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Low Cost Wireless Biosignal Acquisition from Human Body for Biomedical Application

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Abstract: Human Body generates a various biosignal mainly ECG and EMG that can be measured and monitored in continuous. This signal has proved their importance in disease diagnosis such as Heart Disease detection, Musckuloskeletal disorder. However, ECG has a prime importance in detection of cardiovascular diseases. Expensive cost and complex operation of medical equipment limits the availability of better services to all people in developing countries. We have developed a low cost wireless acquisition system having real time PC/ laptop based monitoring of ECG and EMG. In this system ARM7 controller used for high digital transmission, MATLAB R2017a is used for monitoring and analysis. Data is transmitted with Zigbee to achieve a low power consumption of system. In this system, Peaks detected and intervals calculated of ECG to detect the disease at earlier stage.

Keywords: Low Cost, Wireless Acquisition, ECG, EMG, Biomedical Diagnosis.

I. INTRODUCTION

ECG and EMG signal from human body can be sensed with the help of Skin-surface transducer[1], which is commonly used for ECG (Electrocardiograph) and EMG (Electromyograph) . ECG and EMG signals are non-invasive in nature can be measured independently. Generally, these signals used in many applications such as Human-machine interface, disease diagnosis, entertainement etc. Utilization of biosignal can be facilitate and improved using wireless transmission[2], which provides portability to patient or individual. Processing of biosignal requires digital filteration to reduce analog components for which inexpensive microcontroller is suitable[7]. Half of the world population lives in Asia including large number of developing and under developed countries, for which cardiovascular disease prevention is major issue for World Health[8]. Surveying literature wireless monitoring of biosignal [2][3] enables measurement on moving subject. One wired system in review requires mobile connected with OTG[4], which limits the patient movement in respect of monitoring unit.

Our research aims to develop a complete low cost wireless biosignal acquisition system affordable to all people of developing and under developed country, enabling ECG diagnosis. This paper present a prototype biosignal acquisition system of low cost, portable, battery powered and low power consumption. In this system biosignal is transferred using Zigbee technology with wireless connectivity upto 8m. This paper is organized as follows: Section II shows system architecture, Section III described proposed methodology, Biosignal analysis is mentioned in section IV, Software implementation is discussed in Section V. Experimental measurement and result mentioned in section VI, Finally section VII is conclusion.

II. SYSTEM ARCHITECTURE

Figure 1 shows the system architecture of proposed system. It is described as below.

A. Acquisition Transmission Side

In this system 3 electrodes [9] are used to sense biosignal from body. AD8232 module [10] used as signal conditioning for biosignal. System consist of ARM7 develped Kit with its peripherals used for analog to digital conversion. Zigbee is used for wireless transmission.

B. Data Acquisition Unit & Monitoring

It's simply consist Zigbee interfaced with laptop, no additional hardware is required. Serially transmitted data is received at interface Host. MATLABR2017a used for monitoring and analysis

