ECE 585 Microwave Engineering II
Lecture 16 Supplemental Notes

Modeling the Response of a FET Amplifier Using Ansoft Designer

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Consider a simple FET microwave amplifier circuit shown below, designed to include source and load matching circuits producing maximum gain at 4 GHz. This is the circuit discussed in Example 11.3, pp. 602-603 of the Pozar 2/e textbook. We will model the FET as a simple 2-port network whose S-parameters we will supply over the range 2 GHz – 5 GHz. We will call this device "Q1". We use the Designer schematic layout board to add the four distributed transmission lines (including two open-circuit stubs), along with 50 ohm input and output ports. The schematic is shown in Figure 1.

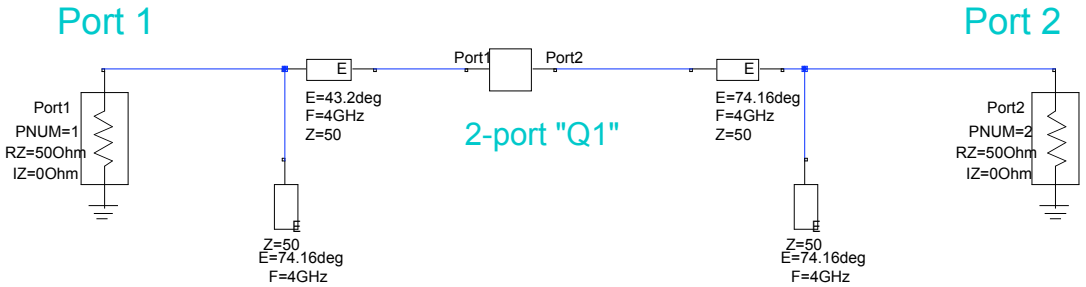
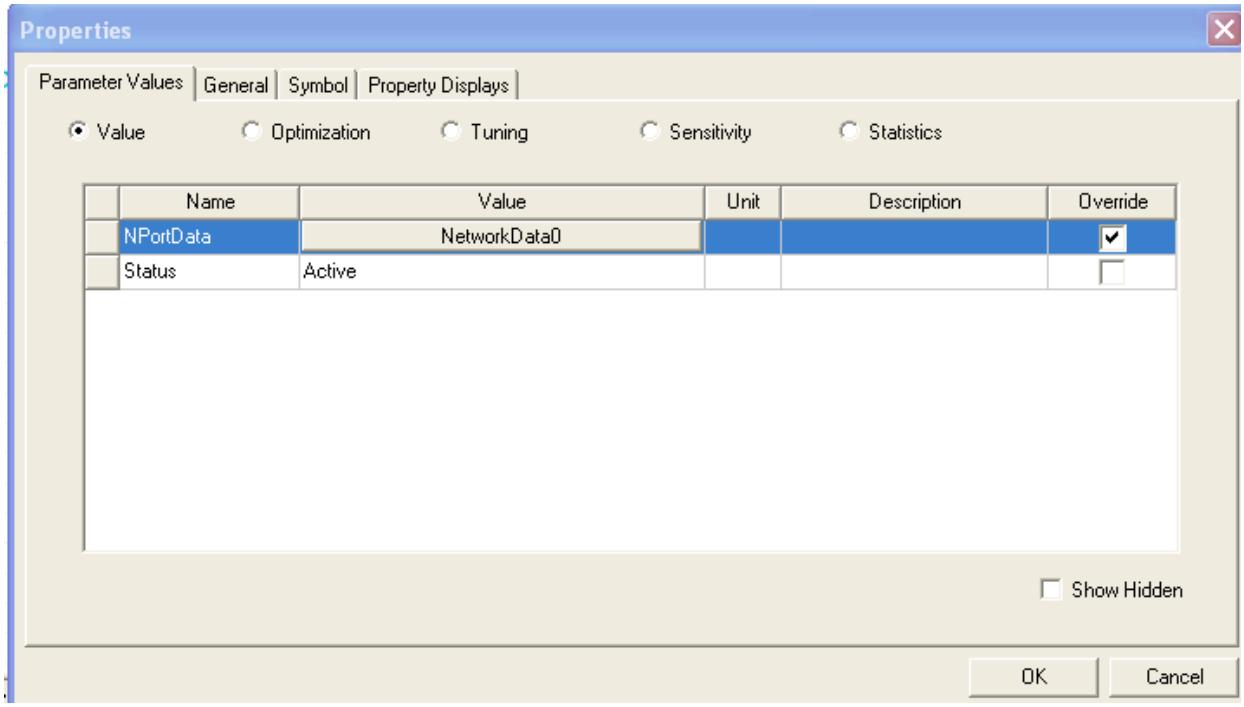


Figure 1. Schematic layout of FET amplifier circuit.

