Meenakshi Sundararajan Engineering College

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Department of Electronics and Communication Engineering

Design of Low Noise Amplifier For WLAN IEEE 802.11ax Standard

Team Members: Mohammed Bazith. M, Sendhan Amudhan. M, Vignesh. A **Internal Guide:** Rajendran. M, M.E., [Ph.D]., MISTE.,

ABSTRACT

The receiver's sensitivity can be increased by using a low noise amplifier (LNA), which is able to effectively amplify low radio frequency signals while diminishing overall system noise. The circuit features three stages, of which the first two stages are for minimum noise amplification and the final stage is for maximum gain amplification wide-band amplifier is developed and simulated using Agilent's ADS, and the amplifying stage makes use of the common source topology to enhance gain and achieve greater isolation. For the purpose of increasing the stability of the circuit through the influence of impedance matching, small micro-strip lines are added to the source tone in this design. To minimize the noise figure, traditional source inductive degeneration is used. The developed circuit is subsequently analyzed and simulated. It illustrates that the gain is between 29 dB and 31 dB between 5.9 GHz and 7.1 GHz (6 GHz center frequency), the noise figure is less than 1.5 dB, and the input and output reflection coefficients are less than -15 dB.

INTRODUCTION

Low-noise amplifiers are an essential component in RF systems, including satellite communications, radars, and WLAN applications. The primary function of a low-noise amplifier is to amplify the weak signal received by the receiver system while suppressing the noise signal, thereby reducing the noise figure and increasing the Signal to Noise Ratio (SNR).IEEE 802.11 is a set of LAN technical standards that specify MAC and PHY protocols for implementing WLAN computer communication. IEEE 802.11ax, officially marketed by the Wi-Fi Alliance as Wi-Fi 6 (2.4 GHz and 5 GHz) and Wi-Fi 6E (6 GHz), is an IEEE standard for wireless local-area networks (WLANs) and the successor of 802.11ac. It is also known as high-efficiency Wi-Fi, improving the overall performance of Wi-Fi 6 clients in dense environments. The standard is designed to operate in license-exempt bands between 1 and 7.125 GHz, including the 2.4 and 5 GHz bands already in common use, as well as the much wider 6 GHz band (e.g., 5.925–7.125 GHz in the US, a band 1.200 GHz wide).

