VERIFICATION AND SIMULATION OF HIGH GAIN CLASS C POWER AMPLIFIER USING GAN TRANSISTOR AT X BAND FREQUENCY

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ABSTRACT

In the current methodology Effective impedance matching is essential for GaN transistors to get maximum performance, which may be difficult owing to their high-frequency and power attributes, frequently necessitating precise biasing for effective operation in Class AB mode. Maintaining stability across the operational frequency spectrum might be more intricate than using silicon transistors. Class C power amplifiers utilizing GaN (Gallium Nitride) transistors present numerous advantages over Class AB power amplifiers, especially in scenarios demanding efficiency and elevated power. Class C amplifiers function with a conduction angle of less than 180 degrees, yielding significantly greater efficiency than Class AB amplifiers. GaN transistors improve efficiency owing to their increased electron mobility and less on-resistance. The increased efficiency of Class C amplifiers results in less power dissipation as heat. GaN transistors, due to their exceptional thermal performance, permit more efficient heat management, which is essential in high-power applications. This proposal presents the design of a GaN power amplifier operating at S-band frequency. Class AB power amplifiers with GaN (Gallium Nitride) transistors have several benefits, such as enhanced efficiency and power density. The suggested power amplifier may be developed with the ADS (Advanced Design System) software tool at 150nm technology. The amplifier's properties, such as gain, stability factor, and harmonic balancing, will be advantageous for radar applications.

Keywords: GaN HEMT, High gain, High Band width, X-band Applications

I.INTRODUCTION

High-performance power amplifier development is essential for a number of applications, such as satellite communications, radar systems, and telecommunications. The Gallium Nitride great Electron Mobility Transistor (GaN HEMT) is one of the most promising technologies for attaining great efficiency and power output in these systems. GaN HEMTs outperform conventional semiconductor materials like silicon in terms of power handling, thermal stability, and efficiency, making them especially useful in high-frequency applications. Because of these characteristics, GaN HEMTs are perfect for use in X-band power amplifiers, which are essential parts of many cutting-edge systems that operate in the 8–12 GHz frequency range.

The choice of a suitable GaN HEMT device is the first of many crucial phases in the construction of the X-band amplifier. Since the transistor must fulfill the power and frequency requirements for X-band operation, the selection is crucial. An important development in RF and microwave engineering is the GaN HEMT-based X-band power amplifier, which has the potential to provide high-power, high-efficiency amplification in demanding applications. This amplifier design pushes the limits of current communication and radar technologies while simultaneously [1] satisfying the technical requirements of X-band systems by using the special qualities of GaN HEMTs. The design guarantees that the amplifier will operate dependably and effectively by means of thorough modeling, optimization, and validation, providing a crucial part for the next generation of high-frequency systems. Section I serves as the introduction to this study. Section II is an overview of the literature. Section III: Current Approach. Section V: Conclusion and Future Scope; Section IV: Suggested Approach.

II. LITRATURE SURVEY

Applications in the X-band including military communication, satellite communication, and radar need for power amplifiers that can manage large power outputs and function [3] well at high frequencies. At higher frequencies, the power handling and thermal management capabilities of conventional semiconductor materials like silicon and gallium arsenide (GaAs) are limited. In order to satisfy the demanding criteria of X-band power amplification, GaN HEMTs are particularly advantageous due to their capacity to function with larger power densities and reduced losses at raised frequencies. The need to maximize output power and efficiency while minimizing power consumption also affects the design of power amplifiers in the [2] X-band. Designing power amplifiers that can provide high output power without using excessive amounts of energy is becoming more and more crucial as systems becoming more complex and power-hungry. A GaN HEMT-based X-band power amplifier's design must take into account a number of important factors to guarantee that the amplifier operates as intended. These consist of circuit design, heat management techniques, and the choice of suitable GaN HEMT devices.Device Selection: Choosing the right GaN HEMT device that satisfies the X-band application's power, frequency, and efficiency [5] criteria is one of the initial stages in the amplifier design process. When choosing the device, important factors including thermal resistance, current handling capability, maximum drain-source voltage (Vds), and gate-source voltage (Vgs) are considered. Simulation and Testing: Advanced Design Systems (ADS) and other simulation tools are utilized to get the most out of the GaN HEMT-based X-band power amplifier. These tools make it possible to create intricate models of the amplifier circuit that include thermal properties,[4] biasing conditions, and device specifications. Before physically constructing the circuit, designers may use simulations to assess the amplifier's performance in terms of power gain, efficiency, linearity, and other important factors. This guarantees that the design satisfies all requirements while drastically cutting down on development time

