Design and implementation of mobile laser data transceiver

Hayder M. Hamodi *, Mohamed A. munshid, Khalid S. Shibib**

Laser & optoelectronics Eng. Department*
Laser & optoelectronics Eng. Department **
Laser & optoelectronics Eng. Department ***

Abstract

The laser communications systems consist of three main parts are a transmitter, free space channel and receiver. In this work the circuit of mobile laser transceiver has been designed to use for data exchange between computers. The electronic parts that have been used to implement the mobile laser transceiver are laser diode of 650 nm used as transmitter, a phototransistor IS485 has been used as receiver, MAX232CPE is an IC used to as data controller, inverter DM74LS04 has been used to invert the received signal from a phototransistor IS485 and the program that has been designed and used to control the data exchange between computers is Visual Studio 2010. The programs have been used to exam receiving and transmitting file are free serial monitor and WinMerge. A laser beam transmits data form 1m to 20m of range with no errors in different free space conditions. The baud rates that have been achieved are from 9600bps to 256000bps.

Index Terms: FSO, laser communications, transceiver, OOK modulation.

I. Introduction:

The technology of communication has become very interesting recently. The continual development in this technology demands higher bandwidth to transfer higher bit rate data at fastest possible speed. This bitrate data can be modulated on a signal with frequency starting from a few kiloHertz at Marconi's time to many hundred teraHertzes by using laser systems.

The line-of-sight conditions between the transmitter and receiver is a must. The benefits of laser communications systems are doesn't need for broadcast rights and buried cables. The laser diode is typically generating the carrier used for the transmission signal. Two parallel laser beams are required, one for transmission and the other for reception. The laser communication offers high bandwidth, which can be employed in neighborhood by putting and aligning the laser communication systems on the top of the existing buildings which offers a multi-gigabyte of communication speed. One of the other applications of Laser communications technology is temporary connectivity needs (e.g. disaster scenes, sporting events, or conventions), or space based communications. The following figure explains the main diagram of free space optics (FSO) systems:

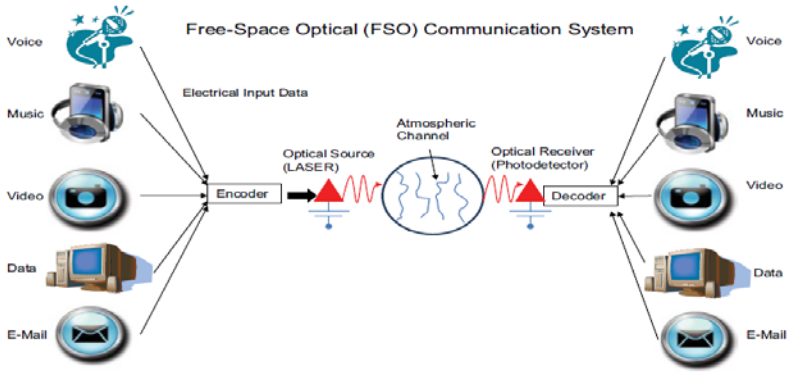

Figure 1.0 a scheme of FSO communication technology with optical wireless

David O. Caplan studied the designs of optical transmitter and receiver that are particularly well suited for average power limited photon famished links where channel bandwidth is readily available. He also studies a simple direct-detection systems used in short terrestrial or fiber optic links [1]. Yan Wang (et.al) studied the analysis for PPM modulation mode and the method of pulse (MOPA) type fiber laser based on

the PPM modulation system was designed. Where their simulation verified that it can reach 1 Mbps transmission rate [2], M. A. Minshed, studied signal modeling using bacterial foraging optimization algorithm in LADAR [3].

The most important advantages of FSO versus microwave communication are:

1. Beam width narrowness.
2. The large directivity of the laser versus RF.
3. The higher bandwidth of the laser by comparing with RF.

In this work the modulation that has been used is ON-OFF KEYING, the transmitter is a laser diode (wavelength 650nm) and the receiver (phototransistor). The maximum baud rate that has been achieved is 256000bps.

