

# Performance Analysis of 4T-GNRFET based Cascode Amplifier at 45 Nanometer Technology Node for A.I. Applications

Nasreen Bano<sup>1</sup>, M. Nizamuddin<sup>2</sup>

Jamia Millia Islamia, New Delhi, India<sup>1,2</sup>

**Abstract:** In this research paper, design and simulation of 4T-GNRFET Cascode Amplifier at 45 Nanometer Technology Node has been performed. DC voltage gain, average power, bandwidth and output resistance have been computed using HSPICE Software. Further, the low voltage Cascode Op Amp has better DC Gain, output resistance and less power dissipation. DC voltage gain is 39.5dB, average power is 30 nW, bandwidth is 3.6MHz, Phase Margin 89.3<sup>0</sup> and Output Resistance 35.15 K-Ohms as obtained from simulation results of HSPICE Software. The proposed circuit of 4T-GNRFET based Cascode Amplifier at 45 Nanometer Technology Node is suitable for A.I. Applications due to astonishing electronic properties of proposed circuit.

**Keywords:** 4T-GNRFET-Cascode amplifier, Output Resistance, Band width, Average Power, DC Gain

## INTRODUCTION

Operational amplifiers are integral to enhancing the functionality of VLSI chips, particularly in the rapidly evolving field of IoT (Internet of Things) and Artificial Intelligence (AI), they face performance challenges due to the limitations of conventional CMOS (complementary metal oxide semiconductor) technology. As feature sizes shrink, gain and bandwidth degradation arise from dopant variations, mobility degradation, and increased wire resistivity [1–4]. This necessitates the exploration of alternative technologies to overcome these limitations and improve analogue circuit performance. Simultaneously, the demand for innovative VLSI designs in IoT and Artificial Intelligence (AI) applications underscores the need for advancements that address both the opportunities [1-4].

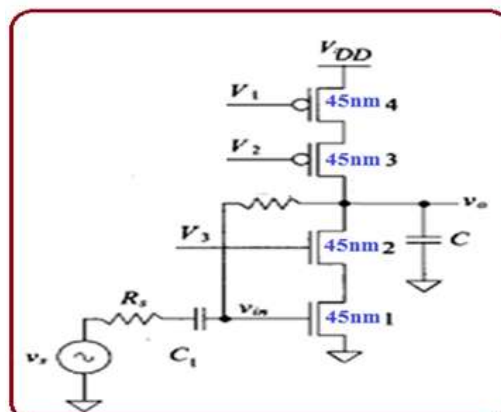


Fig 1 Conventional CMOS Cascode amplifier

This paper begins with an overview of CMOS and GNRFET based Cascode Amplifier in section 2, Simulations of proposed 4T-GNRFET-Cascode Amplifier in section 3, & Section 4 gives its conclusion.

## Graphene and Graphene Nanoribbon (GNR)

Graphene is a single graphite sheet having a 2-D honeycomb structure. It is renowned for lacking a bandgap, which results in inherent and exceptional conductivity. The design can be considered an unrolled carbon nanotube [5-6]. The material has remarkable properties, such as higher carrier mobility than typical silicon technology, allowing for the display of ballistic transport. Excellent thermal conductivity and high carrier velocity suit it for fast switching applications. Graphene can be patterned into 1-D narrow strips, often dubbed Graphene Nanoribbons (GNRs) less than

10 nm wide, opening up a bandgap and creating excellent semiconducting. Theoretical investigation has revealed an inverse link between the band gap of GNRs and their width [5-8]. The edge condition also has an impact on conductivity. Armchair-edged GNRs (AGNR) are predominantly semiconducting, whereas zigzag-edged GNRs (ZGNR) have metallic properties [7-8].

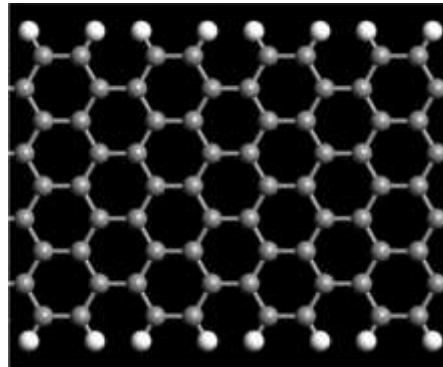


Fig 2. Armchair-type GNR lattice structure with dimer lines = 9.

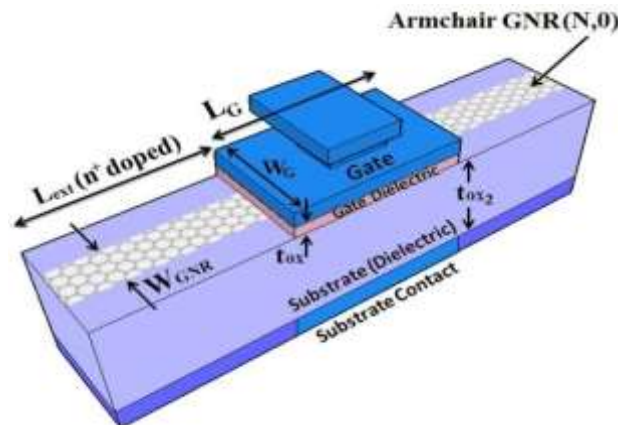


Fig 3. GNR-FET transistor structure

**PROPOSED 4T-GNRFET- CASCODE AMPLIFIER**

Common Source amplifier with current source load is implemented using GNRFET Technology of 45nm. The gain of the general Amplifier is low. To boost the gain of the single-stage amplifier and to eliminate, or more correctly to reduce, the Miller effect, consider the cascode amplifier. The gain of the cascode amplifier is the resistance in the drain divided by the resistance in the source of the amplifying device. Input ac signal is applied at the gate of M1 to amplify.

