Microwave Amplifier

Microwave Design and Measurements (EERF 6396)
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Submitted By

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1. Introduction

Objectives:

- Design, simulate and build Microwave Amplifier using NE32584C FET on a FR-4 substrate using AWR MWO (Axiem).
- Compare the measurement results and Axiem simulation results.

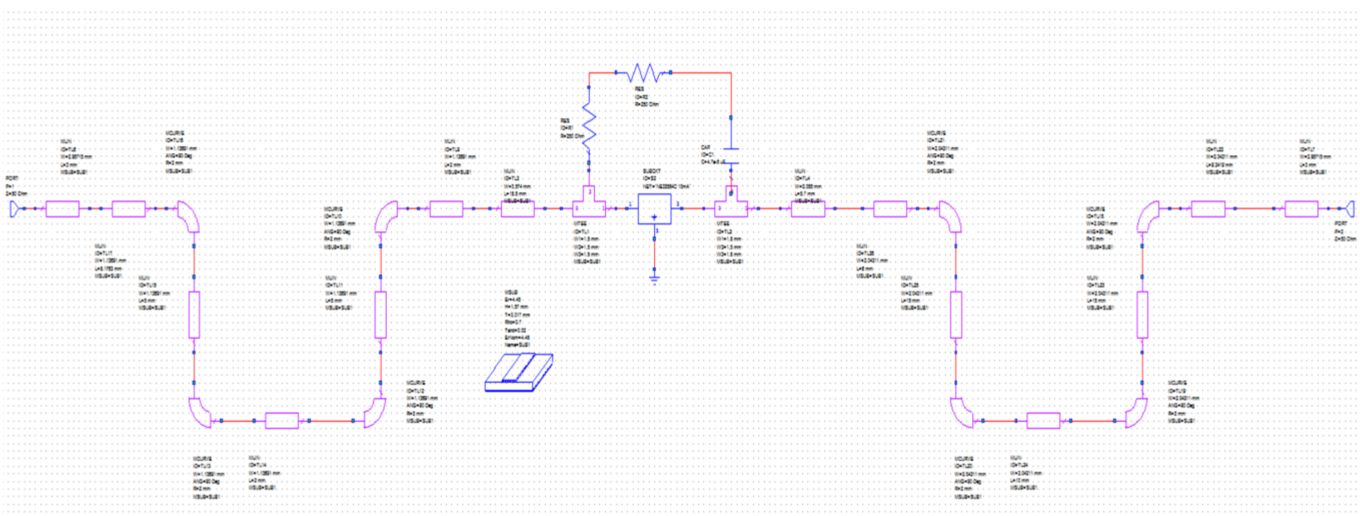
2. Design

A. Design Process

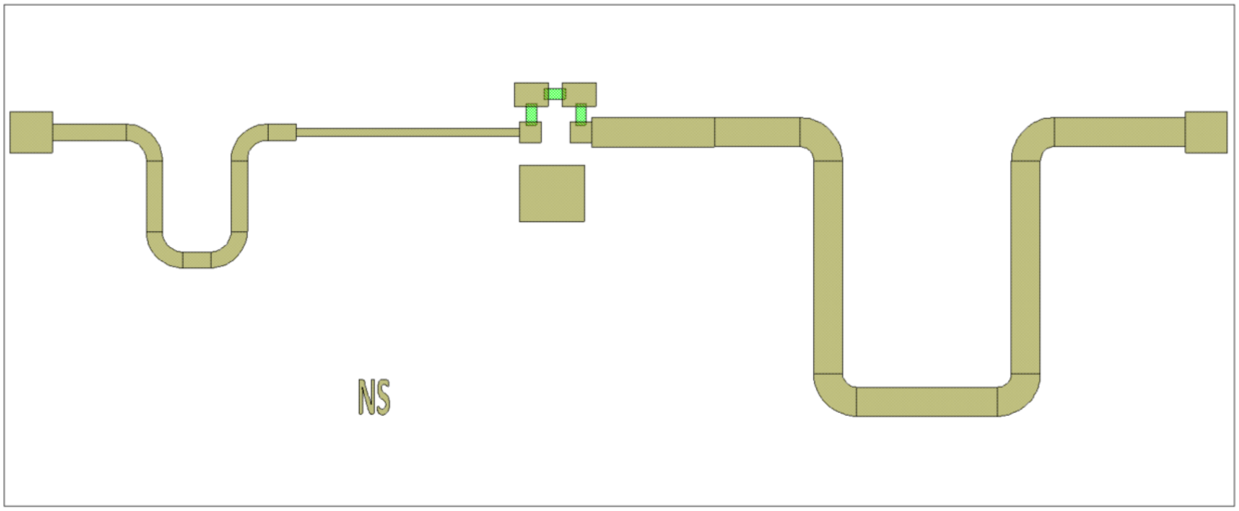
- Using NE32584C data sheet S-parameters (I_{DS} = 10 mA) microwave amplifier was designed. For achieving stability k >1 for 0.1 GHz to 18 GHz, resistor of 250 ohm and capacitor of 47 pF were connected in feedback network.
- Center frequency = $\sqrt{(0.8 * 1.1)}\ GHz$ = 938 MHz was used to find the input impedance and output impedance of the amplifier design along with feedback.
- Input and output matching networks were designed. In smith chart, real axis was reached by moving in constant resistance circle which gives an inductor. To match the design to 50-ohm further quarter wave transformer was used on both sides.
- Another 250-ohm resistor was added in feedback network to achieve stability k > 1 for range 0.1 GHZ to 18 GHz.

B. Figures related to design:

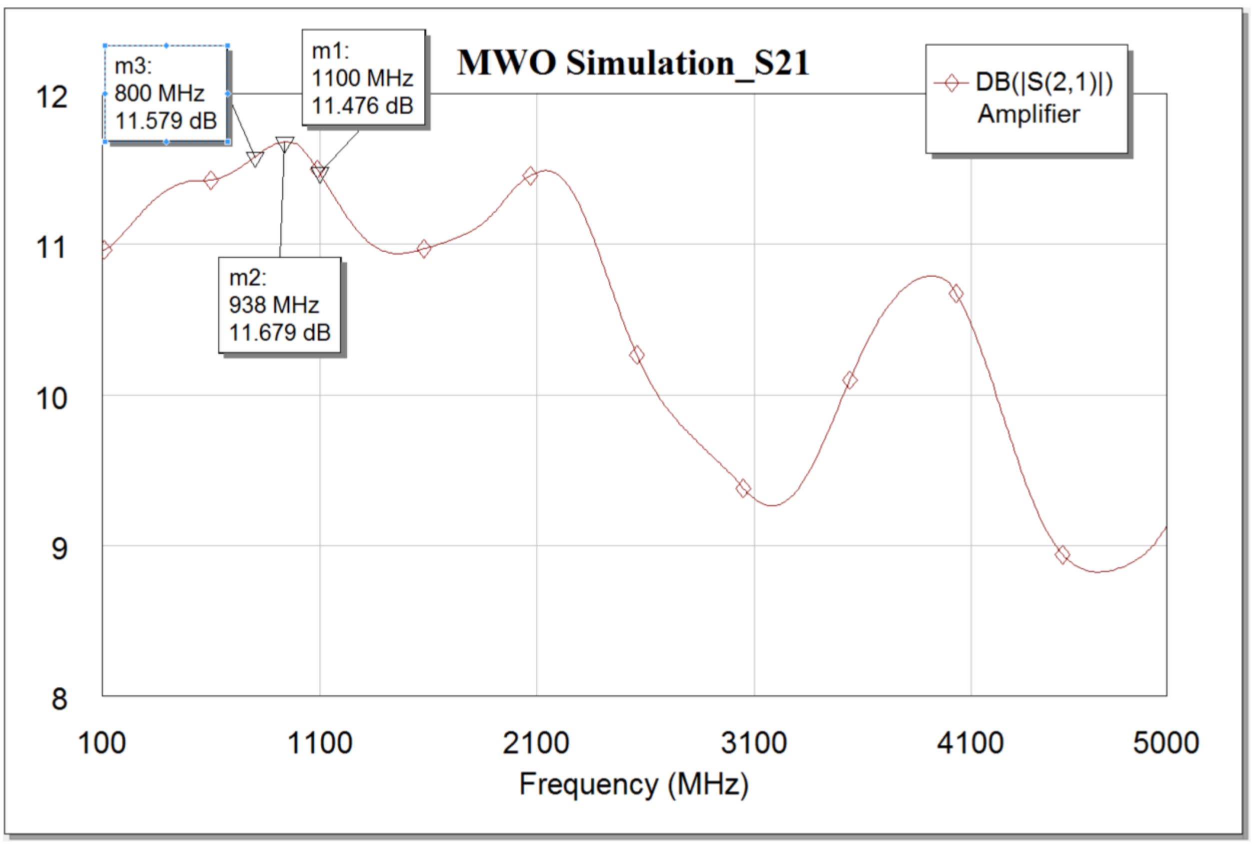
Circuit Schematic:

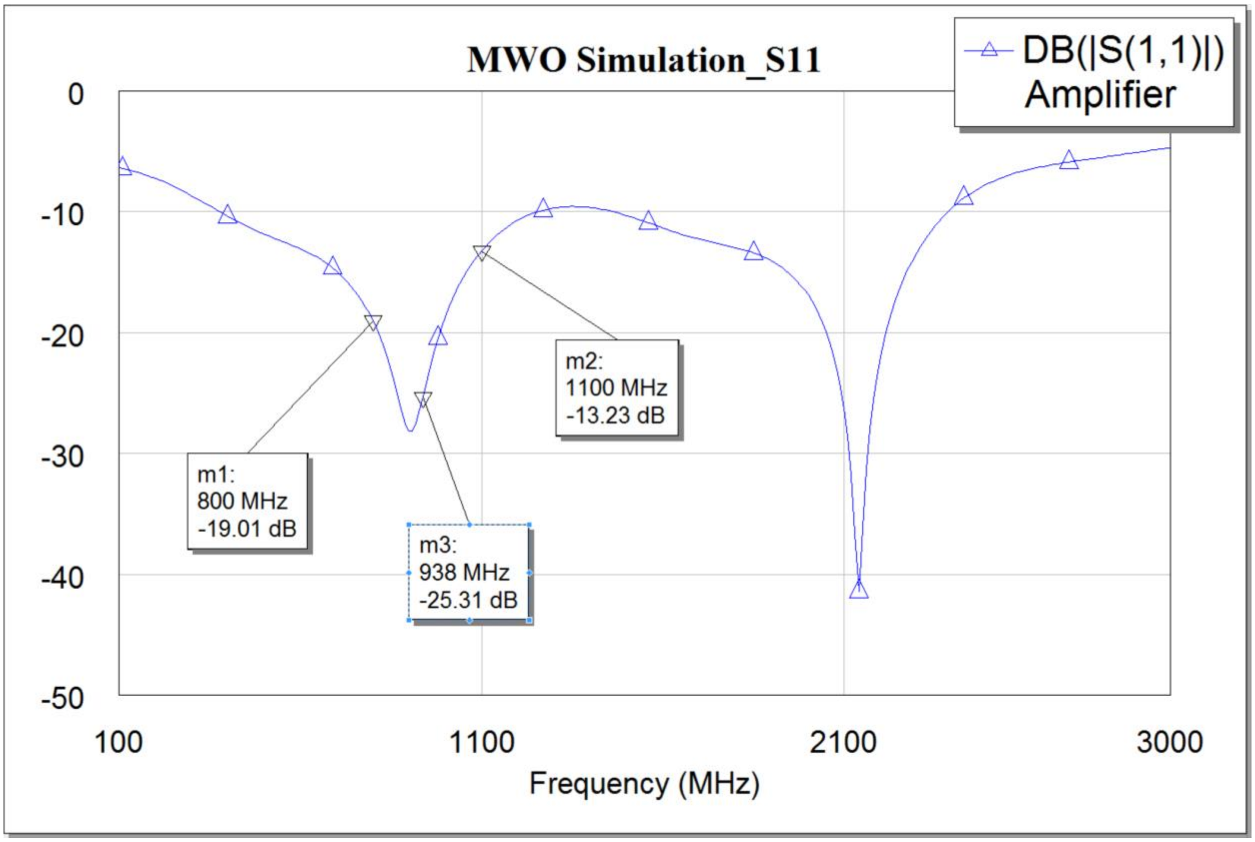


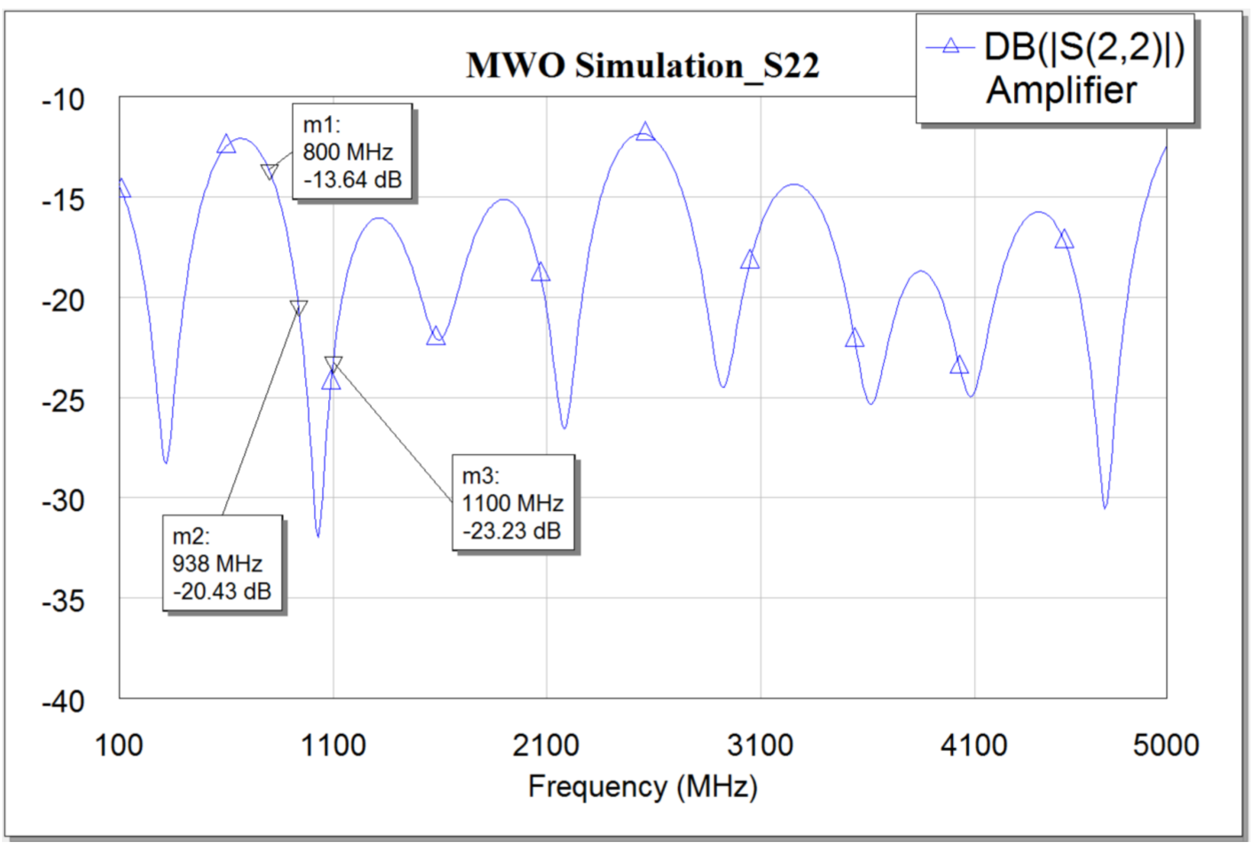
Layout:

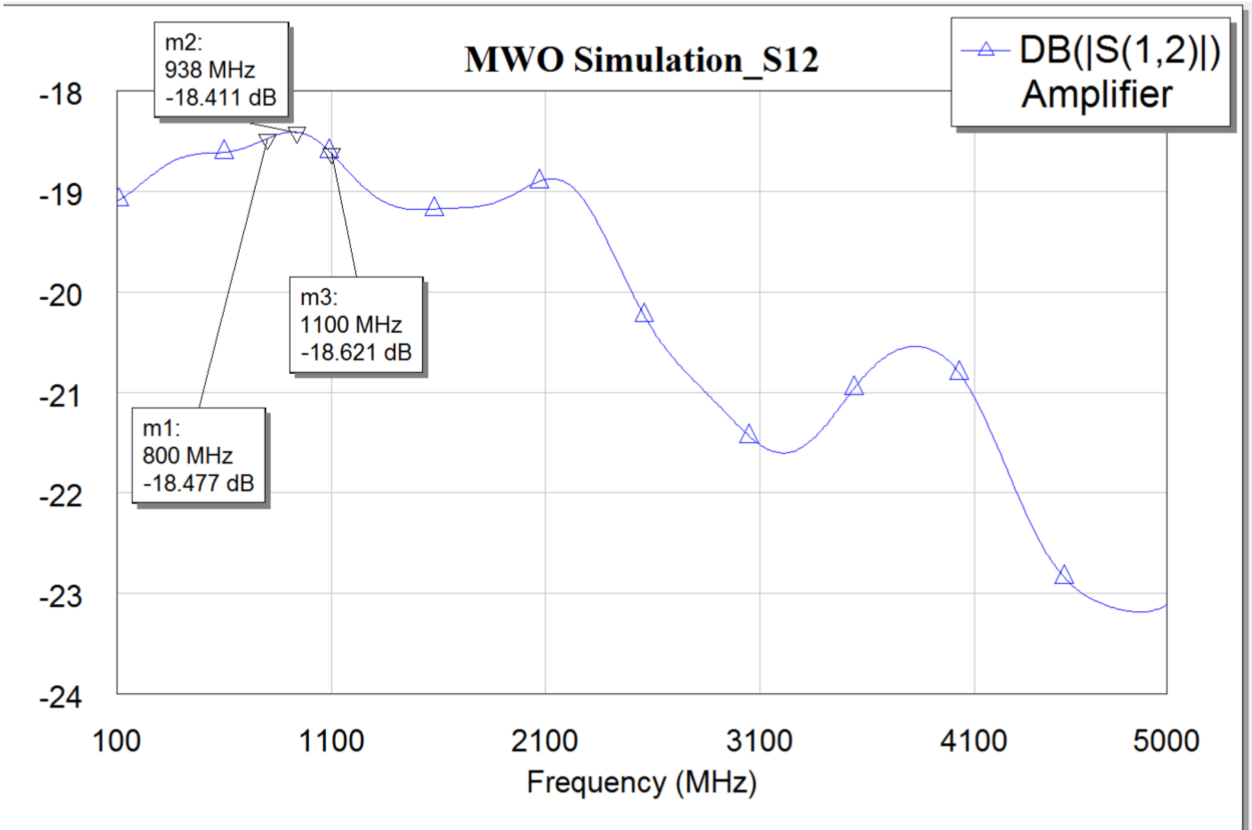


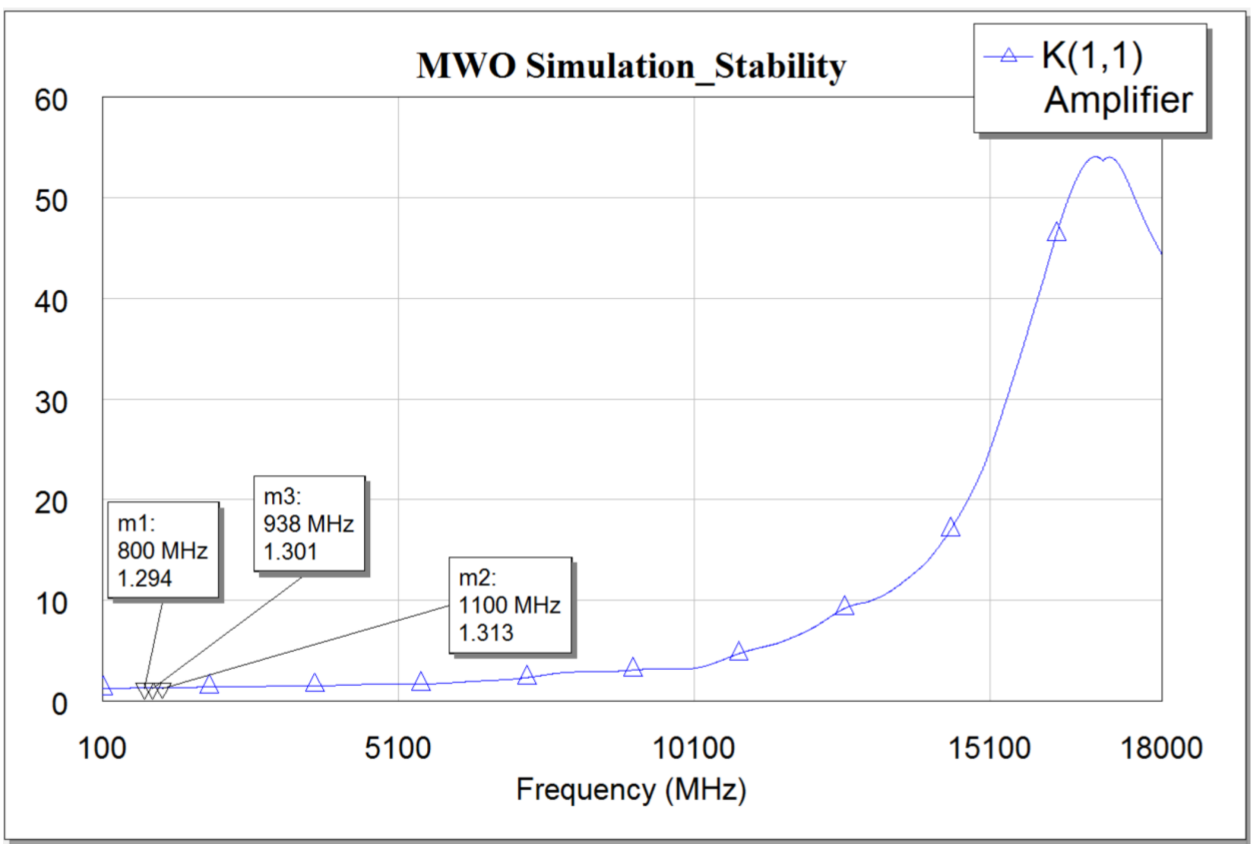
MWO Simulation:




MWO Simulation_S11
DB(|S(1,1)|)
Amplifier
0
-10
-20
-30
-40
-50
100
1100
2100
3000
Frequency (MHz)
m1:
800 MHz
-19.01 dB
m2:
1100 MHz
-13.23 dB
m3:
938 MHz
-25.31 dB