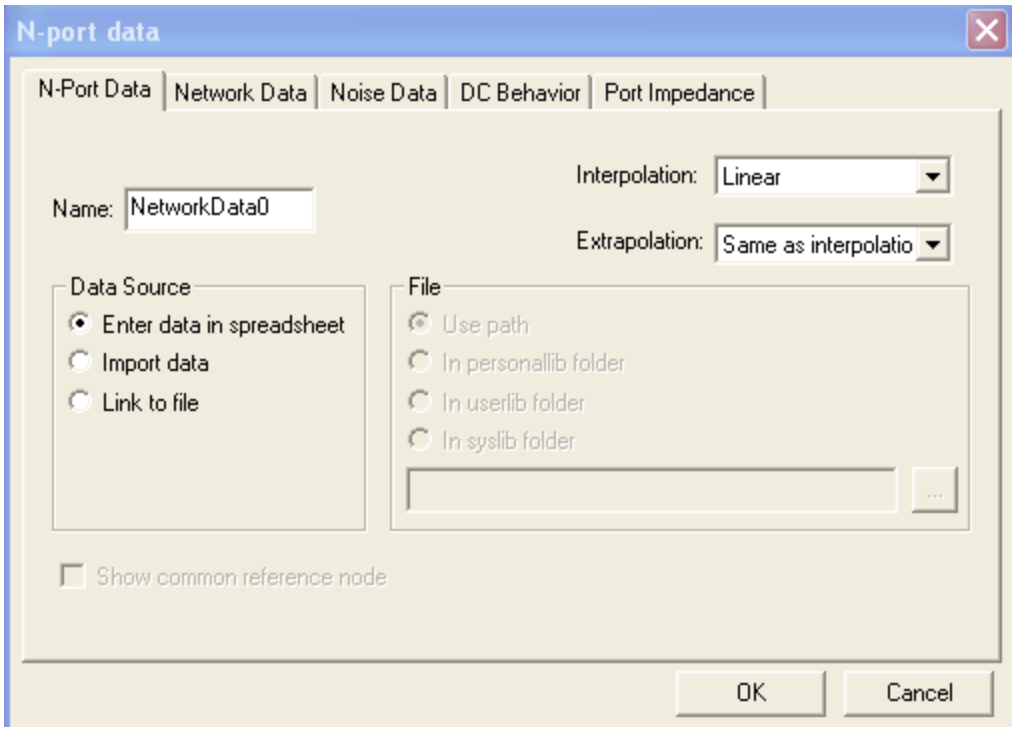
The 2-port network Q1 that represents the FET has the following S-parameters:

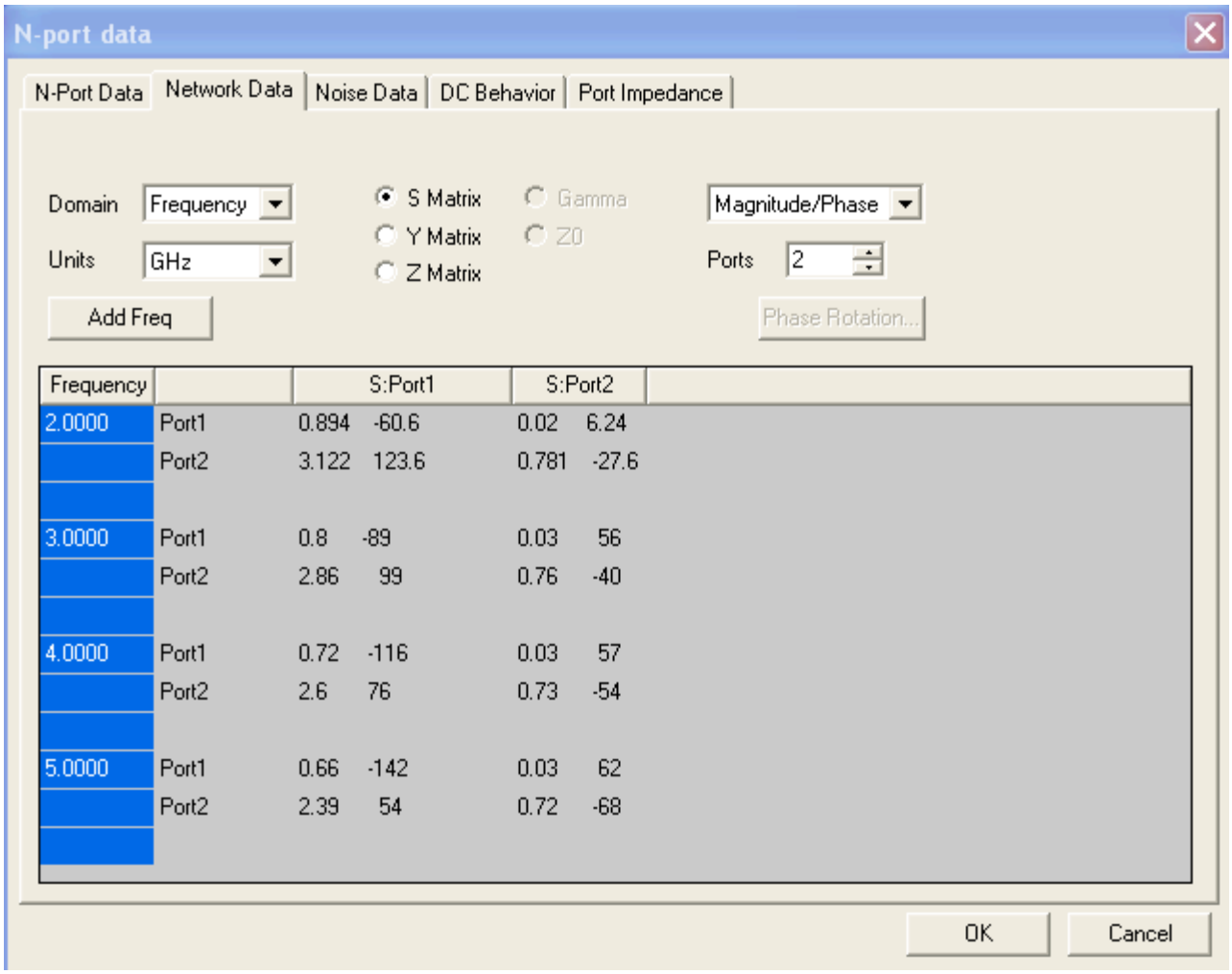
Freq	| S11 |	S11-ph	| S21 |	S21-ph	| S12 |	S12-ph	| S22 |	S22-ph
2 GHz	0.894	-60.6 deg	3.122	123.6 deg	0.02	6.24 deg	0.781	-27.6 deg
3	0.800	-89.0	2.860	99.0	0.03	56.0	0.760	-40.0
4	0.720	-116.0	2.600	76.0	0.03	57.0	0.730	-54.0
5	0.660	-142.0	2.390	54.0	0.03	62.0	0.720	-68.0

To enter the S-parameters into the 2-port FET component, double-click on the 2-port symbol to open its properties box:



To enter the Network Data for this 2-port, double-click on the Value "NetworkData0" to open the N-port data box. We see that the name of this data set is NetworkData0, which we will leave unchanged. We also will accept the Linear Interpolation. We want to enter the data in a spreadsheet format, so accept that choice, and click on the Network Data tab:



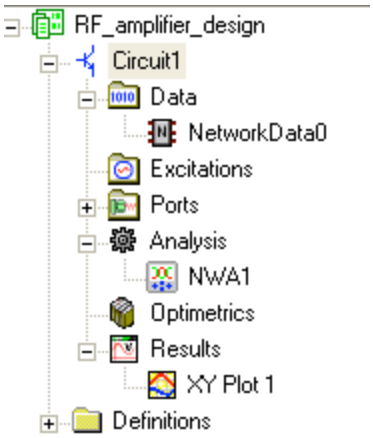


In this box, set the Domain to Frequency and the Units to GHz. We will enter the Magnitude/Phase of S11, S21, S12, and S22 for each frequency. Under the Frequency column, enter 2.0. For the Port 1 row, under S:Port 1, enter the value 0.894, -60.6 then hit Enter. Note that we're entering the magnitude followed by a comma, followed by the phase in degrees of S11. The next column (under S:Port 2) is S12, and we follow the same procedure. The next row down (Port 2) enter S21 (3.122, 123.6), then S22.

