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Designing of Microgrid Inverter using Battery & PV Hybrid System

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Abstract: This project deals with the design and control of micro-grid, including various alternative energy resources (photovoltaic and wind) and battery energy storage system which operates in stand-alone as well as in grid connected mode. The proposed micro-grid is controlled via various non-isolated converters while an energy management is performed through switching based algorithm. According to the strategy, the Photovoltaic (PV) is used as the primary power source while the wind is added to improve the reliability of system under different weather conditions. The battery module is utilised as an energy storage system during surplus power and /or backup device during demand. In this project we are going to demonstrate both DC and Ac load control based on the demand. In addition to this, one 16×2 LCD Display is given to display various current and voltage parameters.
Keywords: Renewable energy, Solar panel, Photovoltaic cell, Hybrid technology, Microgrid, Inverter

I. INTRODUCTION

A microgrid is a small scale stand alone electrical grid. It acts as a next generation electrical system that combines renewable energy such as solar or wind power with an energy storage system, A Microgrid Inverter is one of the element that make up the overall system, and it operates in a grid- connected mode or a standalone mode Figure 1 shows the structure of a microgrid Inverter, which has a 3 phase inverter, filter, and static switch. Micro-grids offer the potential of substantial environmental benefits and facilitate the public through the integration of RES with high efficiency. Although RES (PV and wind) have many, they are unpredictable, highly intermittent and sensitive to climatic conditions which compelled RES to integrate energy sources.

This paper presents design and power control of a PV/Wind/Battery based MG with grid connected and islanded mode. The proposed technique efficiently shares all the available RES and energy storage system according to the real time weather and load conditions.

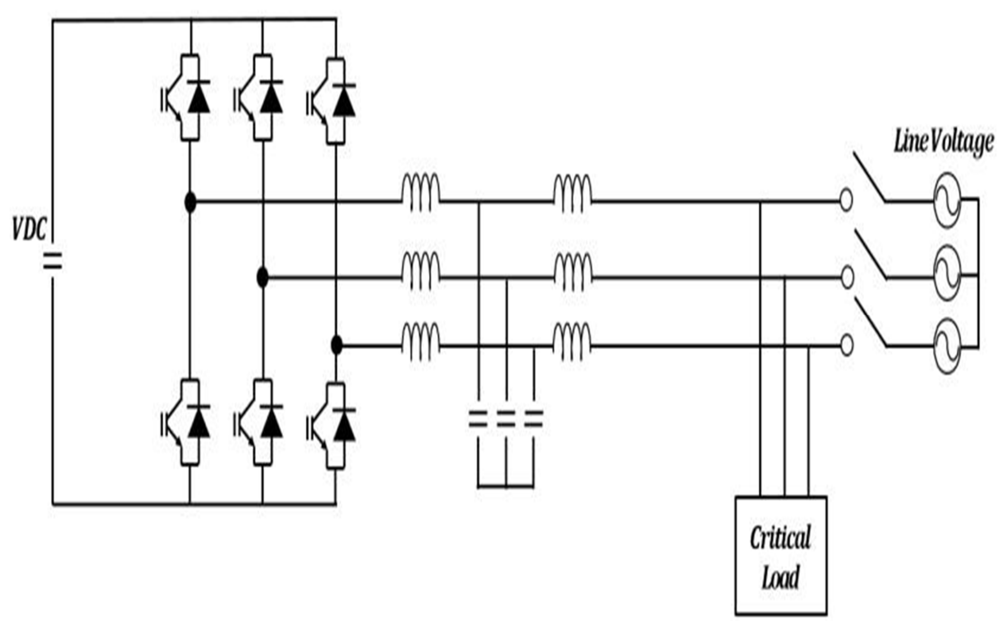

Figure 1- Three-phase Micro-grid Inverter

II. SYSTEM DESIGN

As shown in figure 2(a) total two Inverters are there. Project has battery charging facility using grid as well as solar power system. LM2596 based 5V Power supply is given. 12V/1.2Ah two lead acid batteries have been used here for the backup purpose. The Inverter which is being used for the backup purpose. The Inverter which is being used here works on 12V and the triggering pulses given from the ATMEGA328 microcontroller. For microcontroller 5V IS required. That is why to convert 12V into 5v, we have used LM2596 based SMPS circuit

