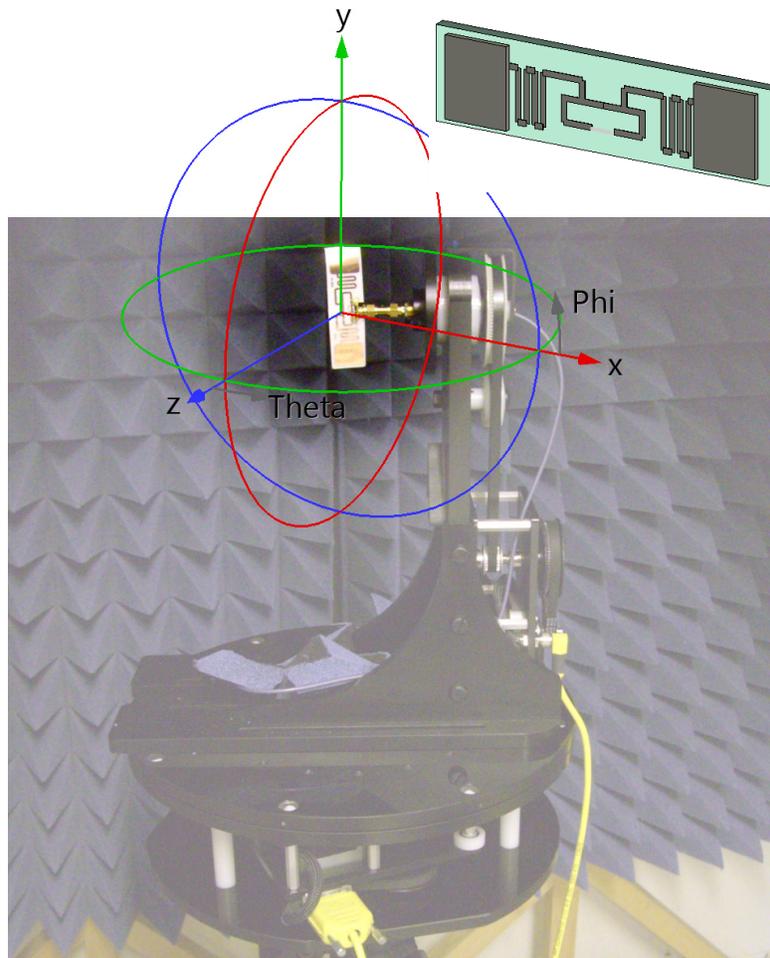

RFID Antenna Measurement



This example demonstrates the basic measurement technique and utilizes most (but not all) of the DAMS Software capabilities.

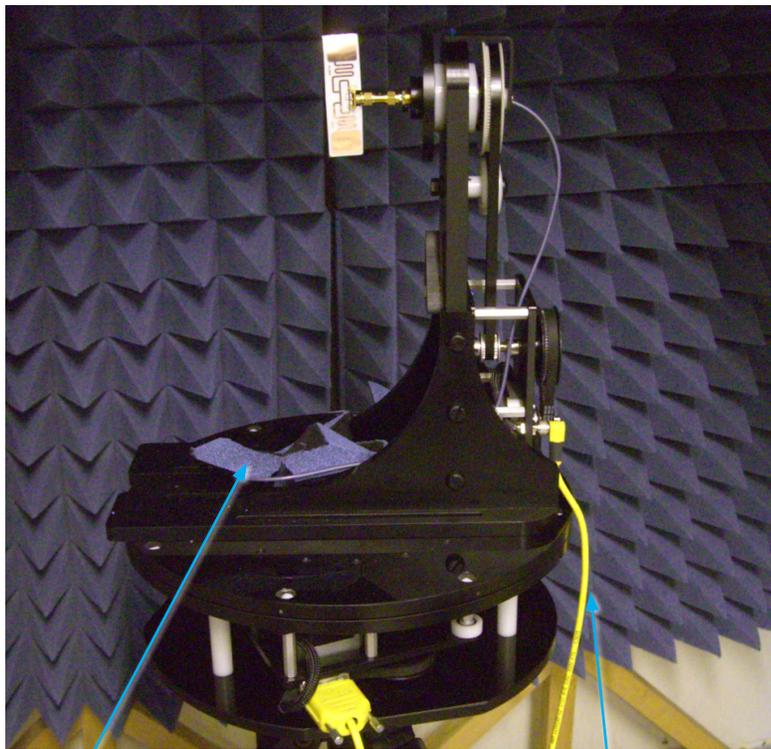
This example will determine:

- Gain (Phi and Theta)
- Match
- Efficiency
- 10dB spherical compliance
- Antenna range (assuming 10 Watts Tx, RFID Retransmit efficiency=.001% 920MHz)

Test System Specifications

System:	DAMS6000 with FSM-5
Frequencies:	800MHz to 1GHz with 101 points
Azimuth:	0 to 360 (Step 5)
Elevation:	-90 to +90 (Step 10)
Method:	Gain Transfer calibrated Yagi Ref.

Apply Sampling 8th order to correct errors Ignore the absence of the Balun choke normally supplied by the RFID chip.



Absorber over rotary joint

NOTE: Be sure to switch the Azimuth and Elevation cables when using the FSM attachment.

System Calibration

- 1 Ensure the picture in Configured Positioner is your platform.
- 2 Select your test equipment.
- 3 Perform a VNA calibration from the reference to the DAMs rotary joint. (DAMS provides scalar cal for non-vector measurements.) In settings menu check Additional Parameter S11 or S22.
- 4 Configure the Az-EL movement
- 5 Set the default monitor plot items
- 6 Make sure the AUT is properly positioned. Use the jog and Zero Positioner.
- 7 Initiate SCAN Az/El and begin the measurement. Button will turn grey until finished.

Measurement time remaining will update here.

The screenshot shows the Antenna Measurement Studio software interface. The title bar indicates 'Antenna Measurement Studio 5.998Z - HTTP://www.diamondeng.net'. The main window is divided into several sections:

- Top Bar:** Includes 'MOTION DISABLED' status, 'ENABLE' button (7), 'QUIT!' button, and 'Diamond Engineering Automated Measurement Systems' logo.
- Left Panel (SYSTEM OPTIONS):** Contains 'Select VNA or Source' (2) set to 'VNA EMULATOR', 'Select Receiver' (3), 'CAL SYSTEM' set to 'Scalar Cal OFF', 'CalPAD(dB)= 0', and 'PM Cal OFF'. Below are 'Az Extents' and 'EL Extents' configuration sections (4).
- Center Panel:** Features 'MEASURE AZIMUTH CUT', 'MEASURE ELEVATION CUT', 'SCAN Az/El' (7), 'Proceed to Data Processing', 'Reset ALL Init Pos', 'Position Platform to peak', 'PAUSE MEASUREMENT', and 'STOP MEASUREMENT' buttons. A 'STATUS' section shows 'Ready to Measure' with 'Start Freq', 'Stop Freq', 'No. Points', 'Az Pos.' (0), and 'El Pos.' (0) fields.
- Right Panel:** Shows 'Configured Positioner' (1) with a camera view of the test setup and 'Positioner Settings'.
- Bottom Panel:** Includes 'Center Frequency Amplitude / Polar Preview' (5) with a polar plot, 'AZ Progress' and 'EL Progress' indicators, 'S21 Averaging' settings (e.g., '<S21(f)> OFF', '# Avg's 1'), and 'Meas. Delay 0'.
- Bottom Left:** 'Azimuth Jog delta' and 'Elevation Jog delta' controls (6) for manual positioning.

TIP: You can make multiple measurements for averaging and min/max delete.

Monitor Plots

- 1 After the measurement is complete proceed to Data Processing to save the data. (See next page)
- 2 Return and rotate Reference Antenna 90 degrees. Repeat measurement and save data. (See next page) **Where? How?**
- 3 The monitor plots display the link data by default. They can also be set to gain data in the Monitor Plots menu. Additionally, real time gain can be invoked for pre-test or experimentation.

 **TIP:** When utilizing the real-time gain plot, you can jog or zero the position.

Saving Your Data

To save your data to a REG and then save REGs to your drive:

- 1 Save each data set to a register(Reg1& 2). Label the Registers
- 2 Load the Alternate Parameter (Sxx match) to the display Register.
- 3 Save Alternative Parameter to unused Reg4.
- 4 Save the data to the disk
- 5 In the event of data loss go to RECOVERY in the Register Utilities

The data is now secure. Next the data can be processed into Gain data. While the math can be done in the array calculator the Gain Transfer is set up for this. It requires knowledge of the path and the reference antenna.

