# Reflection Amplifier Rev 2 Testing

Pouyan Keshavarzian

January 16, 2018

# Contents



# List of Figures



# List of Tables

# 1 Executive Summary

A reflection amplifier with $\approx 15dB$ gain has been designed and tested. The amplifier is stable when biased at $\approx 0.275mA$ and loaded with $50\Omega$. The frequency of operation is $\approx 5.3GHz$. This differs from the design frequency of $\approx 5.9GHz$. Furthermore the biasing conditions are adjusted from simulated. The simulated bias will be refered to as the *Design Bias* and the altered measured bias will be referred to as the *Optimized Bias*. Analysis shows that the circuit is considerably more capacitive in the measured case vs simulated. The resonance is exactly at the intended frequency however the increased capacitance reduces the $Q$ which manifests itself as a shifted S11 magnitude response with respect to $50\Omega$. The cause of the increased capacitance is believed to be the transistor. A conversation about the operation of and theory behind the amplifier design should help verify if this hypothesis makes sense.

# 2 Intro

The purpose of this report is to show the testing results of the reflection amplifier compared to simulated results and to try and elucidate the reasoning for the differences. It's important to remember that while S11 (dB) is the performance metric that we are interested in, reflection coefficient can be a little misleading when trying to understand the discrepancy in measured vs simulated. Therefore the focus will be on impedance parameters to try and explain the difference... It may seem like I am jumping around a bit but hopefully the method to my madness will become clear as your read on.

# 3 Results

Let's first look at the testing results in the intended design configuration, that is, at the *Design Bias*

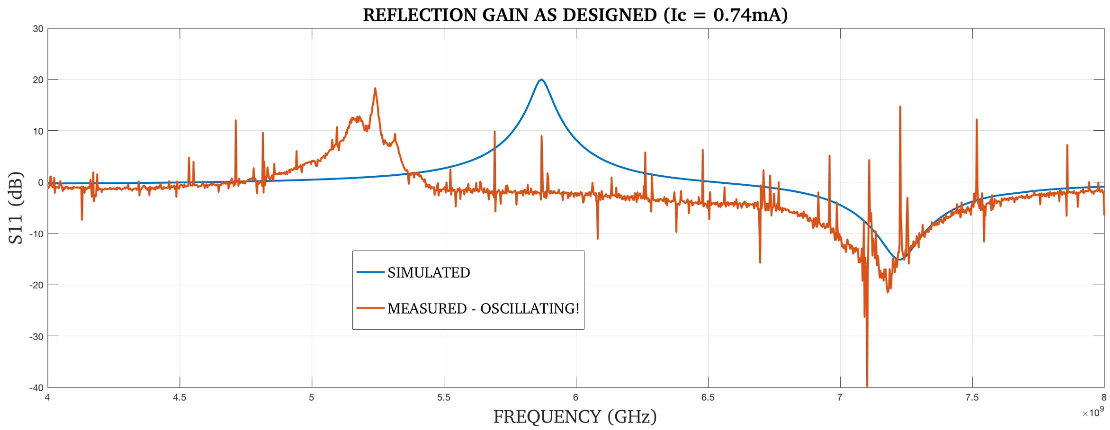


Figure 1: Simulated Vs Measured at Design Bias

Clearly we can see that the design is oscillating when tested at the *Design Bias*. When the bias current is reduced we can remove the oscillation. A graph of the Measured vs Simulated at the *Optimized Bias* is shown below.

