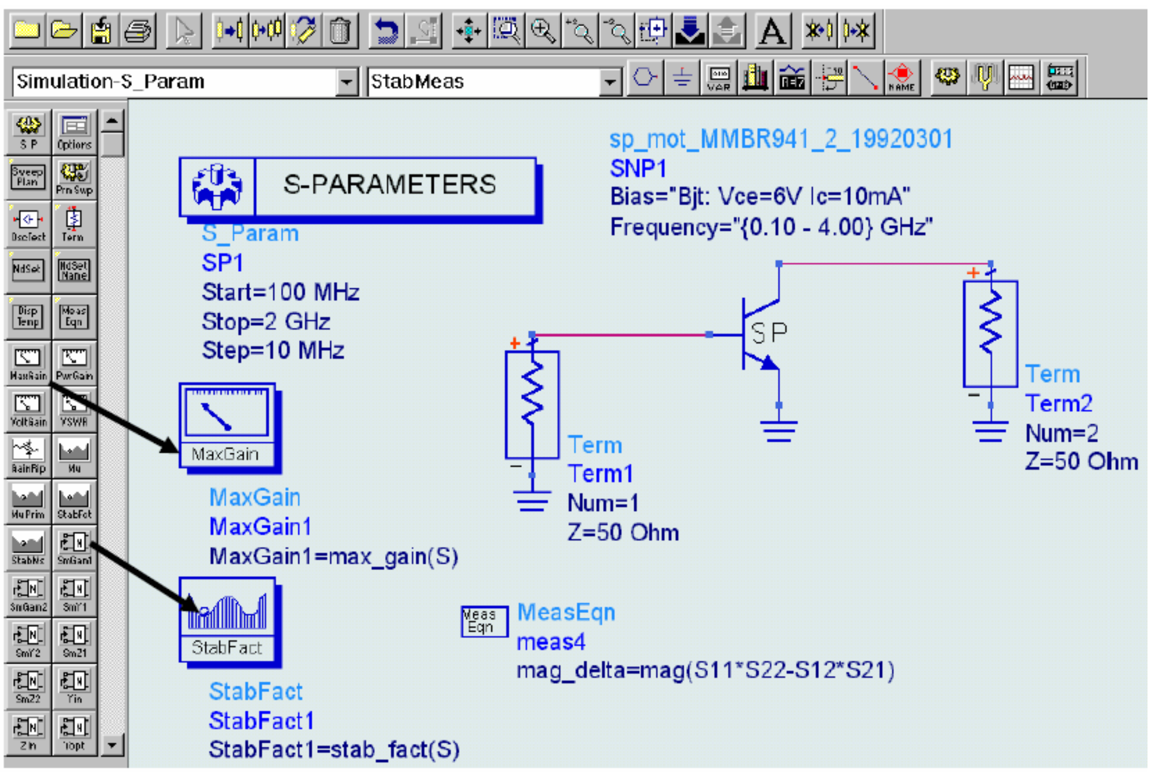
ADS TUTORIAL

STABILITY and GAIN CIRCLES

The first step in designing the amplifier with the S parameter method is to determine whether the transistor is unconditionally stable or potentially unstable. This can be easily estimated using the K stability factor and delta. The amplifier will be unconditionally stable if:

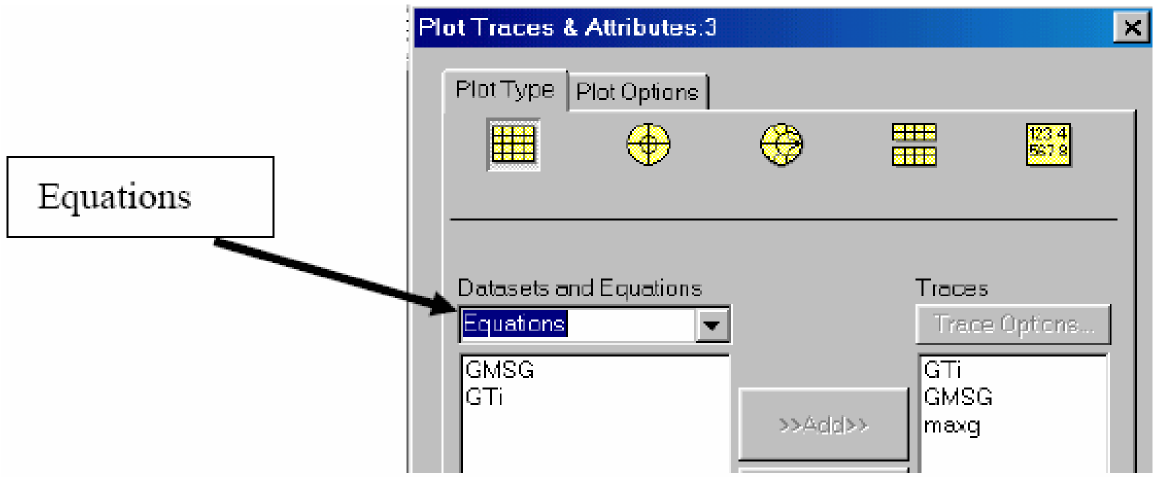
$$K > 1 \text{ and } mag(\Delta) < 1.$$

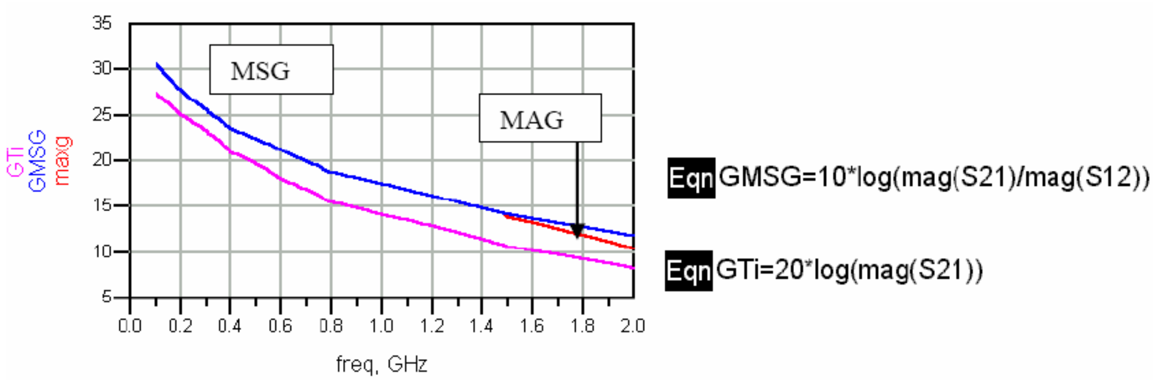
These factors are easily calculated using Measurement Equations in the ADS schematic panel. K is pre-programmed in as StabFact which can be selected from the S-parameter palette on the left. Delta can be programmed yourself using a blank MeasEqn. The maximum available gain (MAG) and maximum stable gain (MSG) can also be calculated using the MaxGain function.