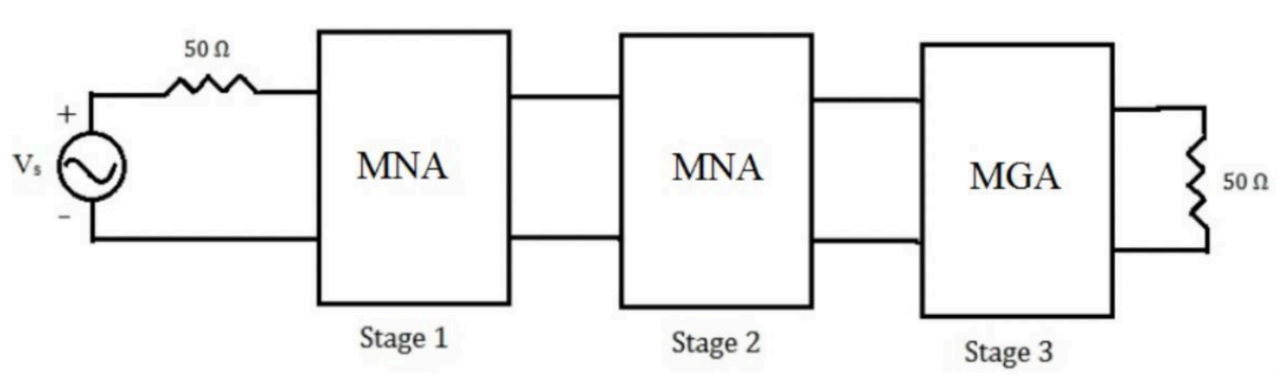
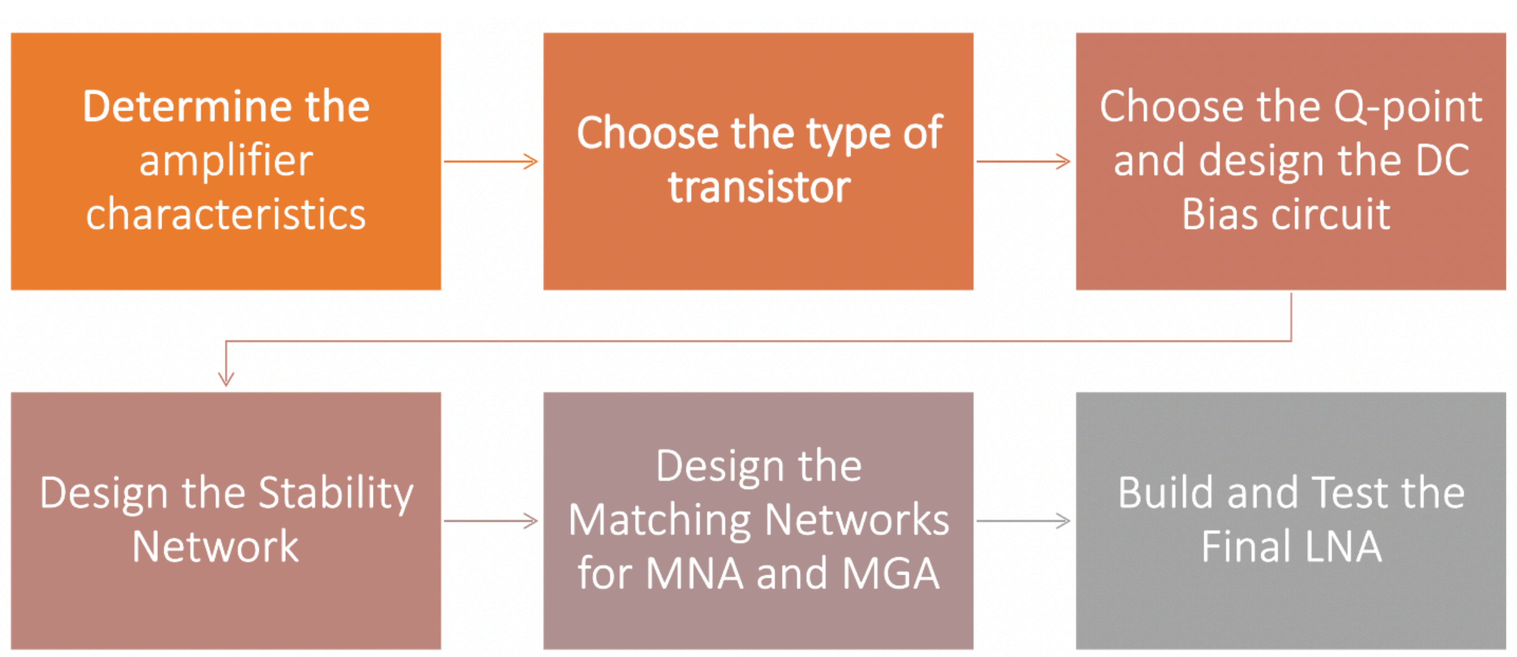


Figure 1: Block Diagram of the Proposed LNA

METHODOLOGY

- Design a LNA for WLAN IEEE 802.11ax standard (Wi-Fi 6E) using three stages of amplifiers.
- Where the first two stages are dedicated for minimum noise amplifications.
- The final stage is used for maximum gain amplification.
- The individual amplifiers of each stage are designed using common source topology.
- Common source topology provides high power gain with low noise figure.



RESULT

The proposed low power LNA for 6-GHz band WLAN IEEE 802.11ax applications has been designed using Agilent's ADS software. The LNA utilizes an ATF-13136 GaAs FET and has a drain and gate bias of 2.41 V and -0.3 V, respectively, drawing a current of 22.9 mA from a 5 V supply voltage. The power dissipation (Pdc) of the LNA is 59 mW. Simulated results of the LNA are presented in Figures 2-6. The ADS software was used for optimization and simulation of the circuit design. The simulation results presented in this paper reveal that the designed LNA exhibits a maximum gain of approximately 31 dB and a noise figure of around 1.042 dB over the frequency range of 5.9 to 7.2 GHz, as evidenced by Figures 2 and 4. Since the noise figure of the LNA is a critical factor in determining the overall noise figure of the RF system, these results indicate that the LNA provides an exceptionally low noise figure for the entire RF system. Furthermore, Figure 3 shows that the input and output reflection coefficients are approximately -15 dB, which indicates that the LNA is well matched. This conclusion is reinforced by the data in Figure 6 which shows that the S11 and S22 parameters are close to the unity point of 1, indicating that the overall LNA is well matched. These results suggest that the designed LNA provides superior performance characteristics, which are essential for 6-GHz band WLAN IEEE 802.11ax applications.