# 4 Results

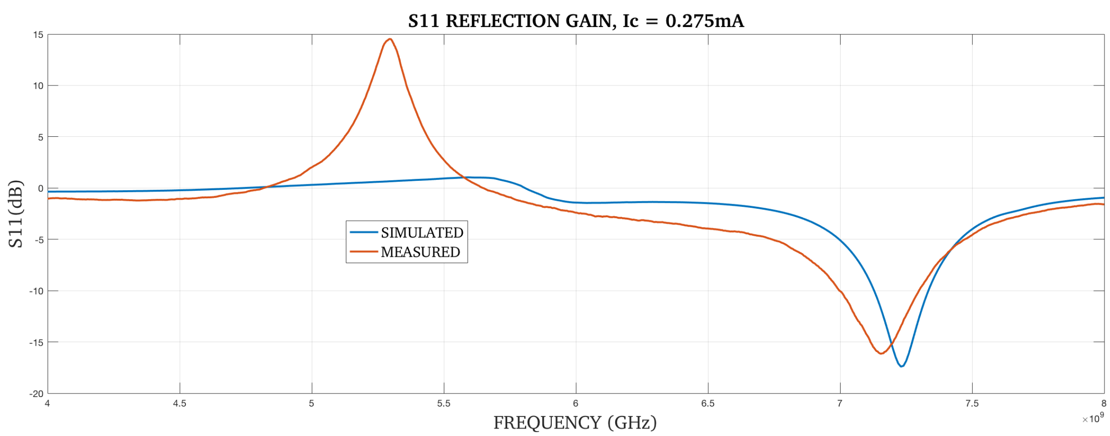


Figure 2: Simulated Vs Measured at Optimized Bias

The stability is confirmed by attaching the amplifier to a spectrum analyzer. To understand why the frequency is shifted and why a different bias condition is required for stability we must analyze the impedance parameters.

# 5 Comparison of Impedance Parameters

## 5.1 Unpowered Analysis

First let's take a look at the magnitude plot of the input when the transistor is unpowered and then break it down to it's input impedance

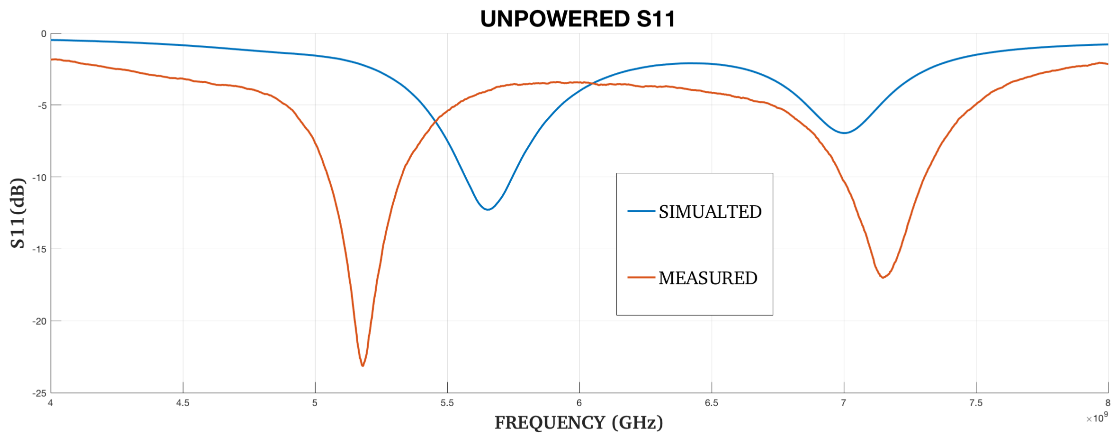


Figure 3: Unpowered S11 Magnitude (dB)