Now click on Add Freq., and manually type in 3.00 (GHz) and continue this process until the Sij parameters are all added at 2,3, 4 and 5 GHz. The formatting shown above will not be displayed until you click on OK, and re-open this dialog box.

We have now characterized the 2-port FET's scattering parameter behavior, and are next ready to set the frequency range for the analysis.

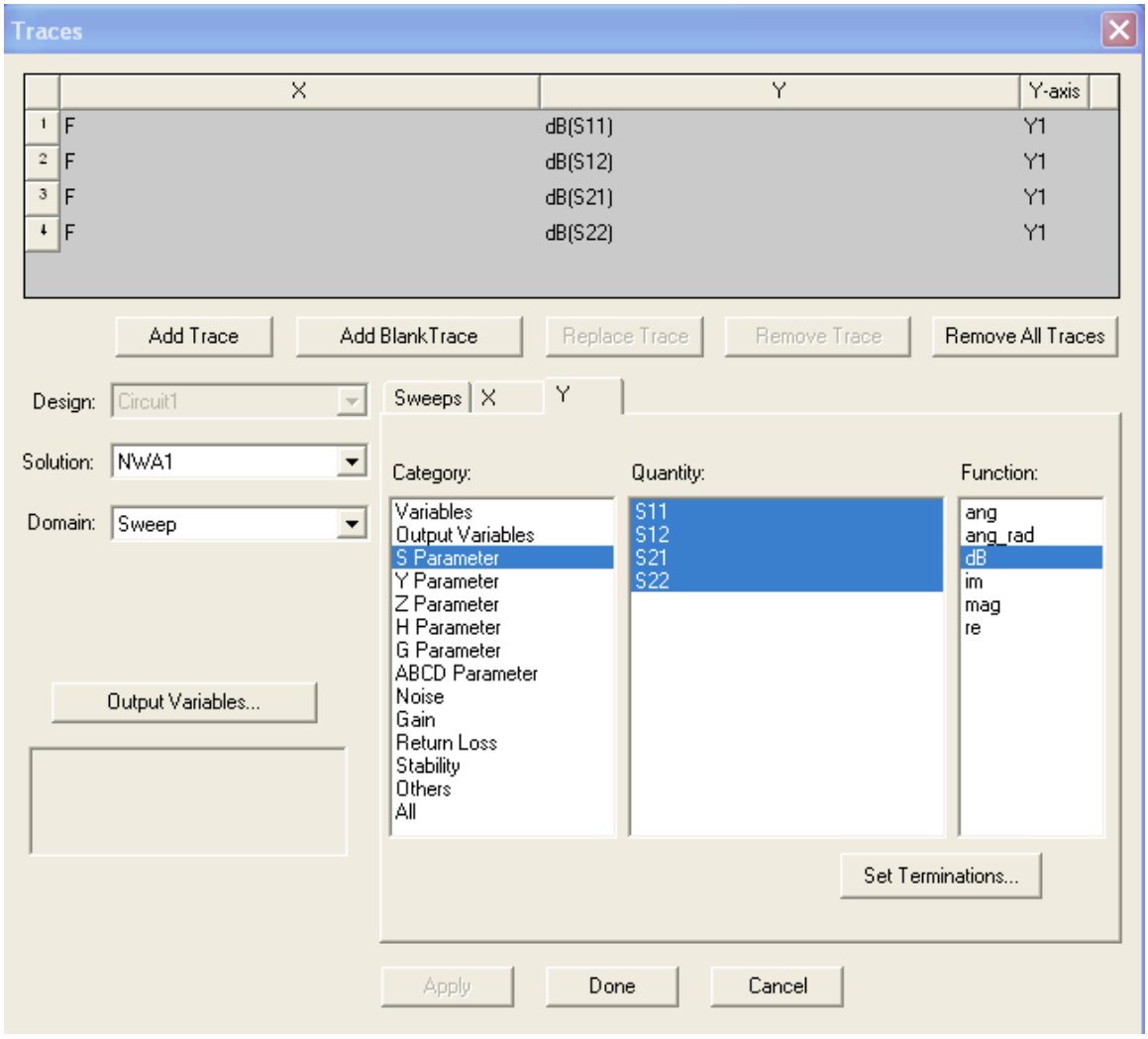
Under the Project management window



We now set up a linear analysis NWA1. Right-click on Analysis, and set up the frequency sweep from 2 GHz to 5 GHz with 10 MHz steps. (Later we will change the steps to 100 kHz for setting data markers.)