The screenshot shows the Antenna Measurement Studio software interface. The title bar reads "Advanced Processing Go to 'Start Here' to proceed". The main window title is "Antenna Measurement Studio Precision Antenna Measurement System and Data Processing Software". The current dataset is "C:\Documents and Settings\Mike\Desktop\RFID\RFID2.dat".

Key interface elements and callouts:

- Callout 1:** Points to the "Link Data E-theta" button in the "Data Registers" panel.
- Callout 2:** Points to the "Alternate Parameter Data" input field in the "Data Registers" panel.
- Callout 3:** Points to the "Load Alternate S-Param." button in the "Data Visualization Options" panel.
- Callout 4:** Points to the "Save Reg1-4 To Disc" button in the "Data Registers" panel.
- Callout 5:** Points to the "Load Reg1-4 From Disc" button in the "Data Registers" panel.

The "Active Register" panel shows "New Measurement 1/4/2011 4:04:59 PM" with "Active = Reg0 EMPTY", "Start = 800M", "Stop = 1G", and "Data Points = 219".

The "Data Manipulation Options" panel includes buttons for "Generate Path Loss", "Gain Xfer", "Efficiency", "Flip EL sign", "Print", "EL Swing Corr.", "Import REF Antenna", "3-Point Gain", and "Gain Substitution".

The "Register Math" panel shows a calculator interface with "Reg0" through "Reg4" and various mathematical functions like "10Log(REGx)", "REGx^2", "SQRT(REGx)", "REGx(MAX)", "REGx(MIN)", and "1/REGx".

The "Advanced Calculator" panel shows a table of data points:

Active Register	Mag	INV	20 Log	Clip data	Active Register Phase
0:	1.193	1.374	1.494		0:
01:	1.188	1.368	1.487		01:
02:	1.173	1.35	1.467		02:
03:	1.148	1.32	1.433		03:
04:	1.113	1.279	1.388		04:
05:	1.069	1.227	1.33		05:
06:	1.017	1.166	1.262		06:

 **TIP:** Register Utilities can be used to load multiple files. See "Load single Register".

Path Loss Generator

- 1 Enter the Separation Distance and select the appropriate unit of measurement and click "Continue".
- 2 Additionally, besides TxRx separation, you can use the group delay, specify a fixed path loss, or use the Laser Borsite tool to determine distance, pointing angle and path loss.
- 3 Left scale (yellow) is path loss. Right scale is path loss sensitivity to length (dB/in)
- 4 Invoke Generate Path Loss. Once done, button will turn green.

(Continues next page...)

PATH LOSS CALCULATION

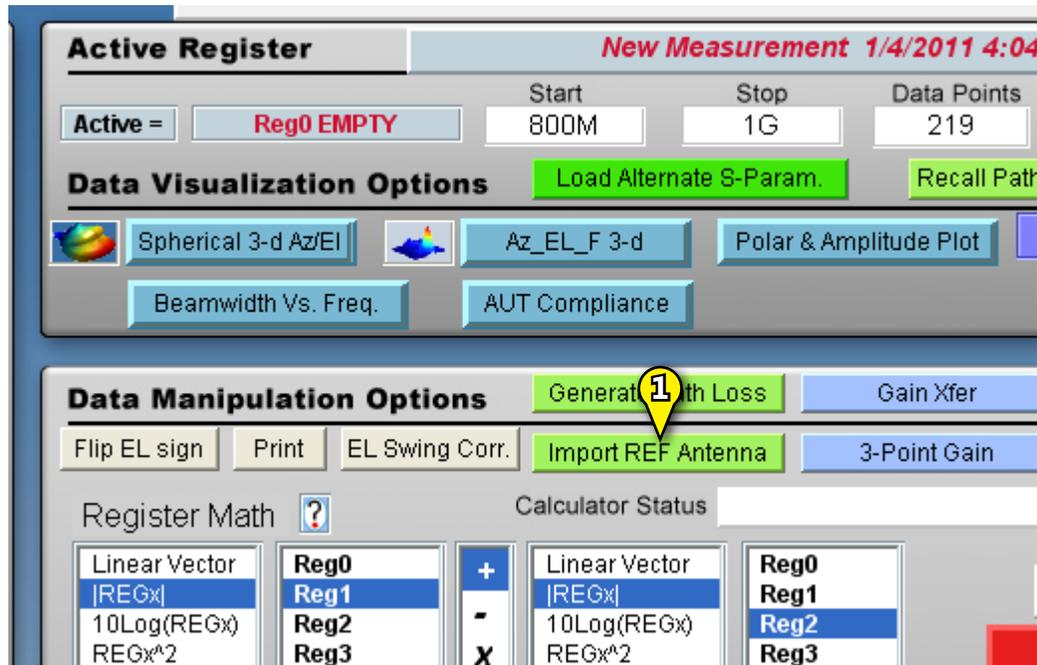
This will calculate path loss into the internal PL register with the size, shape and frequency extents of the data currently in REG0. The path can be specified by distance, distance from group delay, fixed attenuation or distance by Laser Tool. Principal phase is also calculated.

A **green** PathLoss button in the Previous page(Advanced Data Processing) indicates PL is present.

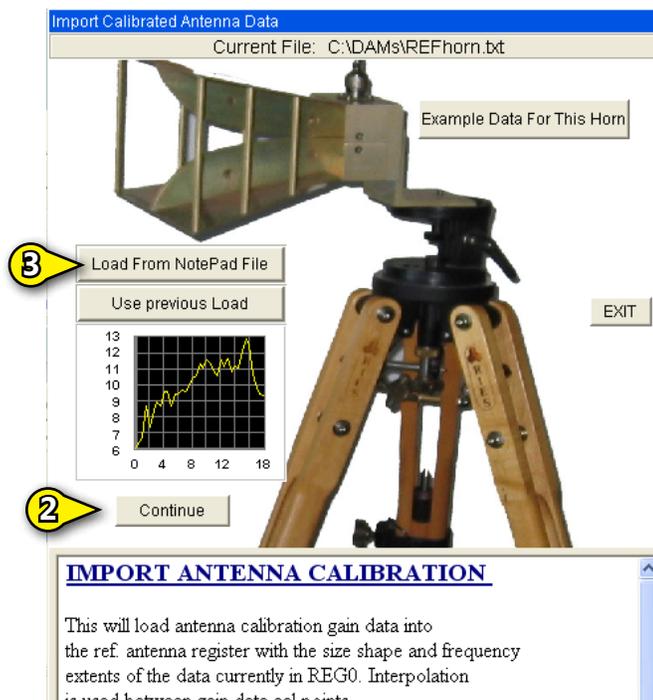
Use S21 Phase REG0 to calculate the path loss from the group delay. Be sure you have performed a vector calibration from the AUT feed (rotary joint) to the Tx feed. When exiting Group delay be sure the plot is in distance units not time. This distance will update PL distance.

The dB/inch scale (green, right) is the sensitivity of the separation to path variations. To

- 1 Invoke Reference Antenna. Once done, button will turn Green
- 2 Follow instructions to create reference antenna file. Press Continue when done.
- 3 You can import arbitrary losses by adding them to the Ref Horn file.



(Data in REG1 is used for Gain Transfer. REG1 was EQ.)



(Continues next page...) [?]

- 1 Invoke Gain Xfer for REG1 (EQ) and REG2(EF)
- 2 Calculate ABS AUT Gain=REG4&0 "Total Power Factor"
- 3 Re-save ABSgain to REG3 so REG4 can be used for other things
- 4 "Calculate Total Power factor" will convert REG1 and REG2 to Gain and calculate the ABS gain and store to REG4&0

TIP: You can perform circular, 3-point or substitution measurements in the Data Transfer window.

