Low Cost Voice Communication Device Design Using Ordinary Laser Torch and LDR Available in Bangladesh

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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 Bangladesh, using an ordinary available LDR and Laser torch of cost BDT 727. This is almost 86% cheaper than the lowest cost voice transmission system available in this country.**

***Index Terms*—laser torch, voice transmission, low cost design**

I. Introduction

From the beginning of human living, before the invention of language, communication was the biggest challenge. Human being had always the necessity for communication throughout the history. Initially, communication was done through signals, voice or primitive forms of writing. As time has changed, the necessity of communication through distances was grown to pass information from one place to another. Different ways to exchange information over long distances like pigeons and smoke signals have been adopted in every stages of civilization advancement, some of them have sustained and some has vanished. All these methods were the pioneer of today's modern technological long-distance communication system. This system involves transmission and reception of a large amount of information in a short period of time. Gradually through the technological development, man has invented different procedure of communication with each other. Now communication has entered in our daily life in many ways like telephone, radio, televisions, cell phone, computer and Internet, in our office and home. Different modes of communication can provide rapid connection from every corner of the globe and even out of the globe (aircrafts, rockets and satellites in space). Along with the wire communication system like telephone, two ways wireless communication system like mobile, internet have become popular now a day. As Laser is stimulated radiation, problem of interference occurs in electromagnetic wave is eliminated, it can be a good substitution of present day communication systems [1], [2]. The laser based voice communication system currently available in market is expensive, $614 [3], in respect to our country's general people income. The people of our country generally use cell phone now days to communicate with each other for general purpose and sometimes spent hours and money (as call tariff) to talk with next door neighbor, specially young generation. A simple device can be made with minimum cost by cheap electronics parts and Laser torch available in Bangladesh

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which can be affordable and usable by the general people of our country.

II. Literature Review

Optical communications has not been started in modern era. The Egyptians invented it before 5000 years by transmitting signal using glass and the Troy fall was transmitted in VI BC by the Greeks through torches [4]. All Modern day optical fiber communication is based on ancient system. The functioning Laser was first operated by Theodore H. Maiman in May 16, 1960 [5] and first visible light laser diode was demonstrated by Nick Holonyak in almost 1960 [6] and latter it was improved by several scientist of the world including USA at IBM, MIT Lincoln Laboratory, Texas in 1962 [7]. Laser diode is suitable for using in optic communication as it is monochromatic (coherent) light source and easy modulates [8]. Low attenuation optical fiber invented by Kapron in 1970 can be used for communication through Laser in which some amount of power is lost at least [4]. A project has been done to transmit voice data from one station to other for short distance by using different types of high quality and costly lasers such as Gas lasers, Chemical lasers, Excimer lasers, Fiber-hosted lasers, Photonic crystal lasers, Semiconductor lasers, Dye lasers, free electron laser etc where one condenser microphone for capturing sender voice, one transistor BC548 as amplifier, a photo transistor as receiver and a LM386 basic power amplifier IC and 0.5w Speaker was used [9]. In other project, signal was transmitted by using laser torch through laser beam just like fiber optic communication. In this system, in transmitter a 9v condenser is used for taking the audio signal coupled with laser beam and in receiver an NPN photo transistor, common emitter amplifier and speaker is used [10]. another project of laser torch based voice transmission system was constructed with Laser torch(up to wave length of 920nm), IC 741 as volume controller, BC 548, BD 139 as electrical signal amplifiers, Condenser (electrostatic microphone) in transmitter and IC 741, IC 386, with 2n5777 Photo Transistor and 0.5w/8Ω Speaker in receiver [11]**.** Robert T. Sparks, Stephen M. Pompea and Constance E. Walker have made one system to transmit music or voice over 350 feet by using laser for class room use in schools. In this project they have used the same receiver which is used in NASA SOFIA Active Astronomy Infrared Kit which consists of radio Shack and small solar cell along with a clip-activated laser pointer and centre tapped audio transformer [3]. Peter Phillips described a low cost laser beam communicator project in 1993 by using visible laser diode (5mW, 65Onm) in transmitter [12]. An Idea of wireless voice transmission has been given by Thiyagarajan. K, ECE Department, ASM college of Engineering, Chennai, India, which can be a substitution of optical fiber communication system. In his circuit, he has used resistors of 100R, 1K, 10K, 22K, 100K, 220K, 680K, 1M and 100K Koa trim-pot, Capacitors (10 and 2100 μF electrolytic and 10.1 μF monoblock), microphone, transistors, Laser source and photo transistor as a sensing element [13]. Another circuit of Laser Torch-Based Voice transmission system has been collected from circuit idea by Pradeep. G which contents condenser micro phone, transistor amplifier BC 548, an op-amplifier μA741, 1MΩ variable resistor, Base transistor BD139, a 3V Laser torch, 9V power supply etc in transmitter circuit and an NPN phototransistor as light sensor, two stage amplifier and audio amplifier in receiver circuit [14].

