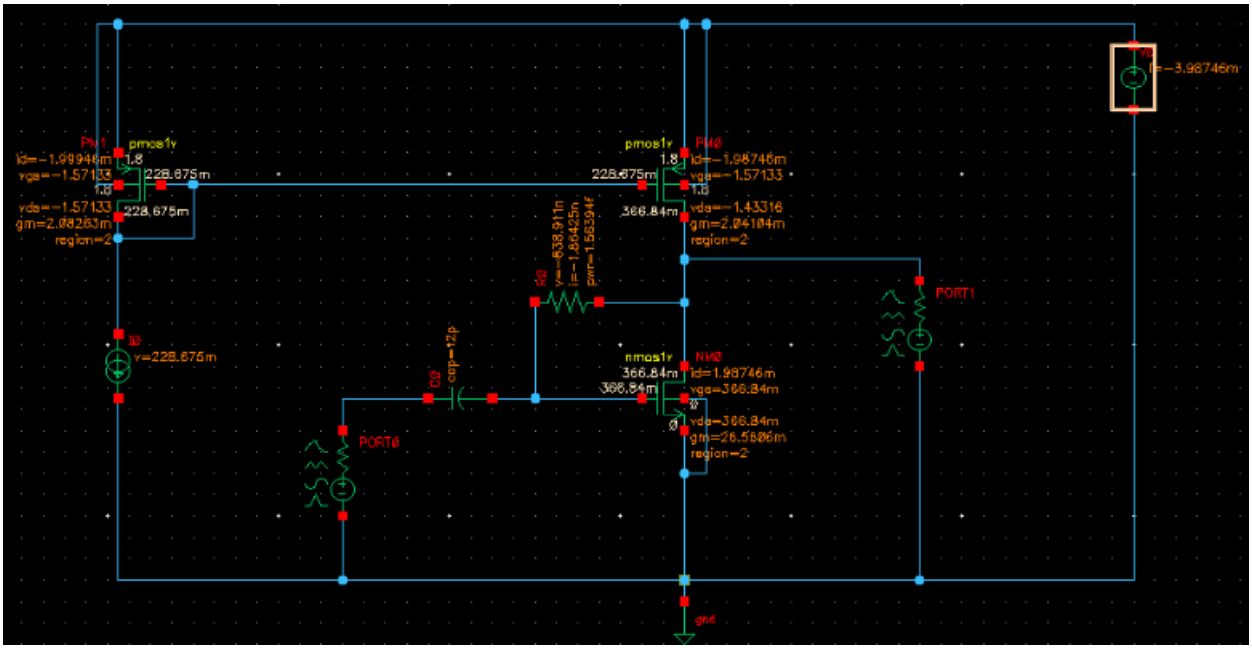
Lab #4
Low Noise Amplifier (LNA)

In this lab you will simulate a CS LNA with resistive feedback and measure its Gain, stability, NF, S11, and IP3.

Begin by drawing the circuit schematic as shown in the following figure.

