Transmission of Sound Using Lasers

[I]Navneesh Singh Malhotra, [II]Harman Malhotra
[I]Student, B. Tech, Dept. of Electronics and Communication, Jamia Millia Islamia, New Delhi
[II]B. Tech, Electronics and Communication, BPIT, GGSIPU, New Delhi

Abstract

Light is already becoming a popular means of communication, thanks to fiber optics, which can guide optical data much like a wire transmits current. It might seem impractical to use lasers without a guiding medium to transmit information. However, in contexts where a physical connection is impossible or unfeasible, and the need for a focused beam arises, it would seem logical to use laser light. We decided to create a simple and inexpensive proof-of-concept to demonstrate the advantages of this seemingly impractical scheme. The unique property of laser is that its light waves travel very long distances with very little divergence. In case of a conventional source of light, the light is emitted in a jumble of separate waves that cancel each other at random and hence can travel very short distances only. It is this coherency that makes all the difference to make the laser light so narrow, so powerful and so easy to focus on a given object. Light with such qualities is not found in nature.

The main purpose of this project is to realize a transmission-reception system to transfer sound via Laser without a guiding medium, using Intensity Modulation with little quality loss.

"Nearly all inventions are not recognised for their positive side either when they're made. So, for example, scientists didn't go out to design a CD machine: they designed a laser. But we got all sorts of things from a laser which we never remotely imagined, and we're still finding things for a laser to do."

-Robert Winston, Professor of Science and Society at Imperial College London.

"The atoms become like a moth, seeking out the region of higher laser intensity."

-Steven Chu, co-winner of the Nobel Prize in Physics in 1997 for the "development of methods to cool and trap atoms with laser light".

I. Introduction

Our project is divided into two distinct sections: audio transmission and reception via hardware. The transmission media is unguided. The main objective of this project was primarily to realize a transmission-reception system to transfer sound via Laser without a guiding medium, using Intensity Modulation with little quality loss. Secondly, to demonstrate the fact that the large bandwidth available when we use laser for communication purposes can be utilized to send and receive multiple signals at a time using the concept of FDM. Thirdly, for military applications where laying down of cables is not viable this communication system solves the purpose without much hassle. The audio signal is fed to the laser and results in intensity modulation (flickering). This laser beam is received at the receiver and is converted into a current signal, which is proportional to the input audio signal. This current signal is in turn amplified an fed to a speaker and we obtain the input audio signal with minimal quality loss.

II. Lasers

The acronym *laser* stands for "light amplification by stimulated emission of radiation." Lasers work as a result of resonant effects. The output of a laser is a coherent electromagnetic field. In a coherent beam of electromagnetic energy, all the waves have the same frequency and phase.

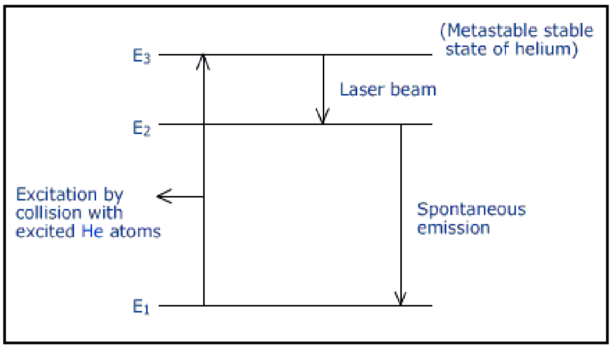
In a basic laser, a chamber called a *cavity* is designed to internally reflect infrared (IR), visible-light, or ultraviolet (UV) waves so they reinforce each other. The cavity can contain gases, liquids, or solids. The choice of cavity material determines the wavelength of the output. At each end of the cavity, there is a mirror. One mirror is totally reflective, allowing none of the energy to pass through; the other mirror is partially reflective, allowing approximately 5 percent of the energy to pass through. Energy is introduced into the cavity from an external source; this is called *pumping*. [1]

As a result of pumping, an electromagnetic field appears inside the laser cavity at the natural (resonant) frequency of the atoms of the material that fills the cavity. The waves reflect back and forth between the mirrors. The length of the cavity is such that the reflected and re-reflected wave fronts reinforce each other in phase at the natural frequency of the cavity substance. Electromagnetic waves at this resonant frequency emerge from the end of the cavity having the partially-reflective mirror. The output may appear as a continuous beam, or as a series of brief, intense pulses.

