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FACTS Based Static VAR Compensation using Thyristor Switched Capacitor

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Abstract: In today's world the consumers have a large interconnected inductive load which generally causes the power system network to be dominated by lagging load current by equipments such as electric motors, transformers, etc. due to which the power factor is considerably decreased. The aim of the power system is to maintain the power factor in between .95 to 1 so that the current and voltage are in phase with each other. In order to do so and compensate the lagging load current we use back to back thyristors which trigger the shunted capacitors and help in improving power factor. The shunt connected capacitors draws current which leads the source voltage. Thus, in order to improve the power factor a capacitor bank is used in the circuit which is triggered by the SCR's. In order to calculate the power factor, the time lag between the voltage and current waveforms is measured by respective zero crossing detectors. The output of these detectors is fed to the interrupts pins of programmed 8051 microcontroller which calculated the power factor and send signals to the SCR whenever compensation is required.
Keywords: Power factor, lagging load, compensation, lagging load, capacitors, microcontroller.

I. INTRODUCTION

According to Wikipedia power factor is defined as "the power factor of an ac electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number in the closed interval of −1 to 1. A power factor of less than one means that the voltage and current waveforms are not in phase, reducing the instantaneous product of the two waveforms (v × i)".

Real power is the actual power that is consumed in the circuit to do useful work. Apparent power is the product of voltage and current in the circuit. Since there are energy storing elements or devices, the apparent power is usually greater than real power in the circuit. Whenever power factor is decreased in the circuit it means that the load will draw a high current as compared to a load with power factor close to unity of same amount of useful power consumption.

Higher current being drawn in the circuit will result in increased losses, requirement of large diameter wiring as well as increased cost of consumption. Thus, in order to avoid large rating equipments as well as wastage of energy, certain electronic devices can be implemented and power factor can be considerably improved which can mitigate these negatives. Electrical utilities generally cost higher to those industries which have a constant low power factor. Necessary facts technology can be implemented in the system resulting in improving the power factor and save cost.

II. LITERATURE SURVEY

With the rapid increase in the demand of power generation, many factors are taken into consideration for the same such as transmission, distribution and finally consumption. Voltage stability and its regulation have gained a lot more attention as compared to previous years. As the use of electrical machines and inductive devices is increasing the demand is also increasing thus, resulting in more and more reactive power absorption.

In power systems, load models are categorized into two types, namely, static load and dynamic load. Static loads are fixed, continuous and are not a function of time. On the other hand, dynamic load varies with time. Utilities are trying hard in order to find an effective way for reactive power compensation. FACTS (Flexible AC Transmission Systems) are used by utilities for compensation of reactive power in order to provide voltage stability in power systems. Thyristors controlled facts devices are commonly used for this purpose. T

ill now, many authors have simulated TSC (thyristor switched capacitors) using different computer programs such as ATP, PSCAD, MATLAB etc. In this paper, the effects of TSC for improving power factor is studied.

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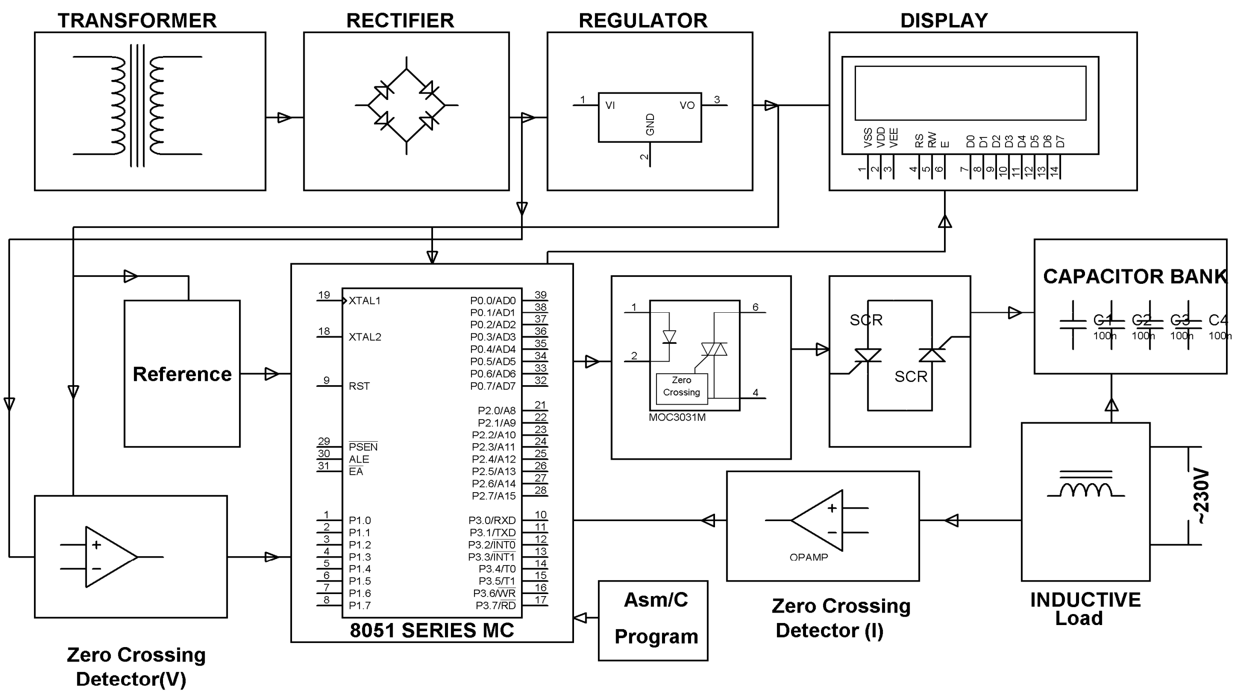
III.BLOCK DIAGRAM



