

# Design of Secure and Self Adaptive Neuro Fuzzy Interference System for the Optical Signal Communication

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## ABSTRACT

Free space optical (FSO) communication has emerged as a viable technology for broadband wireless applications and secures communication in surveillance networks. A Prototype Implementations of multi-transceiver electronically-drive communication structures to measure the performance of a voice/data file transfer over such multi-transceiver systems. Assigning multiple logical data streams to appropriate physical transceivers and transfer different voice files simultaneously to multiple FSO nodes with channel-adaptive data streaming scheme which adjust data bit rate (BER) according to channel condition. It implements a Laser Communication System, with a laser light as a carrier signal. At the transmitter an audio signal is applied to the condenser microphone. The signal is modulated with a laser as a carrier and transmitted through open space. At the receiver a phototransistor detects the signal and demodulation of the received signal is carried out. The demodulated signal is then fed to a loudspeaker where the input audio signal could be heard. This paper involves the study of wireless, open channel communication system using laser as a carrier for audio signals. Using this circuit I can transmit amplified audio signals wirelessly up to a few 20-50 meters. Instead of RF signals, light from a laser torch is used as the carrier in the circuit. And I design a low-cost of Bit Error rate tester for Data transmission through optical wireless communication. A Self-Adaptive Neuro Fuzzy Inference System (ANFIS) scheme which adjusts data bit rate according to channel condition. I also introduce quantum key distribution to detect and prevent eavesdropping.

**Keywords** — Free Space Optics, voice transfer, adjust BER, ANFIS, Quantum key distribution.

## 1. INTRODUCTION

This template, modified in MS Word any version and saved as a “Word 97-2003 Document” for the PC, provides authors with most of the formatting specifications needed for preparing electronic versions of their papers.

Free space optical (FSO) communication has emerged as a viable technology for broadband wireless applications and secures communication in surveillance networks. FSO

technology offers the potential of high bandwidth capacity over unlicensed optical wavelengths. Optical satellite communication is one of the major areas that remain to be comprehensively researched [1]. Optic Inter satellite links (OISL) provides an attractive alternate to microwave systems for both military and commercial applications. The advantage of optic ISL is it includes higher band width, smaller antenna size and lower power requirements. It is important in optical

satellite communication to dissipate minimum power and to obtain minimum BER. This aim can be achieved by very small transmitter divergence angles to assure maximum received power. Such design reduces the price of the mission and increases the reliability of the system [4]. The overall system performance of a communication link is easily quantified by three important parameters: transmitter power, receiver sensitivity, and propagation losses. This receiver sensitivity is the amount of optical power needed to maintain the signal to noise ratio required to achieve a desired quantity of service. In satellite communication, modulation is necessary to transfer the information between satellite and the earth. Free-space optical (FSO) communications is a concept that has been there for many years.

Today's market is primarily ISLs for space-based optical communications. Free Space Optics (FSO) is a new communication technology that uses the light propagating in free space. That is to transmit data between two points and although there are several companies currently producing systems for ground based commercial use, deep space optical communications remains a controversial topic [1]. Radio has had such a strong hold on space communications that the huge infrastructure surrounding it makes it hard for a new technology to break into the field. Many opponents will say that radio works fine, so why change it.

And this is a large reason why a lot of the free space optical communication technology currently coming to fruition has been around only in the form of ideas and on paper for close to 30 years. FSO is particularly applicable to inter-satellite communications as it is relatively interference free, travels for longer ranges and offers better connections than RF signals. Lasers provide high bandwidth communication links between satellites, lenses, mirrors, deep-space probes, and orbiting telescopes using lasers. These connections allow for fast communication between transmitters and receivers [2].

Some space-based FSO communication links operate reliably millions of miles apart. ISLs can send and receive data that are exponentially larger than RF signals can provide, while using less power. There has been a new spark of interest from the NASA Mars program, which has been a major driving force in the push for deep space optical communication [8]. FSO system uses a laser beam as a

wireless connectivity between transmitter and receiver, free space as propagation medium for carrying information. The performance of the system is greatly influenced by the propagation medium. Thus, the selection of modulation technique is a vital role in the design process of the system.

The most common modulation scheme used in satellite communication is BPSK. In this work, QPSK and DPSK systems have been compared. The system is modeled using Optisystem 12 software from Optiwave. This project illustrates that QPSK can give better results.

## 2. SYSTEM ARCHITECTURE

The major systems in an FSO communication system are illustrated in Fig.1 a source producing data input is to be transmitted to a remote destination. This source has its output modulated onto an optical carrier; typically laser, which is then transmitted as an optical field through the atmospheric channel. The important aspects of the optical transmitter system are size, power, and beam quality which determine laser intensity and minimum divergence obtainable from the system.

At the receiver, the field is optically collected and detected, generally in the presence of noise interference, signal distortion, and background radiation. On the receiver side, important features are the aperture size and f/-number, which determine the amount of the collected light and the detector field-of-view (FOV). The basic architecture used to model ISL system is shown in Fig 1. This gives an overview of proposed optical ISL system. Then, the selection of suitable optical wavelength which is used for deep space links. Then we revise the ISL link performance and freeze the system parameters focusing on transmitted bit rate between LEO satellites at bit error rate (BER) ranged from  $10^{-6}$  to  $10^{-9}$  employing APD detector and QPSK modulation at desired wavelength maximizing the quality of the system.

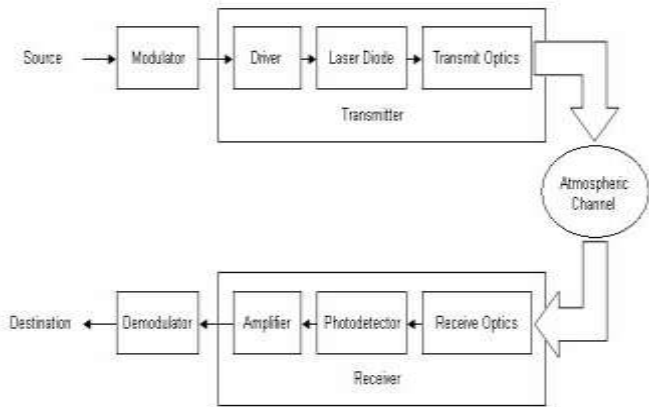
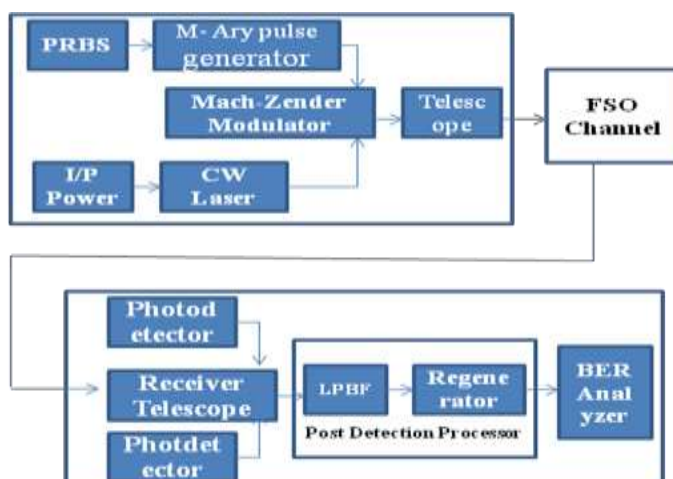


Fig-1: FSO communication.

The basic architecture used to model ISL system is shown in Fig 2. This gives an overview of proposed optical ISL system. Then, the selection of suitable optical wavelength which is used for deep space links. Then we revise the ISL link performance and freeze the system parameters focusing on transmitted bit rate between LEO satellites at bit error rate (BER) ranged from  $10^{-6}$  to  $10^{-9}$  employing APD detector and QPSK modulation at desired wavelength maximizing the quality of the system. Modulation technique is one of the most significant processes in ISL system where the RF electrical signal is applied to modulate the optical carrier. Optical modulation methods can be categorized into two main groups: direct modulation and external modulation.

Direct modulation, a simple technique, directly modulates the amplitude of the laser beam but suffers from a laser-frequency chirp effect that degrades severely the performance of the system. However, this can be eliminated by using the external-modulation scheme that is used to modulate the phase of the optical carrier. No doubt such systems are capable of meeting the future requirements of High speed high data transfer



services.

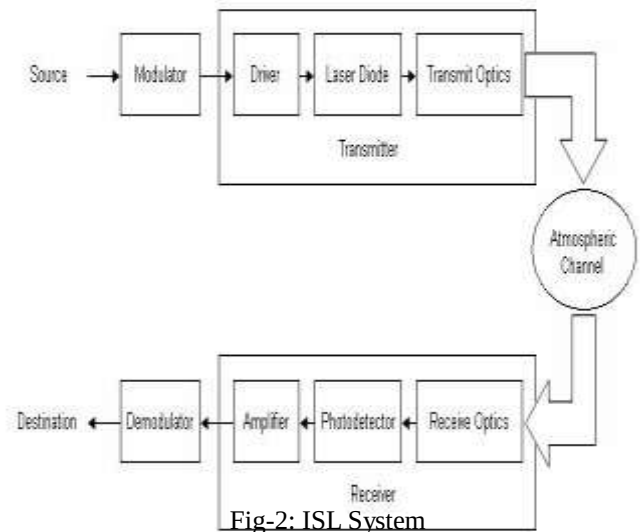


Fig-2: ISL System

The optical system of ISL is consisting of two transceivers communicating by means of emitting and receiving optical signals. The proposed ISL uses continuous wave (CW) lasers in free space channel as a signal carrier as well a wireless connectivity between transmitter and receiver as in. Using this FSO channel is considered as a key technology for realizing an ultrahigh speed and long-haul communication system. CW laser is modulated by a phase modulator using 2.5 Gps non- return to zero (NRZ) data to generate the desired signal.

The generated signal is emitted using an optical antenna and is sent over FSO bearing some losses. The optical path loss depends on the laser wavelength and distance between transmitter and receiver platforms. At the receiver, the process is reversed and optical signal is converted into a bit stream. These bit streams modulated using Non Return to Zero (NRZ) modulation because it is superlative scheme for obtaining maximum coverage distance of the link. It becomes extremely difficult to modulate the laser directly; therefore Mach Zehnder (MZ) modulator used as an external and alternative optical modulator as shown in Figure 4. External modulators are either integrated with Mach-Zehnder interferometers or electro absorption modulator.

The MZM remains the proven technology for high speed optical systems [12]. A Mach- Zehnder modulator consists of a beam splitter that divides the laser light into two paths, one of which has a phase modulator. The two beams are then

recombined. At the output changing the electric field on the phase modulating path will determine whether the two beams interfere constructively or destructively, and thereby control the intensity or amplitude of the exiting light [13]. Main objective of this research is to design and simulate the QPSK modulation scheme to achieve data rate of 2.5 Gbps at a wavelength of 1550 nm using external modulation in free space optics using Optisystem 12 software. This design is about components that will be used in this system including the specific parameters of each component, how it works and the function of the system.

### 3. SYSTEM PERFORMANCE

Performance of a system can be evaluated in many ways such as by analyzing the BER and Q-factor. BER can be said to be the ratio of the number of bit errors detected in the receiver and the total no. of bits transmitted. Bit error happens when the receiver results in incorrect decisions due to the presence of noise on a digital signal [15][16]. Meanwhile, Quality factor, Q, describes the sharpness of the system's response and is a measurement of the signal quality. Q factor is proportional to the systems signal to noise ratio.

In optical communication, the BER is typically too small to measure hence Q-factor is more suitable to be used [14]. The relationship between Q-factor and BER can be given as

$$\text{BER} = 1/2\text{erfc}(Q/\sqrt{2}) \approx 1/\sqrt{2\pi}Q\exp(-Q^2/2) \quad [17]$$

The attenuation, A, for ISL and satellite to earth link is calculated using the equation,

$$A = L2 (\lambda/DT)^2/DR^2TRTT (1-LP)$$

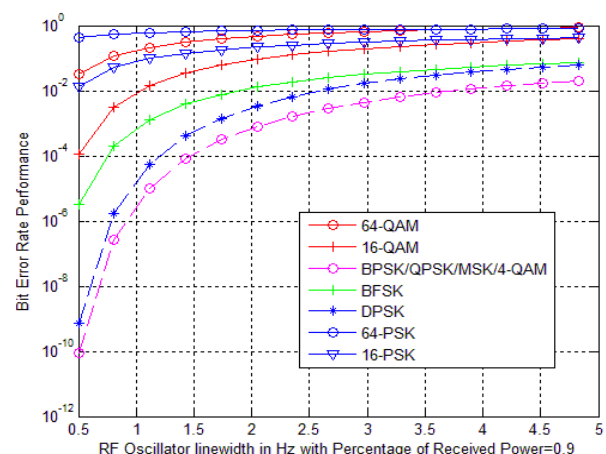
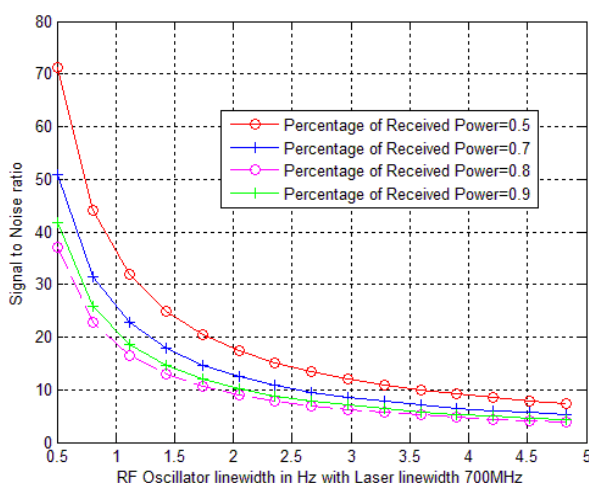
Where  $\lambda$  is the wavelength, L is the distance between the

transmitter and receiver, DR is the optical receiver antenna diameter, TR and TT are the transmission factor for the transmitter and the receiver respectively, LP is the pointing loss, DT is the diameter of the optical transmitter antenna. According to Pfennigbauer [18] following values are considered  $D=DT=DR$ ,  $LP = .2$ ,  $TR=TT=0.8$ ,  $\lambda=1550\text{nm}$ .

### 4. RESULTS AND DISCUSSIONS

The Fig 3. illustrates SNR ratio with respect to RF oscillator line width with laser line width 700MHz for different percentage of received power range from 0.5 to 0.9. It is observed that that signal to noise ratio is having exponential decrement as per the RF oscillator line width varied from 0.5 to 5Hz. The signal to noise ratio are 70dB, 50 Fig-3: BER with respect to SNR dB, 42 dB and 38 dB with value of percentage of received power 0.5, 0.7, 0.8 and 0.9 respectively. Thus, approximately 30 dB decrement in SNR is found out as per increment in percentage of received power from 0.5 to 0.9. Therefore, the bandwidth on which percentage of received power depends should be selected carefully in a ROF system. The BER performance of ROF system is depicted in Fig. 3 and Fig. 4. The BER varies from  $10^{-34}$  to nearly  $10^0$  as RF Oscillator line width varies from 0.5 Hz to 5 Hz with percentage of received power 0.5 and BER varies from  $10^{-10}$  to nearly  $10^0$  as RF Oscillator line width varies from 0.5 Hz to 5 Hz with percentage of received power 0.9.

Thus, BER increases as per increment in RF Oscillator line width as well as percentage of received power. Also, it is found that BER is minimum for modulation scheme BPSK/QPSK/MSK/4-QAM in comparison with other



modulation scheme.

Fig-4: BER with respect to RF oscillator

## 5. CONCLUSION

The RF is replaced into FSO in antenna- antenna communication. The data was transferred in the FSO communication channels with the connectivity speed of 660 Mbps. BER had been reduced  $\sim 7$  in percentages and the SNR in measured. Eye pattern in given as an output to analyze the results. Robustness and secured communication were made by alerting and tripping off the communication.

## 6. FUTURE SCOPE

This dissertation is pioneering in its efforts to implement the two advanced enhancements in FSO communication systems, namely time delayed diversity receiver system, and the random signal is threshold detected using a constant threshold value, yielding non-optimal system performance. The idle performance may be achieved if adaptive thresholding is used. Since the signal fluctuation is relatively slow compared to the data, a digital low pass filter can be used to provide the dynamic threshold. Therefore, future research could try to incorporate this method into the system and should provide additional performance improvement.

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