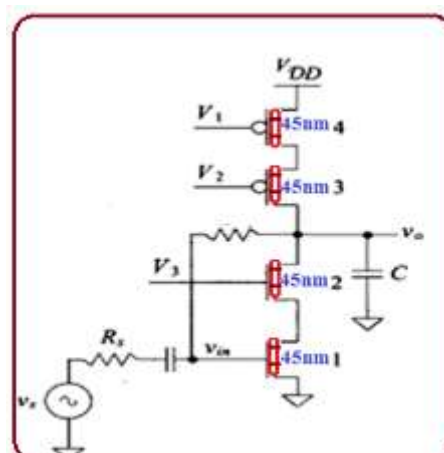


Fig 4: Proposed 4 T- GNRFET Cascode amplifier

**SIMULATIONS OF PROPOSED 4T-GNRFET-CASCODE AMPLIFIER**

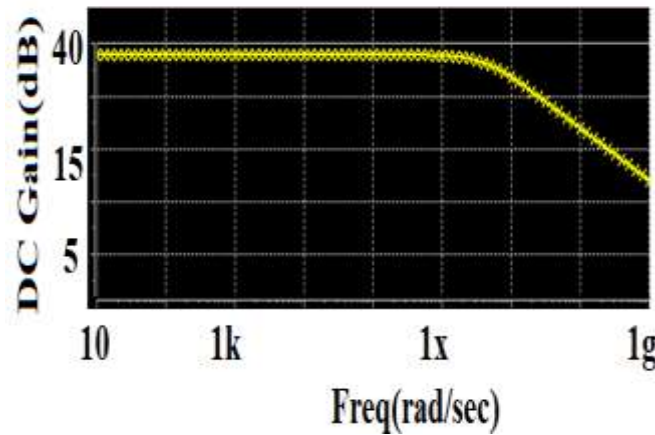


Fig 5: Frequency response of 4T-GNRFET-Cascode Amplifier at 0.9V

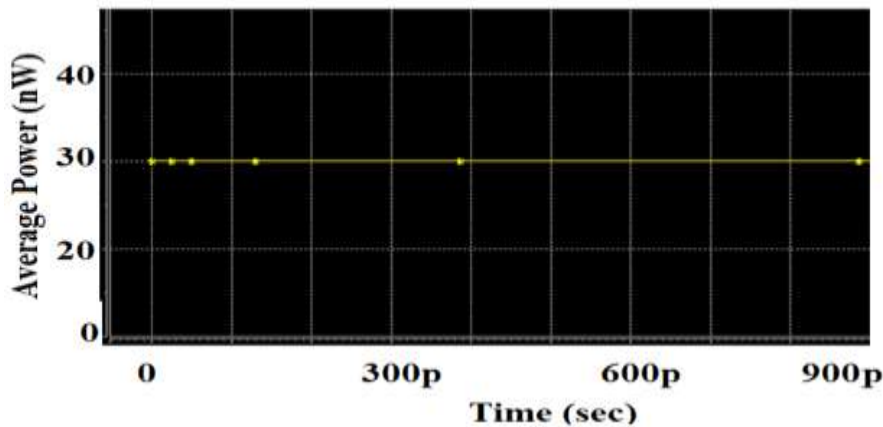


Fig 6 : Average Power of 4T-GNRFET-Cascode Amplifier at 0.9V

**RESULT AND CONCLUSION**

This paper has successfully designed and simulated 4T-GNRFET- cascode amplifier at 45nm. Further, the low voltage Cascode Op Amp has better DC Gain, output resistance and less power dissipation. DC voltage gain is 39.5dB, average power is 30 nW, bandwidth is 3.6MHz , Phase Margin 89.3<sup>0</sup> and Output Resistance 35.15 K-Ohms as obtained from simulation results of HSPICE Software. The overall design and indicates that the four transistor GNRFET based cascode amplifier has excellent performance in terms of DC gain, output resistance, Band width and average power as desired for AI. And IoT Applications.

Table 1: Comparative analysis of Simulation of 4T-GNRFET-Cascode Amplifier at 45 Nanometer Technology Node.

S. No.	Parameters	4T-GNRFET-Cascode Amplifier at 0.9 V
1	DC Gain	39.5dB
2	Bandwidth	3.6 MHz
3	Output Resistance	35.15 K-Ohms
4	Average Power	30 nW
5	Phase Margin	89.3 <sup>0</sup>



Table 2: Parameters used in the proposed 4T-GNRFET-Cascode Amplifier

S. No.	Parameters	Value	
1	Channel Length	45nm	
2	Channel Width	763nm	
3	Supply Voltages	0.9V	
4	GNRFET-nMOS Transistors	2	
5	GNRFET-pMOS Transistors	2	

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