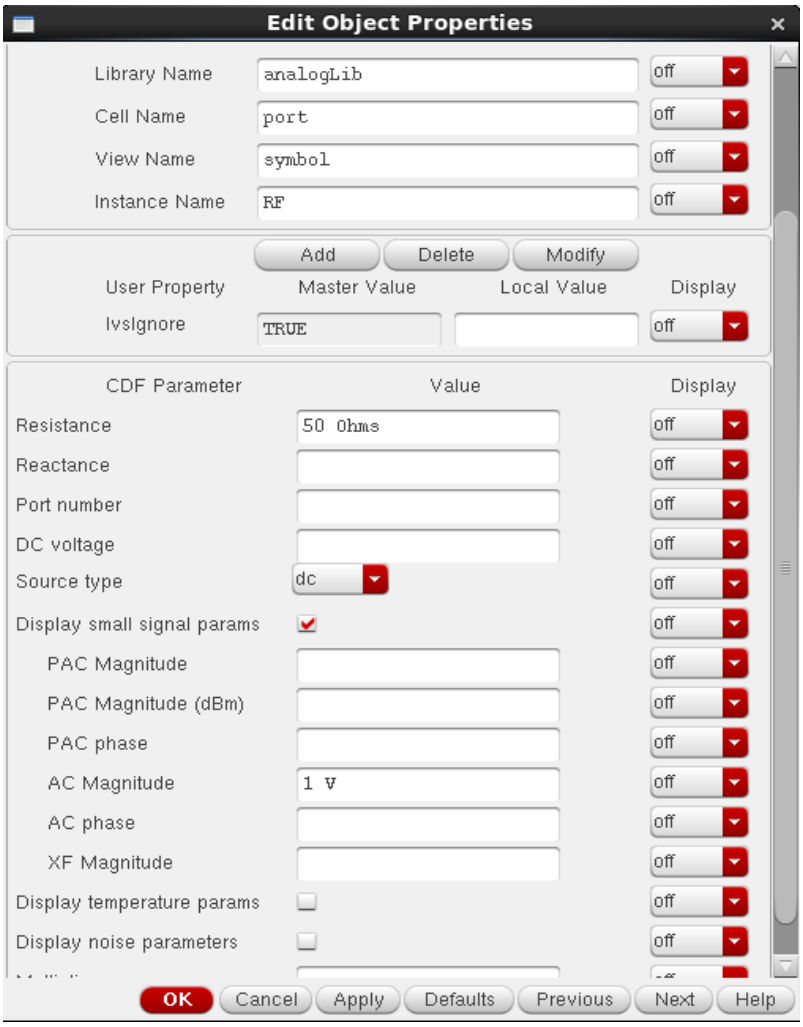


- **VDD = 1.8 v.**
- **Idc = 2 mA.**
- **C1 = 12 p F.**
- **RF = 450 Ω**
- **Nmos 1v** transistor has **N= 3, W =30µm** and **L = 130nm**.
- **Pmos 1v** transistors have **W = 15µm** and **L = 600nm**.

Part (A):

For Gain, NF, S11 and Kf simulations:

- Set the properties of the **In port** as below:



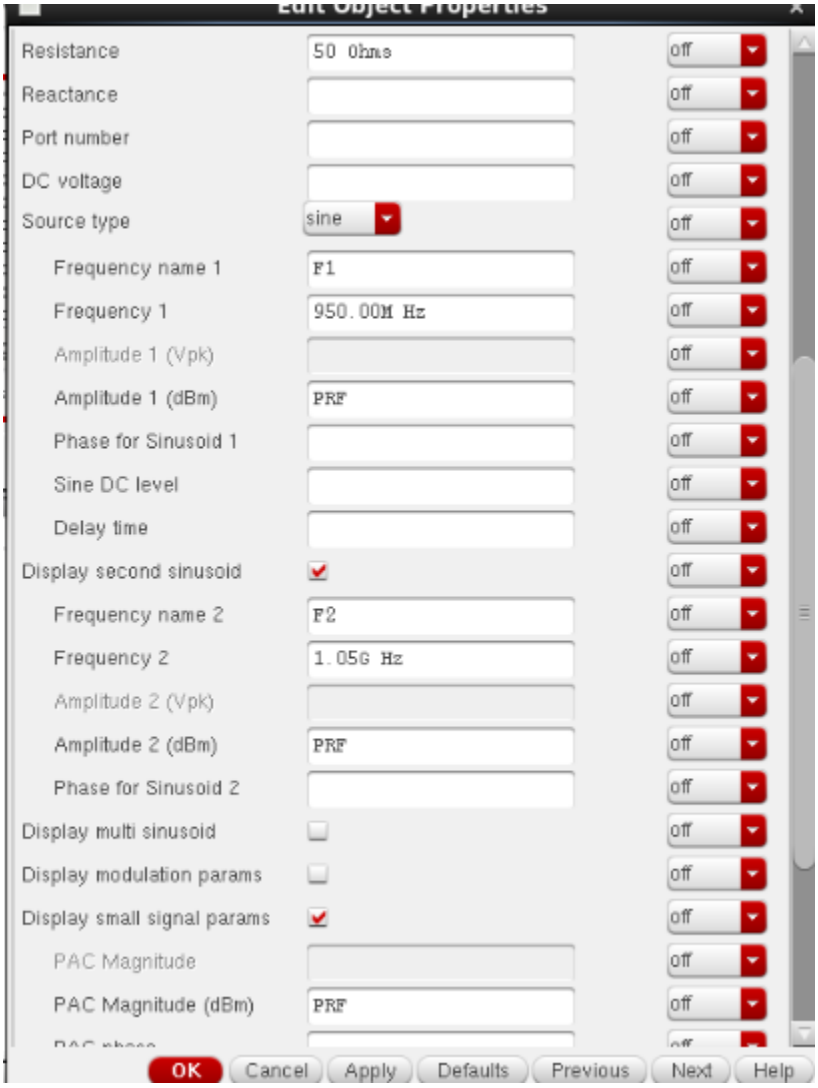
- Set the type of **Load port** same as **In port** but make its resistance very large (1G ohms for example) and leave **AC magnitude** blank.
- Save your schematic.

