5XTC0, Components in wireless technologies

Module 6: Lab amplifier measurements

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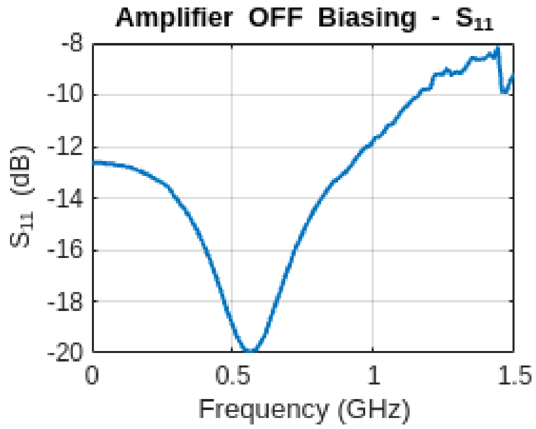
Measurements lab 6:

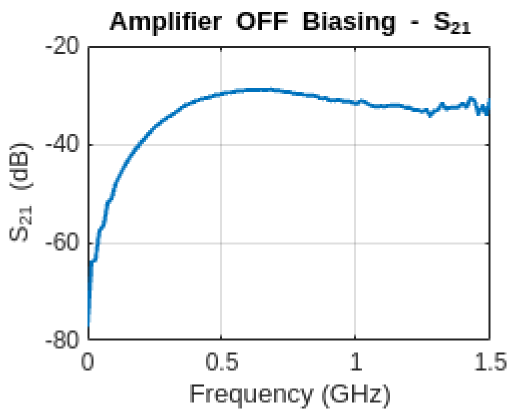
Follow the steps from the slides to measure the S-parameters from 50kHz till 1.5GHz for the 5XTC0_V2 amplifier board with the NanoVNA.

1. No biasing applied:

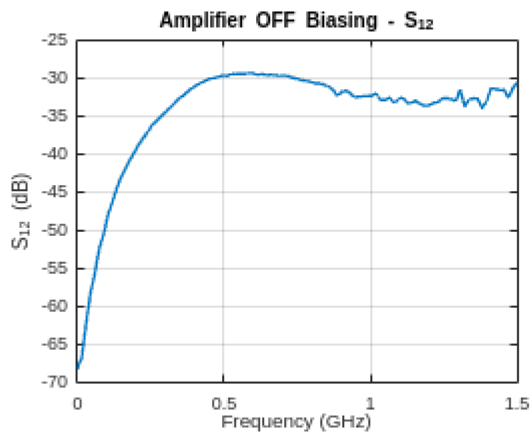
S11 plot:



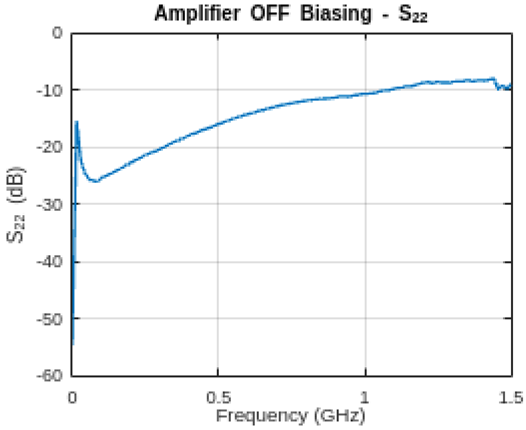
S21 plot:



S12 plot:

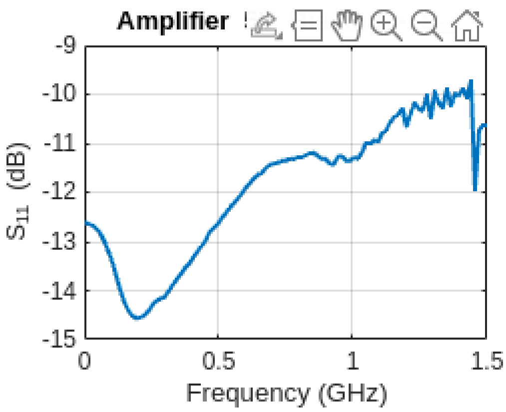


S22 plot:

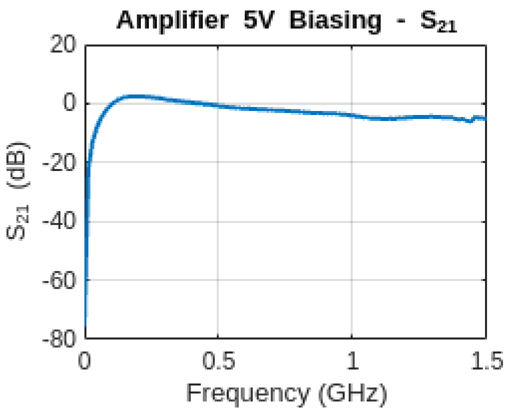


2. 5V/85mA biasing applied:

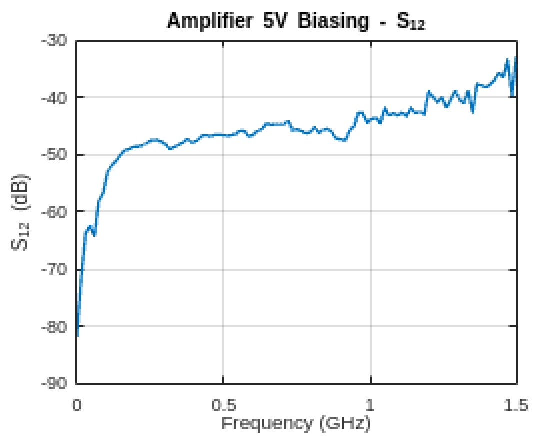
S11 plot:



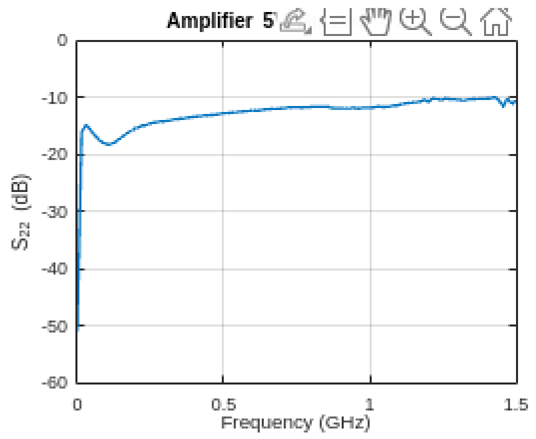
S21 plot:



S12 plot:

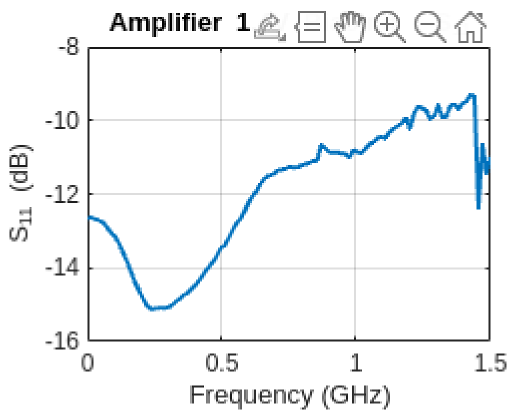


S22 plot:

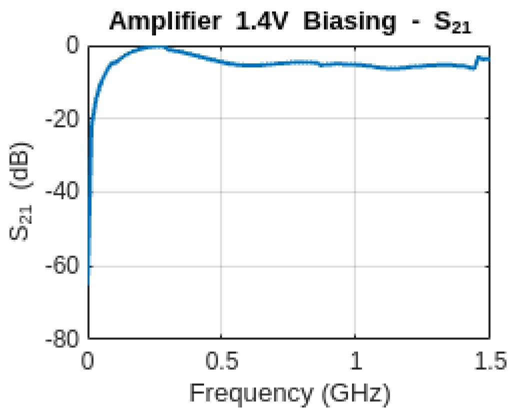


3. 1.4V/20mA biasing applied:

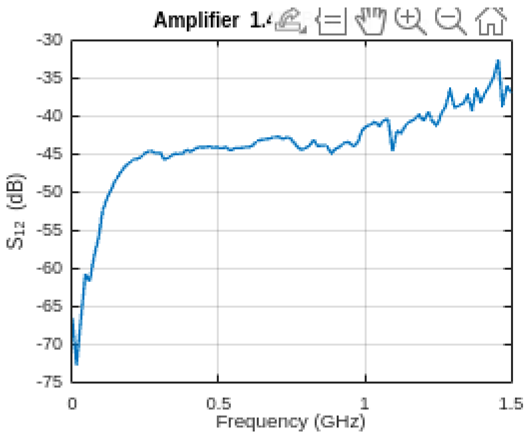
S11 plot:



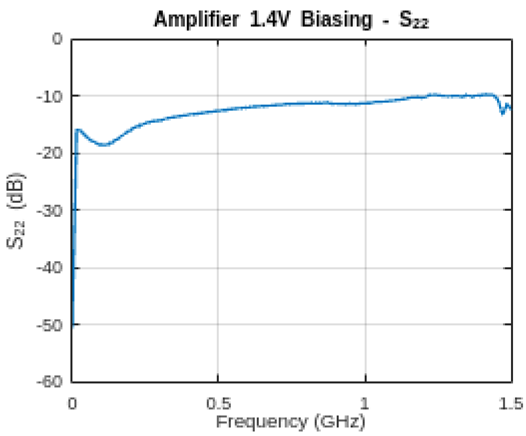
S21 plot:



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 ~8–10 dB difference), likely due to component tolerances, PCB parasitics, connector losses, or calibration errors.

   S21: The measured gain is close to simulation, but with some deviations, especially a dip around 1.2 GHz (possibly due to VNA error or mismatch).

   S{12}: Highly distorted, likely due to the limited dynamic range of the NanoVNA (especially above 900 MHz where the range drops to ~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?

   The voltage divider formed by the 82 (\Omega) and 50 (\Omega) resistors, along with the 50 (\Omega) input impedance of the amplifier, results in significant attenuation. Using voltage transfer calculations:

$\left[V_{\{out\}} = \frac{50}{50+82} \cdot V_{\{in\}} \approx 0.378 \cdot V_{\{in\}} \right]$The resulting attenuation is: [$20 \cdot \log_{10}(0.378) \approx -8.46$ dB] When including impedance mismatch and additional voltage division with the amplifier input, the total attenuation is approximately (-9.8 dB).

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?

To drop the voltage from 5V to 1.4V at 20 mA, we calculate the required resistor value using Ohm's Law:

R = (5 V - 1.4 V) / 20 mA = 3.6 V / 0.02 A = 180 Ω

So, a 180 Omega resistor is placed in series.

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?

According to the NanoVNA datasheet:

- Output power: ~0 dBm ((± 2) dBm), i.e., between –2 dBm and +2 dBm.

- Amplifier input power limit (TAMP-72LN+): up to ($+27$ "\ dBm\ ) .

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 NanoVNA outputs a signal at 0 dBm. This signal passes through an input attenuation network made of resistors, which introduces a loss of 9.8 dB. As a result, the power at the amplifier input is:

0 dBm − 9.8 dB = −9.8 dBm.

The amplifier has a gain of approximately 18.7 dB at 700 MHz. However, the output experiences a further attenuation of about 25.5 dB due to measurement setup losses. Therefore, the output power of the board is:

−9.8 dBm + 18.7 dB − 25.5 dB = −16.6 dBm.