Week 4 Report
ECE 432 Microwave Circuit Design II

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I. Introduction

Goal of this session is to explore simulation tools (ADS) usage in design for stability, noise and gain. We will use SAV-541+ transistor and you should have its S2P parameters stored somewhere thats easily accessible. We will follow the first 30 pages or so from reference[1]. Basic idea is to apply the same techniques explained in there but to our own transistor. For our overall FSK receiver project your design has to cover 2.4 2.6 GHz range with at least 10dB of gain. Noise figure should be minimized but it is not of primary importance, i.e. it can be sacrificed for gain.

II. Questions & Answers

1. Design a bias network for SAV-541+ transistor with VDS=3V and IDS=60 mA. Present schematic and result for your design. You can use any of the several designs in various application notes but you may want to start with a simple resistive design.

a. Investigate and comment on sensitivity of your bias to variations of component values.
b. Comment on how well your design will integrate with future matching network that you will design (i.e. think about this as you design your bias circuit).

Figure 1 shows the DC bias network for the SAV-541+ transistor[1]. Figure 2 shows the screenshot result from the DC simulation in ADS. The results from the bias network provided by the application circuit are accurate.

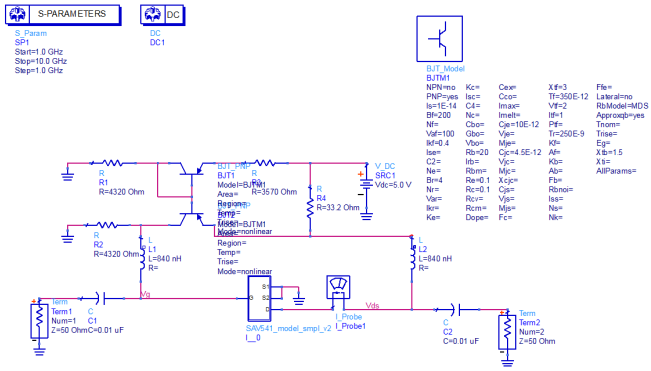

Fig. 1. DC bias network for the SAV-541+ transistor.

[1]The circuit was taken from the SAV-541+ Application Circuit in the datasheet

freq	I_Probe1.i	Vds	Vg
0.0000 Hz	-60.37 mA	2.991 V	502.7 mV

Fig. 2. Current and voltage parameters from the DC bias network for the SAV-541+ transistor.

2. Do a "quick" comparison between S-parameters given by the manufacturer and S-parameters you get from a model that was distributed. Report back if you find any significant discrepancies, in particular in |S21|.

Figure 1 shows the S-Parameter biased network transistor circuit (same as DC bias network; note the capacitors and inductors). Figure 3 shows the S-Parameters comparison between the untuned bias network circuit and the manufacturer S2P data. The bias network shows little discrepency. 3. Using

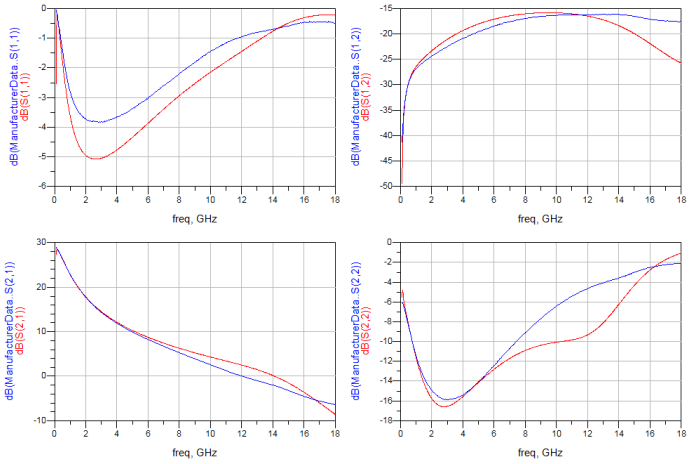

Fig. 3. S-Parameter simulation result comparison between the bias network and the manufacturer S2P data file.

