RF Amplifier for 5G Applications

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Abstract- The design of RF Amplifier and analysis of 5G NR Test Signal on fabricated RF Amplifier has been discussed in this paper. RF Amplifier is designed based on the Macom XF1001-SC HFET Transistor. The design was simulated on Electronic design automation software tool Keysight Advanced design system software. The various parameters of the proposed RF Amplifier were evaluated and analyzed such as Gain & return loss. Also analyzed 5G NR test signal on Fabricated RF Amplifier by verifying Error Vector Magnitude. Results establish that the RF Amplifier can effectively be utilized for 5G Applications.

Keywords – RF Amplifier, 5G NR, Error Vector Magnitude

I. INTRODUCTION

Wireless Cellular standards are developing faster than ever & latest among them is Fifth Generation Wireless Technology namely 5G, which are changing the communication with a paradigm shift towards a user and application centric technology. 5G is targeting two frequency bands: sub-6 GHz and mm-Wave. RF Amplifiers are in the final stage of Communication Systems are designed with utmost care to have enough output power to overcome channel losses between the transmitter and the receiver. Design and analysis of RF Amplifier based on WCDMA presented in [1].A 15 GHz 6W GaAs HEMT RF Amplifier for 5G Communication presented in [2].In this paper, a HFET Transistor based RF Amplifier is proposed which will resonate in sub-6 GHz frequency band of 5G NR with a gain of 10 dB . The Amplifier is designed using Keysight Advanced design System software. The fabricated amplifier gain & return loss are verified using Vector Network Analyzer and Analysis of 5G NR test signal by verifying Error Vector Magnitude is done using Vector Signal Generator & Signal Analyzer with 5G NR Test Application.

The rest of the paper is organized as follows. Proposed Amplifier design and simulation results using Keysight ADS software are presented in section II. Results of Fabricated RF Amplifier tested using Vector Network Analyzer, Vector Signal Generator & Signal Analyzer are presented in section III. Concluding remarks are given in section IV.

II. PROPOSED AMPLIFER DESIGN

Design steps involves

1. Import S2P Touchstone file of XF1001-SC HFET & plot S-Parameters in ADS Software.
2. Plot the Stability Factor,µ & µ Prime to find the stability of Amplifier
3. Plotting the Load & Source Stability circles of the HFET
4. Designing the matching circuit based on the impedance point chosen at the desired frequency of interest

