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Design and Development of Free Space Optical Communication System for Transmitting Data & Voice

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Abstract: ***Design and development of wireless optical communication system up to a range of 1km for voice communication and secure communication for military. Access technology is gaining importance in the telecom sector to provide various types of services to the subscribers at affordable cost. Though DSL technology is providing solutions, it has certain limitations on the reach (distance to be covered). In view of this, the wireless optical communication can break the distance barrier by reaching nearly 1km, which is sufficient to cover wide range of access applications. Wireless optical communication, is an alternative and replacement to radio/cable/fiber optic, especially in harsh and explosive industrial environments to communicate voice signals. These wireless optical links are ideal for electrically noisy environment such as power stations, reactors and automated factories.***
Keywords- wireless, Free space, point-to-point, optoelectronics

I. INTRODUCTION

Free space communication system is a wireless technology which has bandwidth with maximum rate up to 2.5 Gbps, at lower cost and ease of installation, making it superior to optical fibre-based communication system.

There is no requirement of spectrum license due to its range of frequency and is immune to interference. Point-to-point transmission is provided for the transmission of data through the atmosphere (air) using the optical signals as the carrier frequencies. This system involves optical transceiver which has an optical transmitting lens system and a receiving lens system provides full duplex capability.

An optical source (Laser or LED) is used to transmit light through the atmosphere to the optoelectronic device which has high power capacity and receives the information at the receiving end. The electrical to optical and optical to electrical signal conversions are carried out by the transmitter circuit and receiver circuits of the system.

II. DESCRIPTION

The objectives of the designed project include: The design and construction of a transmitter system to receiver system and to send the information from transmitter to receiver and a receiver system will receive the transmitted information. The whole system would made up of transceiver system that is transmitter receiver pairs would operate at different centre frequencies. Respectively, for isolation improvement. The frequency separation is not only to achieve specific system bandwidth, but also to reduce harmonics and beating effects. This paper proposes to develop a low power, versatile and cost-effective optical communication system [1]. We aim to develop a working communication system where two nodes can transfer data to each other using optical signal, and demonstrate that such a system can indeed work. In this paper, we will explain the motivation for such a system, where a diode-based network has advantages over traditional RF ones, and how we implemented our prototype network.

III. METHODOLOGY

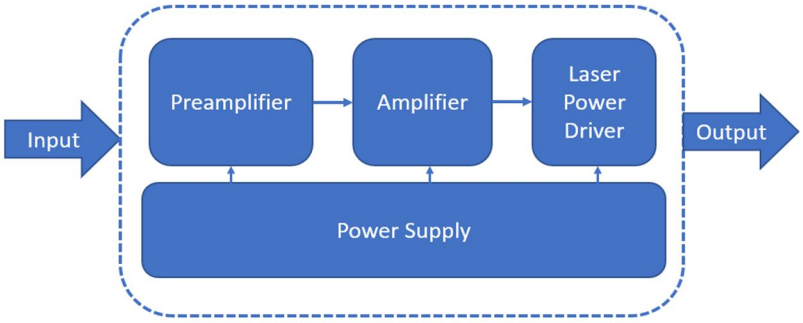


Fig. 1: Transmitter Block

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A low voltage recoded audio signal is inputted to the transmitter then the signal is allowed to pass through pre amplifier and amplifier.

The amplifier which is used to amplifies the audio signal and modulates into appropriate electrical signal by using a DC power source [2], the high intensity signal is sent to a Laser Diode, which produces a coherent optical signal.

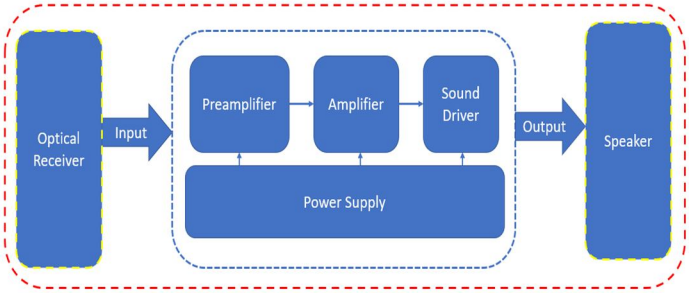


Fig. 2: Receiver Block

The light signal transmitted is received by a low input optoelectronic device which converted into low voltage electric signal from the high intensity optical signal. This low voltage electric signal is given to a preamplifier and to an amplifier to be amplified and modulated for an appropriate level of the signal to be outputted. The amplified and modulated signal produces an output through speakers at the transmitting end.

