Low Cost Voice Communication Device Design Using Ordinary Laser Torch

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Abstract

As living in the society, communication is the most important activity of human being. All most for every purpose we are communicating with each others. Different modes of communication are used and voice communication is one of those categories. From the beginning of technological advancement, many processes have been used for the voice communication purpose and among those, Laser Voice Transmission Process is much more useful because of wireless connectivity and free from disadvantage of radio frequency transmission. Long distance high cost Laser voice transmission system is not economic for the purpose of ordinary communication. This paper deals with the designing of a very low cost voice transmission system which is perfect for information transmission of general conversation in small area, using an ordinary available photo transistor and Laser torch of cost 200 INR. This is almost 89% cheaper than the lowest cost voice transmission system available in this society.

I. Introduction

There's something rather futuristic about talking 'over' a laser beam, which is what this inexpensive project allows. It will easily give a communication distance of several hundred metres, and with a parabolic light reflector, up to several kilometres. It transmits high quality audio and the link is virtually impossible for anyone else to tap into. As before, there are two sections: the transmitter board and the receiver board, both powered by a separate 9V battery or a fixed voltage power supply, depending on your needs. The transmitter board has an electrical microphone module at one end, and the laser diode at the other end. The electronics modulates the intensity of the laser beam according to the output of the microphone. The laser diode has an inbuilt collimating lens, and is simply a module that connects to the transmitter board. The previous design required brackets for the laser diode assembly.
The receiver uses a photodiode as the receiving element, and the onboard amplifier powers a small 0.5W/8ohm speaker. This board is therefore a high gain amplifier with a basic audio output stage. But what about results - are they better? Sure. Because this design uses a higher power (and visible) laser beam, the range is improved, and alignment is easier and not all that critical, especially over a few hundred metres. The quality of sound transmit ted by the link is quite surprising. As a simple test, we set up the prototype with the transmitter microphone near a radio. The received sound was clear and seemed to cover the full audio bandwidth. Even we have tried feeding an audio signal directly to the transmitter, and undoubtedly it give even better results. So clearly, this project is ideal for setting up a speech channel between two areas, say adjacent houses, or offices on opposite sides of the street. Or you could use it as a link between the work shop and the house. For duplex (two way) communication, you'll obviously need two laser 'channels'. An important feature of transmission by laser beam is privacy. Because a laser beam is intentionally narrow, it's virtually impossible for someone to tap into the link without you knowing. If someone intercepts the beam, the link is broken, signaling the interception [1]. Fibre-optic cables also have high security, as it's very difficult to splice into the cable without breaking the link. However it's theoretically possible; so for the highest security, you probably can't beat a line-of-sight laser beam [2][8]. You can also use an infrared laser. While this gives even better security, as you can't see the laser beam without special IR sensitive equipment, it also makes alignment more difficult.

II. Importance of The Project

Laser communication is a wireless communication system which is economic, reliable and can replace costly optical fiber communication and radio signal [3] [4].The another advantage of this project that the circuit can be easily constructed as well as no communication licenses required. On the other hand The laser transmission is very secure because it has a narrow beam and there are no recurring line costs. It has good Compatibility with copper or fiber interfaces and no

bridge or router requirements. Lasers can also transmit through glass; however the physical properties of the glass have to be considered. It has also narrow beam divergence and high data rate. Laser transmitter and receiver units ensure easy, straightforward systems alignment and long-term stable, service free operation, especially in inaccessible environments, optical wireless systems offer ideal, economical alternative to expensive leased lines for building[3][9].

III. Proposed Methodology

After prepare this low cost project, several related circuit diagram has been downloaded from different websites [7][11]. After verification, a suitable circuit has been chosen for modification according to the equipments available for preparing a low cost design. Block diagram of the total working of the circuit was prepared. The design was modified in such a way so that general people can make it quite easily with affordable equipments here and there. The designed

circuit was constructed on a bread board. The transmitter and the receiver circuit were tested differently and every stage output was examined carefully by using an adopter for power supply instead of 9V battery at electronics laboratory of NSHM knowledge Campus. Among different stage test, first the transmitter was tested using general laser torch available in anywhere in the market. Electronic equipments have been changed in different stages according to the need and availability in order to get proper output with the possible minimum cost. After getting desired output, the efficiency as well as the range of the system was verified. Comparison of cost of this system and available low cost system has been done. "Fig. 1" shows total working order of the system on the block diagram from the transmitter to the receiver output [12].

