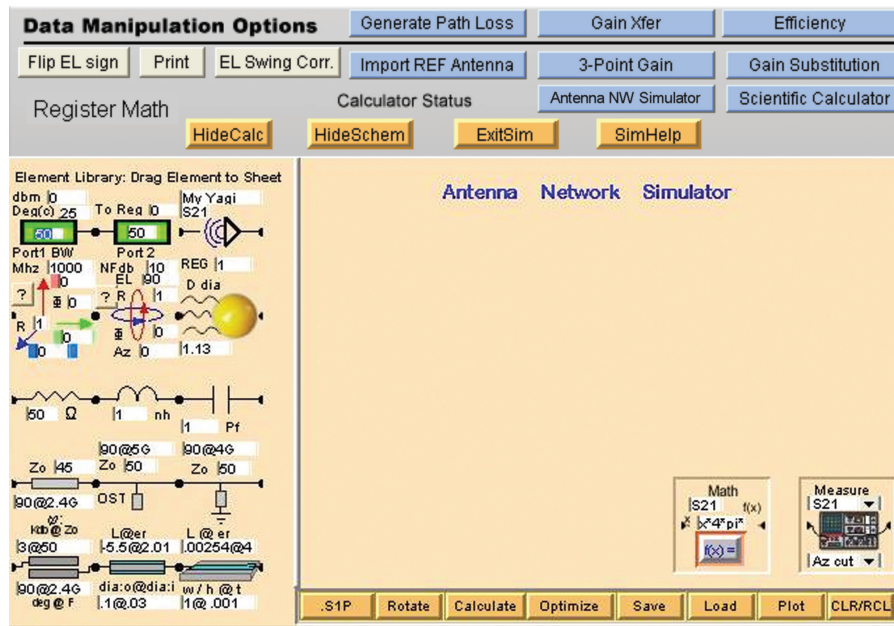


Antenna Network & Measurement Simulator

Basic & Advanced Simulation Examples



The Antenna Network & Measurement Simulator module enables DAMS Antenna Measurement Studio to perform a whole host of simulation capabilities. It's designed to be fully customizable with drag-n-drop icon-based schematics which utilize capture vectors (cascading two-port with wave addition). Also includes many other features such as circuit matching, radar cross-section, axis translation and rotation, among others. The following examples illustrate how to custom design various common simulations such as:

Basic Processes:

- » Basic Measurement Simulation 1
- » Isotropic Dipole Simulation 3

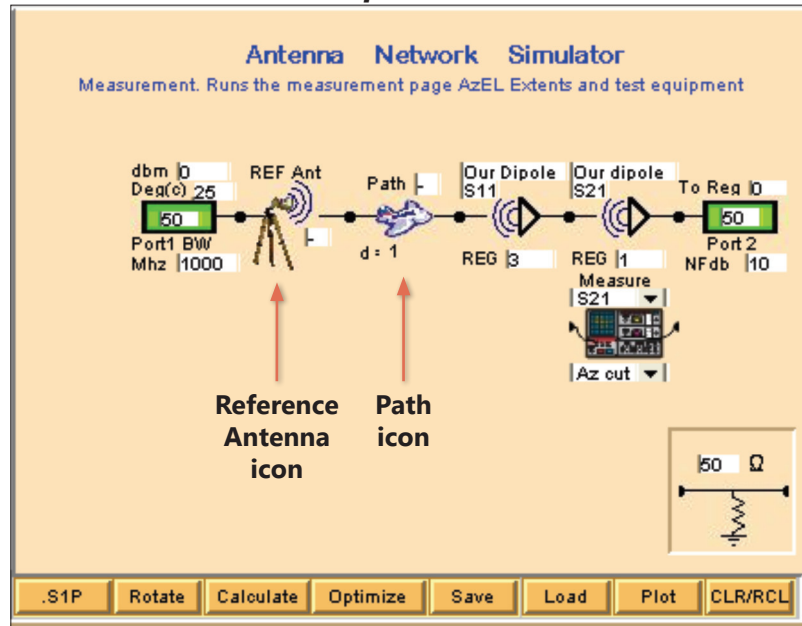
Advanced Processes:

- » Phased Array Dipole Simulation 4
- » WiFi Array Simulation 5
- » RCS Measurement Simulation 6
- » Coupled Line WiFi Filter Simulation 7
- » Utilizing the Math Icon 8
- » Utilizing the Mirror Icon 9
- » Utilizing Time Domain 10

