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Low Noise Wireless Speaker Using LASER and Infra-Red Technology for Public Address System

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Abstract- This work present a point to point transmission of voice signal wirelessly through the atmosphere with a LASER diode or infra-red device. Optical communication is gaining popularity because of its high bandwidth, low loss power, high security, low cost and most importantly no electromagnetic interferences. Like any other wireless communication system, LASER network consists of transmitter, receiver and free space channel but however the signal is in light domain. Here both the transmitter and receiver is built with LM386 op-amp with telescopic LASER or infrared red Led as optoelectronic(OE) source which converts the electrical signal into light signal at the transmitter and optoelectronic detector at the receiver which converts the incoming light signal into electrical signal. One challenging problem for successful LASER communication is maintaining a line of sight between OE source and OE detector. In this paper the problem of aligning between transmitter and receiver is solved by using solar panel of 4x4 cm^2 areas as OE detector because of its large physical capture area. For better output with less noise the detector is enclosed within a dark compartment for receiving only the signal of interest. The proposed circuit works efficiently with 9V DC and 3.32mA circuit current. The total circuit power consumption is 29.88 mW. LASER wavelength use is 630-650nm with maximum output power of 5mW. The designed module is tested for sinusoidal input of 1V peak to peak and frequency of 1 KHz. The receiver receives satisfactorily within a range of 20 to 25 feet away from the transmitter. This can be implemented in classroom PAS and in conference room eliminating the messy wiring system

Keywords- line of sight, OE source, OE detector, op-amp, gain

1. INTRODUCTION

A Laser communications system is a wireless network through the atmosphere which carries the information in light domain rather than electrical domain in RF communication. The working principle is much like to optical fiber communication. In fiber optics network the light is confined and guided inside the fiber through total internal reflection, but in LASER communication the light beam is transmitted through free space without the need of any cable. Unlike in fiber optics, LASER communication however should maintain the line-of-sight conditions between the optoelectronics source and optoelectronics detector of transmitter and receiver respectively. This system eliminates the intrinsic and extrinsic losses which occur in both hang and buried fiber optic cables. Laser communications systems can be implemented in point to point communication easily because of their low cost, small hardware, low power and absence of electromagnetic interference. For two way communication two parallel beams are required, one for transmission and other one for reception of signal. The detail blocks representation of Laser communication in shown in Fig.1 and Fig.2. The input which is in the form of voice is initially amplified with a pre-amplifier circuit before further amplifier by the second stage amplifier which provides the overall gain of the transmitter. The signal is then fed to a Laser diode through a driver circuit. Laser will convert the electrical signal into light signal and send the signal into free space. The transmitter attains modulation of Laser signal which acts as carrier by the modulating signal from condenser mic or from audio jack input.

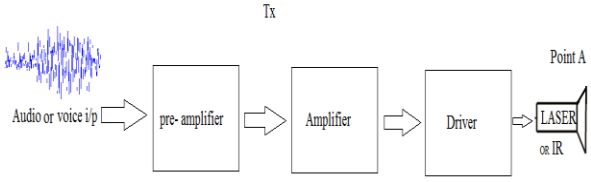

Fig.1. Transmitter section of LASER Communication

Maintaining a perfect line of sight (LOS) between point A and point B is the key feature of Laser communication. The OE detector at the receiver will intercept the incoming light signal and converts back into electrical form which is again amplified by cascaded amplifiers and fed its output to a load through a driver as shown in Fig.2.

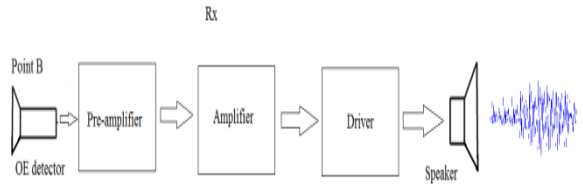

Fig.2. Receiver section of LASER Communication

Since optical communication offer a lot of advantages over RF communication, in recent year's different work has been carried out and publish in the area of optical communication. The concept of free space optical communication in order to fabricate physical connections between two systems i.e PC to PC communication having a line of sight arrangement, using serial communication for transfer of data is designed [1].The circuit of mobile laser transceiver has been designed for data exchange between computers using serial communication[2]. Another work describes the design and implementation of infrared (IR) and laser-based electronic ciphering systems instead of radio frequencies for use in both indoor and outdoor wireless remote control applications [3].The analysis, optimization, design and system level development of signal transformation between satellites or any two sources using Laser communication eliminating the need for broadcast rights and buried cables is also presented [4]. Other work which involves Laser communication is a simple laser network system to send audio signals over a distance through free medium using a laser diode as light source and the detector as photo resistor [5]. As optical space communications is on the verge of being reality, Laser based satellite communication system is already introduced. The paper includes briefly analysis, optimization, design and system level development of signal transferring between satellites [6]. The microcontroller based communication system using laser light as a device to transmit data is also reported. Microcontroller is connected with a PC where the PC act has an input in the form of audio, text and video to transmit with the help of laser medium [7].A circuit is designed for voice transmission to communicate with neighbors wirelessly. When Laser torch is used as the carrier in the circuit and phototransistor as a detector at the receiver, voice can be transmitted up to a distance of about 500 meters [8]. Designing of a very low cost voice transmission system using an ordinary available LDR and Laser torch for point to point conversation is also presented [9].