Start Frequency: 3 GHz

Stop Frequency: 5 GHz

Step size: 0.1 GHz

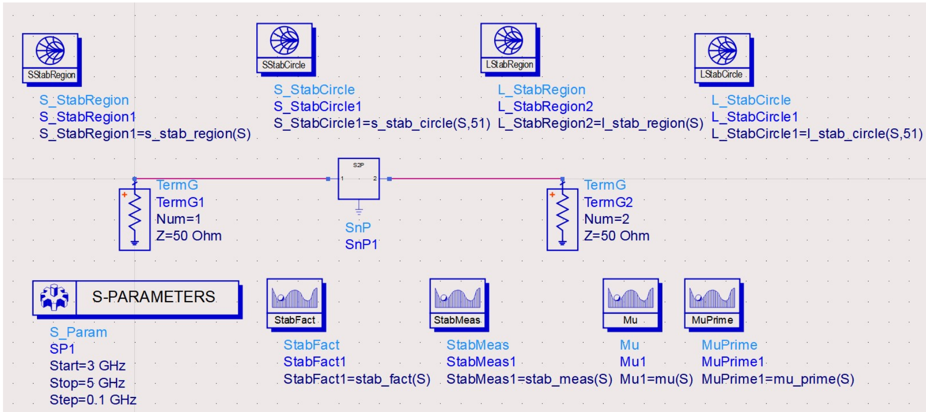


Fig.1a Shows Workspace in ADS Software for Amplifier Characterization

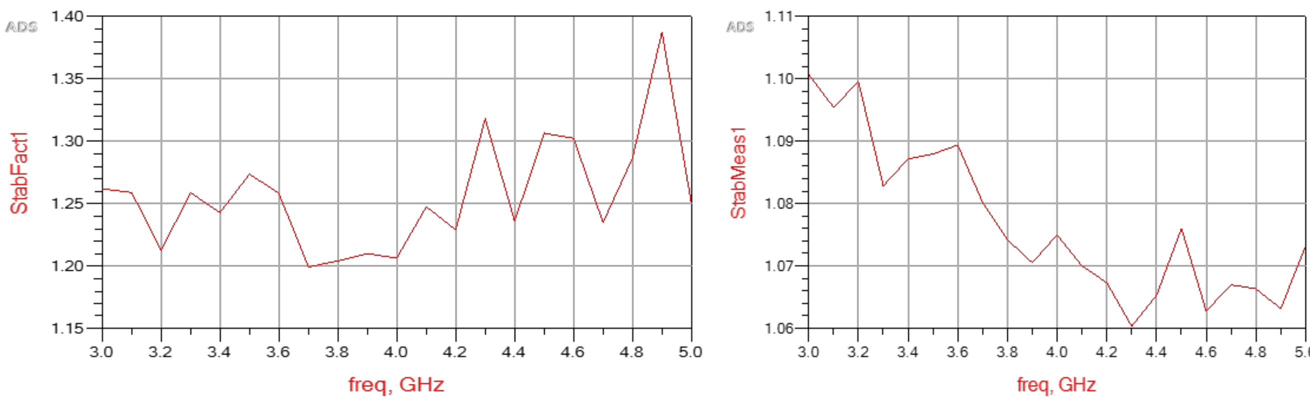


Fig.1b Plot shows the stability factor of XF1001-SC Transistor

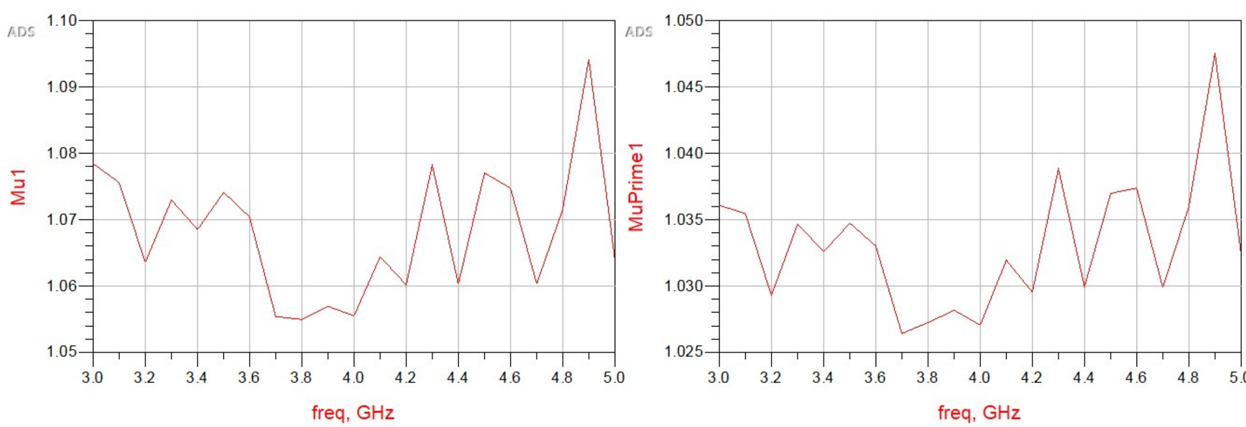


Fig.1c Plot shows the Mu & Mu Prime of XF1001-SC Transistor

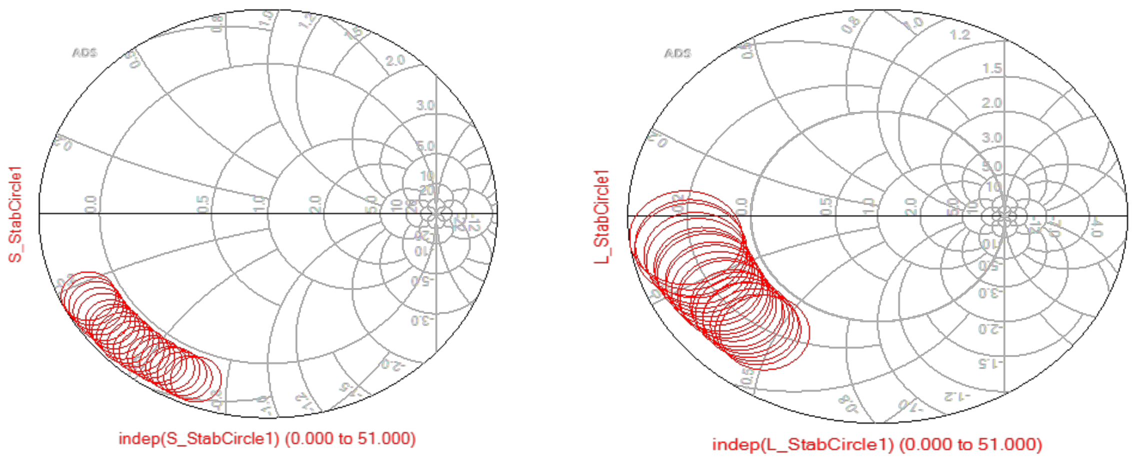
