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An Automated Electrical Protection Systemagainst Lightning Strike

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Abstract: ***Lightning is very difficult to predict and causes permanent damage to electrical appliances. A lightning protection device will be developed which will be less costly than the others and it can be simply controlled by any common people and can automatically protect electrical systems. This lightning protection device is for small or medium electric systems where lightning strike frequency and damage by lightning strike is very high. This lightning protection device can protect devices struck by lightning directly while the system is running. This device 'Lightning Breaker' has been designed with ESP8266 and lightning detector circuit, two relay modules, TP4056 module, XL6009 module, and 5v 250mAh solar cell. This device has very compact structure that increases portability and decreases mounting costs.***
Keywords: ESP8266, IOT System Lightning, Lightning Protection and Lightning Detector

I. INTRODUCTION

Lightning is an unavoidable natural phenomenon. Lightning can damage [1] electronic components [2] and sometimes it can cause a massive fire accident. But the proposed device can reduce electrical systems getting damaged from lightning. This research intends to provide an alternate solution to the lightning damage on electrical systems problem by developing lightning protection technology [3] that can operate automatically. The device is operated manually using onboard control or control via web interface. This device is made to detect lightning over a long distance to avoid direct lightning strikes while the system is running. This device 'Lightning Breaker' is designed by interfacing the ESP8266 module with a lightning detector circuit. The web interface makes the lightning protection device remotely controllable and easy to control and check the lightning detector status. The ESP8266 is connected to a wireless access point and the wireless access point help to access the lightning protection system from any LAN devices. Lightning Breaker can be accessed through an IP generated by ESP8266. The architecture of the Lightning Breaker is so designed that it can operate efficiently over the battery. In our device, a 4.2V 2000mAh rechargeable Li-Ion battery combined with a solar charging system is used and it is sufficient to operate the device for over 24 hours. The battery of the device is automatically recharged bysolar cell. The uniqueness of our project is its cost-effectiveness and ease to control by any web interface device. This design provides a simple and effective lightning protection device.

II. PROPOSED PROTOTYPE AND SCHEMATIC

In the lightning detector circuit [4], resonant circuit is formed by parallel connection of a capacitor, resistor, and two inductors with unequal values in series to make an unequal tapped inductor. When a bolt of lightning strikes, it produces an RF frequency [5] which is received by the antenna connected with the RLC oscillator and creates a weak resonance frequency in the RLC oscillator then this output is taken via a 100pF capacitor (this capacitor removes unwanted frequency from the oscillator). This output signal is fed to a BC547 transistor whose base is biased by a 1MΩpotentiometer very close to its saturation and because of this a weak signal from the RLC resonator saturates the BC547NPN transistor and conducts. The collector of the BC547 NPN transistor is connected to the 5V supply voltage through a 1kΩ resistor, emitter to ground. The collector Pin is connected to Pin 2 of NE555 IC, so without any signal Pin 2 stays high to supply voltage. When the transistor goes into saturation and conduct Pin 2 of NE555 IC goes LOW and the internal flip flop trips and starts the timing signal from Pin 3 which is set by a resistor and capacitor. The NE555 IC Pin3 timing signal fed into ESP8266 D1 Pin through a 1kΩ resistor. When NE555 IC generates a pulse from Pin 3 that pulse turns ESP8266 D1 Pin state HIGH. So this way the short RF pulse from long-distance lightning can be amplified and extended to a larger pulse which is easy to detect. At first, Lightning Detector is connected with ESP8266. The Lightning Detector NE555 IC Pin 3 is connected to ESP8266 Pin D1. After that, two relay modules input will be connected with ESP8266's Pin SD2 and SD3. For controlling ESP8266 switch1 (Sw_1), switch2 (Sw_2) and RST Switch (RST) switch's connected to Pin D5, Pin D7 and RST Pin. To power this device a 4.2V 2000mAh battery and TP4056 module are connected with a 5v 250mAh solar cell for charging the battery. The battery output is 4.2 volts to boost the voltage up to 5v.

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TP4056 battery output is connected with the XL6009 module. The XL6009 module boosts the battery output voltage to 5v and distributes power to the lightning detector, ESP8266, and two relay modules.

