iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 2026 **Issue:** Conference **Month of publication:** May 2026

**DOI:** https://doi.org/10.22214/ijraset.2026.82957

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# IC555-Based Sound-Activated Alert System with ESP32 IoT Mobile Notification

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***Abstract—This paper presents the design,implementation, and experimental validation of a low-cost, real-time sound-activated alertsystemintegratingclassicalanalogIC designwithInternet- of-Things(IoT)connectivity.Acondensermicrophoneamplified by a BC547 NPN transistor triggers an IC 555 timer [7] in monostablemode,generatingapreciselytimedoutputpulseof$T \approx$ 1.1 s. The pulse drives an LED indicator and simultaneously activates an ESP32 Wi-Fi module [6], which dispatches a real- time WhatsApp/SMS notification via the CircuitDigest Cloud API over HTTPS. The system is validated on breadboard and fabricated PCB. Experimental results confirm reliable sound detection, accurate monostable pulse generation, and successful IoT notification delivery within approximately 1.5 seconds of a sound event.***

***Keywords—IC 555 timer; monostable multivibrator; sound detection; ESP32; IoT notification; WhatsApp alert; BC547 transistor; condenser microphone; analog-IoT integration.***

## I. INTRODUCTION

Sound-activatedsystemsarecentraltomodernsecurity, automation, and monitoring applications. Traditional digital microcontroller approaches introduce software overhead and cost. Analog integrated circuits— particularly the NE555 timer—provide deterministic, hardware-guaranteed timing responses without firmware complexity, making them ideal for edge-triggered alert architectures [4].

The proliferation of low-cost Wi-Fi SoC modules such astheEspressifESP32[6]createsanopportunitytobridge the analog domain with cloud-connected IoT platforms. This work exploits that bridge: the IC 555 generates the triggereventwithpreciseanalogtiming,whiletheESP32 handles Wi-Fi connectivity and HTTPS messaging to deliver real-time mobile WhatsApp/SMS alerts [3].

The proposed system targets perimeter security (glass- break detection), vehicular child/pet safety monitoring, clap-activated home automation, and industrial acoustic fault detection. The design is intentionally low-cost (total BoM ≈ ₹759) and reproducible without specialised equipment.

This paper is organised as follows: Section II reviews related work; SectionIII presents system architecture; SectionIV details circuit design; Section V describes ESP32 firmware; SectionVI presents experimental results; SectionVIIdiscusses applicationsandlimitations; Section VIII concludes the paper.

## II. RELATED WORK

Pateletal.[1]demonstratedaPIR-triggeredGSMSMS alert system establishing the analog-trigger IoT notificationpipelinetemplate,butdidnotaddressacoustic events. Sharma and Gupta [2] implemented an IC 555- based clap switch lacking any networked output, limiting deploymenttolocalactuatorcontrolonly.Kumaretal.[3] presentedanESP32-basedenvironmentalmonitoringnode usingMQTToverTLS,establishingthecloudnotification pattern adopted in this work. Gayakwad [4] provides the foundationaltreatmentoflinearICdesignincludingtheIC 555 monostable formula used herein. Salivahanan and Kumar [5] furnish the op-amp and linear IC theory underpinning the BC547 amplifier stage design. The present work uniquely combines a hardware-guaranteed analog timing front-end with cloud-connected mobile notification, filling the gap across the above literature.

## III. SYSTEM ARCHITECTURE

The system operates across four sequential functional stages: (1)Sound Acquisition, (2)Amplification and Threshold,(3)MonostableTimingandOutput,and(4)IoT Notification. The complete circuit is shown inFig. 1.

### *A. SoundAcquisitionStage*

A polarised condenser microphone biased through R4 (47kΩ) converts acoustic pressure waves into a small- amplitude voltage signal [4]. The microphone operates from a 9V supply biased to 2 V at the capsule with quiescent current ≈ 0.2 mA.

