iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VIII **Month of publication:** August 2017

DOI: http://doi.org/10.22214/ijraset.2017.8102

Study on Transmission of Audio Signal using Laser Communication System

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Abstract:* Laser communication systems are wireless connections through the atmosphere and it works on the principle of "Amplitude Modulation" process. In the process of amplitude modulation, the amplitude of the carrier is varied according to the instantaneous amplitude of the input modulating signal. In this system carrier signal corresponds to laser beam, amplitude stands for intensity of laser beam and input signal refers to audio signal. Hence, the intensity of the laser beam is varied according to the instantaneous value of audio signal and the same is sensed by the optical sensor at the receiver. In present investigation laser communication system consists of two sections Transmitter and Receiver. At the transmitter audio signal is coupled to the laser light by using a transistor operating in common collector mode. Since, in common collector mode transistor acts as Impedance matching device, therefore intensity of the laser beam changes in proportion to audio signal strength. At the receiver this varying intensity is sensed by solar cell. The photo transistor is biased and connected to the input of audio amplifier (LM386) which drives the loud speaker. In present study frequency response and gain of received signal have been studied by varying the medium (air, fresh water, salty water and muddy water), its density and the distance between transmitter and receiver.
Keywords— Laser communication system; Amplitude modulation; Transmitter; Receiver; Solar cell; Audio amplifier (LM386)

I. INTRODUCTION

Lasers have been used for communication purpose for many years to transmit information via CD, DVD etc. In 1964 laser was used by NASA for airplane communication and after that in 2013, data on earth was received by a craft orbiting the moon through pulsed laser [1,2]. M. Toyoshima et al. have presented their work on laser communication link between LEO satellite and ground station [3]. In November 2014 the first ever gigabit transmission was realized through laser communication system by European Space Agency (ESA) [4]. Since then many advancements have been made in this field. In this mode of communication, the information is transferred through free space without any obstruction. Such condition is also called line of sight condition

Laser communication is one of the emerging areas of wireless communication system. They have the benefit of eliminating the need for broadcast rights and buried cables. Laser communications systems can be easily deployed since they are inexpensive, compact, low power and do not require any radio interference studies. In laser communication system bandwidth could be distributed in neighborhoods by putting system on top of homes and pointing them towards common transceivers with a fast link to the internet. It supports possible transmit speeds of up to a gigabit per second. Laser communication can be used to transmit sound and data signal through the laser beam of system [5].

In present investigation a lab model of laser communication system has been fabricated. As the medium between transmitter and receiver plays an important role in deciding the overall gain at receiver end, present work is focused on the study of frequency response and gain of received signal by varying the medium (air, fresh water, salty water and muddy water), its density and the distance between transmitter and receiver.

II. EXPERIMENTAL DETAILS

The circuit has been fabricated according to one of the standard design [6]. It comprises of two sections, transmitter and receiver. After fabrication of circuit, it is subjected to the study of frequency response of audio signal, as input signal corresponds to the audio one in the present investigation. The gain at receiver has been observed using air as medium between transmitter and receiver. After that, medium has been changed from air to fresh water, salty water and muddy water. Gain has also been noted by varying the density of medium. In next step, the effect of distance between transmitter and receiver on gain has been studied.

A. Working of Transmitter Components

The circuit diagram of transmitter is shown in Fig.1. Here an mp3 song has been used as input signal from mobile acting as modulating signal. The input in form of mp3 song is a weak signal. It is then amplified by the amplifier LM386 to a high value. A

9v DC Power Supply is given to the Amplifier by a battery as the power source. The amplified input signal generated by the amplifier is transmitted by a laser light. This laser beam carry the original amplified input signal (transmitted data) and is transferred to the receiver sensor (solar panel). Hence laser communication system transmits sounds though a laser beam. The intensity of laser beam changes with the amplitude of sound signal coming from the mobile. The variation in laser beam intensity is converted to variation in voltage level by a solar panel. The voltage variation in solar panel is amplified by a low voltage audio power amplifier LM386 and reproduced by speaker. The maximum output of audio amplifier LM386 is 1Watt,