(REG0 is the display REG used for plotting)

After step 4 we have:

Gain Transfere

Calculate Gain(AUT) from Calibrated Reference And Path Loss

$$G_{AUT} = \frac{[S_{21}]^2}{[G_{REF}]^2} \left(\frac{\lambda}{4\pi r d}\right)^{-2}$$

Linear Gain Requirements:

1. Measurement Data Saved to REG1
2. Invoke path loss (Sets internal variable)
3. Import Tx Gain (Sets internal variable)
4. Invoke "Calculate AUT Linear Gain = REG4&0"

Phase: Principal phase (0 to 180 and 0 to -180) is also calculated

Circular Gain Requirements Using H-V Linear Tx Horn with FSM Mount:

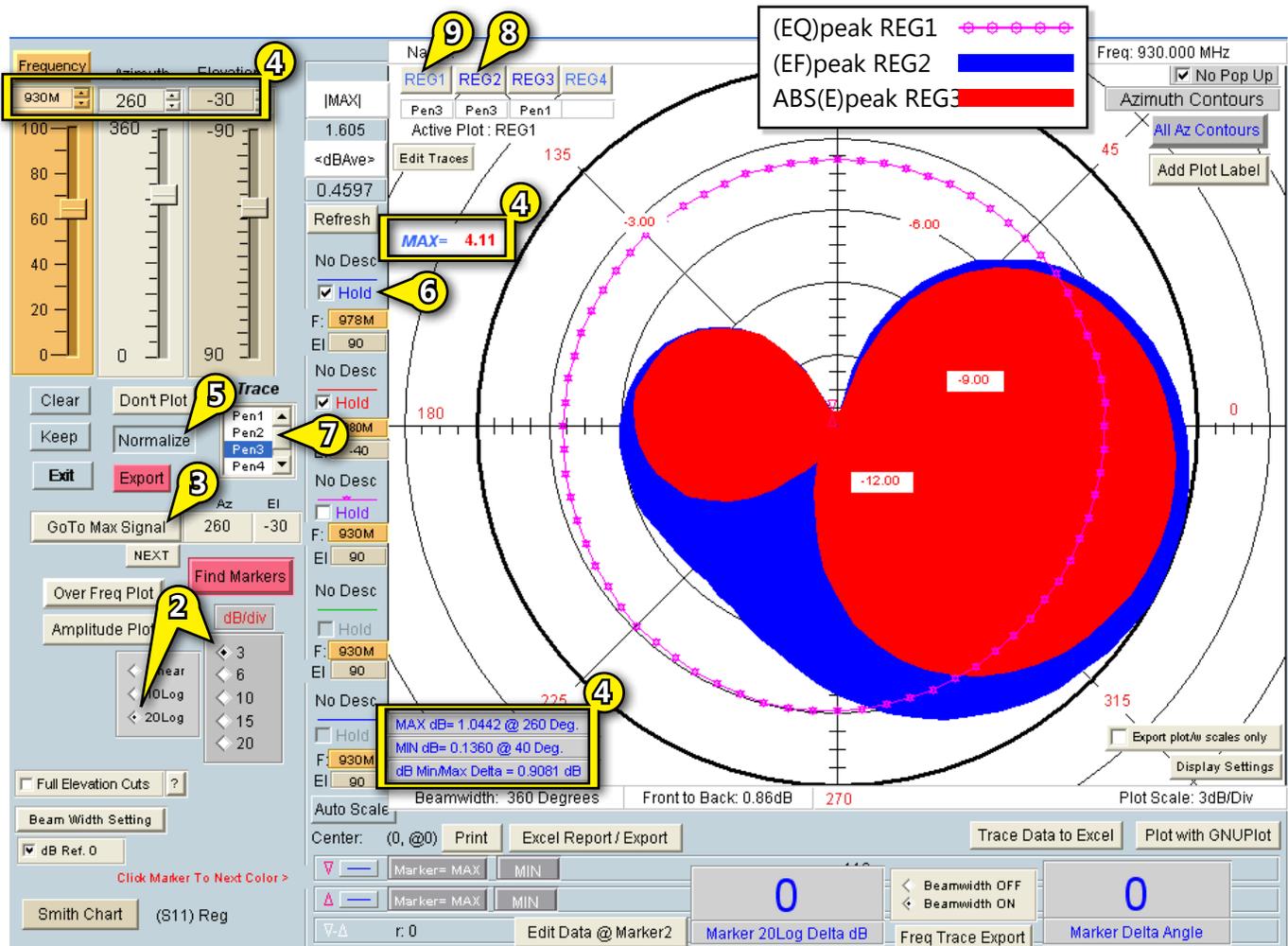
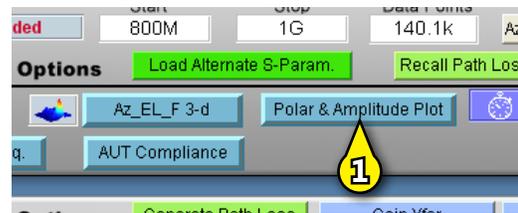
IMPORTANT: Rotate horn CCW to make H measurement, RCH is relevant to the AUT

View Application Note

- 2 Calculate Linear AUT Gain = REG4&0
- 3 Calculate Circular Gain using H & V Linear Tx
- 4 Calculate Total Power factor SQRT(Eh^2+Ev^2)
- Cancel

Compare the PeakEQ,EF Gains to Absolute Gain

- 1 Enter Polar & Amplitude Plot, then recall REG3(ABS(G))
 - 2 Check dB and 3dB/div **with 20 Log (?)**
...as indicated in img?
 - 3 Click Goto Max Signal
 - 4 Read peak gain **and** associated F,Az-EL positions, and note **all three sets of[?]** parameters
...as indicated in img?
 - 5 Click "Normalize"
 - 6 Check Hold
 - 7 Switch to Pen2
 - 8 Recall REG2 and repeat steps 3-7
 - 9 Recall REG1 and repeat steps 3-7
- ▲ **TIPS:** - You can set the linetype, point type and label by clicking on "No Desc"
- You can export any contour to Excel.



(Color shading shown is for illustrative purposes only.)

Plot Peak Abs(E) Gain and Associated Ef,Eq Gains

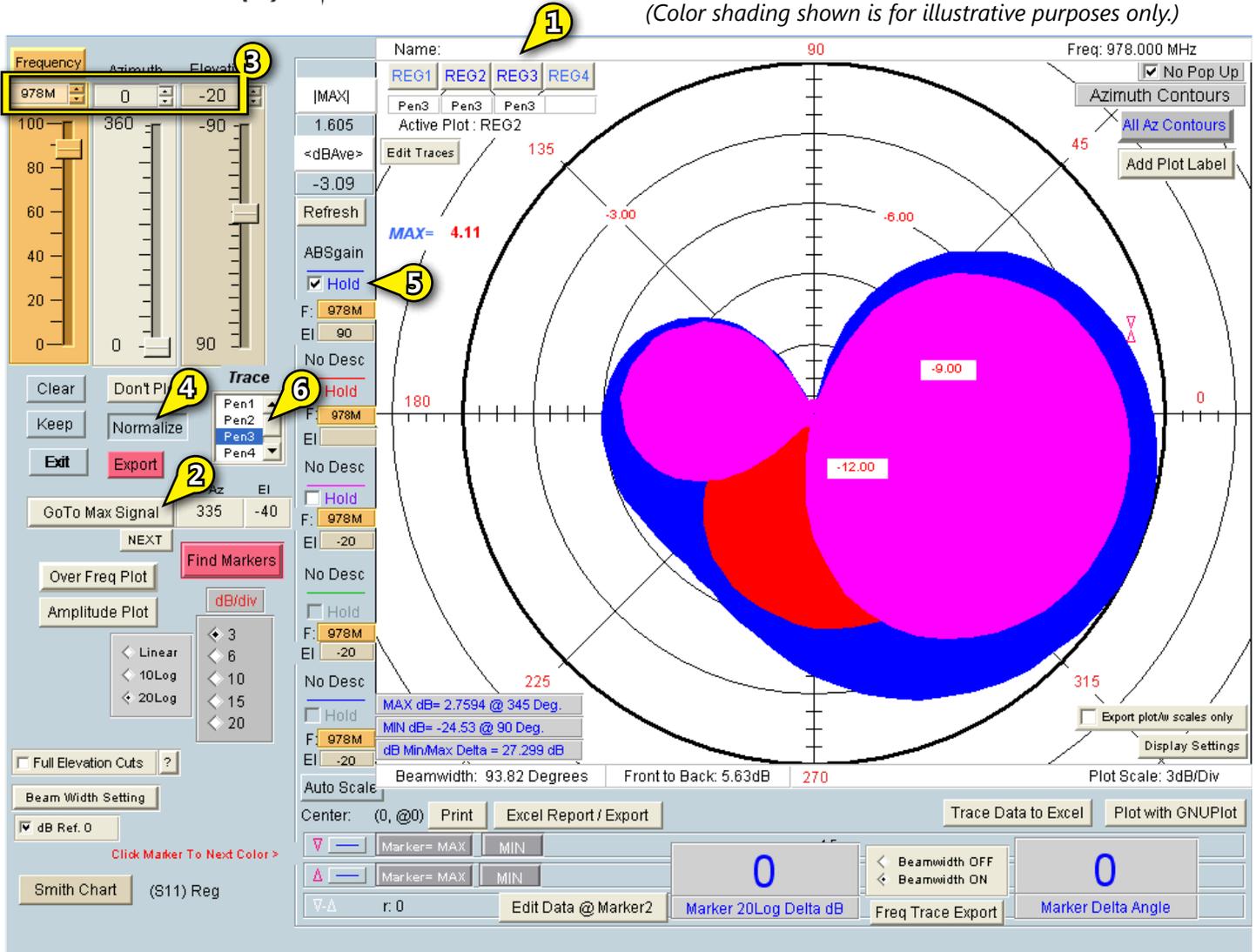
- 1 Recall ABS(E) REG3
- 2 Click Goto Max Signal
- 3 Note the Az,EL,f on top of sliders
- 4 Click "Normalize"
- 5 Check Hold
- 6 Switch to Pen2
- 7 Recall REG2 (See 1)
- 8 Reset sliders (See 3)
- 9 Check Hold (See 5)
- 10 Switch to Pen3 (See 6)
- 11 Recall REG1 (See 6)
- 12 Reset sliders (See 3)