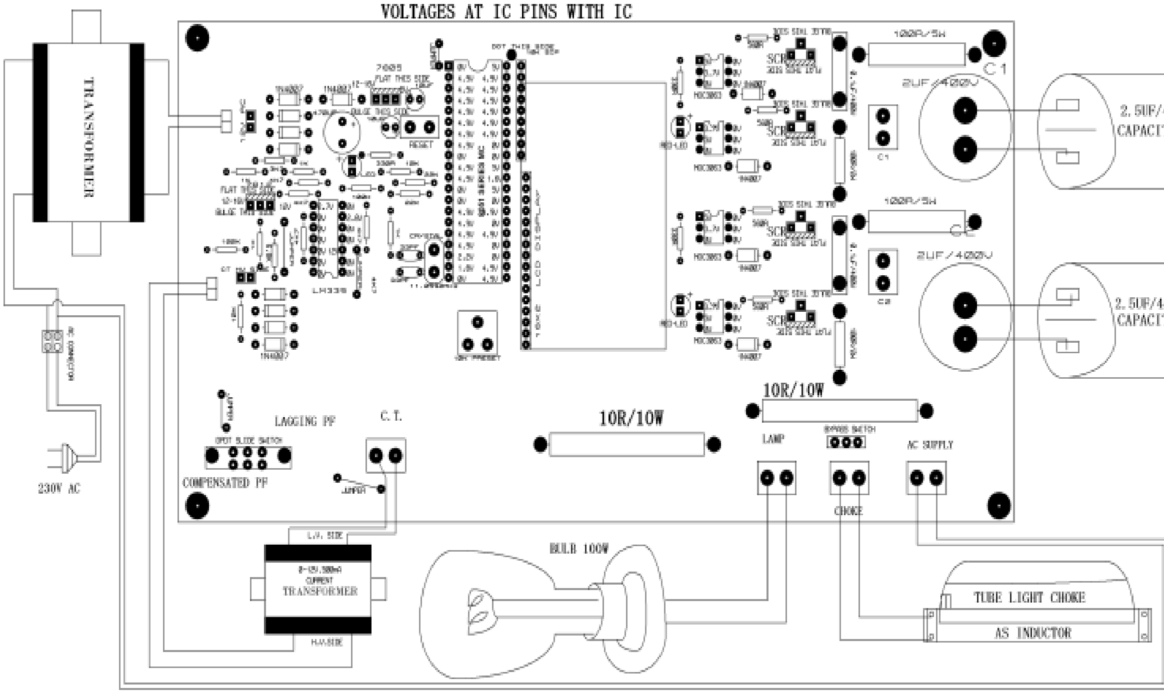
A. Hardware Requirements

1) TRANSFORMER (230 – 12 V AC)
2) VOLTAGE REGULATOR (7805,7812)
3) RECTIFIER(1N4007)
4) FILTER
5) MICROCONTROLLER (AT89S52)
6) OPTO-ISOLATOR (MOC3063)
7) SCR
8) PUSH BUTTONS
9) LCD(16X2)
*10)*LM339
*11)*CURRENT TRANSFORMER (0-12V 500mA)
*12)*INDUCTIVE LOAD-Ballast (706.8 mH)
*13)*SHUNT CAPACITOR(2uF/400V)
*14)*LED
*15)*1N4007 / 1N4148
*16)*RESISTOR
*17)*CAPACITOR (470uF /1000uF)