The *ruby laser*, a simple and common type, has a rod-shaped cavity made of a mixture of solid aluminum oxide and chromium. The output is in pulses that last approximately 500 microseconds each. Pumping is done by means of a helical flash tube wrapped around the rod. The output is in the red visible range. [2]

The *helium-neon laser* is another popular type, favored by electronics hobbyists because of its moderate cost. As its name implies, it has a cavity filled with helium and neon gases. The output of the device is bright crimson. Other gases can be used instead of helium and neon, producing beams of different wavelengths. Argon produces a laser with blue visible output. A mixture of nitrogen, carbon dioxide, and helium produces IR output.

Lasers are one of the most significant inventions developed during the20th century. They have found a tremendous variety of uses in electronics, computer hardware, medicine, and experimental science. [3]



Normally, the atoms are in the lowest energy state or ground

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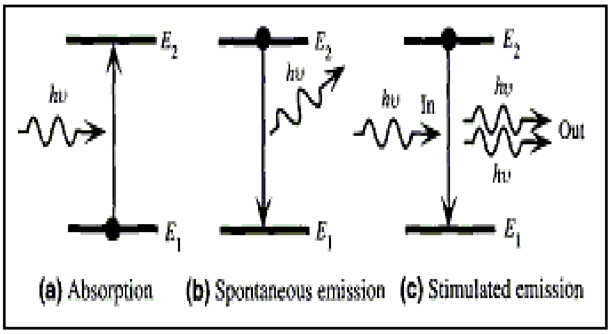
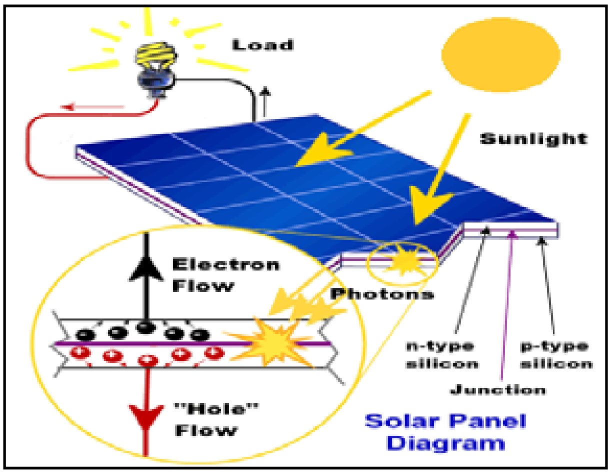
state. When light from a powerful source like a flash lamp or a mercury arc falls on a substance, the atoms in the ground state can be excited to go to one of the higher levels. This process is called absorption.
After staying in that level for a very short duration (of the order of 10-8 second), the atom returns to its initial ground state, emitting a photon in the process. This process is called spontaneous emission. The two processes, namely, absorption and, spontaneous emission, take place in a conventional light source. In case the atom, still in its excited state, is struck by an outside photon having precisely the energy necessary for spontaneous emission, the outside photon is augmented by the one given up by the excited atom, Moreover; both the photons are released from the same excited state in the same phase. This process called stimulated emission is fundamental for laser action. Thus, the atom is stimulated or induced to give up its photon earlier than it would have done ordinarily under spontaneous mission. [4]