Q1) Follow the same steps as given in the previous lab tutorials to simulate the gain, NF, S11 and Kf (stability factor) versus frequency (from 100MHz to 3GHz). Comment on the results.

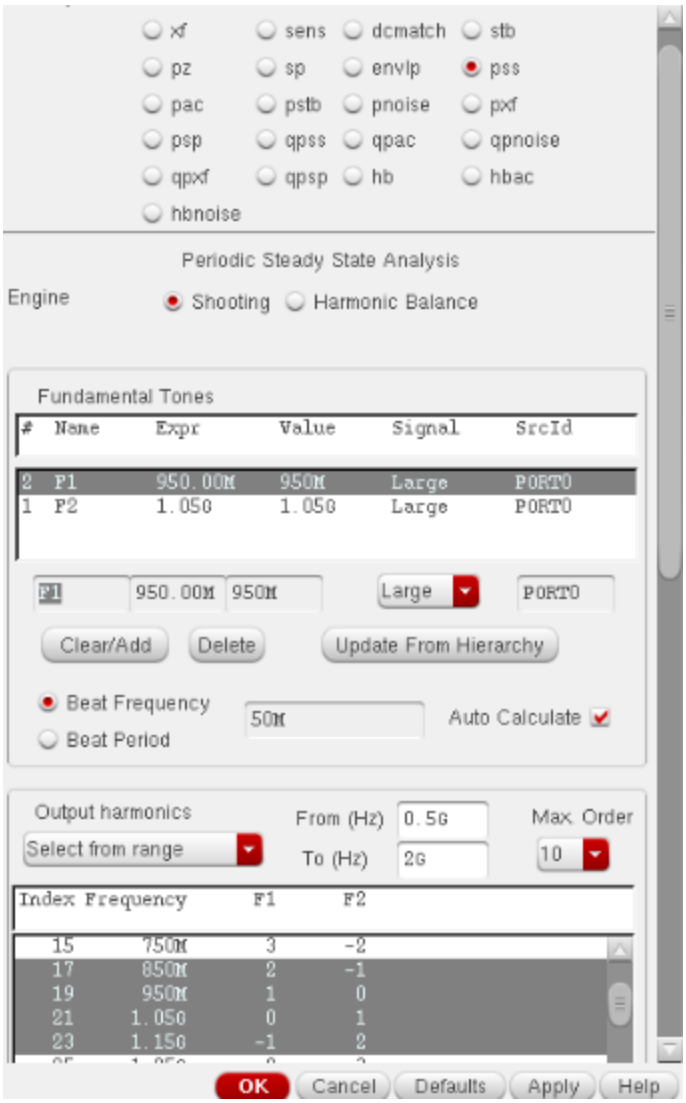
Part (B):

For IP3 simulations:

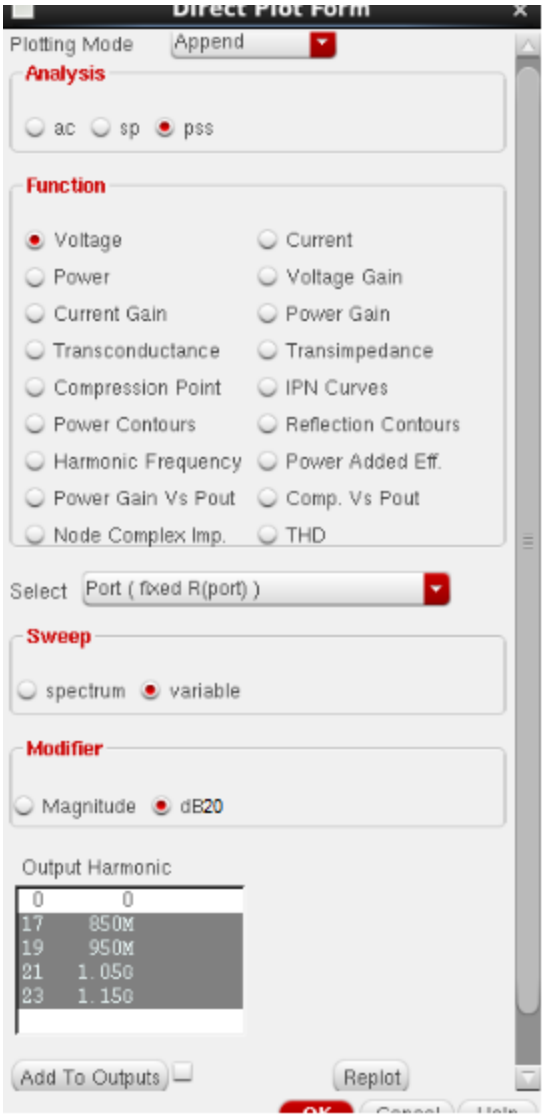
- Set the properties of the **In port** as below to do the 2 tone test for checking linearity of the LNA:



- Leave the properties of **Load** port unchanged.
- Save your schematic.
- Set up the PSS analysis as shown below.



- Run the simulation.
- Choose Results → Direct plot → PSS.
- Set up the pss simulation results setup as below.

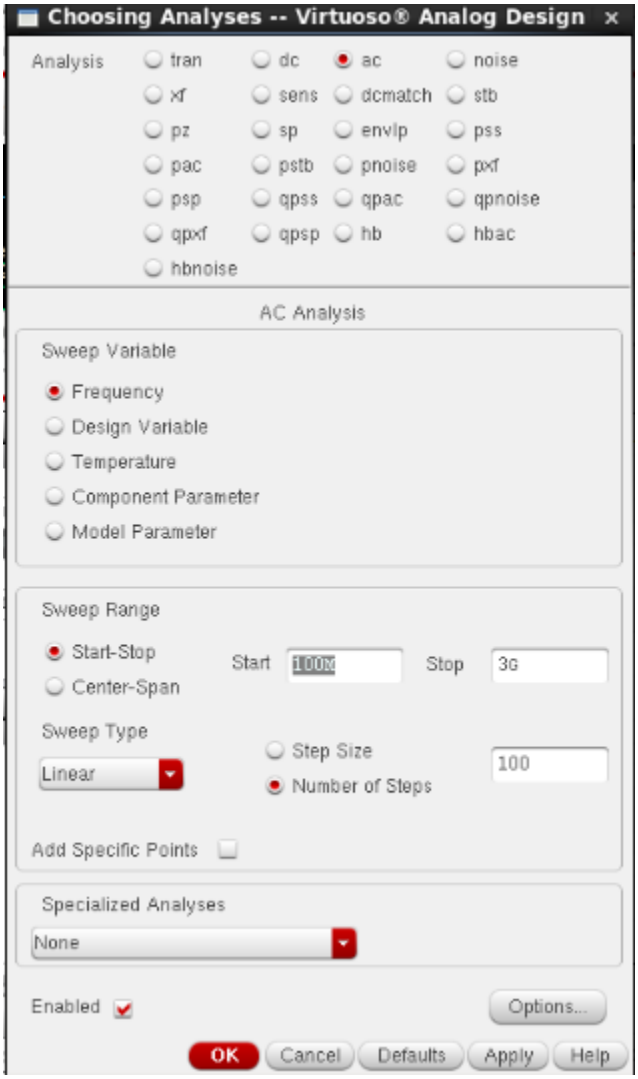


Then calculate IIP3 for the LNA graphically.

