International Journal of Modern Agriculture
ISSN: 2305-7246
Volume 10 Issue 2, 2021

Free-Space Laser Communication

Dr. rohini deshpande[1], gagan ganapathy [2], govind kumar r[3], lokesh guptha[4], jayant verma[5]

[1]REVA University Bangalore, Karnataka, India, rohinideshpande@reva.edu.in

[2]REVA University Bangalore, Karnataka, India, gagcmk@gmail.com

[3]REVA University Bangalore, Karnataka, India, govind.r9480@gmail.com

[4]REVA University Bangalore, Karnataka, India, kowshiklokesh@gmail.com

[5]REVA University Bangalore, Karnataka, India, jayharshu8088367130@gmail.com

Abstract:

Laser communication is one of the key areas in wireless Communications. This paper deals with analysis optimization, design, and system level development of signal Communication through laser beam between two sources. Such system works analogous to fiber optic system except that the beam is transmitted through free space. While the transmitter and receiver must require line-of-sight conditions, 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, small, low power and free from radio interference.

KEYWORDS: Wireless Communication System, Laser Communication Link, Audio Amplifier LM386, Operational amplifier uA741.

I. INTRODUCTION

Laser Communication is one of the emerging areas of wireless communication system. Its high signal to noise ratio makes it as one of the well-suited communication media for exchange of information. Currently laser commutation is adopted in satellite communication for space research activities. Due to its high efficiency, high signal to noise ratio, low cost, low power, flexibility and its immunity to the radio interferences, lot of research is being carried especially in wireless communication [1]. In this process, the proposed paper explains the principle of laser communication for information exchange between any two devices.

In this proposed paper laser communication system is implemented for wireless connection through the atmosphere. Major focus is on increasing the signal to noise ratio. Laser communications systems work similar to fiber optic systems, except that the beam is transmitted through free space. In Laser Communication the transmitter and receiver must require a line-of-sight conditions. Also, 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 and small. The carrier used for the transmission signal is typically generated by a laser diode. Two parallel beams are needed, one for transmission and one for reception.

Lasers have been considered for space communications since their realization in 1960. However, it was soon recognized that, although the laser had potential for the transfer of data at extremely high rates, specific advancements were needed in component performance and systems engineering, particularly for space-qualified hardware. Advances in system architecture, data formatting, and

component technology over the past three decades have made laser communications in space not only a viable but also an attractive approach to intersatellite link applications. The high data rate and large information through put available with laser communications are many times greater than in radio frequency(RF) systems.[5]

This paper proposes a very important concept of laser communication which is one of the under-developed and upcoming field of communication. So, this type of communication will be further implemented in future in many domains, such as computer communication, satellite communication etc. This will reduce the usage of busses within the circuitry, which may also reduce the usage of metal, hence reducing e-waste.

This field of communication is one of the fastest, most accurate, and safest mode of communication, which has the great potential of getting implemented very soon in every range of communication. Laser as a communication medium can provide a good substitute for the present-day communication systems as the problem of interference faced in case of electromagnetic waves. This paper involves the study of wireless, open channel communication system using laser as a carrier for the message signal. High data rate, small antenna size, narrow beam divergence and a narrow field of view are characteristics of laser communication that offers a number of potential advantages for system design.[2]

Laser communication will have a pivotal role in providing very high data rates and capacity. Radio and Microwave have some inevitable downfalls that make data communications increasingly difficult at extremely long distances. Optical Laser transmission has many inherent advantages compared with RF transmission.[6]

