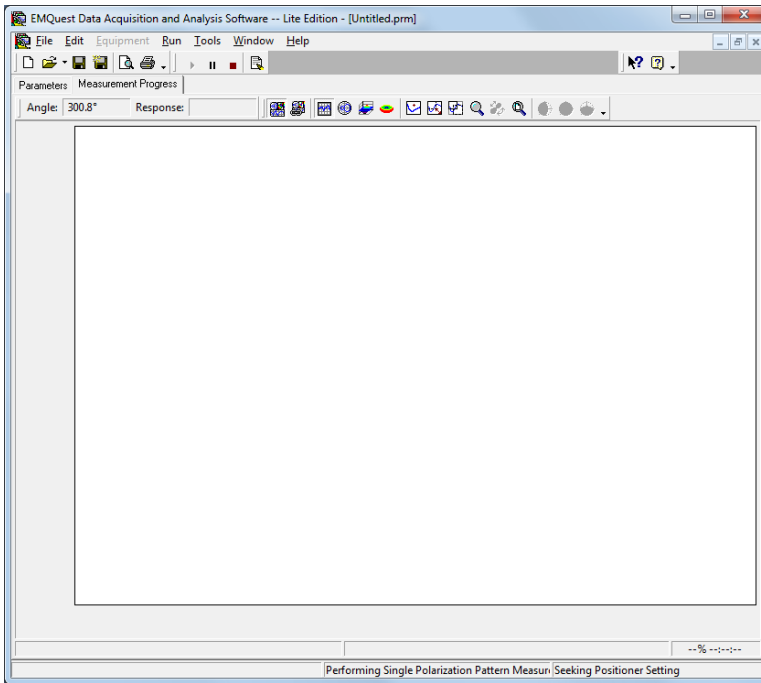


Figure 13. Initial measurement progress example window.

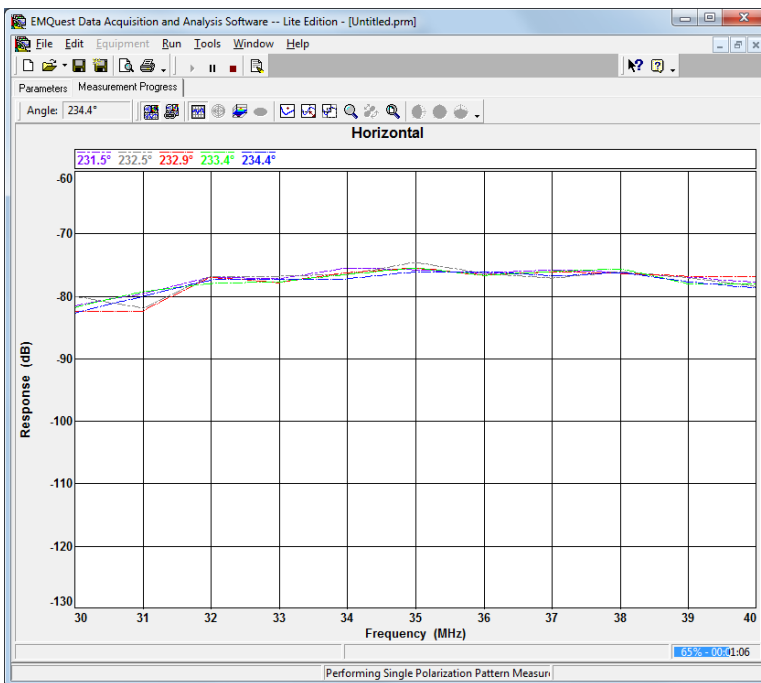


Figure 14. Measurement progress example window (65% complete).