A. Amplification Stage

LM386 is an integrated circuit, which contains low voltage audio amplifier. It is an 8pin dual in line package and by using a 9V DC power supply can produce output up to 0.5 watts power. The current is adjusted for the laser torch and a thermistor is used to sense the temperature over the period of time of the laser [3].

The transistor is used to control the quiescent current flowing through the laser diode which is operated by the buffer in the next stage. The overall system and control of the laser diode is done by using the VR.

B. Modulator/Demodulator

Modulator is used for long distance communication for an intrinsic requirement which has a high frequency carrier signal to modulate the input message signal as to shield the message from channel. Demodulator is used to remove the message signal from the receiver to avoid channel error and attenuation.

IV. DESIGN ISSUES

While designing FSO link and in order to achieve certain performance level certain parameters are taken into consideration.

A. Environmental Factors

Certain environmental factors to be taken into consideration while designing an FSO system. Environmental factors like climatology, physical characteristics which impair visibility or reduce line of sight distance severely degrade FSO link performance. Few of them are window attenuation, atmospheric attenuation, building motion or alignment, scintillation, solar interference or line-of-sight obstructions.

B. Attenuation Factors

There are two types of attenuation: Internal attenuations which are of geometrical nature and by changing internal parameters it can be controlled and external attenuations are of atmospheric nature which largely depends upon atmospheric conditions like snow, rain and fog, and by proper choice of parameters it can be controlled like wave length and modulation techniques.

C. Atmospheric Attenuation

One of the major contributors to attenuation in FSO communication is fog. Rain and snow also contribute but it is comparatively less. Fog which is formed by vapour consists of tiny water droplets that is said to be only few hundred microns in diameter, through a combination of scattering, absorption and reflection it can completely hinder the passage of light.

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V. IMPLEMENTATION

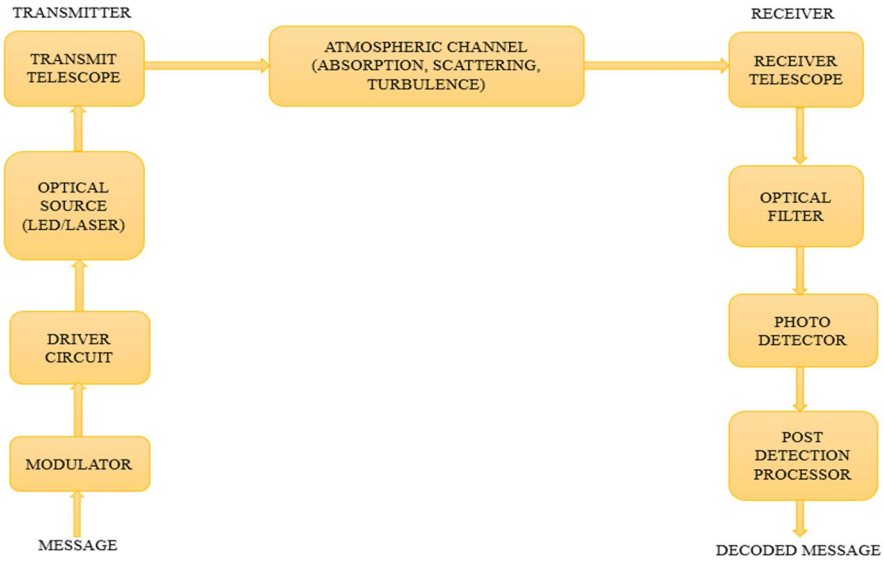


Fig. 3: Block diagram of FSO system

The actual implementation involves the preamplifier system, the transmitter and the receiver collimator lens systems. As shown in the block diagram, message (voice signal) is passed through a modulator before being given to the driver circuit then to the preamplifier at the transmitting side through an audio jack port. The driver circuit and optical source converts the signal into optical pulses. The intensity of the pulses varies using various modulation techniques [4]. The light is fed through transmitter lens collimator comprising of lenses that control light beam divergence by confining light beam into narrow beam cone using well collimated lenses if the source doesn't produce sufficiently parallel beam. Collimation means narrowing beam so that it can move in specific direction. Here we are using a light emitting diode to transmit the light signal into through free space [5]. For the light beam to cover the whole area, the focal length of the lenses must be adjusted accordingly.

At the receiver side, the focal length of the lens is adjusted such that the line of sight is adjusted to cover the whole area of the optoelectronic device surface. The unwanted noise from receiving signal is removed by using optical filter. The optoelectronic device converts the light energy (signal) into electrical signal ten the converted energy(signal) is fed into an amplifier (similar to that of the transmitting side with at higher voltage) [6]. The very low-level signal can be converted into a significantly amplified signal with an adequate bandwidth using this. Post detection processor will process the signal amplified and convert it into readable format. The quality of signal received at receiver depends highly on the distance that the light signal has to travel from transmitter, the condition of the free space link (atmospheric condition mostly), the parameters of the circuit at transmitter as well as receiver side and the quality of amplification [7].

VI. RESULTS AND DISCUSSIONS

The discussion done above has been mostly about the quality of the system, but if the transmitter system function as desired, it can be used as a starting point for more advanced research on optoelectronic and other laboratory projects. Further work could concentrate on the improvement of the range of transmission, speed of transmission-reception [8], noise reduction in the signal with possibilities of designing different filters, and the upgrading of the parameters of the systems in general (power figures, amplification).

Laser diodes can be used as the optical transmitting elements for a longer distance of transmission instead of light emitting diodes, which has proved to be more efficient for longer distance transmission of signal [9] in light form. There multiple project that could be undertaken like a study on how atmospheric conditions affect the performance of optical transmitter –receiver system, research on the development of a system with a simplified design for laser radar scattering system [10]. For experimental purpose the two LEDs are used one is 5mm and the other one is 10mm. Let us see the results for both 5mm and 10mm and its comparison.

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Fig. 4: Implementation of the Communication System



Fig. 5: Position of Tx & Rx in the communication System

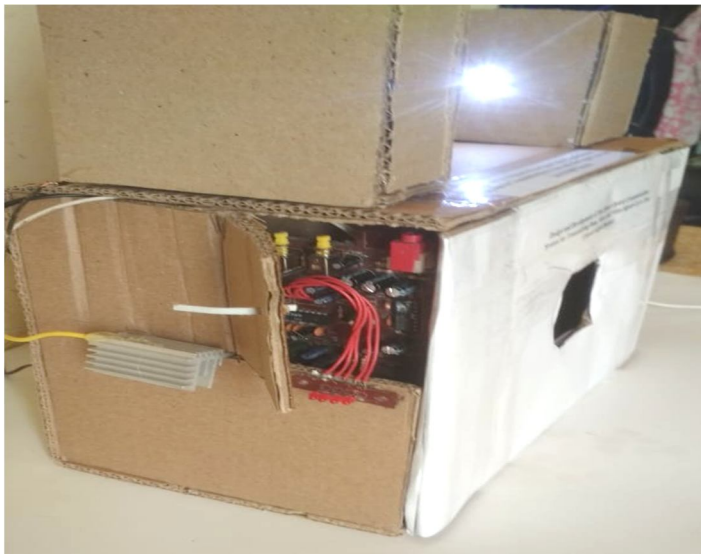


Fig. 6: Position of Circuit in the Communication System

Figure 4, 5 & 6 Shows the implementation of the communication system along with the transmitter and receiver positions .The amplifier unit, power supply and few more components are placed at the side of the system as shown in the figure 6.

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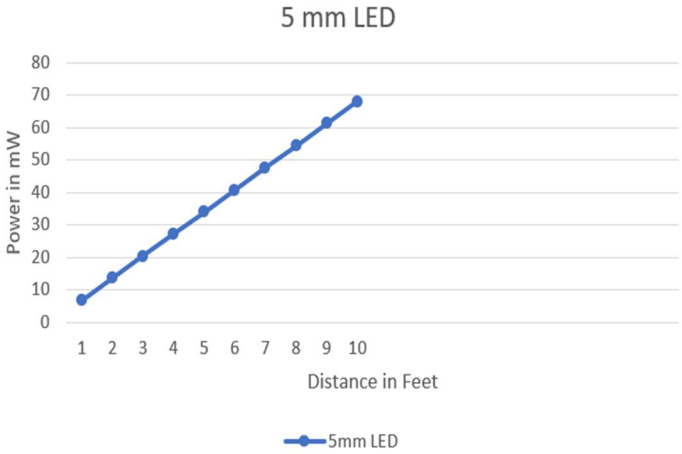


Fig. 7: 5mm LED used for data transmission

Figure 4 shows the distance at which the data can be transmitted using 5mm LED. The maximum distance the data can be transmitted without inducing noise is 10 Feet.

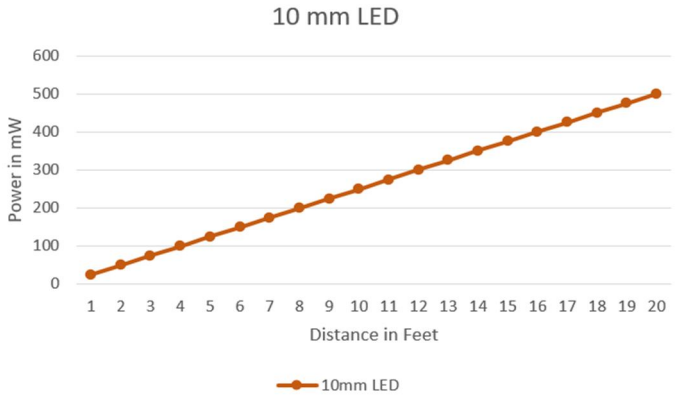


Fig. 8: 10mm LED used for data transmission

Figure 5 shows the distance at which the data can be transmitted using 10mm LED. The maximum distance the data can be transmitted without inducing noise is 20 Feet.

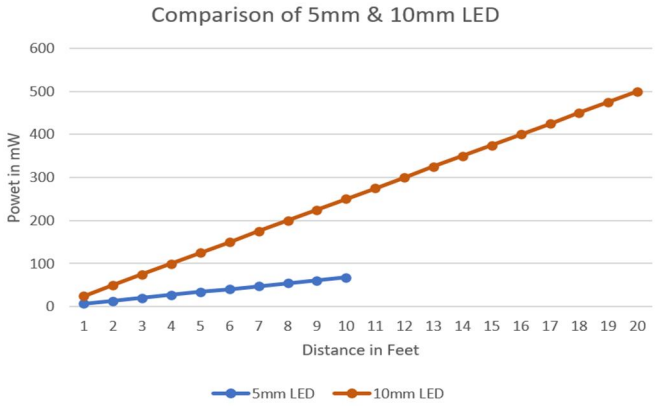


Fig. 9: Comparison of 5mm & 10mm LED used for data transmission

Figure 6 shows the distance at which the data can be transferred without any noise from 5mm and 10mm LED is compared and see. It shows that the 10mm LED can transfer the data longer distance as compared to 5mm LED.

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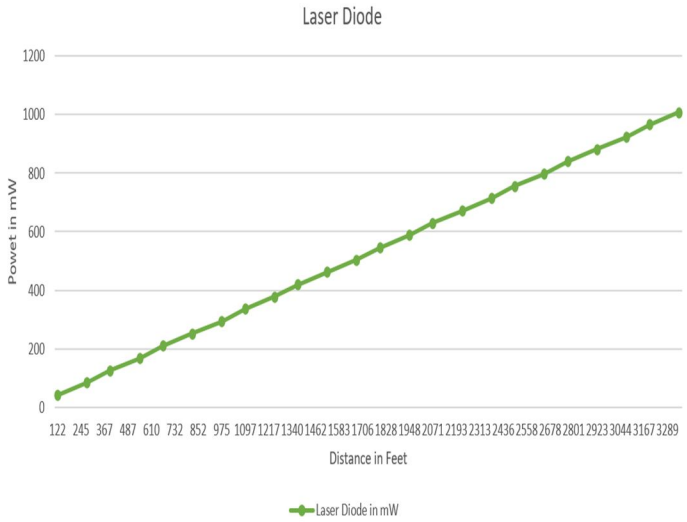


Fig. 10: Red Laser Diode used for data transmission

Figure 7 shows that the data can be transmitted without any noise from a source using laser diode is at a distance of 1km.