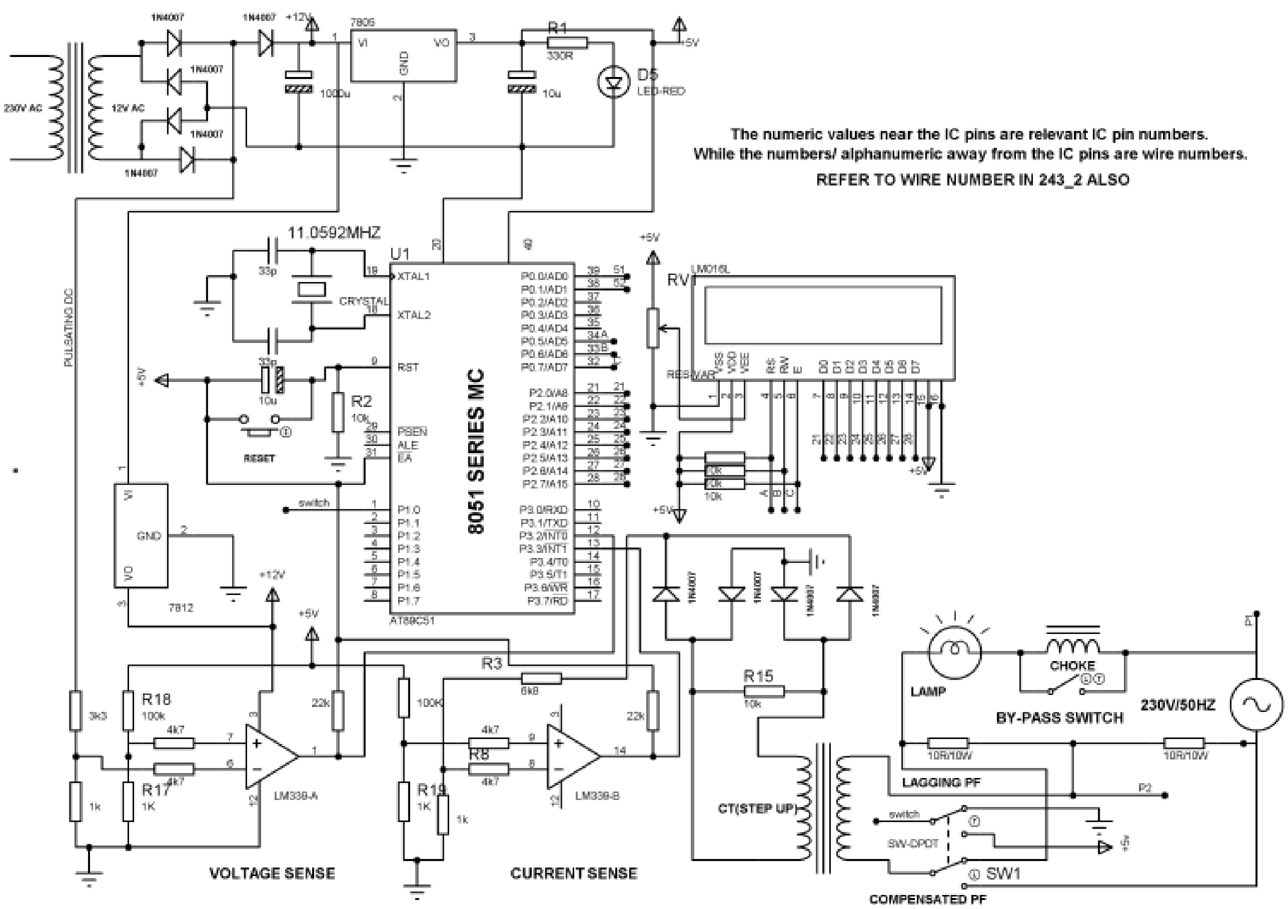
B. Software Requirements

1) Keil compiler
2) Languages: Embedded C or Assembly

IV. LAYOUT DIAGRAM



V. CIRCUIT DIAGRAM



VI. WORKING AND METHODOLOGY

This circuit is designed with DC power supply unit, capacitors, SCR, opto-isolator, LCD display, Microcontroller, zero voltage crossing detectors. The DC power required by the microcontroller is obtained by stepping down the 230 volts AC supply to 12 volts AC with the help of voltage transformer, then converting it into DC supply with the help of bridge rectifier (designed by IN4007 diodes) and then finally regulating it with the help of 7805 voltage regulator. In order for the microcontroller to calculate the power factor we need digital current and voltage signals. The voltage pulse from the supply after rectifying it into DC is then fed to LM339 comparator which produces the required digital voltage signal. In order to generate digital current signal, the voltage drop across the load is measured by the 10 ohms resistor. By this the voltage signal is converted into digital current signal. Now both the digitalized voltage and current signals are fed to programmed microcontroller. The 8051 microcontroller now calculate the time lag between voltage and current signals which is directly proportional to the power factor and it finally determines in what range the power factor is. All this calculation done by the microcontroller is displayed on the LCD. Depending upon the range in which the power factor is, the controller sends signal to the opto-isolator which in turns triggers the SCR to bring the shunted capacitors in the circuit which will finally improve the power factor. The number of capacitors to be connected in parallel depends upon the inductive load in the circuit. In this we have