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Base Line Wander, Power Line Interference Noise Suppression and QRS Detection in ECG Signal using SCILAB

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Abstract: ***The ECG signal contain base line wander noise (0.5 to 0.6Hz), power line interference(50Hz) and EMG noise(above 100Hz). High pass filter can be used to remove base line wander noise with cutoff frequency of 0.6 Hz.50 Hz power line interference can be removed using band stop filter. QRS detection is done using differentiation method. Scilab. is used for performing signal processing task of removing common noise in ECG signal.***
Index terms: base line wander noise, power line interference, QRS detection, Scilab.

I. INTRODUCTION

The ECG may be monitored continuously when the patient is in emergency care, in a coronary care unit, an intensive care unit or during stress tests[1]. In these cases only one lead, usually lead II is monitored, on a display[2]. ECG machine is a vital part of hospitals and aid the doctors to keep track of patient's vital sign during emergency. The electrocardiogram is the graphic recording or display of time variant voltage produced by the myocardium during Cardiac cycle. The electrocardiogram is used clinically in diagnosing various diseases and conditions associated with the heart[3]. It also serves as a timing reference for other measurements. Engineers working in the medical profession are encouraged to learn as much as possible about medical and hospital practices and in particular about physiology of human body[4]. It is only by gaining such an understanding that they can communicate intelligently with medical professionals. This interaction between the two fields has led to the development of sophisticated medical equipment and systems. The heart is made of a special kind of muscle, so that it can beat automatically without having to be told to do so by the brain. The left side of the heart drives oxygen rich blood out of the aortic semi-lunar outlet valve into circulation where it is delivered to all parts of the body. Blood returns to the right side of the heart low in oxygen and high in carbon dioxide and is then pumped through the pulmonary semi-lunar pulmonic valve to the lungs to have its oxygen supply replenished before returning to the left side of the heart to begin the cycle again. We have to suppress 50 Hz noise, motion artifact, EMG noise and baseline wander. We have used derivative based algorithms for QRS detection. To remove baseline wander and power-line interference from the ECG, a band-pass filter is applied, while to enhance the QRS complex, a five-point first-order differentiation, absolute and backward cumulation operation were used.

II. COMMON ECG NOISES

A. Baseline Wander

Baseline wander is slow-varying artifact, which is mainly due to the variation of the electrode skin impedance, appearing in the form of a low-frequency component added to the ECG. Impedance modification can occur as consequence of patient breath, electrode–skin contact and smooth movements.

B. Power Line Interference

This noise is generated by the power line electromagnetic field and exhibits its peak at 50 or 60 Hz. Its nature is stationary in terms of frequency in the affected intervals, even if the presence of these artifacts are not foreseeable in terms of the onset, offset, length and power in the corrupted intervals.

C. Motion Artifacts

These artifacts are generated by the electrode motions away from the contact zone on the skin. They are hard contaminations, as their morphology and frequency are unpredictable.

D. Muscle Noise

This contamination is due to the electromyography signal (EMG), originating from skeletal muscle contractions. During ECG recording, the EMG signal overlaps with the ECG as if they have the same frequency spectrum, both of which are characterized by significant energy.

E. Other Interferences

Other noise sources affect the ECG signal, such as instrumentation noise produced by the equipment composing the recording section (probes, cables, analog to digital converter, etc.). Obviously, these types of interferences could be significantly reduced by a careful choice of high-quality devices.

III. METHOD

ECG signal is taken from physionet database. ECG measurements may be corrupted by many sorts of noise. The ones of primary interest are: Power line interference, base line wander noise. These artifacts strongly affects the ST segment, degrades the signal quality, frequency resolution, produces large amplitude signals in ECG that can resemble PQRST waveforms and masks tiny features that are important for clinical monitoring and diagnosis. Cancelation of these artifacts in ECG signals is an important task for better diagnosis[5].

A. ECG Signal Import in Scilab

In Scilab Microsoft Office Excel i.e. Excel 97-2003 Worksheet (.xlsx) file can be accessed directly into the workspace. A variable can be assigned to ECG amplitude.