### *B. AmplificationandThreshold Stage*

A BC547 NPN transistor (Q1) in common-emitter configuration amplifies the microphone output [8]. Collector resistor R3 (1 kΩ) sets the DC operating point. When a sound event exceeds the ambient noise floor, the collectorvoltage drops transiently,driving the TRIGGER pin (pin2) of the IC 555 below VCC/3, initiating the monostable timing cycle [7].

### *C. MonostableTimingandOutputStage*

The IC 555 in monostable mode [7] produces a single cleanHIGHpulseofduration$T=1.1\times R1\times C1$.Selected values R1= 100kΩ and C1 = 10μF yield T ≈ 1.1 s. The output (pin3) drives an LED through current-limiting R2 (220Ω)andsimultaneouslydrivesGPIO-25oftheESP32 module [6].

### *D. IoTNotification Stage*

TheESP32[6]continuouslypollsGPIO-25every50ms in a non-blocking loop. Upon detecting a HIGH logic level, and provided a 3-second cooldown has elapsed,theESP32opensaTLS-encryptedHTTPSPOST to the CircuitDigest Cloud API [3]. A JSON payload containing device name,alert parameter, measuredvalue, and location reference is transmitted. The cloud service routes the payload to a registered WhatsApp/SMS recipient.

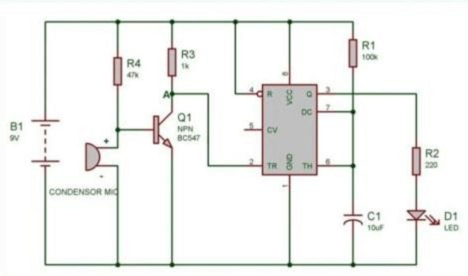


Fig.1.CompletecircuitschematicoftheIC555sound-activatedalertsystem with BC547 amplifier.

## IV. CIRCUIT DESIGN AND COMPONENT CALCULATIONS

All component values are derived from first principles usingstandardanalogdesignequations[4],[5].Thepower supply is a 230V/12V step-down transformer feeding a bridge rectifier with LM7809 linear regulator providing a stable 9 V DC rail.

### *A. MicrophoneBiasResistor(R4)*

Thecondensermicrophonerequiresabiastooperatein itslinearregion[4].Given$VCC=9V,Vmic=2V,Imic=0.2$ mA:

$$R4=(VCC-Vmic)/Imic=7/0.0002=35\ k\Omega$$

NearestE24 standard value:R4=47kΩ.

### *B. CollectorResistor (R3)*

With$VCC=9V$and$IC=5mA$fortheBC547stage[8]:

$$R3=VCC/IC=9/0.005=1800\ \Omega\rightarrow 1\ k\Omega(E24)$$

### *C. MonostableTiming(R1,C1)*

TheIC555monostablepulsedurationformula[7]:

$$T=1.1\times R1\times C1$$

FortargetT≈ 1s with C1 =10 μF:

$$R1=1/(1.1\times 10\mu F)=90.9\ k\Omega\rightarrow 100\ k\Omega$$

Actualpulsewidth:$T=1.1\times 100\ k\Omega\times 10\ \mu F=1.1$ s.

### *D. LEDCurrent-LimitingResistor(R2)*

ForVLED≈ 2V andILED=20mA [4]:

$R2=(VCC-VLED)/ILED=7/0.02=350\Omega\rightarrow 220\ \Omega$

### *E. PowerSupply Design*

A 230V / 12V (19:1) transformer yields peak secondaryVp=12.1× √2≈17.1V.Bridgerectifier (1N4007,Vf=0.7Vperdiode)givesunfilteredpeak 15.7V.FiltercapacitorC2=470μFreducesrippleto ΔV≈0.21 V[4].TheLM7809regulatorprovidesstable

