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DESIGN OF WIDEBAND LOW NOISE AMPLIFIER WITH BYPASS SWITCH USING HYBRID MICROWAVE INTEGRATED CIRCUIT TECHNOLOGY

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ABSTRACT

Low Noise Amplifier is a key component of the radio receiver front end circuit. This project presents a wideband low noise amplifier based on hybrid microwave integrated circuit technology (HMIC) and is mostly suitable for applications such as GPS, satellite, navigation system and cognitive radio receiver. Microstrip is fabricated using printed circuit board technology and it is used as a transmission line to convey microwave frequency signals that's why stability of LNA increases. The proposed work will be intended to give low noise figure, high gain and small size. LNA with Bypass switch allow user to control amplifier in the presence of both high and low signal levels by bypassing the LNA when the signal strength is large. With bypass switch the overall circuit power consumption will reduce in bypass mode.

Keywords: ATF-54143, LNA, low noise amplifier, cognitive radio receiver, navigation application, pHEMT.

1. INTRODUCTION

In every communication system low noise amplifier is the key component. Received signals strength is usually very weak. Low noise amplifier amplifies this weak signal with sufficient gain and adds noise as little as possible at the same time.

In a satellite communications system, received signal by receiving antenna is very weak. To amplify this weak signal low noise amplifier is used after antenna. Because of limited power, satellite uses low power transmitters. Also satellites are far away from the receiving station for example low earth orbit satellites might be 200km away. Large ground antenna would give a strong signal, but a large antenna can be more expensive than adding a low noise amplifier.

Microstrip is a type of transmission line which is fabricated using printed circuit board technology, and is used to convey microwave frequency signals. Microstrip consists of a conducting strip separated from a ground plane by a dielectric layer known as the substrate. Semiconductor devices such as transistor and passive components such as resistor, inductor and capacitor are bounded to a substrate is called Hybrid Microwave Integrated Circuit (HMIC) technology. For this work FR-4 dielectric substrate is used which is having a dielectric constant of 4.6.

2. THE DESIGN OF WIDEBAND LOW NOISE AMPLIFIER WITH BYPASS SWITCH

The most important four parameters in LNA design are: stability, gain, noise figure and impedance matching. For the designing of LNA mostly s-parameter of transistor is used.

The figure number 1 shows the proposed low noise amplifier. Above block diagram contains different blocks they are input matching, output matching, single stage amplifier, DC biasing and bypass switch.

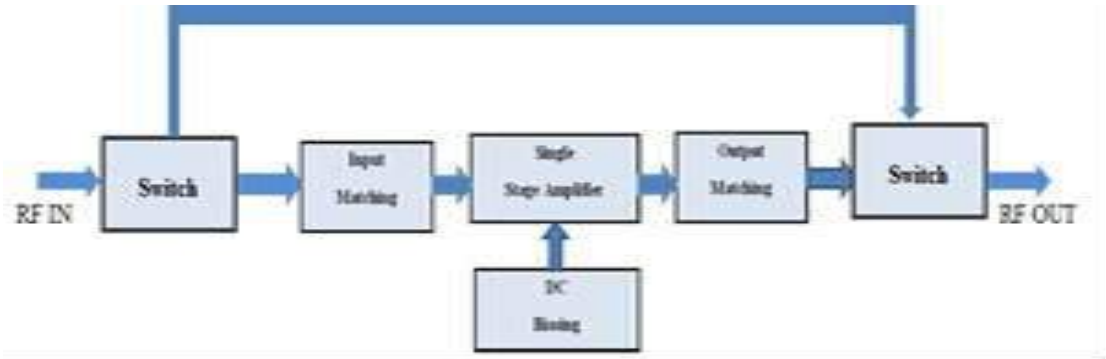

Fig 1: Block Diagram

By limiting the number of components between the antenna and LNA input, noise figure degradation can be mitigated [3]. A high Q input matching network provides an optimal noise figure and gain performance because of the minimal loss, but these networks are often quite sensitive to variations in process, voltage, temperature, and component value.

LNA with Bypass switch allow user to control amplifier in the presence of both high and low signal levels by bypassing the LNA when the signal strength is high [3]. With bypass switch the overall circuit power consumption will reduce in bypass mode. This proposed work will design a wideband low noise amplifier with bypass switch using hybrid microwave integrated circuit technology.

3. BIASING CIRCUIT FOR TRANSISTOR

For transistor biasing we choose the typical operating point, Vdd =5 V, Ids = 60 mA, Vd = 3 V, Vgs = 0.59 V and Ibb = 2mA, according to the datasheet [6]. The design of bias circuit is shown in figure number 2.

