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Designing and constructing audio transfer system via FSO type telecommunication channel

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Abstract

A new method of transferring sound via laser using FSO type telecommunication system The system that is going to be explained is completely practical and professional and has many applications. We are constructing a laser link and must determine our purposes for constructing this project and then based on the purposes start to design it. The only image we've ever since had of optical and laser telecommunication has been uniquely optical fiber. If you are interested of one of the wonderful applications of laser light namely Data-Video-Voice and if you're willing to gain experience to construct a laser system, we recommend you to read this article.

Key words: laser , voice , light channel , FSO type telecommunication system

1- Introduction

Telecommunication systems and subsequently light transmit methods have progressed significantly. In this article, we study laser applications in free space or light transmit outside fiber environment. After reading the article, we will also be familiar with different concepts of laser emission in atmosphere and the effect of hindering factors such as absorption and dispersal and will get an image beyond the common communication systems.

In common telecommunication systems like radio systems; we should assemble them on the carrier. In radio systems, the carrier is the radio wave and in light is used as the carrier.

Modulation processes in (FSO) systems of light systems are almost like the modulation processes in radio telecommunication. The article deals with an important issue called (Free Space Optic) telecommunication.

Since the FSO system has many important applications in secure communication, military and non military communications and can solve the problems that are due to creating optical fiber paths at least in short range, and also because laser links in many cases are good substitutes for microwave radio links, the designed system is even able to send sound within the water.

One of the oldest and most familiar modulations in analog communication and radio systems is amplitude modulation or (AM). In this modulation, the amplitude of the carrier wave is affected by the amplitude of the message and is modulated. In optical

communication whether in FSO type or optical fiber we use this method of modulation. The only difference is that instead of changing the amplitude, we deal with the changes in irradiance intensity of the laser optic.
n case that we change the amount of light irradiance of a source of any kind –whether laser type or normal type- in relation to the message signal, we call this type of modulation namely irradiance modulation which is abbreviated as IM(intensity modulation).
These days, this modulation has many applications in optic communication systems. Besides being quite simple in its circuits, it is able to create a great bandwidth. Most modern laser diodes can be placed under the supervision of IM modulation in a very simple way and by the use of the least circuit complexity.

2- Some of the limitations of radio waves in telecommunications

- Radio waves can be influenced by noise and natural or artificial interferences with other electrical and radio fields.
- There is a possibility of interception and eavesdrop of radio signals.
- In order to use the radio bands, there is a need to get permission.

3- The advantages of using optic and laser for communications

-great bandwidth
-directional light and the ability to transfer information point to point
-It has an excellent single- direction property
- It has one wavelength: having a high security (very low probability for eavesdropping)
-It is possible to focus it by devices such as lenses

4- In general, the advantages of laser optic diodes are as the following:

• The ability to create laser light in the visible and invisible spectrum such as infrared
• ability to create forces to some mille-watt and more which is more ideal for the conventional applications of communication.
• Unaffected by the electrical and radio noise
• a very small volume
• No need for driver sources with high voltage or current
• ability to direct modulation of laser radiation
• great bandwidth to the extent of GHZ in modern diodes
• Ease of use and ability to connect to the other equipments
• being cost-effective economically

However, by making laser diodes or semiconductor lasers, there is no need to use gas lasers in this regard and they were excluded over time but this doesn’t mean they have been totally abandoned.

5- FSO system

In fact, FSO is the abbreviation of Free Space Optic or optic communication in free space. The applications of this system include:
-In telecommunication satellites, for the communications among satellites on Earth Orbit
- In the military and spying satellites, to transmit data to the earth station
-Transferring information at a very high volume from one point to another

- In military and battlefield telecommunications
-In trading companies for their internal communications
The system that is going to be explained is completely practical and professional and all designing and construction processes have been done and has many applications. In fact, the major propose is to construct a laser link.
What should you do to increase the range of laser link?
The weakening of a light beam while being emitted from the air is calculated by the Beer-Lambert law. Look at this relation:

$$I(X) = I_0 e^{-ax} \quad (1)$$

I_0 is the primary optical intensity in terms of Watt, I(X) is the light beam intensity of the X direction in terms of meter and $\alpha$is the attenuation coefficient of the transmit environment in terms of m^{-1} .It is very essential to get the right bits sent from the transmitter and this kind of systems to measure this parameter BER or Bit Error Rate is used.

$$BER = \frac{number\ \ of\ erronous\ \ recieved\ \ bits}{total\ \ number\ \ of\ bits} \quad (2)$$