Appendix:

For gain simulation:

1) Go to the ADE and modify the ac analysis to be according to the following figure.

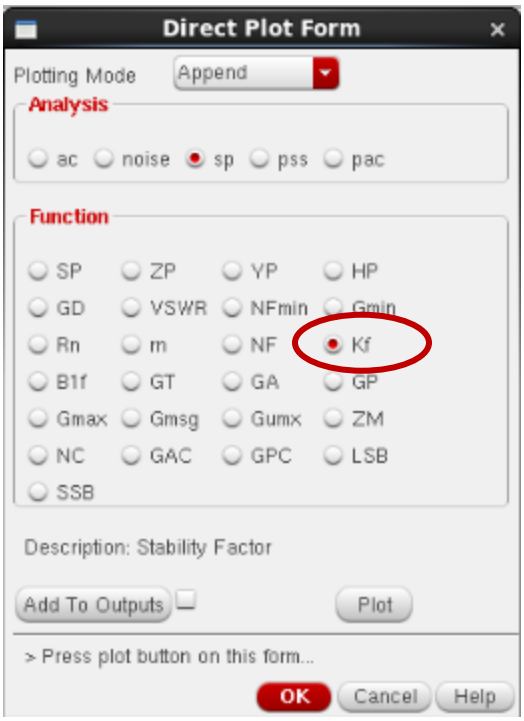


2) Then run the simulation.
3) Go to the Main form and plot the Voltage as dB20 as shown.

Q. Comment on your results. Comment on the results after adding a capacitor at the output equals 100fF.

For Stability simulation:

Plot "**Kf**", you will find it in the function field as shown.



"**Kf**" represents K factor, which is very important to measure stability, Kf is a formula driven from S parameters to guarantee stability and the formula is given by:

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|}$$

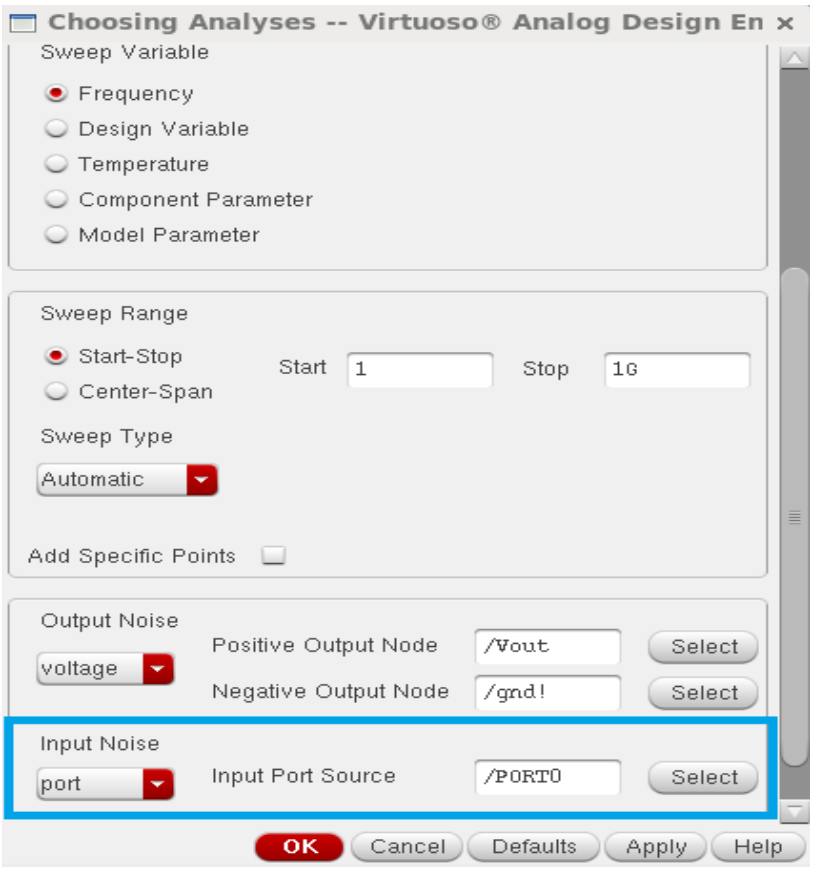
Where Δ is the determinant of the S matrix
The important thing to know for stability is that:

Kf > 1 and |B1f| < 1 → System is unconditionally stable

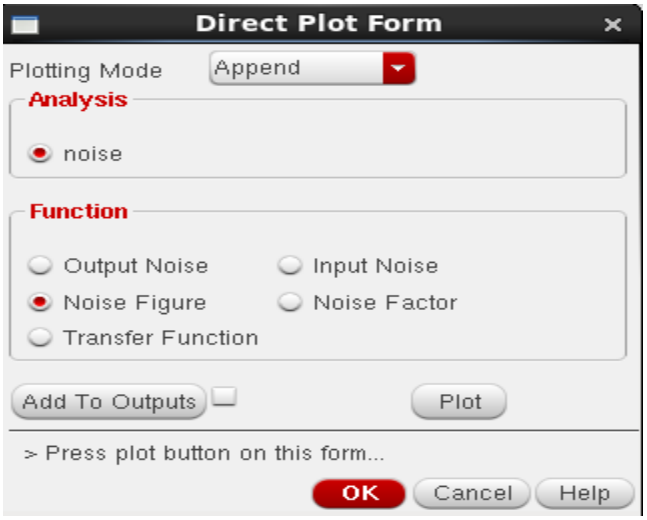
Kf < 1 or |B1f| > 1 → System isn't guaranteed to be stable (it can be unstable under certain source or load conditions)

For Noise analysis:

4) Go to the ADE and modify the noise analysis to be according to the following figure.

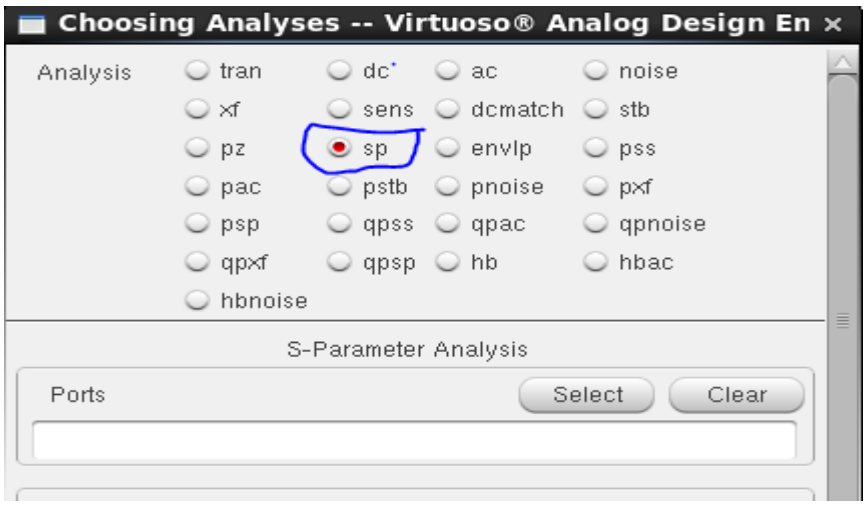


5) Then run the simulation.
6) Go to the Main form and plot the NF as shown.

