

LASER COMMUNICATION: SHEDDING SOME LIGHT

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ABSTRACT

LASER is the mightier, newer ‘avatar’ of light. This wonder beam has penetrated in to normal life, more than any other form of concentrated energy. Today the word “LASER” is familiar to everyone due to the various manifestations of its potential, be it medicine, communication, defense or industry. It touches almost every part of nature. “Amplitude Modulation” is the basic principle of working of Laser Communication systems. The amplitude of the carrier signal is varied according to the instantaneous amplitude of the modulating signal. Here “Carrier refers to the Laser Beam”

“Intensity of Laser Beam refers to the amplitude”

“Input signal used as audio signal”

Hence, the intensity of the laser beam is varied according to the instantaneous value of audio signal and the same is sensed by the optical sensor at the receiver. In this paper we will refer to the one of the applications of Laser Technology and the recent researches and experiment which are going around for lasers, such as NASA recently conducted an experiment to put a laser based communication system in Earth orbit.

I INTRODUCTION

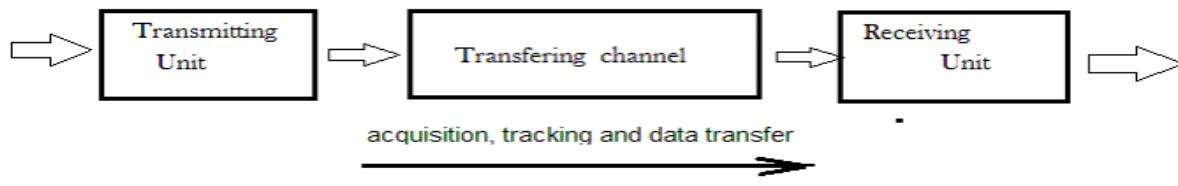
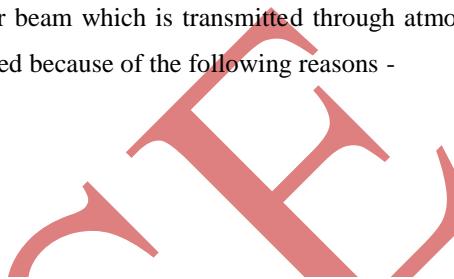
“LASER” stands for “Light Amplification by Stimulated Emission of Radiation”. Light is radiated by laser through a process of optical amplification based on the stimulated emission of electromagnetic radiation. It produces a highly directional, monochromatic, intense and coherent beam. A very useful and interesting application of laser is in the field of communications, which takes advantage of its wide bandwidth and narrow beam width over long distances. The laser beams can be created in a range of wavelengths from the ultraviolet to the infrared regions of the electromagnetic spectrum. The color of the emitted light is not as such important. The infrared region is usually taken by the military academy, as it is more difficult to detect.

The advent of semiconductor lasers has made possible the use of lasers for signal transmission. They are stimulated directly by electric current to yield a laser beam in the invisible infrared region. A particular demeanor of laser transmission, which makes it desirable to the ordinary radio waves for military purposes is the strict secrecy provided by the narrow beam width. Since no unwanted reception outside the narrow bundles of rays is possible, a high degree of secrecy can be maintained between two points, and thus, an interception-proof communication network can be realized. Besides, laser communication system is immune from jamming and from interference by spurious radio noise.

II LASER COMMUNICATION SYSTEM

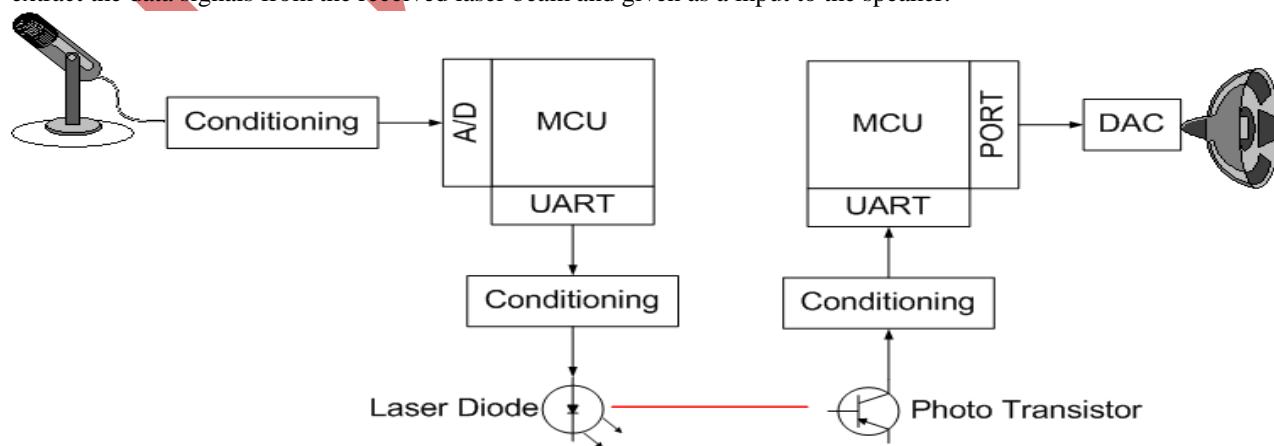
A line-of-sight condition requires the transmitter and receiver in the Laser communication system. It has the advantage of reducing the need for broadcast rights and buried cables. A laser diode is used to generate the carrier which is used for the transmission signal. For the transmission and reception, two parallel beams are required separately. In the atmosphere the Laser communications systems are connected through a wireless connection, which is focused on decreasing the noise ratio in optical communication system. Laser communication system operates hand to hand with fiber optic links, except the carrier beam which is transmitted through atmosphere i.e. free space. Laser communications systems can be easily deployed because of the following reasons -