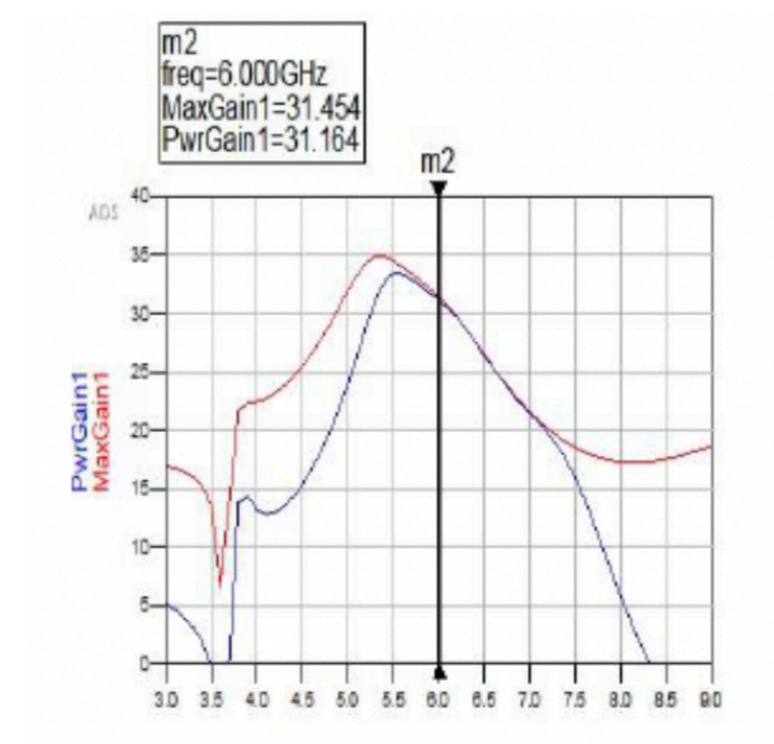


Figure 2: Power Gain and Voltage Gain

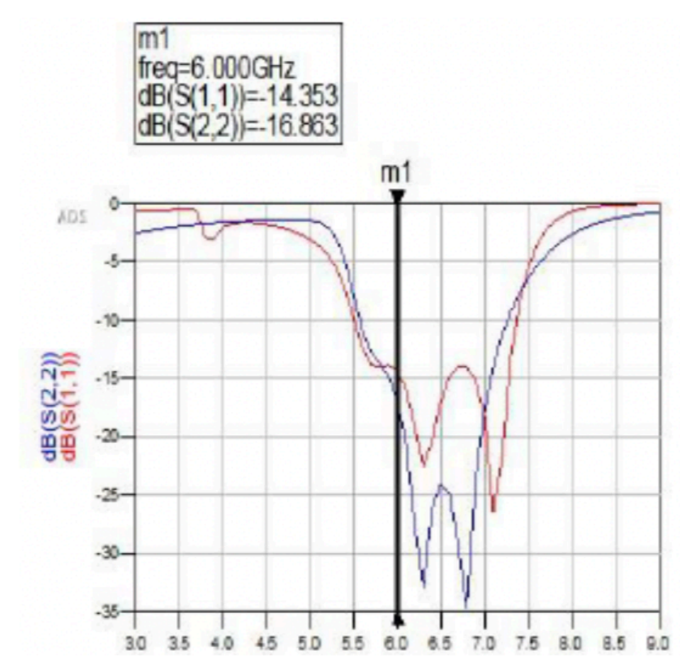


Figure 3: Input and Output Reflection Coeficient

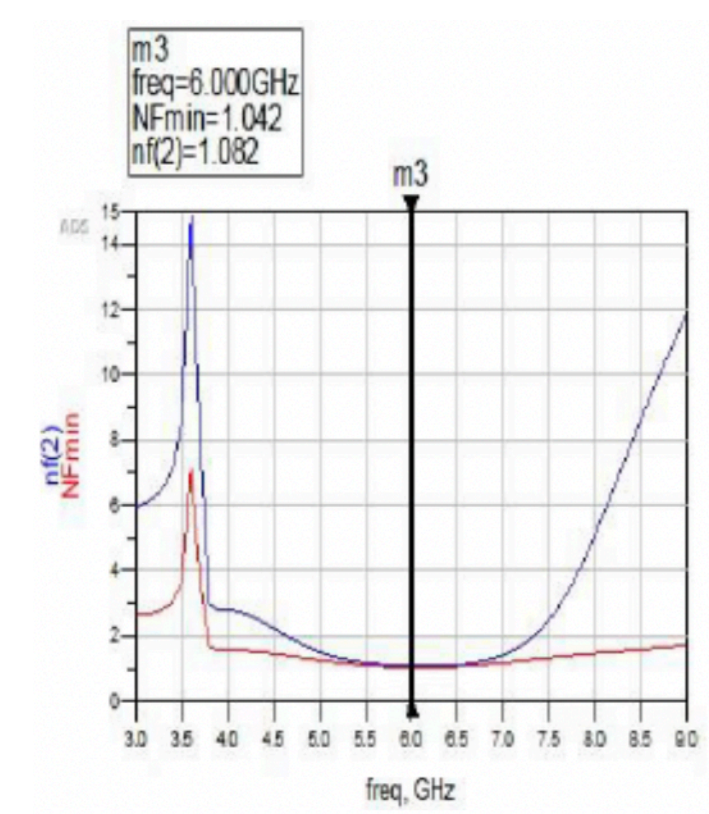


Figure 4: Noise Figure

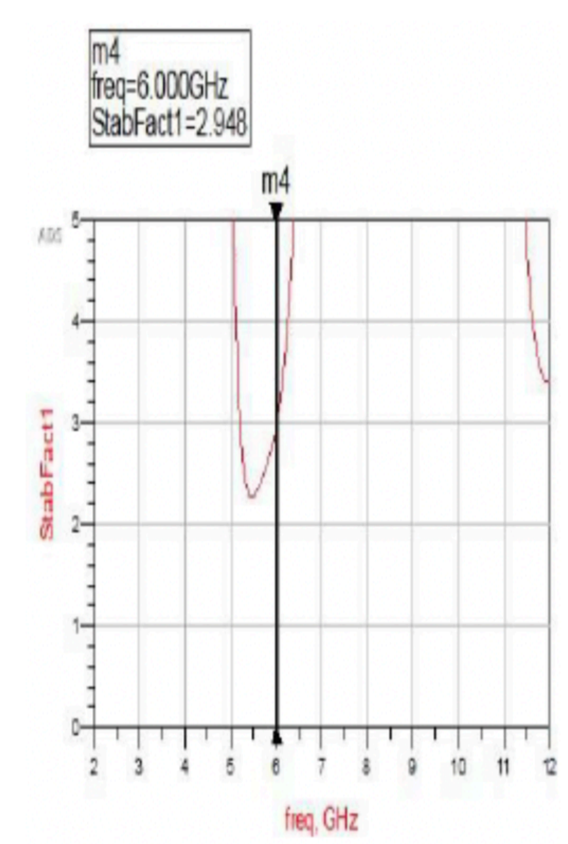


Figure 6: Stability Factor K

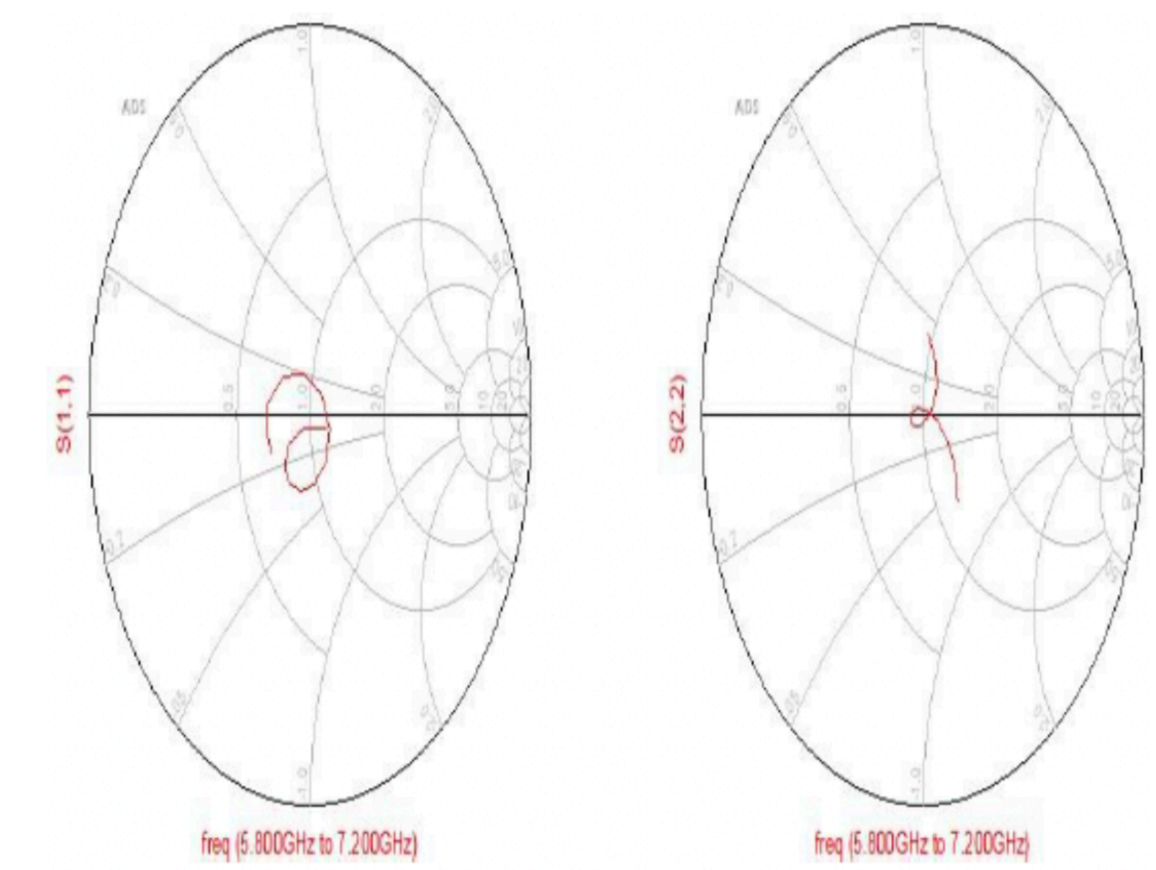


Figure 5: Input and Output Reflection Coefficients in the Smith Chart

CONCLUSION

This project presents the development of a three-stage low-noise amplifier (LNA) for WLAN IEEE 802.11ax. The active device, theATF-13136 transistor, was selected among more than 20 manufacturers, and the ideal bias circuit, input matching network, output network, and inter-stage network were sequentially designed and added to the transistor. The practical LNA was then developed based on the ideal design after tuning and optimization. The final LNA has a maximum gain of 31.54 dB, noise figure less of 1.042 dB, and