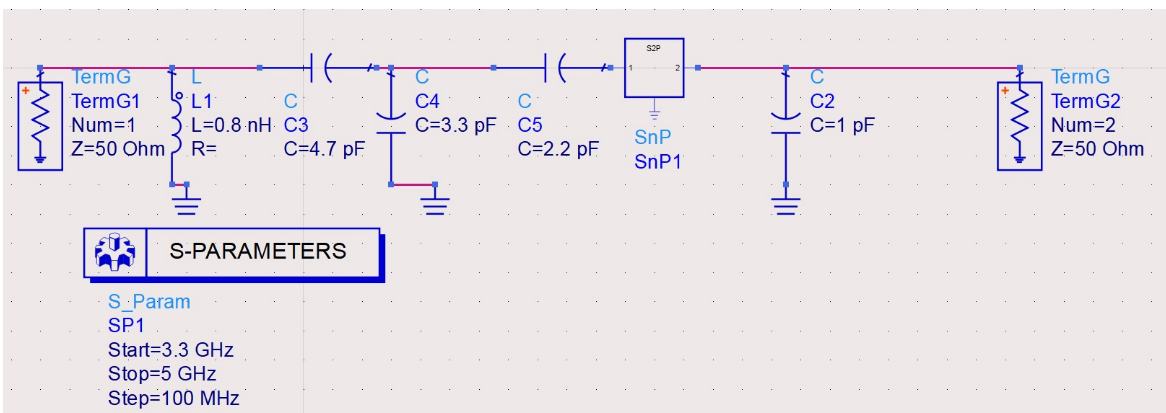
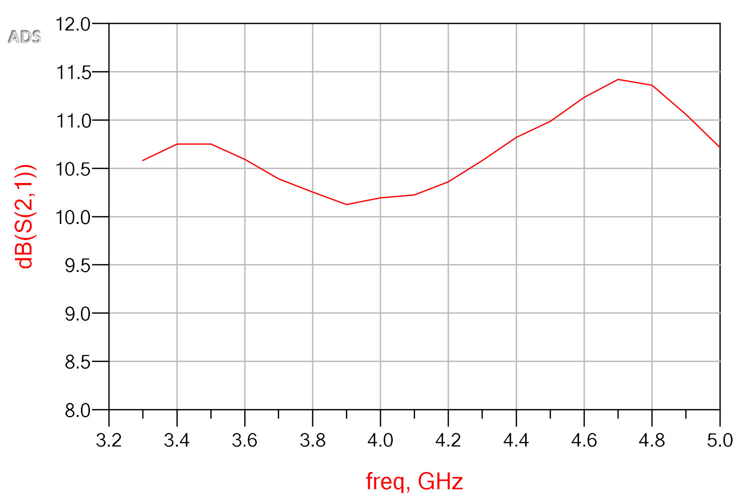


Fig.1d Plot shows the Stability Circle of the XF1001-SC Transistor

Fig.1a, 1b, 1c shows the XF1001-SC Transistor is stable & from Fig.1d, this indicates that any impedance point on the smith chart presented at source and load can attain unconditional stability. Designing the matching circuit based on the impedance point at the desired frequency of interest.