12. The resulting plot is shown in Figure 15 below, where all traces are plotted together:

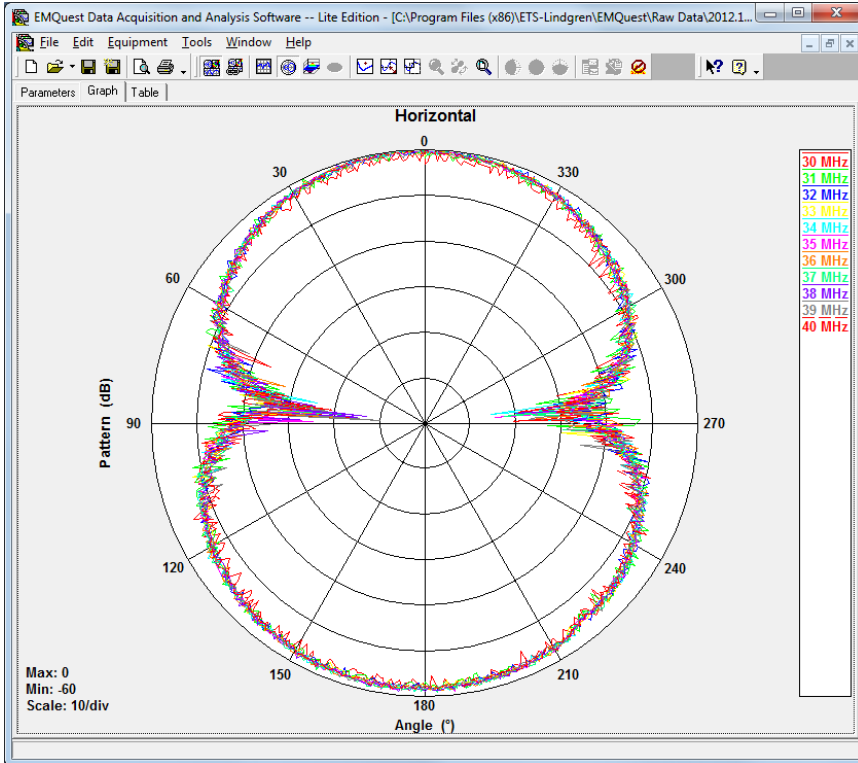


Figure 15. Radiation pattern (all traces).

You may also customize the graph settings for each trace (Figure 16) and display the results in a table (Figure 17).

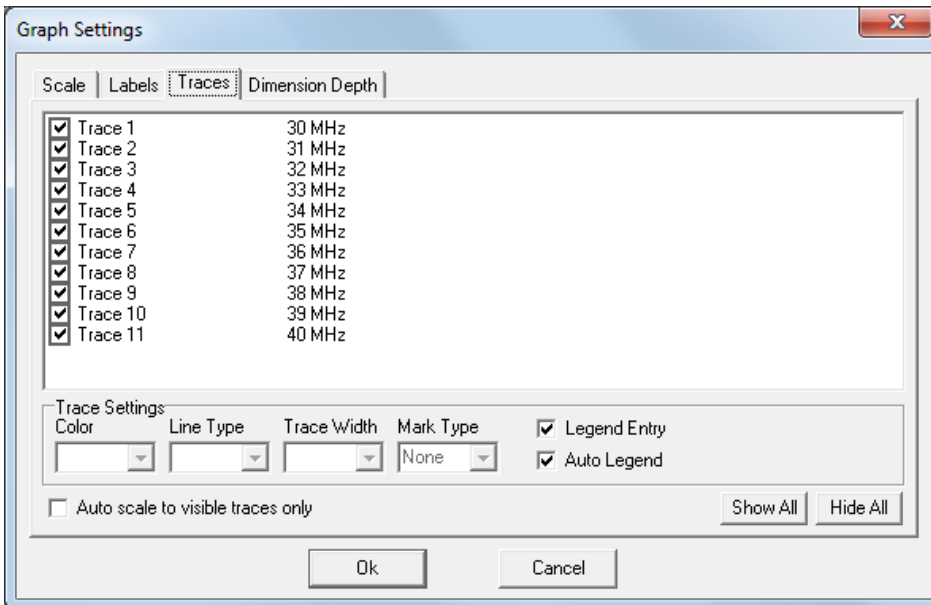


Figure 16. Graph settings window.