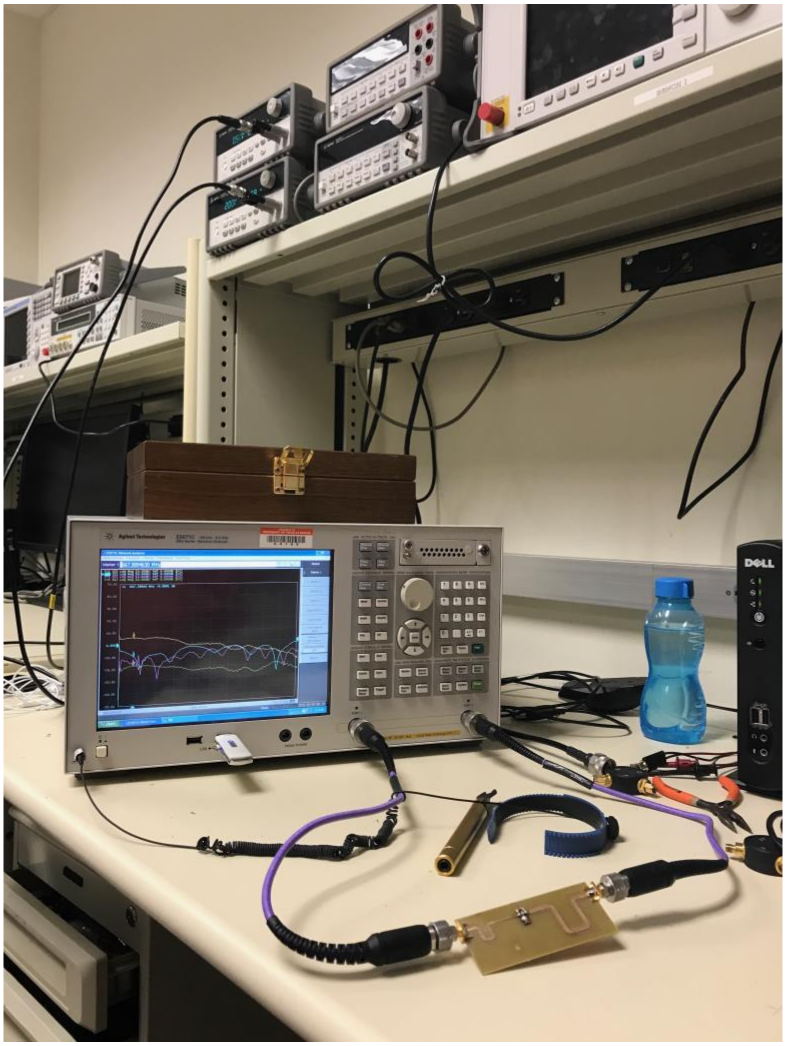

MWO Simulation_S22
DB(|S(2,2)|)
Amplifier
-10
-15
-20
-25
-30
-35
-40
100
1100
2100
3100
4100
5000
Frequency (MHz)
m1:
800 MHz
-13.64 dB
m2:
938 MHz
-20.43 dB
m3:
1100 MHz
-23.23 dB

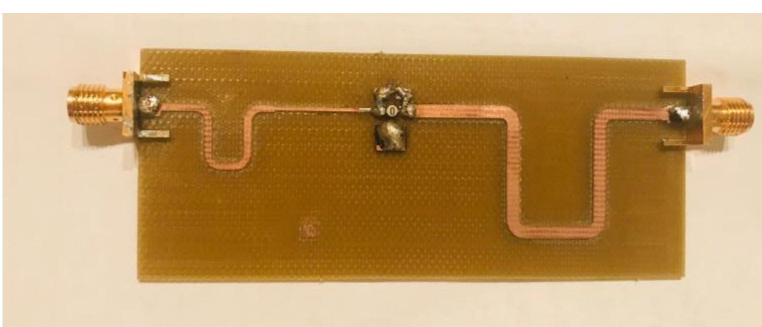

MWO Simulation_S12
DB(|S(1,2)|)
Amplifier
m2:
938 MHz
-18.411 dB
m3:
1100 MHz
-18.621 dB
m1:
800 MHz
-18.477 dB
-18
-19
-20
-21
-22
-23
-24
100
1100
2100
3100
4100
5000
Frequency (MHz)


MWO Simulation_Stability
K(1,1)
Amplifier
m1:
800 MHz
1.294
m3:
938 MHz
1.301
m2:
1100 MHz
1.313
60
50
40
30
20
10
0
100
5100
10100
15100
18000
Frequency (MHz)

3. **Measurement**

A. Photographs of measured circuit:

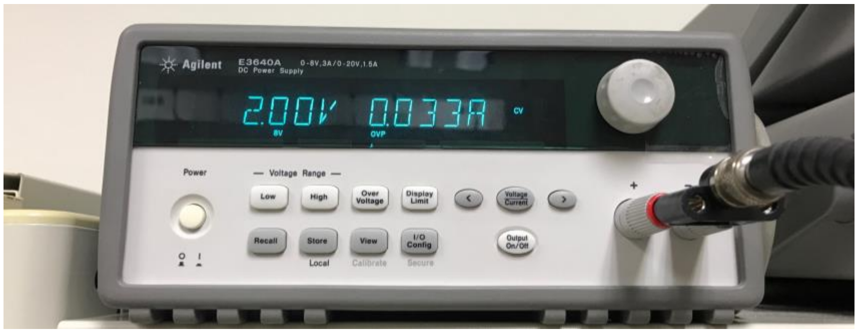




B. Plots of Measured Data

DC MEASUREMENTS:

a. Idss @ Vds = 2V, Vgs = 0V



Idss = 33 mA

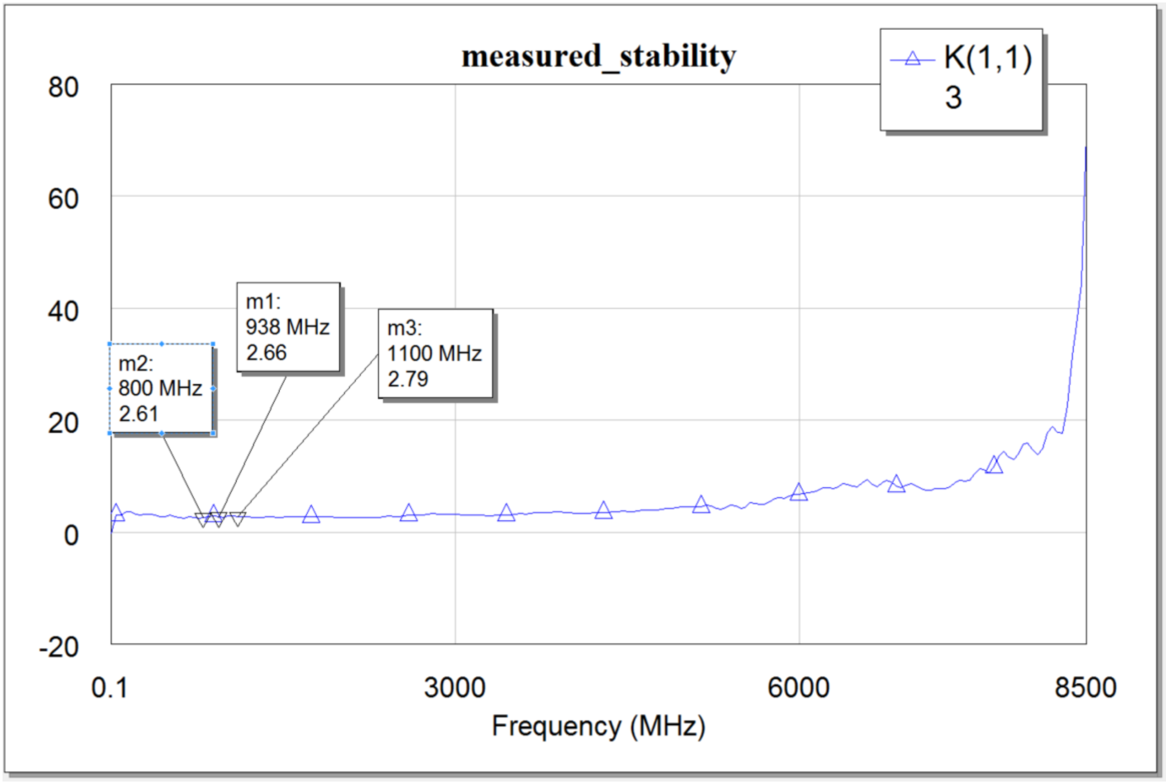
b. Vpo = 0.79V

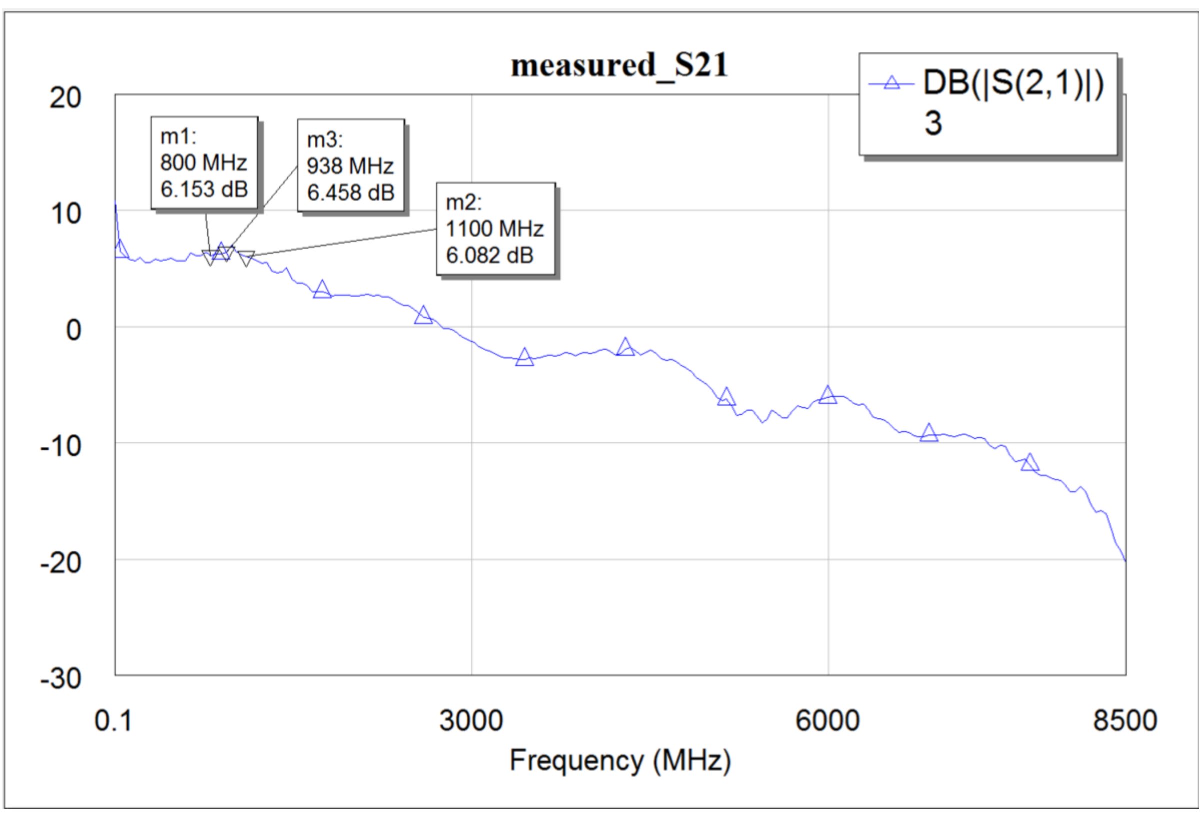
c. Gm @ Vds = 2V, Ids = 10mA

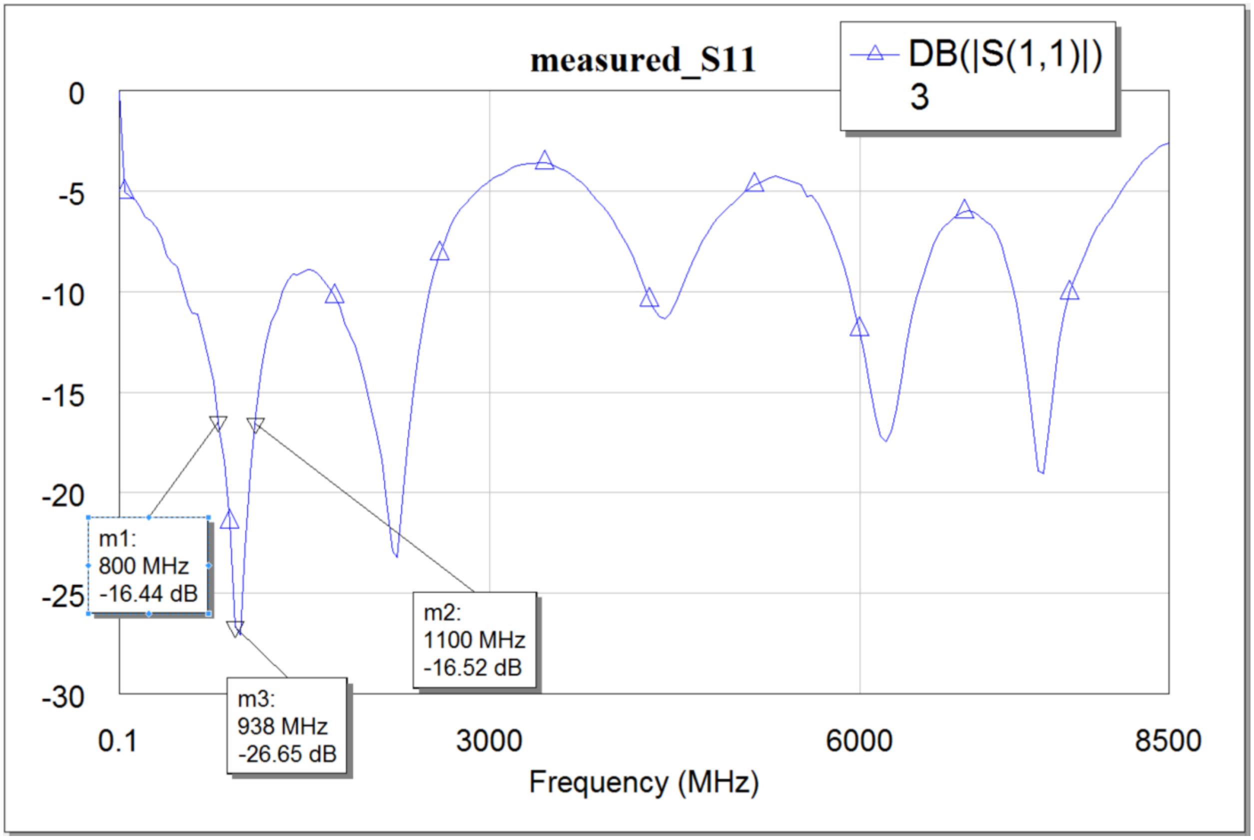
Vgs = 0.42 V, Ids = 12mA
Vgs = 0.40 V, Ids = 8mA

