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Voltage Gain in Non- Isolated DC/ DC Converter Using GAN FET

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I. PROBLEM STATEMENT

Most of power devices made from silicon (Si), are approaching their theoretical performance limits as they suffer from high conduction and switching losses under harsh operating conditions. Wide bandgap (WBG) semiconductors contain superior materials allowing power devices to operate efficiently at higher blocking voltages, switching frequencies, and junction temperatures.

II. INTRODUCTION

The depleting resources that are causing the energy crisis, is compelling the world to shift to renewable resources for a sustainable future. The low output voltages and discontinuous characteristics of renewable energy sources can be alleviated by various step-up DC-DC converters. Two-inductor non-isolated step-up converters have been gaining popularity in recent years owing to their simpler operation and higher step-up voltage gain when compared to conventional boost converters [1]. Apart from that, Technological advancement has also brought many changes in semiconductor devices like MOSFETS etc.

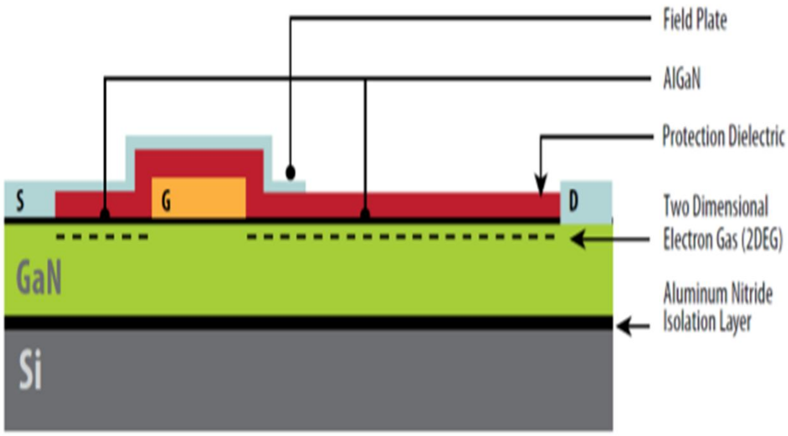

Figure 1. Basic structure of GAN [2]

The technology of silicon power devices that has been widely used in semiconductor devices for decades has matured as well. Their limits in terms of power density, operating temperature and switching frequency have also been reached [3]. However high density power converters operating temperature, and switching frequency are still very demanding in several application areas.

New wide bandgap semiconductor materials, shows advantages to overcome the limits of silicon semiconductor materials. The bandgap characterization of a material pertains to the energy required for an electron to jump from the top of the valence band to the bottom of the conduction band within the semiconductor [4].

Semiconductor materials that fall under the heading of “wide bandgap materials” typically require energy larger than two or three electron-volts (eV). Nowadays, two very important wide bandgap materials promising a great future are Gallium Nitride (GAN) and Silicon Carbide (SIC). These wide bandgap semiconductors show several advantages over traditional semiconductors and are gradually changing the market.

Table 1.1 shows several material properties of silicon carbide (SIC), silicon (SI), and Gallium Nitride (GAN), including critical field, bandgap, electron saturation velocity and electron mobility. These material properties have major influence on fundamental performance characteristics of the corresponding devices [4]

Table 1.1 Material properties [5]

Material properties	Si	SIC	GAN
Bandgap [eV]	1.1	3.2	3.4
Critical field [MV/cm	0.3	3.0	3.5
Electron mobility [cm2/Vsec]	1450	900	2000
Electron saturation velocity [106cm/sec]	10	22	25

The bandgaps of SIC and GAN are 3.2 eV and 3.4 eV respectively, which are about three times higher compared to that of Si (1.1 eV). The bandgap property has major influence on the concentration of intrinsic carriers in a semiconductor device in the form of an exponential function [6].

$$n_i^2 = Nc\, N_V \exp[-E_G / k_b T] \qquad \text{Eq 1}$$

where E_G is the bandgap energy, T is the temperature, N_C is related to conduction band density of states, N_V is associated with valence band density of states, and k_B is the Boltzmann constant [6].

The main reason that the operating temperature of normal Si devices is limited is that the leakage current is significant at high temperatures [7]. However, for wide bandgap materials, such as SIC and GAN, the p-n junction leakage current in these materials can remain relatively low at high temperatures. It is because they have higher bandgap energy compared with Si, so that the influence on leakage current due to temperature increase can be reduced [8]. As a result, the wide bandgap characteristics allow SIC and GAN power devices to operate under much higher temperature conditions than Si power devices. [4] The GAN power device in the converter offers better performance, lower switching loss, and more energy efficiency than the conventional interleaved boost converter with Si devices [9].

III. OBJECTIVES

The objective of this work is to

1) Implementing Two-Inductor Non-Isolated DC-DC Converter with High Step-Up Voltage Gain
2) Design a non-isolated two inductor dc/dc converter using GAN
3) Assess the performance of GAN FET in Two Inductor DC to DC converter
4) Comparison of resulting total power loss and overall efficiency of the two converters

IV. METHODOLOGY

To achieve the objective the study will focus on the following tasks.

1) To simulate two-inductor non-isolated DC-DC converter that features a high voltage boosting capability along with a wide voltage gain in MATLAB and to achieve a 95% efficient circuit
2) Replacing the MOSFET switch in existing circuit by GAN FET using MATLAB or PSIM.
3) Calculating the efficiency of DC to DC Converter with GANFET
4) Comparing the efficiencies of MOSFET and GAN FET.

