COMPARISION IN MODULATION TECHNIQUES FOR FSO COMMUNICATION SYSTEM

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Abstract: Free space Optical (FS0) communication has been emerged as a more conventional means of communication rather than the traditional optical communication. Performance of FSO communication system depends upon number of parameters. These parameters can be divided into two categories such as (i) internal parameters (ii) external parameters. Internal parameters are concerned with design of FSO system and include wavelength, optical power, transmission bandwidth, divergence angle and optical loss on the transmitter and bit error rate (BER), receiver lens diameter, and receive field of view (FOV) on the receiver. External parameters are linked with environment such as visibility, atmospheric attenuation, scintillation etc. which come under the effects of atmospheric conditions. There are a number of techniques to take the edge off these channel effects such as selection of an efficient modulation scheme, aperture averaging, receiver diversity, diversity (in space, time or frequency), coding, adaptive optics etc. The keen focus of our paper will be on effective modulation for FSO system. We will discuss various modulation schemes associated with FSO systems.

Keywords: Bit error rate , Free space optics, ON OFF Keying, Quadrature amplitude modulation

1. Introduction

FSO functions same as fiber optics but at a very low cost and very fast deployment speed [1]. FSO is been emerging as a viable wireless communication system for long and short haul networks. FSO communication totally runs by means of light thus modulation plays a vital role for transmitting data here. As there are lot of modulation techniques available for wireless communication thus it is very important to choose a modulation technique which makes the system more efficient according to the suitable conditions . This paper discuss a comprehensive survey of FSO communication with main focus to study different modulation techniques so as to minimize the different losses taking place when light signal passes through free space.FSO systems are mainly implemented by employing On–Off keying (OOK) modulation because of the simple system and low cost, however alternative modulation technique, pulse-position modulation (PPM), has been proposed for FSO communication instead of (OOK) modulation [2]. It has been found that PPM is more power efficient as compared to OOK but has poor bandwidth efficiency. To overcome the limitations of OOK and PPM, subcarrier phase-shift keying (PSK), Qadurature amplitude modulation (QAM) has been proposed for high bandwidth efficiency[3]. Also in order to achieve a better spectral efficiency than that of PSK, the use of subcarrier quadrature-amplitude modulation (QAM) for FSO systems has been recently proposed. The error rate of FSO systems using subcarrier QAM over log-normal and gamma–gamma turbulence channels was derived in [4]. Also in [5] Hassan et al. derived the closed-form expression of error rate for gamma–gamma and log-normal channels using a series expansion. Quadrature amplitude Modulation (QAM) is a complicated name for a simple technique. It is basically the combination of amplitude modulation and phase shift keying. We can say quadrature amplitude modulation is a modulation in which data is transferred by modulating the amplitude of two separate carrier waves, mostly sinusoidal, which are out of phase by 90 degrees (sine and cosine) therefore due to this phase difference, they are called quadrature carriers. In simple (OOK) modulation signals exhibit only two positions enabling a transfer of either a 0 or 1 but in quadrature amplitude modulation, it is possible to transfer more bits per position as there are multiple points of transfer.

2. Modulation of a wave

Modulation means to change .So changing the carrier wave in accordance to the signal is termed as modulation. Frequency of an RF channel is related as the frequency of a carrier wave. A carrier wave is sine wave with a constant frequency but it doesn't carry much information that we can relate to (such as speech or data)..To add related data information, input signal is mounted, on top of the carrier wave. This process of loading an input signal onto a carrier wave for required data transmission is called modulation. In other words, modulation changes the shape of a carrier wave to somehow encode the speech or data information that we were interested in carrying. Modulation is like hiding a code inside the carrier wave. There are different ways for modulating the carrier wave. One of the common ways is to tweak the height of the carrier or we can say the amplitude of the carrier. If an modulating signal's amplitude varies with the loudness of a user's voice and then adds this to the carrier, then the carrier's amplitude will change corresponding to the input signal that's been loaded on to it. In various modulation techniques, the message signal frequency is raised to a range so that it is more useful for transmission. The importance of modulation in communication system is that the signals from various sources are transmitted through a common channel simultaneously by using multiplexers. If these signals are transmitted simultaneously with certain bandwidth, they cause interference. To overcome this, speech signals are modulated to various carrier frequencies in order for the receiver to tune them to desired bandwidth of his own choice within the range of transmission.

2.1 Need of modulation:

Also the need for modulation arises from the antenna size .The antenna size is inversely proportional to the frequency of the radiated signal. The order of the antenna aperture size is at least one by tenth of the wavelength of the signal. So if the signal has a frequency of 5 KHz its antenna size is not practicable therefore, raising frequency by modulating process will certainly reduce the height of the antenna. Modulation allows transferring the signals over large distances, since it is not possible to send low-frequency signals for longer distances. Similarly, modulation is also important to allocate more channels for users and to increase noise immunity.