 **TIP:** You can set the linetype, point type and label by clicking on "No Desc"

The $ABS(E) \leq E_{\theta}, E_{\phi}$

$$\text{since } ABS(E) = \sqrt{E_{\theta}^2 + E_{\phi}^2}$$

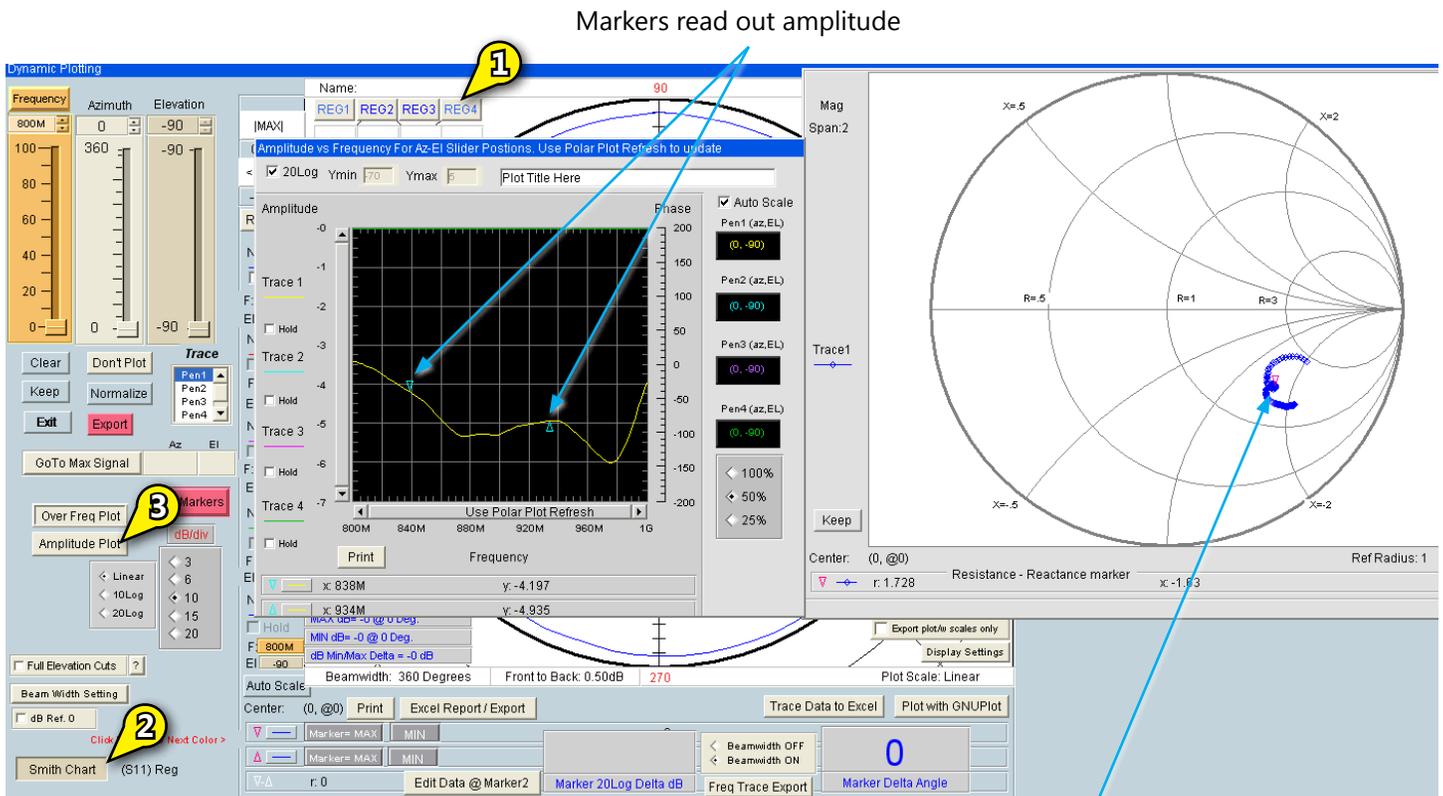
Need color code key like on page 9...?
(Color shading shown is for illustrative purposes only.)



Plot the AUT Reflection Coefficient

- 1 Recall the previously loaded S11 data REG4
- 2 Invoke the Smith chart
- 3 Invoke the Amplitude plot

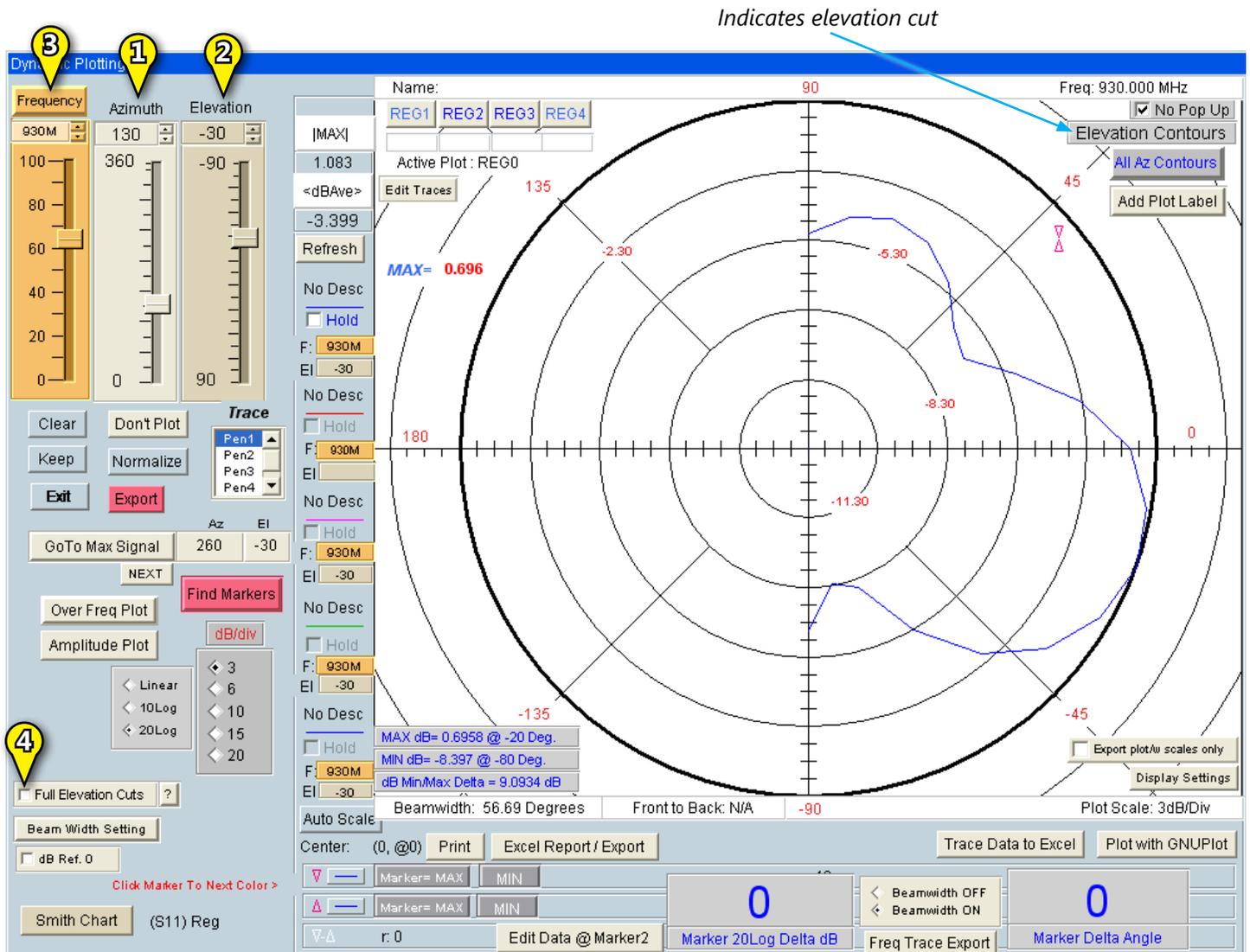
This enables the AUT match amplitude and phase to be plot.