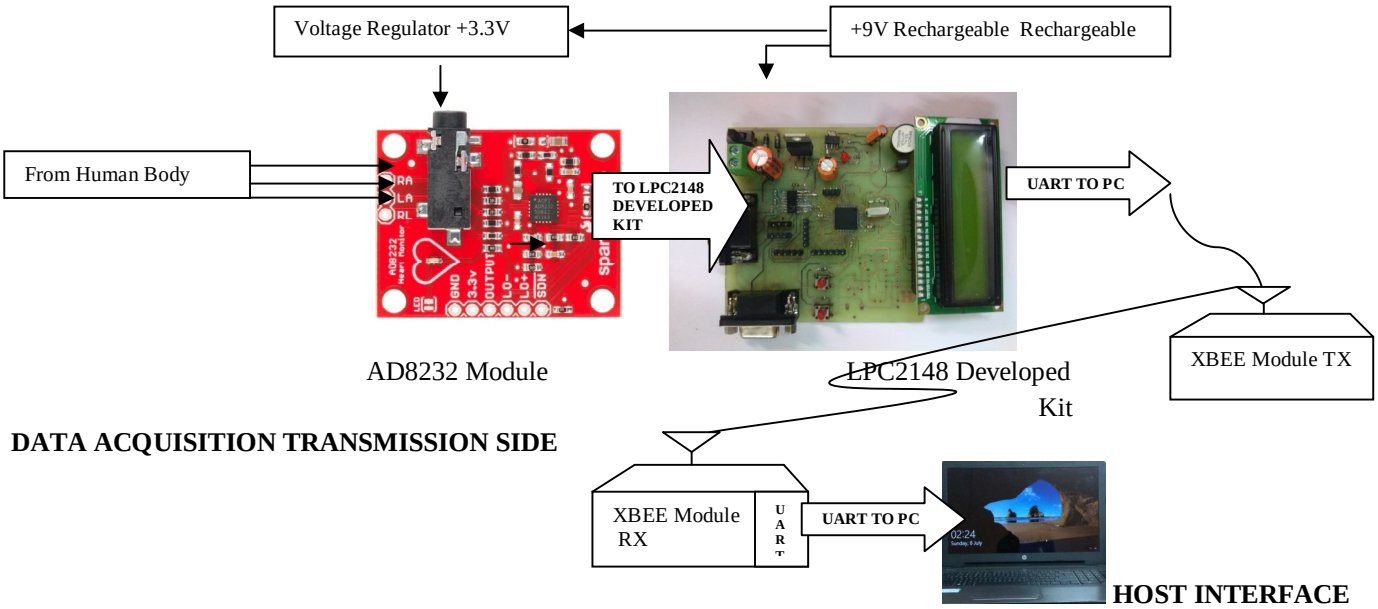

Fig1: Proposed System Architechture.

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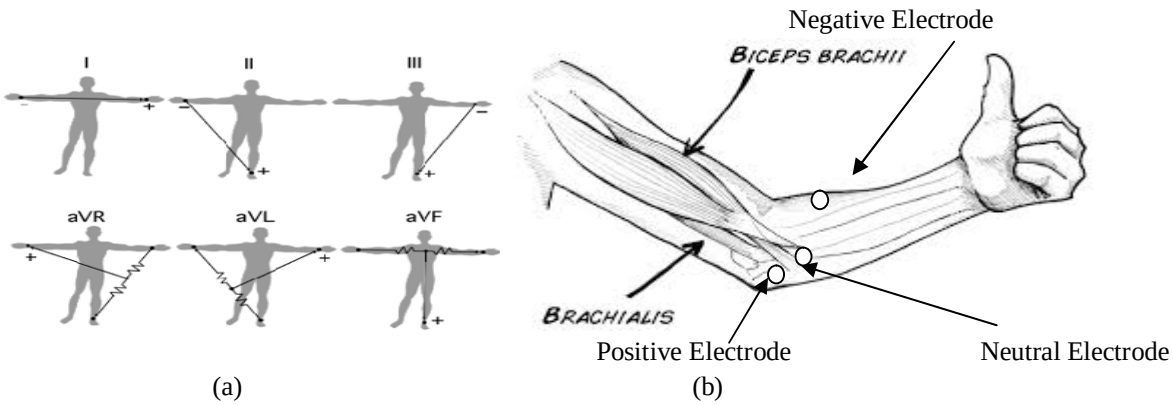


(a) (b)

Fig2: (a) Limb leads and augmented limb leads for ECG, (b) Electode position for EMG

III.PROPOSED METHDOLOGY

The methodology to developed system comprises of sensing of Biosignal, Signal Conditioning, Digital Filteration, Microcontroller unit for transmission, Power supply, portable reception, monitoring and analysis of signal. Detailed description mentioned in following section:

A. Biosignal Acquisition & Conditionig

For sensing ECG, EMG from body surface a commercially available medico electrode named as Bio Protech T716[9] is used. Fig 2 shows the electrode positions for ECG and EMG. ECG signal ranges from 0.05-100Hz and corresponding amplitudes from 10uv to 5mV, which is typically 1 mV[7]. Similarly, EMG signal ranges from 0-500Hz with 0 to 10mV(peak to peak)[1]. However, the biopotential signal (ECG,sEMG) are extremly noisy due to motion or remote electrode placement. In our system AD8232 SparkFun module is used which is integrated signal conditioning block for ECG and other biopotential measurement. Additionally, AD8232 consist of LED indicator that pulsate propotional to heart beat and operates at +3.3V.