output return loss of -16.86 dB in the frequency band of 5.9-7.2 GHz. Microstrip lines were used to replace the transmission line, and the frequency range was expanded from the central frequency to the design goal band. The incorporation of a fourth stage in the ultimate low noise amplifier (LNA) design leads to an increase in the overall gain by approximately 40 dB. However, it is worth noting that the other constituent elements in the RF receiver may contribute to the amplification process, rendering the addition of the fourth stage redundant. Moreover, including the fourth stage results in an unnecessary consumption of space within the overall LNA.

Table 1: Simulated Result

Parameter	Result Achieved
Maximum Gain	31.45 dB
Power Gain	31.16 dB
Noise Figure	1.042 dB
Input Reflection Coefficient (S11)	-14.35 dB
Output Reflection Coefficient (S22)	-16.86 dB
Power Consumption	59 mW
VDS (Drain to Source Voltage)	2.41 V
VGS (Gate to Source Voltage)	-0.3 V
IDS (Drain to Source Current)	22.9 mA

FUTURE SCOPE

In the field of WLAN applications, future enhancements in LNA design may involve the use of advanced techniques to improve linearity, dynamic range, and power efficiency. One potential approach is the use of wide-band or multi-band LNAs that can operate across multiple frequency bands, enabling greater flexibility in wireless communication systems. Another avenue for improvement is the integration of LNAs with other components, such as filters or mixers, to reduce system complexity and improve overall performance. Additionally, the use of advanced digital signal processing techniques, such as adaptive filtering or interference cancellation, may enable the design of highly robust and reliable WLAN systems. Overall, future advancements in LNA design for WLAN applications are focused on enabling higher data rates, longer ranges, and improved quality of service in wireless networks.