FSO system's range equation

$$P_R = p_T \left[\frac{A_r}{(D_1 + R\Delta\theta_1)^2}\right] \quad (3)$$

Where P_R is the received optical signal's power, P_T is the sent optic power, A_r is the surface f the light collecting lens in the receiver telescope and T is the amount of sending efficiency at the sender and the receiver. The ray of light in the distance R is also determined by $(D_1 + R\Delta\theta_1)^2$ .K is the loss coefficient due to the deviation of one for a non-coherent light source like LED which for the coherent laser optic, it will be 1. To increase the range of a laser link, the following methods can be used:
- Increasing the laser power at the transmitter
- Increasing the diameter of the lenses or mirrors collecting the laser optic
- Increasing the sensitivity of the amplifier circuits of the receiver
- A combination of all the above methods
Now, let us examine each of the above methods and compare their advantages and disadvantages. Basically, all these systems need a minimum radiation power to guarantee the communication. Suppose that we want to create a communication system between the earth and the moon by using laser, it is apparent that in this case, we will need a more powerful laser generator than when we want to do this in a city. To communicate with the moon, a laser generator with several watt of power is needed, whereas, to communicate within a large city, a few milli-watts of power would suffice.

6- Increasing the laser power

Undue increase of power will have the following disadvantages
- The useful life of the transmitter equipments will decrease
- It requires larger power sources and the bulk of system will increase.
- Heat dissipation of system will increase.

- The possibility of interception and eavesdrop will be more on high radiation power.
- Powerful laser rays are very dangerous for the human eye.

As far as possible, instead of increasing the transmitter power, it is better to apply other methods especially at the receiver part unless increasing the laser power in inevitable. These days, laser diodes and laser transmitter module are available in different powers and models which can be chosen depending on the required need, communication type and the distance between the two points.

Increasing the diameter of the lens or mirror collecting light at the receiver unit

One of the best methods of increasing the range of a telecommunication system is to increase the sensitivity and power of the receiver because it will not have the problems of the previous method. In FSO systems, it is possible to increase the reception power and ultimately add efficient range of the system by optimizing the optical equipments.

As we increase the diameter of the lens or the mirror collecting ray, the amount of received energy will rise. As the amount of focused rays on the receiver sensor increase, the volume of received signals will also rise.

7- Increasing the sensitivity of the receiver circuits:

In the method of increasing of the diameter of the lenses we were able to increase significantly the sensitivity and the efficiency of the receiver. By designing better circuits at the receiver unit, increasing the gain value and amplification coefficient of this unit, we can influence the sensitivity of the receiver part and finally increase the efficient communication range of the system. In telecommunication receivers of radio and optical type, as we make the primary circuits and amplifiers more sensitive and increase the amplification coefficient, the system's ability to interfere with the weak signals will increase and the efficient range and the communication quality will be improved. Of course, in this phase, we will be encountered with some limitations, i.e.as we increase the sensitivity of a receiver, relatively; we will decrease the systems' immunity against the noise because in addition to the ideal signals, the receivers get and amplify some noises and parasites which are emitted in the environment or are due to the natural noises of the components.

8- An example of an FSO system

A sample optical communication system in free space is composed of the following components:

- A small source of laser optic which can be modulated directly via high speed information
- Optical guide unit which is composed of a system of lenses and transfers the laser beam to the target.
- A ray receiver lens or mirror which collects the ray and focuses it on a photodiode.
- Electronic part which includes signal amplifier and data implementation circuits (Demodulation)
- The emitted laser optic passes through the air and may be absorbed, diffused or redirected that depends on the factors such as weather conditions, laser optic frequency and the ray width. If the laser optic is transferred to 200 to 500 meter distances, it may shift from the meeting point (receiver telescope of the opposite link) under some conditions such as the building vibrations and air layers'

turbulence and it may exit the acceptance angles and information transmission may be subject to impairments. In such cases, it is necessary to install the strong laser and to cope with the vibrations caused by the wind and buildings.

9- Project properties to construct a laser link:

- It is cheap and can be built with common components of the market

- It has a good communication quality to 500 meter radius.
- It has voice transmission capability with desirable quality.
- It is a stable and reliable system.

As it is shown in the following image, at the exterior view, the laser communication system is composed of three main parts which include:

- Light collecting telescope at the receiver part
- Laser transmitter
- Electronic circuits' part

Fig1 - laser link

The most important and sensitive part of the project is the optical telescope which is responsible to collect and focus the received laser optic on the receiver sensor which is a photodiode. Since the laser beam is subject to dispersion on its way over time, it is necessary to collect more rays by the telescope and focus them on the sensor. In case that telescope is not used, the system range will be extremely limited and reduced. The used telescope is a refractive one.

10 - Description of the transmitter part (circuit image)

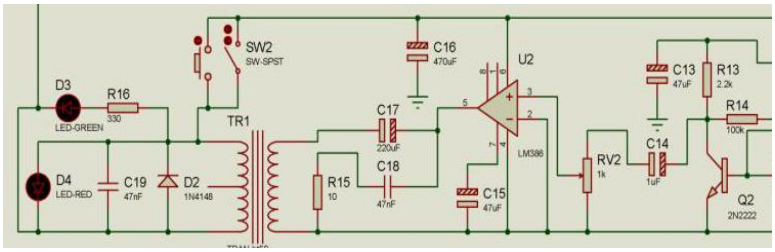

Fig 2 - transmitter part

At first, the sound is received by a capacitive type microphone which is placed in all the headsets on the market. So, we use 10 kilo ohm of resistance 12 to supply it. Resistance 11

and capacitor 11 are placed at the pre-amplifier of the microphone as a filter to prevent the creation of disturbing noises. The sonic signal is applied to the transistor 2 through couplage capacitor 12 and after being amplified, it is applied to number (LM386) power amplifying IC 2 through potentiometer 2. This IC is a famous sound amplifier with 1 watt power that is used as a speaker driver in most portable devices such as radios and Walkie Talkies. This the way this transmitter functions: laser diodes Dc supply is done via the speaker's transformer and the audio signal received by the sonic amplifier makes a few changes in laser diode current. These current changes relative to the sound intensity cause some changes in the laser irradiance and in fact we obtain irradiance modulation or IM. Capacitor 19 is placed at the extreme ends of the laser diode to shorten the connection of the intense temporary currents.
SW-2 and SW-3 switches are used to turn on and turn off the laser permanently or for a moment. Regarding that the laser diode will drag the most amount of the current from the device battery, and regarding its sensitivity and in some cases we will be just receiving, we have placed these switches in the circuit so that the device can also function in a Half Duplex way.
The multi potentiometer determines the sensitivity value of the microphone. Based on the regulation of this Multi Turn type potentiometer and is regulated on the circuit for once, you can obtain the best audio quality at the opposite link.
LM386 IC is an audio amplifier IC. The act of internal audio amplifying of it is 20 times higher where its 1 and 8 bases are free, by placing the resistance and the capacitor between 1 and 8 bases, we can increase the amplification value to 200 times higher.

11- The circuit of the receiver part

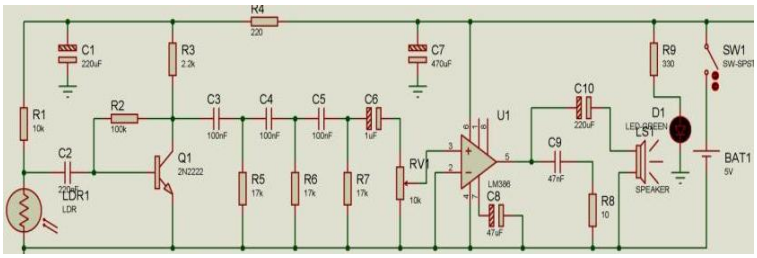

Fig 3 - receiver part

This part of circuit is also very similar to the transmitter circuit and almost the same elements are used. The received energy of the laser which is actually collected by the optical telescope lens and is radiated on the photodiodes at the lens' focus is given to this part. The photodiode receives the laser optic with variant intensity which is created by the transmitter and according to the resistance with R1 biasing, the variable voltage at the two sides of the photodiode has been created and through C2 couplage capacitor, it goes to the entrance of the pre- amplifier transistor to be amplified.

12- Filter

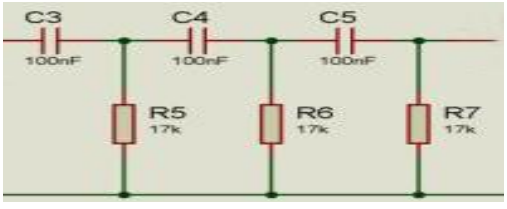

Fig 4 – Filter part

When the receiver telescope gets the disturbing lights, we'll hear a disturbing and thematic sound with the received voice from the opposite link on the receiver. To reduce this disturbing effect, we can place a high-pass filter with a central cutoff frequency of about 100HZ to minimize the negative effects of the industrial lights. As it is clear in the arrangement picture of this filter, C3=C4-C5 capacitors and R5-R6-R7 resistances constitute a high-pass link with about 100HZ cutoff frequency.
The above filter consists of three floors (In order to increase the amount of filtering). The formula for calculating the cutoff frequency of the R-C filter is Fc=1/2*3.14RC.

13- References

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