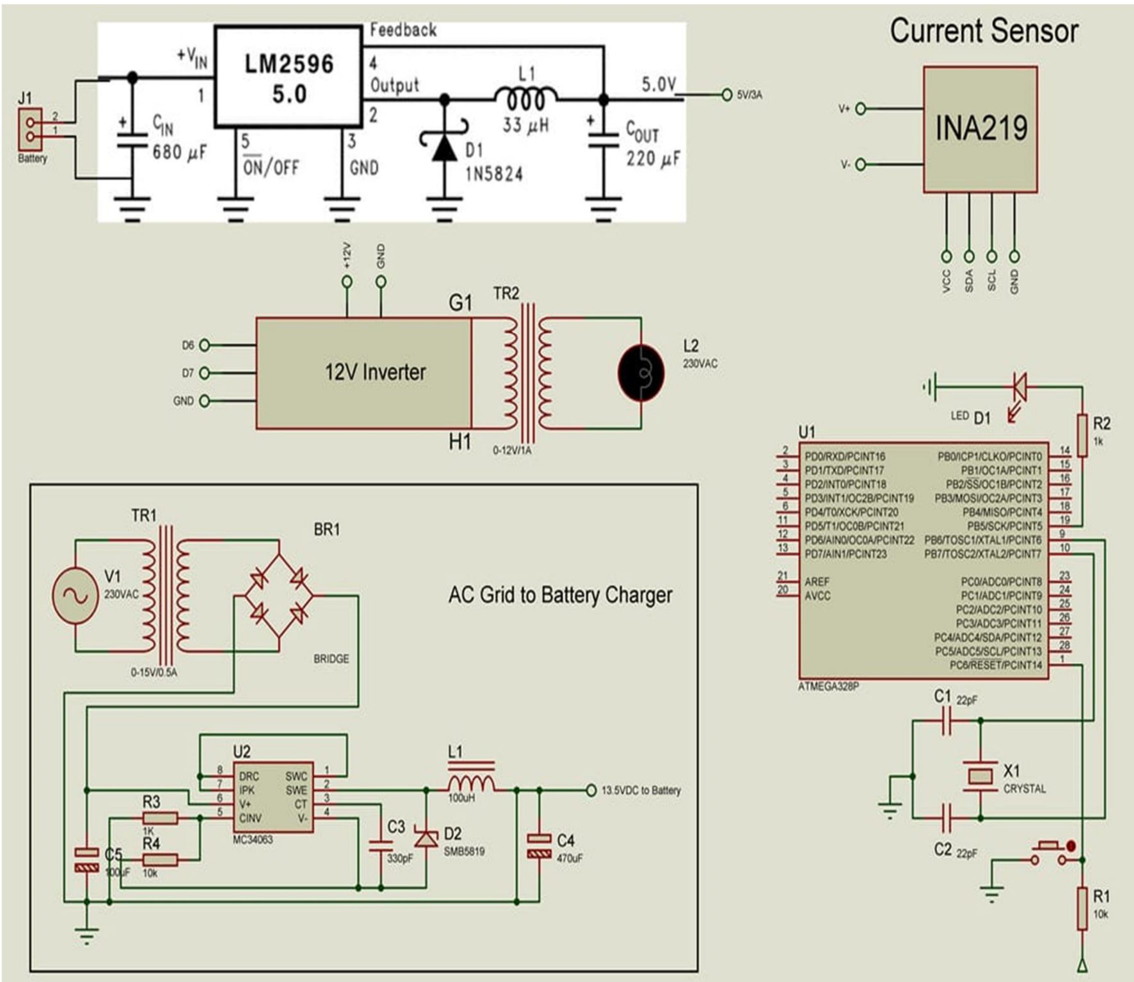

Figure 2(a)-Circuit arrangement

As shown in figure 2(b) two microcontroller based inverters are used here which will convert 12VDC into 230VAC. The working of inverter is basically divided into 4 parts.