III. Solar Panel

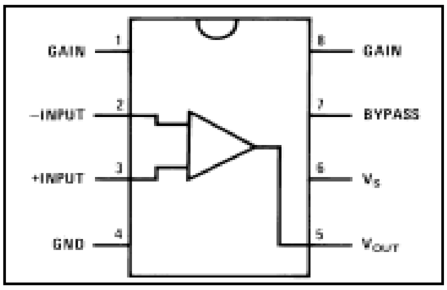
Solar panels convert the impinging light into electricity.. Silicon is what is known as a semi-conductor, meaning that it shares some of the properties of metals and some of those of an electrical insulator, making it a key ingredient in solar cells. Light is composed of photons. As these hit the silicon atoms of the solar cell, they transfer their energy to lose electrons, knocking them clean off the atoms. The photons could be compared to the white ball in a game of pool, which passes on its energy to the colored balls it strikes. Freeing up electrons is however only half the work of a solar cell: it then needs to herd these stray electrons into an electric current. This involves creating an electrical imbalance within the cell, which acts a bit like a slope down which the electrons will flow in the same direction. Creating this imbalance is made possible by the internal organization of silicon. Silicon atoms are arranged together in a tightly bound structure. By squeezing small quantities of other elements into this structure, two different types of silicon are created: n-type, which has spare electrons, and p-type, which is missing electrons, leaving 'holes' in their place. When these two materials are placed side by side inside a solar cell, the n-type silicon's spare electrons jump over to fill the gaps in the p-type silicon. This means that the n-type silicon becomes positively charged, and the p-type silicon is negatively charged, creating an electric field across the cell. Because silicon is a semi-conductor, it can act like an insulator, maintaining this imbalance. As the photons smash the electrons off the silicon atoms, this field drives them along in an orderly manner, providing the electric current. [5]



[6]

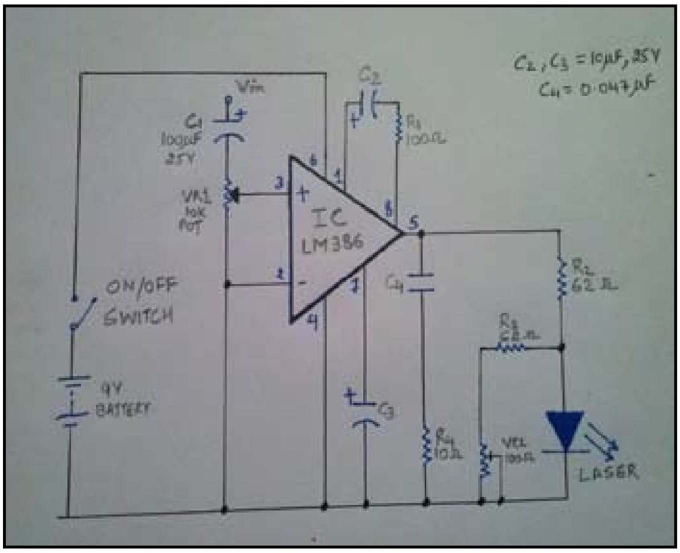
IV. IC LM386

The LM386 is a power amplifier designed for use in low volt-age consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200.
The inputs are ground referenced while the output automatically biases to one-half the supply voltage. The quiescent power drain is only 24 mill watts when operating from a 6 volt supply, making the LM386 ideal for battery operation.
To make the LM386 a more versatile amplifier, two pins (1 and 8) are provided for gain control. With pins 1 and 8 open the 1.35 kΩ resistor sets the gain at 20 (26 dB). If a capacitor is put from pin 1 to 8, bypassing the 1.35 kΩ resistor, the gain will go up to 200 (46 dB). If a resistor is placed in series with the capacitor, the gain can be set to any value from 20 to 200. Gain control can also be done by capacitive coupling a resistor (or FET) from pin 1 to ground. Additional external components can be placed in parallel with the internal feedback resistors to tailor the gain and frequency response for individual applications. For example, we can compensate poor speaker bass response by frequency shaping the feedback path. This is done with a series RC from pin 1 to 5 (paralleling the internal 15 kΩ resistor). [7]