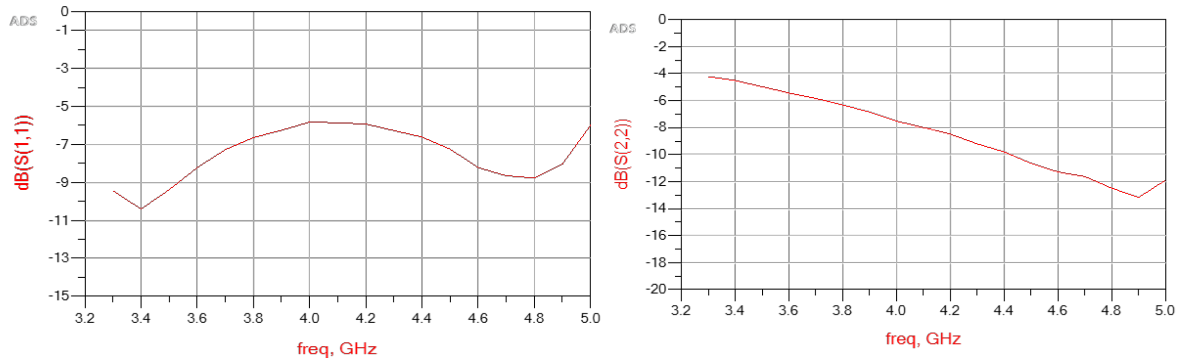
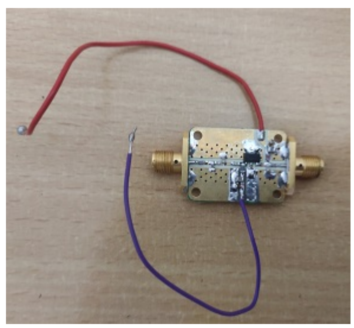


Fig.2. Schematic Diagram & simulation results of RF Amplifier

Figure 2 shows the schematic diagram of the RF Amplifier and simulation results indicates the gain 10 dB in the frequency range of 3.3 GHz to 5 GHz which is sub-6 GHz band of 5G NR.

III. RESULTS OF FABRICATED RF AMPLIFIER



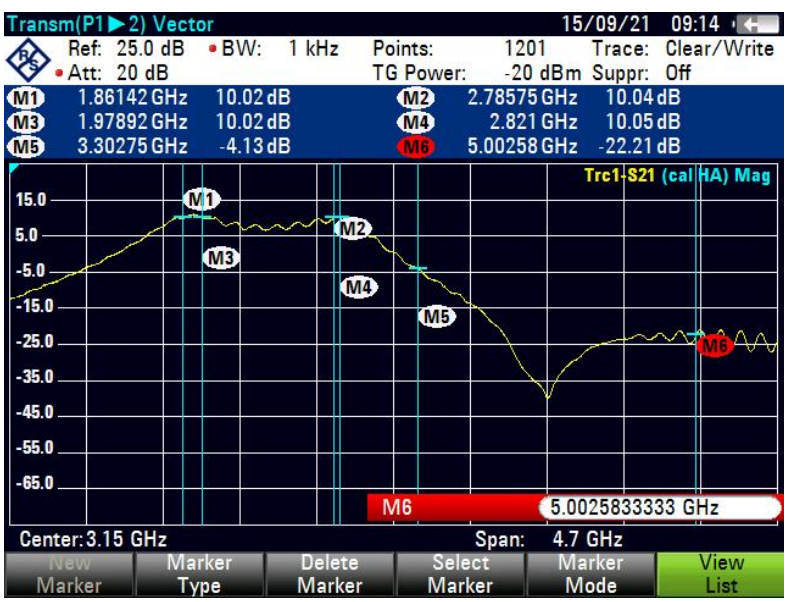


Fig.3 Plot of Gain (S21) measured in Vector Network Analyzer

The Figure 3 shows the gain (S21) measured using R&S Vector Network Analyzer. Observed the shift in the frequency when compared the measured results in Vector Network Analyzer and Simulation results.

To verify the 5G NR Test signal on the RF Amplifier selected 1.97 GHz as center frequency although amplifier not resonated at the desired frequency.

5G NR downlink test signal has been generated at Center Frequency 1.97 GHz, Power level of -10 dBm & Bandwidth of 40 MHz with R&S Vector Signal Generator comprising 5G NR option and analyzed the same using R&S Signal Analyzer & Vector Signal Explorer software with 5G NR option.