ADS design guide for amplifiers, reproduce figure 13 from[1]. In your report comment on the amount of gain and stability. Limit your frequency range to 0.1 6 GHz. Do you anticipate any problems based on these results?

Figure 4 shows various information provided by the ADS amplifier design guide tool. Observing the Stability Factor, K (mu_{source}/mu_{load}) graph, the circuit is potentially unstable below around 4 GHz. Thus, stabilizing resistors will be necessary in order to make the transistor unconditionally stable between 2.4 - 2.6 GHz (the intended frequency range).

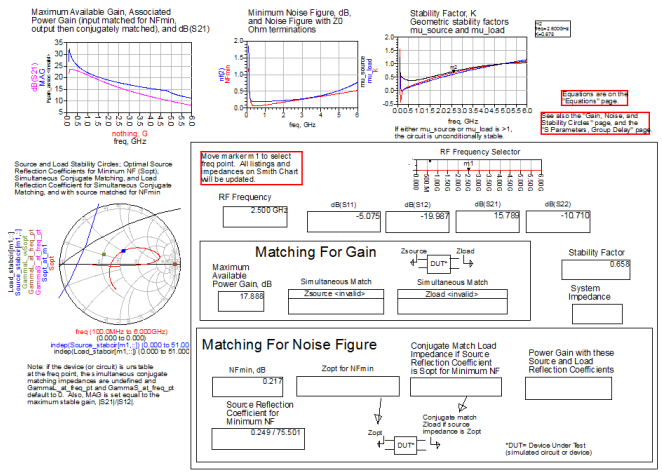

Fig. 4. Amplifier design guide generated in ADS for the bias network for the SAV-541+ transistor.

4. Decide on circuit that you will use to stabilize your transistor and make appropriate changes in DesignGuide, as explained in [1]. Examine your results carefully just because simulation is converging (or appears to be converging!) does not mean that the results make sense. Once you are satisfied with your design, include schematic (Figure 14) and results (Fig 15). If possible, use standard component values or, even better, components that are available in IEEE store.

Figure 5 shows the circuit method used to unconditionally stabilize the transistor (under 3 GHz). Figure 6 shows the Design Guide for the stabilzed circuit. It shows the circuit is unconditionally stable with a gain of 12.225 dB.

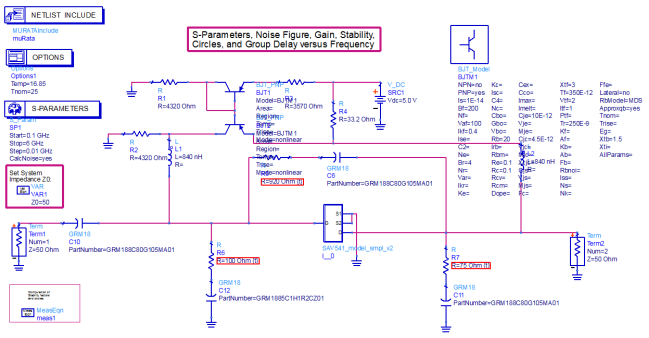

Fig. 5. Stabilized transistor bias circuit for the SAV-541+ using feedback and stabilizing resistors.

5. Add SMD component models from the library and see if parasitic effects change your results see pages 18 21 in [1]. Re-optimize your stability circuit, as needed.

The capacitors and inductors from Murata were added in the prior steps. Unfortunately, the Murata component library did not have 840 nH inductors.

6. Add ground inductance into source lead of SAV 541+. Start with 0.4 nH and increase it to 1 nH. What effect does it have on noise, gain and stability?