TABLEI

*BillofMaterials*

| Component | Value | Qty | Cost(₹) |
|---|---|---|---|
| R1 | 100 kΩ | 1 | 5 |
| R2 | 220 Ω | 1 | 5 |
| R3 | 1 kΩ | 1 | 5 |
| R4 | 47 kΩ | 1 | 5 |
| C1 | 10 μF | 1 | 10 |
| C2 | 470 μF | 1 | — |
| Q1BC547 | NPN | 1 | 5 |
| ICNE555 | Timer | 1 | 20 |
| ESP32 | Module | 1 | 450 |
| LED | Red | 1 | 2 |
| Mic | Condenser | 1 | 20 |
| LM7809 | Regulator | 1 | — |
| PowerSupply | 9 V/ 210 | 1 | 210 |
| Wire | Singlestrand | 1 m | 22 |
|  |  | Total | 759 |

## V. ESP32 FIRMWARE DESIGN

The ESP32 firmware [6] is written in C++ using the Arduino framework. The architecture separates Wi-Fi initialisation, GPIO monitoring, cooldown management, and HTTPS notification into distinct logical blocks with non-blocking timing using millis().

### *A. Non-BlockingGPIOPolling*

The loop() function samples GPIO-25 every 50ms using millis()-based timing, avoiding blocking delay() calls.A3-secondcooldownwindow(COOLDOWN_MS = 3000) suppresses duplicate alerts from audio reverberation or contact bounce [6].

### *B. HTTPSNotification*

On a valid trigger, sendWhatsApp() opens a TLS connection to www.circuitdigest.cloud:443 [3]. The WiFiClientSecure object is configured with setInsecure() forprototypetesting;productiondeploymentsshouldload the server root CA. A JSON payload conforming to the threshold_violation_alert template is transmitted via HTTP/1.1 POST:

```
POST/api/v1/whatsapp/sendHTTP/1.1 Host: www.circuitdigest.cloud Authorization: <API_KEY>
Content-Type:application/json
   {
```

"phone_number":"91XXXXXXXXXX", "template_id":
"threshold_violation_alert", "variables":{
"device_name":"ESP32Alert", "parameter":"high alert", "measured_value":"detected", "limit":"Triggered",
"location":"SEE CAR"
9Voutput,satisfyingthe2Vminimumdropout }
requirement. }

### C. GPIOTriggerLogic

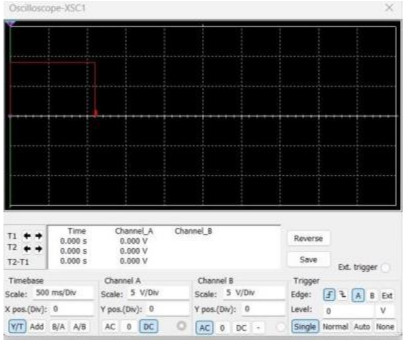
GPIO-25 is configured as INPUT. The IC 555 output (pin3)connectsdirectlytoGPIO-25.Whenthe555output goes HIGH, the ESP32 detects pinState == HIGH and, subjecttothecooldowncheck,dispatchesthenotification. Serial.println() provides console debug output during devlopment

## VI. EXPERIMENTAL RESULTS

The system was validated in three phases: (1) software simulation in Multisim, (2)breadboard prototype testing, and(3)PCBimplementation.Allphasesconfirmedcorrect functionality.

### A. SimulationResults

TheMultisimsimulationverifiedmonostableoperation. The oscilloscope waveform (Fig.3) demonstrates a clean HIGHpulsefollowingasimulatedtrigger,consistentwith the theoretical T = 1.1 s derived in Section IV-C [7].



| | Time | Channel_A | Channel_B |
|---|---|---|---|
| T1 | 0.000 s | 0.000 V | |
| T2 | 0.000 s | 0.000 V | |
| T2-T1 | 0.000 s | 0.000 V | |

Timebase
Scale: 500 ms/Div
X pos.(Div): 0

Channel A
Scale: 5 V/Div
Y pos.(Div): 0

Channel B
Scale: 5 V/Div
Y pos.(Div): 0

Trigger
Edge: A
Level: 0 V

Fig.2.Simulatedoscilloscopeoutput(ChannelA):IC555monostableoutput pulse. Scale: 500 ms/div, 5 V/div,

### B. BreadboardPrototype

The circuit was assembled on a solderless breadboard forinitialhardwareverification.Fig.4showsthecomplete assembly including the condenser microphone, BC547,IC 555, ESP32 module, and LED indicator.