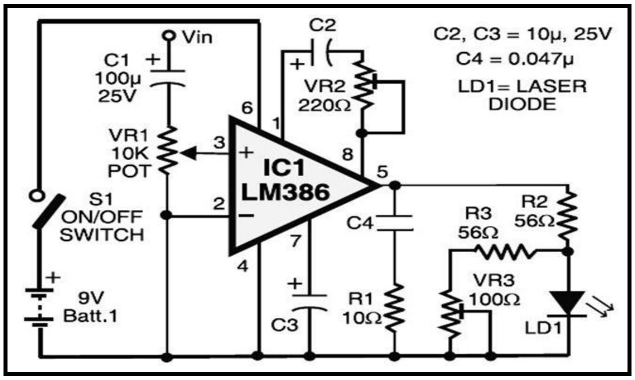

Fig. 1 Circuit diagram of transmitter

its voltage gain is 20 to 200. The laser diode used in the present circuit has maximum operating voltage 2.6 V and maximum operating current 45 mA. Potentiometer VR1 is used to change the level of the input audio signal. The gain of audio power amplifier LM386 IC can be varied by Capacitor C2 and potentiometer VR2. The voltage divider network formed by R2, R3 and VR3 keeps the voltage as well as the current for the laser diode in the safe region.

B. Working of Receiver Components

Laser beam coming from transmitter carries the audio signal and it acts as input data for the receiver circuit. Receiver circuit consists of a solar panel, amplifier, demodulator, audio amplifier and a loudspeaker (headphones/earphones) as shown in Fig. 2. The transmitted light is received by the solar panel and is amplified by audio power amplifier LM386. The gain of the amplifier is fixed by capacitor C7. Preset VR4 is used to change the signal level from solar panel. C5 acts as coupling capacitor to removes the DC voltage from the solar panel. The output is fed to speaker via another coupling capacitor C8.

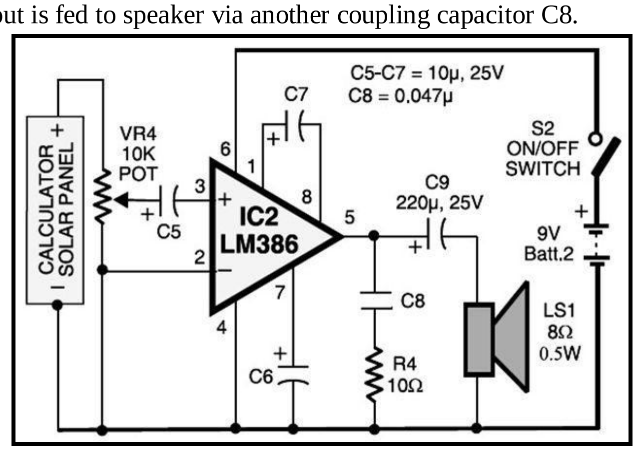

Fig. 2 Circuit diagram of receiver

C. Working of Combined Circuit

After assembling the transmitter and receiver circuits on separate PCBs, they are enclosed in suitable cabinets as shown in Fig. 3. In the transmitter cabinet, two terminals are fixed for connecting the audio signal. Switch S1 is also fixed on the front panel and the laser diode (LD1 or laser pointer) to the rear side of the cabinet. 9V battery is placed inside the cabinet. In the receiver cabinet, calculator's solar panel is fixed on the rear side such that the transmitted beam directly falls on it. Similarly switch S2 is fixed on the front panel and the speaker to the rear side. One 9V battery is kept inside the receiver cabinet.

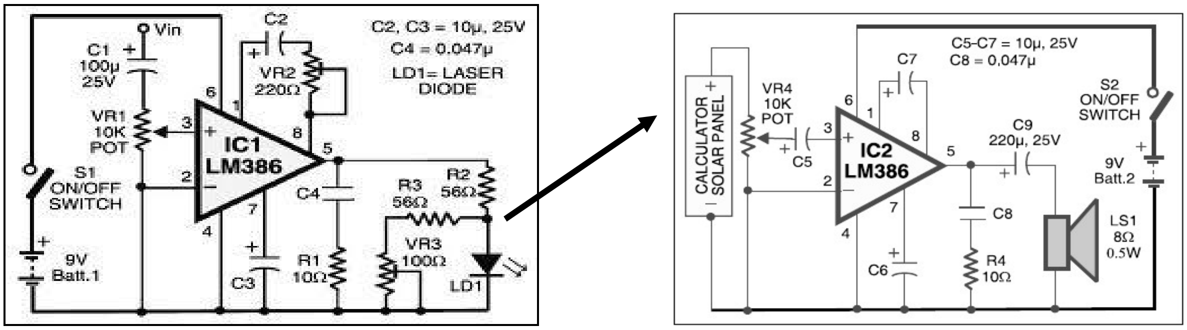

Fig. 3 Combined circuit diagram of transmitter and receiver

D. Frequency Response of Audio Signal

As the input signal in the present work corresponds to audio one, therefore at the first step frequency response of transmitter and receiver was studied. For this experiment, following instruments/components were taken - frequency generator (20 Hz to 2 MHz), laser communication system (both transmitter and receiver), digital CRO and its cable wires ,connection wires and two 9V batteries. In this set-up (Fig.4) audio signal produced by frequency generator was coupled as input signal to the transmitter. The output signal was collected at receiver end and was fed to CRO to note the voltage level. The ratio of output to input voltage was calculated to observe the gain corresponding to each frequency. The gain was plotted with respect to frequency to obtain the frequency response curve.

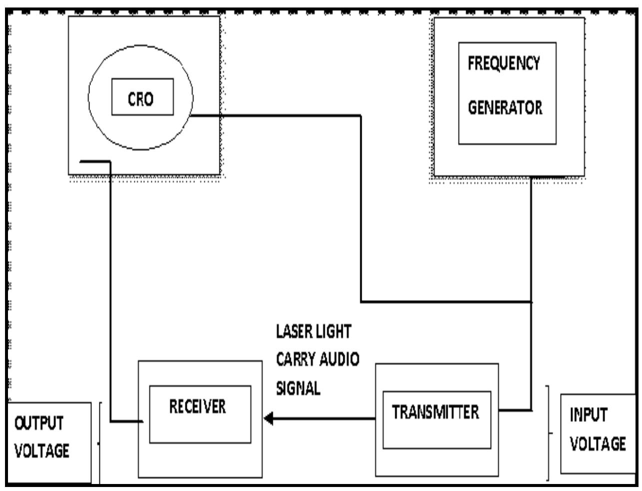

Fig. 4 Block diagram of experimental set-up to study frequency response

E. Variation in Gain by Changing the Medium and its Density

As the laser beam passes through free space, it is quite interesting to find out the effect of medium on the gain received by receiver. To visualize this effect study was made by changing the medium between transmitter and receiver. The experimental set-up included frequency generator, digital CRO, laser communication system, cables and connecting wires, two 9V batteries, beaker (diameter 10cm and height 6.5cm), fresh water, common salt and mud. Fig. 5 describes the above set-up.

Fig. 5 Experimental set-up to study the effect of medium on gain

F. Variation in Gain by Varying the Distance Between Transmitter and Receiver

The application of laser communication particularly belongs to space communication; therefore it is of prime importance to study the effect on gain by changing the distance between transmitter and receiver. The experimental set-up consisting, frequency generator, digital CRO, laser communication system, cable wires, connecting wires, two 9 V batteries and measuring scale is shown in Fig. 6.

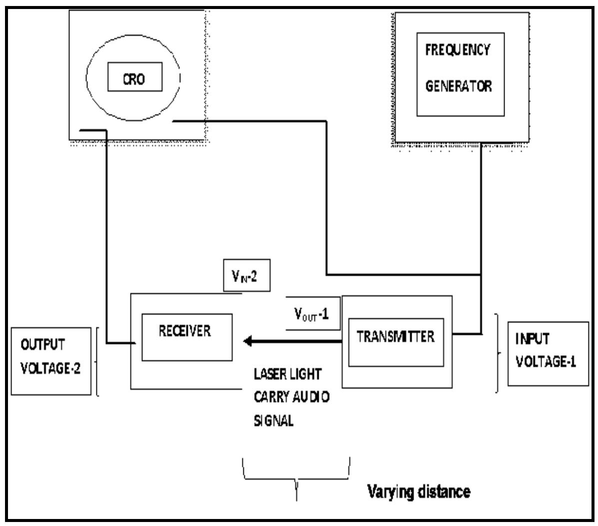

Fig. 6 Block diagram of experimental set-up to study effect of distance on gain

III. RESULTS AND DISCUSSIONS

A. Frequency Response of Audio Signal

Frequency response curve of audio signal is plotted in Fig. 7. It is found that the output frequency remains the same as the input, and the shape of the signal (a sinusoidal in present work) is preserved within the audible range. The gain is calculated as ratio of output voltage at receiver end and input voltage at transmitter (Fig. 4). At around 50 kHz the response time of the photodiode is no longer negligible and some distortion is seen. While high frequency signals are transmitted uniformly, the response drops off at the low end. The system acts on a whole as a high-pass filter with a critical frequency near 100 Hz. Therefore, audio with heavy bass components will suffer the most while other components will be largely unaffected. Thus the laser communication system in present investigation is successfully working in audible range.

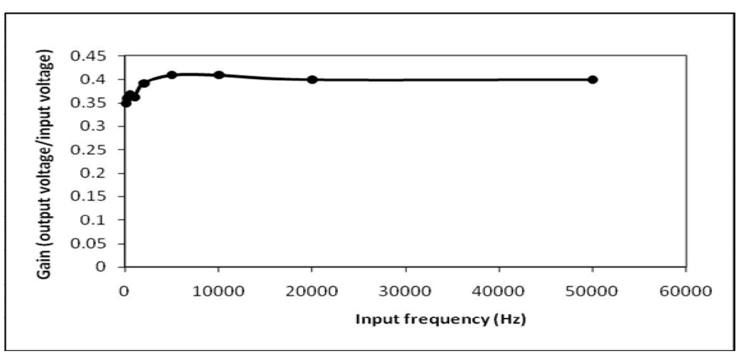

Fig. 7 Frequency response curve

B. Effect on Gain by Varying the Density of the Medium

1) *For Salty Water:* Fig. 8 displays the variation in gain by mixing the ordinary salt in fresh water. Gain is found to decrease upon increasing the density of water. The gain is calculated as the ratio of output voltage at receiver end to the output voltage at

transmitter end. When density of water is changed from 1.0 gm/cc to 1.24 gm/cc by adding salt, gain decreases to a value of 95% of maximum. Hence laser communication is better in fresh water than salty water for audio signal.

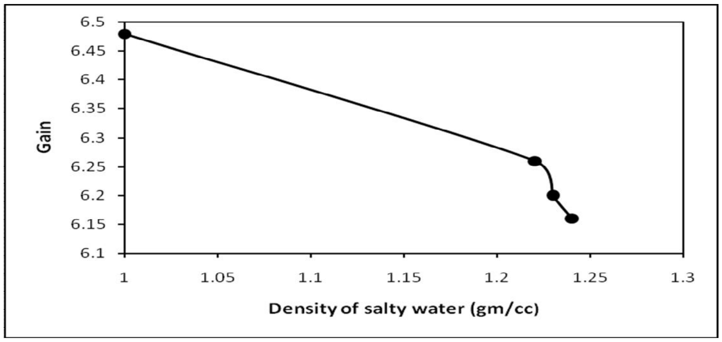

Fig. 8 Variation of gain with density of water by adding salt

2) *For Muddy Water:* As the natural water has often the particles of mud, the variation in gain is noticed by increasing the density of muddy water. This variation is shown in Fig. 9. Gain is calculated in a similar manner as described in previous experiment. Here again the gain is maximum for fresh water and decreases continuously by increasing the density. Gain falls more rapidly in muddy water than salty water. Particles of mud block path of laser which results in poor communication through laser. In denser medium presence of more particles blocks the intensity of laser which results in failure of transfer of data or information from transmitter to receiver. Therefore density factor inversely affects the gain of laser communication system. The loss in gain is due to scattering of laser light by the molecules of solute.

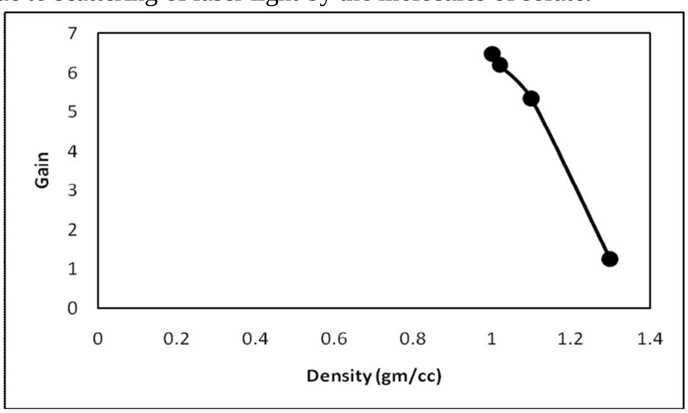

Fig. 9 Variation of gain with density of muddy water

C. Effect on Gain by Changing Distance Between Transmitter and Receiver

To see the effect on gain by changing the distance between transmitter and receiver a curve is plotted between gain and distance of transmitter and receiver. This curve is shown in Fig. 10. The gain is constant within the experimental range, reflecting negligible loss in gain during travelling from transmitter to receiver. Hence laser is suitable for long distance communication purpose. For very long distance communication it will work properly by increasing the strength of laser.

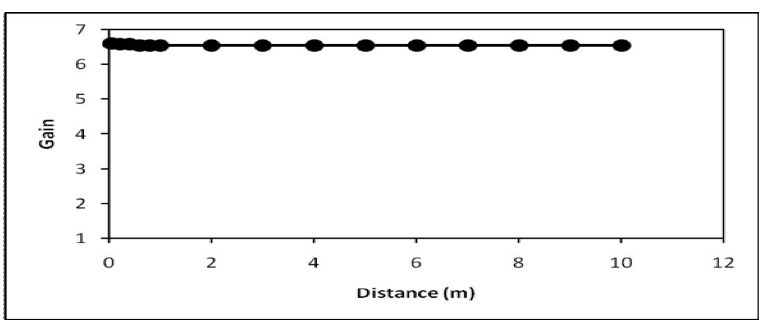

Fig. 10 Variation in gain by changing the distance between transmitter and receiver

IV. CONCLUSIONS

From above experiments following conclusions can be drawn:

A. From frequency response curve it is concluded that all types of audio signal ranging from 20 Hz to 20 KHz are successfully transmitted through laser communication system.

B. Gain depends on the choice of medium between transmitter and receiver. It also depends on the density of medium. Increasing the density of medium, gain falls. It falls more rapidly in muddy water than salty water. In denser medium presence of more particles blocks the intensity of laser which results in failure of transfer of data or information from transmitter to receiver.

C. Upon increasing the distance between transmitter and receiver up to 10 m, the gain remains constant. It reflects that laser communication can be used for long distance as well as for point to point communication.

D. In the present study, transmission of mp 3 songs from mobile is transferred successfully through laser communication system. This system is safe and without radiation, so it is harmless for living beings. The system can likely transmit data and sound much faster (1 GB/s) than the other system. Because of this laser communication system may become more popular than other system.

V. ACKNOWLEDGMENT

This study is the result of dissertation during Post Graduate Course in Physics. Authors are grateful to Head of the Department Dr.D.P.Bhatt for helpful discussion.