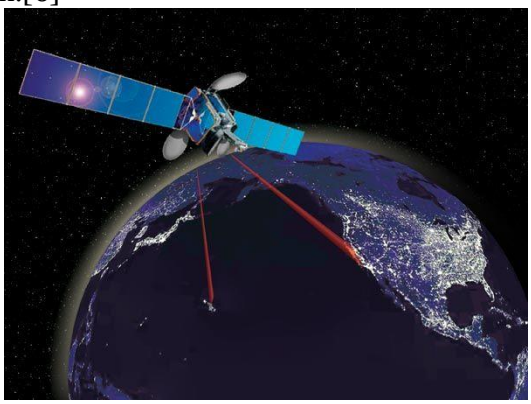

Figure 1: ***Satellite Communicating with the help of laser.***

II. WORKING PRINCIPLE

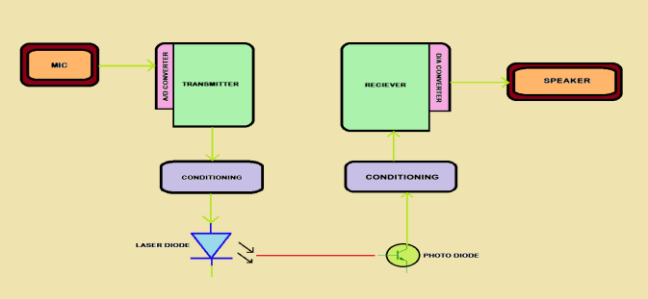

Figure 2: ***Block Diagram of Laser Communication System***

Laser Communication System works on the principle of "Amplitude Modulation" process. In this the amplitude of the carrier is varied according to the instantaneous amplitude of the modulating signal (Input Signal). A sound signal which is the input is

transmitted through transmitter circuit and laser beam carried the transmitting signal via laser diode to a receiver circuit to produce the output signal.

The transmitting system involves the signal processing electronics which can be analog or digital, a laser modular and a laser with visible and near-visible wavelength. Here, **"Carrier Signal refers to Laser Beam", "Amplitude refers to 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.

This simple Laser Communication System consists of two sections Transmitter and Receiver. At the Transmitter any audio device can be 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. Due to this intensity of the laser beam changes proportional to audio signal strength. The first step in transmitting sound is to digitize sound waves. For this an electric microphone is used. The signal coming off the microphone was far too low to be read (with any degree of precision) by the analog to digital converter. For that we are using the LM386 op-amp to increase the power and signal. Before the signal is put through the amplifier, signal is passed through a capacitor to remove DC, and then through a voltage divider to appropriately bias the signal. The gain is adjusted by the resistors and for the microphone the gain is around 50-100. The transmitter circuit should be powered by a 9V supply; however, we can directly connect the laser torch (3V) to the emitter terminal of the transistor T2 after removing the battery. Similarly, the spring-loaded lead projected from inside the torch can be grounded.

The project unlike other wireless media use laser light from the transmitter torch as a carrier instead of RF signals used in the conventional system. At the receiver end, the phototransistor should be aligned in a line-of-sight position such that the laser beam from the torch falls perfectly on it. However, communication is not possible if there is any obstacle in the path of beam and no sound will be heard at the receiver end.[4]

III. IMPLEMENTATION

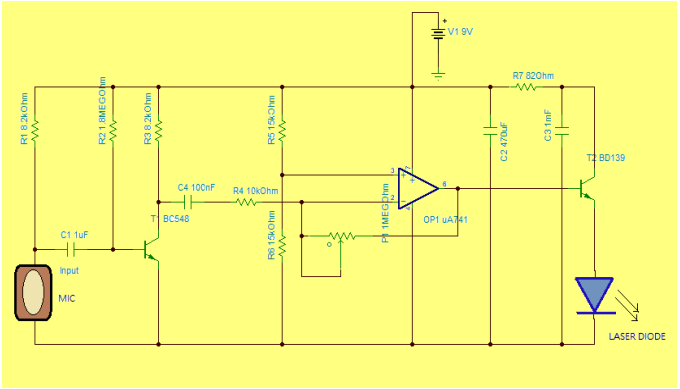

Figure 3: ***Transmitter Circuit***

- **Microphone & Resistors R1, R2, R3 & R5:**

The condenser microphone is used to get the audio signal and a laser diode is used to create the laser signal. Also it includes photodiodes for feedback to ensure consistent output. The resistors R1, R2, R3 are used for controlling the amount of voltage that is supplied to the circuit.