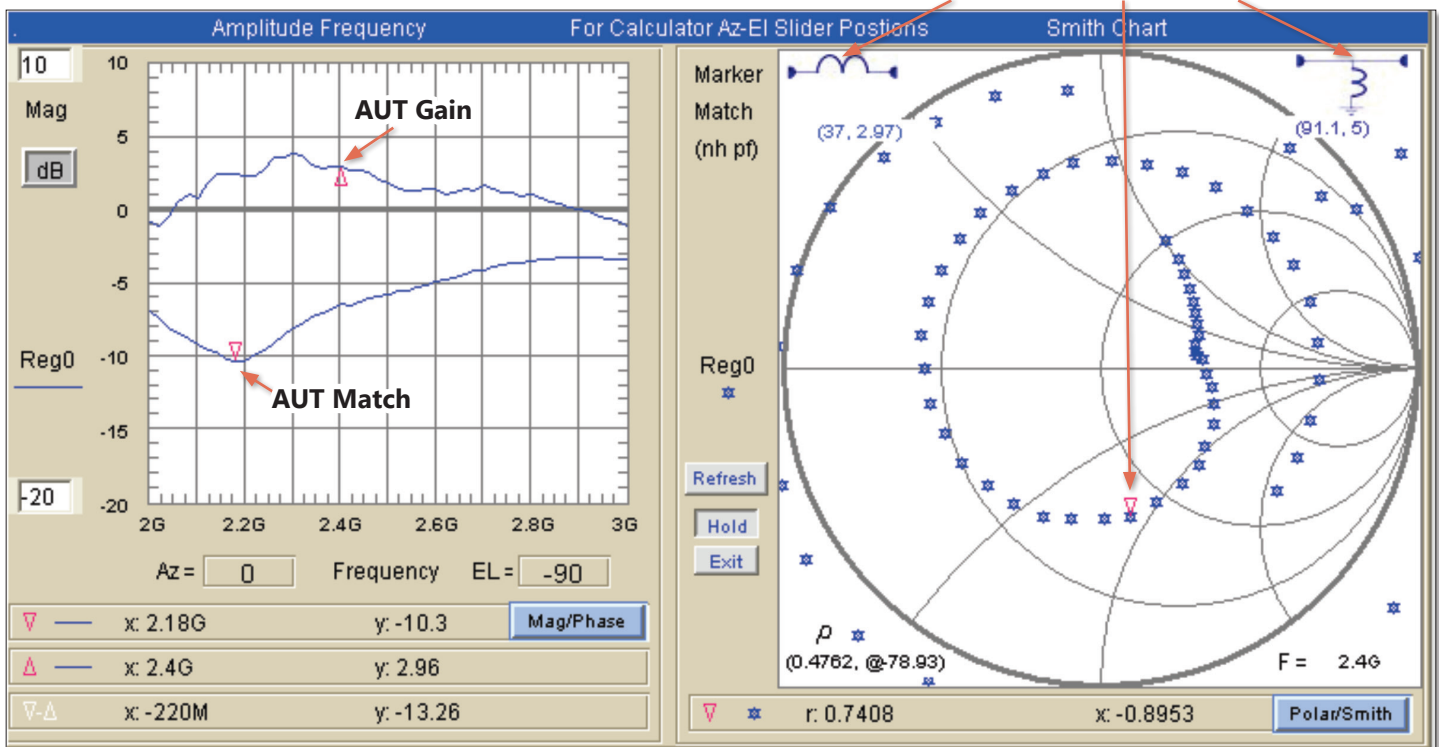
Basic Measurement Simulation

The example below demonstrates a basic measurement simulation. First, an actual 2.4 GHz dipole was measured including the match. The **REF Ant** and **Path** icons utilize the **Import REF Ant** and **Generate Path Loss** data results we've previously stored in the register (**REG1**). As we can see, the dipole was not matched well at 2.4 GHz and the required match is automatically suggested by the marker. (The measurement icon can take measurements directly from the schematic as well.)

Example Schematic

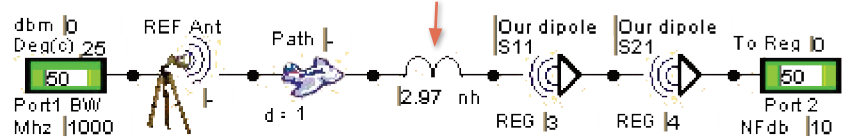


Marker set to 2.4 GHz indicates matching elements

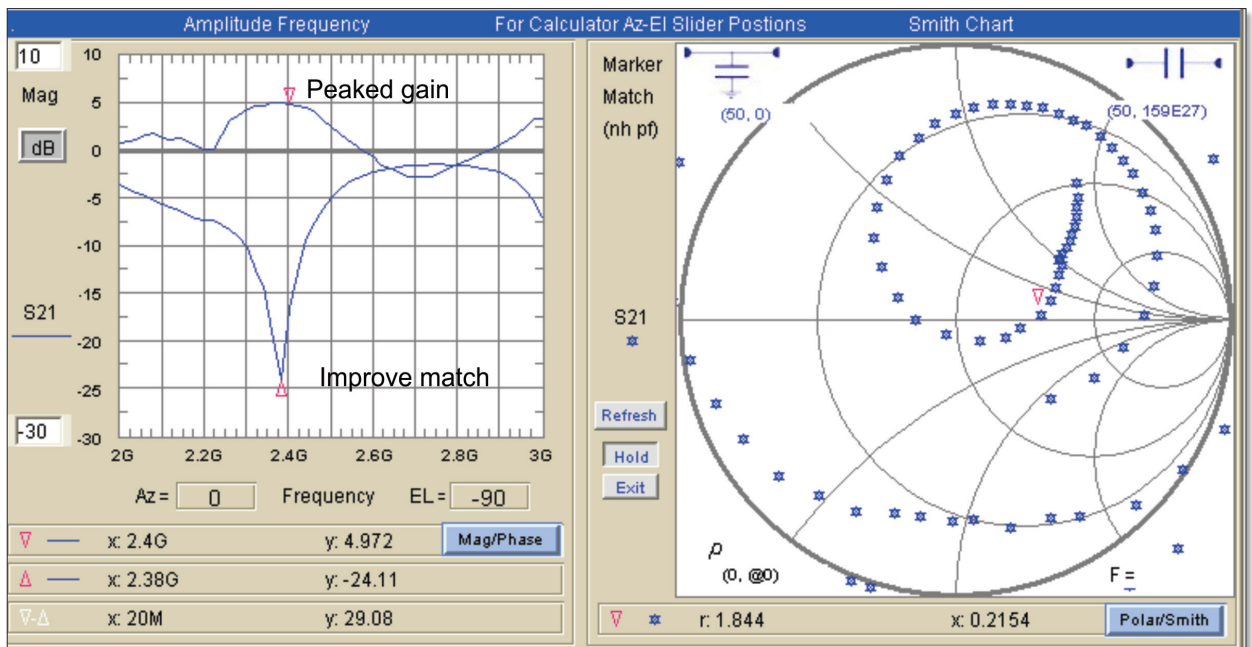
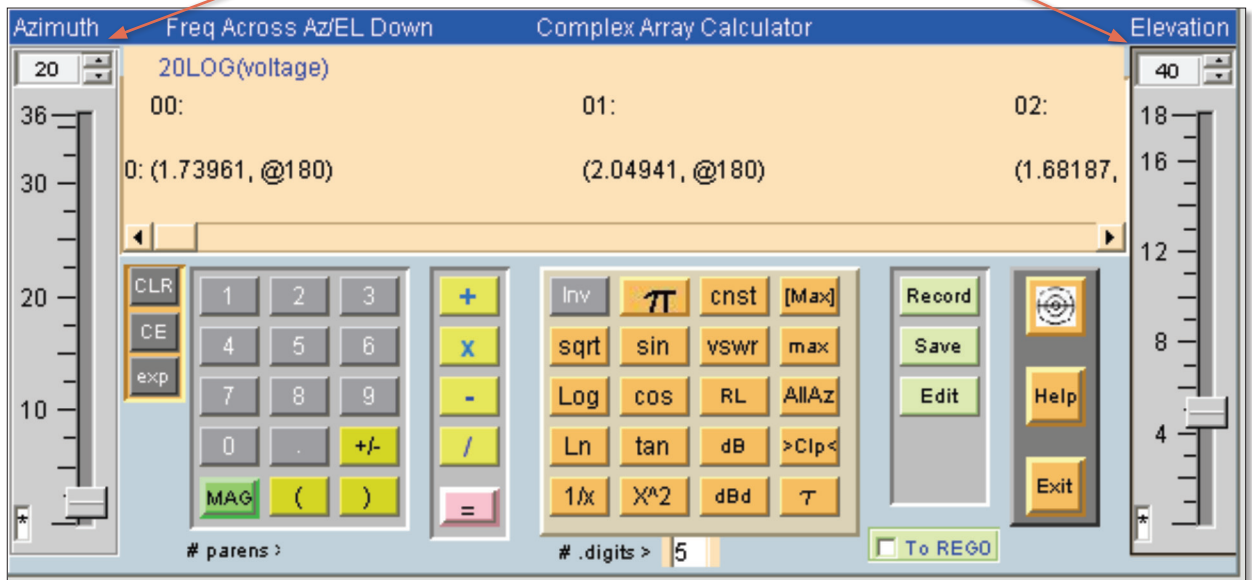