used 2 capacitors of 2.5 microfarad each and an inductive load of 706.8 mH. For large connected inductive load, the number of capacitors can be increased in parallel. As per the circuit arrangement supply is switched on keeping the inductive load OFF with the help of DPDT switch. The compensation switch is also turned OFF to see whether compensation is taking place or not. During the initial condition one lamp is connected in the form of load. This lamp indicated resistive load. At this initial stage when the supply is switched on the LCD displays that the power factor as unity and the time lag between current and voltage is zero, which means that they are in phase. Next the inductive load (ballast in this case) is switched on. The microcontroller senses the current and voltage signal and displays on the LCD that the power factor is reduced to 0.790 also current is lagging voltage by time 2.059 mS. In order to compensate the lagging power factor, the compensation switch is turned ON. The microcontroller then gives signal to the opto-isolator which in turns triggers the SCR to energize the capacitors. In this situation only one capacitor is energized which is indicated by glowing of one of the LED's. The result on the LCD is power factor=1 and is compensated. This means that one 2.5 microfarad capacitor is enough to compensate choke coil (lagging load) of rating 40 watts, 250 volts, 0.4 amps, 50 cycles.

VII. RESULT

It was seen that at purely inductive load (resistive lamp of 100 Watts) the power factor was found to be unity. When the ballast was switched ON the power factor decreased to 0.790 (I lagged V by time: 2.059 mS). In order to compensate the power factor and make it unity, capacitor of 2.5 microfarad was energized in the circuit with the help of 8051 microcontroller.