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V. WORK PLAN

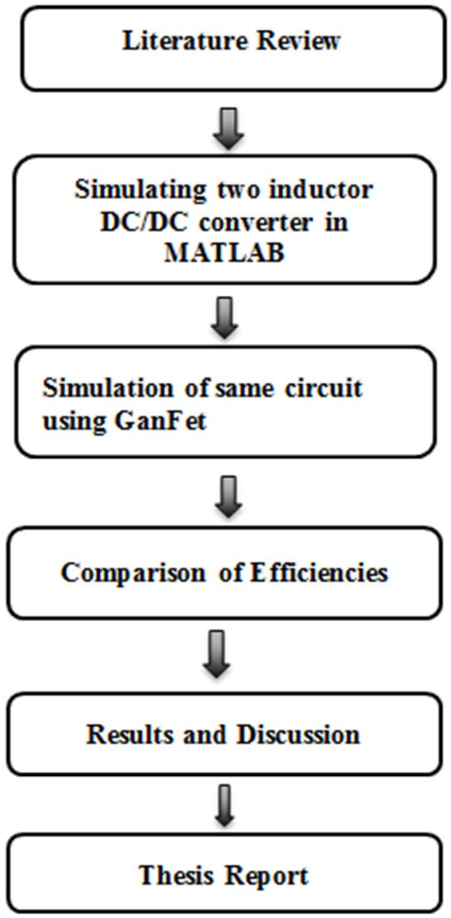

Figure 2: Research flow Chart of the proposed Methodology

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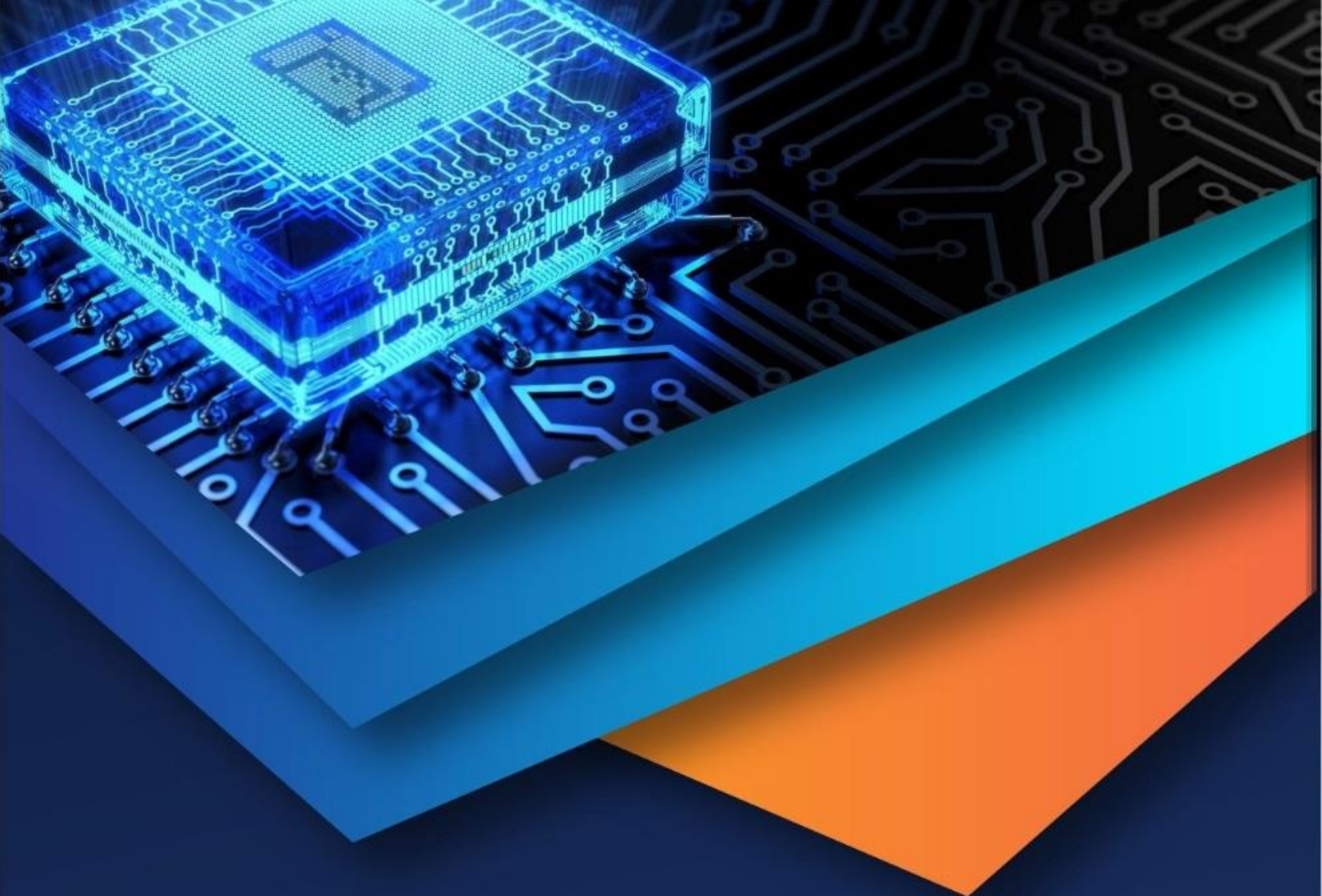
Contributions to the Field/ Benefits

The results of this research work will be useful in the field of power electronics. It will dramatically

1) Reduce the size of AC/DC Power supplies
2) Increase the efficiency of the Converters.



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