III.EXISTING METHOD

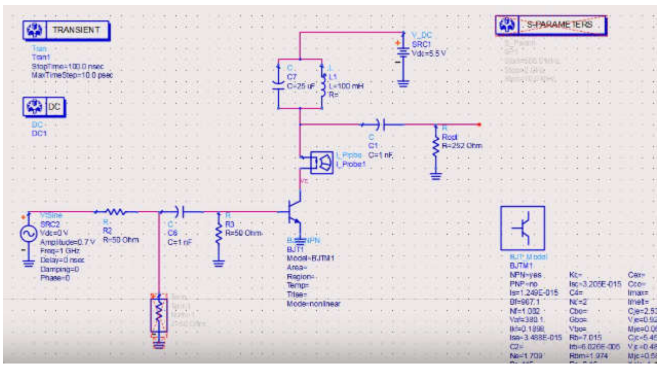

Fig.1. Existing method Class C Power amplifier

Wideband HPAs are necessary for the future generation of radar and wireless communications systems in order to support [6] numerous bands and operating standards. Additionally, as HPAs are the most energy-intensive parts of radar transmitters and wireless telecommunications systems, great efficiency and small size will also be necessary if the HPAs are used in a mobile platform. It will be less expensive and need less inventory with a single multiband HPA. A cutting-edge European foundry that has been creating GaN technology and products for many years is United Monolithic Semiconductor. Over the last several years, the development of high-power, efficiency-enhancing methods and the idea of broadband amplifiers have gained significant attention. Harmonic tuning is a popular method of efficiency increase. Nevertheless, narrowband applications with fractional bandwidths of up to 10–20% are the only ones that employ these amplifiers.[7] Furthermore, it is challenging to sustain suitable higher harmonic loading conditions across many bandwidth octaves for high-efficiency classes of operation. The current approach suffers from high power conversion, band width requirements, gain augmentation, and power amplification. The suggested approach provides a precise answer to the issues mentioned above.

IV.PROPOSED SYSTEM

Several crucial steps are involved in the design of a GaN HEMT-based X-band power amplifier to guarantee peak performance in high-frequency applications. [9] Establishing the operating parameters, including the frequency range (8–12 GHz), target output power, power-added efficiency (PAE), and gain, is the first step in the process. High breakdown voltage, excellent thermal conductivity, and high power density are just a few of the remarkable qualities that make the GaN HEMT device the perfect choice for high-frequency and high-power amplification. These characteristics are essential for guaranteeing reliable performance and effectiveness in demanding applications like satellite communications and radar. A small chip that incorporates the GaN HEMT and other passive components is known as an MMIC layout design. Transmission lines are either coplanar waveguide or micro strip, [8] and precise grounding procedures reduce electromagnetic interference. Metal deposition for strong electrical connections, photolithography for accuracy, and epitaxial growth of GaN on SiC substrates for temperature control are some of the techniques used to construct the MMIC. The manufactured amplifier is then put through a thorough testing process to confirm its functionality. Real-world scenarios are used to measure linearity, [10] efficiency, output power, and gain. Based on these findings, the design is adjusted to guarantee that the amplifier operates at peak efficiency with the least amount of distortion and with the highest level of dependability