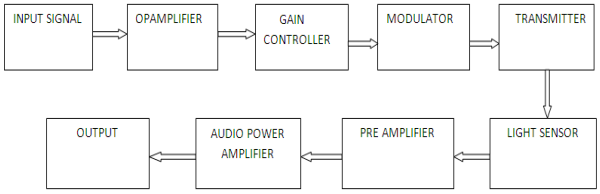


Figure 1: Block diagram of total working order of the system

A. Design and Working principle of the system

There were two sections, transmitter and receiver, both powered by a separate 9V fixed voltage power supply. The transmitter board contained a microphone and a laser torch at opposite ends. The electronics equipments controlled the intensity of the laser beam according to the output of the microphone. Laser torch starts emitting light after its threshold current. The output light is proportional to the current through the torch. Amplitude modulation can lessen the distortion in laser beam output. A 3Volts laser torch used in this project can give its maximum output with a threshold current of 30mA. Further increasing the current can damaged the torch [10].

B. Transmitter Circuit Operation

The circuit is based upon the principle of LIGHT MODULATION where instead of radio frequency signals; light from a laser torch is used as the carrier in the circuit. Here, the transmitter uses 9V power supply. Audio signal or voice is taken as input from the condenser mic, which is, followed transistor amplifier BC548 along with op-amp stage built around UA741. The gain of the op-amp can be controlled with the help of 1 mega ohms potmeter. The AF output from op-amp UA741 is coupled to the base of the power transistor BD139, which in turn, modulates the laser.
However, the three volts laser torch can be directly connected to the emitter of BD139 and the spring loaded lead protruding from inside the torch to the ground. In the transmitter circuit, audio signal of the non-sinusoidal waveform and having a few mV of amplitude is taken as input from condenser mic. Condenser mic is directly followed by the transistor amplifier stage consist of BC548. Transistor BC548 is connected in common emitter configuration. Resistor R1 is the source resistor, which is directly connected to the power-supply. R2, R3 and capacitor C1 are acting as self-biasing circuits, which is used for the biasing transistor. These circuit arrangements provide or establish a stable operating point. The biasing voltage is obtaining by R2 and R3 resistors network. Self-bias is used for obtaining entire audio signal as input. Capacitor C1 is the coupling capacitor, since audio input signal is having a non-sinusoidal waveform of different amplitude and frequency, coupling capacitor is used to reject some of the dc noise/line as well as level from audio input signal. The self-biased circuit is connected with the BC548 in CE configuration. It is transistor amplifier stage, where the low amplitude audio signal is amplified to the desired voltage. The output is taken from the collector terminal; so inverted audio input signal is obtained. Transistor pre-amplifier stage is coupled with op-amp stage built by ua741. C2 is the blocking capacitor while R4 is the op-amp stage resistor. Op-amp ua741 is easily available general-purpose operational amplifier. Pin configuration of UA741 is shown in the glossary. Here pin no. 1 and 5 are not connected in order to nullify input-offset voltage. Pin no. 7 and 4 are VCC as well as –VEE supply voltage. Pin no. 3 is non-inverting input while pin no. 2 is inverting input. Between pin no. 2 and 6, 1 mega-ohm potmeter is connected as voltage series negative feedback, which control the infinite gain of the op-amp. Resistors R5 and R6 of it value acts as a voltage-divider network, thus it gives a fixed voltage at the non-inverting pin. Input inverted audio signal is applied to the inverting pin. Op-amp works on the differences into the applied two input voltage and provide a output at pin no. 6. Since, input is applied to the inverting pin the output is also an inverting one. Thus, again we get in phase high power and high amplitude level audio signal. Capacitors C3, C4 and resistor R7 are acting as diffusion capacitors and feedback resistor respectively. These diffusion capacitors stored the carriers like holes and electrons in the base and thus provide self-biasing of the transistor. Power dissipation rate of UA741 is very high, which is not practical for driving other electronics devices, so heat sink power transistor BD139 is used. Power transistor BD139 absorbs most of the power and supplies the suitable power to drive the laser torch. This in turns modulates the laser beam, since laser torch acts like a balanced modulator, where two signals – one is message signal (audio signal) and carrier laser signal, superimposed. So, laser beam modulates and transmits the signals to large distances.

