POWER VS DISTANCE ANALYSIS FOR POINT TO MULTIPOINT APPLICATION'S AT 650NM USING FREE SPACE OPTICS

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ABSTRACT: Point to multipoint link has been proposed using 650nm LASER over a Free Space Optics Technology. A comparative analysis of Power Vs distance has been carried over free space optics link. Prototype model send the data to other users wirelessly. Prototype model is designed in such a way that it transmits the data through light instead of using any Radio Frequency signal. Light from a LASER torch transmit up to the distance of 43metres with the lesser power of 5mw. Using 650nm LASER, power of system has been analyzed.

KEYWORDS: LASER, LM386, Wireless, RF, FSO, LOS, NLOS.

INTRODUCTION

Communication media is of two types one is wired communication and other is wireless communication. Wired communication provides higher data rate whereas wireless provides superior flexibility in the mobility conditions. Both these types have their own pros and cons. So by taking the benefits from wired and wireless communication, a new system is designed which is based on the Free Space Optics Technology (FSO). FSO technology needs a line of sight in between transmitter and receiver. It consists of light source at transmitter side such as LASER, LED and IR LED and use air as a medium in between transmitter and receiver through which light propagates and on the receiver side, it consists of avalanche photodiode and PIN diode. It can easily transmit the voice, image and video signals. It takes voice as an input and converts it into electrical signal further electrical signal converts into light signal which propagates through the medium and on the receiver side light is received by photo detector. Photo detector converts light signal into electrical signal and then electrical signal into voice signal. FSO solves the problem of interference which comes from the electromagnetic waves and also provides the high security [1].

FSO use the LASER at transmitter side because of its benefits like LASER provides a link which is virtually impossible for anyone else to tap into the link so in this it transmit the high quality signal with high security. Another important feature available in fibre optic cable is security but it is having various problems like trenching and splicing [2]. Another important aspect associates with LASER is its applicability for satellite communication as LASER radar requires very small aperture in comparison with microwave radar and also translate a very precision range measurement. LASER gives the monochromatic output. It mean it transmit the light in a single beam not in a scattered mean. Because of this benefit LASER is mainly used for long distance communication. Nowadays, LASER is used in both wide-band and high-speed communication [3]. FSO is free from any kind of electromagnetic interference so it is mainly used in hospitals and also it is free from any king of multipath fading. [4]. FSO transmit the data in three different way one is line-of-sight (LOS), Non-line-of-sight (NLOS) and hybrid transmission as shown in Fig. 1 and Fig. 2. Line of sight is also known as direct transmission. This type of transmission gives the

efficient output but it needs a high precision while setting the angle of line-of-sight [5]. Second method is known as non-line-of-sight or diffused transmission. This type of transmission gives the output with less efficiency because most of the part of signal absorb by the walls or objects. The main advantage of non-line-of-sight is that, there is no requirement of highly directional beam of light [6]. Sometimes, combination of LOS and NLOS is used while transmission and it is also known as hybrid transmission.

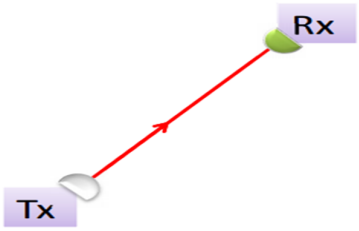

Figure 1. Line-of-Sight Transmission

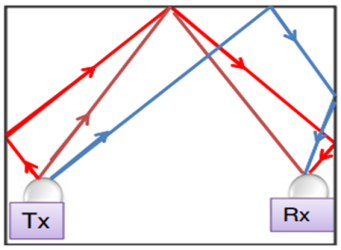

Figure 2. Non- Line-of-Sight Transmission

Figure 3. Block Diagram of Working Principle of a System

In this paper, a system is proposed for providing the point to multipoint link in between transmitter and multiple receivers. Transmitter consists of one light source using LASER or LED and on the receiver side each receiver consists of photo detector. When light falls on photo detector then it receives the information from the transmission side. This system is mainly used in academics where the head of the department want to send information to the various departments then with the help of this architecture, information can be easily transmitted. The main requirement of the given system is just a line of sight in between transmitter and receiver.