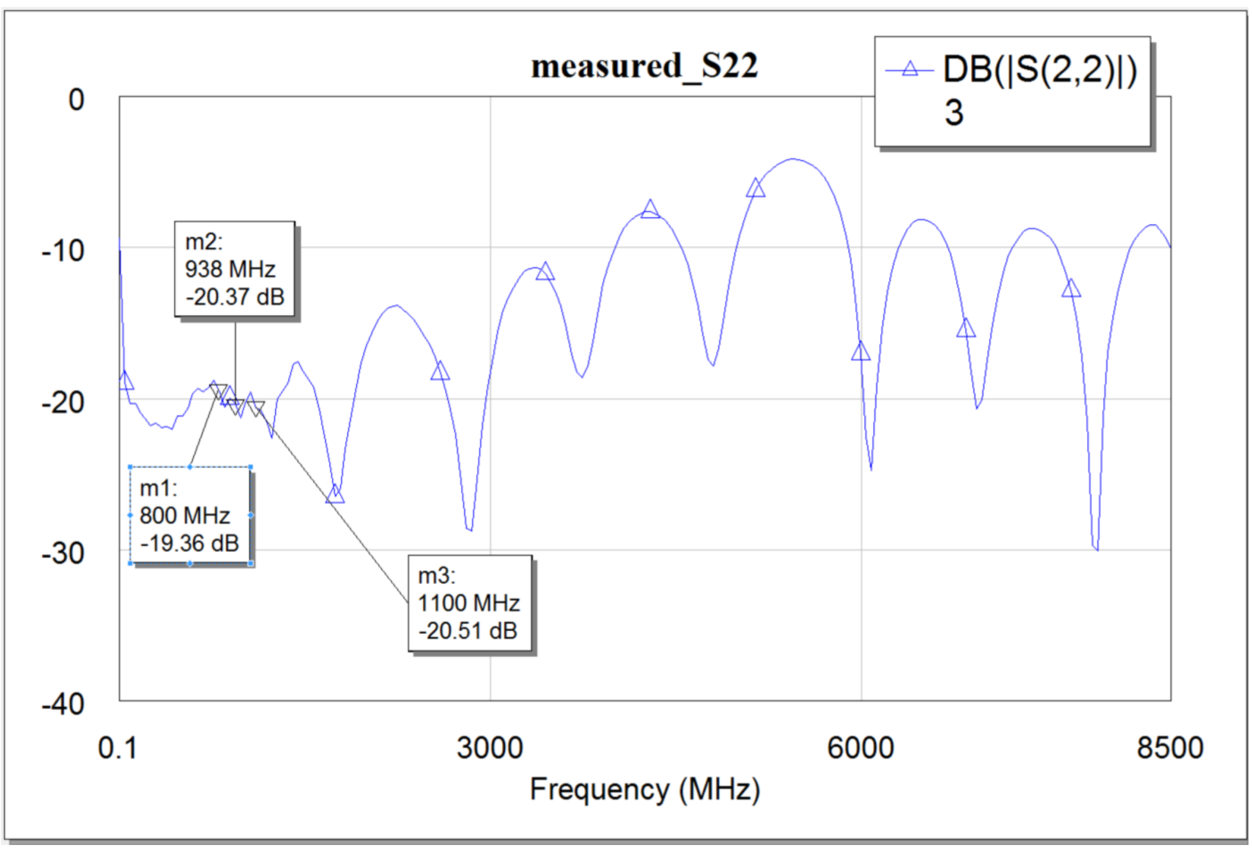
Gm = 200 mS

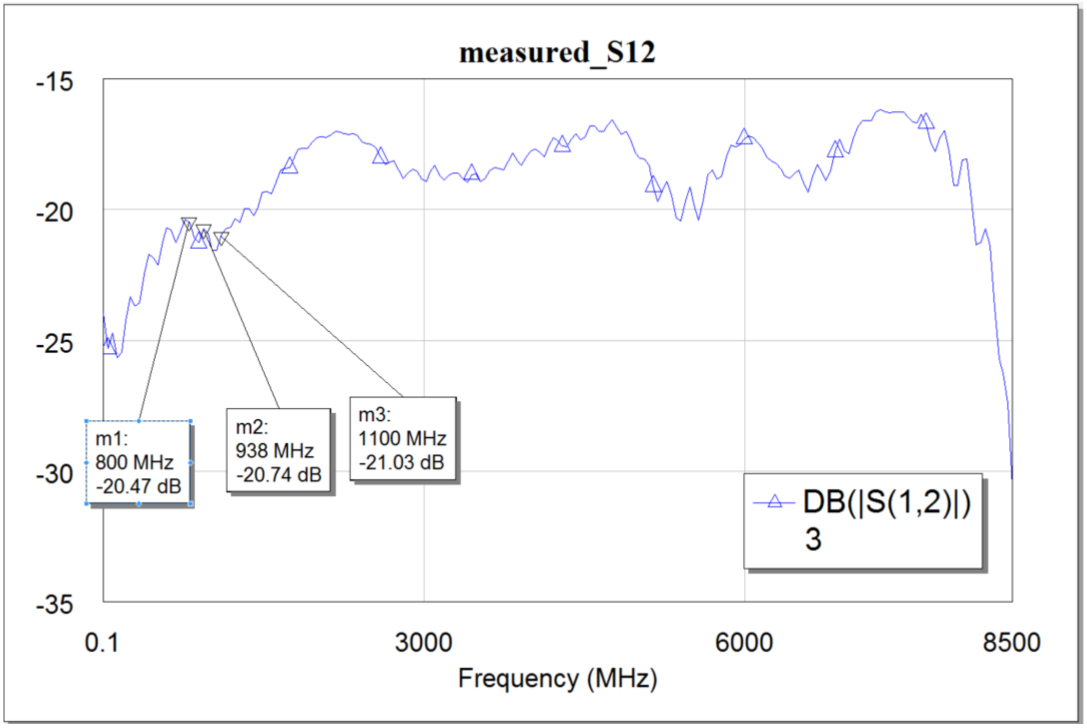
AMPLIFIER MEASUREMENTS:





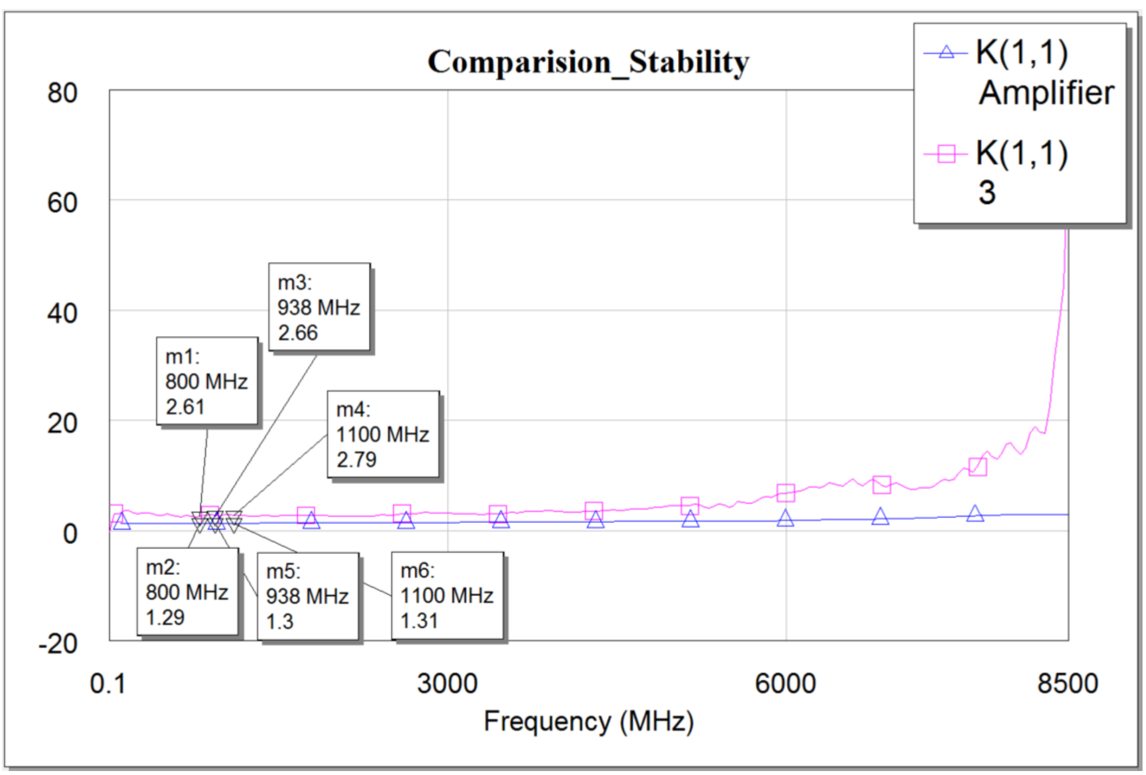

measured_S11
DB(|S(1,1)|)
3
0
-5
-10
-15
-20
-25
-30
0.1
3000
6000
8500
Frequency (MHz)
m1:
800 MHz
-16.44 dB
m2:
1100 MHz
-16.52 dB
m3:
938 MHz
-26.65 dB


measured_S22
DB(|S(2,2)|)
3
0
-10
-20
-30
-40
0.1
3000
6000
8500
Frequency (MHz)
m2:
938 MHz
-20.37 dB
m1:
800 MHz
-19.36 dB
m3:
1100 MHz
-20.51 dB

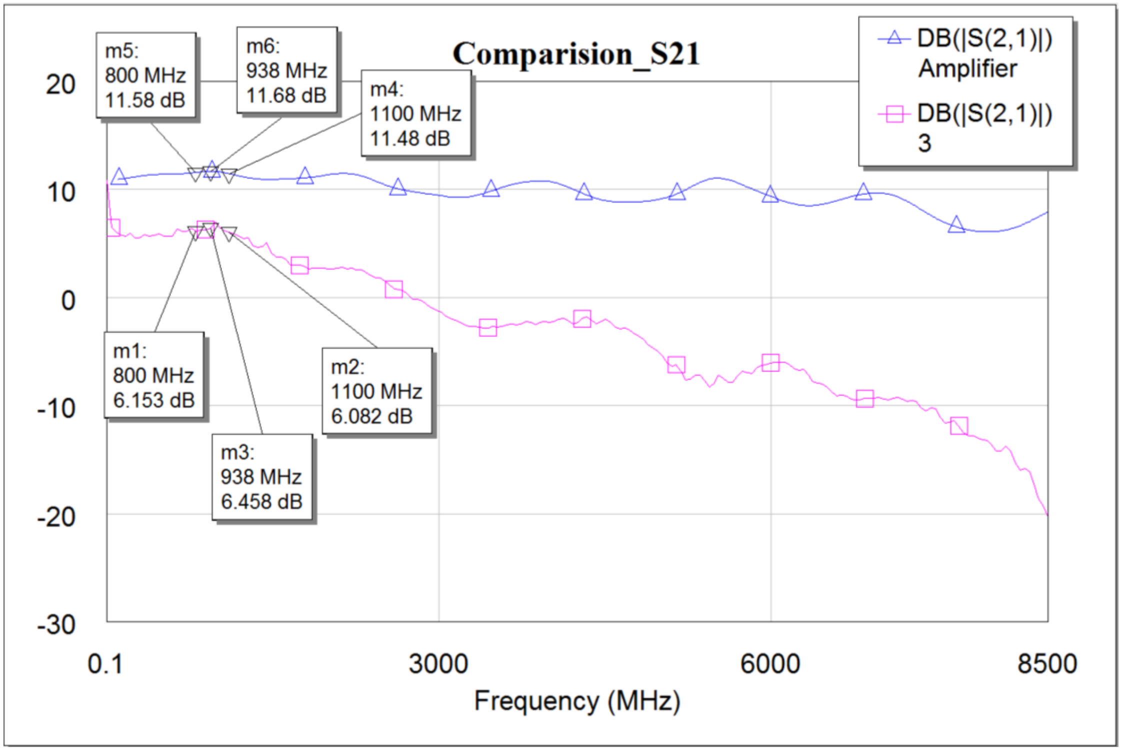


4. Analysis

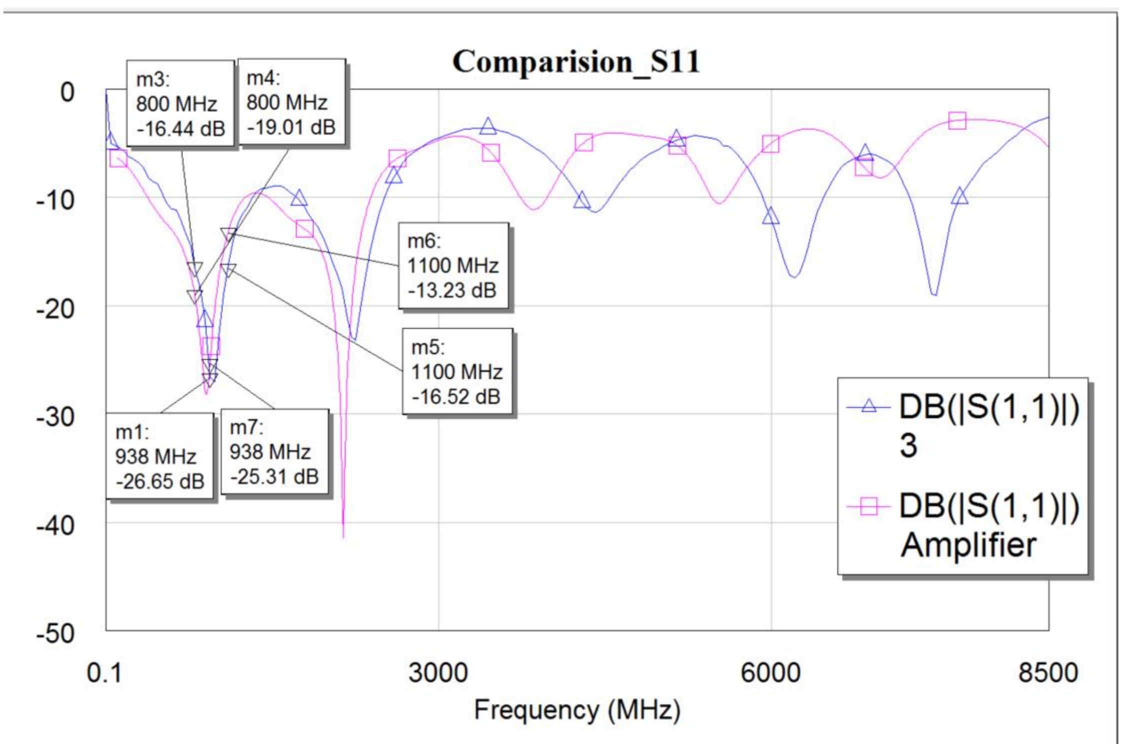
A. Comparison graph of predicted and measured graph