Polarization	Frequency (MHz)	30	31	32	33	34	35	36	37	38	39
Horizontal	Angle (°)	Pattern (dB)	Pattern (dB)	Pattern (dB)	Pattern (dB)	Pattern (dB)	Pattern (dB)	Pattern (dB)	Pattern (dB)	Pattern (dB)	Pattern (dB)
	0	0.00	-2.14	-0.77	-0.02	-0.21	0.00	-0.53	-0.25	-0.51	-0.87
	0	-0.38	-0.18	-0.54	-0.63	-0.40	-0.43	-0.53	-0.35	-0.65	-0.61
	0.1	-0.89	-0.57	-0.30	-0.43	-0.23	-0.49	-0.25	-0.19	-0.52	0.00
	0.3	-1.66	-1.22	-0.37	0.00	-0.53	-0.74	-0.44	-0.52	-0.96	-1.24
	0.7	-1.51	-0.23	-1.33	-1.11	-1.07	-0.16	-1.02	-0.51	-0.47	-0.49
	1.1	-2.75	-0.83	-0.67	-0.70	-0.16	-0.33	-1.25	-0.25	-0.74	-0.61
	2.1	-0.90	-1.05	-0.92	-0.67	-0.57	-0.73	-0.71	-0.42	-0.64	-0.46
	2.6	-1.65	-0.09	-0.91	-0.58	-0.19	-0.49	-0.17	-0.49	-0.68	-0.66
	3.1	-1.00	-1.16	-1.04	-0.52	-0.93	-0.73	-0.85	0.00	-0.19	-0.78
	4	-2.17	-0.87	-1.32	-0.26	-0.79	-0.73	-0.57	-0.40	0.00	-0.52
	4.5	-2.53	-0.99	-0.93	-0.66	-0.40	-1.25	-0.29	-0.11	-0.24	-1.79
	5.4	-1.38	-1.20	-0.55	-0.30	-0.43	-0.63	-0.78	-0.91	-0.23	-1.08
	5.9	-2.02	-0.67	-0.58	-0.69	-0.67	-0.65	-0.68	-0.45	-0.35	-0.55
	6.9	-2.03	-0.35	-0.42	-0.67	-0.81	-0.63	-0.73	-0.53	-1.16	-0.22
	7.3	-1.56	-0.87	-1.13	-0.90	-0.59	-0.44	-0.84	-0.44	-0.30	-0.95
	7.8	-2.18	-2.06	-0.29	-0.69	-0.64	-0.90	-0.91	-0.44	-0.76	-0.62
	8.3	-1.91	-0.69	-0.49	-0.64	-1.15	-0.31	0.00	-0.62	-0.56	-0.99
	9.3	-0.70	-1.47	-0.94	-0.98	-0.47	-0.50	-0.27	-0.77	-0.67	-1.17
	9.8	-2.26	-0.85	-0.84	-1.18	-0.96	-0.62	-1.47	-0.67	-0.29	-1.18
	10.2	-1.90	-1.88	-0.62	-0.40	-0.87	-0.77	-0.99	-0.73	-0.91	-1.14
	11.2	-2.52	-1.12	-0.94	-1.18	-0.42	-0.52	-0.97	-0.46	-1.18	-0.83
	11.7	-1.26	-0.92	-0.53	-0.99	-0.17	-1.05	-1.17	-0.26	-0.49	-1.47
	12.1	-2.58	-1.25	-1.23	-0.50	-0.80	-0.57	-0.19	-0.72	-1.22	-1.24
	12.6	-1.76	-1.00	-0.79	-0.77	-0.72	-0.80	-0.79	-0.15	-0.88	-1.16
	13.6	-1.30	-1.27	-1.85	-1.48	-0.81	-0.82	-0.76	-0.30	-1.27	-0.23
	14.5	-1.88	-1.05	-0.64	-0.96	-1.21	-0.80	-0.28	-1.00	-0.75	-0.65
	15	-3.10	-0.34	-0.96	-0.80	-0.53	-0.57	-0.46	-0.74	-0.60	-0.68
	15.5	-1.91	-1.63	-0.30	-1.35	-0.95	-1.04	-1.31	-1.30	-1.61	-1.25

Figure 17. Results table.

13. Save your .prm file and export the results for further processing.

**Notes on System Coordinates Definitions:**

In **EMQuest**, the turntable controls the azimuth rotation which is defined as theta  $\theta$ , whereas the vertical mast controls the elevation rotation which is defined as phi  $\phi$ .

In rectangular coordinates, the definitions are as follow:

