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Brain Computer Interface for Paralyzed People

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Abstract*: This paper presents the Brain Computer Interface for paralyzed people. The purpose of the Brain Computer Interface (BCI) is to connect the human brain to an external device in order to read the electric signals generated by the brain. These electric signals are then forwarded to a signal processor which differentiates the various signals that are generated by the brain. The signals can be read by using a sensor named electroencephalogram (EEG). The main objective is to focus on the electric signals produced by the brain to understand whether the patient is in under stress or not. In addition to EEG readings, patient's pulse and eye-blinks are also taken into consideration. If these readings exceed beyond a normal limit an alarm is made to ring and also a SMS will be send to the respective caretakers. This will help the caretaker to assist the patient at times of stress. The first section of this paper specifies Brain Computer Interface (BCI) for paralyzed people which explain the theme of this project. The second section specifies about implementation of brain computer interface for paralysed people.*
Keywords*: Brain computer interface for paralyzed people, Stress Detection, BCI, paralyzed people, EEG*

I. INTRODUCTION

A brain computer interface (BCI) is a specialized framework that permits a man to control the outside world without depending on muscle movement. Instead of relying upon the body's typical yield pathways of nerve cells and muscles, the input control signals are denoted by electrophysiological motivations recorded straightforwardly from the cerebrum. The dominant part of all current brain computer interface frameworks, incorporating the one created in this venture, utilize recordings of the electrical action in the cerebrum, utilizing electroencephalogram (EEG), as the source of input. A brain computer interface, once in a while called a direct neural interface or a brain machine interface.

Brain computer interface [BCI] is a joint effort between a cerebrum and a gadget that empowers signals from the cerebrum to direct some outside action, for example, control of a cursor or a prosthetic limb. The interface empowers an immediate correspondences pathway between the mind and the object to be controlled. The Brain Computer Interfaces (BCI) can be classified as invasive and non-invasive. In invasive Brain Computer Interfaces (BCI), the electrical action of the mind is recorded from inside the head with at least one microelectrodes which can record the action of a solitary neuron. The non-invasive Brain Computer Interfaces (BCI) depends on the EEG measured from scalp of the human cerebrum. Brain Computer Interfaces (BCI) can be utilized for communication, to assess a computer, or control of gadgets, for example, a wheelchair or prosthetic arm, among different applications. Basically anything that can be controlled by a PC could possibly, be controlled by a BCI. Brain Computer Interfaces (BCI) is being inspected as a rehabilitation device to help individuals recapture motor skills that are lost from stroke, and additionally a prosthetic gadget to swap or compensate for motor skills that will stay away for the indefinite future.

II. RELATED WORKS

The research in the field of brain computer interface began in 1970's. BCI research and development has focused primarily on neuroprosthetics applications that aim at restoring damaged hearing, sight and movement [6].The four major phases in BCI systems are data acquisition, signal processing classification, computer interfacing application. The signal acquisition can be done using any of the following approaches: Firstly invasive approach, which gives quality signals since electrodes are placed inside the skull in a brain surgery, secondly partial invasive approach, where signals are read from the skull using BCI devices implanted outside the grey matter in the brain, thirdly non-invasive approach, where the electrodes are mounted on the scalp for the acquisition of the signal. The input signals for signal processing and classification are always recorded with some unwanted data called noise. Some of the common pre-processing techniques for filtering noise are Basic Filtering, Adaptive Filtering, Blind Source Separation, Independent Computer Analysis (ICA), and Matching Pursuit Algorithm Computer Interfacing requires proper feature extraction using appropriate method and these features are translated using translation algorithm [7]. Basic filtering uses instrumentation amplifier, notch filters, high pass filters and low pass filters for filtering artifacts and noise [8].

Various works have been done in the field of BCI to monitor brain activity. Mind-Controlled Wheelchairs are designed for helping elderly people. The system uses EEG headset for signal acquisition and an Arduino Microcontroller to translate these signals to

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commands [9]. Detecting drowsiness while driving hence giving an alert is done using one channel EEG Sensor device developed by Neurosky Mind wave which can provide eight brainwave signal such as Delta, Theta, Low Alpha, High Alpha, Low Beta, High Beta, Low Gamma, and Mid Gamma[10].