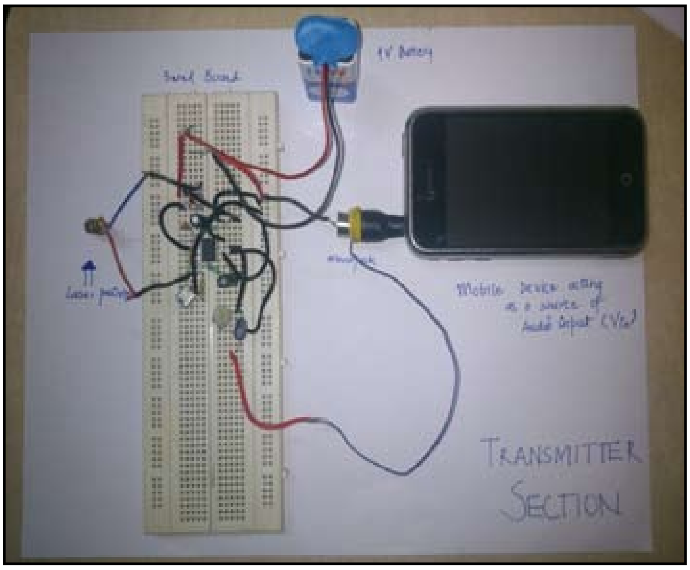


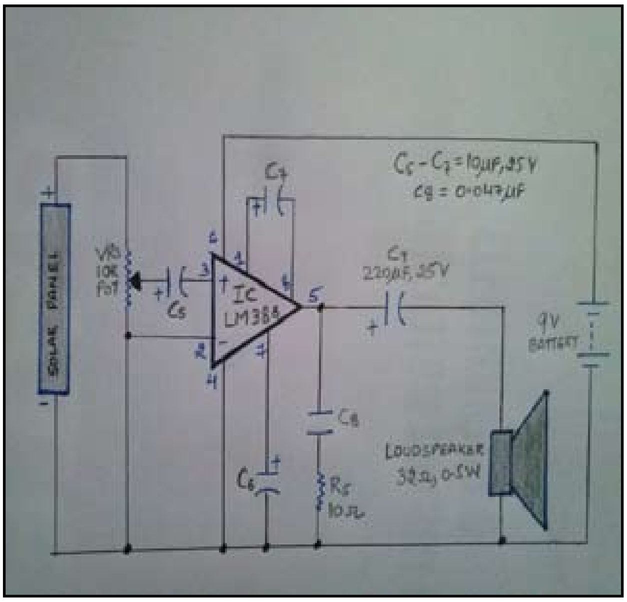
V. Transmitter Section

The audio is fed to the circuit through a standard 3.5mm audio jack through the input Vin shown in the Circuit Diagram below. Simply connect an audio source (such as a CD player) to the mono jack and turn on the laser. The modulations of current produced by the audio device causes the laser to modulate accordingly. It will get slightly dimmer and brighter, depending on the music. However, this is very difficult to detect by the human eye .Potentiometer VR1 (10-kilo-ohm) is used to change the level of the input audio signal. The audio input (Vin) is taken from the preamplifier output of the music system (CD player, DVD player, etc). Capacitor C2 and preset VR2 are used to vary the gain of the LM386.



The given pictures are original and are a part of the project.





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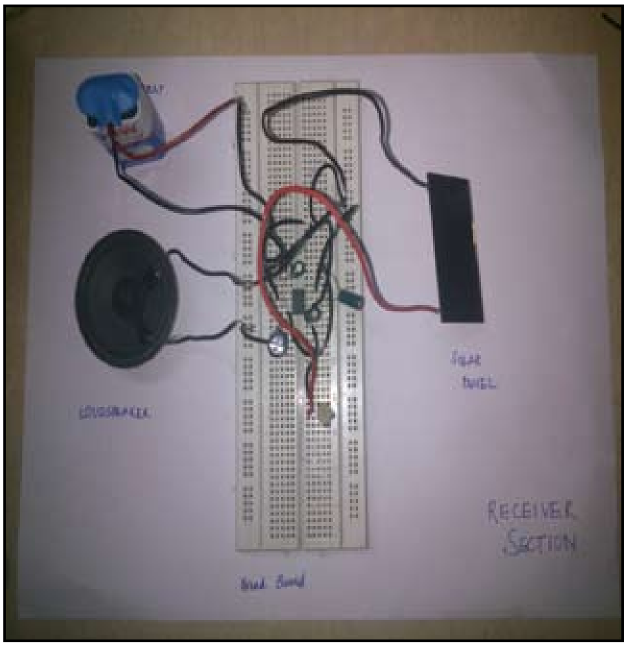