After examining our initial simulated measurements, an inductor is added to the circuit which successfully improves match and gain, as shown below. This is one of many ways the DAMS Simulator Module is a valuable R&D solution that's guaranteed to save time and money.

Simulated inductor

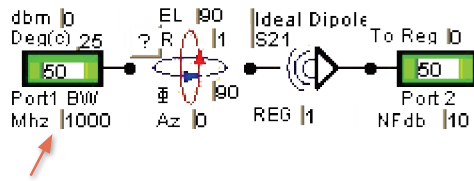


Sliders set AZ-EL contour for both the plot and the calculator

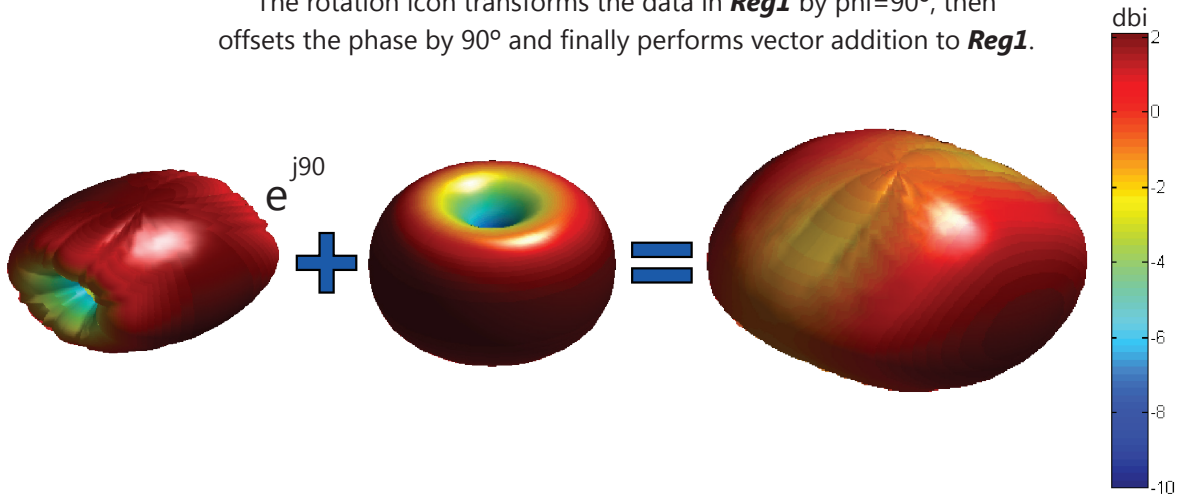


Isotropic Dipole Simulation

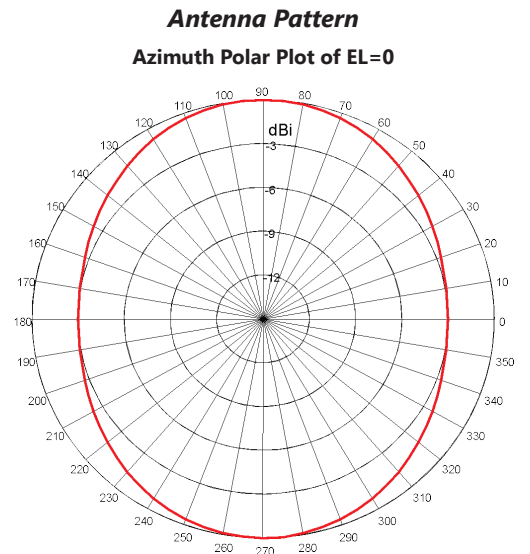
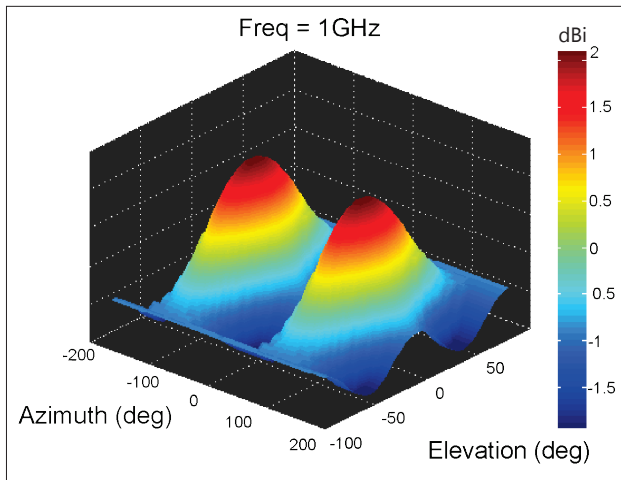
In this example we take an ideal vertical dipole and combine it with a 90° version of itself. The resulting pattern proves to be isotropic to within 3dB.