Doctors cannot always monitor a particular patient in total working hours. Heart rate sensor and temperature sensor are used for patient monitoring. Sensors give accurate output. Therefore, it rules out the use of traditional medical instruments such as thermometer and other devices. This paper provides relief to medical advisory for patient monitoring and also to patients for freedom of movement. For continuously sending message from patient's location to medical advisory, a GSM modem is used. To alert medical advisory about present health condition of patient by SMS, the buzzer will turn ON if body temperature and heart beat exceeds or lower below the threshold level. GSM modem requires postpaid SIM card. Message cannot be send to medical advisory without network coverage. Heart rate sensor and temperature sensor which measure the heart rate and body temperature sends SMS through GSM module to the medical advisory for the preliminary precaution so that patient can be prevented from serious situation before reaching the hospital . For temporary storage of data, PIC16F877A controller device is used. To display the measured values of the heartbeat and body temperature, the LCD is used. This paper is advantageous where continuous monitoring of patients is required under critical condition. It is applicable in hospitals, homes and also in ambulances. [4]

III. METHODOLOGY

A. *Objective of our Project*

In order to enable the immediate health care to the paralyzed people, this concept is being introduced.

B. *Block Diagram*

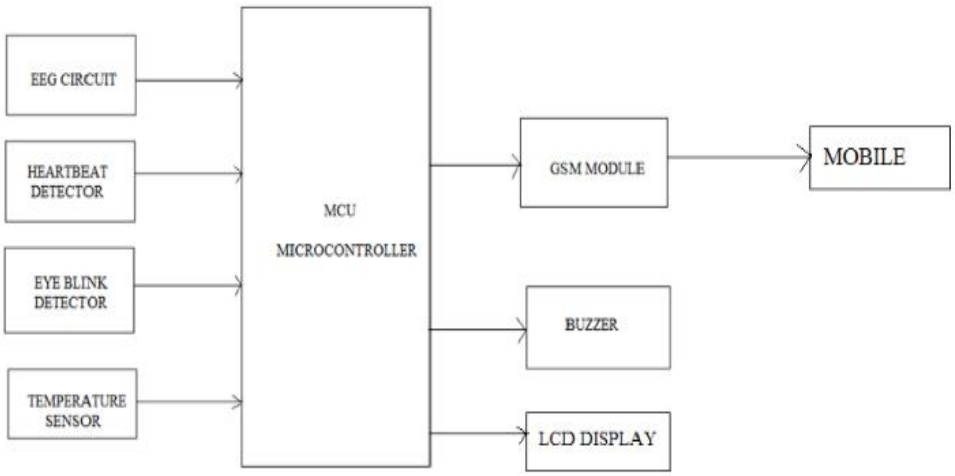

Figure 1: Block diagram of BCI for paralyzed people

C. *Module Description*

1) *EEG Sensor:* Human brain is complicated and its analysis is a challenge in the field of brain computer interface (BCI). An attempt to study the brain waves is made possible by the use of an EEG sensor.

Sources of bio-signals for a paralyzed person are mainly heart and brain which are constantly working. Heart and brain works naturally and living organisms rather have no control on its functioning. However, thoughts and mental states of brain are controllable up to certain extent by humans. This tendency can be exploited to devise new technologies. Brainwaves pertaining to certain mental state can be sensed, analyzed and processed to drive any physical device.

The brain cells communicate via electrical impulses. An EEG sensor detects the electrical activity in the brain with the help of small electrodes which are placed at appropriate positions on the scalp.

These EEG signals detected by the sensor consist of various bands, whose amplitude normally lies between 0.5 and 100µv. It shows difference under varying mental states. EEG signals measured by the sensor have been categorized into different bands as Delta (0.5 -3 Hz), Theta (4 -7 Hz), Alpha (8-13 Hz), Beta (14-30Hz) and Gamma (>30Hz). These bands are related with different brain activities.

Volume 5 Issue III, March 2017
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RHYTHYM	FREQUENCY RANGE (Hz)	AMPLITUDE (μv)	STATE OF MIND
DELTA	Up to 4	High amplitude (20-200)	Deep sleep
THETA	4-8	More than 20	Emotional stress, drowsiness and sleep in adults
ALPHA	8-13	30-50	Relaxed awareness
BETA	13-30	5-30	Active thinking, active attention, alert
GAMMA	Above 31	Less than 5	Mechanism of consciousness

The brain waves that show higher amplitude at the time of stress in paralysed people are the beta waves. They are very fast brain waves, having too much beta may lead to experiencing excessive stress and/or anxiety. The higher beta frequencies are associated with high levels of arousal.

2) *Eye Blink Sensor:* This Eye Blink sensor is IR based. The Variation across the eye will vary as per eye blink. If the eye is closed means the output is high otherwise output is low. This to know the eye is closing or opening position. This output is given to logic circuit to indicate the alarm. This can be used for project involves controlling accident due to unconscious.
3) *Heartbeat Sensor:* Heart Beat can be measured based on optical power variation as light is scattered or absorbed during its path through the blood as the heart beat changes. It measures the change in volume of blood through any organ of the body which causes a change in the light intensity through that organ.
4) *Temperature Sensor:* Working principle is, the resistance depends upon temperature. When temperature changes, the resistance of the thermistor changes in a predictable way.
5) *GSM Module:* GSM /GPRS Modem-RS232 is built with Dual Band GSM /GPRS engine- SIM900A, works on frequencies 900/ 1800 MHz The Modem is coming with RS232 interface, which allows you connect PC as well as microcontroller with RS232 Chip(MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM /GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in 2M interface. The onboard Regulated Power supply allows you to connect wide range unregulated power supply. Using this modem, you can make audio calls, SMS, Read SMS; attend the incoming calls and internet etc through simple AT commands.
6) *Buzzer Module:* The buzzer module takes as input the output from the microcontroller. If the amplitude of beta waves exceed beyond a normal limit the buzzer or alarm is made to ring.
7) *LCD Display:* The LCD module is used to display the recordings of heartbeat sensors, temperature sensors and eye blink sensor.
8) *Peripheral Interface Microcontroller (PIC) 16F778A:* It takes input from EEG sensor, heartbeat sensor, eye blink sensor and temperature sensor. It gives input for LCD display, GSM module and the buzzer module.

Volume 5 Issue III, March 2017
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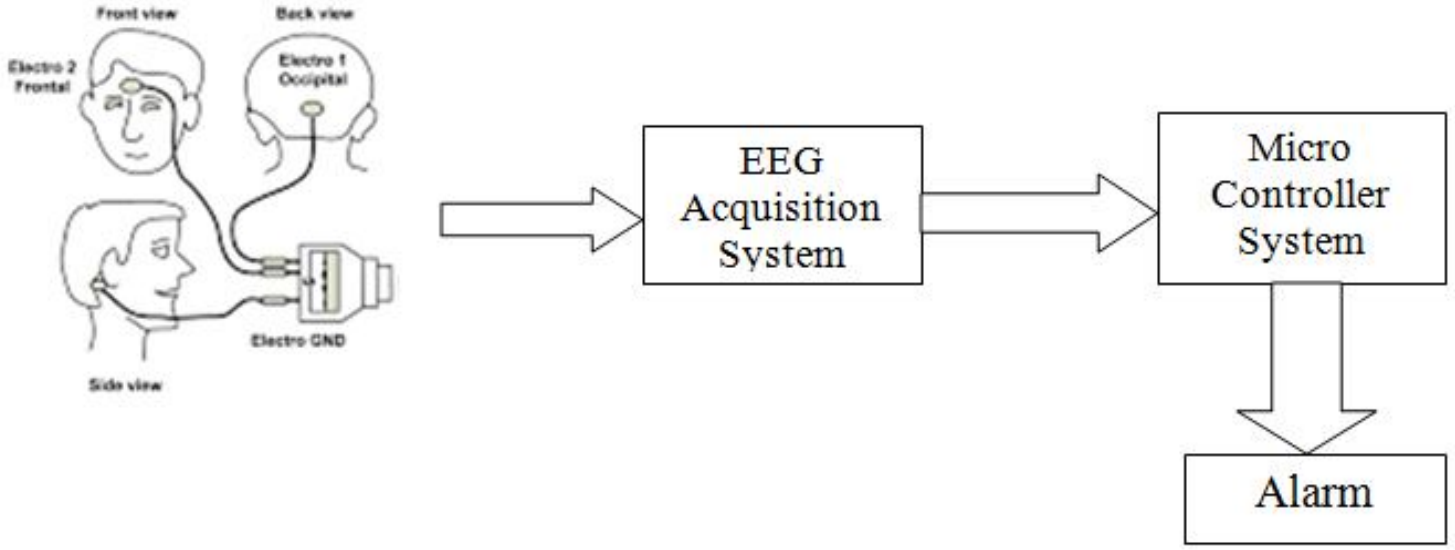
IV. SYSTEM IMPLEMENTATION