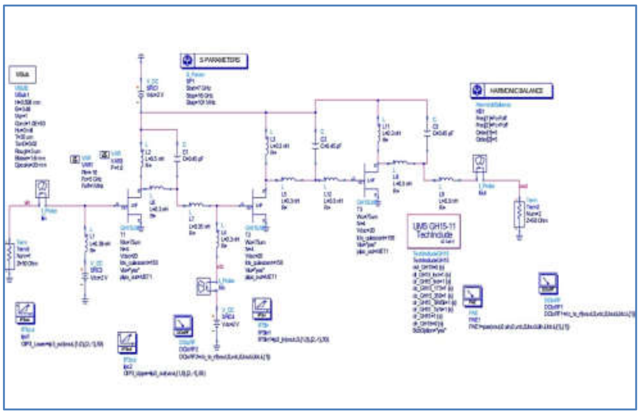

Fig.2. Proposed method Class C Power amplifier

This schematic shows a well-structured design to [11] maximize high-frequency performance and describes the whole operation of an RF/microwave amplifier. A termination block (Term1), which usually represents the source impedance of 50 Ω, opens the input stage. The source impedance is then matched to the input impedance of the first GaN HEMT transistor (GH15_1) by a meticulously constructed input matching network made up of lumped components (capacitors and inducers). Over the designated frequency range, the matching network guarantees effective power transmission and reduces reflections. The GaN HEMT transistors, which are high-performance devices appropriate for high-power, high-frequency amplification, are the foundation of the active device stage. To select the correct operating points, such as Class A, AB, or C operation, depending on the intended application, the transistors are appropriately biased with the use of specialized V_DC sources. Using RF chokes and bypass capacitors to stop signal interference preserves bias stability. The implementation of an [12] interstate matching network between the active stages guarantees optimum signal transmission from the first transistor's output to the second transistor's input. While keeping a high gain and bandwidth, this network further minimizes signal losses and reflections. This low-noise amplifier (LNA) uses a GaN transistor to amplify signals at high frequencies, around 5 GHz. Applying the input RF signal [13] via a 50-ohm termination guarantees that the source and input impedance match. High-frequency signals may flow via an inductor in the input channel that functions as an RF choke, blocking DC components. By connecting a DC voltage source via this inductor, the transistor is biased to provide the required gate voltage for correct functioning. Trans conductance and the impedance at the input define the gain [14] of the transistor, which amplifies the radio frequency signal. In order to provide optimal power transmission from the source to the transistor and improve the amplification efficiency at the intended operating frequency, the reactive components (and) are essential for impedance matching and resonance. The output matching network, which consists of a capacitor and inductors, receives the amplified signal at the drain. By limiting reflection losses and matching the transistor's output impedance to the load impedance, this matching network guarantees effective power transmission. Analyzing the circuit's performance using harmonic balancing simulation focuses on variables such as gain, [15] power-added efficiency (PAE), and intermodulation distortion (IP3). The LNA is perfect for applications like radar and satellite communications because it can achieve high gain, low noise, and efficient operation with the proper tuning of the matching networks and bias conditions.

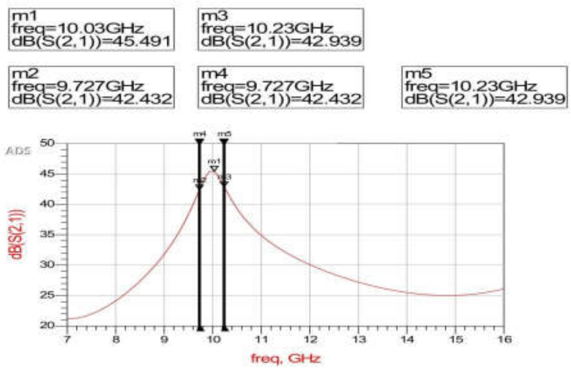

Fig.3. Proposed method Class C Power amplifier Simulation Results

COMPARISON TABLE

Ref.	Technology	Freq. [GHz]	Operation Class	Stages	Pout [W]	G1 [dB]	PAE [%]
SE-HPA	0.15μm GaN	8-12.5	AB	2	14-17	23	50-62
BA-HPA	0.15μm GaN	8-12	AB	2	14-17	22	50-55
[6]	0.25μm GaN	9-11	AB	2	35-45	19	40-52
[7]	0.25μm GaN	7.8-8.8	AB	2	22.5	26	50
[8]	0.15μm GaN	/	AB	1	28-31.5	11-12.5	57-60
[9]	0.14μm GaN	9.8-11.5	Cascode	1	5.8-9.2	7-12	50-62
This Work	0.15um GaN	8-12	C	3	56.2-74	21-26	40-49

V.CONCLUSION AND FUTURE SCOPE

Using Gallium Nitride (GaN) HEMT technology, this project effectively illustrates the design and implementation of a sophisticated X-Band Power Amplifier MMIC. Utilizing a Class AB architecture, the amplifier meets the demanding requirements of contemporary radar and communication systems operating in the 8–12 GHz X-band by striking the ideal balance between linearity and efficiency.With a power output of 40–50 dBm and a Power Added Efficiency (PAE) of 30–40%, the amplifier produces an impressive 45 dB gain. This efficiency much surpasses conventional amplifier technologies, although being somewhat below theoretical maximums, demonstrating the supremacy of GaN HEMTs in high-power RF applications

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