The rotation icon transforms the data in **Reg1** by $\phi=90^\circ$, then offsets the phase by 90° and finally performs vector addition to **Reg1**.

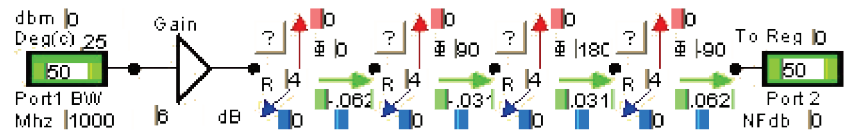


The rotation icon is used to rotate the data to any angle. AZ over EL data can be converted to Full EL over AZ data, which can be used when it is not possible to mount the test antenna in an azimuth orientation.

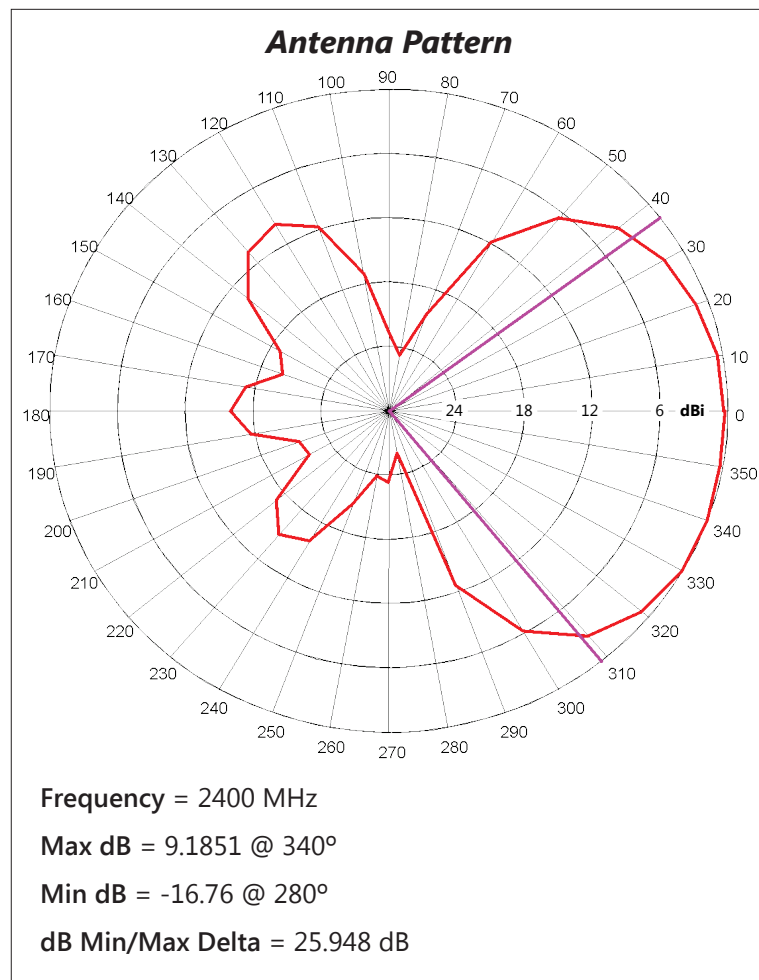
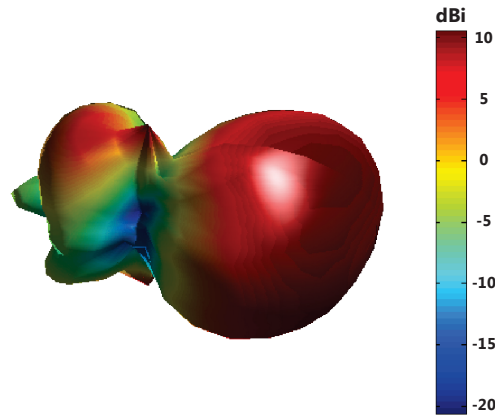


Phased Array Dipole Simulation

The previous measured dipole will now be combined in a phased array. The tuned data was saved to **Reg4**. We will now create a four-element collinear array sequentially phase shifted by 90°.



Four-element dipole array with sequential 90° phase offset. Each element is spaced a quarter wave along the x-axis utilizing the data which was measured from previous example. Power for each dipole (generated from common port) is compensated by adding a 6db gain block.



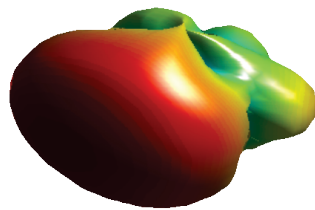
WiFi Array Simulation

In this example we use a previously measured WiFi patch and create a two element array. First the patch is rotated 90 degrees and given a 90 degree Azimuth rotation. Then it is cascaded with the original patch.

Measured patch data rotated 90° with ideal 90° phase shift offset

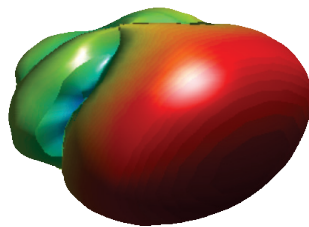
Original Measured Patch

Freq = 2.33GHz Az = 45 EL = 45

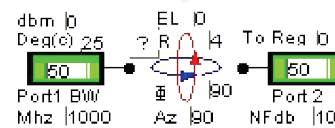


Rotated Patch

Freq = 2.33GHz Az = 45 EL = 45



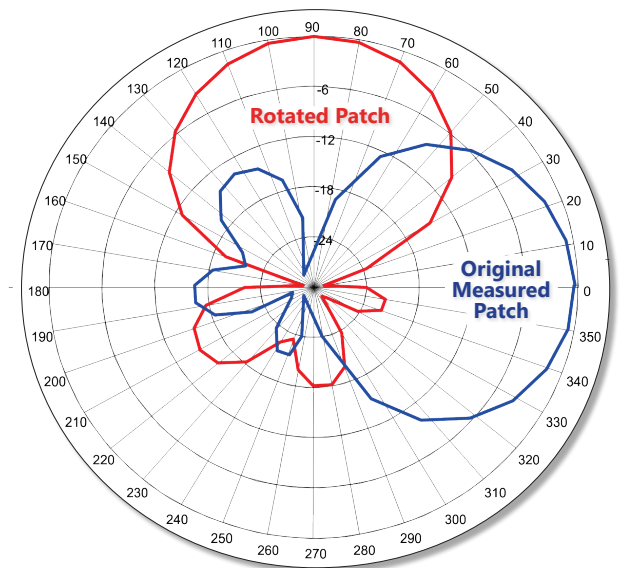
The rotation matrix icon is applied to the x-axis and/or the y-axis.