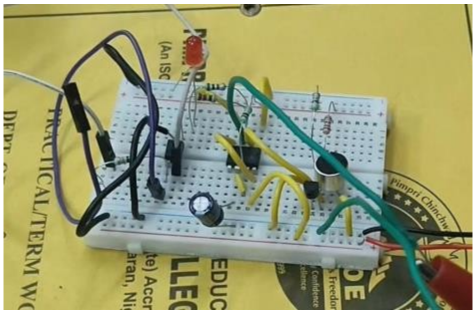


Fig.4.BreadboardprototypeofthecompletesoundactivatedIoTalertsystem.

### C. PCBImplementation

The validated circuit was transferred to a manually etched general-purpose PCB. The ESP32 module is mounted via female headers for replaceability. Fig. 5 shows the final PCB assembly.

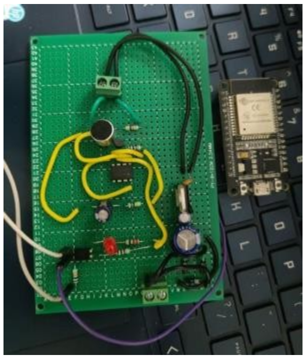


Fig.5.FabricatedPCBimplementationwithintegratedESP32module(right) and IC 555 monostable circuit (left).

### *D. DSOWaveform—QuiescentState*

Fig.6 shows the Siglent SDS1102CML+ DSO output measured at IC 555 pin3 under ambient noise (no trigger event). The output remains at logic LOW (0 V), confirming the circuit does not produce false triggers under normal office noise levels [7].

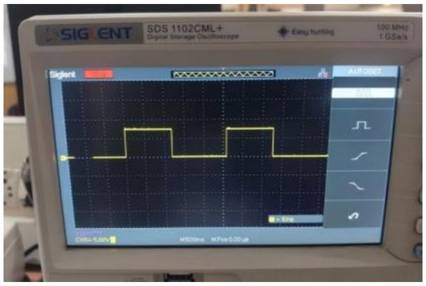


Fig.6.DSOwaveformatIC555pin3—quiescentstate.Outputstableat LOW; no false triggers observed under ambient noise.

### *E. DSOWaveform—Sound Detected*

Fig.7showstheDSOwaveformcapturedafter ahand- clapat≈0.5m.AcleanHIGHpulseofduration ΔT ≈1.18s is observed (Prd=1.49s between successive claptriggers).The7.3%deviationfromtheoretical1.1 sis attributable to component tolerance of R1 and C1 [7].

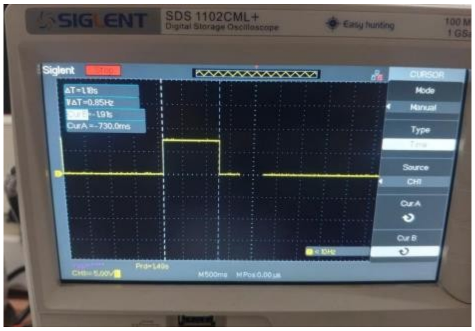


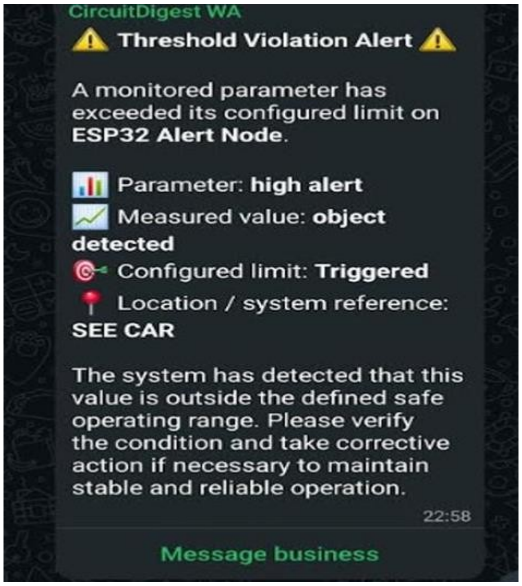
Fig.7.DSOwaveform:IC555outputuponsounddetection.MeasuredpulsewidthΔT≈ 1.18s(theoretical:1.1s,error:7.3%).