III. 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 [9], [13]. Vast data can be transmitted with less interference and crystal clarity with the help of Laser, the youngest form of communication [9]. Different kinds of Laser based transmission system has been implemented for different purposes by using various electronic equipments. Our project is not expensive for using in Bangladesh for middleclass people and can be made with the equipments available here and can be used for general conversion purpose as well as for confidential data transmission. It can also be used for inter building communication like in office or in a conference room. It is the cheapest design within the range of lower middle class society. Now a day huge amount of money is spent by the young generation for useless talking over mobile phone to the next door neighbor. The design is so easy, inexpensive and makeable with the available equipments that the technical as well as non technical person can construct it by themselves for their personal use. This device can eliminate the expenditure by setting it over the roof top with only minimum construction cost.

A. Statement of the Problem

The Laser torch based voice transmission system available in market is at $614 [3] which is very expensive in respect to normal use of general people in Bangladesh. One low cost system was designed which can be constructed at US $60 [3] or 5100 BDT which is not too cheap for general use for low income people here in Bangladesh. All previous designs have used photo transistor as receiving sensor. Though photo transistor response is better, it's operation is frequency sensitive [15], [16]. We have analyzed many circuit diagram used in previous system, the photo transistor used for the receiver circuit is not available in Bangladesh. We tried to have desired output by using photo transistor available in Bangladesh but could not get desired output. It is possible to construct the circuit here in Bangladesh by

collecting the photo transistor from outside of our country, but it would not economical for the use of general people for normal conversation. Moreover, the construction cost will increase rather than decrease.

B. Objectives

The main aim of this paper is to construct a Laser communication system by using low cost laser torch and available electronic equipment which can be got easily form local electronics shop everywhere in Bangladesh and people can construct for their personal use.

- To implement light based voice transmission and reception system by using light from a laser torch as the carrier of the signal.
- To design and implement a new circuit with the substitution of photo transistor (LDR) available at local electronics market (stadium market, Dhaka)
- Using this circuit to communicate with the neighbor place wirelessly.
- Calculate the total implementation cost to compare with the previous implemented design.

C. Hypothesis

The main aim of our project construction was to build a communication system using laser which can be built by the general people quite easily at home with very low cost with the available equipment in Bangladesh. The problem faced by photo transistor can be solved by using LDR, a cadmium sulfide cell which has inverse relationship with incident light intensity [16], [17]. Phototransistor is a 2 or 3 pin device and incident light on base determines the amount of collector current [18]. In Fig. 1a the collector current of the photo transistor, controlled by the incident light on base, flows through the resistor R which determine Vo=Ic×R. On the other hand in Fig. 1b the current though LDR, controlled by the resistance of LDR (light intensity) flows through R which determines the output voltage Vo=I×R. LDR can be connected in similar way of photo transistor in the receiver circuit as base pin is not connected electrically [18]. However photo transistor has greater sensitivity than LDR and can amplify the current [19]. This problem can be eliminated by using an amplifier at the end of the receiver circuit. Moreover, our designed system cost will be lower than the system we have analyzed.