Marker reads out AUT impedance

Full Elevation for Full-Circle Azimuth Cuts

- 1 Move Azimuth slider to see elevation cuts
 - 2 Move Elevation slider to see azimuth cuts
 - 3 The "Frequency" button can be used to enter frequency.
(M,G and k are valid multipliers.)
 - 4 Check for full 360 deg Elevation cut. Only valid for full scan data
- TIP:** You can export this data to Excel.

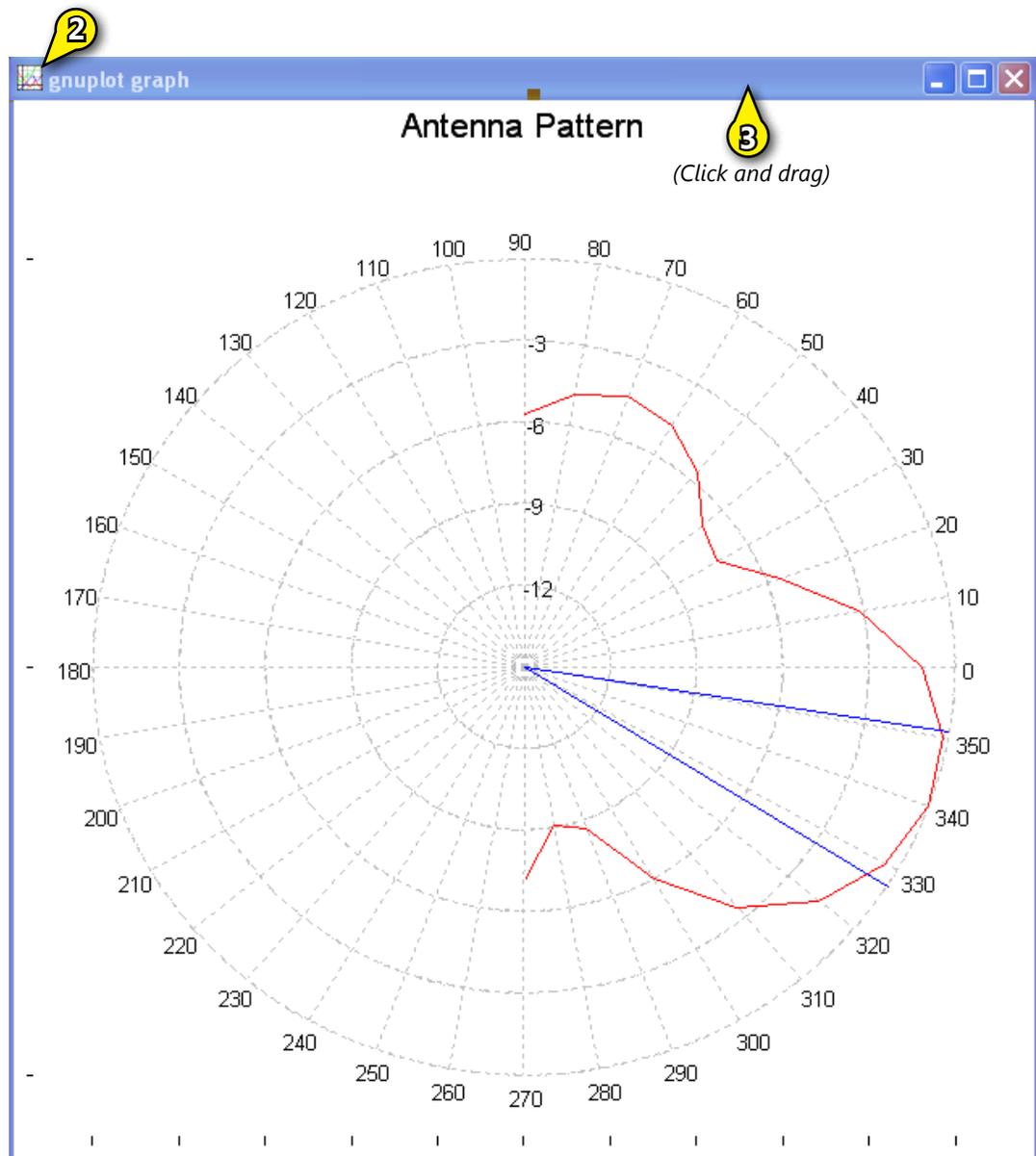
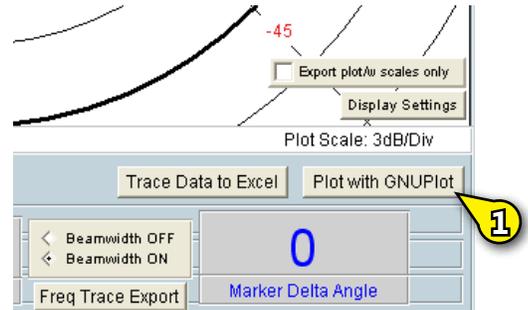


GNU Plotting

GNU plotting provides more marketable plots. To utilize GNU, follow these steps:

- 1 Click "Plot with GNUPlot".
- 2 Click here to reveal more options
- 3 Move the polar plot aside. It's best to have DAMS full screen so more plots can be run simultaneously.

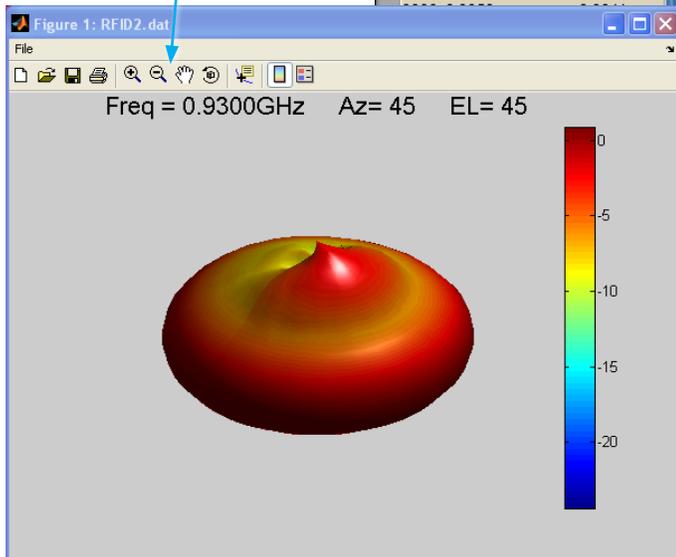
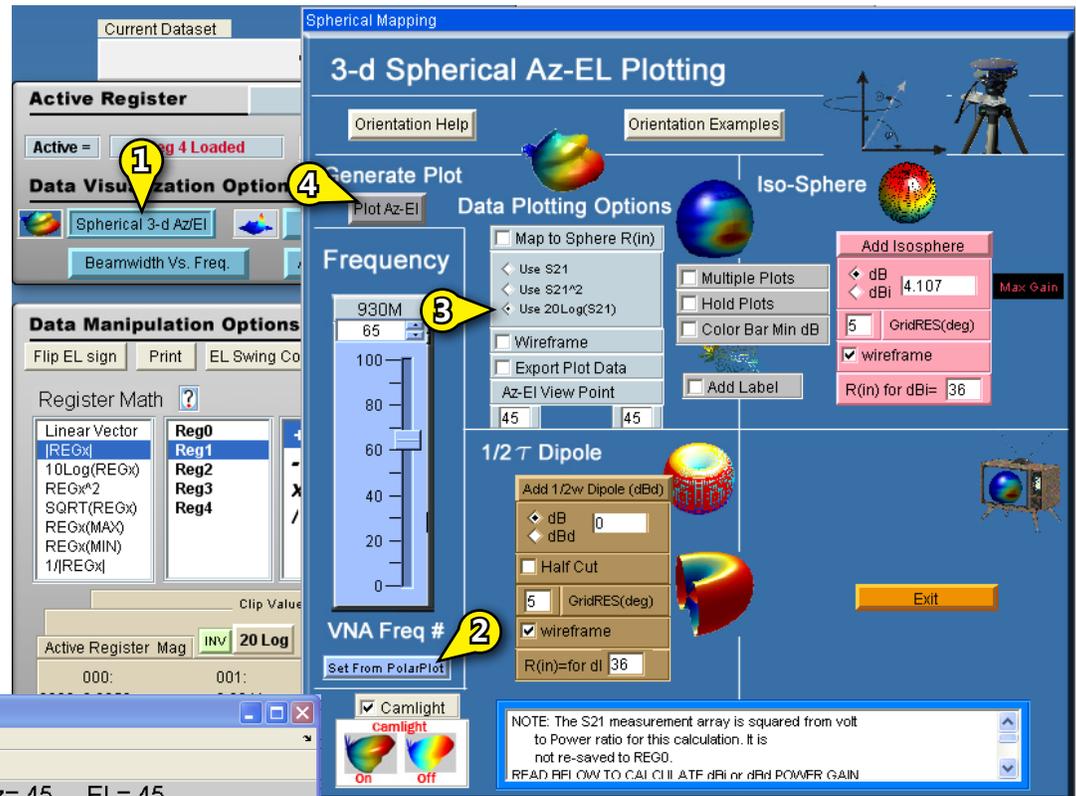
 **TIP:** The amplitude plot may also be used to plot with GNU.