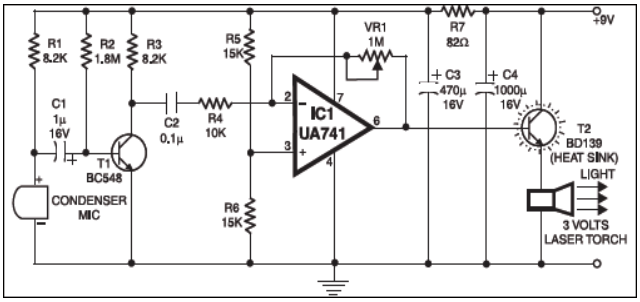
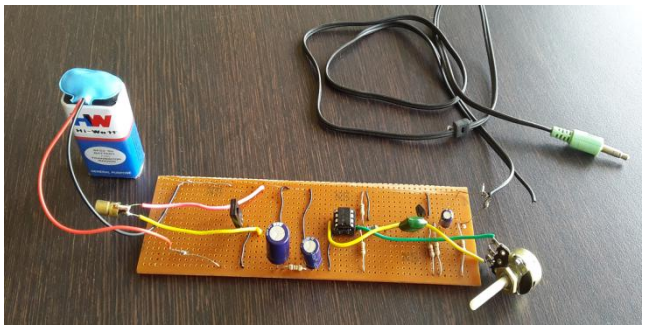


Figure 2: Laser based Voice Transmitter Circuit



PCB DESIGN OF TRANSMITTER CIRCUIT

C. Receiver Circuit Operation

The receiver circuit uses an NPN phototransistor (2N5777) as the light sensor. The output voltage of this phototransistor is amplified by the operational amplifier around Ul. This amplifier has a gain of 20 or so, and connects via R_3 to U2, an LM386 basic power amplifier IC with a gain internally set to 20. This IC can drive a speaker with a resistance as low as four ohms, and 35OmW when the circuit is powered from a 9V supply. Increasing the supply voltage will increase the output power marginally. The voltage to the transistor amplifier stage is regulated by ZD I to 5.6V, and decoupled from the main supply by R2 and C2. Resistor R3 supplies forward current for the photodiode. (Incidentally, the photodiode used for this project has a special clear package, so it responds to visible light, and not just infrared.)

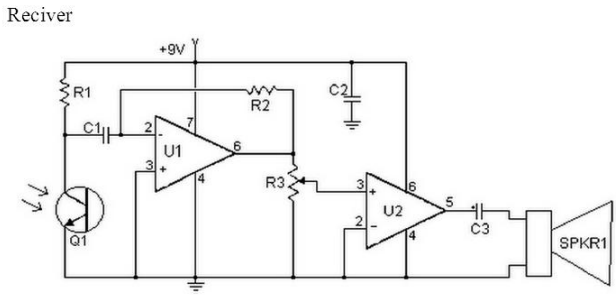
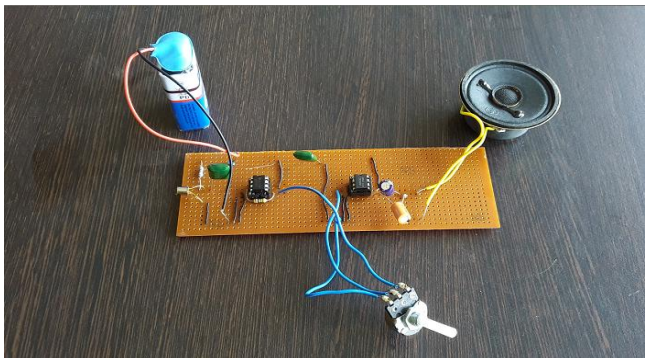


Figure3: Laser based Voice Receiver Circuit



PCB DESIGN OF RECEIVER CIRCUIT

D. Equipment's Used For This Project

Table :1 represents the necessary equipment's for preparing transmitter circuit.

TABLEI: EQUIPMENTS NECESSARY FOR TRANSMITTER CIRCUIT

Resistors	Capacitors	others
R_1=8.2K=R_3	C_1=1uF 16v	CONDENSER MIC
R_2=1.8M	C_2=0.1uF	TRANSITOR T_1=BC548
R_4=10K	C_3=470uF 16v	TRANSITOR T_2=BD139
R_6=15K=R_5	C_4=1000uF 16v	IC=741
R_7=82Ω		LASER TORCH

TABLEII: EQUIPMENT NECESSARY FOR RECEIVER CIRCUIT

Resistors	Capacitors	others
R_1=100Ω	C_1=0.1uF	NPN POHOTOTRANSISTOR
R_2=1mega Ω	C_2=0.1uF	IC=741
R_3=10kpot	C_3=100uF 25v	IC=386 AUDIO AMPLIFIER
		BREAD BOARD-2
		PCB-2

IV. COST CALCULATION

A. We *Cost of Transmitter Circuit*

Table III represents the cost of all resistors which is necessary for transmitter circuit.