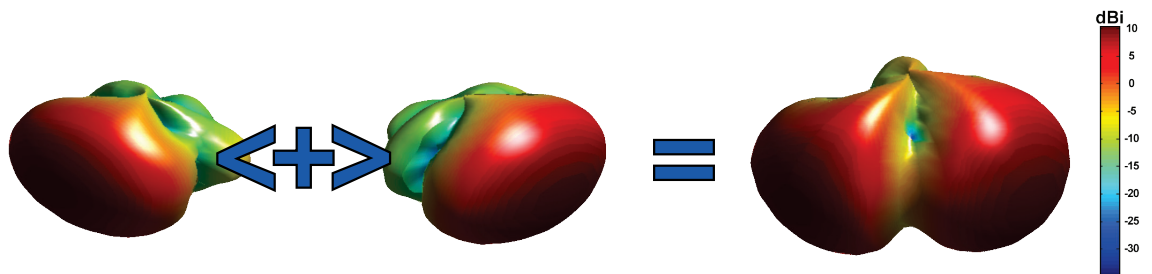
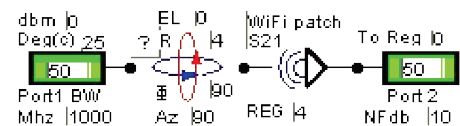
$$R_x(\theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \theta & -\sin \theta \\ 0 & \sin \theta & \cos \theta \end{bmatrix}$$

$$R_y(\theta) = \begin{bmatrix} \cos \theta & 0 & \sin \theta \\ 0 & 1 & 0 \\ -\sin \theta & 0 & \cos \theta \end{bmatrix}$$

$$R_z(\theta) = \begin{bmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$



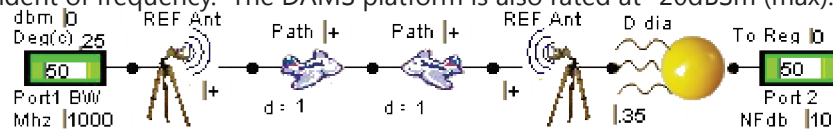
The rotated patch is cascade with the original patch. The rotation icon tells the simulator to vector add the next element in the cascade. The source is split to feed both elements.



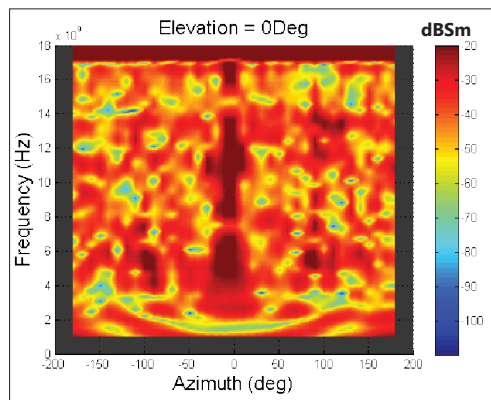
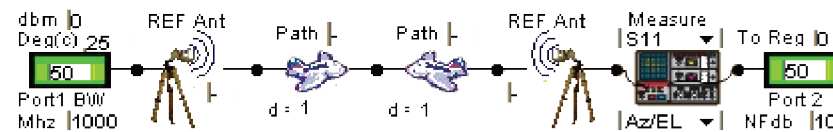
RCS Measurement Simulation

In this example we perform a simulated and actual RCS measurement. The DAMS 6000 platform with the optional FSM mount is measured using an Anritsu handheld vna with gated time domain with 1 to 18 GHz 801 points at 1 meter. The measurement is S11 using an AH systems reference horn.

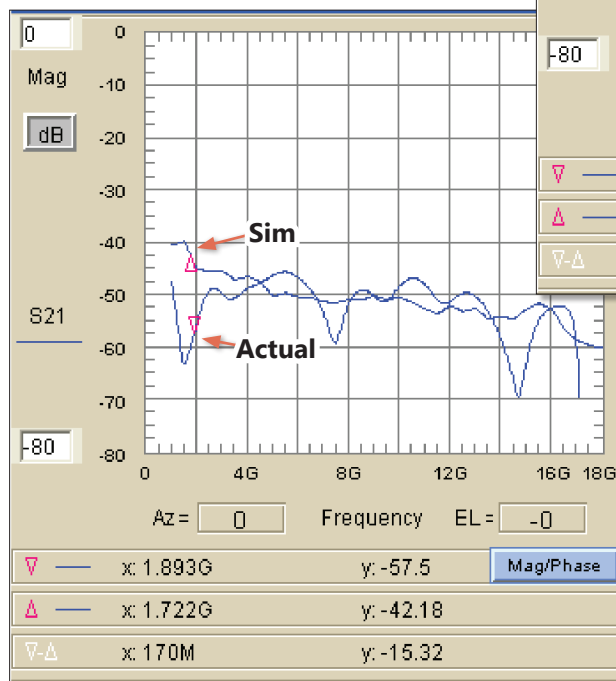
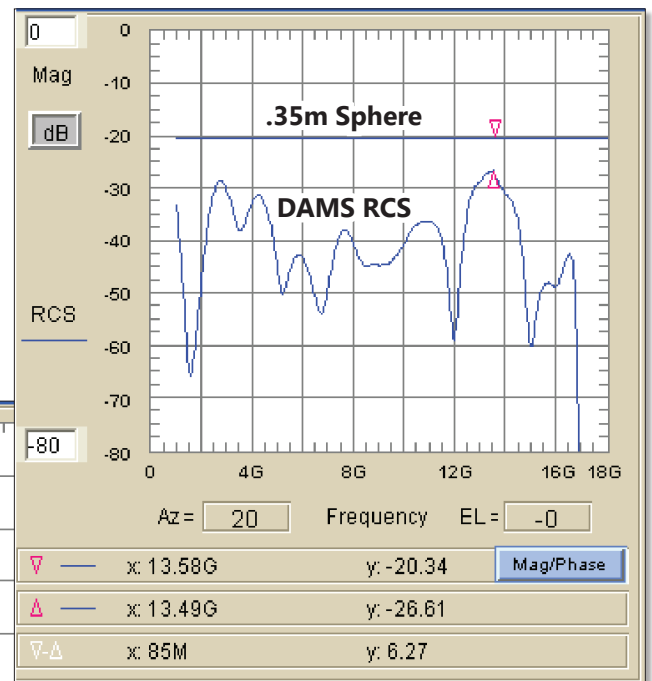
First, the measurement is simulated using a 0.35m diameter ideal sphere known to exhibit -20dBsm RCS independent of frequency. The DAMS platform is also rated at -20dBsm (max).