Plotting Peak Spherical Gain

- 1 Invoke the spherical 3-d Az/EL
- 2 Set the frequency slider to peak gain by invoking "Set From Polar Plot"
- 3 Check Use 20Log(S21)
- 4 Invoke Plot Az-EL, which opens the 3D rendition as seen below[?]

 **TIP: Processing toolbar offers a host of plot tools.**

 **TIP:** Generally the polar plot is used to identify a desired (Az,EL,f) contour. The Spherical frequency can be set "2" from the polar frequency slider in another window[?].

Where is said slider? Isn't the visible blue slider for the "VNA Freq #" as it says below it?

Spherical Plot of Gains (EQ),(EF),ABS(E)

⚠ IMPORTANT: See note in spherical regarding multiple dB spherical plotting for exceptions. Where is this?

1. Be sure the REGs are as follows (from Gain Xfer Total Power)

Data Registers Load Reg1-4 From Disc
Save Reg1-4 To Disc

REGISTER UTILITIES # Measurements

CLR	Data Storage Reg 1	Recall Reg 1	140.1k
	REG1 is V(AUT) Linear Gain		(Ef)
CLR	Data Storage Reg 2	Recall Reg 2	140.1k
	REG2 is H(AUT) Linear Gain		(Eq)
CLR	Data Storage Reg 3	Recall Reg 3	140.1k
	REG4 is Total Power Sqrt(Ev ² +Eh ²)		ABS(E)
CLR	Data Storage Reg 4	Recall Reg 4	7373
	S11		N/A

Where? 2. In the Polar Plot recall ABS(E) and invoke "Go To Max" to set the frequency slider to the frequency associated with max ABS(E)

- 1 Set the freq slider to polar plot (max)
- 2 Check Multiple Plots
- 3 Check 20Log(S21)

(Continues next page...) [?]

Spherical Mapping

3-d Spherical Az-EL Plotting

Orientation Help Orientation Examples

Generate Plot Iso-Sphere

Plot Az-El Data Plotting Options

Frequency VNA Freq #

978M Set From PolarPlot

89 Camlight

100 On Off

80 1

60 2

40 3

20

0

Map to Sphere R()

Use S21

Use S21²

Use 20Log(S21)

Wireframe

Export Plot Data

Az-El View Point

45 45

Multiple Plots

Hold Plots

Color Bar Min dB

Add Label

Add Isosphere

dB value 4.107

Az cut 0-360

5 GridRES(deg)

wireframe

1/2 τ Dipole

Add 1/2w Dipole (dBd)

Multiplier 1

Az cut 0-360

5 GridRES(deg)

wireframe

Exit

Isosphere: When data is plot, the dB value window displays the peak data dB value. By subtracting 3 from the value and "Add Isosphere" the 3dB beamwidth can be seen. The "set From Polar Plot" button will set the frequency slider to the slider frequency in the Polar plot. That is useful for viewing the peak signal or a desired signal as determined in the Polar Plot.

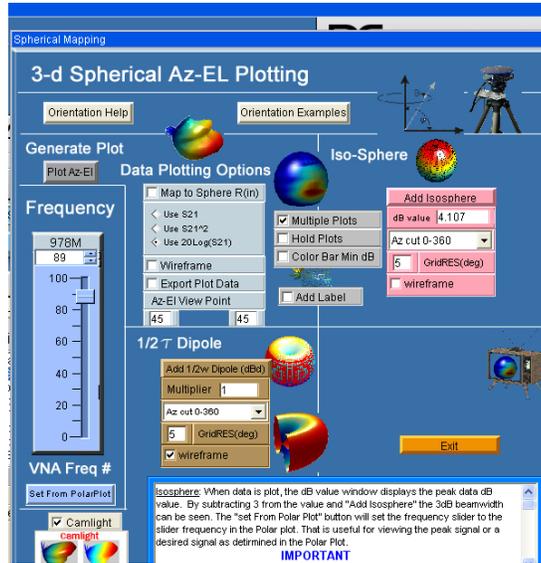
IMPORTANT

Mapping linear coordinates to spherical coordinates has some special considerations.

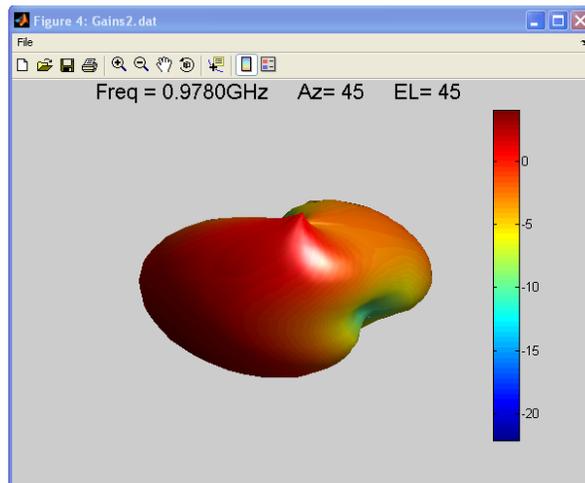
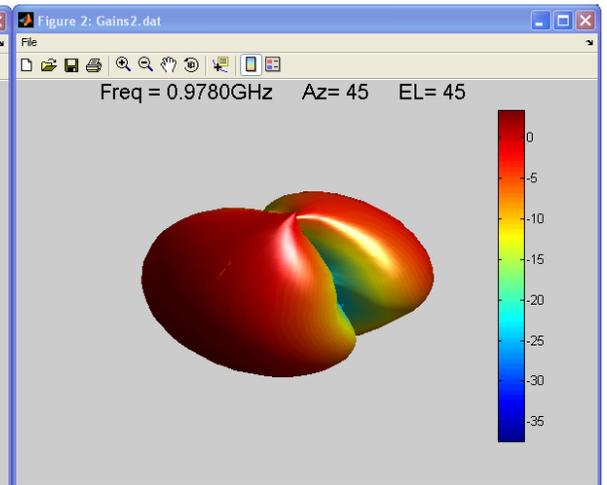
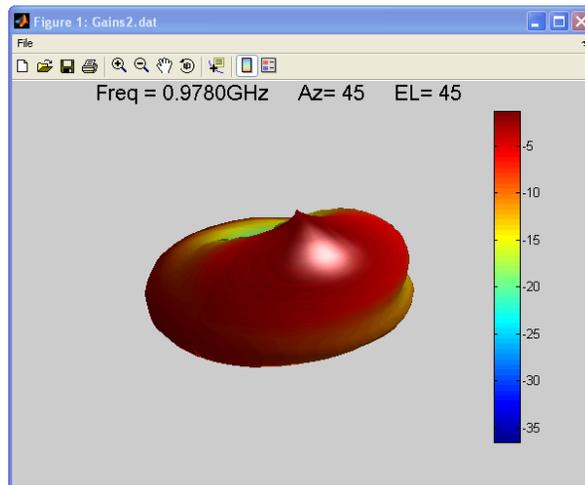
1. Recall REG1, Plot (EF)
2. Recall REG2, Plot (EQ)
3. Recall REG3, Plot ABS(E)