2. DEVICE WORKING PRINCIPLE

The circuit main components for the voice transmission is built with the following devices
1) Optoelectronic source (Laser)
2) Optoelectronic detector (Solar panel)
3) LM386 op-amp

2.1 Laser: The acronym LASER (Light amplification by stimulated emission of radiation) is a device that emits a beam of coherent light through an optical amplification process. The circuit symbol is shown in Fig.3

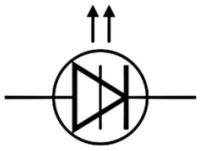

Fig. 3. Laser Diode

There are two types of emission as spontaneous emission and stimulated emission. If the atom is in the ground state, with energy E1, the photon may be absorbed so that it is excited to the upper energy level E2. Subsequently de-excitation will occur producing the emission of radiation in random manner. This process is spontaneous emission as shown in Fig.4 (b). On the other hand if the atom is already in the excited state, then the incident photon may stimulate a downward transition with the emission of radiation. Photons emitted in this process are coherent with the stimulating photon i.e both the stimulating and stimulated photons have the same energy, same momentum, and same state of polarization as shown in Fig.4 (c)

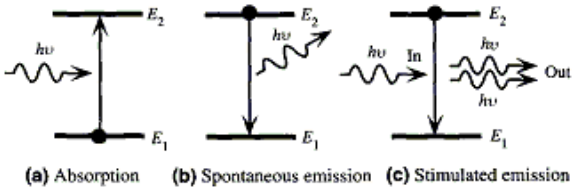

Fig .4 spontaneous and stimulated emission

For Laser action to occur either three- level or four-level atomic system is required as shown in Fig. 5. In order to achieve population inversion i.e more number of atoms in the higher energy state than in the lower one, it is indeed a hard work in three-level atomic system. Hence four-level system is preferred for better amplification [10]. Here the system is pumped by photon of energy hν14.

The absorption of such photons excites atom to E4, from where they quickly relax to E3. The transition from E3 to E2 is radiative but slow and the transition from E2 to E1 is again fast and non-radiative. In this scheme, it is relatively easy to provide level E3 with an inverted population over E2 because E2 is not well populated in the first place and atoms do not

accumulated there, as they quickly relax to ground state [10].

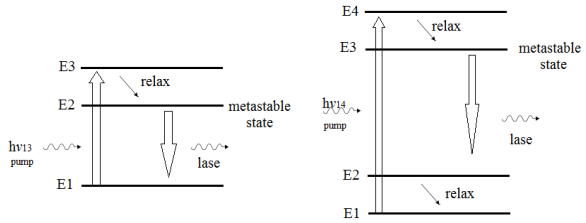

Fig. 5 Three and four level atomic system

2.2 Optoelectronic detector: It converts the optical signals at the receiver end back to electrical signals for further processing. Fig. 6 shows the basic reverse biased p-n junction as detector. When the photon of energy greater than the band gab of the semiconductor material i.e hν ≥ Eg is incident on the depletion region of the device, it excites an electron from the valance band into the conduction band. The vacancy of electron creates a hole in the valance band. Electrons and holes so generated experience a strong electric field and drift rapidly towards n and p sides respectively. The resulting flow of current is proportional to the number of incident photons. Such a reverse-biased junction, therefore, acts as a photo detector which converts light into electrical signal.

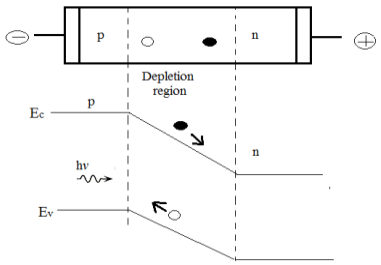

Fig.6. P-N junction energy band diagram showing carrier generation and their drift

2.3. LM386 Op-amp: LM386 is a compact 8 pin general purpose IC use for low voltage audio amplification. The internal gain of the IC ranges from 20 to 200, but by default the gain is set to 20 without using any external component. However gain can be increased to 200 by using resistor and capacitor between PIN 1 and 8, or just with a capacitor. LM386 work perfectly between 5-12 DC supply voltages. The Pin out diagram of LM386 is shown below in Fig.7.