For easy understanding and explanation the complete system can be divided into
Measurement Unit
Processing Unit
Communicating Unit

A. Measurement Unit - Measurement Unit consist of

1) EEG Sensor:



Three EEG electrodes are used to acquire signals from the patient's brain. First electrode is placed at the occipital lobe (one of the four major lobes of the cerebral cortex in the brain of mammals). Second electrode is placed at the frontal lobe and third is placed behind the ear, it acts as ground.

2) Heartbeat Sensor: Sensor is designed to provide digital output of heartbeat when a finger is placed on it. When a heartbeat detector is working, beat LED flashes in unison with each heartbeat. This digital output can be connected to Arduino Uno to measure Beats Per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse.

3) Temperature Sensor: Temperature sensor is a device which senses variations in temperature across it. LM35 is a basic temperature sensor that can be used for experimental purpose. It give the readings in centigrade (degree Celsius) since its output voltage is linearly proportional to temperature. It uses the fact that as temperature increases, the voltage across diode increases at known rate (actually the drop across base-emitter junction of transistor).

Its advantage is:

a) You can measure temperature more accurately than a using a thermistor.
b) The sensor circuitry is sealed and not subject to oxidation, etc.
c) The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

4) Eye-Blink Sensor: Connect regulated DC power supply of 5 volts. Black wire ground, Next middle wire is Brown which is output and Red wire is positive supply. These wires are also marked on PCB. To test sensor you only need power the sensor by connect two wires +5V and GND. You can leave the output wire as it is. When Eye closed, LED is off and the output is at 0V.Put Eye blink sensor glass on the face within 15mm distance, and you can view the LED blinking on each Eye blink. The output is active high for Eye close and can be given directly to microcontroller for interfacing applications.

5) Eye Blink Output: 5V (High) → LED ON when eye is close.
0V (Low) → LED OFF when eye is open.

Volume 5 Issue III, March 2017
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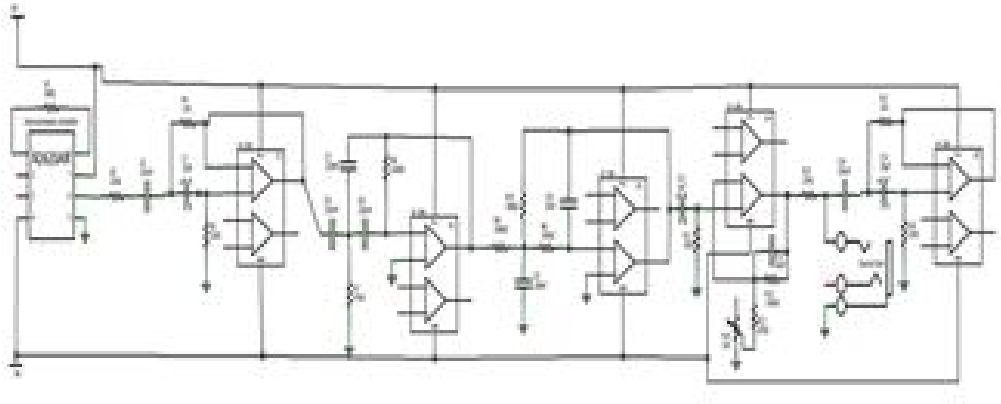
B. Processing Unit

1) EEG Signal Processing:



The EEG signals acquired using the EEG sensors should be processed in order to find the stress condition of the patient. Firstly the signals are passed through an instrumentation amplifier, which is a differential amplifier that amplifies the difference between various signals in the EEG spectrum.