We can now ask Designer to analyze the circuit. Right-click on Analysis again and choose "Start Analysis."

To see the results, right-click on Results and choose Create Report. You will get a Create Report dialog box. Accept the default settings and click on OK. The following screen appears:



Select all the Sij parameters (dB), click on Add Trace to add the four traces for display, then click on Done.

You will obtain an XY plot of S11 (return loss), S21 (insertion gain), S12 and S22. Edit the vertical axis scale to range from –60 dB to 20 dB with 10 dB major divisions. Right-click on the plot to enter labels S11, S22, and S21 for the three lines. Also use the data marker mode (right-click) to click on the peak value of S21 at 4.0 GHz. This indicates a maximum gain (S21) of 16.71 dB for the amplifier circuit, as shown in Figure 2.

Next we wish to make a separate plot of the transducer gain (GT) for the amplifier. In the dialog box above, under Category, choose Gain, then GT, Add Trace, then Done. Adjust the Y-axis so the gain plot ranges from -20 dB to +20 dB. Place a marker at the peak, e.g. 16.7 dB at 4.0 GHz, and two additional markers at 3 dB below this[1]. By looking at the graph of Figure 3, we can see that the 3 dB bandwidth is about 240 MHz.

[1] To get good resolution in setting data markers, change the NWA1 sweep delta-F to 100 kHz, and have Designer re-analyze the circuit.