II. Theory of optical communication systems

The aim of communication systems is to transmit information which can be achieved in many ways. The FSO communications technology mainly depends on propagation of laser beam through atmosphere and other media. These media are interacting and affecting the quality of the propagating laser signal [4].

The most important parts of the communication systems are the transmitter and receiver, in the optical communication system the transmitter converts an electrical signal bit sequence to an optical data stream. Because the light output of a laser diode is defined as a function of the input current instead of voltage, laser diodes are driven by currents. The driver of laser can be considered a simple high speed current switch controlled by a modulated data stream at the input [5].

The receiver antenna of the optical communication systems is the optical detector which converts the optical signal to electrical signal. The receiver mainly determines the total performance because it handles the lowest signal level in the communication link [5].

Modulation is the process of facilitating the transfer of data of information over a carrier medium. There are two types of modulation (analog and digital). The moving to digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications, and quicker system availability.

1. Link calculations

The performance of the FSO overall systems is measure by applying equation of range of link budget driver, which is collect all affecting parameters on the system to get the received power at the receiver [4]. The affecting parameters are: transmitter, propagation losses, and receiver's sensitivity.

The transmitter consist of three stage they are laser power, transmitter antenna gain and transmitter transmission, while the propagation losses can be divided into two parts they are atmospheric transmission and space loss, and finally the receiver's sensitivity consist of receiver antenna gain and receiver's transmission as shown in figure 2.0 [4].

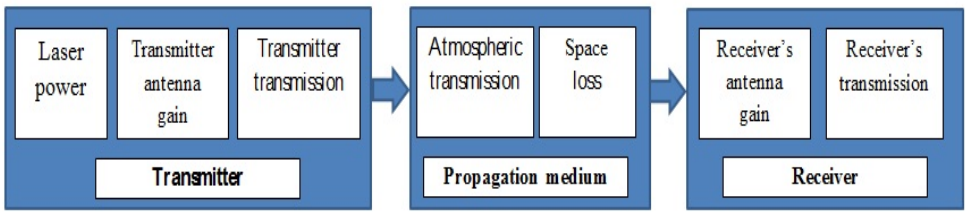

Figure 2.0 optical link affecting parameters.

2. Laser transmitter

The main properties of the laser diode transmitter are: Turn on delay, Frequency chirping and Temperature effects. The optical transmitter converts the electrical signal into an optical signal. The main sources of the optical signals in FSO communication systems are the Light Emitting Diode (LED) and the Laser Diode (LD), the LD has many advantages over LED they are: unique size, high efficiency, specific spectral region of operation (coherent light), high speed of operation, small divergence angle of propagation and appropriate for long distance of transmitting [6].

3. Modulation

The output of the laser diode is depending on the injected current to the diode instead of voltage. The current is driving the laser diode. Laser driver circuit regarded as a simple high speed current switch controlled by a modulated data stream at the input current, the used input current method of data offers many advantages such as reduced noise and a higher bandwidth [5].

Modulation that has been used is directly modulated transmitter consisting of a LD and a LD circuit. The data stream inputs directly modulated by the LDC. The emitting light output of the laser diode is response to the logic of "one" or "zero". The simplest, most common and widely used modulation is direct modulation of the light intensity by data, called On-Off Keying (OOK) [6].

The Amplitude-Shift keying (ASK) modulation technique is the modulation technique that has been used in this FSO system. The On-Off Keying is a special case of the ASK, where in ASK the changing of the amplitude is depends on the information otherwise it's still fixed as shown in figure 3.0[5].

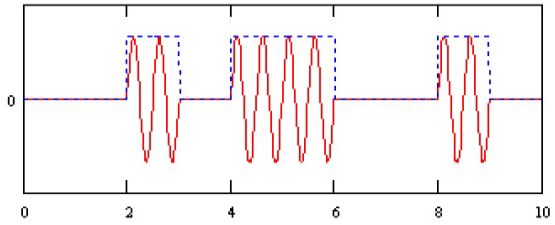

Figure 3.0 ASK modulation

4. Receivers (Photodetectors)

The optical power and the electromagnetic wave power converted into electrical power by the photodetectors. Because of the photodetectors can be regarded as a sensor for the light (in general electromagnetic wave) they are developing very fast with photonics applications (e.g. telecommunication, spectroscopy, military technology, photosensors, medicine, information processing, laser material processing and etc.) [7].

III. Design and construction of mobile laser transceiver

Optical transceiver is one of the FSO communication systems. The function of the electronic circuit that has been built is optical communication transceiver. The free space is the media of data exchange.

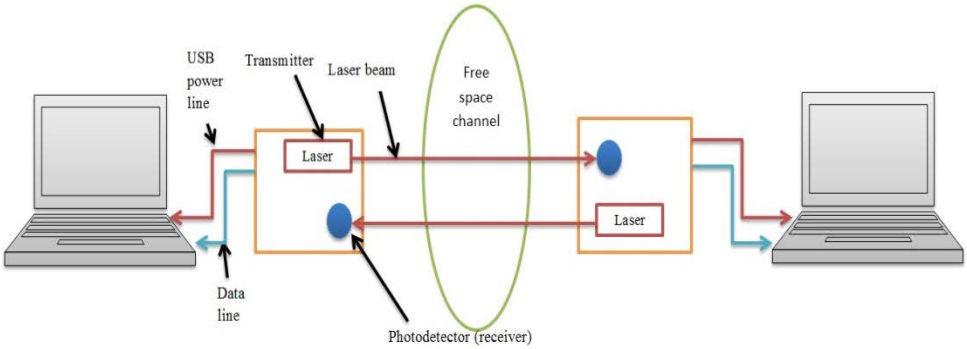

Figure 4.0 General schamatic diagram of the system

The proposed electronic circuit has been used to transmit data between the computers and networks. The parts of the optical communication transceiver are: transmitter (Laser Diode), receiver (Photodetector), other electronic circuit components, connection cable, power source and Software (visual studio program).

1. data transmission sequence

Transmitting: first step of the data process, the computer program decoding the selected file into zero –ones code and delivers this code through the data connection cable to the data process IC then the IC sends this code to the laser transmitter, the transmitter will modulate the data on the laser beam using ON-OFF keying modulation, the laser beam is then modulated with the code of data.

Receiving: on the other hand, the transmitted laser beam will be received from the photodetector (phototransistor), the phototransistor will invert the logic zero into logic one and vice versa this is because of the phototransistor design, the output of the phototransistor will be sent into inverter IC to make the code similar to the original one (the sent code), the next step is the data process IC, the data process IC will deliver the code to the computer program, which will encode the received code and convert it into file like the sent file with a deferent name.

2. transceiver circuit design

The design of transceiver circuit contains MAX232CP work as data traffic control, DM74LS04 inverter which invert the received signal from the phototransistor (IS485) and laser diode (650nm) as transmitter, figure 5 illustrates the transceiver design.

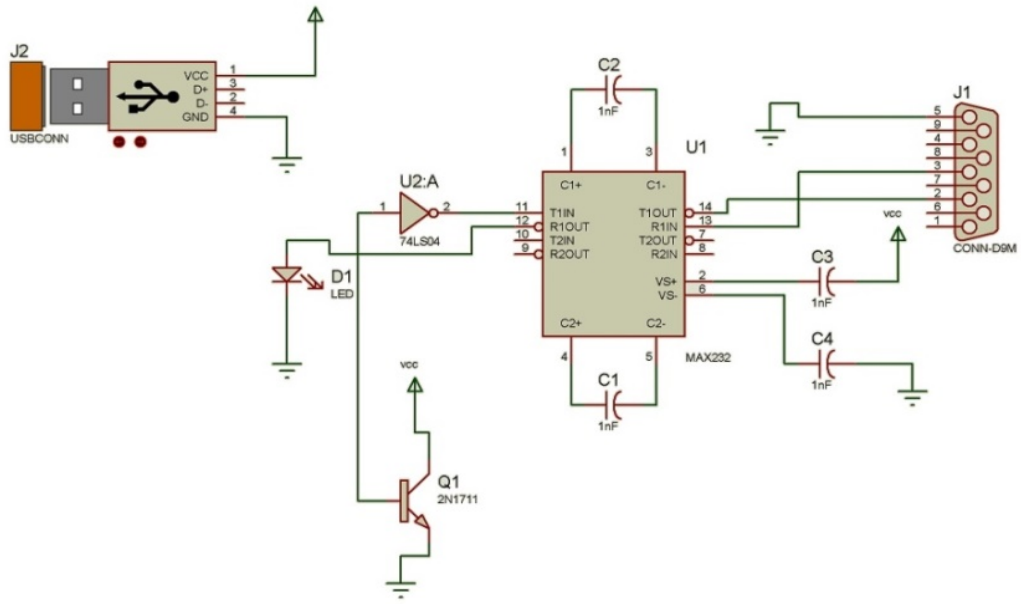

Figure 5.0 transceiver circuit designs.

IV. Results

Figure 6 illustrates the transmitted and the received signals as electrical signal that has been got from oscilloscope, where channel 1 is representing the received signal, while channel 2 is representing the transmitted signal.

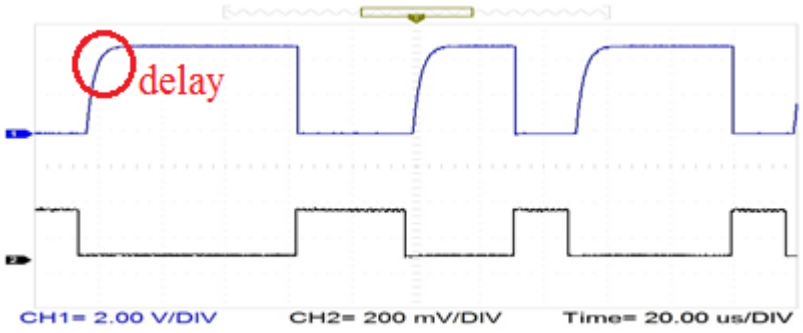

Figure 6.0 Sample of actual transmitted and received signals.

The amplitudes of the received signal as shown in figure 6 is bigger the transmitted because that the phototransistor (IS485) include internal amplifier and a Schmitt trigger circuit. A circle shown in figure 10 refers to the delay of the phototransistor (IS485) and this delay will be terminated when the signal takes out of the inverter (DM74LS04) because the inverter (DM74LS04) work in TTL (Transistor-Transistor Logic), this gives the circuit more reliability.

Using same transceiver device (by reflecting the transmitted laser beam into the receiver and baudrate 256000bps) and using free serial monitor program, the contents of a file will be obsevable as illstrates in figure 7 and the observer can observe that the contents of the sent and received files are the same. The allignment must be perfect because the time duration of transmitting data will decrease with increasing the baudrate.