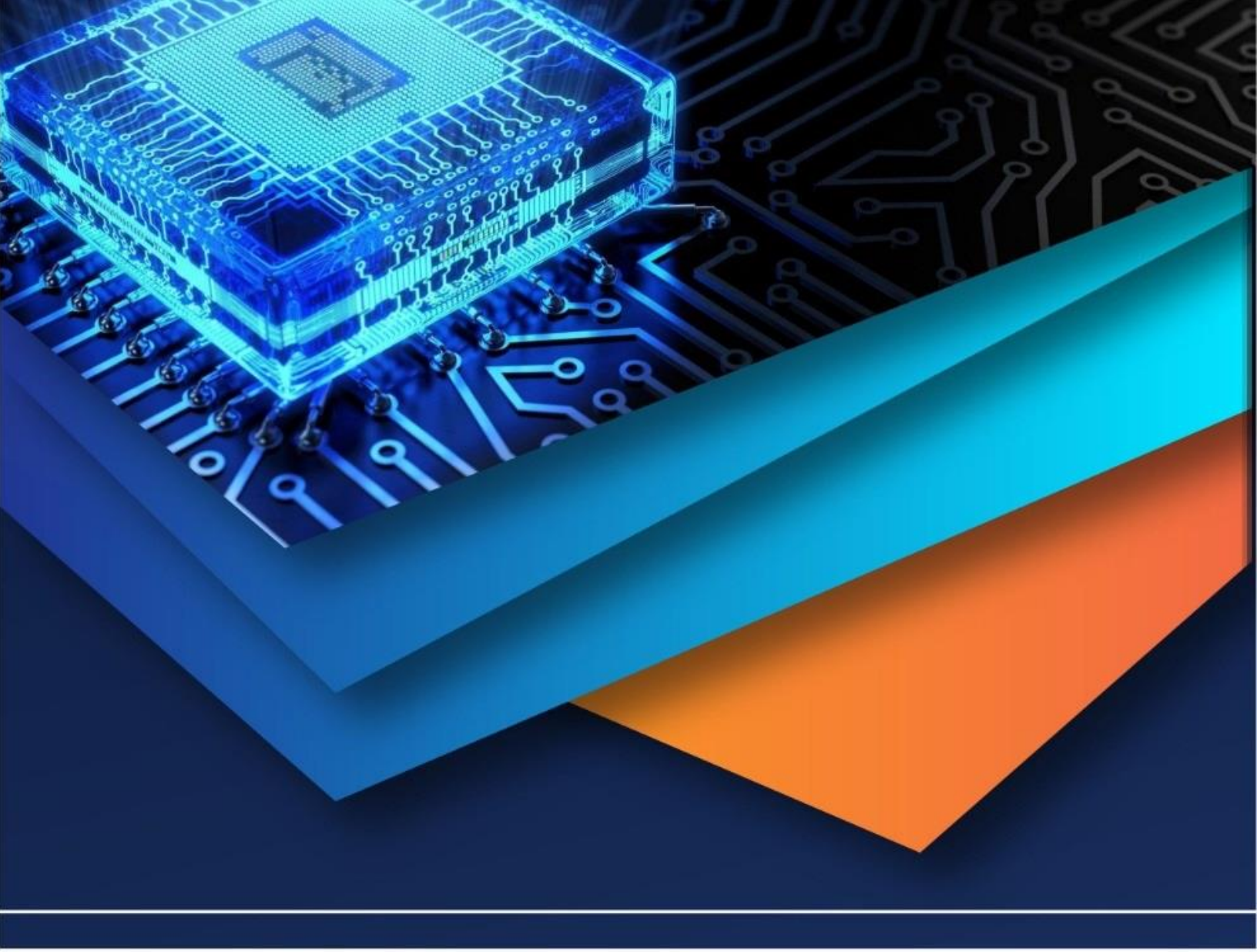
VII. CONCLUSION

During the process of designing and implementing this project, the emphasis was made on audio, video and data signals transmission using a wireless communication system from a transmitting side to the receiving side with a free space link instead of an optical fibre. All major components (Transmitter system and receiver system) have been designed successfully and the implementation has gone positively. The alignment of both side of the complete system is assured by the mechanical assembly and a stable mounting. The evolution in the area of Free space optical communication is still vast and technologies are still being studied as much many products has already been commercialised for terrestrial and space applications. Further research and testing could be made to advance the technology for free space optical communication to have more extensive and broader practical application.

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