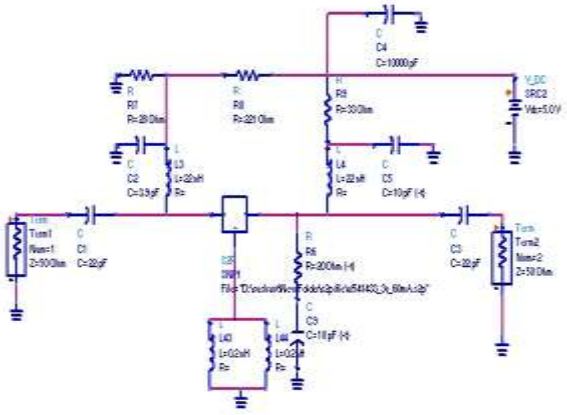

Fig 2: Biasing Circuit

4. LOW NOISE AMPLIFIER DESIGN

Low noise amplifier is designed using pHEMT ATF-54143 transistor. HEMT transistors operate at higher frequency and low noise performance than ordinary transistor [2, 4, 5]. In any LNA design the first step of design is selection of transistor. For low noise figure and high linearity we selected ATF-54143 transistor. In addition, the ATF-54143 is an enhancement mode device, thus it does not require a negative gate voltage. Gate width of transistor is 400 micron. Figure number 3 shows the schematic of low noise amplifier. Low noise amplifier schematic shows Input matching circuit, output matching circuit and biasing circuit.

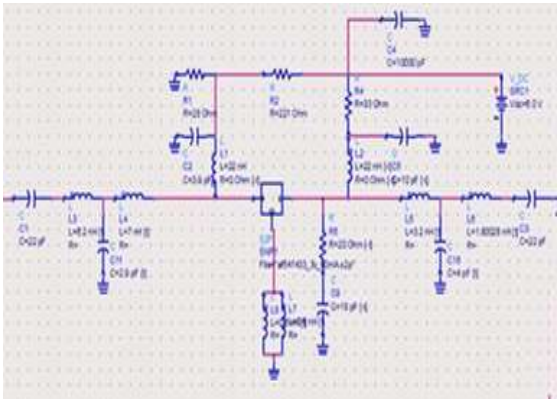

Fig 3: LNA Schematic

5. BYPASS SWITCH

This is used to bypass the LNA when the received input signal strength is high. For this purpose SPDT switch is used. The HMC190BMS8(E) is a low cost SPDT switch in a 8-lead MSOP package. It is especially suited for low and medium power applications using positive control voltages. For SPDT switch positive control voltage 0/+3V is used. Insertion loss is only 0.4dB for HMC190BMS8(E).

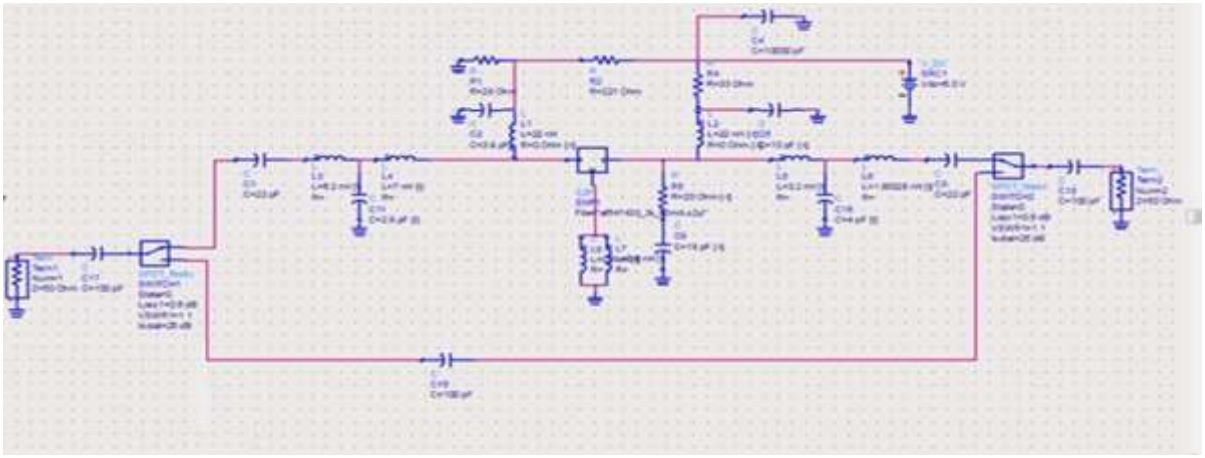

Fig 4: LNA with Bypass Switch

6. STABILITY DESIGN

Low noise amplifier interface with outside world, it must remain stable at all frequencies and any source impedance. To measure stability of microwave design a stern factor is used.

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{21}||S_{12}|} \quad \Delta = S_{11}S_{22} - S_{12}S_{21}$$

If K>1 and Δ<1, the circuit is unconditionally stable.