- inexpensive
- small size
- low power
- no requirement of any radio interference studies.



III LASER COMMUNICATION SYSTEM: BLOCK DIAGRAM

The block diagram shown below of Laser Communication System consists of two sections such as Transmitter and Receiver sections. The data and sound signals are transmitted through the Transmitter section, which comprises of microphone, conditioning circuit, analog to digital converter and laser diode to generate medium for transmission of signals. The receiver section receives the laser beam, using photo transmitter, which incorporates the data or sound signals from the transmitter which comprises of Conditioning circuit, MCR and Digital to Analog converter to extract the data signals from the received laser beam and given as a input to the speaker.



3.1 Description of Block Diagram

a) Microphone Amplifier

The first step in transmitting sound is to digitize sound waves. For this we used a microphone amplifier. The microphone amplifier had three leads, which are considered as power, ground, and signal. The signal coming from the microphone amplifier was far too low to be read (with any degree of precision) by the analog to digital converter. For that we are using the **LM386 operational amplifier** to increase the signal as well as power. Before placing the signal through the amplifier, the signal is placed through a capacitor to remove DC, and finally through a voltage divider to bias the signal properly. The resistors are then used to adjust the gain and for the microphone the gain is around 50-100 (depending on how much popping and how much quality we want).

b) UART (Universal Asynchronous receiver/transmitter)

It is a component of computer hardware that translates data between parallel and serial forms. Serial communication must first be converted back into parallel form by a universal asynchronous receiver or transmitter for increases the speed of the signals. The universal designation indicates that the data format and transmission speeds are configurable and that the actual electric signaling levels and methods typically are handled by a special driver circuit external to the UART. A UART is a part of an integrated circuit used for serial communications. The UART hardware initiates a start bit, shifts the required number of data bits out of the line and adds the stop bits, as soon as data is deposited in the shift register after completion of the previous character. A dual UART, or DUART, then converts a single chip by combining two UARTs.

c) Laser Driver- Transmitter

After the microphone's signal is converted into 8 bits by the Analog to Digital converter, the appropriate bits are generated by the MCU which are then sent (including start and stop bits) and then these bits are applied to the laser driver circuit with a 5V and 0V signals. At 5V, the BJT turns ON and provides the proper current according to the diode.

d) Receiver

The laser pulses are detected by a photo diode in a different (distant) location. A comparator is used to place the signal in order to generate solid 5V and 0V values which are applied on the microcontroller in the receive pin.

e) Laser Driver -Receiver

The signal is boosted and low pass filtered (to improve sound quality), once it is put through the DAC.

IV APPLICATIONS OF LASER COMMUNICATION SYSTEM

a) Information Technology

The largest application of lasers is in optical storage devices, in which a focused beam from a semiconductor laser, less than one millimeter wide, scans and reads the surface of the disc. Other everyday laser uses include barcode readers, laser pointers as well as laser printers. Since last 25 years, the publishing and newsprint industries have been revolutionized by the use of lasers, which have replaced traditional “hot metal” printing.

b) Telecommunications

The second application of lasers is in fiber-optic communications. Transmission of light pulses along optical fibers is necessary for broadband communication, which are generated and relayed by the lasers. This is made possible by fiber amplifiers, invented in the UK, which are an important component in long-distance fiber links.