VI. Reciever Section

The voltage variation in solar panel is amplified by a low voltage audio power amplifier LM386 and reproduced by speaker. The maximum output of audio amplifier LM386 is 1 watt, while its voltage gain is 20 to 200. Here laser diode with maximum operating voltage 2.6Volt and maximum operating current 45mA is used to transmit the audio signal. The voltage divider formed by R2, R3, VR3 keep the voltage as well as the current for the laser diode. Potentiometer VR1 is used to change the level of the input audio signal. Apply input audio signal from mic, CD player or any other device.

Capacitor C2 and preset VR2 are used to vary the gain of audio power amplifier LM386 IC.

VII. Working

The audio signal is connected to the circuit using a capacitor C1. This capacitor passes only audio, and blocks any direct current (DC) that may influence the biasing conditions of the amplifier.

R1 is potentiometer, which is used as a volume control for audio signal (simply acts as an attenuator).To make the LM386 a more flexible audio amplifier, two pins (1 and 8) are provided for gain control and gain adjustments. With pins 1 and 8 open, the 1.35 kW internal resistance sets the gain at 20 (26 dB). If a capacitor is placed from pin 1 to 8, bypassing the 1.35 kW internal resistor, the gain will go up to 200 (46 dB).Next part in our circuit is the LM386 low voltage audio power amplifier IC, which amplifies the audio input by means of power from the battery or Vcc supply .The resistor R2 and

capacitor C5 forms a filter circuit, which prevents high frequency signals coming from the amplifier, most probably noise picked up or generated in the amplifying process of LM386 IC. The capacitor C6 connected at the output pin has the same function as the capacitor used in the input stage i.e. to prevent direct current

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(DC) due to the biasing of LM385 amplifier IC, causing undesired operation of the speaker.

VIII. Advantages and Applications

1. The advantages of laser communication is that it allows very fast communication service between two or more devices than other modes of communications.
2. It can provide speed more than 1GBps.So it overtakes the LAN or wireless LAN comprehensively.
3. Laser communications systems have the benefit of eliminating the need for broadcast rights and buried cables.
4. 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.
5. The transmitting and receiving station are smaller and lighter for given range. Less overall power is required for the given distance and data rate. Higher data rate may be achieved for given distance and power output.
6. A tiny light detector may allow for superfast broadband communication over interplanetary distances. This technology advance offers the space laser communication system designer the flexibility to design very lightweight, high bandwidth, low-cost communication payloads for satellites whose launch costs are a very strong function of launch weigh.
7. Signals can be reproduced without distortion, even long distances. So the system could be use for communication and cable television transmission.
8. A one way laser communications system that is capable of the transmission of both text and sound.
9. In the Laser communications systems bandwidth could be distributed in neighborhoods by putting laser communication systems on top of homes and pointing them towards a common transceiver with a fast link to the Internet.
10. With possible transmit speeds of up to a gigabit per second, with the powerful laser, it would even be possible to communicate using satellites to reflect the signals.
11. It can be used to reproduce sound in large public meetings on open grounds or for communication between tall buildings.
12. Direct communication between high-rise buildings in a crowded city would become Easy.

IX. Conclusion

- A circuit for sound transmission using laser was designed and developed.
- The transmitter and receiver circuit were designed separately to perform the required function.
- An optical source, Laser, was used on which the audio signal was successfully modulated and transmitted. Finally the optical signal was received by the solar panel.
- The complete hardware circuit was successful in performing the desired function i.e. transfers of sound from the transmitter circuit to the receiver's circuit loudspeaker via unguided media.

X. Acknowledgment

Big thanks to our parents, for their extensive support and help.

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