1) *Opto Coupler Circuit:* We have used TLP250 optocoupler to isolate the triggering microcontroller circuit from the Inverter high power circuit. By using optocoupler triggering pulses for MOSFET will be given but without any physical connection.
2) *MOSFET Gate Driver:* IR2110 based MOSFET gate driver IC will be required for the triggering of MOSFET without any short circuit.
3) *ARDUINO Pulse Generator:* As we know, Inverter must generate frequency of 50 Hz. That is why we have to generate the triggering pulses in such a way that inverter frequency should be 50 Hz. To get 50 Hz frequency the time period must be 20ms and single half cycle must be 10ms. Hence in microcontroller we are using two digital pins to generate complimentary pulses and programming will be done in such a way that inverter will generate frequency of 50 Hz.
4) *Step UP Transformer:* Inverter will convert 12VDC into 12VAC with the help of battery and microcontroller but the required output is 230VAC.To get 230VAC we have to step up the voltage level of 12VAC. For this purpose we need a transformer of 0-12V/2A.

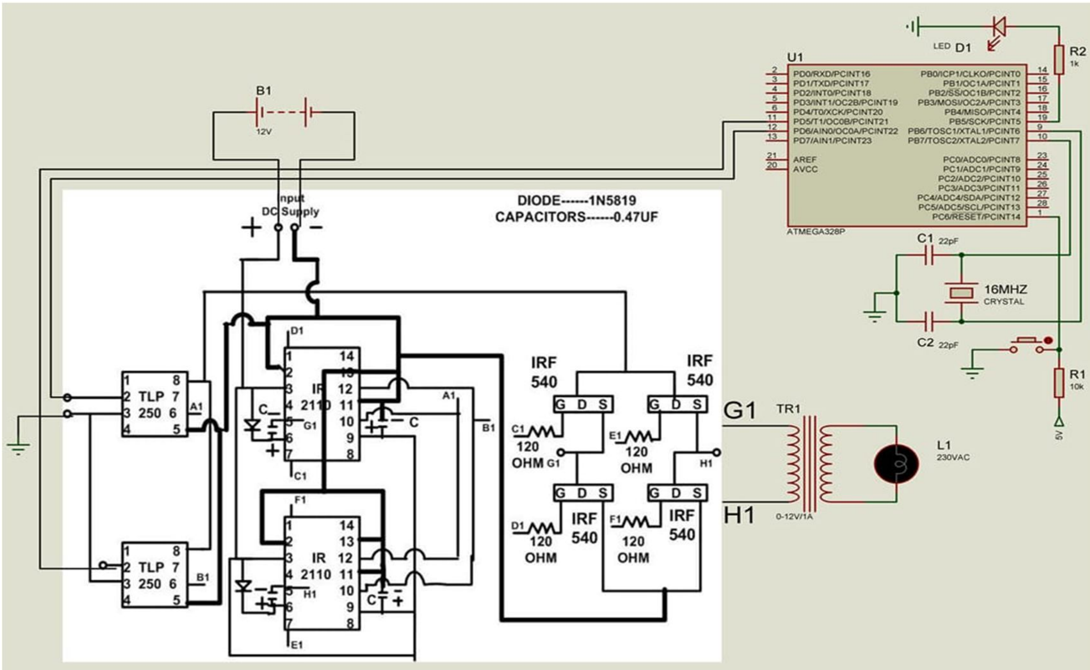

Figure 2 (b) Inverter Circuitry

III. DESCRIPTION OF PROPOSED MICROGRID

This section explains the architecture of proposed micro-grid. The complete structure of MG is shown in figure 3. The proposed MG consist of wind turbine(WT) farm, PV arrays, battery bank, residential load(RL) and national grid(NG). The RES along with energy storage device build up the AC half of converter. In DC half, the WT is connected with Permanent Magnet Synchronous Generator (PMSG). The PMSG is connected with switch mode base rectifier. At output of rectifier, an optimal torque based boost converter is connected followed by voltage regulator. The second component of DC half is PV array. The PV array is connected with Maximum Power Point Tracking (MPPT) based boost converter followed by voltage regulator. Finally, the battery is connected with buck boost converter. It is used for charging and discharging of battery.