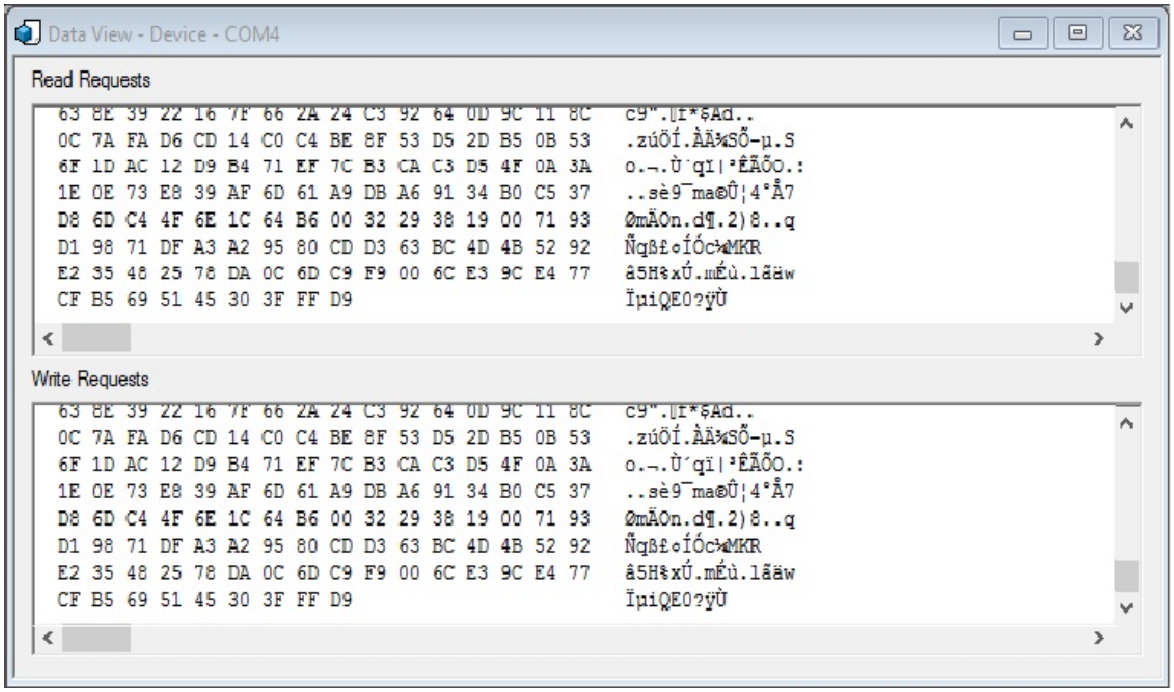

Figure 7.0 received image and sent image content

Now by using Win Merge program which is compare between two files and find the matching percentage, the result will be as shown in figure 8 which shows the different percentage between the two files and this difference is coming from the different files names because the program that has been designed (in Visual Studio) write the received file with different name.

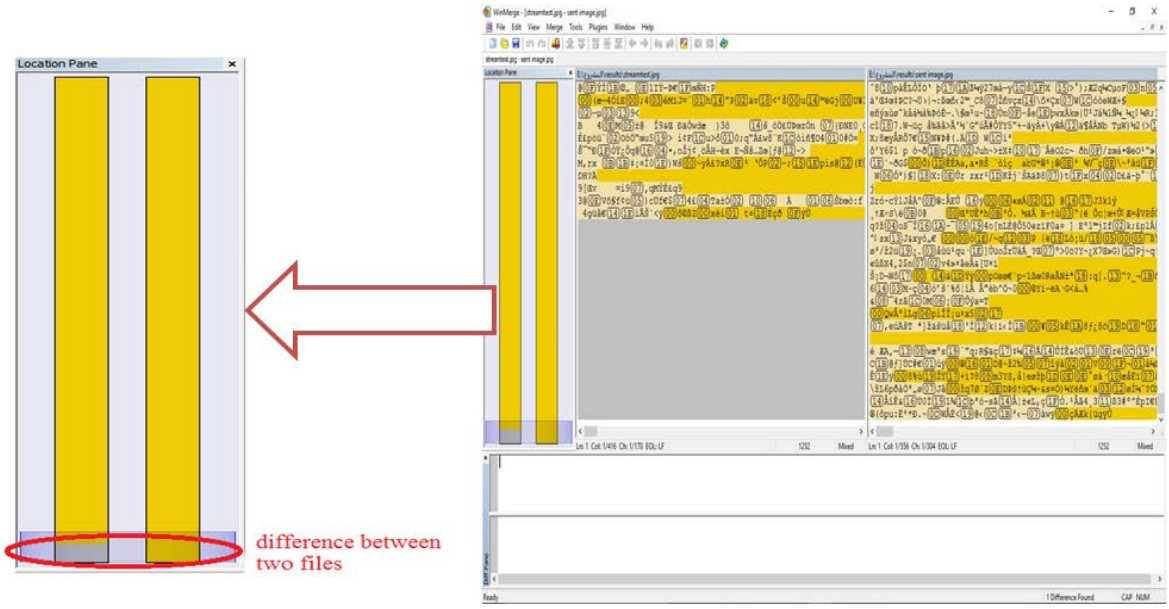

Figure 8.8 received image and sent image content difference.