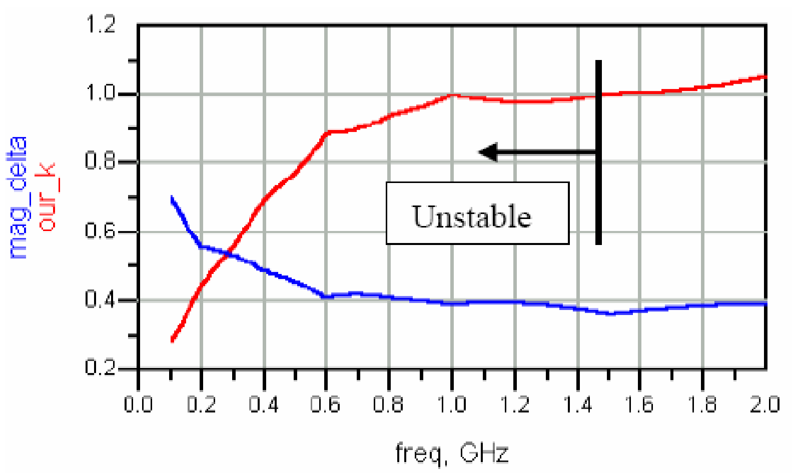


When swept over a range of frequencies, it can be clearly seen where the device will be unconditionally stable. Note that the user-defined equation capability of the display panel can be used to also calculate and plot MSG and the intrinsic transducer gain, Gti, the transducer gain when both Γ_S and $\Gamma_L = 0$. In the regions where $K < 1$, the max_gain function plots MSG. When unconditionally stable, it plots MAG.

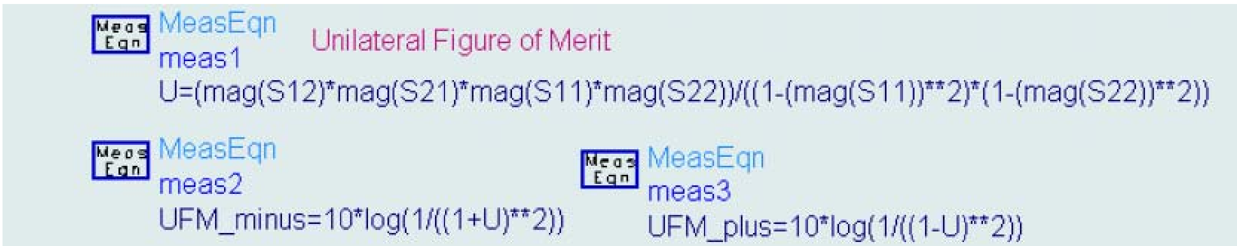
When you want to plot from your user-defined equations, you need to select the equations dataset in the plotting panel.







Next, you could check to see if the device is unilateral. Evaluate the Unilateral Figure of Merit, U, at the design frequency using a Measurement Equation.



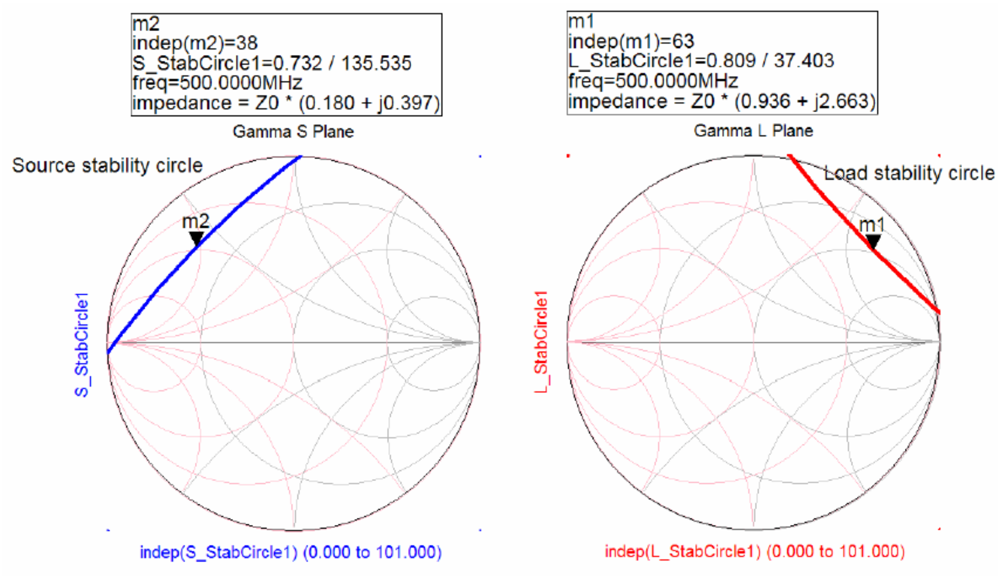
Bilateral design. If the device is unconditionally stable at the design frequency, then the input and output can be conjugately matched and the maximum available gain can be obtained. Γ_{MS} and Γ_{ML} can be determined uniquely. The input and output VSWR would = 1 in this case. This would be applicable for this device in the region where K > 1. The conjugate match reflection coefficients can be calculated on ADS using the Smgam1 and Smgam2 measurement equation icons in the S-parameter palette.