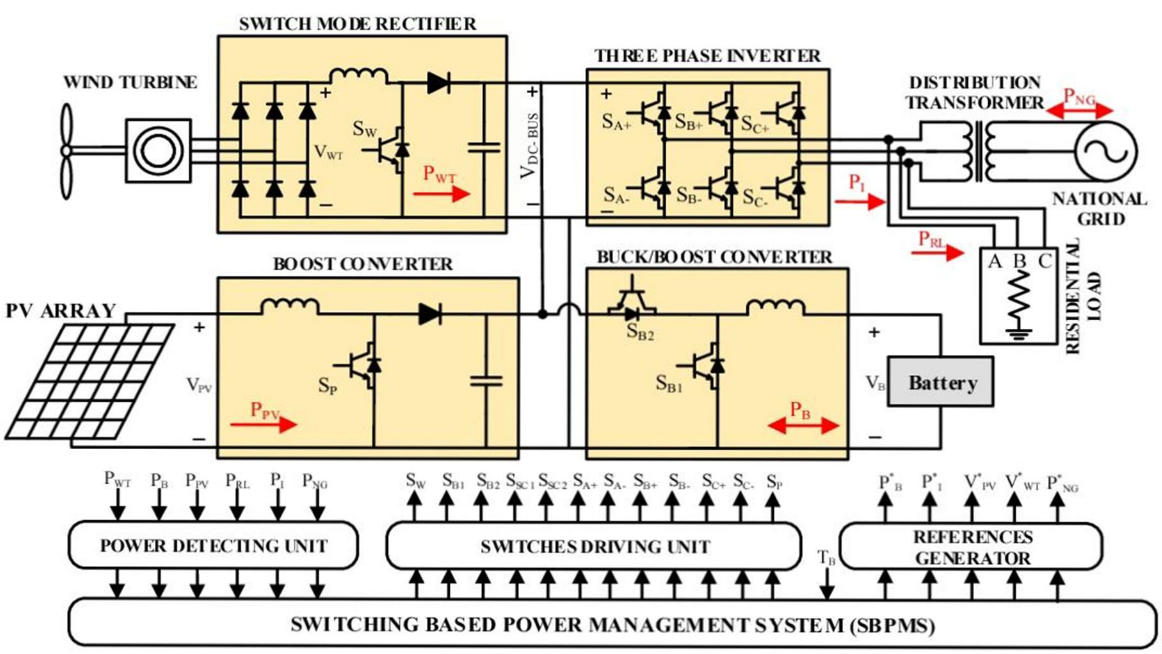

Figure 3- Architecture of Proposed Micro-grid

IV. BLOCK DIAGRAM DESCRIPTION

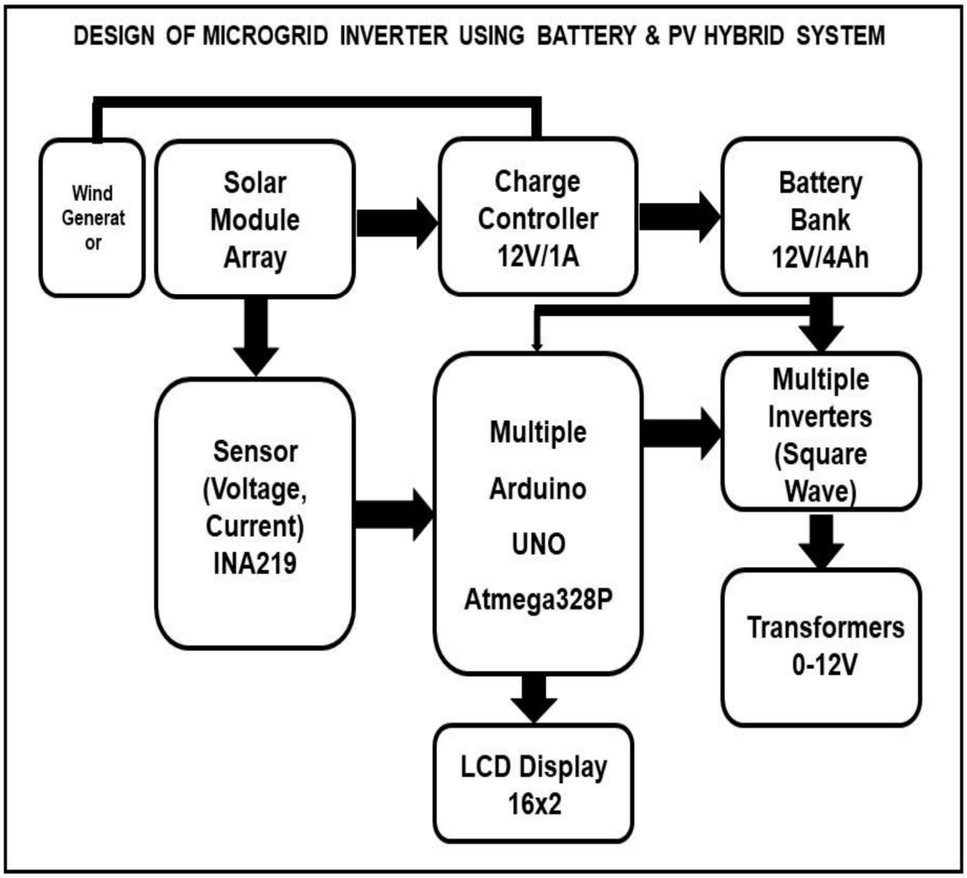

Figure 4 Block diagram of Microgrid Inverter using battery and PV hybrid system

A. Solar panel

It is used with 2.5 watts, 5 volts and 500mah. Solar panels work by absorbing sunlight with photovoltaic cells. If conductors are attached to the positive and negative sides of a cell, it forms an electrical circuit. When electron flows through such a circuit, they generate electricity.

B. Battery

The battery can be charged from solar power system and Grid. So we have separate electronic circuitry for both the charging facilities.

1) *Battery charging using Solar Power System:* The solar module is producing 20VDC. But the charging voltage required for battery is around 13 to 14VDC. That is why we have used MC34063 Based SMPS circuit which converts 20VDC. But the charging voltage required for battery is around13 to 14VDC. That is why we have used MC34063 based SMPS Circuit which converts 20V to 14V depending upon the battery state of charge.
2) *Battery charging using Grid:* We are converting 230VAC into 18VDC using Transformer, Rectifier and Filter. 18VDC IS given to MV34063 based SMPS circuit which converts 18V to 14v which is required to charge the battery.

C. Charge Controller

The term charge controller or charge regulator may refer to either a stand-alone device, or to control circuitry integrate within a battery pack, battery-powered device. A solar charge controller is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging.

D. Arduino UNO

The Arduino UNO is an open source Microcontroller based on the Microchip ATmega328P microcontroller and developed by Arduino. The board is equipped with sets of digital and analogue input/output (I/O) pins that may interfaced to various expansion boards and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analogue I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9volt battery, through it accept voltage between 7 to 20 volts.

Figure 5-Arduino UNO

E. Photovoltaic array

It is contain of several amount of PV cells in series and parallel connections. Series connections are responsible for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the array. It generates maximum 180W in full sunshine. Large the total surface area of the area of the array, more solar electricity it will produce.

