

Week 2 Report

ECE 432 Microwave Circuit Design II

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I. INTRODUCTION

This lab involves measuring a SAV 541+ transistor from MiniCircuits and obtaining the transfer characteristic curves. The results obtained in the lab agree very well with the manufacturer's data.

II. QUESTIONS & ANSWERS

1. Make nice plots of items 1-2 above. For item 1 comment on how well it compares with specs. For item two, plot the I-V curve but also calculate g_m (transconductance) and overlay it. Comment on the dependence of g_m on I_{DS} . What are the pros and cons of trying to maximize g_m ?

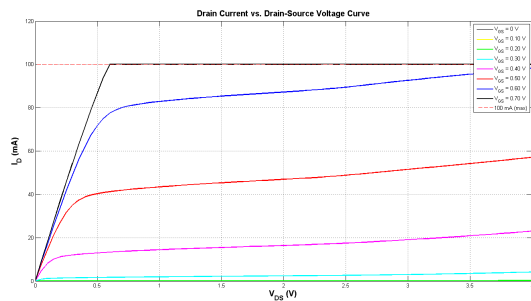


Fig. 1. I_D vs. V_{DS} Curve

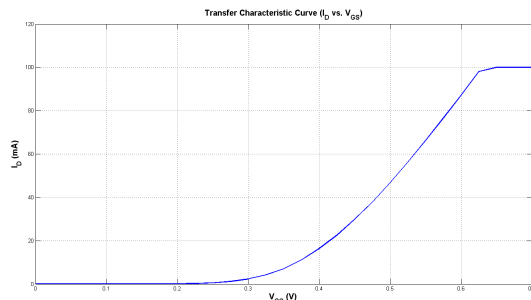


Fig. 2. Transfer Characteristic

Comparing Figure 1 against the manufacturer specs shows a fairly significant difference between the drain current for a given drain-source voltage.

The relationship between g_m and I_{DS} are given by the following equation:

$$g_m = \frac{2I_{DS}}{V_{GS} - V_T} \quad (1)$$

The pros of maximizing g_m is higher current gain (acts more like an amplifier). The main tradeoff to this is higher power consumption and more heat dissipation.

2. For items 3 and 4 compare measured data with S-parameters provided by the company (it's in Touchstone format). Do it separately for all four S parameters and use dB plots for magnitude. For S11 and S22 also plot Smith chart and compare the two results.

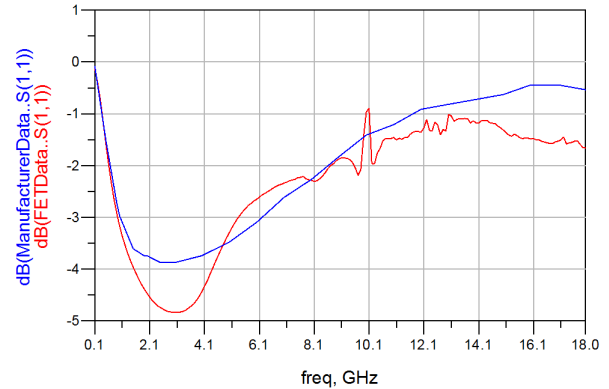


Fig. 3. S11 Magnitude

The measurements from the lab matched the manufacturer figures well¹. Looking at the S11 and S22 Smith Charts (see Figure 7 and Figure 8) gave poor results. This is most likely due to interference caused by the test fixture; deembedding the data may help clean this up.

3. Measure S-parameters for the fixture and try to use our deembedding procedure from 431/531. Comment on whether this improves the data overall and comparison with manufacturer's data? (for this we may have to de-solder some parts first)