B. Power Supply Unit

Our system is powered with two 8V lead acid rechargeable batteries to achieve system portability. Voltage regulation of +5V is using LM7805 to protect from short circuit. Also, LM1117 is used for +3.3V ouput for AD8232 and LPC2148.

C. Digital Filteration

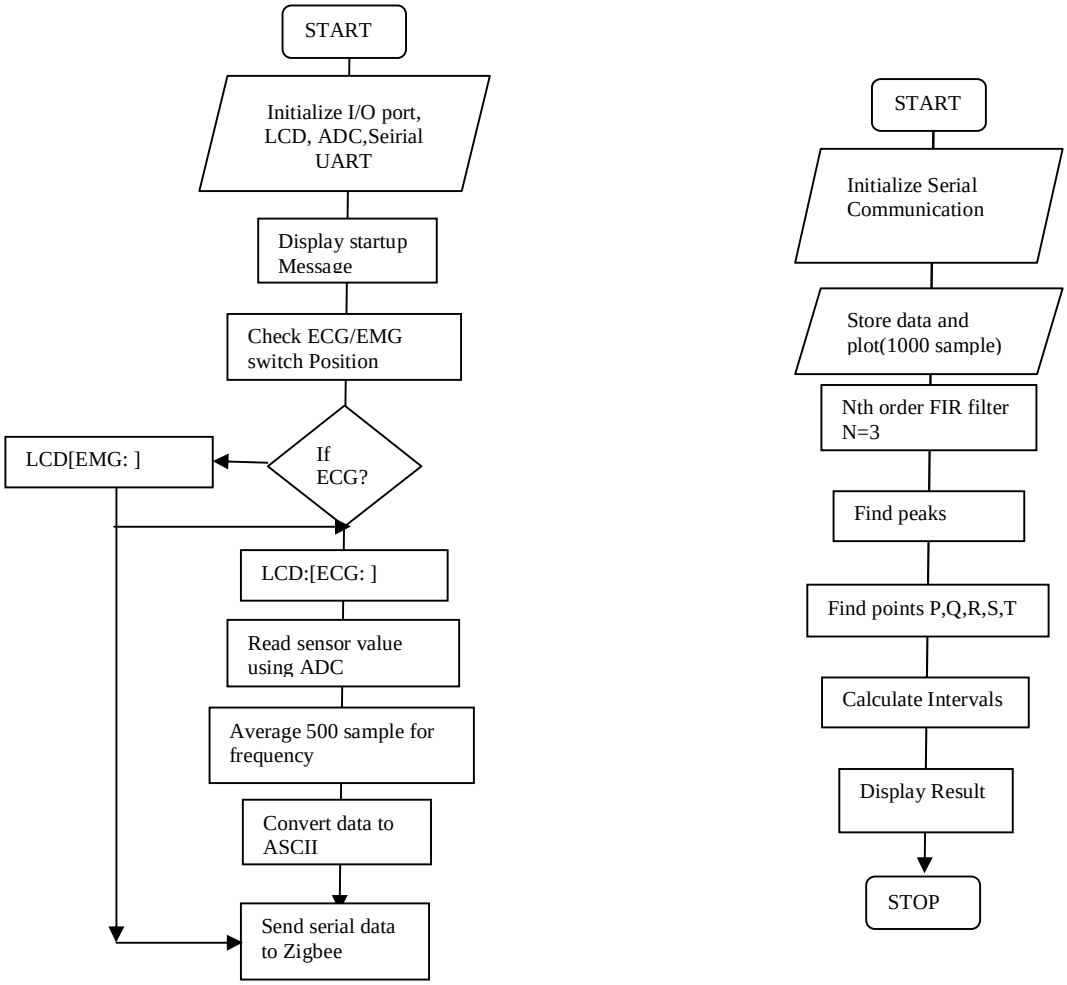
ECG and EMG are extremely affected with small noise. However, ECg module[10] reduces the noise upto greater extent, to improve the result of later processing we used a Median Filter[11] using ARM7 controller. We used a window size of 500 , indicates each single point on GUI is 500 times averaged compared to AD8232 output.

D. Transmitter Section

This section consist of LPC2148 developed board and zigbee module. We have developed the LPC2148 board after designing PCB schematic in Eagle7.2.0. Along with all required peripherals of controller an LCD display and switch added on board to show acquisition signal type(ECG, sEMG) based on switch position. LPC2148 has 14 channel 10-bit ADC, for analog signal 0V-5V it returns a linear value of 0 to 1023 respectively[14]. For serial transmission sampling rate is 1Ksps and transmission baud rate as 9600bps. Zigbee does the serial transmission between LPC2148 and laptop. ARM7 decision making flow is shown in figure3(a).

E. Recieving and Monitoring Section

Serial reception consist of same Zigbee module as transmitting side interface with laptop host through UART to USB connector(micro SATA cables USB to serial TTL Cp2102 UART port Module). Main feature of zigbee to low power consumption[15] improves operating duration of system and battery life. MATLABR2017a used for a real time visualization of ECG & EMG.ECG button stores data, for result and corresponding REPORT button is added in GUI. MATLAB stores data for further detection.



3(a) 3(b)

Fig3: (a) ARM7 LPC2148 Active loop of ECG, EMG for real time Monitoring (b) MATLAB analysis.

IV.BIOSIGNAL ANALYSIS

ECG signal consist of P wave, QRS complex, T wave & their corresponding intervals are used for diagnosis of ECG.In our system ECG diagnosis is done using peak detection detection[14] and interval calculation. Following are the steps of ECG analysis. Flow of MATLAB analysis is shown in fig3(b).

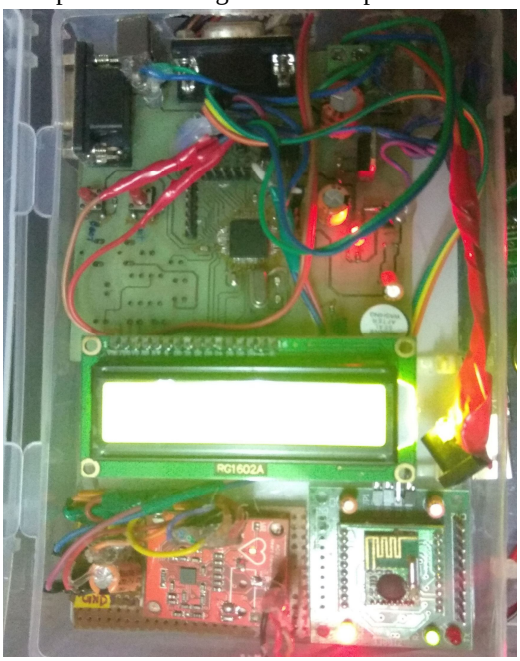
1) Step 1: Initialize serial communication port in MATLAB.
2) Step2: Store data xECG ECG from fig2 and plot 1000 sample/sec.
3) Step3: Filter serial data with Nth order FIR filter with a frame length of 11 sample.[6]
4) Step4: Find peak of ECG (P peak, R peak)[16].
5) Step5: QRS witdth calculated with respect to.
a) Dearivative to supress P, T wave .
b) Bandpass Filteration to remove base line wandering, power line noise.
c) Squaring (Y[n]= X[n]^2).
6) Step5: Mark the point of peak P,Q,R,S; instant of time.
7) Step 6: Required interval propotional to difference of time peak.