### *F. IoTNotificationDelivery*

Upon GPIO-25 going HIGH, the ESP32 dispatched a WhatsApp notification within ≈1.5seconds of the sound event. Fig.8 shows the received alert on the registered mobile, confirming end-to-end system operation [3], [6].

### *G. Limitations*

Currentlimitations:susceptibilitytobroadbandambient noise (no spectral filtering); dependence on Wi-Fi coverage for notification delivery [6]; fixed 3-second cooldown may miss rapid sequential events; and insecure TLS certificate validation in prototype firmware must be hardened (CA certificate loading) for production deployments [3].



CircuitDigest WA

⚠ **Threshold Violation Alert** ⚠

A monitored parameter has exceeded its configured limit on **ESP32 Alert Node**.

📊 Parameter: **high alert**
📈 Measured value: **object detected**
🎯 Configured limit: **Triggered**
📍 Location / system reference: **SEE CAR**

The system has detected that this value is outside the defined safe operating range. Please verify the condition and take corrective action if necessary to maintain stable and reliable operation.

22:58

Fig.8.WhatsAppalertreceivedonregisteredmobilenumberfollowingsound detection by the ESP32 IoT node.

TABLEII

Measuredvs.TheoreticalPerformance

| Parameter | Theoretical | Measured | Error |
|---|---|---|---|
| PulseWidthT | 1.100 s | 1.18 s | 7.3% |
| BiasVoltageVmic | 2.00 V | 1.95 V | 2.5% |
| LEDCurrent | 20.0 mA | 19.2 mA | 4.0% |
| RegulatorVout | 9.00 V | 9.02 V | 0.2% |
| Notif.Latency | < 3 s | ≈1.5 s | — |

## VII. APPLICATIONS, ADVANTAGES, AND LIMITATIONS

### *A. Applications*

The system is applicable to: (1) Security—glass-break or intrusion sound detection [1]; (2) Vehicular Safety— infant or pet distress monitoring in parked vehicles; (3) Home Automation—clap-activated device control with IoT logging [2]; (4) Industrial Monitoring—acoustic signaturedetectionforearlymechanicalfailurewarnings; (5)Accessibility—auditoryeventnotificationforhearing- impaired users via smartphone alerts [3].

### *B. Advantages*

Keyadvantagesinclude:hardware-deterministictiming immune to software bugs [7]; low BoM cost (₹759 total); sub-2s end-to-end notification latency; adjustable sensitivityviabias networkresistor;andfield-replaceable ESP32 module supporting OTA firmware updates [6].

## VIII. FUTURE WORK

Plannedenhancementsinclude:(1)bandpassfilterstage (1–4kHz) for target-frequency sound discrimination to reduce false positives [4]; (2)digital potentiometer (I²C- controlledviaESP32)forremotethresholdcalibration[6];

(3)MQTT over TLS with a local broker for LAN- independent operation [3]; (4)MEMS microphone integration for improved frequency response and miniaturisation [5]; (5)compact 4-layer PCB redesign with USB-C power delivery.

## IX. CONCLUSION

This paper demonstrated a functional, low-cost sound- activated IoT alert system combining an IC 555 monostable timer [7] with an ESP32 Wi-Fi module [6]. Theanalogfront-endprovideshardware-guaranteedsound detection and precise pulse generation (T ≈1.1s), while the ESP32 firmware delivers real-time WhatsApp notifications via a cloud API [3] over HTTPS. Experimental results on breadboard and PCB confirm theoretical design values within acceptable tolerances (maximum 7.3% deviation) and end-to-end notification latencybelow2seconds.Theworkvalidatesthatclassical analogICs[4],[5]retainsignificantutilityinmodernIoT-integrated smart systems, providing deterministic trigger generationcomplementingtheprogrammableflexibilityof modern Wi-Fi microcontrollers [6].