Increasing ground induction has many effects on the

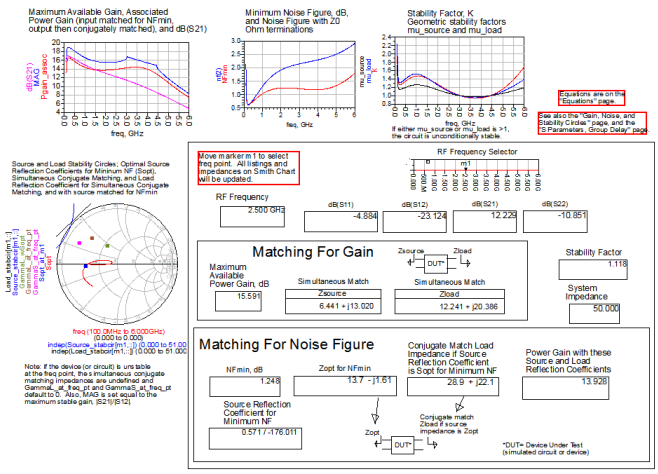

Fig. 6. Amplifier design guide generated in ADS for the bias network for the SAV-541+ transistor.

following parameters:

- Gain: Increasing the inductance decreases the gain. Specifically, the inductance has a greater effect on higher frequency gain.
- Noise: Increasing the inductance increases the noise figure. Specifically, the inductance affects the noise figure at higher frequencies more.
- Stability: Increasing the inductance has a bipolar affect on the stability. The stability increases at the low frequencies (below 3.5 GHz) and decreases for high frequencies (above 3.5 GHz).

7. Design a final stabilizing circuit that will ensure stability across 0.1 6 GHz range and satisfy the criteria for gain and NF in our LNA project.

Figure 7 shows the finalized stabilizing circuit for the SAV-541+ transistor. Figure 8 shows the design guide plots. By observing the mu_{load}/mu_{source}, the circuit will be unconditionally stable between 0.1 GHz - 6 GHz. In addition, the gain is above 10 dB.

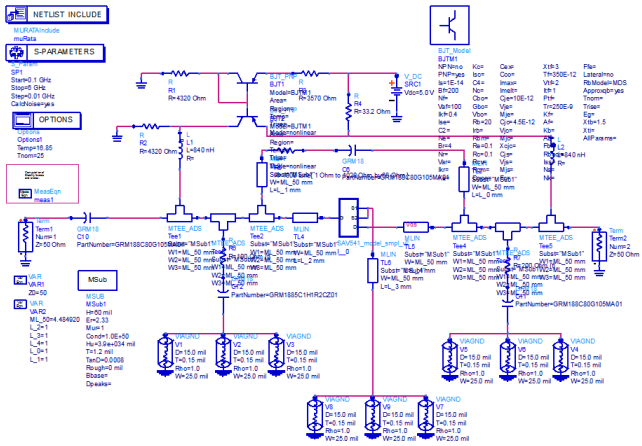

Fig. 7. Final stabilizing circuit for the SAV-541+ transistor.

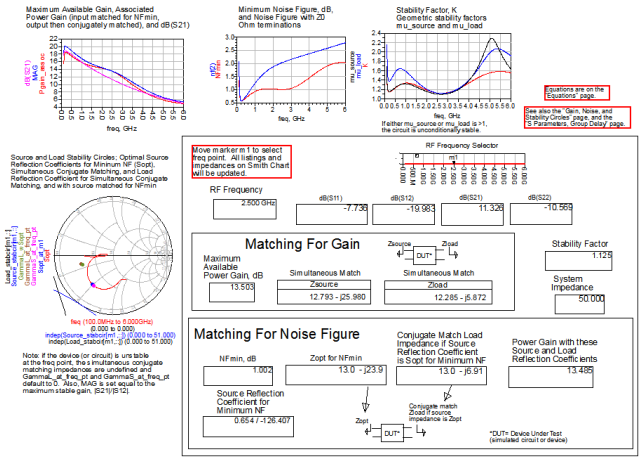

Fig. 8. ADS design guide simulation results for the stabilizing circuit for the SAV-541+ transistor.

8. Final step involves designing either for maximum gain or some smaller value. Now that you have unconditionally stable device you can do simultaneous conjugate match. What gain do you simulations predict?

REFERENCES

[1] K. Payne, "Practical RF Amplifier Design Using the Available Gain Procedure and the Advanced Design System EM/Circuit Co-Simulation Capability," Agilent Technologies (5990-3356EN), 2008.