V. SOFTWARE IMPLEMENTATON

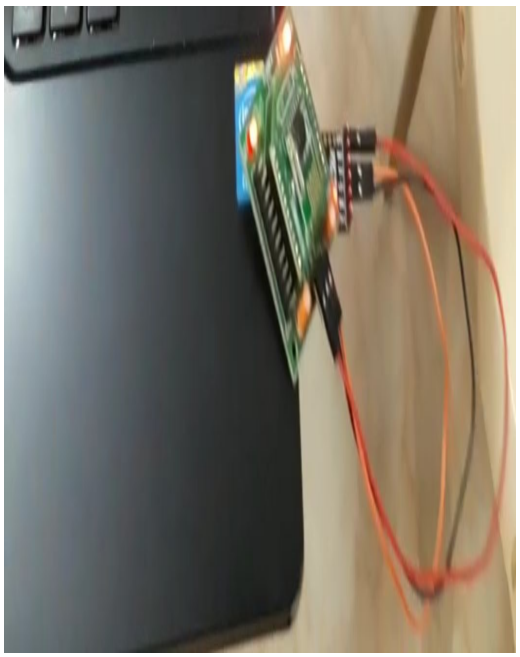
It mainly consist of device layer and application layer software structure . Device layer programming is responsible to drive prototype hardware while application programming gives biosignal visualization. Microcontroller is programmed with C code thourgh keil compiler uVision v4 hex file, ISP flash magic is used to burn program in microcontroller. GUI is designed to plot the serial data using MATLAB. MATLAB programmed to filter ECG and to generate multiple ECG report for comparision .

VI.EXPERIMENTAL MEASUREMENT AND RESULT

Figure 3 shows the active operating state of prototype used for acquisition.. For monitoring laptop with specification of windows 10, core i3 and 4GB RAM is used. ECG and EMG signal is acquired from a boy of 24 year old.
10msec/sample of data for 1000 samples is recorded for analysis by ECG button on GUI. Reports generated for each cardiac wave in one complete window of GUI, results of ECG waves shown in fig 6 and respective comparision noticed. Figure 5(a) shows the real time EMG response following muscle compression while fig5(b) shows real time ECG data.



4(a)



4(b)

Figure4: (a) Acquisition Transmission Side (b) Data Acquisition Host

ECG button on GUI enables the recording of continious ECG for one complete window of 10sec for analysis. Reports generated for each cardiac wave in one complete window of GUI, results of ECG waves shown in fig 6 and respective comparision noticed.