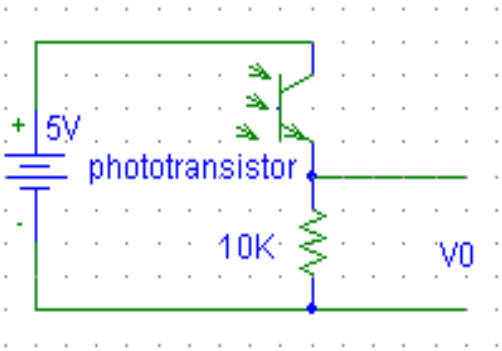

Figure 1. 1a: Connection of photo transistor in a circuit

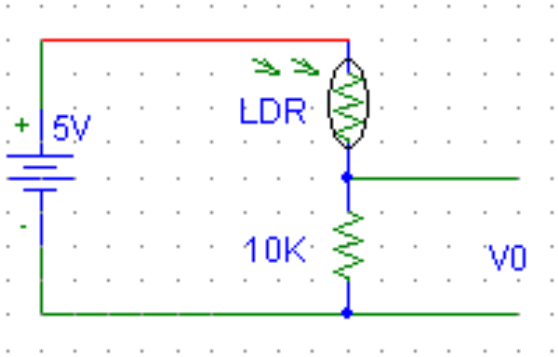

Figure. 1b: Connection of LDR in a circuit

IV. Methodology

To prepare this low cost project, several related circuit diagram has been downloaded from different websites. After verification, a suitable circuit has been chosen for modification according to the equipments available in our country for preparing a low cost design. Flow chart of the total working of the circuit was prepared. The design was modified in such a way so that general people of Bangladesh can make it quite easily with affordable equipments here and there in Bangladesh. 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 Chittagong University of Engineering and Technology. 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 Bangladesh 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. 2" shows total working order of the system on the flowchart starting from the transmitter to the receiver output.

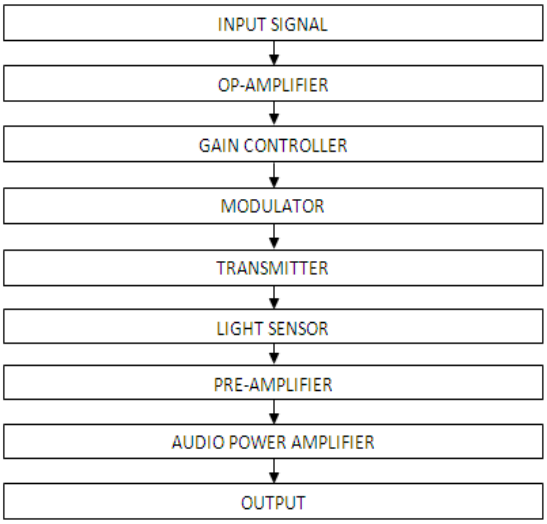

Figure 2. Flow chart of total working order of the system

A. Design and Working 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. An LDR was in the receiver as a receiving element and the high gain amplifier with a basic audio output stage powers a small speaker.

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 650nm, 5mW 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.

B. Transmitter Circuit Operation

In "Fig. 3", an adjustable current source was used through which the laser torch was being supplied. A thermistor (68ohm NTC) was used to minimize the effect of temperature as the threshold current of lased torch is temperature sensitive; heat sink was not used here. Q_2 controlled the quiescent current of laser torch which was operated by buffer stag $IC_{2b.}$ The base current of Q_2 controlled the collector current of transistor as well as the current through laser torch. The overall system sensitivity and the intensity of the Laser beam depended upon the adjustment of VR_1. The audio modulation voltage comes from the emitter of Q_1, an emitter follower stage driven by audio amplifier stage $IC_{2a,}$ was faded to the + polarity of the laser torch and the laser current varied by around +/- 3mA beyond its set point. Diodes D_4 to D_7 was used to limit the modulating voltage at +/-1.4V and capacitors C_4 and C_5 were used to block the DC voltages at the emitter of Q_1 as well as the end of the laser torch. R_{10} limited the current (audio signal variation) to the laser torch to few mA. LED_1 was used to give the indication of modulation signal and Diodes D_2, D_3 and resistor R_8 was for limiting current through LED_1 FET Q_3 and its associated circuitry eliminated the problem of constant level of output (independent of the audio level at microphone) through inverting amplifier $IC_{2a,}$ which has a form of compression. C_9, D_8, D_9 and C_8 were used as cascaded voltage doublers to rectify the audio signal for feeding to the emitter of Q_1 which caused a negative DC voltage at the gate of Q_3. When the audio signal was increasing, the negative bias as well as drain-source resistance of Q3 was increasing as R_7,R_5 and effective resistance of Q_3 determined the gain of $IC_{2a.}$ Clamping network (D_4-D_7) neutralized the effect of sudden voltage rise during the time of compression circuit response. The microphone was powered through R_1 which was faded to the non inverting input of IC_{2a} through C_6 because fixed DC voltage output was needed to bias Q_1. IC_1 (5V three terminal regulator) was used to regulate the supply voltage.

C. Receiver Circuit Operation

In "Fig. 4," the Transmitted Laser beam was detected by LDR whose resistance is inversely proportional to the intensity of receiving light. As LDR is typically used in voltage divider circuit, a resistor R_1 was used to drop voltages of supply before connecting to the LDR [16]. A two stage Signal amplifier, Q_1 and Q_2 in RC coupling with C1 and C_2 was used to amplify the receiving audio signal before fading to speaker [20]. Fixed bias and collector to base bias was used for proper operation of the amplifiers using R_2, R_3, R_4 [21]. The value of the resistors was fixed after the physical experiment in trial and error basis.

D. Equipments Used for This Project

"Table I" represents the necessary equipments for preparing transmitter circuit.

TABLE I. EQUIPMENT NECESSARY FOR TRANSMITTER CIRCUIT

Resistors All of (1/4)W, 5% unless otherwise stated	Capacitors	Others
R_1 =4.7k	C_1,C_2 =10 µF 16V electrolytic	LED_1= 5mm green LED
R_2-R_3= 1 00k	C_3= 4.7 µF 16V electrolytic	Laser 5mW/650nm laser torch
R_4 =68k	C_4,C_5= 100 µF 16V electrolytic	Q_1,Q_2= BC557 PNP
R_5 =10k	C_6,C_7 andC_9 =68 nF ceramic	Q_3 =2N5484 N-ch JFET
R_6 =4.7M	C_8 and C_{10}= 0.47 µF monolithic ceramic	D_1-D_7=1N4148 signal diode
R_7 =220k	-	D_8, D_9 = 1 N60 germanium diode
R_8-R_{10}= 220 ohm	-	IC_1= 7805 5V regulator
R_{11}-R_{12}= 47k	-	$IC_{2a,}$ IC_{2a} =LM358 op-amp
R_{13}= 56 ohm 1/2W	-	Miscellaneous
R_{14} =68 ohm NTC thermistor	-	PCB (65mm x 36mm)
V_{R1}= 100k trim pot	-	microphone element
-	-	8-pin IC socket
-	-	9V battery and battery clip

Equipments necessary for receiver circuit are given below:

All Resistors are of 0.5 watt
R_1, R_2, R_3, R_4 =10K
C_1, C_2= 0.1 µF ceramic capacitor
Q_1= 2N3904
Q_2 =2N2222A
LDR (Light Dependent Resistor)
Speaker

E. Circuit Diagram

For Transmitting System

"Fig. 3" represents the transmitter circuit of Laser torch based voice transmission system and "Fig. 5" is the connected circuit of transmitter on PCB board of our project. The idea of the circuit was collected from PETER PHILLIPS, 1997 [12]. We have used an ordinary Laser torch instead of Laser diode of PETER

PHILLIPS's circuit. 9V dry cell battery were used for empowering both transmitter and receiver circuit.

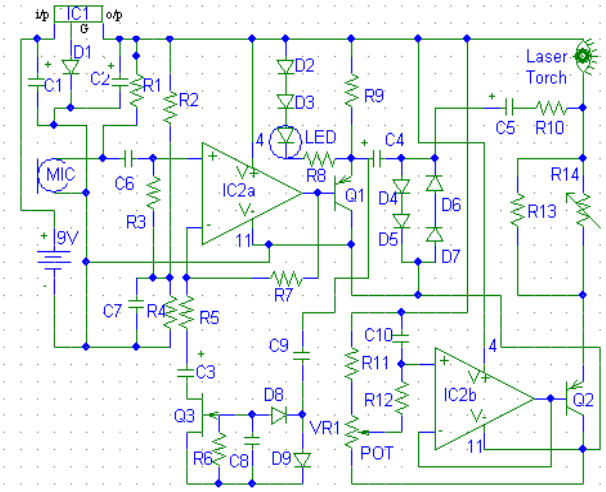

Figure 3. Laser torch based voice transmitter circuit.