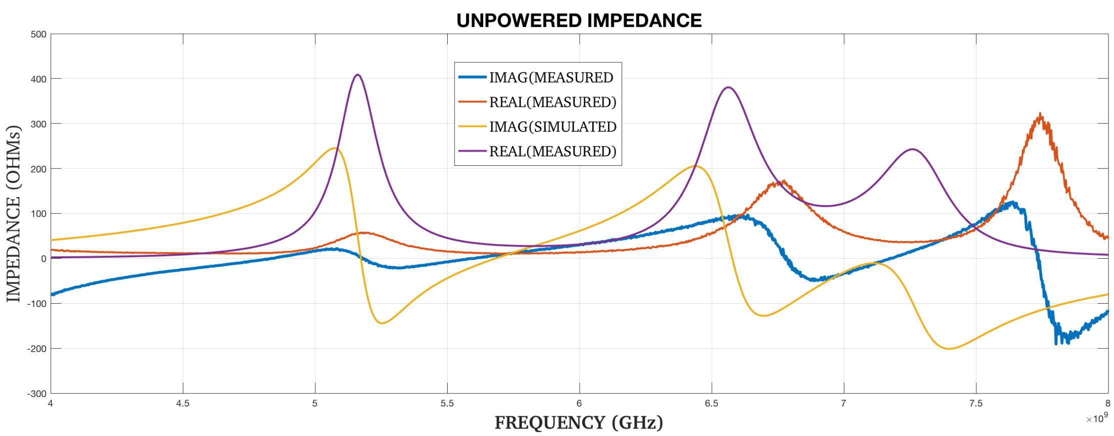


Figure 4: Unpowered Real and Imaginary Impedances

In the area of interest (5-6GHz) it is see that the input is considerably more capacitive in the measured case. This results in a lower Q at the resonance. We will see if the same phenomena is present in the powered case. (**NEXT PAGE**)

## 5.2 Powered at Optimized Bias

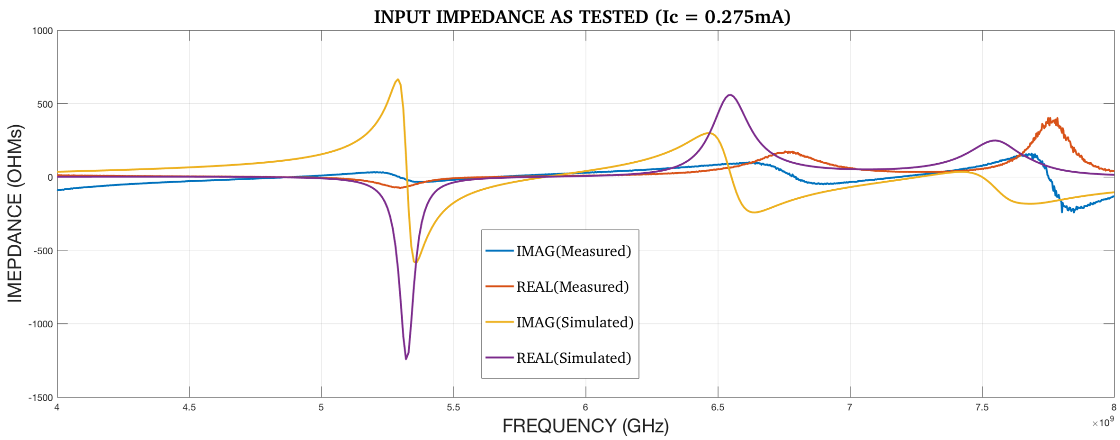


Figure 5: Powered Real and Imaginary Impedances at Optimized Bias

It can be see that the resonant frequency in the negative resistance region is the same for both simulated and measured. However the magnitude is different. Again it is clear that the imaginary component has been shifted capacitively (bizarre). This explains why both the frequency is shifted and why it will oscillate at the *Design Bias*. I will elaborate...

We know from negative conductor theory that the magnitude is inversely proportional to transistor $g_m$ therefore the value of the negative resistance (seen as the dip in Figure 5) will increase as the bias current is decreased. We also know from negative conductor theory that oscillation occurs at $|G_{IN}(0,\omega)| > G_L(\omega)$. Therefore as we reduce the bias current $|G_{IN}(0,\omega)|$ is also reduced and oscillations are removed. The shift in frequency with respect to the S11 Magnitude plot is also easily explained by observing these impedance parameters. Since the $Q$ of the circuit is different the frequency at which the resistance looks close to $50\Omega$ is slightly different.

I think it will be helpful for us to have a conversation about the design and theory of the circuit. That'll probably help reveal what is going on.

# A Meeting Agenda

- First let's take a look at the magnitude plot for 3 different tested units and the executive summary
- Review operation of transistor circuit
- Discuss Executive Summary
- Impedance plot powered showing change in Q
- Impedance plot unpowered with extended frequency range showing additional resonance.
- Appears more lossy... thoughts????
- Moving forward... thesis goals.
- Rotman lens design... retrodirectivity + analysis of radar cross section of system
- TIME FOR SEMINAR?