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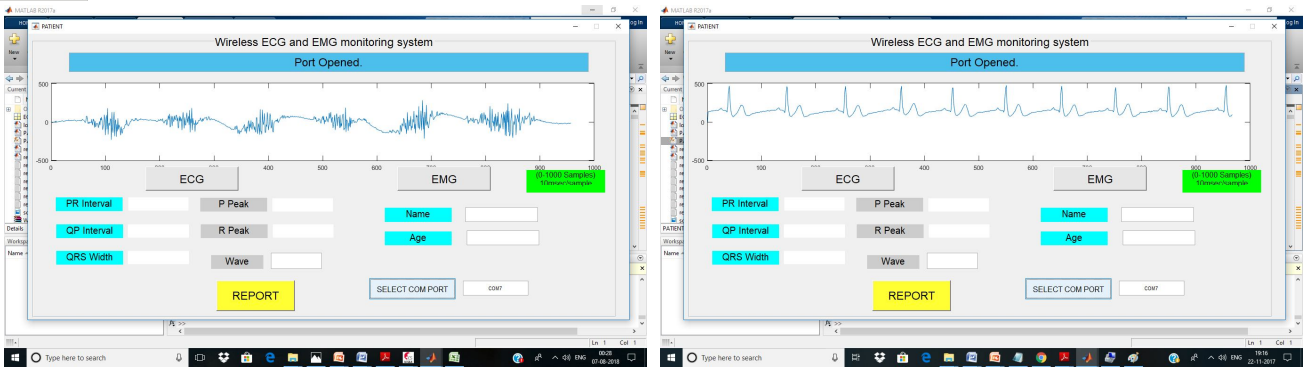
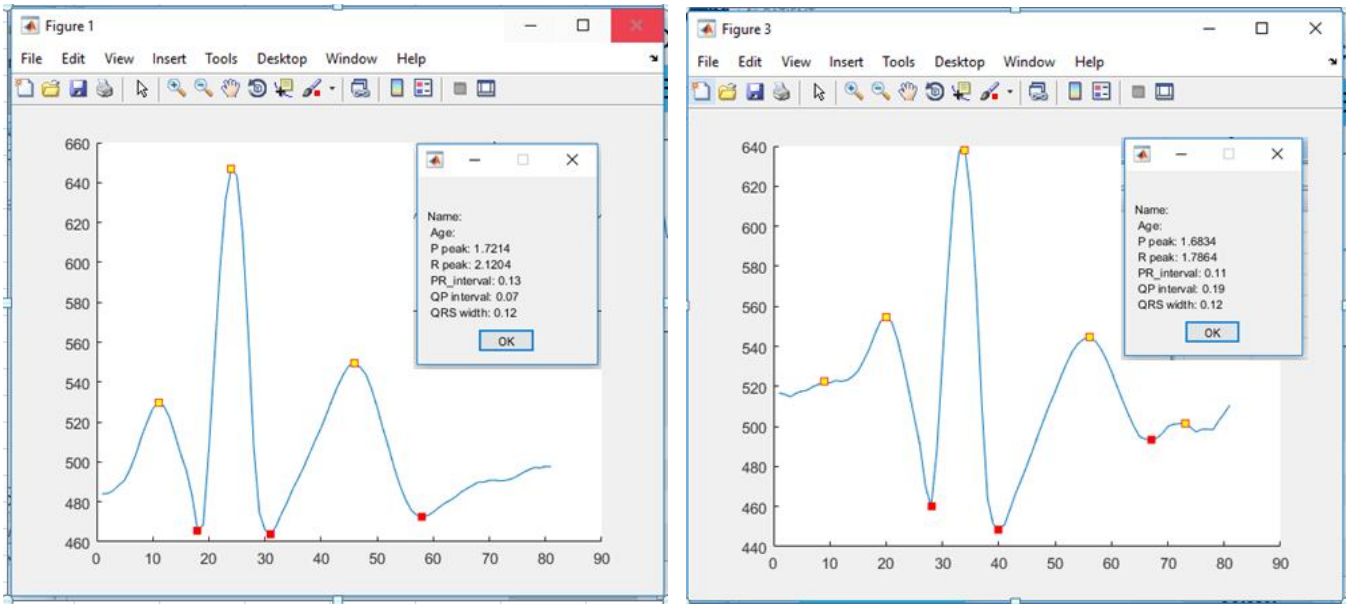


5(a) 5(b)

Figure5: (a) Real Time ECG plot (b) EMG signal from forearm.



6(a) 6(b)

Figure6: (a) Report of 2nd ECG wave (b) Report of 3rd ECG wave

Apart from the results in figure 6, additional feature in our system is results in fig5 are smooth and clearly visible. One can judge the improper behaviour of ECG,EMG signal from eye; say inverted P wave and T wave of ECG. Results in figure6 are numeric intervals for diagnosis as shown in TABLE I .TABLEI shows the measured result and related diagnosis detection.

Tablei: Measured Result

Paraemeter	Normal Range	Measured Range	Diagnosis
PR interval	0.12-0.2	0.13	>0.2s (Complete Heart Block)
QRS width	0.08-0.12	0.12	If <0.08 Hypercalcaemia
P Peak	16-1.8	1.7214	If< -less blood push into ventricles If >- High blood push into ventricles
R Ppeak	1.8-2.4	2.1204	Poor response myocardial infraction
QP interval	0.12-0.2	0.12	If < > onset artial polarization then < ventriclular depolrization

VII. CONCLUSION

We have developed low cost biosignal acquisition system for ECG and EMG. The average cost of our system is 50 USD which makes it inexpensive compared to medical equipment.We fullfills the motive as our system is easily available for the people of developing and under developed country. Our system provides the improved noise free biosignal acquisition with portability within a range of 8m.ARM7 controller provides the high data transmission of 1Ksps with digital filteration. Zigbee were used as the main candidate of serial communication to achieve low power system. MATLAB used to store serial data, visualization and analysis of ECG. Our system is low power, low cost, average size, portable system with improved ECG diagnosis at earlier stage.