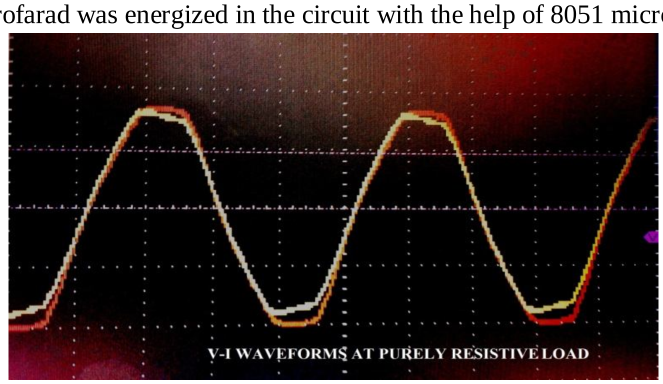


Fig 1: V-I waveforms at purely resistive load

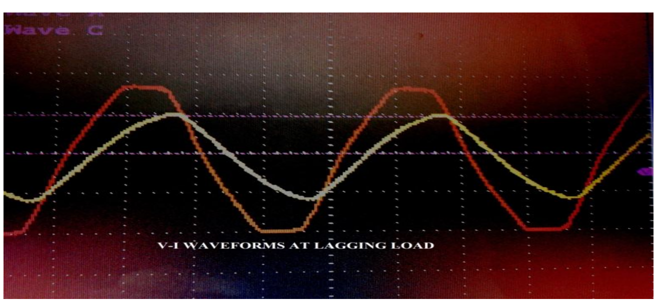


Fig 2: V-I waveforms at lagging load

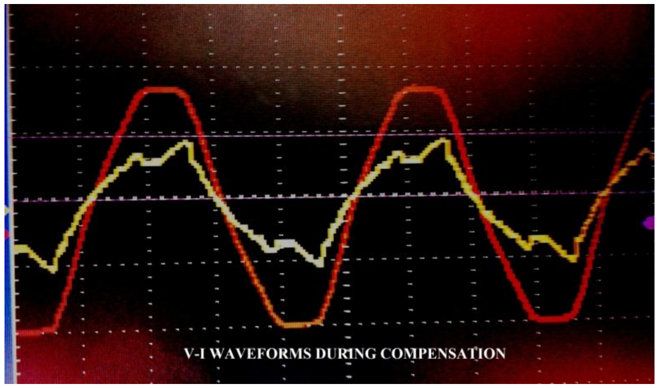


Fig 3: V-I waveforms during compensation

VIII. TESTING IMAGES

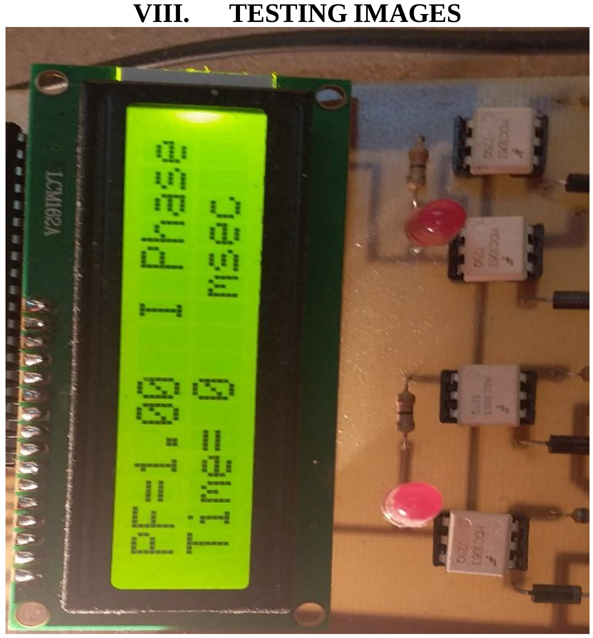


Fig:4 Power factor at resistive load

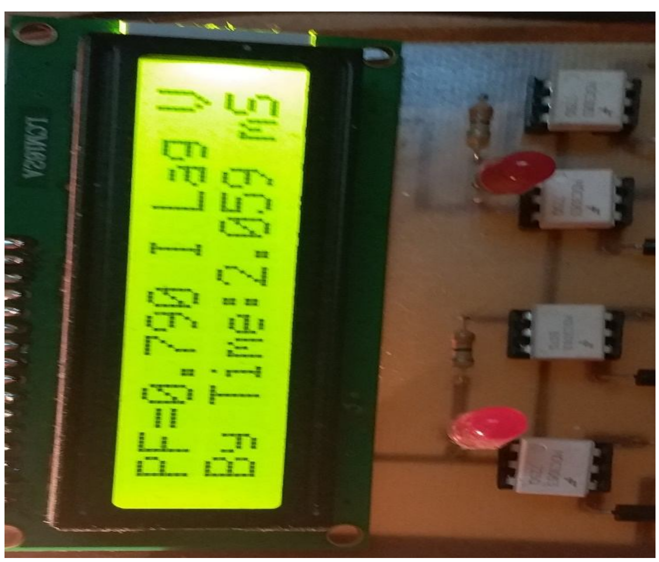


Fig 5: Power factor at inductive load.

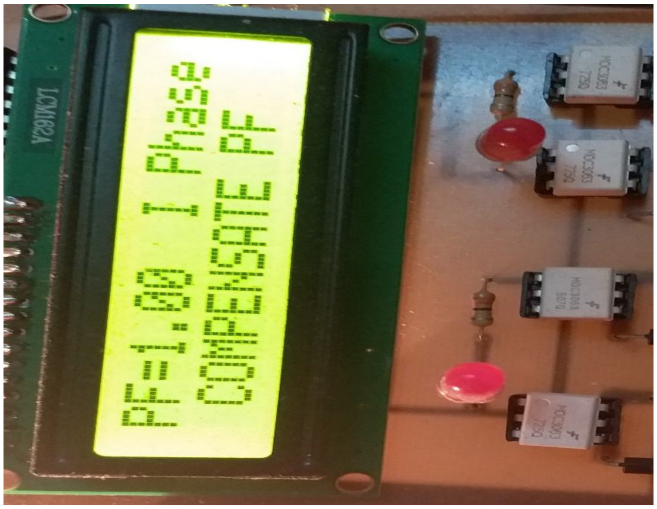


Fig 6: Power factor after compensation.