These amplified signals are the passed to a notch filter. The notch filters are filters that filter only a particular frequency. We use notch filter to filter out noise from dc sources that come under the frequency range of 60Hz.

Now these signals are passed through a band pass filter. The band pass filter is a combination of a low pass and a high pass filter. A low-pass filter is a filter that passes signals with a frequency lower than a certain cut off frequency and attenuates signals with frequencies higher than the cut off frequency. A high-pass filter is an electronic filter that passes signals with a frequency higher than a certain cut off frequency and attenuates signals with frequencies lower than the cut off frequency. The band pass filter is used to filter out frequencies in the range of EEG spectrum i.e. 0.5μV to100μV.

The needed spectrum of signals is then amplified using an amplifier circuit. At last the signals are again passed through a notch filter to remove dc noises. This signal is then given as input to the microcontroller. The amplitude of Beta wave is monitored continuously and stress condition is detected.

2) Microcontroller: The microcontroller unit in the brain of the system. It takes input from EEG sensor, heartbeat sensor, eye blink sensor and temperature sensor. It gives input for lcd display, GSM module and the buzzer module.

If the readings from the sensors exceed a normal value the microcontroller make the buzzer ring and inform the GSM module to send a SMS.The current sensor readings are displayed on the LCD display.

C. Communicating Unit

1) GSM : GSM (Global System for Mobile communication) is a digital mobile telephony system that is widely used in Europe and other parts of the world. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). It is used to send a SMS to the caretaker at times of stress. GSM /GPRS Modem-RS232 is built with Dual Band GSM /GPRS engine - SIM900A, works on frequencies 900/ 1800 MHz

2) Buzzer: Buzzer is an electrical device, which is similar to a bell that makes a buzzing noise and is used for signalling. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

Abbreviations and Acronyms

Brain Computer Interface – BCI

Electroencephalogram – EEG

Independent Computer Analysis – ICA

Global system for mobile communication - GSM

Liquid crystal display – LCD

Infrared – IR

General packet radio service – GPRS

Short message service – SMS
Peripheral Interface Microcontroller – PIC
Beats per Minute – BPM
Light emitting diode – LED
Printed circuit board – PCB
Time division multiplexing access –TDMA
Ground - GND

V. RESULT AND EVALUATION

The Brain Computer Interface for paralysed people is implemented to detect stress condition in paralyzed people. It employs various sensors, microcontroller and GSM module to perform this task. The main advantage of Brain Computer Interface for paralysed people is that the stress measurements will be accurate since it notices three symptoms from the patient. Other advantage is that the system also sends a notification to the caretaker so even if the caretaker is far and unable to listen to the alarm, he will be informed by the notification.

The BCI system is perfectly reliable once it is adjusted to the features of a person or trained for a person. Since every individual body reacts in different manner the BCI system should be trained for the patient. One major problem is that the signals can go weak due to interference, so readings should be taken faster. However the fact that BCI systems are a blessing for paralyzed people cannot be neglected and the system can be further modified in the future for the wellbeing of people.

VI. CONCLUSION & FUTURE ENHANCEMENT

The project has very important scope in future. The project can be implemented by using EEG headset. With the proposed system of brain computer interface (BCI) for paralyzed people we can only turn on the alarms and send message to the caretaker as well as to nearby hospitals. This can be also modified in such a way that a call can also be originated. To make the readings of the brain signals accurate, we can use the 64 electrodes that are attached to the brain instead of the 3 electrodes used here. We can also use the EEG sensor to record the accurate reading of the eye blink instead of using separate eye blink sensor. In the same way we can also use EEG to detect the heartbeat of the patient. Better filtering circuits can be also included. We can also use wireless equipment instead of wired equipment's. Since the GSM is having connectivity problems we can use other technologies such as zigbee, RF transmitter. Instead of using separate sensors for monitoring the patient we can take all the readings using EEG.