 **TIP:** Plots can also be over laid by checking "Hold". "Wire" can be used to delineate plots.

 **TIP:** By clicking wire or no wire multiple plots can be made more visible.

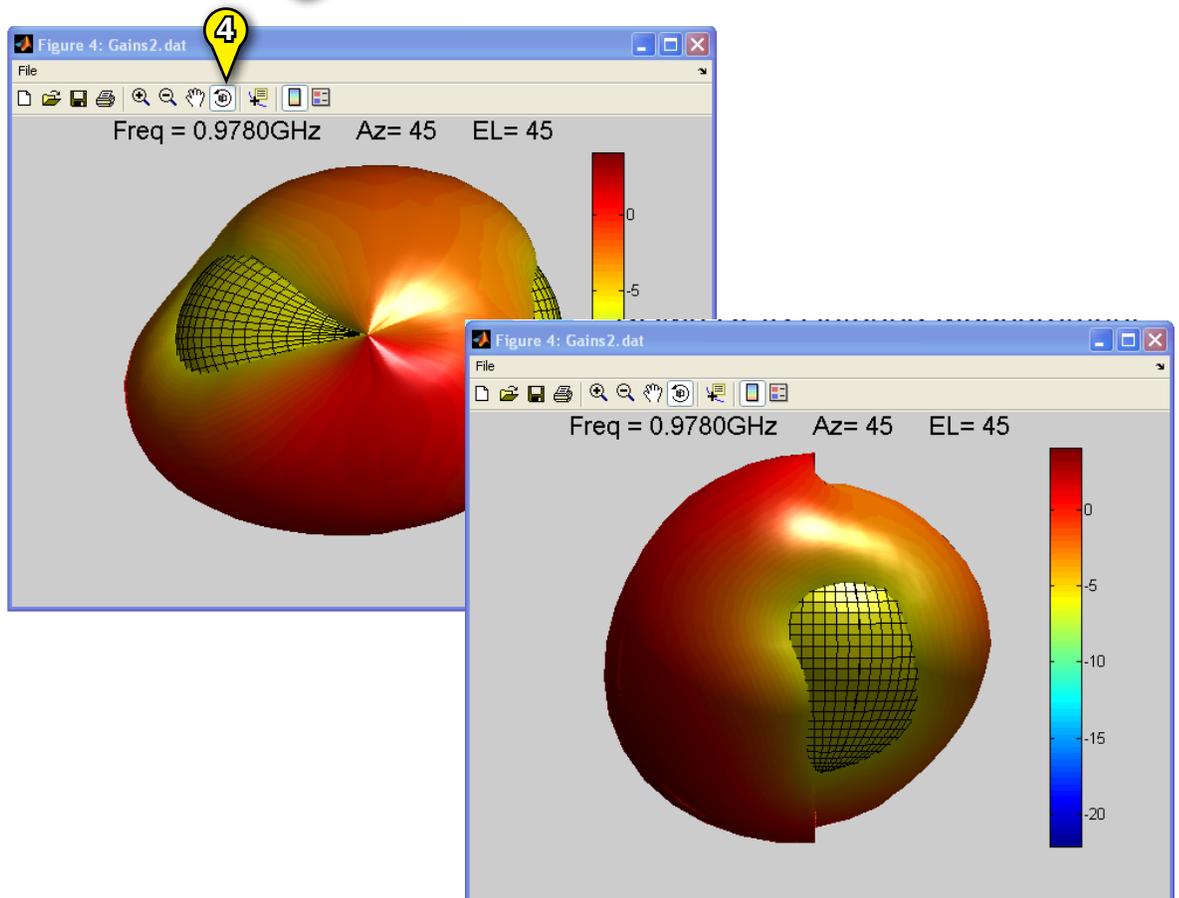
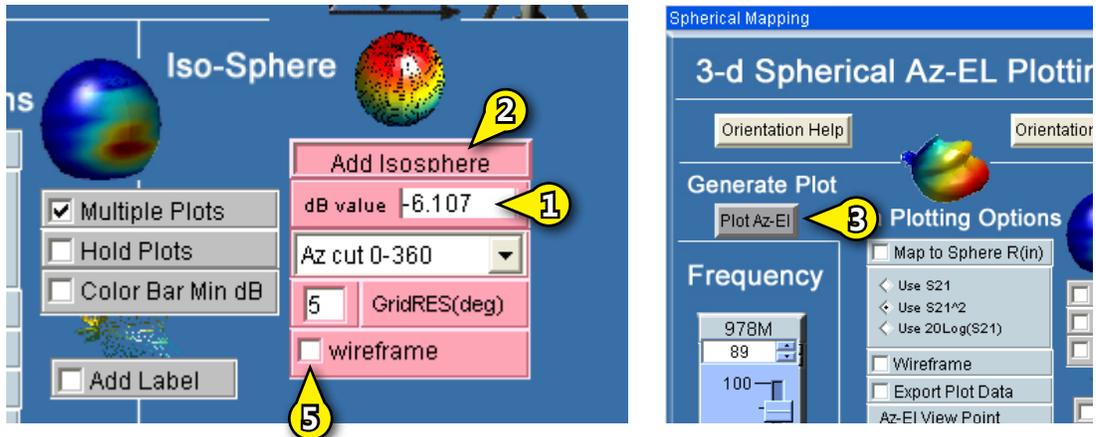


What is this entire page?????



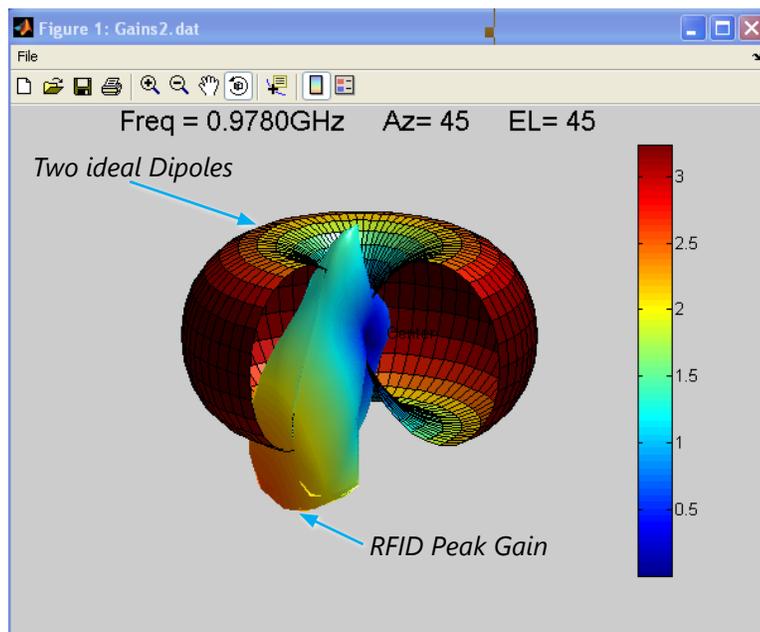
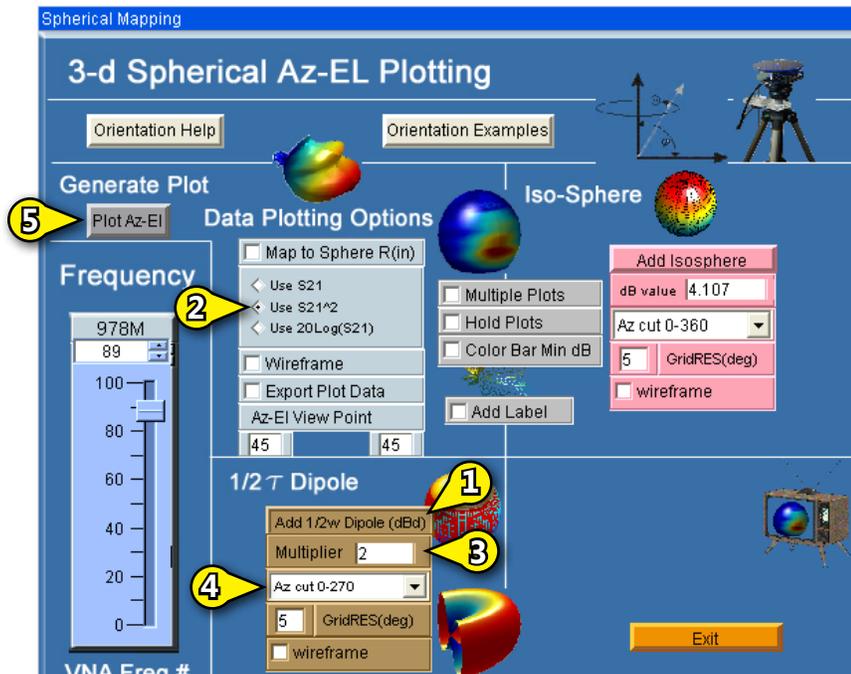
Determine Spherical Areas Less Than 10db Down From Peak