¹There was an abnormal glitch noticed at 10 GHz

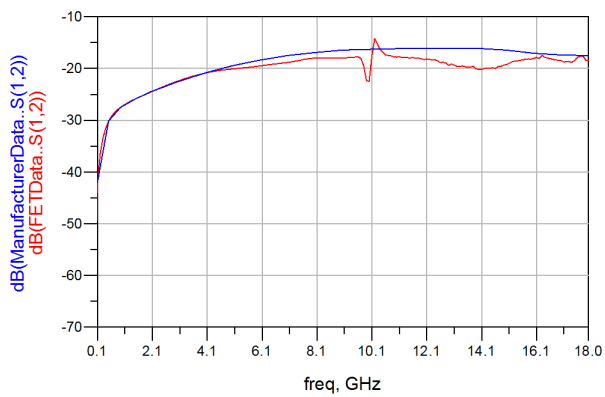


Fig. 4. S12 Magnitude

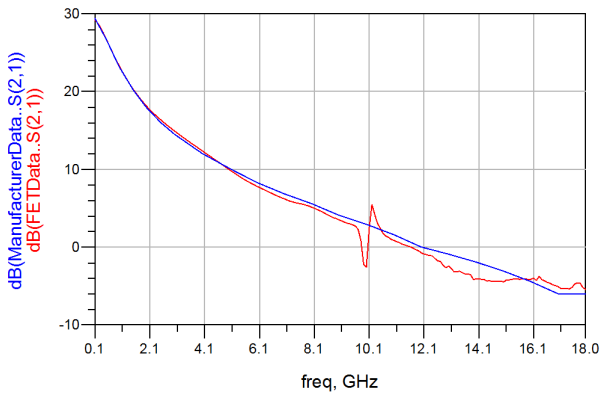


Fig. 5. S21 Magnitude

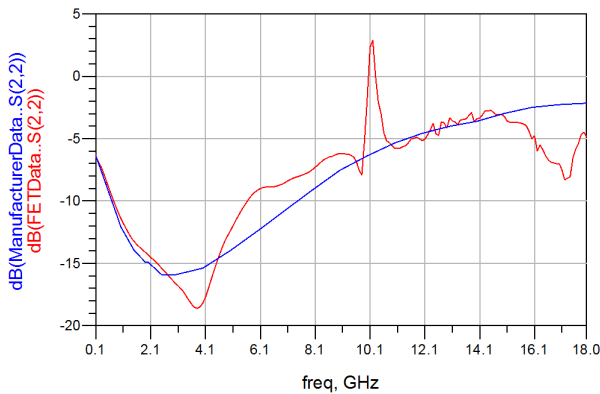


Fig. 6. S22 Magnitude

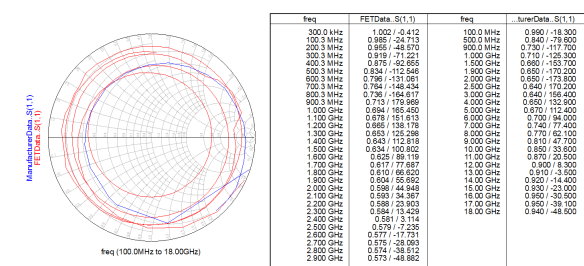


Fig. 7. S11 Smith Plot Before Deembedding

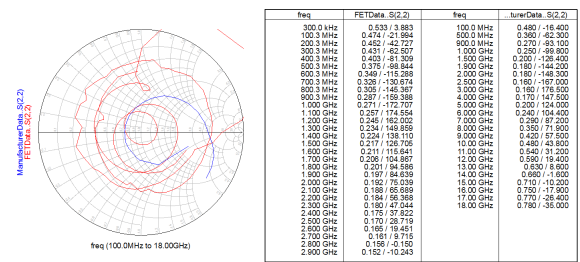


Fig. 8. S22 Smith Plot Before Deembedding

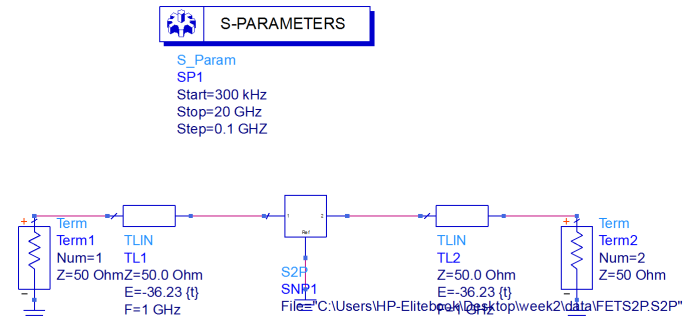


Fig. 9. ADS Deembedding Circuit

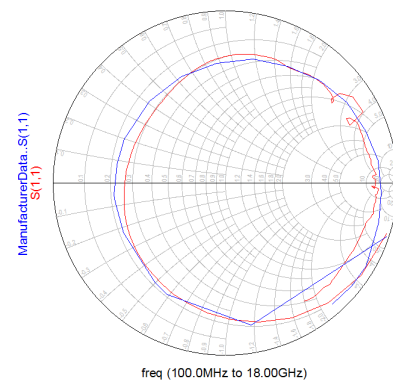


Fig. 10. S11 Smith Plot After Deembedding

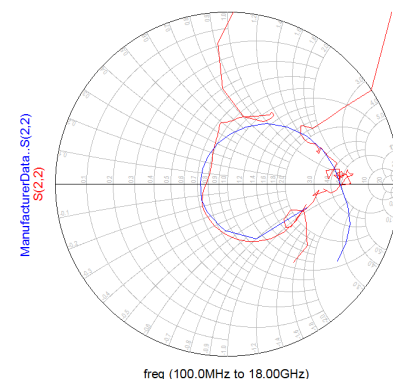


Fig. 11. S22 Smith Plot After Deembedding

Figure 9 shows the circuit used to deembed the lab measurement data. The optimal electrical length was around -36.23 degrees for both sides (the test fixture exhibited symmetrical properties). Looking at the deembedded S11 Smith plot (see Figure 10) showed that deembedding worked well; the S22 Smith plot (Figure 11) has some weird issues that are most likely a glitch in ADS²?

4. Try to replicate $|S_{21}|$ and MSG/MAG plots from manufacturers specs; comment on agreement.

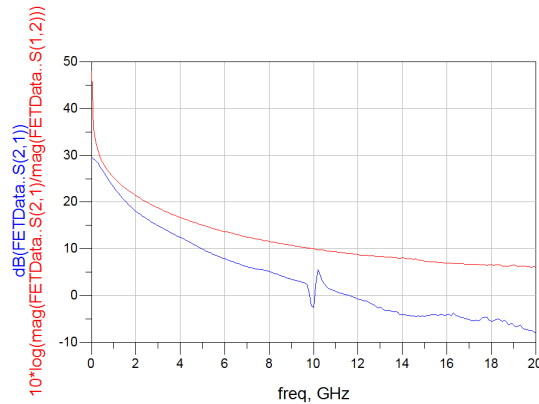


Fig. 12. $|S_{21}|$ and MSG/MAG Plot Generated From Lab Measurement

Figure 12 shows the replicated $|S_{21}|$ and MSG/MAG plot from the in-lab measurement data. It matches the manufacturer's specs extremely closely. This indicates the test setup and measurements were done correctly³.

III. WEEKLY LESSONS

A. In-Class

Stability and MSG/MAG: In lecture and from the lab, I learned about the maximum available/stable gain (MAG/MSG) and the stability factor K. Notably, when K is greater than one, the amplifier is unconditionally stable; when K is less than one it is potentially unstable.

B. Outside of Class

INA vs. Op Amps[1]: This article examined key differences between instrumentation amplifiers (INA) and op amps. Some notable things were that INA generally contains internal feedback (as opposed to external, RLC-based feedback) and has minimal external-setting resistors. In addition, INAs are specifically used in applications demanding high differential-gain and common-mode rejection characteristics. INAs are designed this way to better amplify the signal and reject any common-mode component. The article discussed a few topologies and analyzed the advantages/disadvantages (e.g.

input/output resistance, CMR, and differential gain). Overall, building an INA using discrete op amps, while fully possible, will not have the desired performance characteristics as that of a monolithic INA.

REFERENCES

- [1] <http://electronicdesign.com/power/what-s-difference-between-operational-amplifiers-and-instrumentation-amplifiers>

²I have no idea how to interpret what is going on in the S22 Smith plot simulated from the ADS data

³Props to Dr. B and Lunan for nicely setting up and measuring the transistor circuit