However, at 500 MHz, we find that K = 0.75. We must take into account stability as well as gain. It is wise to design the amplifier for less than the maximum stable gain, MSG, to allow margin for stability. We have 2 choices on how to proceed with the design.

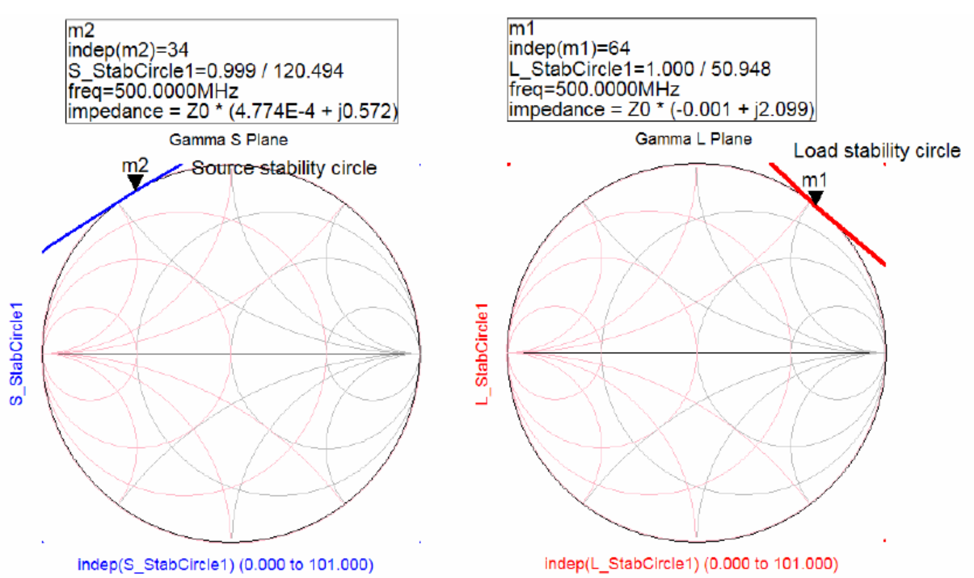
1. We could continue with the design for a bilateral amplifier if the source and load plane stability circles do not contain Γ_S or Γ_L. This is possible only if we can meet the required gain specifications while still avoiding the unstable regions.

2. We could add stabilization resistors to the device to force unconditional stability. Then, we would be less constrained in our choices of Γ_S or Γ_L, but if we over-stabilize the device, we may again find that we can't meet the required gain specifications.

So, let's look at the device first for stability. Stability circles should be calculated. This is done by using the LStabCircle and SStabCircle functions.



Examining the stability circles, we see that it would be relatively easy to resistively stabilize this transistor and make it unconditionally stable at 500 MHz. A series resistance of 0.18(50) = 9Ω at the input or a shunt resistor of 1/(0.117*0.02) = 430 Ω at the output will push the source or load circles outside the Smith chart at this frequency. Of course, after designing the matching networks, we must check the amplifier later over a wider frequency range for stability. We might need to modify the stabilization approach, but if resistance is included in the matching network appropriately, it is often possible to improve stability without sacrificing gain at the design frequency.So, let's take approach #2 and see how effective a shunt 430 ohm resistor on the output of the transistor will be. From the figure below, we see that it provides stability on the load plane and nearly unconditional stability on the source plane (again, remember, this is at a single frequency).



Now, we can proceed with designing the input and output matching networks. In the bilateral case, we need a systematic design method, because changes in Γ_S will affect Γ_{OUT} and changes in Γ_L will affect Γ_{IN}.