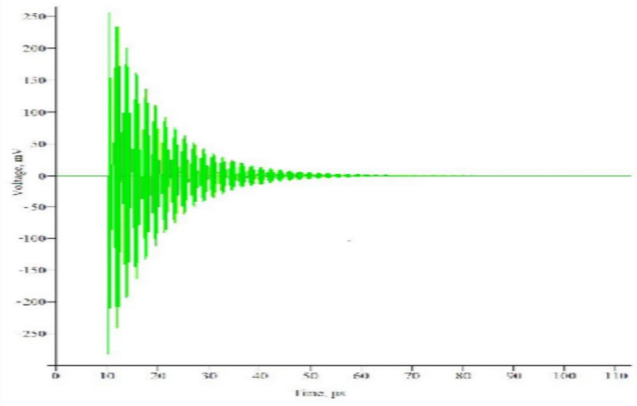


Fig 1: Damped oscillation in RLC circuit

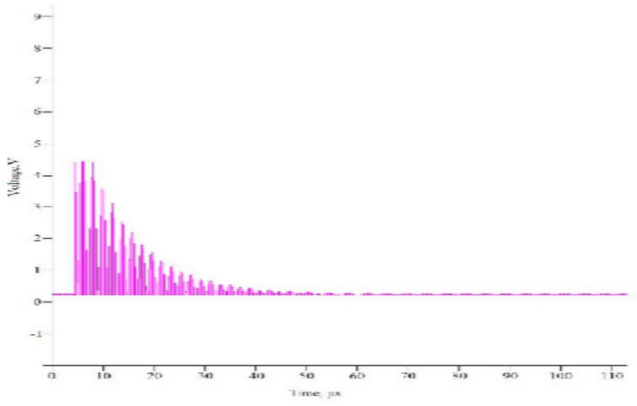


Fig 2: BC547 NPN Transistor signal output

So, Lightning Breaker can operate without any external power, because of ESP8266 and Lightning Detector power consumption low it can run continuously without recharge for over 24 hours. When the ESP8266 is powered on, it scans for Wi-Fi to create a lightweight server [6] and the server's IP address. After creating the server inside of ESP8266 the Pin D1 of ESP8266 get LOW and output Pins (SD2, SD3) gets HIGH. If the D1 Pin of ESP8266 is LOW the SD2, and the SD3 Pin states HIGH when the Lightning strikes the Lightning Detector makes ESP8266 Pin D1 HIGH. When the D1 Pin is LOW the SD2, and SD3 Pin gets LOW and the virtual switch on the server gets an OFF state if the server virtual switch gets an ON state from any web interface device connected to LAN, the ESP8266 SD2 and SD3 Pin gets HIGH and D1 Pin gets LOW. In any emergency condition, it is decided to set output of ESP8266 allows set ON if the lightning strike we can do that using Sw_1 and Sw_2 switches. When the Sw_1 switch is ON the output Pin SD3 stays HIGH until Sw_1 gets OFF and the same with the Sw_2 switch, if the Sw_2 switch is ON the output Pin SD2 stays HIGH until Sw_2 gets OFF and for RST switch it reset the ESP8266.