- **Capacitors C1, Transistor T1 (BC548):**

Input audio signal from the microphone is applied to the coupling capacitor which eliminates the DC component. Next it is fed to the base of the transistor T1 which acts like an amplifier and amplifies the feeble input signal. Further it is then sent to the other part of the circuit towards the capacitor C2 & resistor R4 and later to the IC 741.

- **IC (Integrated Circuit) -741 & VR1**

The signal from T1, after passing from C2 and R4, is now given to the IC 741 which further amplifies the signal and imparts strength to the signal. Here we must make sure to set the gain of the amplifier IC for the desired value. In order to achieve this a potentiometer VR1 is used which in this case is set to 15% of gain.

- **Transistor T2(BD139), LED1, Capacitors C3, C4, & R7**

The amplified signal is now passed to the transistor T2 which produces the modulated power signal. Next it is passed to LED1 which converts electric signals to light signal. Such converted light signal is passed towards the receiver circuit. For effective and noise free communication, the capacitors C3, C4 and resistor R7 are used as power filters.

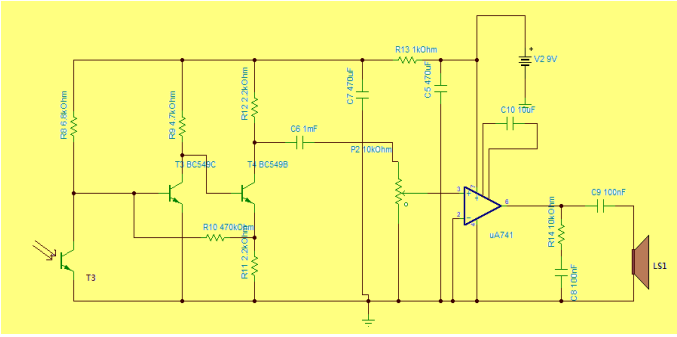

Figure 4: ***Receiver Circuit.***

- **Phototransistor T3, Transistors T4, T5 (BC549)**

The phototransistor receives the light signal sent from the transmitter via the channel that is the atmosphere. The capacitors C5, C6 are used to remove DC components if present. Resistors R8, R9, R10, R11, R12 are used for proper biasing of the transistor and to ensure that correct amount of voltage and current flows throughout the circuit. Also, the transistors T4, & T5 acts as amplifiers that amplifies the signal and then passes the signal to the coupling capacitors C8. Here another potentiometer is used of the range 10k ohms for adjusting the volume level for the IC LM386. Next the signal is amplified/reconstructed and output is obtained at the loud speaker.

- **Loud speaker LS1:**

We obtain the output across this component of the circuit and thus conclude that the circuit is working fine. Thus, a wireless communication is established successfully using Laser.

- **Software used:**

There are many different types of software's used to simulate various circuits and get the desired output, it was initially developed by "Design Soft". TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where we can even edit our circuit during its operation, develop, run, debug, and test the designed circuit. In our project we are using TINA as the simulating tool to get the required output. It is user friendly in nature and easy to learn.

IV. RESULTS & CONCLUSION

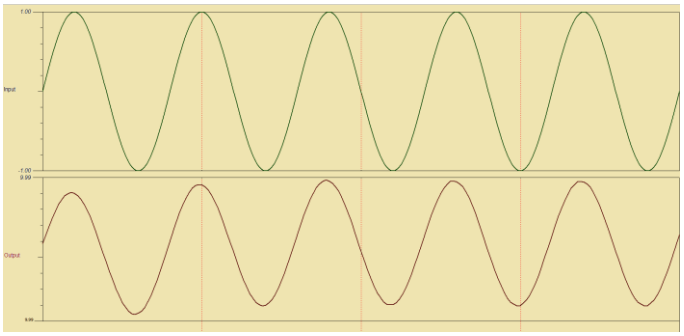

Figure 5: ***Simulated output, by giving 500Hz of Input sine wave of 2V peak-peak, and getting an amplified output of 500Hz sine wave of around 20V peak-peak.***

After the analysis of the circuit and having a good understanding of the working principle of the laser-based communication, we can infer that Laser is a synchronous mode of communication in which the error occurrence is reduced to a large extent when compared to other existing communication methods/technologies.