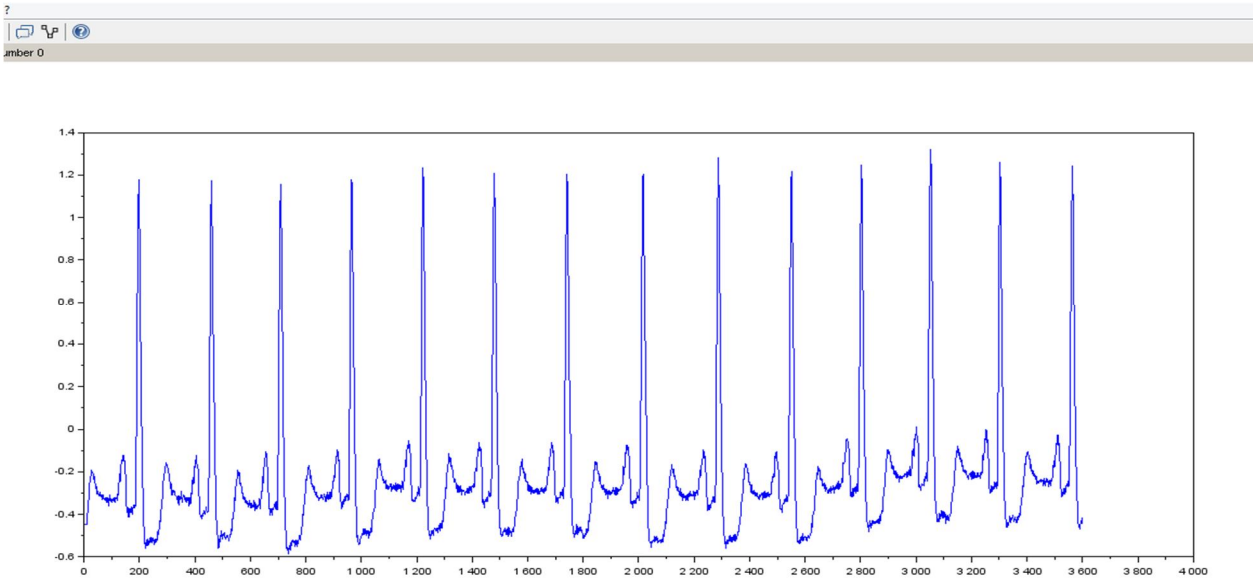

Figure 1: ECG signal MITBIH105 from Physionet

B. Base line Wander Noise Elimination

Base line wander noise[6] of frequency 0.5 Hz can be added to above ECG. High pass filter with cutoff frequency of 2 Hz can be used. Result is shown below in Figure 2

The ideal high-pass filter is given by

$\mathbf{H(e^{jw}) = 0 \quad 0<|W|<W_c}$

$\mathbf{= 1 \quad W_c<|W|<\pi}$

If cutoff frequency is fc= 2 Hz and fs=360 Hz then normalize cutoff frequency is Fcn=2*fc/fs;

h=wfir("hp",51,[Fcn],"re",[Fcn]); Output of high pass filter is shown below:

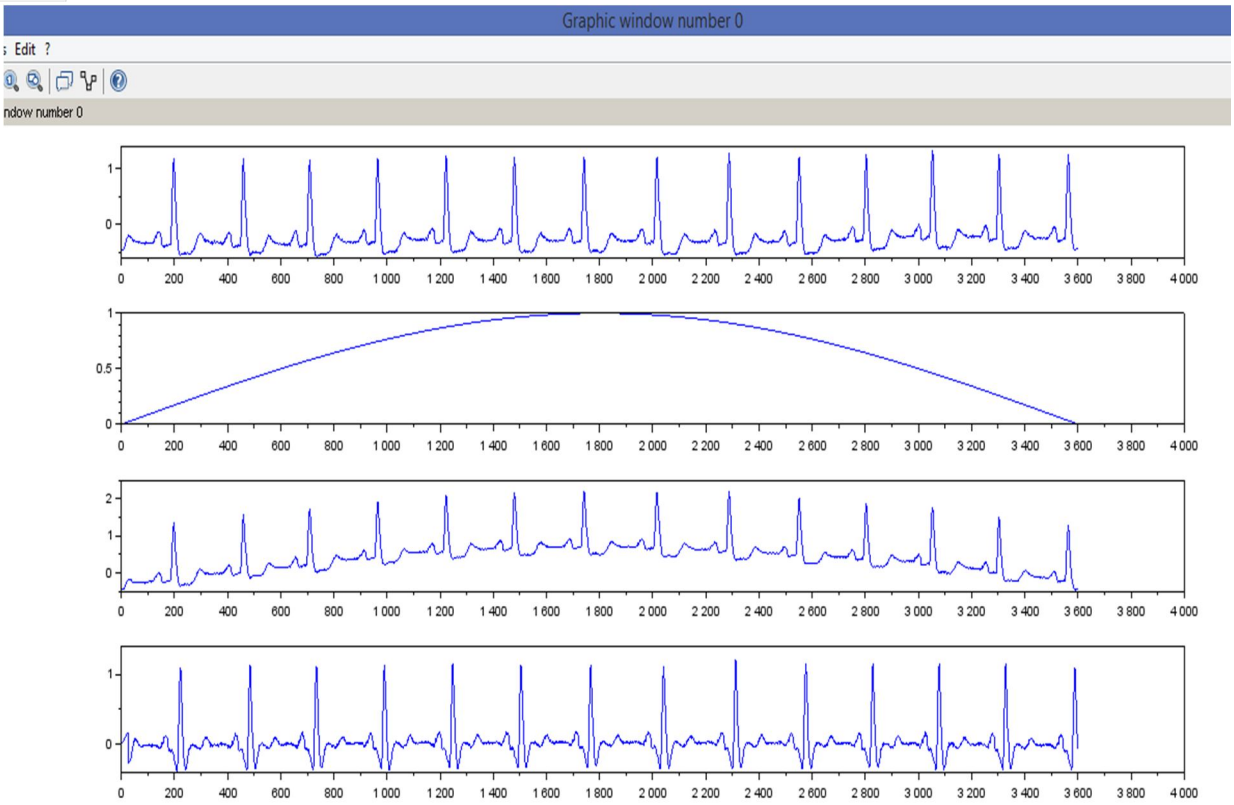

Figure 2: 1st plot is pure ECG,2nd plot is base line wander noise, 3rd plot is ECG with BLW noise and 4th plot is the filtered ECG

C. Elimination Of PLI Noise In ECG Using SCILAB

3- dB stop band bandwidth and the order of the filter were defined to design the FIR notch filter. In the present case, order of the filter is 51 and the 3- dB stop band bandwidth of 60(20–80)Hz were considered[7]. Figure 3 shows the output response of the filter.

fcl=20; fch=80; fcn=[2*fcl/fs 2*fch/fs]; h=wfir(“sb",51,[fcn],"re",[fcn]);

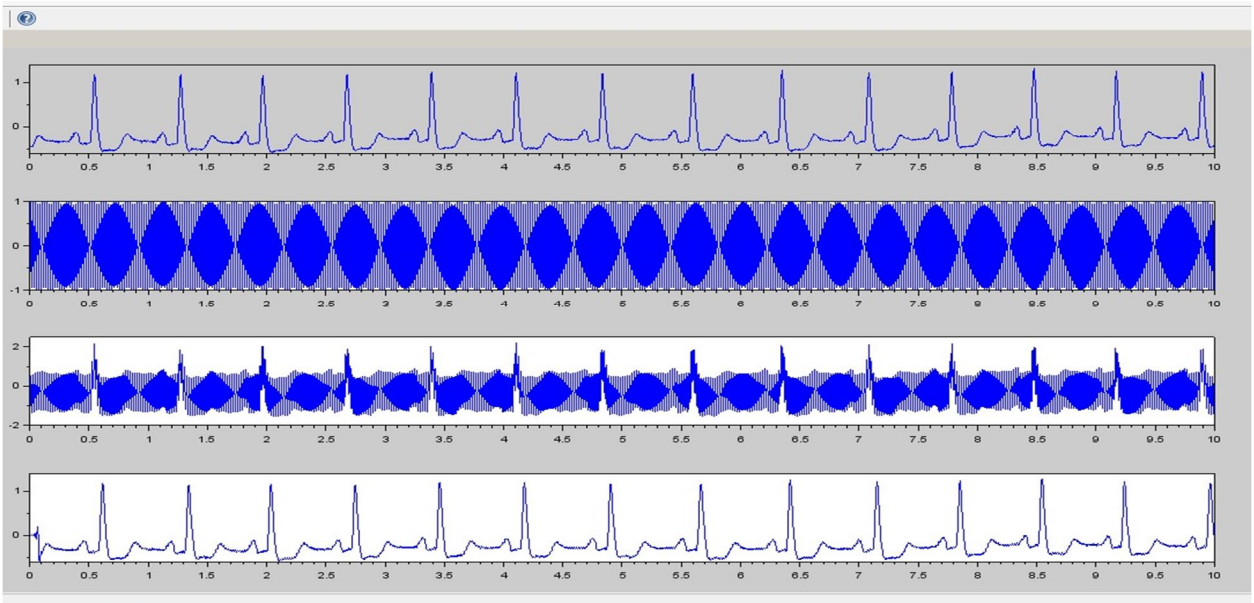

Figure 3: 1st plot is pure ECG,2nd plot is PLI noise, 3rd plot is ECG with PLI noise and 4th plot is the filtered ECG

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D. QRS Detection by Derivative Based Method Using SCILAB

QRS Complex has the largest slope in cardiac cycle by virtue of rapid conduction and depolarization characteristics of the ventricles. Derivative operator enhances the QRS Complex and suppress P and T wave. It is based on the empirical observation that the first and second derivatives of the ECG signals ,when rectified and added together, give a pulse for each QRS complex. The width of the pulse is approximately equal to QRS duration[8,9,10].

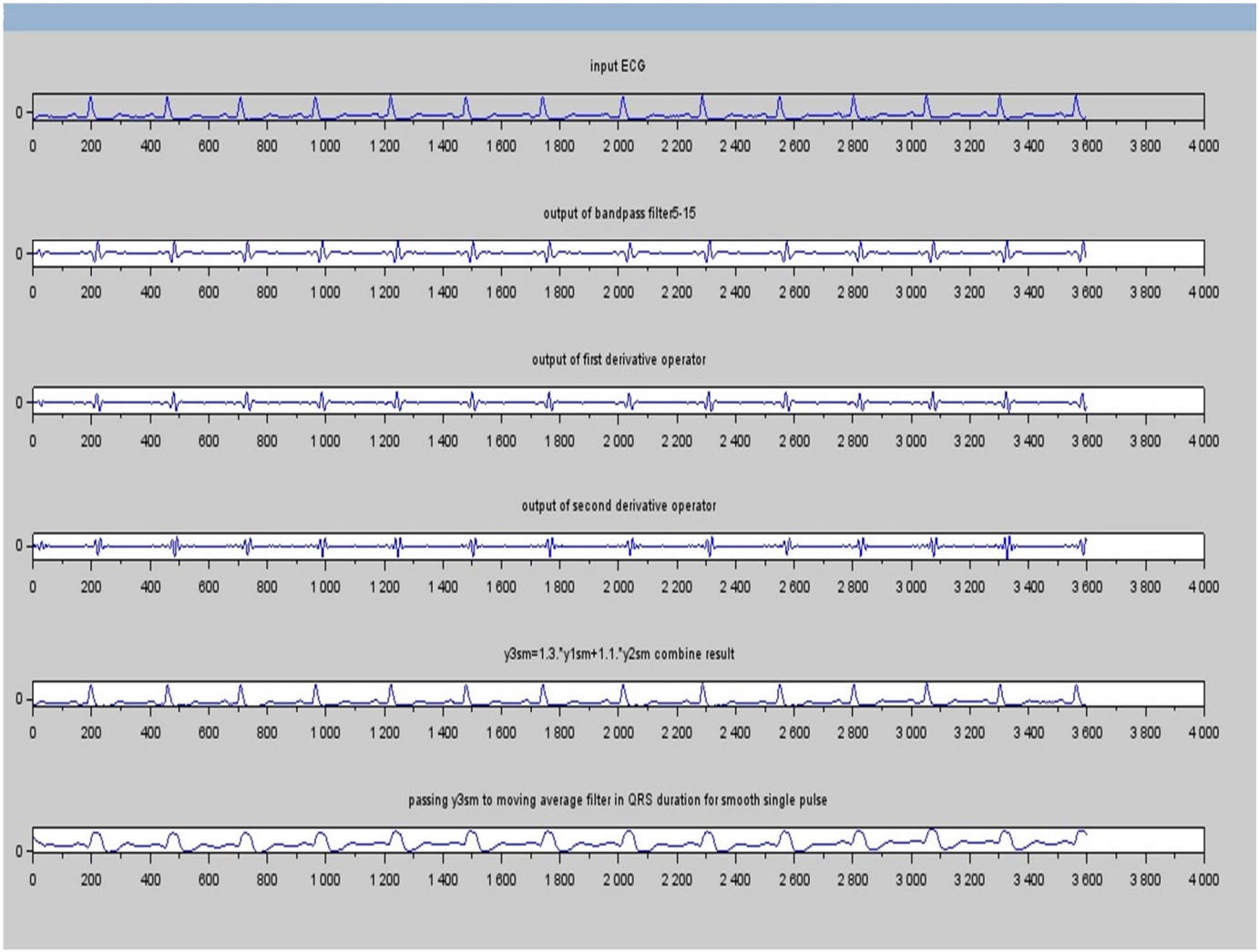

Figure 4: 1st plot is pure ECG,2nd plot is output of bandpass filter, 3rd plot is output of first derivative and 4th plot is the output of second derivative, 5th plot is combined output of first and second derivative, 6th plot is the output of moving average filter for single pulses of QRS duration.FIR filter

IV. OBSERVATIONS

Base line wander noise(0.5 Hz) as seen in Figure 2 can be eliminated using FIR high pass filter order 51 and cutoff frequency of 2 Hz. PLI noise(50 Hz) as seen in Figure 3 can be eliminated using FIR band stop filter order 51 and Flc=20 Hz and Fhc=80 Hz.QRS detection is done using differentiation method. Band pass filter is having band width of 5-15 Hz for QRS detection.FIR high pass filter order of 5 are used for first and second derivative. The combined output shows QRS pulses. These are smoothed using moving average filter order 40 for Fs=360.The output of moving average filter(low pass) consists of single pulses of QRS duration.