FOR RECEIVING SYSTEM

"Fig. 4" represents the receiver circuit of Laser torch based voice transmission system and "Fig. 6" is the connected circuit of receiver on PCB board of our project. We have used an LDR (light dependent resistance) instead of using photo transistor and photo diode of PETER PHILLIPS's circuit [12] and solar cell of the project of Robert T. Sparks, Stephen M. Pompea and Constance E. Walker [3]. We did not get any response by using photo transistor at the time of experiment. Then we connected available LDR in the same circuit and by changing the main circuit idea got desired result.

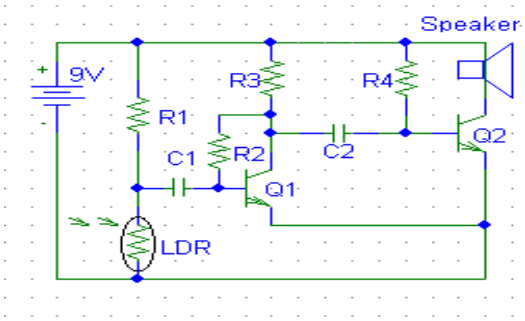

Figure 4. Laser torch based voice receiver circuit.

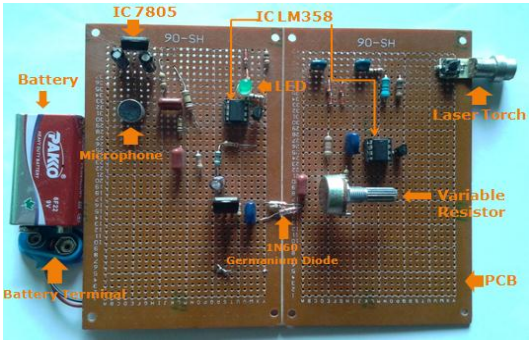

Figure 5. Laser torch based voice transmitter circuit of our project on PCB board.

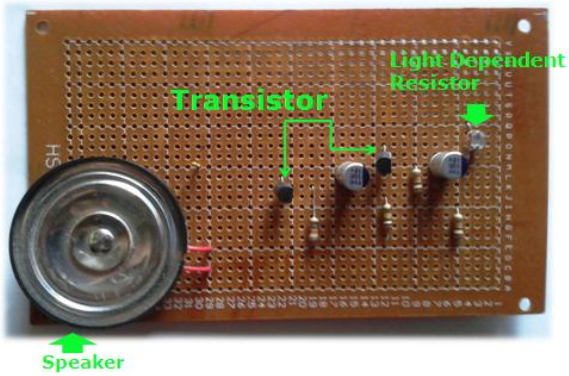

Figure 6. Laser torch based voice receiver circuit of our project on PCB board.

V. Cost Calculation

A. Cost of Transmitter Circuit

"Table II," represents the cost of all resistors in Bangladesh which is necessary for transmitter circuit.

TABLE II. List of Resistors with Their Cost and Specification for Transmitter Circuit

No Of Resistors	Value And Quantity	Price
R_1	4.7K Ω	1 BDT
R_2	100K Ω	1 BDT
R_3	100K Ω	1 BDT
R_4	68K Ω	1 BDT
R_5	10K Ω	1 BDT
R_6	4.7M Ω	7 BDT
R_7	220K Ω	1 BDT
R_8	220 Ω	1 BDT
R_9	220 Ω	1 BDT
R_{10}	220 Ω	1 BDT
R_{11}	47K Ω	1 BDT
R_{12}	47K Ω	1 BDT
R_{13}	56 Ω 1/2w	1 BDT
R_{14}	68 Ω NTC thermistor	30 BDT
V_{R1}	100K Ω	15 BDT
	Total amount = 64 BDT	

"Table III," represents the cost of all capacitors in Bangladesh which is necessary for transmitter circuit.