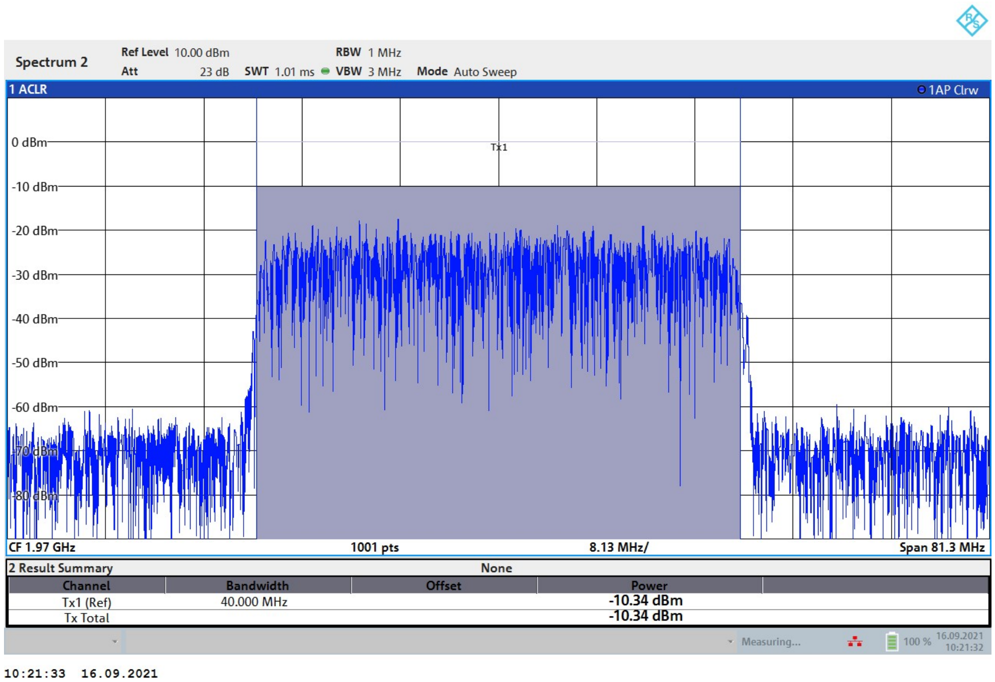


Fig.4. Spectrum & Channel Power Measurements of 5G NR Downlink Signal without RF Amplifier.

Figure 4 shows the measured Spectrum & Channel power of 5G NR Downlink signal without RF Amplifier for a input level of -10 dBm at 1.97 GHz.