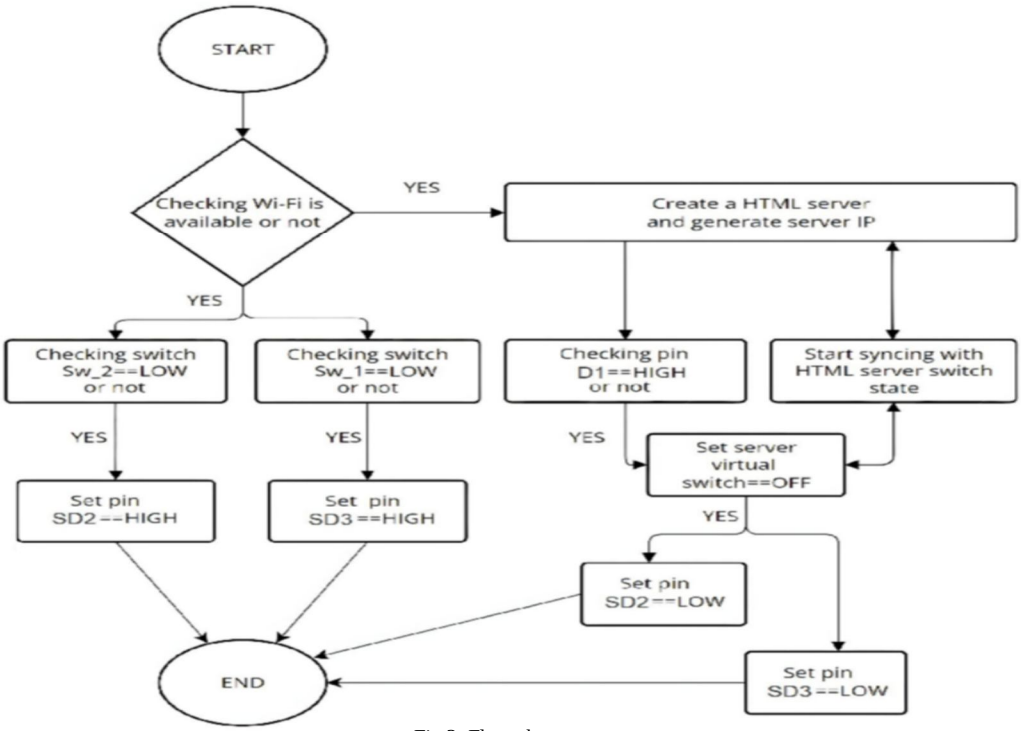


Fig 3: Flow chart

A. *Lines Of Code*

```
if (digitalRead(D1) == HIGH) { digitalWrite(SD2, LOW); digitalWrite(SD3, LOW); digitalWrite(server virtual switch, LOW);
 } else {
  digitalWrite(SD2, HIGH); digitalWrite(SD3, HIGH); digitalWrite(server virtual switch, HIGH);
 }

 if (digitalRead(Sw_1) == LOW) {digitalWrite(SD3, HIGH);
  } else {
  digitalWrite(Sw_1, HIGH);
 }

 if (digitalRead(Sw_2) == LOW) {digitalWrite(SD2, HIGH);
  } else {
  digitalWrite(Sw_2, HIGH);
 }
```

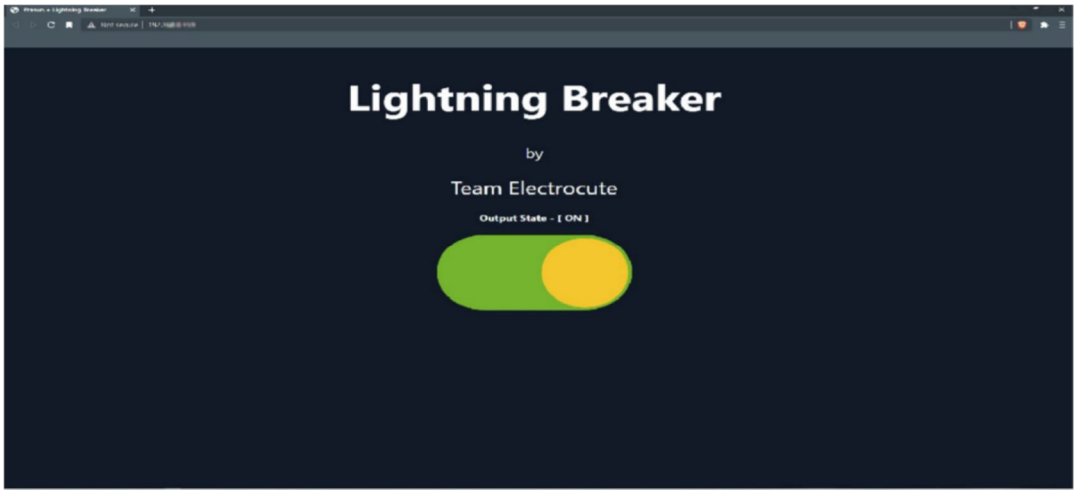
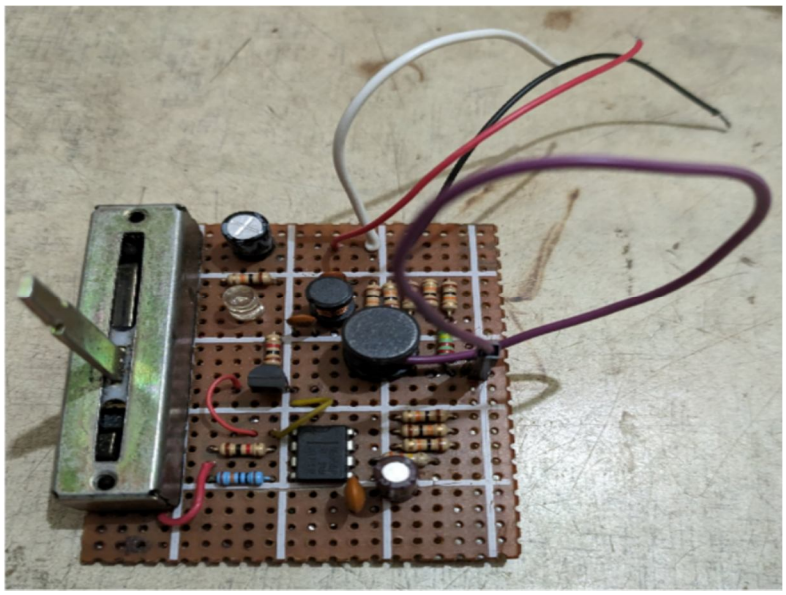