DESIGN OF SYSTEM

Fig. 3 shows the working principle of a system. The transmission in given system has been carried over six phases including Power supply section, input signal audio, video or image, Transmitter section with LASER as light source, air as medium, receiver section with photo detector and speaker, laptop etc. In this data is transmitted through the light only because of this, the given system needs a proper line of sight in between transmitter and receiver. When our transmitted signal propagates from the medium then it is effected by various atmospheric factors like atmospheric turbulence, scintillation etc or it may be comes from the internal losses of the device. The received power strength P_{Rx} [Watts] depends upon the transmitted input power P_{Tx} [Watts], transmitter antenna gain G_{tx}, receiver antenna gain $G_{rx,}$ range loss G_r, system dependent losses A_{system} as in (1).

$$P_{rx} = P_{tx} \cdot G_{tx} \cdot G_r \cdot G_{rx} \cdot A_{system} \qquad (1)$$

Assuming Gaussian beam transmitter aperture gain is given as (2) [7]

$$G_{tx} = \frac{32}{\theta^2} \quad (2)$$

Where θ is in radians and gives the full divergence of transmitted beam range losses G_r depend upon the distance travelled by the light which is given as in (3)

$$G_r = (\lambda / 4\pi L)^2 \quad (3)$$

Receiver antenna gain is given by considering the diameter of telescopic antenna is given as (4) [8]

$$G_{rx} = (\pi D / \lambda)^2 \quad (4)$$

SYSTEM MODEL

The system model consists of various components namely; power supply section, microcontroller interfacing with stepper motor through ULN2003A, transmitter and receiver. Fig. 3 shows the system components which is as given.

Power Supply Section: Input power consists of step down transformer which step down the 230v input voltage to the 5v supply. Because microcontroller works on the 5v supply. So just to give input to the controller section there is a need of step down transformer.

Microcontroller interfacing section: To control the movement of stepper motor there is a need of microcontroller. Fig. 4 shows the interfacing of microcontroller with the stepper motor. In this the stepper motor is connected with microcontroller through the ULN2003. ULN2003 consists of high voltage and high current Darlington transistor array. It is commonly used to operate the LED, lamp and stepper motors. It also overcomes the effect of back emf. Firstly provides the 5v supply to the microcontroller section and then connect ULN2003 with the microcontroller through port2. Then give supply to the ULN2003 at its pin 9 and then interface the motor with its pin 13,14,15,16 as shown in Fig. 5 Transmitter Section.

Transmitter Section: Fig. 5 consists of transmitter section which comprises of power supply, condenser microphone, transistor as an amplifier, OP-Amp (741), filter circuit, BD139 transistor and 3V LASER torch. Firstly power supply is given to the transmitter circuit and this supply can be A.C and D.C if we use A.C power supply then it must be isolated from the transmitter circuit, otherwise it creates noise in our output signal. But for this prototype model D.C supply of 9V is used. The input is speech signal which given through the condenser microphone. Condenser microphone is very sensitive. The diaphragm when struck by sound waves, changing the distance between the two plates and further change the capacitance. If the distance between two plates become lesser then the capacitance increases and it further increases the current and that current will used to trigger the transmitting section. Fig. 5 shows that the voice signal is firstly amplified by the transistor (BC548) which behaves as an amplifier. This amplified output further become the input of OP-Amp through its 2-pin. It behaves as an inverting amplifier and its gain is controlled by the 1MΩ variable resistor and produces the output at its 6-pin, further the signal passes through a filter and become the input of BD139. BD139 further modulates the Signal and this modulated signal apply to the LASER which is connected to emitter terminal of BD139 [9]. LASER transmits the data with very high speed as compare to other light sources. LASER light operates in near

infrared region of spectrum. The LASER source which is used in this model operates at a wavelength of 650nm. For the reliable operation LASER diode needs a certain value of current, called threshold current before it emit the laser light. As we know that output power and current have linear relationship in case of laser diode. So according to it, if we increase the input power then current automatically increases which further increases the intensity of laser diode. For example: in the given prototype model 650nm 5mw LASER diode is used whose threshold value of current is 30milliampere. Beyond this threshold value if we increase the current then it gives high intensity but as we further increase the value of current then it reduces the life span of LASER diode. At a particular value near 80 milliampere, it will destroy the laser instantly. Because laser is very fragile [10]. So the most important thing kept in mind while giving input current to laser diode is its specifications. If the laser operates within its specifications then calculated life span of laser diode is nearby 2000hours. The output of LASER diode is received by photo detector which is at receiver section.

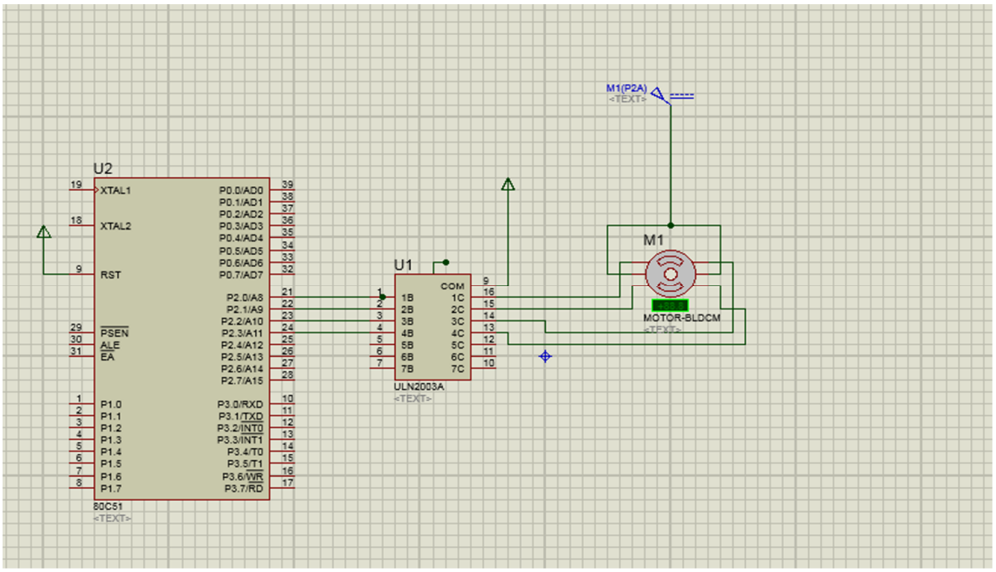

Figure 4. Microcontroller Interfacing with Stepper Motor

Receiver section: Fig. 6 consists of receiver section which comprises of phototransistor, two stage transistor pre-amplifier, LM386 as an audio amplifier. The main requirement of receiver is the proper alignment in between transmitter & receiver. The receiver circuit uses NPN phototransistor which behaves as a light sensor and it is followed by preamplifier stage. Sometimes the received signal is not strong enough so firstly received signal passes through pre amplification stage. After pre amplification stage post amplification process applies to it through audio amplifier namely LM386 whose gain varies with the help of variable resistor. The output of LM386 becomes input of loudspeaker. Loudspeaker is nothing but it behaves as an acoustic transducer that converts an electrical signal into sound signal.

The speaker provides output in accordance with the variations of electrical signal and causes sound wave to propagate through a medium [10] [11]. The main requirement of this system is to keep the line of sight in between transmitter and receiver and also provides isolation in between transmitter and power supply. The proposed system is based on FSO technology which further consists of one transmitter section and four receiver sections. Transmission is possible through light only when there is a clear line of sight in between transmitter and receiver.