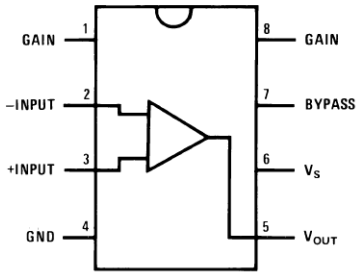

Fig. 7. Pin out configuration of LM386

3. IMPLEMENTATION

As shown in the Fig. 8 (a) the input can be in the form of audio from jack input or voice from the condenser mic at the transmitter. The low audio signal is initially amplified with a one stage transistor pre-amplifier circuit before passing through the second stage amplifier which is built with LM 386 providing the overall gain of the transmitter. The amplified signal is then fed to a Laser diode which converts the electrical signal into light signal and transmits it into free space. The transmitter attains modulation of Laser signal which acts as carrier by the modulating signal from condenser mic or from audio jack input.

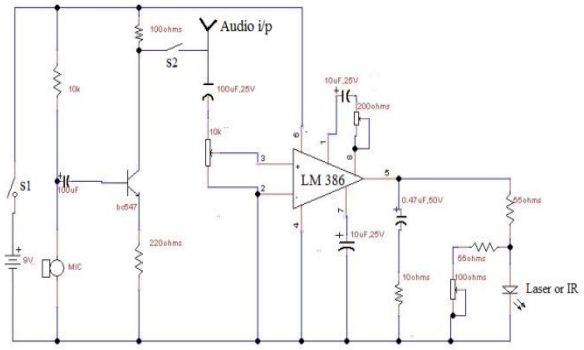

Fig. 8 (a) Circuit diagram of transmitter

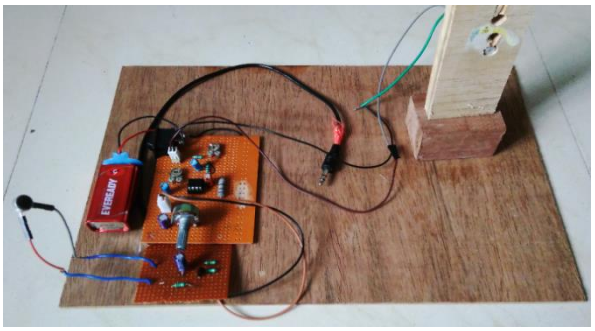

Fig. 8 (b) Hardware implementation of transmitter

The implementation the transmitter circuit is shown in Fig.8 (b) with an audio input. The gain of the transmitter can be control with a potentiometer which is connected between pin no. 1 and 8.The receiver circuit is shown in Fig. 9 (a). The OE detector at the receiver is completely enclosed inside a dark

compartment for cancellation of noise from external light. The detector will intercept the incoming light signal and converts back into electrical form which is again amplified by the LM 386 amplifiers and fed its output to a speaker. For desirable adjustable output 1kΩ potentiometer is connected with the load. The 10kΩ potentiometer is for regulation the input signal for minimum distortion output. The complete hardware design is shown in Fig. 9 (b).

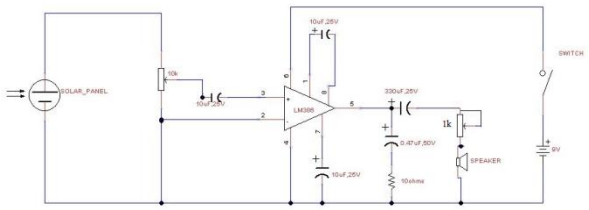

Fig. 9(a) Circuit diagram of Receiver

Fig. 9(b) Hardware implementation of Receiver

The entire set up of transmitter and receiver maintaining a line of sight condition is also shown in Fig. 10. Up to a distance of 25 feet using Laser, the design module works perfectly. IR led covers a distance of 20 feet with less output noise. Comparatively Laser cover a larger distance with some noise and IR covers a lesser distance but with lesser noise.

Fig. 10. Transmission and Receiver with line of sight alignment

3. CONCLUSION:

This work is mainly proposed and implemented for voice or audio transmission from point to point communication wirelessly. Even though Laser communication applications are numerous, the presented paper is specifically for public address system (PA system) in big classroom hall or conference room eliminating the need of wiring system. It work efficiently between 25 and 20 feet for LASER and IR Led respectively with a supply voltage of 9V.The coverage distance can be increase by increasing the transmitted power. Since phototransistor and PIN diode physical area is small, it is difficult to align perfectly the LOS condition between Tx and Rx. This problem is overcome by using solar panel of 4x4 cm^2 area as Laser detector which is enclosed perfectly within a close compartment for external noise cancellation.

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