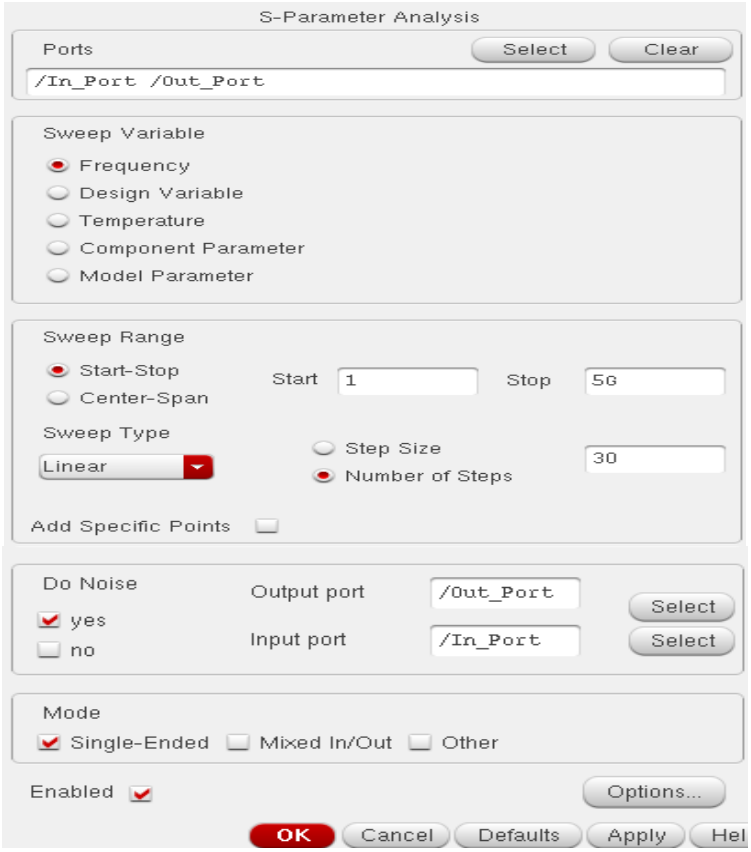


For S-Parameters simulations:

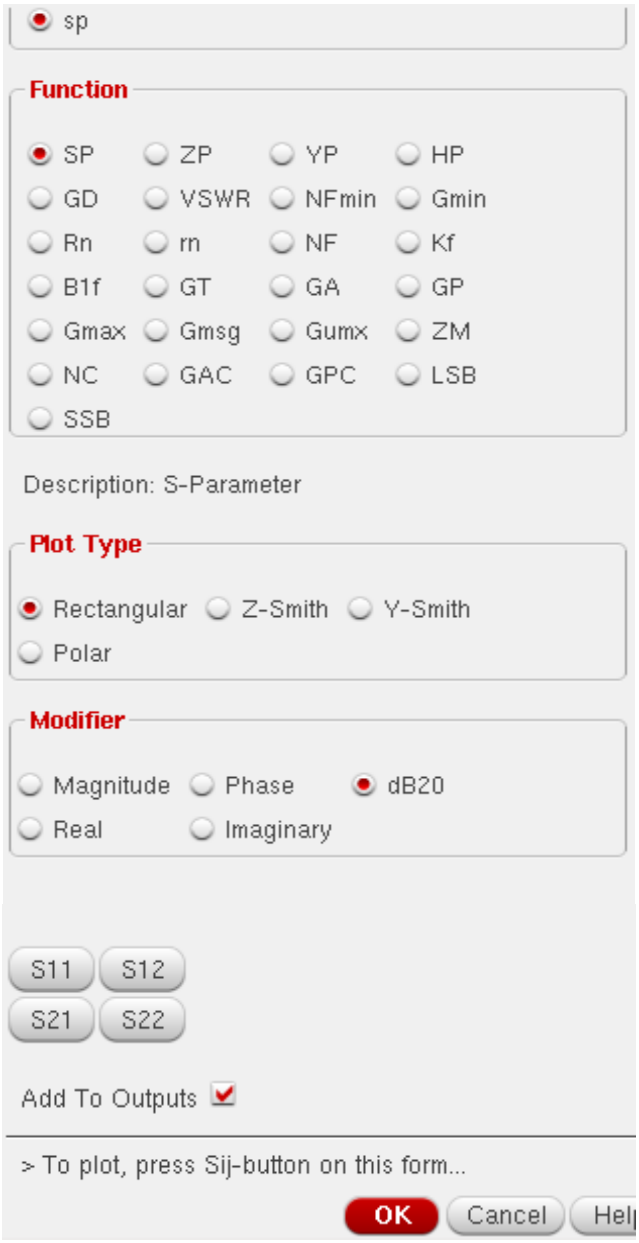
1) Now choose "**sp**" analysis, which is scattering parameters as shown in the figure.



2) Now adjust the sp analysis as shown in the following figure.
   - First: In "**Ports**": select In_Port, then select Out_Port
   - Check the check box in "**Do Noise**", then select Out_Port, then In_Port as shown in the figure.



3) Press ok, then run simulation.
4) Go to the Main Form and do as the following:



5) Make sure to make **Modifier in dB20**.
6) Press on **S11** at the bottom.