V. CONCLUSION

Common noise in ECG like base line wander and PLI noises are eliminated with high pass and band stop filter. Signal processing is done using Scilab.QRS detection is performed using differentiation method. Differentiation is basically high pass filtering and moving averaging is low pass filtering. Single QRS pulses are obtained after moving average filtering with order of 40.

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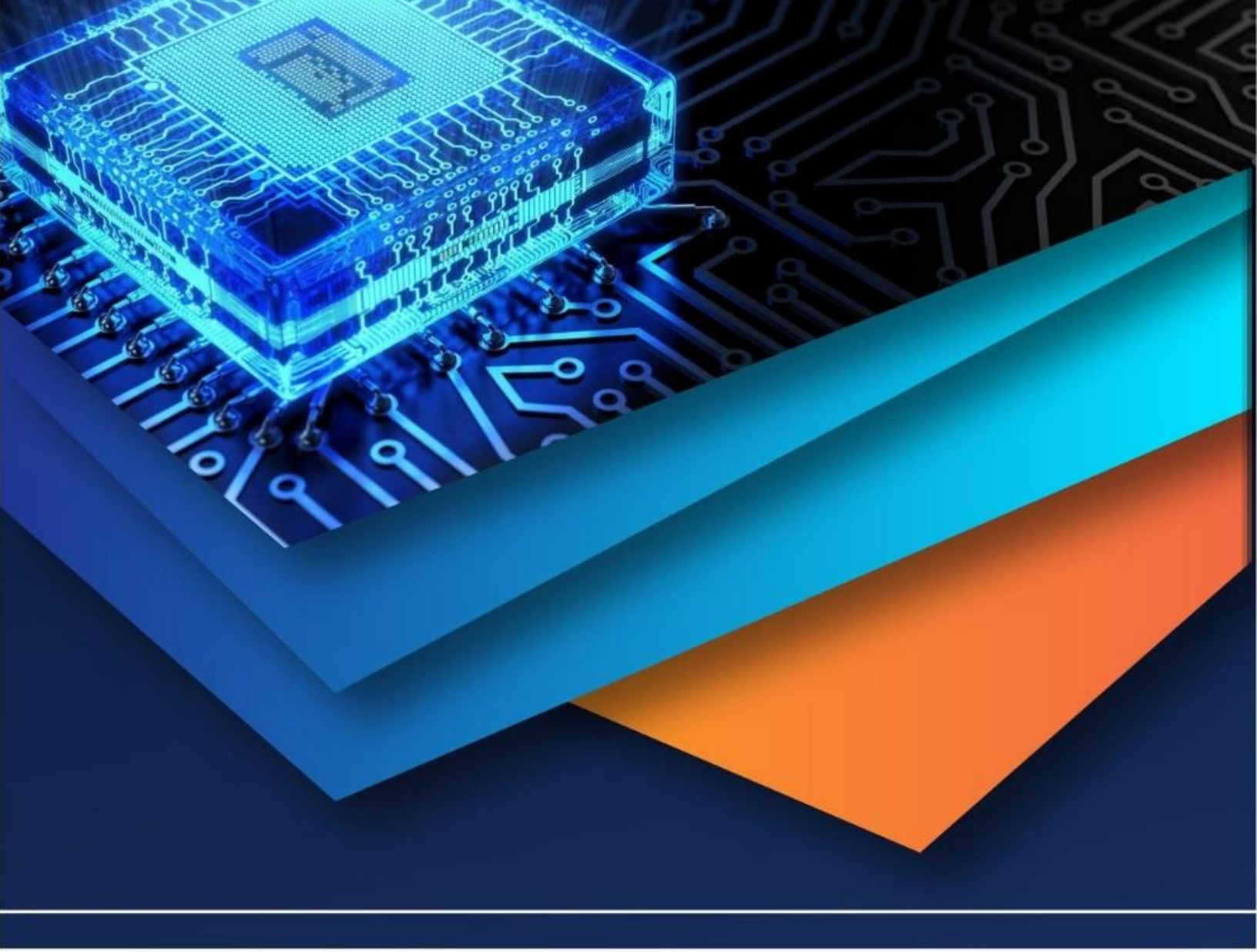

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