The range of this particular project is designed for 0.5km (500m).

V. APPLICATIONS

- **Defense and Sensitive Areas:** This type of system is used to detect enemy's ships and missiles, also used to disable them at the same time.[7]
- **Airport Runways:** Helps the airport's headquarters to know whether the plane is landed or to detect which plane is landed on the runway.[7]
- **Mass Communication:** This type of communication can be implemented in telephone communications and in television channels.[7]
- **NASA:** A NASA's accomplishment was that hey exchanged the message signals through laser pulses with the spacecraft and an Earth-based observatory.

- **Satellite-to-Satellite Communication links:** Some of the NASA's satellites uses lasers to exchange information from one satellite to other.[7]
- **Digital Communication:** Instead of using cables or optical fibers, this mode of communication can be used to link the devices.
- **Substitution of BUS in the computers:** In a computer, instead of using BUS to connect the inner components of motherboard, we can create laser-based communication links for faster transferring of data.
- **Maximum usage of bandwidth:** A single bandwidth can be distributed among many devices, that are pointing towards a common transceiver.
- **Other Security uses:** This type of communication can be used in shopping malls to interconnect the security cameras and for other security purposes (like laser traps), and it can also be used to count number of people entering and exiting the mall etc**.**

VI. ADVANTAGES

- It allows very fast communication service between two or more devices than other modes of communications.
- Laser communications systems have the benefit of eliminating the need for broadcast rights and buried cables.
- Laser communications systems can be easily deployed since they are inexpensive, small, low power and do not require any radio interference studies. The carrier used for the transmission signal is typically generated by a laser diode. Two parallel beams are needed, one for transmission and one for reception.
- The transmitting and receiving station are smaller and lighter for given range.
- Overall power required is less for a given data rate and distance.

VII. OPPORTUNITIES FOR RESEARCH

Laser Based Communication Link can be further implemented by increasing its range, as of now it is designed to operate for a smaller distance communication, but by changing the design and values of the components using and biasing the transistor in a much more efficient way, the range can be increased and it can find a wide variety of applications in the future.

VIII. REFERENCES

[1] Shu Fan Wang, Xiao Tian Wang, Xiang Yang Zou, Yong Wen, Experiment Layout of Space Laser Communication System Based on Adaptive Optical System,3020-3023, July 2011.

[2] Robert T. Sparks, Stephen M. Pompea1 and Constance E. Walker, National Optical Astronomy Observatory, Tucson, Arizona, 85719 USA, The Development of a Low-Cost Laser Communication, System for the Classroom.

[3] A REVIEW OF RECENT ISSUSE AND CHALLENGES IN UNDERWATER SENSOR NETWORK, S.SANDHIYAA, Dr.C.GOMATHY, International Journal Of Advance Research In Science And Engineering http://www.ijarse.com IJARSE, Volume No. 10, Issue No. 02, February 2021, ISSN-2319-8354(E).

[4] Morio Toyoshima, Yoshihisa Takayama, Space-based laser communication systems and future trends,2012, Conference on Laser and Electro-Optics (CLEO).

[5] https://bestengineeringprojects.com/laser-based- communication-link/

[6] https://www.academia.edu/36835571/Study_on_Laser_Communication_Features_Application_Advantages

[7] Space Laser Communication - History (weebly.com)

[8] https://steemit.com/steemstem/@samest/laser- communication-system-full-design-explanation-23c4fb4ae227