c) Medicine

Lasers generate energy in the form of fine controllable light beams, which the physicians use to perform micro-surgery, which is painless and less scarring, also includes lower blood loss and shorter recuperation time in hospital. Laser beams which are delivered through flexible optical fibers allow surgeons to reach inside the gut, for example, sealing a bleeding ulcer. One of the most publicized uses of lasers is in eye surgery which properly treat the eye diseases and, moreover, improves bad eyesight.

d) Manufacturing

Lasers deliver enough power which is able to heat and melt metal joints, and so they are used for welding, as well as for cutting. When lasers controlled by a computer, it can cut complex designs into a material such as wood or paper, as is popularly being seen in furniture and other home goods.

e) Measurements and Analysis

Lasers have been used by the military for the last long for range-finding, but now even estate agents use laser tape measures. Because lasers can be used to produce specific wavelengths, also they are used to analyze chemical and physical structure, and so are used in control of factor quality and to monitor environmental pollutants remotely. Lasers are also used for a type of measurement called interferometry which can measure tiny changes in distance.

f) Scientific Research

Many recent discoveries would never have been made impossible without lasers, which describe the synergic relationship between developments in physics and other fields. Lasers relate with matter at the quantum level in very specific ways and so are important probes in research. Some chemical reactions use laser techniques and clearly explain structure at the atomic and molecular scale. Increasingly, scientists are employing lasers in new types of microscopy which is designed to highlight cellular structures.

V LASERS AT NASA: CURRENT DEVELOPMENTS

On August 23, 2013, an upcoming NASA mission will test a new laser communications system that would be able to deliver high-definition 3D video signals which will initiate from Mars and beyond it. The lunar laser communications experiment will be part of the agency's Lunar Atmosphere and Dust Environment Explorer (LADEE) mission, which is planned to launch on September. 6. The LADEE spacecraft will orbit the moon and collect information on the lunar atmosphere technically an exosphere which is the outermost region of planet's atmosphere for around hundred days. A laser communications module is built into the satellite.

"National Aeronautics and Space Administration has a requirement for high download speeds for data from space and that is increasing day to day, just like it does for the rest of us at home and also from work," told Don Cornwell, who is the mission manager for the lunar laser communications demonstration when he was speaking at a televised NASA news conference on Thursday.

"High-resolution images and movies and 3D even from satellites could be sent that not only surround the Earth but also from probes that will go to the moon and beyond. Radio wave communication has benefitted us well for the last fifty years but now by using light wave technology, we are able to impart data," he said.



Figure: Depiction of NASA's LADEE observatory as it approaches lunar orbit.

Explanation of the working of the system: When the satellite is in orbit around the moon and can be seen from the Earth, one of three ground stations will shoot a laser towards its approximate location. The laser beam from Earth will examine a patch of sky and should lighten the spacecraft at some point. When that happens, the laser beam starts emitting from the spacecraft towards the ground station and the two locks on to each other. The communications begin, as soon as that happens. The ground stations are situated at White Sands in New Mexico, in Wrightwood, at a NASA Jet Propulsion Laboratory site, California, and at European Space Agency site in Tenerife,

Spain. The technology should grant an upstream data rate, commencing from the Earth to the spacecraft, of around 20Mbps and 622Mbps downstream rate. Home Internet speeds typically run from several megabits per second to several tens of megabits per second. That's roughly six times the speed that's currently possible with radio-based transmission, told Cornwell.



Figure: NASA's moon bound LADEE spacecraft using lasers to communicate with earth.

The laser communications equipment also weighs half that of a radio transmitter and costs about a quarter less, he said. Cornwell said he hopes the testing the first step of demonstrating the usefulness of laser communications and building confidence which would be a use in our future missions, also including those that go deeper into space. He said laser communications technology systems get more attractive compared to radio communication technology as further the spacecraft travels from Earth because the communications beam can be better targeted."

VI CONCLUSION

In space, two-way laser communication has long been an objective for NASA because it would allow data transmission rates that are 10 to 1,000 times greater than acceptable radio waves. While lasers and radio transmissions both travel at light-speed, lasers can store more data. It is similar to moving from a dial-up internet connection to broadband. If the technical obstructions could be overcome, lasers would benefit not only to communication, but basic science too. Astronomers could use lasers like very accurate rulers to measure the movement of planets with unprecedented precision.

The possibility and the vicinity of laser application to communication depends on the result of research in many fields, some of which, as those regarding modulation and demodulation, are not, strictly speaking, limited to lasers. There are such enthusiasm and endurance of research in the laser field that it is possible, in a near future, to have a better knowledge of the actual possibilities of laser application to communication in traditional schemes or in new ones which may develop using particular properties of laser .

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