Figure 9 shows the sent and received file with different names

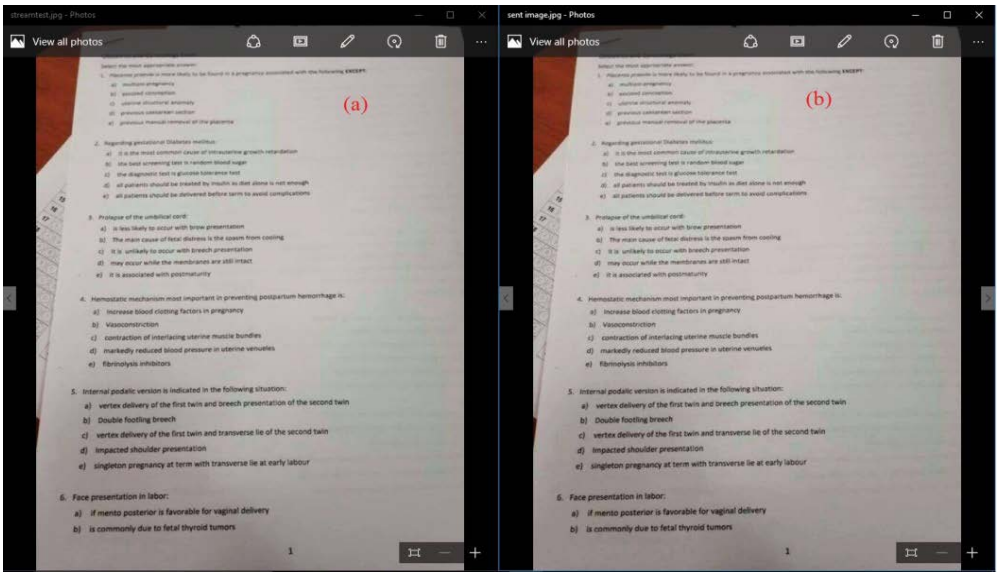

Figure 9 (a) received image (b) sent image

V. conclusion

As evident in the above, this paper seeks to explore the data exchange between two computers, we can conclude the following:

- In order to decrease the error percentage of data exchanges must get perfect alignment between a transmitter and receiver.
- Increasing in baud rate of data transmitting increase the speed of communication that may increases the percentage error of data exchange.
- The difference between two files can be canceled by designing new program.

REFERENCES

[1] David O. Caplan, “Laser communication transmitter and receiver design”, J. Opt. Fiber. Commun. (2007), Rep.4, 225–362.
[2] Yan Wang (Hongzuo Li), “The Research of PPM Modulation in Space Laser Communication Transmitting System”, Sensors & Transducers, Vol. 155, Issue 8, August 2013, pp. 195-204.
[3] M. A. Minshed, "LADAR signal modeling using bacterial foraging optimization algorithm (BFOA)," *Information Science and Digital Content Technology (ICIDT), 2012 8th International Conference on*, Jeju Island, Korea (South), 2012, pp. 352-355.
[4] Arun K. Majumdar, “Advanced Free Space Optics (FSO)”, Springer New York, (2015), vol.: 186, ch2.
[5] Carl Brännlund, “High Speed Electronics for Free Space Optical Communication between Spacecraft”, (2008), vol.: TVE 08 006, Rymdstyrelsen, VINNOVA.
[6] S. Hun Hyun, Design of High-Speed CMOS Laser Driver Using a Standard CMOS Technology for Optical Data Transmission”, (2004), Atlanta, GA 30332.
[7] Sanka Gateva, “PHOTODETECTOR”, (2012),Janeza Trdine 9, 51000 Rijeka, Croatia, ch1.

AUTHORS

First Author – Hayder M. Hamodi, MSc student, University of Technology, and Hayder_maki@yahoo.com

Second Author – Mohamed A. Munshid, Prof. Dr., University of Technology and dr.mohhamedwhab@gmail.com.

Third Author – Khalid S. Shibib, Prof University of Technology and profkhalidsalem@gmail.com.

Correspondence Author – Hayder M. Hamodi, hayder_maki@yahoo.com, 009647903220433