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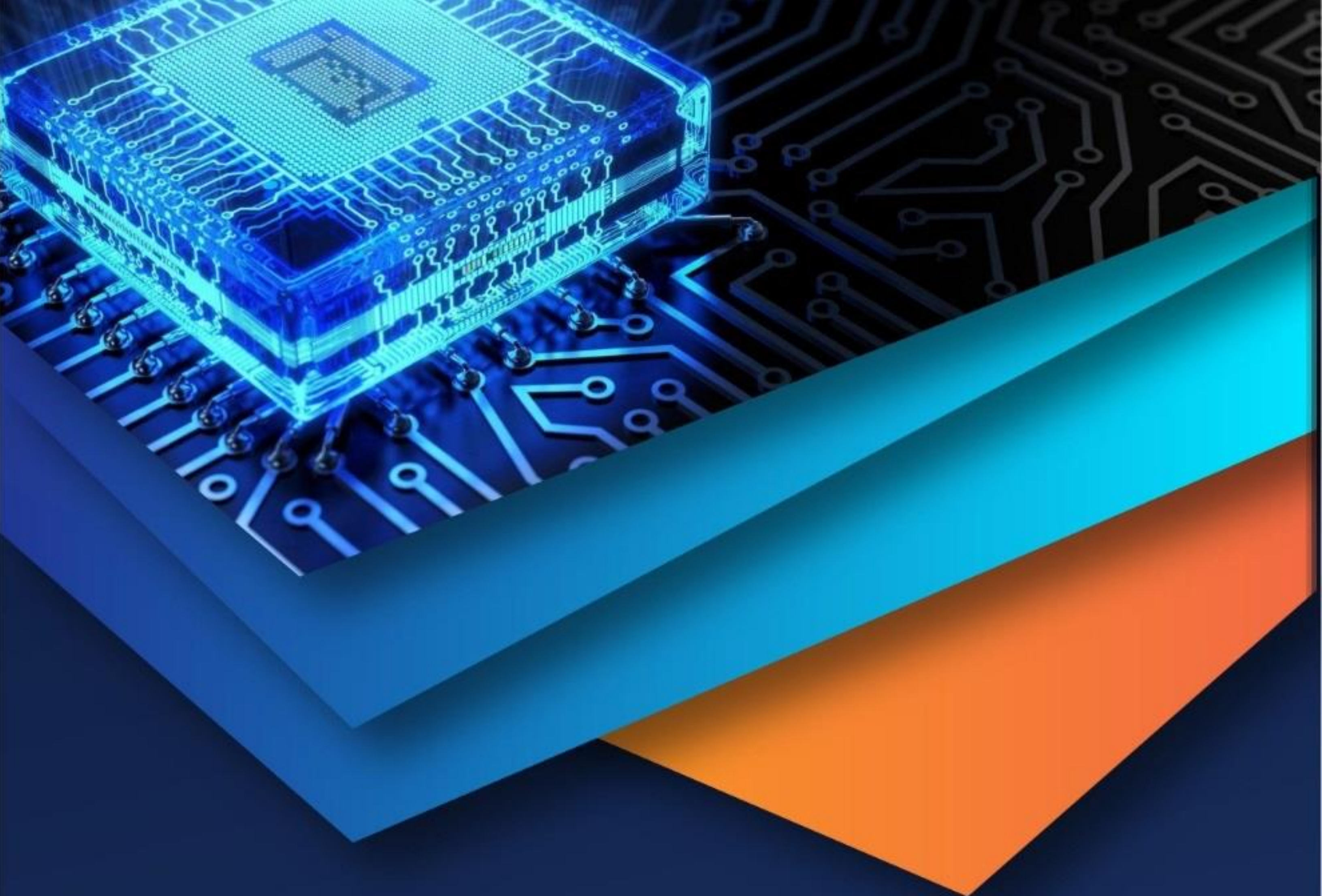

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