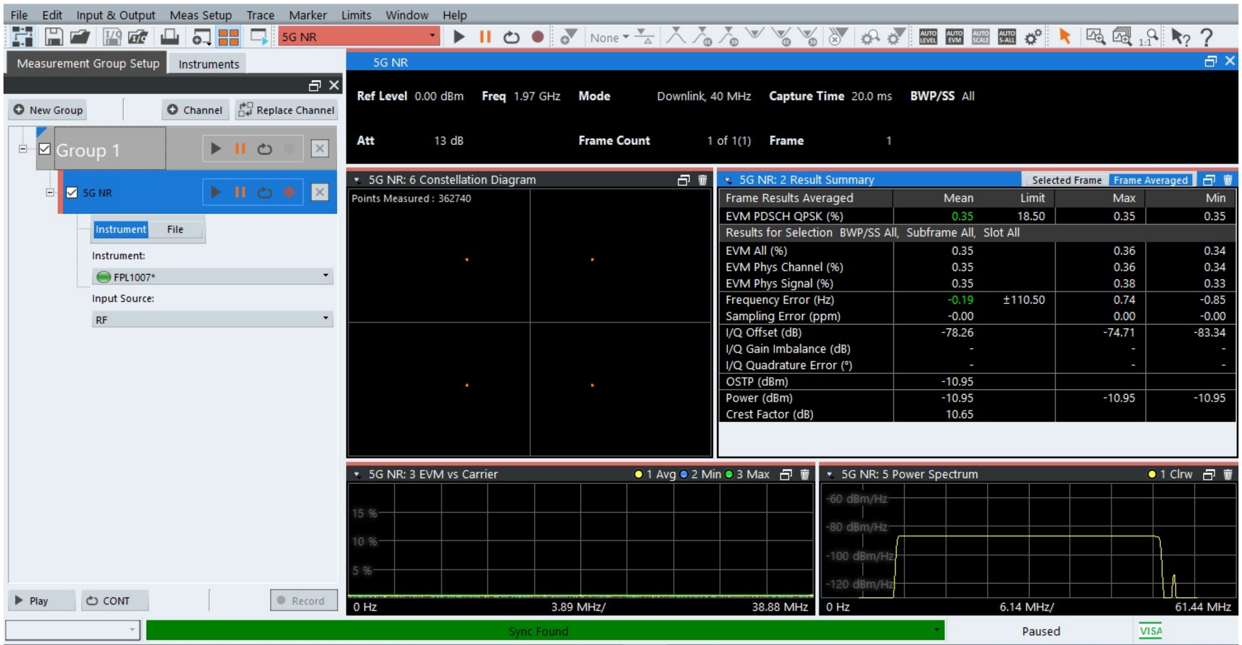


Fig.5 Modulation Analysis of 5G Downlink Signal without RF Amplifier

Fig.5 shows the modulation analysis of 5G Downlink signal without RF Amplifier at 1.97 GHz with Error Vector Magnitude of 0.35%.The figure consists of constellation diagram,result summary,EVM vs Carrier,Power spectrum windows measured using Vector signal explorer software.

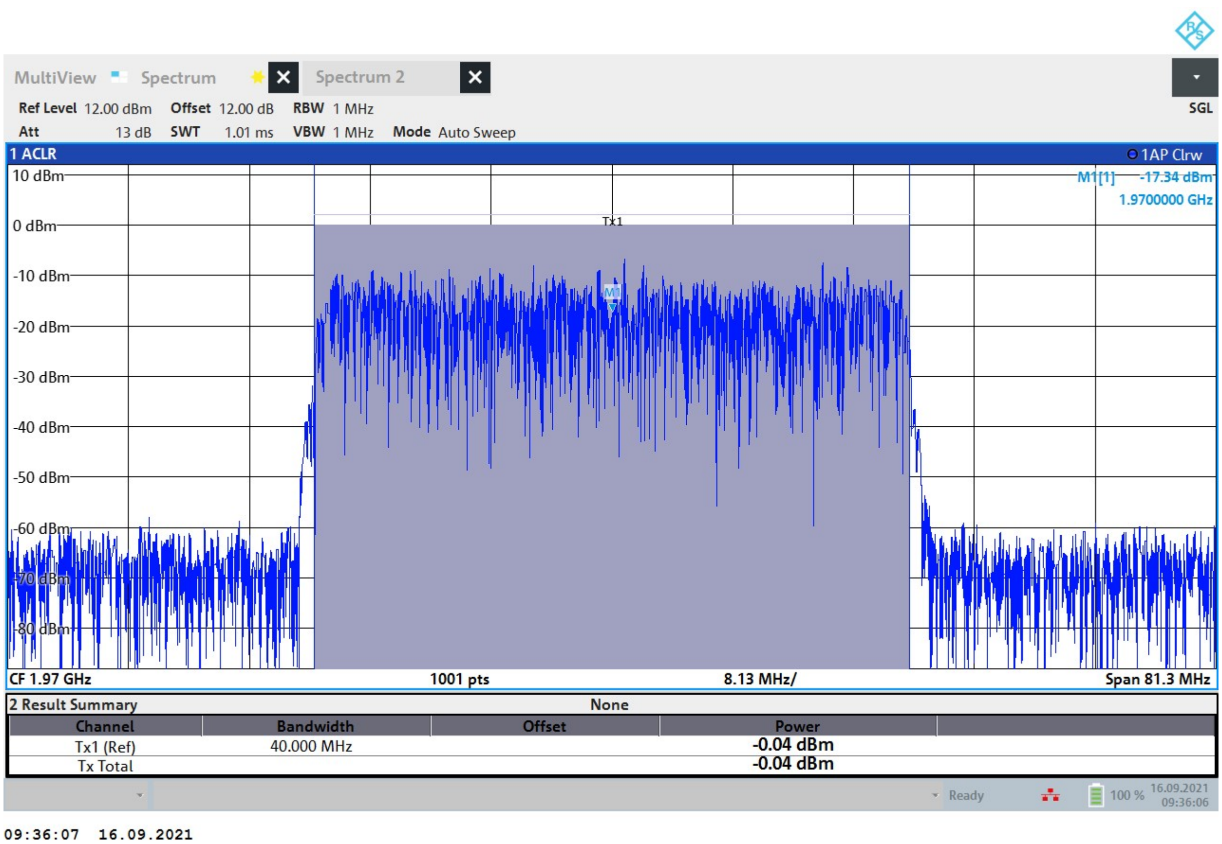


Fig.6 Spectrum & Channel power measurements of 5G NR Downlink signal with RF Amplifier.