VIII. ACKNOWLEDGMENT

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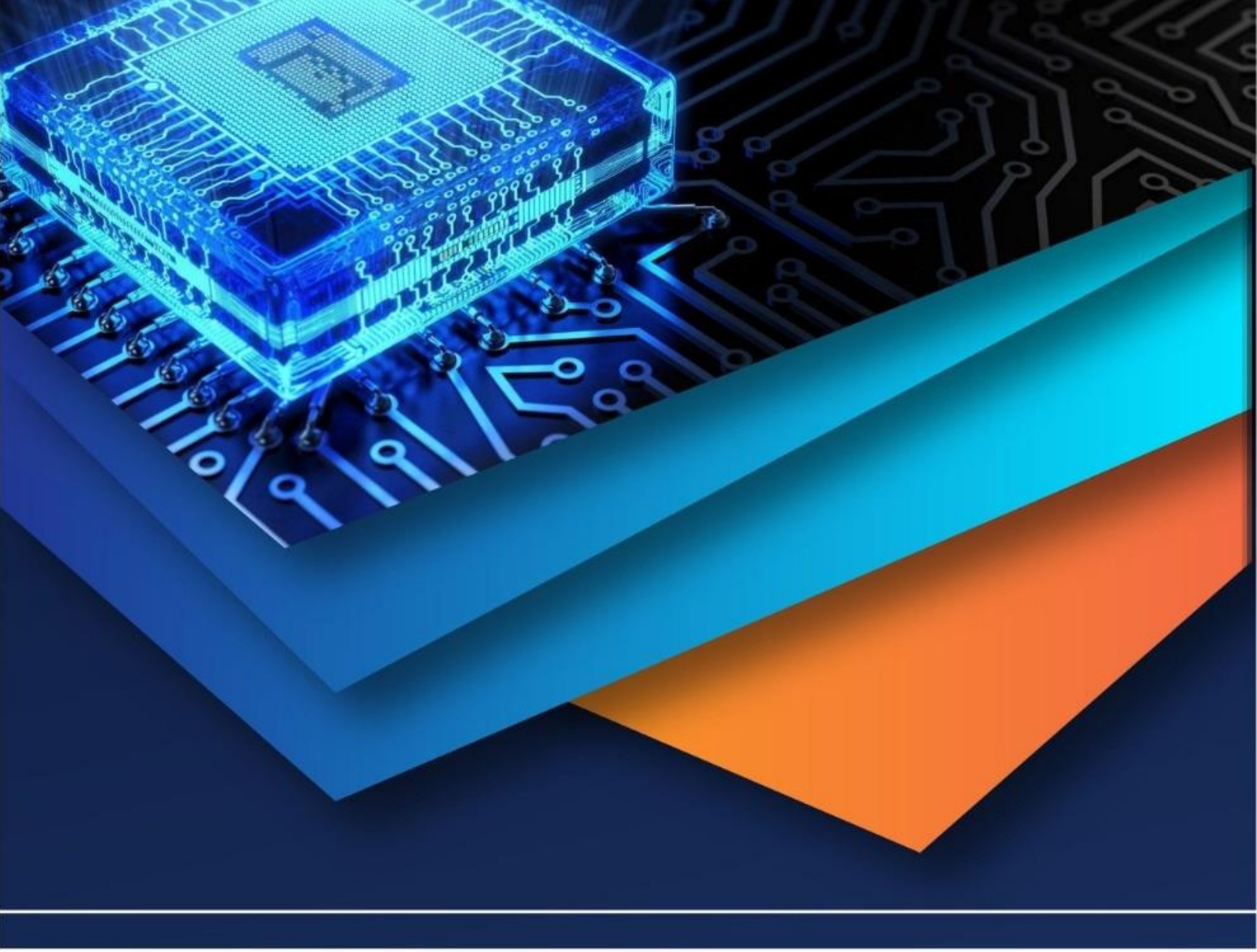

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