Next, the schematic is modified for direct RCS measurement. The ideal sphere is then replaced with the measurement icon. The path and reference horn are de-embedded(-).



Measured RCS dBsm and the .35m sphere

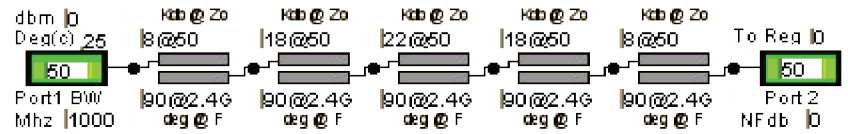


Simulated and actual measurement data with corresponding color map above (gated S11)

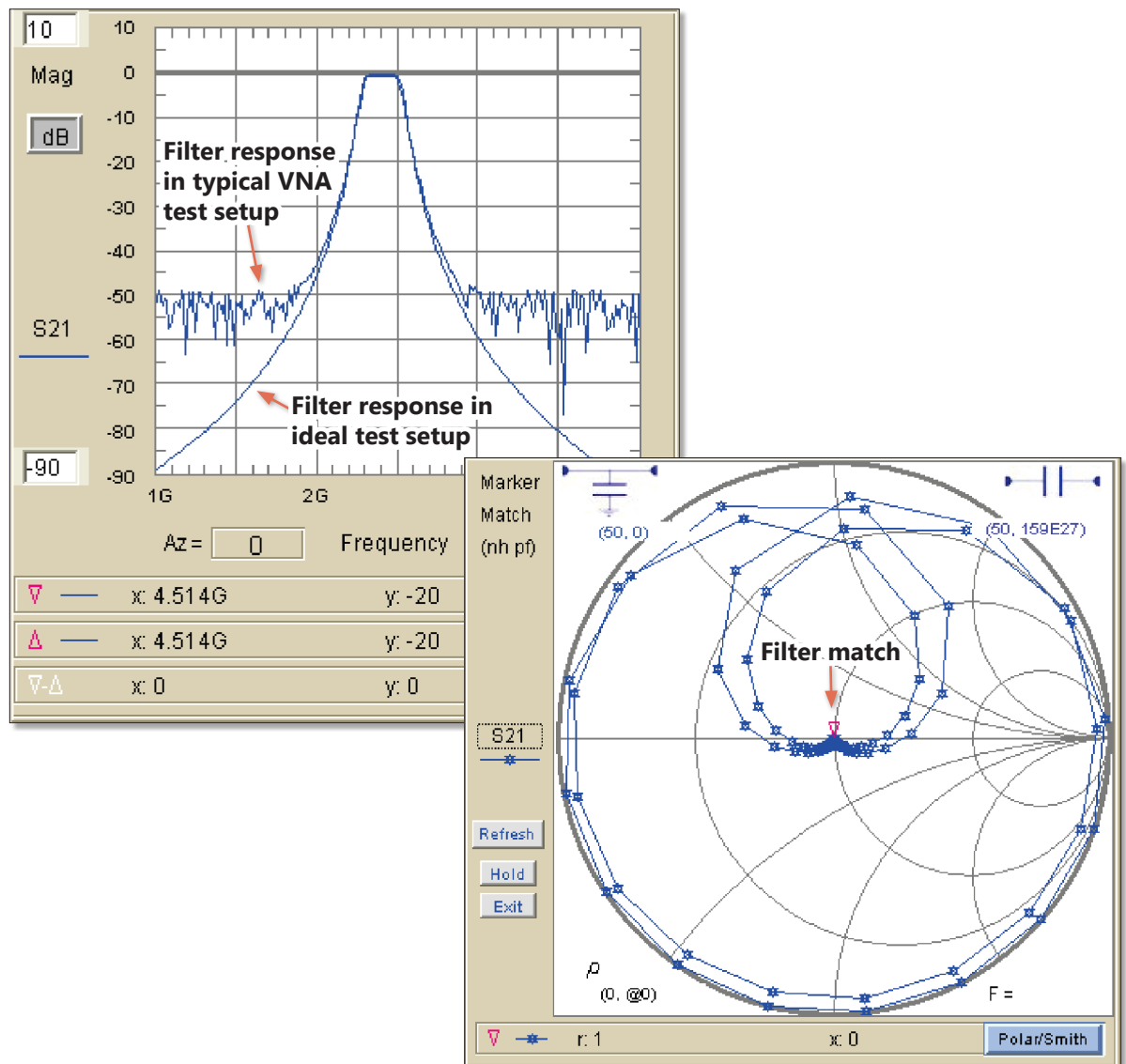
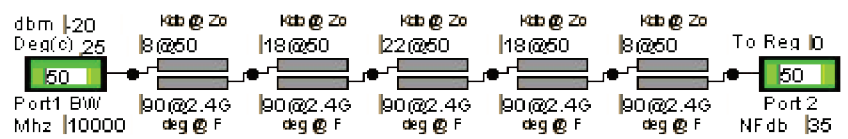
Coupled Line WiFi Filter Simulation

In this example we analyze the measurement of a 5 section coupled line WiFi filter. The coupled line is described in terms of coupling(dB), Zo and electrical length. This makes it possible to design the coupler from experience. The coupling is 8dB while the center resonator is 22dB with 18dB intermediate couplers all at 50 ohm. The measurement will be compared to an ideal test system and a practical vna.