Fig 4: ESP8266 WEB Interface



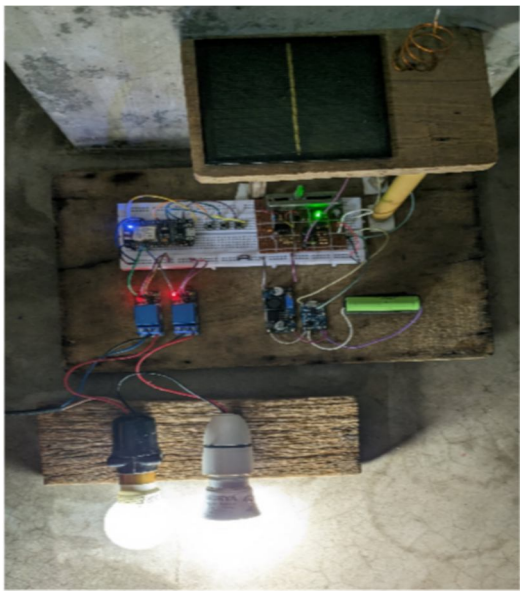


Fig 5: Lightning Detector Fig 6: Schematic working prototype

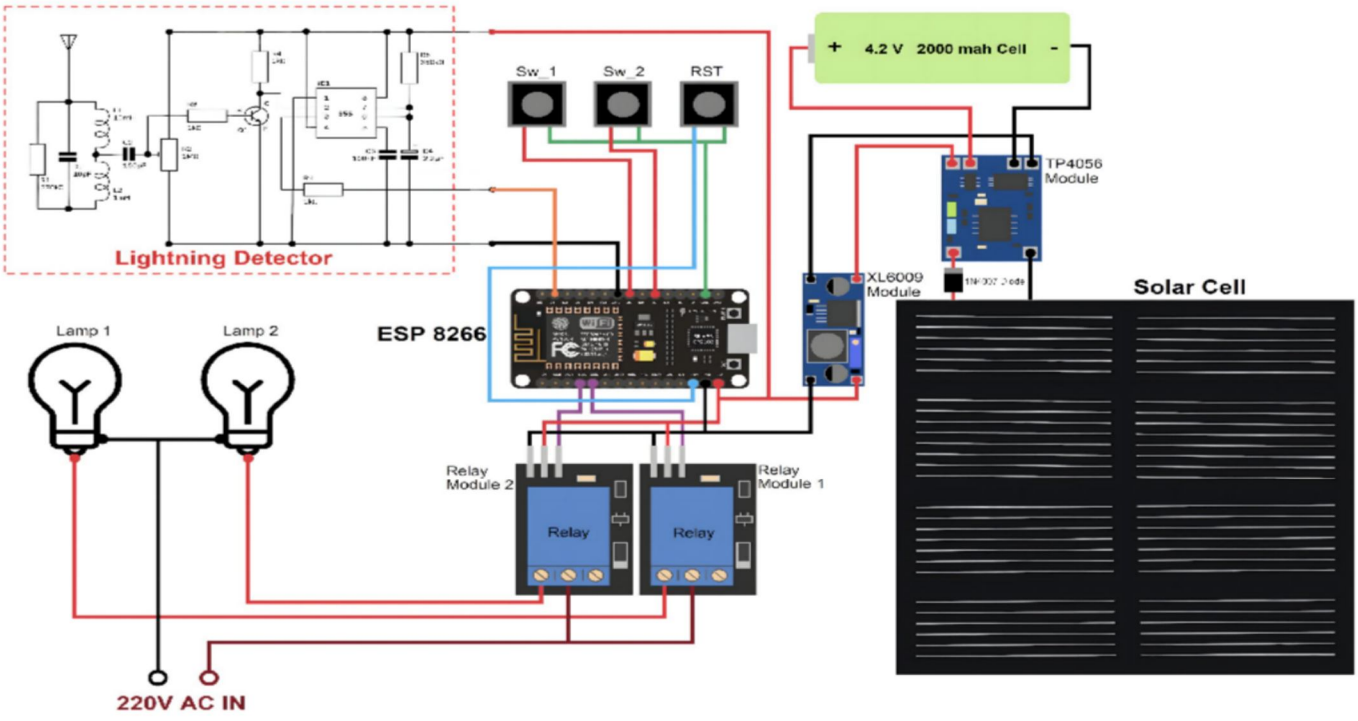


Fig 6: Schematic diagram of our proposed project

III. RESULT

Switches State	D1 Pin State	Server Virtual Switch State	SD3 Pin - Relay	SD2 Pin - Relay
	LOW	ON	HIGH	HIGH
	HIGH	OFF	LOW	LOW
If Sw_1 == LOW		OFF	HIGH	LOW
If Sw_2 == LOW		OFF	LOW	HIGH