IX. CONCLUSION

FACTS (Flexible AC Transmission System) using Thyristor switched capacitors was designed and implemented. FACTS technology based on power electronics, offers an opportunity to enhance controllability, stability and power transfer capability of AC transmission systems. This is an efficient technique to improve the power factor without replacing any components. In order to improve the power factor without electronics devices the whole transmission equipment needs to be modified which cannot be possible and will increase the transmission, distribution cost tremendously.

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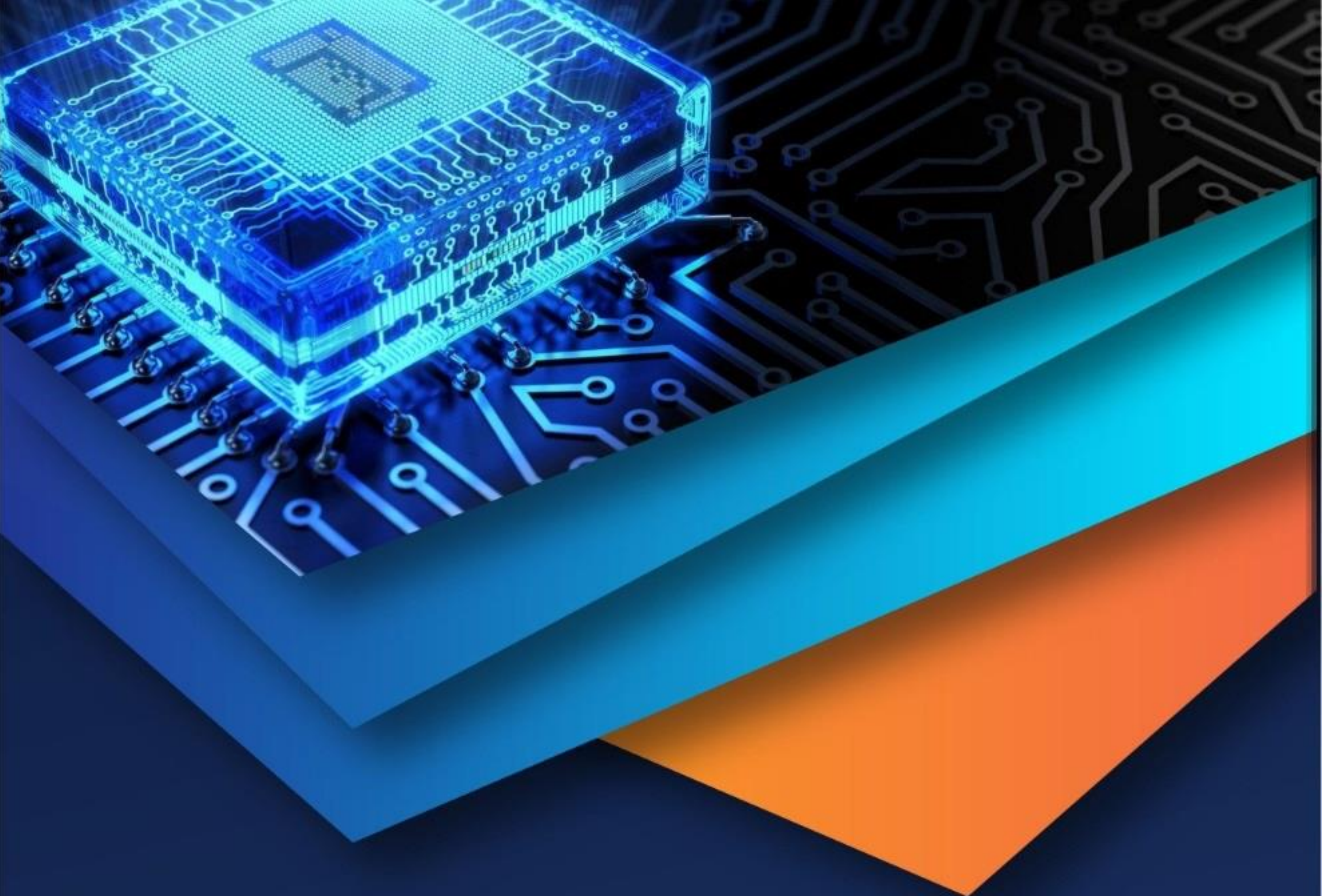

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