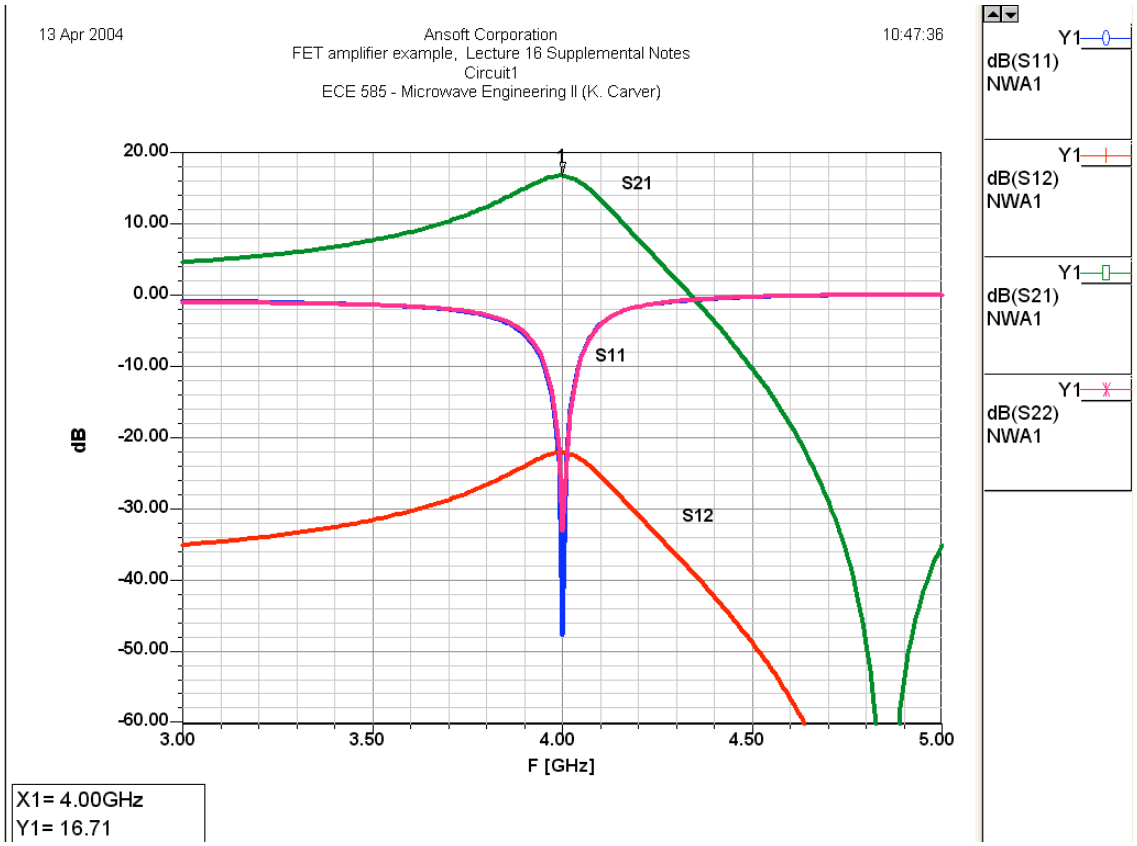


Figure 2. S11, S22, S12, S21 for Designer-simulated FET amplifier.

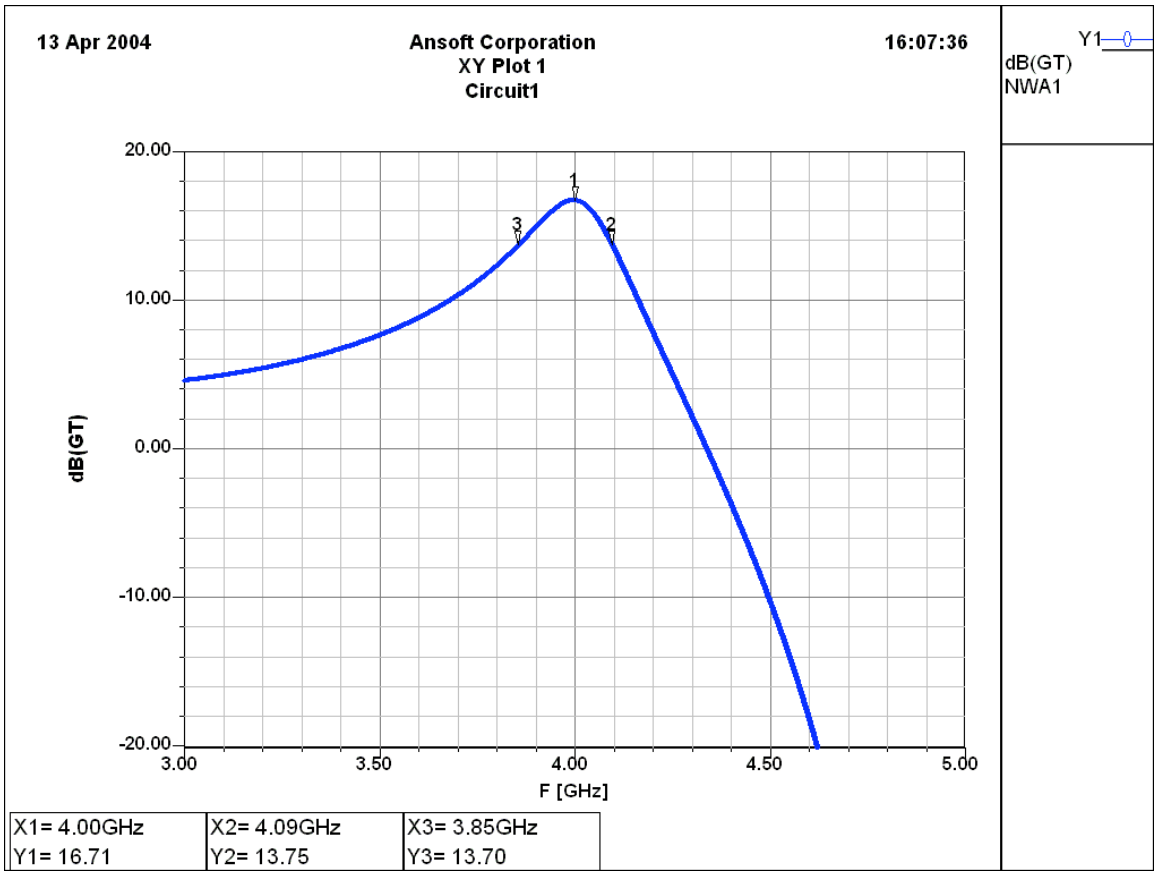


Figure 3. Transducer gain GT response for FET amplifier. Markers 2 and 3 indicate the -3 dB bandwidth points 3.85 GHz and 4.09 GHz.