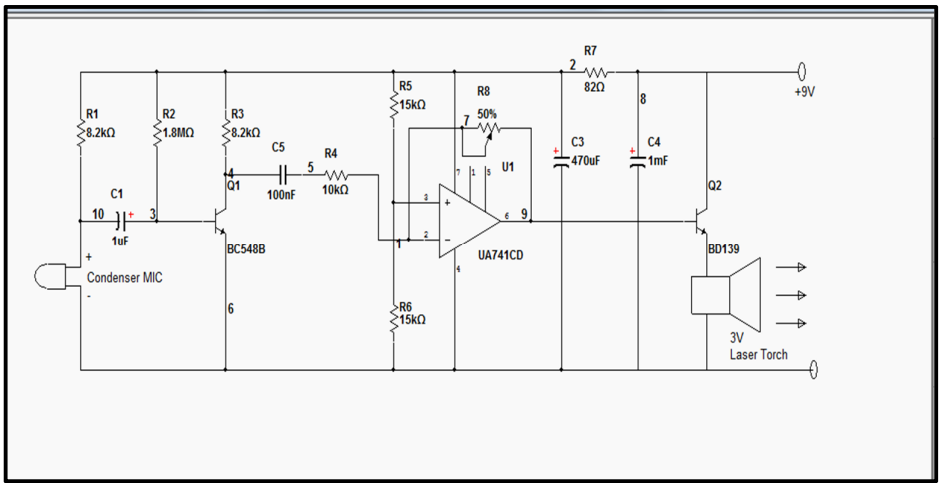

Figure 5. Circuit Diagram of Transmitter Section

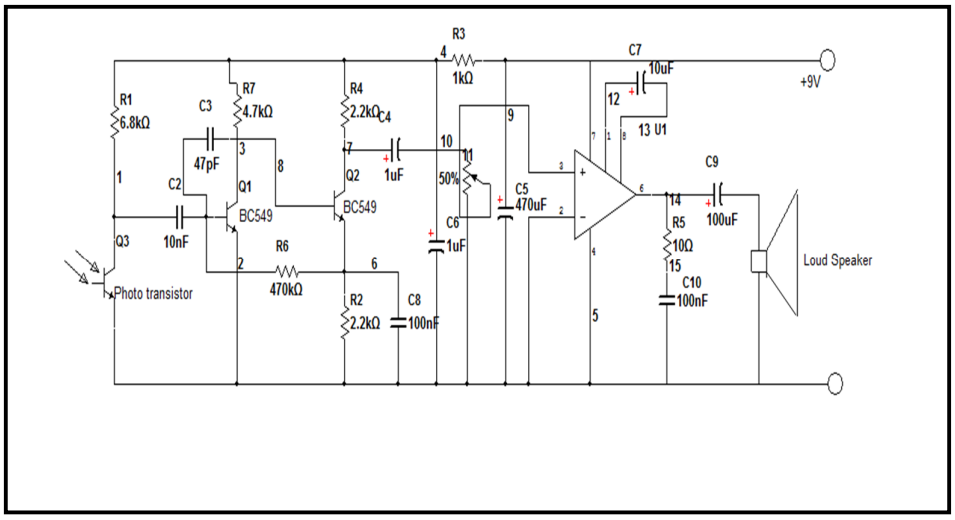

Figure 6.Circuit Diagram of Receiver Section

According to the program stored in microcontroller our stepper motor provides a rotation and makes a line of sight with each receiver at different time and then transmits the data. Stepper motor consists of one light source and on the other side receiver section individually consists of photo detector, when the stepper motor provides a rotation then light from a source falls on a photo detector and make a clear line of sight in between transmitter and receiver and then transmit the data. In this way stepper motor broadcast the data to different users.

RESULTS

Comparison between experimented and previous result has been presented in Table I. TableI shows the various ranges results by varying power of input signal. Fig. 7 shows the graph of Range versus Power. It is clear from table1 that by varying power distance also varies. Using new schematic it is possible to have transmission using low power at longer distances as compared to previous schematic.

Table 1. Comparison in between previous and current results on the basis of range and power

Power (in mws)	Previous results (in mts)	Current results (in mts)	%age increase
3	7	16	56%
5	12	30	60%
7	17	43	61%

To have better view of comparison Fig. 7 represents comparative bar graph which depicts a clear rise in distance with low power as compare to the previous one.

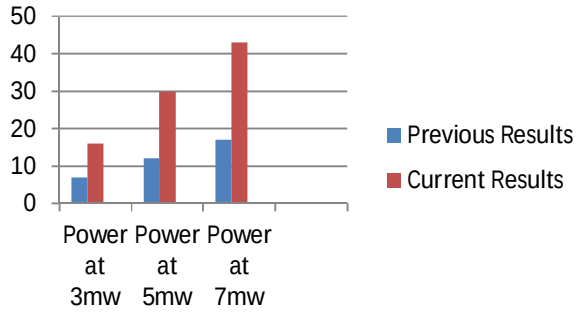

Figure 7. Analysis of previous and current results

ANALYSIS

For the analysis purpose MATLAB tool is used. Fig. 8 compares the previous results with current results. It shows results of Range versus Power. By varying power our distance also varies but with the help of new schematic our system gives high performance and with the use of less power communication is possible at longer distance as compare to previous one.

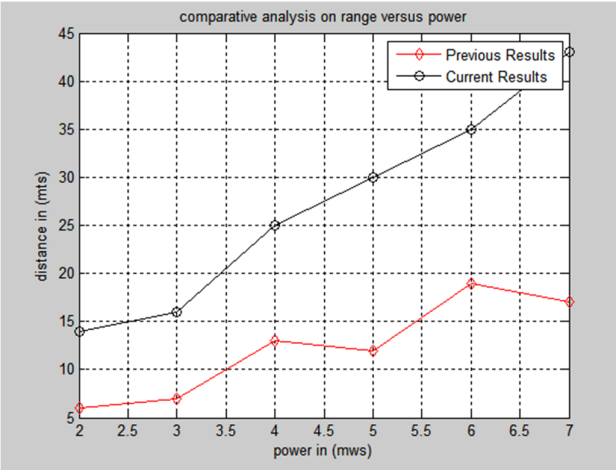

Figure 8. Analysis of previous and current results on MATLAB

Using 650nm LASER with power 3mw approx.56% rise in level of distance has been achieved, with the help of same LASER but using power of 5mw, 60% rise in level of distance has been achieved. Similarly with the help of 7mw the approximate results achieved up to 61%.

CONCLUSIONS

Using above system, The problem of interference which comes from the electromagnetic waves in wireless communication can be avoided easily. In the proposed system, user can communicate with other users wirelessly. It gives us license free operation so it's very cheap as compare to other communication technologies. It can also be used in military areas, conference halls, in inaccessible areas etc. By improving its range factor or by decreasing its power factor, it can also be used for enormous number of applications in future. Proposed schematic design could be used to configure the transmission with less power. With the help of proposed system about 56% results has been achieved by using the LASER power approx 3mw. Similarly with the help of LASER with 650nm, the %age level rise in distance is up to 60% and 61%.

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