IV. CONCLUSION

Lightning is a dangerous natural phenomenon that can cause huge damage [7] to the electrical system and potentially cause massive fire accidents. The overall cost of this device "Lightning Breaker" is low and all the parts are available in the market cheap, and easy to assemble. All components of "Lightning Breaker" run on very low power which makes battery life longer and the components stay in healthy condition for a long time. All these features make this project very efficient.

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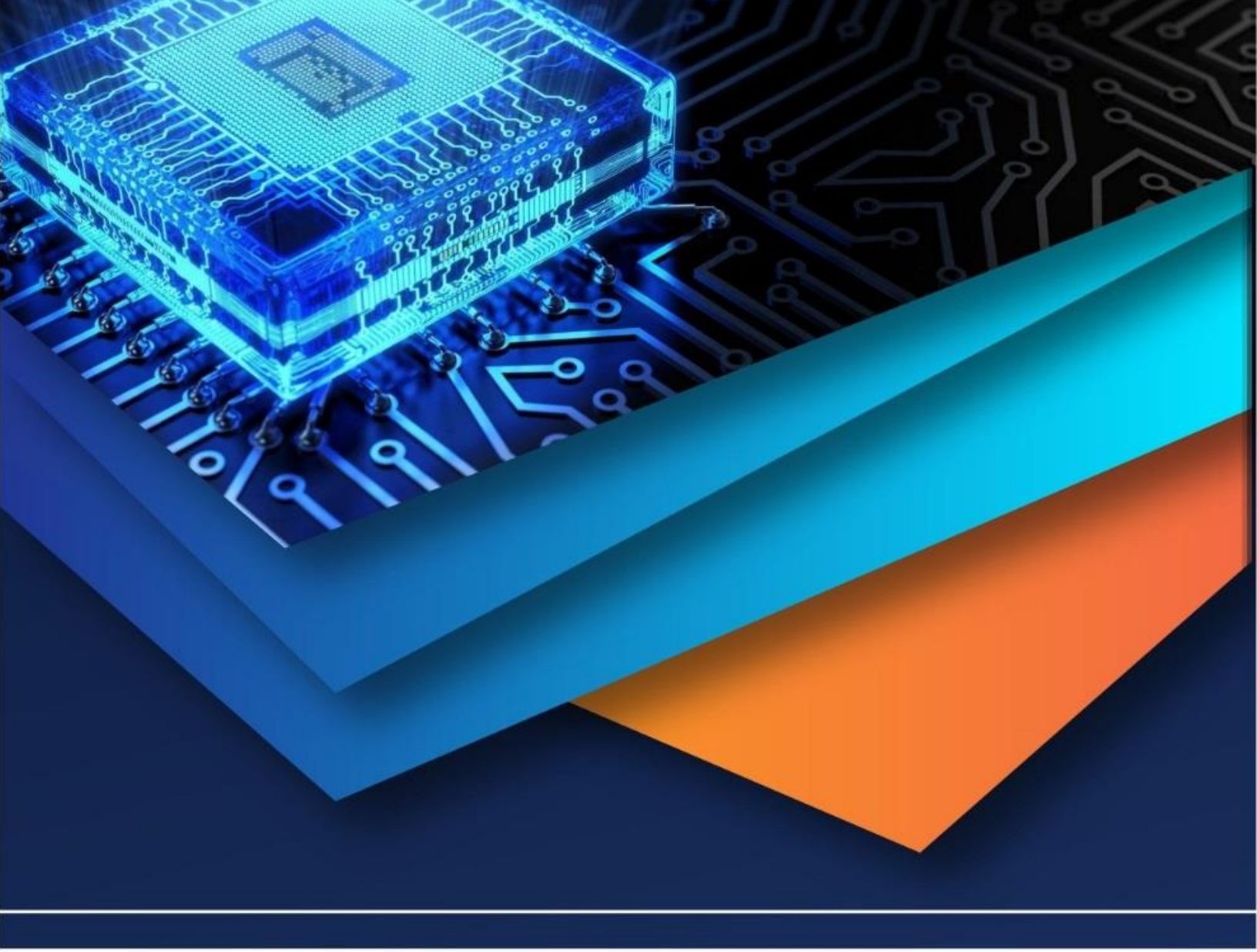

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