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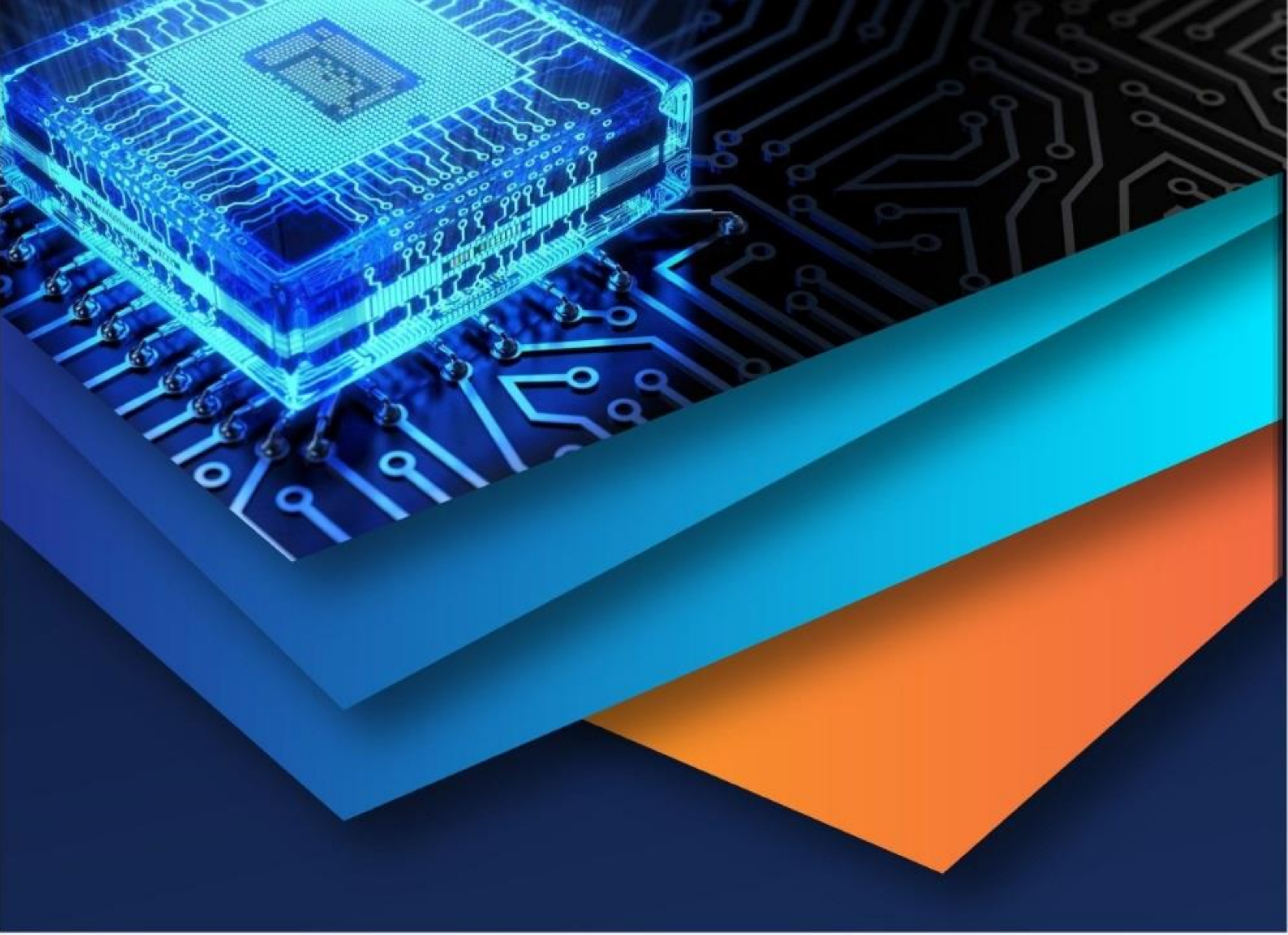

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