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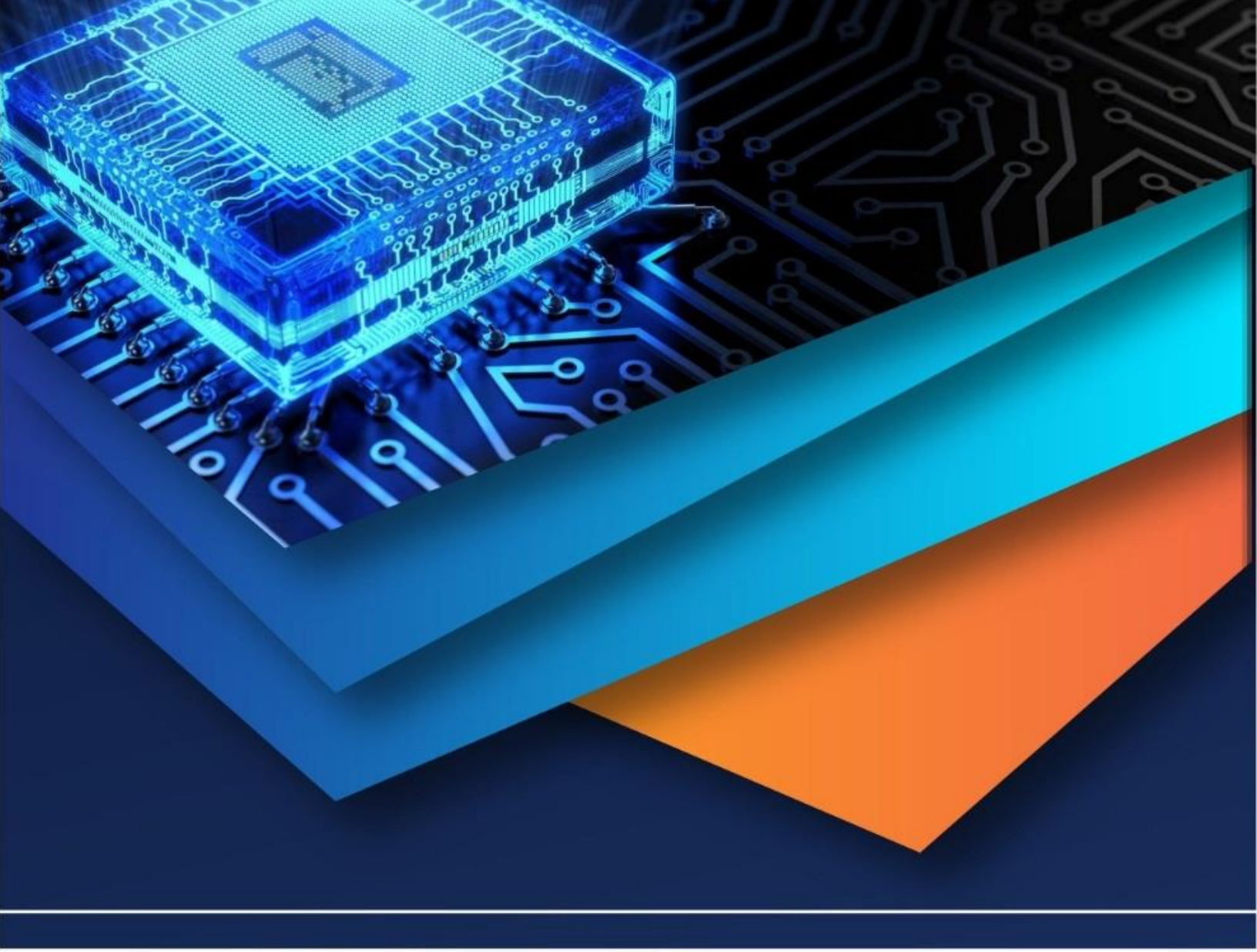

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