TABLE III. Transmitter Circuit's Capacitors List & Cost

No Of Capacitors	Quantity	Price
C_1	10 µF 16V electrolytic	10 BDT
C_2	10 µF 16V electrolytic	10 BDT
C_3	4.7 µF 16V electrolytic	5 BDT
C_4	100 µF 16V electrolytic	10 BDT
C_5	100 µF 16V electrolytic	10 BDT
C_6	68 µF Ceramic	10 BDT
C_7	68 µF Ceramic	10 BDT
C_9	68 µF Ceramic	10 BDT
C_8	0.47 µF monolithic ceramic	10 BDT
C_{10}	0.47 µF monolithic ceramic	10 BDT
	Total amount = 95 BDT	

"Table IV," represents the cost of other equipments in Bangladesh which is necessary for transmitter circuit.

TABLE IV. LIST OF OTHER INSTRUMENTS FOR TRANSMITTER CIRCUIT AND THEIR COST

No of equipment	Identification	price
8-pin IC socket	-	10 BDT
9V Battery, Battery clip	-	80 BDT
PCB Board	2(65mm ×36mm)	100 BDT
Electrostatic micro phone	-	20 BDT
IC_1	7805 5V regulator	10 BDT
IC_{2a}, IC_{2b}	LM358 op-amp	30 BDT
Transistor Q_1	BC557 PNP	5 BDT
Transistor Q_2	BC557 PNP	5 BDT
Transistor Q_3	2N5484 N-ch JFET	30 BDT
D_1-D_7	1N4148 signal diode	35 BDT
D_8-D_9	1N60 germanium diode	30 BDT
LED_1	5mm green LED	2 BDT
Laser laser torch	5mw/650nm	70 BDT
	Total amount = 427 BDT	

Total cost of transmitter circuit in BDT = (64 +95 +427) BDT = 586 BDT

Total cost of transmitter circuit in USD = 7.49314 USD [22].

B. Cost of Receiver Circuit

"Table V," represents the cost of all equipments in Bangladesh which is necessary for receiver circuit.

TABLE V. LIST OF ALL EQUIPMENTS NECESSARY FOR RECEIVER CIRCUIT AND THEIR COST

Equipments Name	Specification	price
speaker	-	30 BDT
LDR (Light Dependent Resistor)	-	10 BDT
Q_1 Transistor	2N3904	10 BDT
Q_2 Transistor	2N2222A	5 BDT
C_1	0.1 µF Ceramic capacitor	10 BDT
C_2	0.1 µF Ceramic capacitor	10 BDT
R_1	10K (0.5 Watt)	4 BDT
R_2	10K (0.5 Watt)	4 BDT
R_3	10K (0.5 Watt)	4 BDT
R_4	10K(0.5 Watt)	4 BDT
PCB	(65mm ×36mm)	50 BDT
	Total amount = 141 BDT	

Total cost of receiver circuit in BDT = 141 BDT
Total cost of receiver circuit in USD =1.80296 USD [22].
Total construction cost of the circuit = transmitter cost + receiver cost = (586 + 141) BDT
= 727 BDT
= (7.49314 + 1.80296) USD
= 9.2961 USD
% of cost less than the lowest cost design = {(60-9.2961)/60} ×100 % = 84.5065%

C. Result

LDR can work in a similar way of photo transistor, photo diode as well as solar cell in care of receiving photo signal. LDR has other advantage over photo transistor is that, it does not need proper biasing for working and easy to use and get here and there. The laser voice transmission system price available in market is 614 USD and the lowest cost laser transmission system was designed at 60 USD by Robert T. Sparks, Stephen M. Pompea and Constance E. Walker of National Optical Astronomy Observatory, Tucson, Arizona, USA [3]. This project construction cost is only 8.4661 USD, 85.8898% lower than that of the lowest cost system.

VI. ADVANTAGES

A remarkable feature of laser is the concentration of its energy to extremely high intensities that's remaining almost constant over long distances because of low divergence [23]. The main advantage of this system is high reliability as it is impossible to track the data on the way of transmission [12]. That is why this design can be used for transmitting confidential data as well as for general conversation. This design of Laser voice transmission system can be made at home with minimum cost and can be used for frequent conversation between neighboring house at free of cost instead of using cell phone.

VII. 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 BDT 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 BDT 727.00 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.

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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