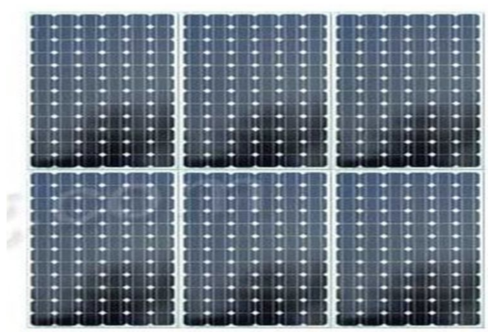

Figure 6 -Photovoltaic array

F. Boost converter

A boost converter is a DC-to-DC power converter that steps up voltage from its input to its output. It is a class of switched-mode power supply containing at least two semiconductors and at least one energy storage element.

G. Buck converter

A buck converter is a dc to dc power converter which steps down voltage from its input to its output. It is a class of switched-mode power supply typically containing at least two semiconductors and at least one energy storage element, a capacitor, inductor, or the two in combination.

H. Wind turbines

Like with windmills, wind turbines take the merit of the wind energy and convert it into another form of energy and convert it into another form of energy. The wind turbine converts kinetic energy in the wind into electrical energy. Small wind turbine like the one designed for this project is usually selected for local usage.

I. Sensor INA219

INA219 digital current sensor has been used here. To measure the battery charging voltage and current.INA219 has 6 terminals. Two power supply terminals i.e. VCC and Ground. Two pins i.e. SDA and SCL used to communicate with the microcontroller to display the current measured. Two more pins will be there. I.e. V+ and V- (Input Pins).This INA219 sensor will be connected to microcontroller.

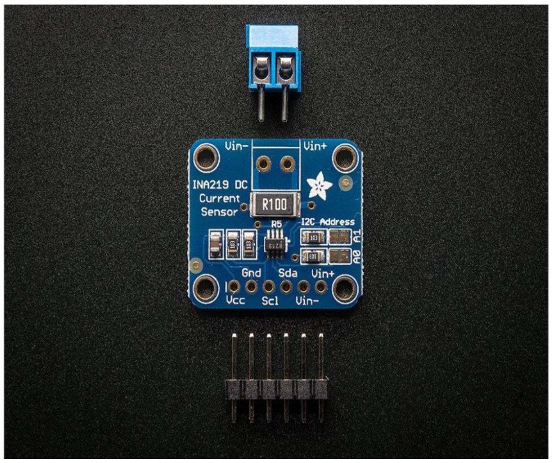

Figure 7- Sensor INA219

V. MERITS OF HYBRID SYSTEM

A. Grid- connected PV systems are comparatively easier to install as they do not require a battery system.
B. Grid interconnection of photovoltaic (PV) power generation systems has the advantage of effective utilisation of generated power because there are no storage losses involved.
C. Continuous Power Supply.
D. Low maintenance cost.
E. High efficiency.

VI. DEMERITS OF HYBRID SYSTEM

A. Complicated controlling process.
B. High installation cost.
C. Less battery life.
D. The number of instruments connected is limited.

VII. APPLICATIONS OF HYBRID SYSTEM

A. Hybrid solar inverters are perfect choices are most suitable for remote or rural areas where the power grid is situated far away from the rural areas.
B. Hybrid systems utilizing wind and solar energy have been designed for irrigation system, rural electrification and wastewater management and they have proved to be cost effective and efficient.

VIII. CONCLUSION

By this project many villages can be lighted. For villages which are much away from the construction site of large power generating stations also to satisfied the increasing demand of electricity with clean hybrid power station by solar-wind can be used. Microgrid for the hybrid power system is designed. By initializing the input load data, sizing of system, Cost analysis and the respective output efficiency and the detailed output data is collected from the simulation tool. According to the strategy, the photovoltaic (PV) is used as the primary power source while the wind is added to improve the reliability of system under different weather conditions. The battery module is utilised as an energy storage system during surplus power and/or backup device during demand. In this project we are going to demonstrate both DC and AC load control based on the demand.