The stability is most important for LNA. The unconditional stability of LNA can guarantee the network to be stable for all load impedance and passive source [7]. Unconditional stability means that with any load present to the input or output of the device, the circuit will not oscillate. Instabilities are primarily affected by three miracles: external and internal feedback around the transistor produced by external circuit, or excess gain outside of the frequency band. For unconditional stability two inductors are added in the source of transistor and series grouping of resistor and capacitor are connected to drain of transistor [1].

7. MATCHING NETWORK DESIGN

Matching network will match the circuit impedance with 50Ω impedance. If input and output impedance is match with 50Ω then you will get more gain and good noise figure.

Figure number 4 shows the low noise amplifier with bypass switch.

8. Simulation Results

Simulated results of Low Noise Amplifier with bypass switch in Advance Design System (Agilent Technology) is shown in following figures.

Figure number 5 to 8 shows simulations results in LNA mode.

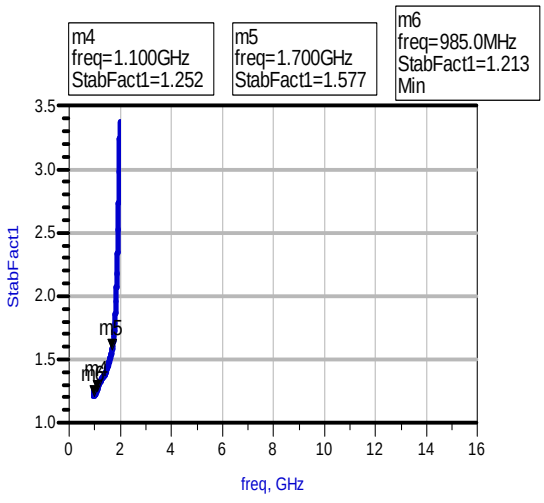

Fig 5: Simulated Result of Stability Factor.

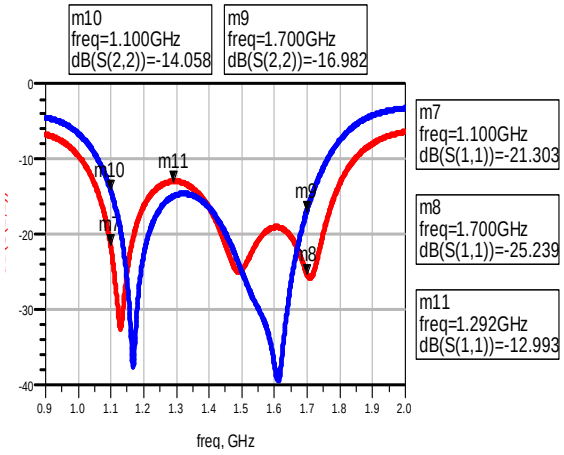

Fig 6: Simulated Result of Return Loss.

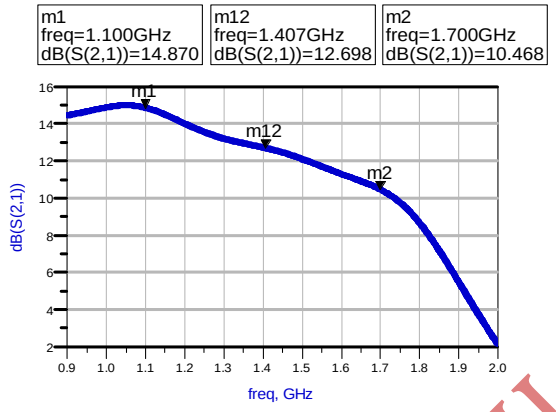

Fig 7: Simulated Result of Gain.

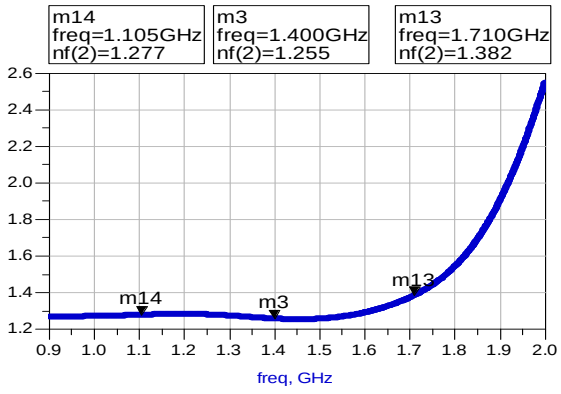

Fig 8: Simulated Result of Noise Figure.

Figure number 9 to 12 shows simulations results in LNA mode.