Fig.6 shows spectrum of 5G Downlink signal with RF Amplifier & measured channel power of 0 dBm @ 1.97 GHz for input level of -10 dBm which shows 10 dB gain of RF Amplifier.

Fig.7 shows the modulation analysis of 5G Downlink signal with RF Amplifier @ 1.97 GHz with a Error Vector Magnitude of 0.39%.The Figure consists of constellation diagram, result summary, EVM vs Carrier, Power Spectrum windows measured using vector signal explorer software.

There is a difference of only 0.04% in Error Vector Magnitude values of 5G Downlink signal measured with & without RF Amplifier. It is evident that the RF Amplifier is amplifying the signal without distorting.

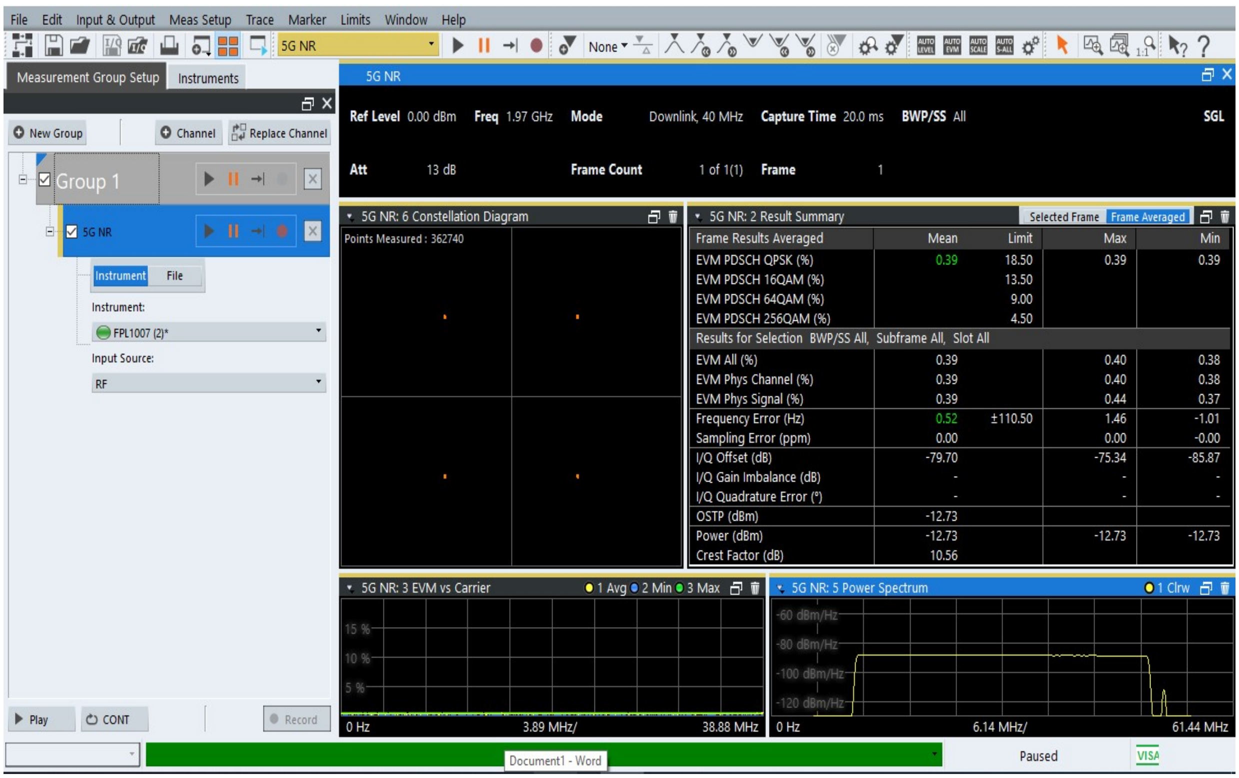


Fig.7 Modulation Analysis of 5G NR Downlink signal with RF Amplifier

IV.CONCLUSION

The RF Amplifier for 5G Applications exhibits good performance when a 5G NR Test Signal is given using Vector Signal Generator in sub-6 GHz band. The Simulation results are found to be at acceptable levels but the fabricated amplifier is to be further investigated to operate at desired frequency range by simulating the DC Model of the Transistor.

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