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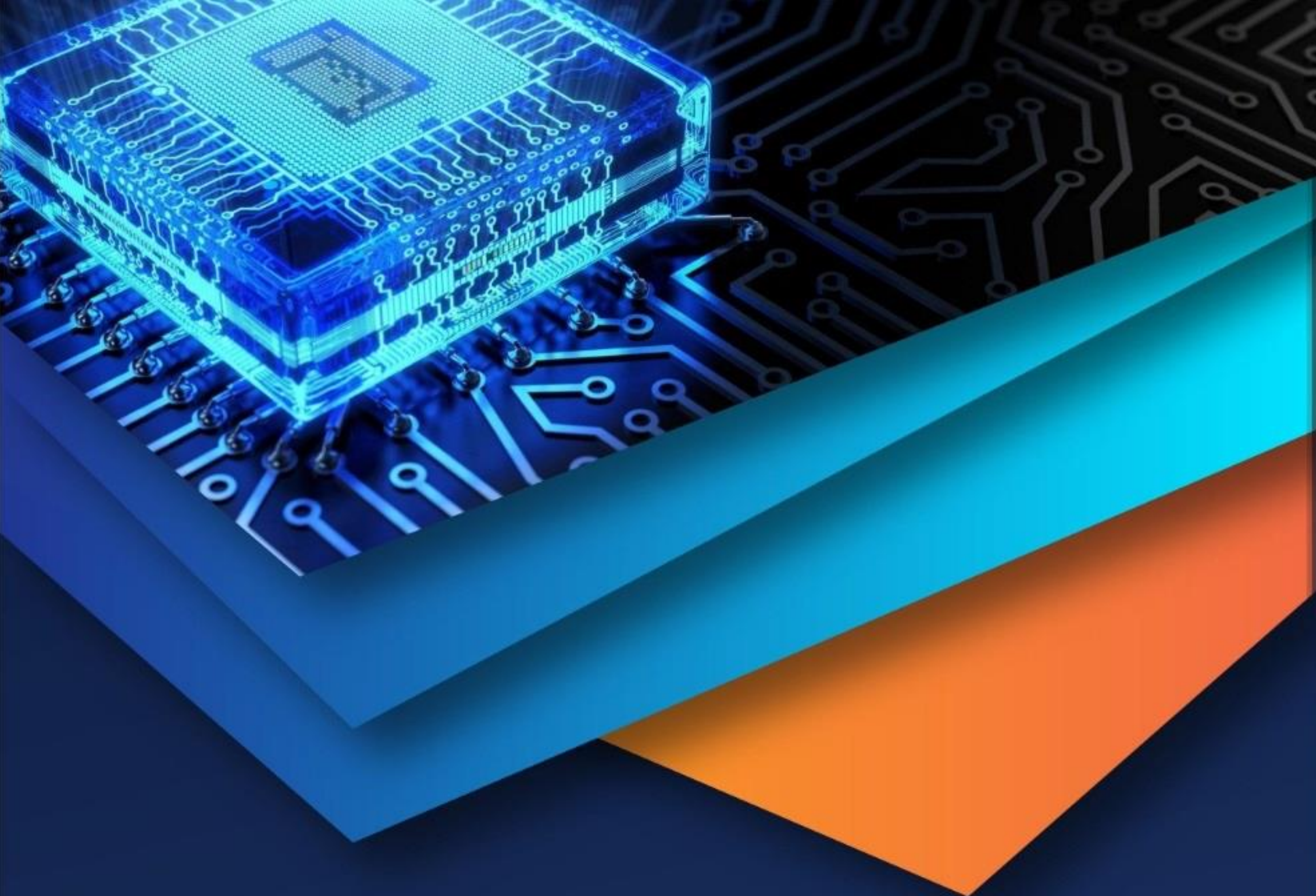

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