For the ideal measurement Port 2 is given 0dB noise figure with the input power level at 0dBm and bandwidth is 1 GHz. (Temperature is at 25° C)



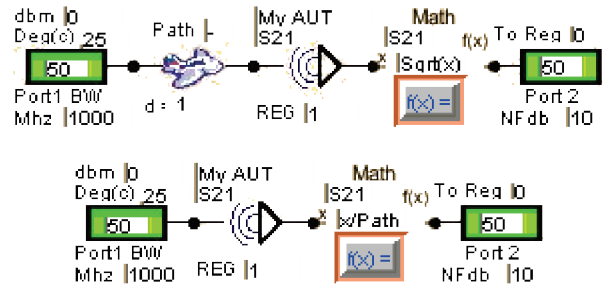
The VNA is modeled with a 35dB noise figure, 10,000 MHz input bandwidth and -20dBm test port power.



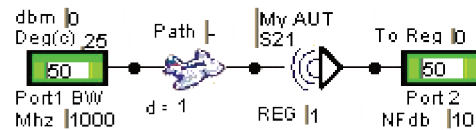
Utilizing the Math Icon

Here we use the **Math Icon** to create complex formulas that can be inserted at any place in the cascade. The Math icon enables access to internal variables like **Path**, **REF**, **Frequency**, **AZ** and **EL**.

Example of applying $f(x) = \sqrt{x}$ to the S21 output of the Reg1/Path. (Necessary when measuring antenna gain in reflection time domain as in our next example.)



Simple gain transfer using the internal Path and REF variables produce the same results as:



The complex **Math Icon** can utilize internal variables to evaluate complex simulation equations:

Standard math operators: +, *, /, sqrt, ^, trig, exp example: $(x^2) * \sin(az * \cos(EL)) + \log_{10}(x + 1e-22) + 10^{(x/20)} + \exp(x) * WL$

Enter Text:

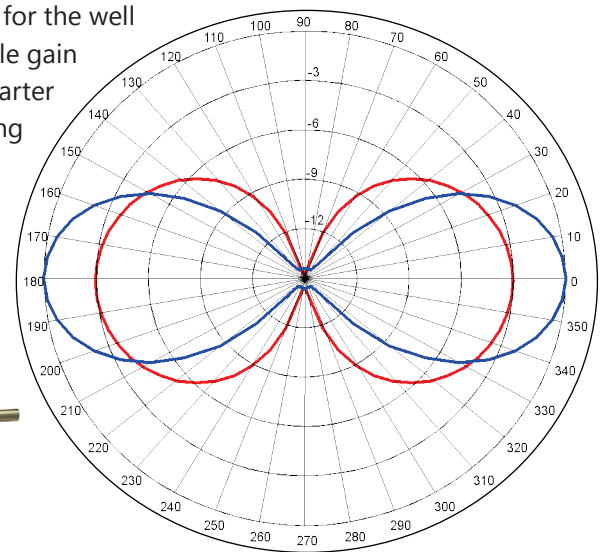
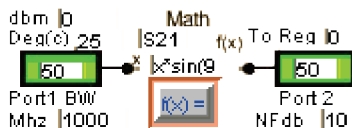
$(x/(\text{Max}(x)/\text{Sqrt}(y))^2 + \exp(j(\text{Im}(y)) * WL * \cos(2 * \text{pi} * WL)))$

OK Cancel

Here is an example of calculating the field pattern for the well established dipole. In this case, the full wave dipole gain is to be determined and compared to the ideal quarter wave dipole. The Azimuth extent is set by emulating a quarter-wave dipole in the DAMS emulator and normalizing the array with the scientific array calculator.

Shape equation:

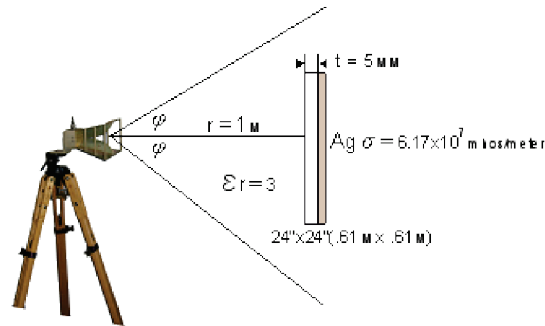
$$x * \sin(90 * \cos(az) / \sin(az))$$



Dipole shape equations are analyzed over DAMS measurement AZ-EL array using the **Math Icon**.

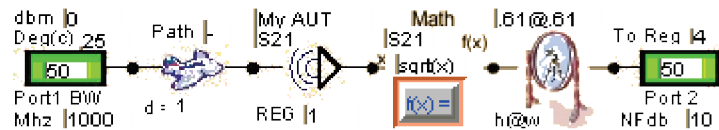
Utilizing the Mirror Icon

In this example we demonstrate a single antenna method for measuring gain. A broad band reference horn is to be measured using the DE calibrated mirror. A high speed vector VNA is to be used in time domain to measure the reflection of the reference horn with it's own image.