TABLEIII: LIST OF RESISTORS WITH THEIR COST AND SPECIFICATION
FOR TRANSMITTER CIRCUIT

Resistors and Value	Quantity	Price
R_1=8.2K=R_3	10	3 INR
R_2=1.8M	5	2 INR
R_4=10K	5	2 INR
R_6=15K=R_5	10	3 INR
R_7=82Ω	5	2 INR
		Total Amount=12 INR

Table IV represents the cost of all capacitors which is necessary for transmitter circuit.

TABLEIV: LIST OF CAPACITORS WITH THEIR COST AND SPECIFICATION
FOR TRANSMITTER CIRCUIT

Capacitors and Value	Quantity	Price
C_1=1uF 16v	3	9 INR
C_2=0.1uF	3	5 INR
C_3=470uF 16v	3	9 INR
C_4=1000uF 16v	3	9 INR
		Total Amount=32 INR

Table V represents the cost of other equipments which is necessary for transmitter circuit.

TABLE V: LIST OF OTHER EQUIPMENTS WITH THEIR COST AND SPECIFICATION FOR TRANSMITTER CIRCUIT

No. of Equipment	Quantity	Price
CONDENSER MIC	2	10 INR
TRANSITOR T_1=BC548	3	12 INR
TRANSITOR T_2=BD139	3	12 INR
IC=741	3	15 INR
LASER TORCH	2	100 INR
BATTERY 9 VOLT	1	35 INR
PCB(65mm×36mm)	1	50 INR
		Total Amount=234 INR

Total cost of transmitter circuit in INR = (12+32+234) INR=278 INR

Total cost of transmitter circuit in USD= 4.1854012 USD [13]

B. *Cost of receiver Circuit*

Table VI represents the cost of all equipment's which is necessary for receiver circuit.

TABLE VI: LIST OF OTHER EQUIPMENTS WITH THEIR COST AND SPECIFICATION FOR RECEIVER CIRCUIT

Equipments	Specification	Price
Name		
Q1 NPN PHOTO TRANSISTOR	L14F1	54 INR
CAPACITORS	C1=0.1uF, C2=0.1UF, C3=100Uf 25V ELECTROLYTIC	7 INR
RESISTORS	R1=100K OHM, R2=1M OHM, R3=10K POT	12 INR
OP-AMP	U1=741 OP-AMP	10 INR
AUDIO AMPLIFIER	U2=LM-386	5 INR
SPEAKER	4 OHM 0.5W	27 INR
BATTERY	9 VOLT	35 INR
PCB board	1(65mm×36mm)	50 INR
		Total Amount=200 INR

Total cost of receiver circuit in INR = 200 INR

Total cost of receiver circuit in USD = 3.01108 USD[13]

Total construction cost of the circuit = Transmitter cost + receiver cost=(278+200) INR

=478 INR

= (4.1854012+3.01108) USD

=7.1964812 USD [13]

% of cost less than the lowest cost design= {(66.4212-7.1964812)/ 66.4212}×100=89.16538514%

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V. Conclusion

Laser Torch Based Transmission and Reception are cheaper and simpler in construction than RF transmitter and receiver. Infra-Red and Blue-Tooth can also be used for voice transmission and Reception purpose, but their range is small compared with their price. This project can be made and used successfully at conference room, political assembly, and class room and for general conversation between two houses. The lowest cost of a cell phone is INR 1000.00 in our country and the users have to pay tariff for each second of communication. On the other hand our device is cheaper at a cost of INR 200.00 and need not to pay any tariff for voice communication. So it is better to use for general conversation with neighbors where confidentiality is a prime issue.

A. *Limitation*

This system cannot be used for communication where there is any obstructer like hills between two communicated places. But the receiver and the transmitter can be set at the top of the high rise building. At the same time this system can used for small distance (within few hundred meters) communication only.

B. Scope for the Future Work

Improved design of this system can be used to transmit confidential voice data from one hill top to other hill top in remote area where cell phone communication is not possible due to the lack of mobile operator's tower by using extra amplifying circuit at the receiver end for having higher efficiency of the system.

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