5XTC0, Components in wireless technologies

Module 6: Lab amplifier measurements

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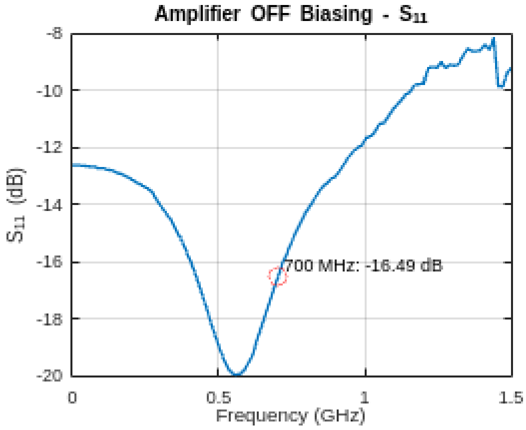
Measurements lab 6:

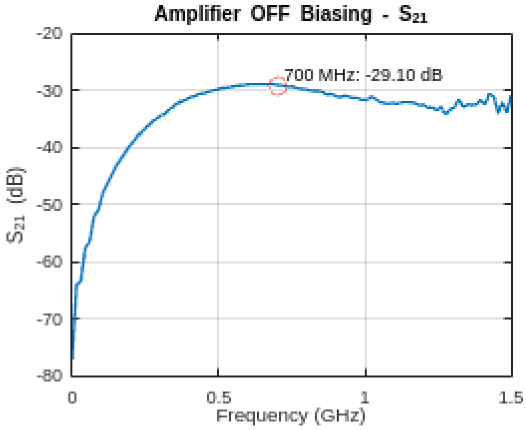
Follow the steps from the slides to measure the S-parameters from 50kHz till 1.5GHz for the 5XTC0_V2 amplifier board with the NanoVNA.

1. No biasing applied:

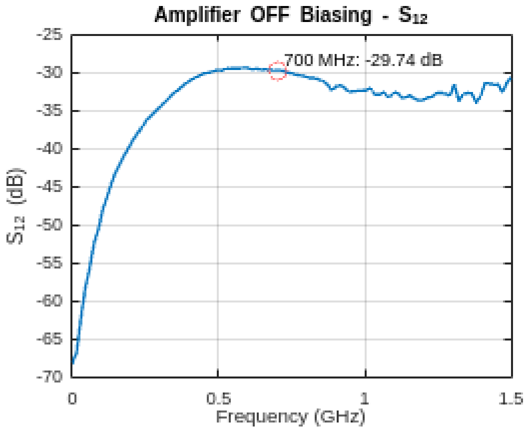
S11 plot:



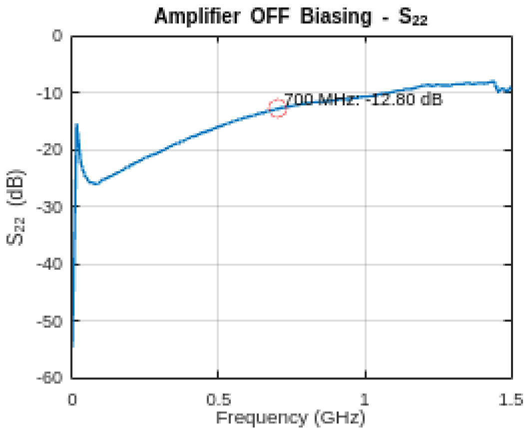
S21 plot:



S12 plot:

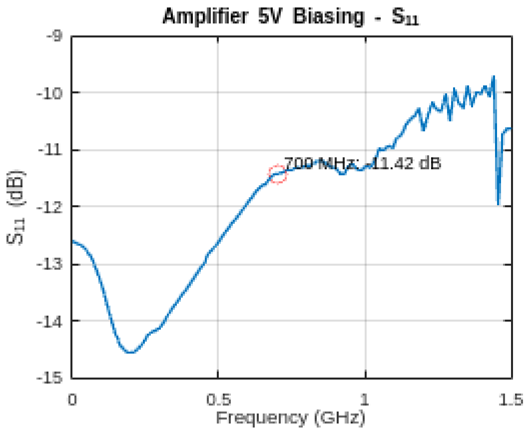


S22 plot:

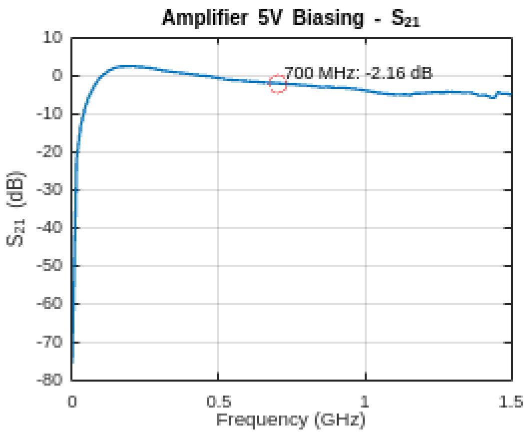


2. 5V/85mA biasing applied:

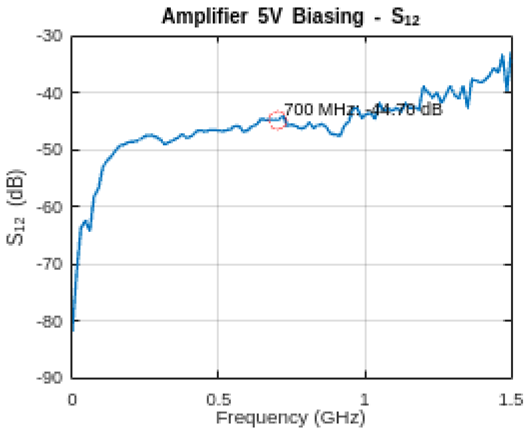
S11 plot:



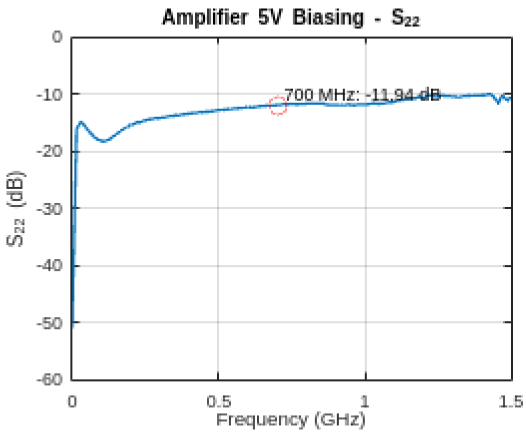
S21 plot:



S12 plot:

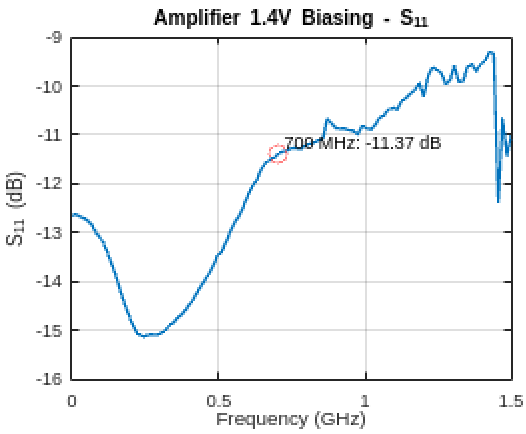


S22 plot:

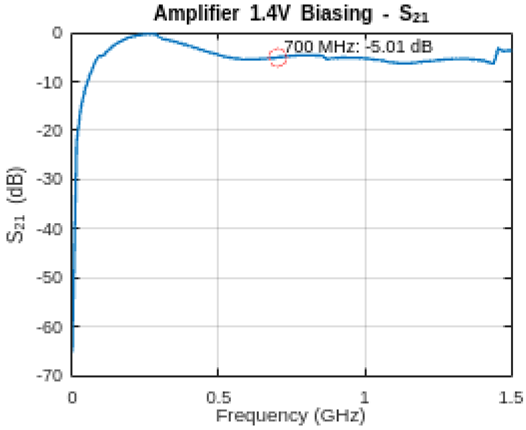


3. 1.4V/20mA biasing applied:

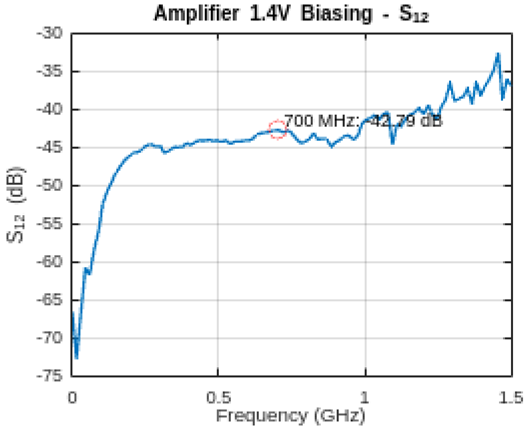
S11 plot:



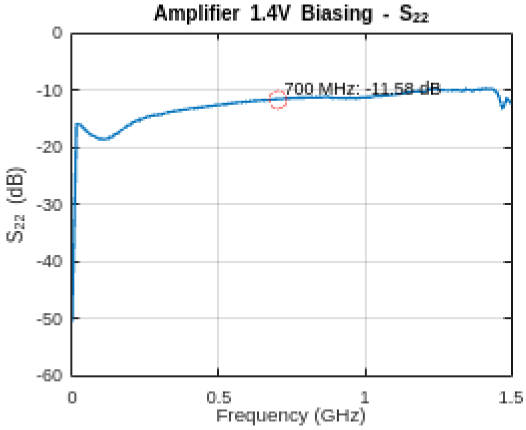
S21 plot:



S12 plot:



S22 plot:



Assignments lab 6:

1. Look at the S-parameters you have measured with 5V and 85mA biasing. Do they match the simulated s-parameters in QUCS? Can you explain the difference?
   The measured S-parameters with 5V/85mA biasing generally follow the same trend as the QUCS simulations, but the exact values differ.

   S11 and S22: Both show greater reflection in the measurements compared to simulation (up to ~4–7 dB difference), likely due to component tolerances, PCB parasitic, connector losses, or calibration errors.

   S21: The measured gain is not close to simulation it's about a scale of 10x worse; it also seems to become worse with higher frequency (possibly due to VNA error or mismatch).

   S12: Matches well in the difference of 1dB but highly distorted, likely due to the limited dynamic range of the NanoVNA (especially above 900 MHz where the range ~40 dB), and general measurement noise.

2. We have mentioned in the previous lab (QUCS amplifier design/simulation) that we had to limit the input and output of the amplifier board not to put the receivers of the NanoVNA into compression. On the RF input side, you see two resistors of 82 Ohm and 50 Ohm. How much attenuation in dB does these resistors give?
   S11:
   Z=(82+50)||51=37ohm
   S11=(Z-Zs)/(Z+Zs)=(37-50)/(37+50)=-0.15
   Vt,1=(S11+1).Vinc,1
   Vt,2=(50)/(50+82).Vt,1=0.322.Vinc,1
   S21=(Vt,2)^2/(Vinc,1)^2=0.322^2=-9.83dB

3. When we changed the switch from 5V/85mA to 1.4V/20mA, we placed an extra resistor in series to bias the amplifier differently. Which resistor (value) is placed there?

   (5V-1.4V)/0.02 = 180 ohm

4. Which <u>output</u> power does the NanoVNA supply to the amplifier (check datasheet of NanoVNA)? Which input power can the amplifier handle? Is it within limits?

   Output power NanoVNA is 0dBm (+/- 2dBm) which is -30 dB of power and the max input power for the TAMP-72LN+ is 27 dBm or -3 dB. This means that it is well within limits.

As frequency of interest for the next question, use 700 MHz.

5. You have just looked up the output power of the NanoVNA at Question 4 and the attenuation of the resistors on the input at Question 2. What is then the input power presented at the input of the amplifier? And what is the output of the total amplifier board taking the gain of the amplifier and output attenuation into account?

The calculated input power of the amplifier is

10*log10(I*V) = -32.8 dB or -2.8216 dBm watt

If we calculate the gain of the right side it comes out the same as the left side.

From there we can calculate that the total gain of the board is

19 dB - 9.8113 dB - 9.8113 dB = -0.6226 dB

On the amplifier board's input, you have two series resistors (often 82 Ω and 50 Ω) forming an attenuator of roughly 9.8 dB. (Your lab or QUCS calculations likely showed something around 9.8 – 9.9 dB.)

P_in,board = 0 dBm (the signal leaving the VNA, heading into the board)

P_in,amp = P_in,board − 9.8 dB ≈ 0 dBm − 9.8 dB = −9.8 dBm

From the datasheet, the TAMP-72LN+ at 700 MHz has about 18.7 – 19 dB of gain. Let's take 19 dB for a round number.

P_out,amp = (−9.8 dBm) + 19 dB ≈ +9.2 dBm

In this lab setup, you typically also include a resistor pad at the amplifier's output (again around 9–10 dB) to protect the NanoVNA receiver from large signals. Let's assume it is also about 9.8 dB.

P_out,board = P_out,amp − 9.8 dB ≈ +9.2 dBm − 9.8 dB ≈ −0.6 dBm