- 1 Spherical plotting displays the Max in the isotropic dB value. Subtract 10 and enter into window.
- 2 Depress "Add Isosphere"
- 3 Click "Plot Az-EL"
- 4 Use rotation to view data
- 5 By clicking wire or no wire multiple plots can be made more visible



Determine the Equivalent Number of Dipoles

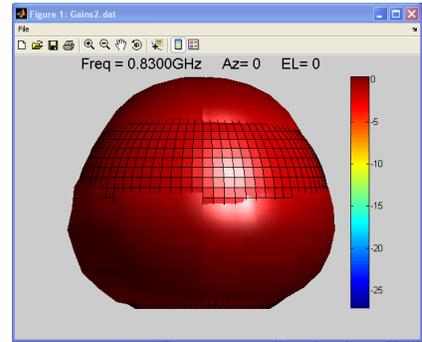
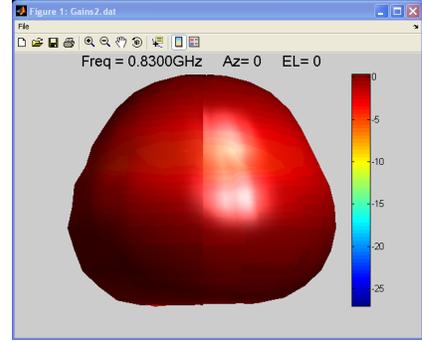
- 1 Depress "Add 1/2w Dipole"
 - 2 Check S_{21}^2
 - 3 Increase multiplier until dipole gain $\sim ABS(G_{max})$
 - 4 Select 3/4 dipole (with no wireframe)
 - 5 Click "Plot Az-El"
- TIP:** By clicking wire or no wire multiple plots can be made more visible



Determine the ABS(E)-3dB Compliance at 830MHz

1. Recall the ABS(E) data REG3 **How?**
2. Check "Use 20Log(s21)
3. Check "Multiple Plots"
4. Set slider to 830MHz
5. Click "Plot Az-El" to plot spherical. (Peak gain should appear in the "Add Isosphere" window, as shown to right.[?])
6. Press "Add Isosphere"
7. Subtract 3 from peak gain. May be performed in Add Isosphere window, (see 5)
What?? Wrong number???
8. Click "Plot Az-El" (see 5)

TIP: Every spherical max is set in Isosphere window



3-d Spherical Az-EL Plotting

Orientation Help

Orientation Examples

Generate Plot

Plot Az-El 5

Iso-Sphere

Add Isosphere 6

Frequency

830M

15 2

100

80

60

40

20

0 4

VNA Freq #

Set From PolarPlot

Camlight

On Off

Data Plotting Options

Map to Sphere R(in)

Use S21 3

Use S21^2

Use 20Log(S21)

Wireframe

Export Plot Data

Az-El View Point

0 0

Add Label

Add Isosphere

dB value 0.3741

Az cut 0-360

5 GridRES(deg)

wireframe

1/2 λ Dipole

Add 1/2w Dipole (dBd)

Multiplier 1

Az cut 0-360

5 GridRES(deg)

wireframe

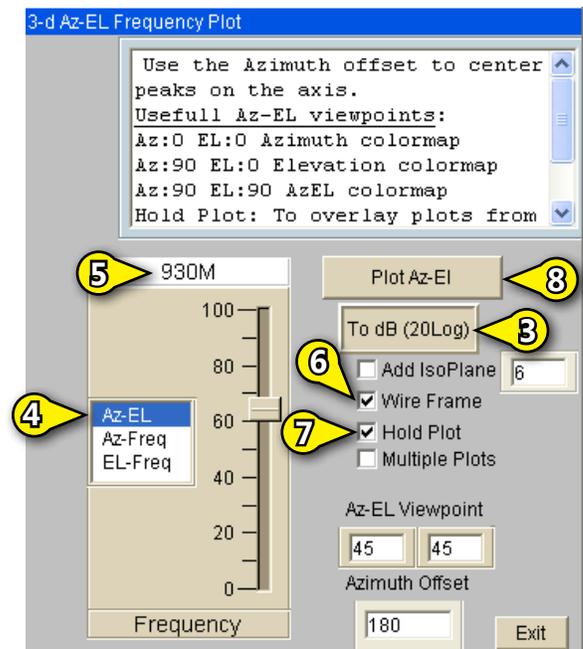
Exit

IMPORTANT

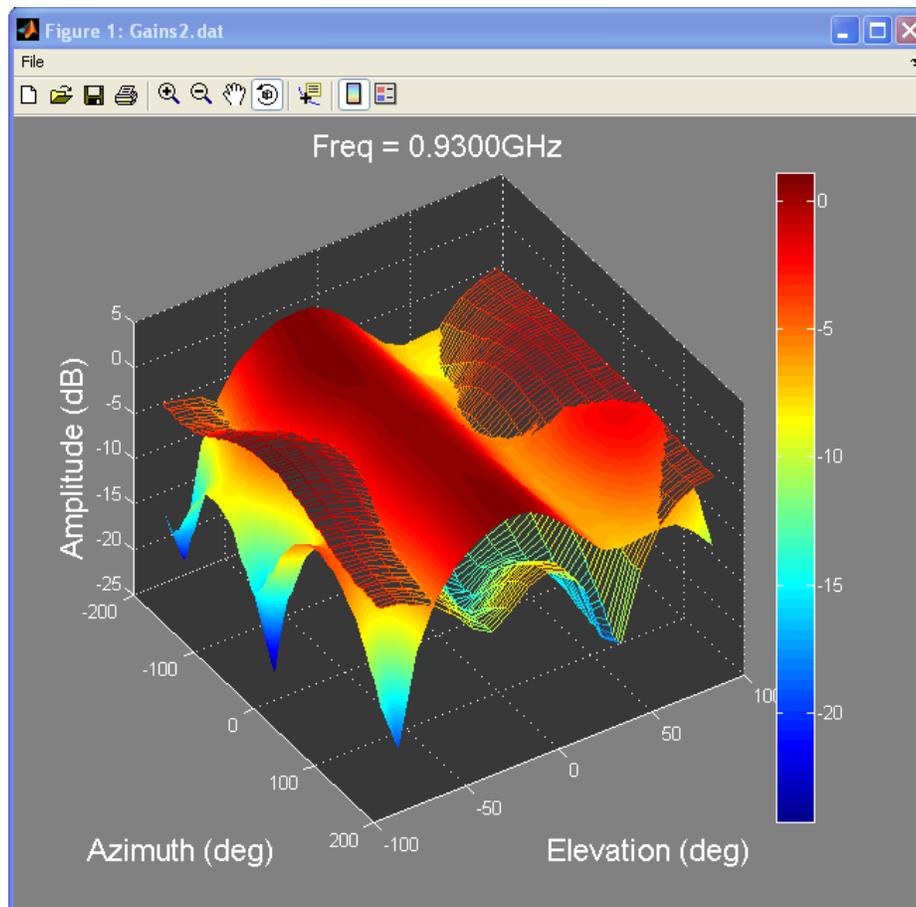
Mapping linear coordinates to spherical coordinates has some special considerations.

Overlay G(theta) and G(phi) AzEL Gain at 930MHz

1. Recall the GQ data from REG1 **How?**
2. Invoke the AzEL 3d plot **How?**
3. Click "To dB (20Log)"
4. Select "Az-EL"
5. Set frequency to 930MHz
6. Check "Wire Frame"
7. Check "Hold Plot"
8. Plot the data
9. Recall the GF data (REG2) **How?**
10. Uncheck "Wire Frame" and plot the data once again, (see 8).



TIP: You can use "Add Isoplane" to determine spec limits and beam widths



Color Plot of Az vs EL at 930MHz

1. Make a color graph of the AzEL plane. **How?**
2. Select Az-EL
3. With the previous plot present, change the Viewpoint angle to Az=90 EL=90
4. Re-plot the data
5. Use the data reader to click on data values

 **TIP:** The slider will change depending on which plot is selected.