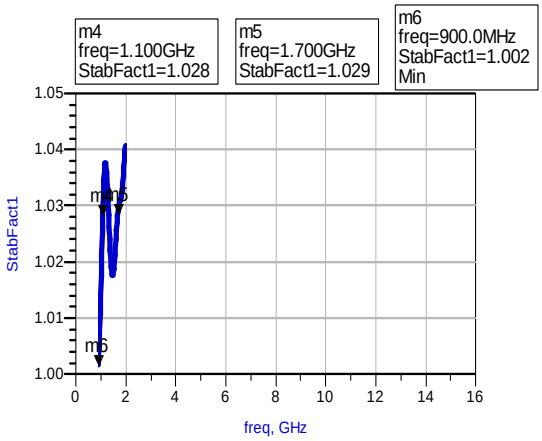

Fig 9: Simulated Result of Stability Factor.

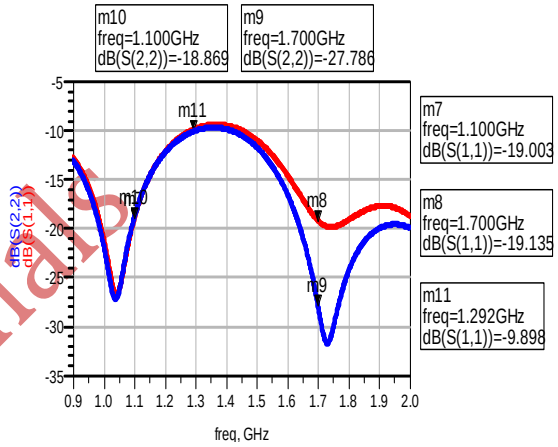

Fig 10: Simulated Result of Return Loss.

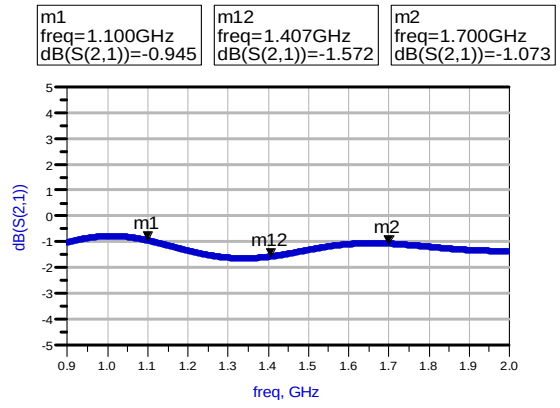

Fig 11: Simulated Result of Insertion Loss.

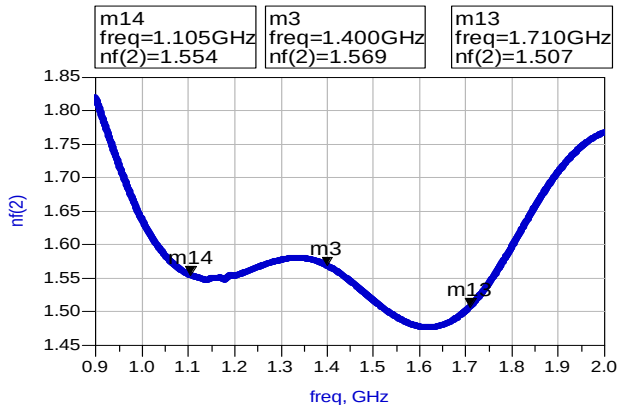

Fig 12: Simulated Result of Noise Figure.

Table 1. Summary of Results in LNA mode

Sr.No	Parameter	1.1 GHz	1.7 GHz	Unit
1	Stability	1.2	1.5	dB
2	Noise Figure	1.2	1.3	dB
3	Input return loss	21.3	25	dB
4	Output return loss	14	16.9	dB
5	Gain	14.8	10.5	dB

Table 2. Summary of Results in Bypass mode

Sr.No	Parameter	1.1 GHz	1.7 GHz	Unit
1	Stability	1.02	1.02	dB
2	Noise Figure	1.5	1.5	dB
3	Input return loss	19	19	dB
4	Output return loss	18	27	dB
5	Insertion Loss	0.9	1.07	dB

9. APPLICATIONS

- Satellite Navigation System.
- GPS, GLONASS, Galileo and BeiDou satellite navigation systems.
- Cognitive Radio Receiver
- Mobile Communication System

10. CONCLUSIONS

A LNA with bandwidth of 1.1–1.7 GHz was designed, which can include the band of GPS, satellite navigation systems and cognitive radio network. We designed the LNA with the HMIC technology to get high gain and low noise figure in ADS (Agilent) tool.

From the above simulation results it is clear that LNA is unconditional stable, noise figure is less than 1.3dB, gain is above 10.5dB and input matching (s11), output matching (s22) parameters are less than -13dB.

11. ACKNOWLEDGMENTS

The designs and simulations were done in ADS (Advanced Design System) at SM wireless solutions. Our thanks to the experts who have contributed in this work.

12. REFERENCES

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