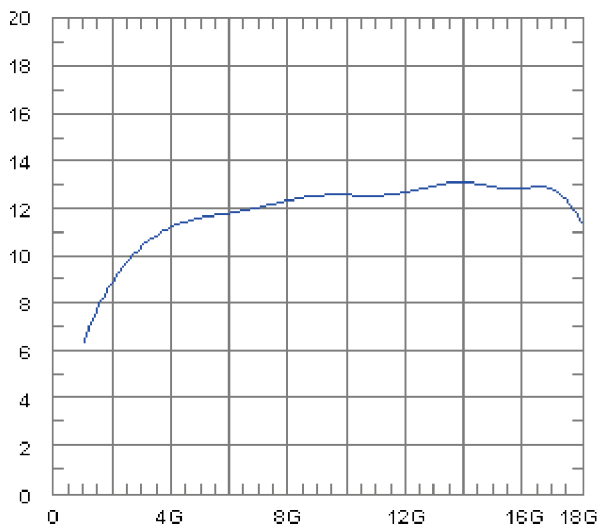
Antenna Network Simulator

Time Domain using Mirror S11. Calculates the aperture angles and corrects the data

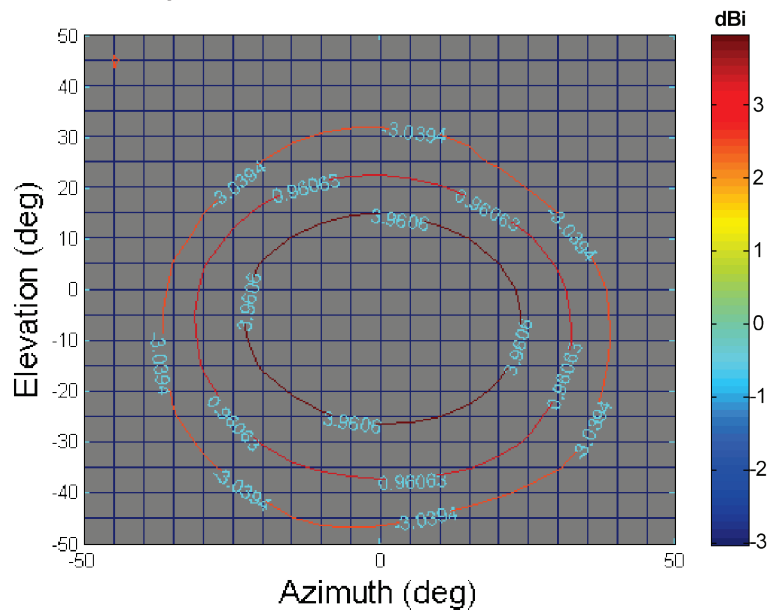


The **Single Path Icon** divides the resulting dB path by two while the **Math Icon** divides the measurement dB by two. The DE calibrated reflection mirror dimensions (0.61m x 0.61m) are represented by the **Mirror Icon**. The net results are sent to **Reg4**. The simulation library also has many other pre-assembled schematics for a wide variety of purposes.

Time Domain Gated Frequency Gain



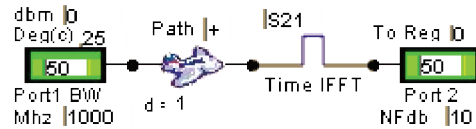
-3, -6 and -10 dB beamwidth contours



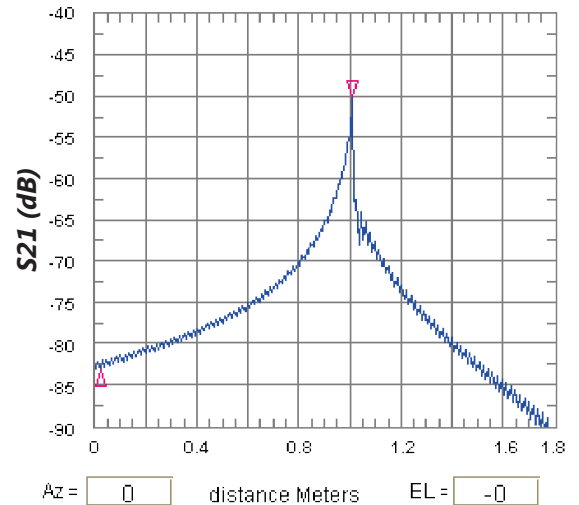
Utilizing Time Domain

In this example we demonstrate the use of the inverse FFT to transform data from frequency domain to time domain. This transformation has many uses ranging from cable fault location to RCS. The spatial units take on the Path units or default (Meters). While many vna's have time domain the TD icon enables time domain in measurement and network model simulation.

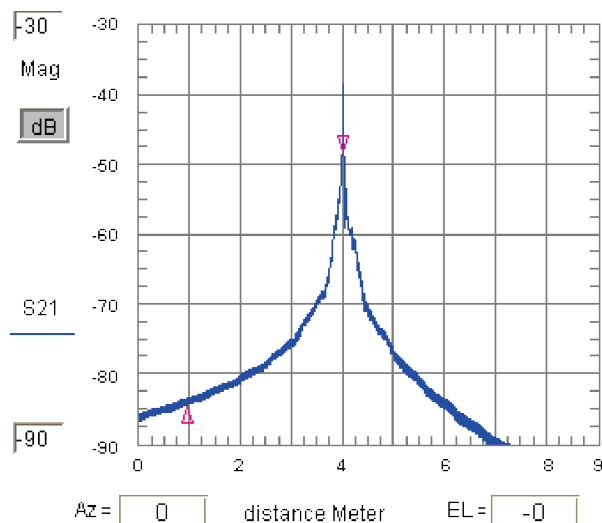
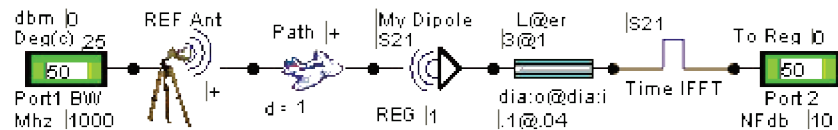
Performs inverse Frequency-to-Time (FTT). Num F>500 Calculate with S21



Time domain can be used to determine the physical distance of the measurement or to determine phase center. Additionally, the Path (measured or calculated) can also be determined. In this example the 201 data points were used over a 1 to 18 GHz sweep.



The schematic below simulates a measured dipole in an actual measurement link. Incorporating the time domain enables us to determine the length of the cable by using the marker difference.



Marker	x	y	Mag/Phase
▽	3.985	-48.27	Mag/Phase
△	0.921	-84.37	
	3.064	36.09	