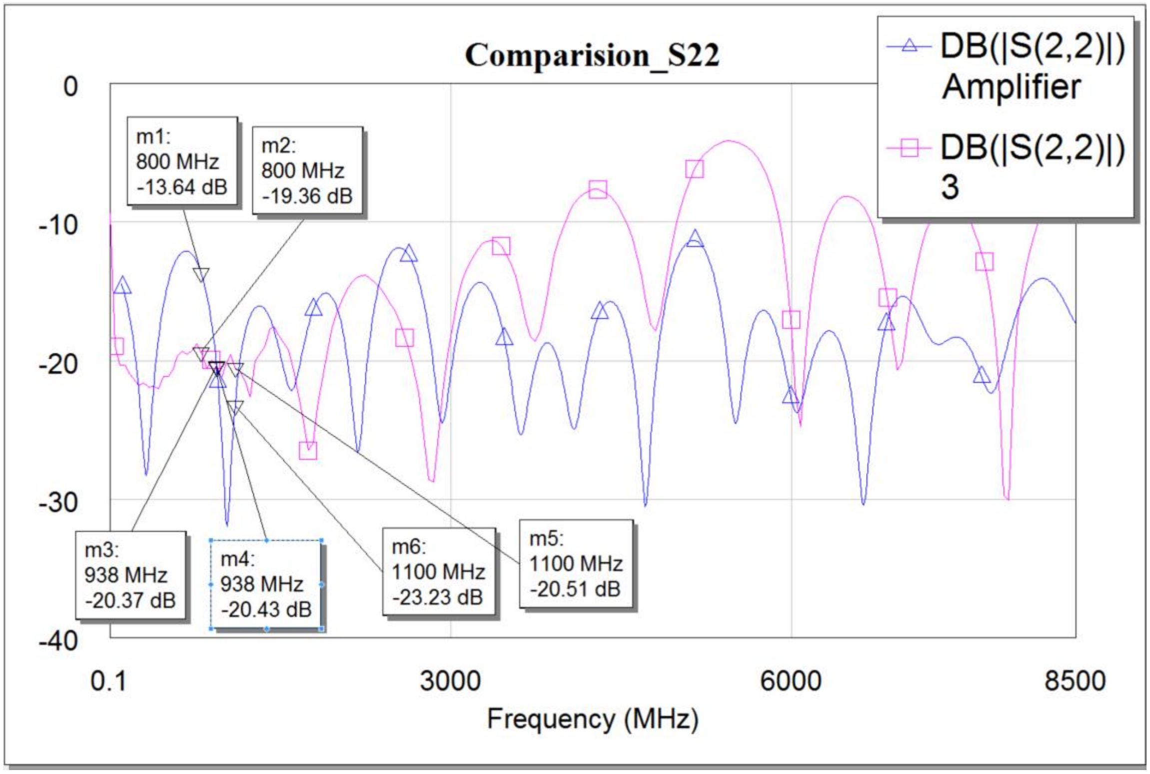
From above shown graph, Predicted Stability(k) at center frequency 938 GHz is 1.3. Measured Stability(k) at center frequency 938 GHz is 2.66.



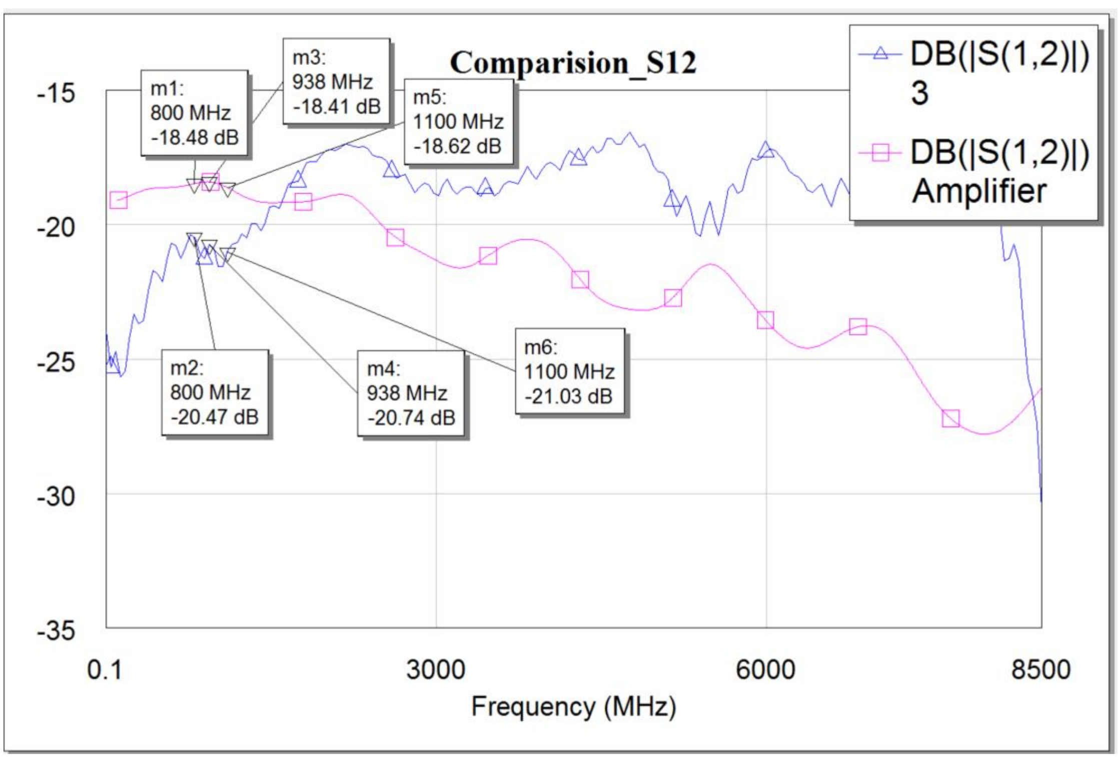
From above shown graph, Predicted S21 at center frequency 938 GHz is 11.68 dB. Measured S21 at center frequency 938 GHz is 6.458 dB.



From above shown graph, Predicted S11 at center frequency 938 GHz is -25.31 dB. Measured S11 at center frequency 938 GHz is -26.65 dB.



From above shown graph, Predicted S22 at center frequency 938 GHz is -20.43 dB. Measured S22 at center frequency 938 GHz is -20.37 dB.



From above shown graph, Predicted S12 at center frequency 938 GHz is -18.41 dB. Measured S12 at center frequency 938 GHz is -20.47 dB.

B. Compliance matrix

Parameter	Design Goal	Predicted Performance	Measured Performance	Compliant (Yes/No)
Frequency Range (GHz)	0.8 – 1.1	0.8 – 1.1	0.8 – 1.1	Yes
Linear Gain (dB)	> 8	11.68	6.458	No
Gain Flatness across band (dB)	< 1	0.203	0.438	Yes
Input Return Loss (dB)	> 15	25.31	26.65	Yes
Output Return Loss (dB)	> 15	20.43	20.37	Yes
V_D (volts)	2	2	2	Yes
I_{DS} (mA)	10	10	33	Yes
k-factor (predicted stability over 0.1-18GHz)	> 1	> 1	> 1	Yes

C. Summary

a. What is the RF output power at the 1dB gain compression point (P_{1dB}) at 1GHz?

Output power at the 1dB gain compression point (P_{1dB}) at 1GHz is 11.83 dBm.

b. What is the RF output power at the 3dB gain compression point (P_{3dB}) at 1GHz?

Output power at the 3dB gain compression point (P_{3dB}) at 1GHz is 12.5 dBm.

2. What could you do to increase overall performance (gain, I/O return loss, BW, etc.) of your amplifier?

Radial stub matching can be used to increase bandwidth. Resistance in the feedback network can be reduced to increase the gain.

5. Conclusion

A. Was the design successful? Why or why not?

Rollett's Stability Factor (k) >1 was obtained over 0.1-18GHz for complete amplifier. Input Return loss and Output Return los were measured to be greater than 15 dB over amplifier range. Gain flatness of < 1 dB was achieved across band (0.8 – 1.1 GHz). Amplifier Gain can be improved by reducing resistance in the feedback network.

B. What lessons did you learn from the lab?

From this lab, I learned about the trade-off between gain and stability parameters of amplifier design.