2.2 Type of modulation

The two types of modulation are analog and digital modulation techniques. In both the techniques, the baseband information is converted to Radio Frequency signals, but in analog modulation these RF communication signals are continuous range of values, whereas in digital modulation these are prearranged discrete states.

Analog Modulation: In this modulation, a continuously varying sine wave is used as a carrier wave that modulates the message signal or data signal. The Sinusoidal wave used in analog modulation consists of three parameters that can be altered to get modulation and they are amplitude, frequency and phase.

Digital Modulation: In digital modulation technique the carrier wave is modulated with the help of digital bits (0 or 1). The great benefit of FSO links is the unguided channel itself. But the FSO system is prone to atmospheric uncertainties like rain, snow, fog, variation of temperatures ,wind speed etc., thus reliable performance remains a major challenge [6]. On off keying is one of the simplest modulation technique used for transmission of data in FSO, but the performance of the system under On off keying systems typically degrades with the increase of turbulence resulting to errors in the data [7].. To tackle these kinds of problems caused by turbulence an appropriate modulation technique is implemented. Various modulation techniques to improve performance efficiency of FSO system have been recently proposed [8].Basic digital modulation techniques include ASK (Amplitude shift keying), FSK (Frequency shift keying) and PSK (Phase shift keying).

3. Comparison between different modulation schemes

Different digital modulation techniques have different symbol rate which is defined as number of samples per second similarly they have different bit rates which is defined as number of data bits per second. The table I shows comparison between these rates for different modulation techniques

Modulation Technique	**Symbol Rate**	**Bit Rate**
i)ASK , FSK , PSK	N	N
ii)QPSK	N	N
iii)4-PSK	N	2N
iv)8-PSK	N	3N
v)16-QAM	N	4N
vi)32-QAM	N	5N
vii)64-QAM	N	6N
viii)128-QAM	N	7N
ix)256-QAM	N	8N

Table 1 Bit rate and baud rate comparison of different modulation types

The bandwidth required for the transmission of the signal is stated by symbol rate.

Where;

N = number of bits used.

M =number of bits used per sample.

Also data compression helps higher data transmission rates at required bandwidth. The Table 2 shows the number of modulated bits, the required minimum bandwidth and many possible output conditions for Amplitude shift keying (ASK), Frequency shift keying (FSK), Phase shift keying(PSK) and Quadrature amplitude modulation (QAM) for bit rate f_b. The best possible way to describe the performance of FSO communication system is bandwidth efficiency.

Modulation Scheme	**Modulated Bits**	**Modulated states**	**Minimum bandwidth**
i)FSK	1 bits	2	f_b
ii)ASK	1 bits	2	f_b
iii)BPSK	1 bits	2	f_b
iv)QPSK	2 bits	4	$f_b/2$
v)QAM	2 bits	4	$f_b/2$
vi)8-PSK	3 bits	8	$f_b/3$
vii)8-QAM	3 bits	8	$f_b/3$
viii)16-PSK	4 bits	16	$f_b/4$
ix)16-QAM	4 bits	16	$f_b/4$
x)32-PSK	5 bits	32	$f_b/5$

xi)32-QAM	5 bits	32	$f_b/5$
xii)64-PSK	6 bits	64	$f_b/6$
xiii)64-QAM	6 bits	64	$f_b/6$
xiv)128-PSK	7 bits	128	$f_b/7$
xv)128-QAM	7 bits	128	$f_b/7$

Table 2 Comparison of different modulation types

Bandwidth efficiency shows that how faster in speed bits are transmitted under a particular bandwidth. Bandwidth efficiency is defined by the formulae given below:

Bandwidth efficiency = $\frac{\text{Bit rates}(f_b)}{\text{Required bandwidth}}$

4.Conclusion

The paper summarized that as we go higher in the order of modulation, data can be transmitted at higher rates but the possibilities of error also increases. With increase in data rate, signal to noise ratio improves but then it also introduces more flawed bits which results in irreparable damage to transmitted data. In short, we have to compromise for one either data transmission rate or amount of noise that our receiver can handle. Based on the values of bandwidth and bit rate from table 1 and 2 we can say that higher levels of QAM have high bandwidth efficiency.

References

[1] V. W. S. Chan, “Free-space optical communications,” J. Light wave Tech., vol. 24, no. 12, pp. 4750–4762, 2006.

[2] Kiasaleh, “Performance of APD-based, PPM free-space optical communication systems in atmospheric turbulence,” IEEETrans.Commun.,vol.53,no.9,pp.1455–1461,Sept.2005

[3] N. D. Chatzidiamantis, A. S. Lioumpas, G. K. Karagiannidis, and S. Arnon, “Adaptive subcarrier PSK intensity modulation in free space optical systems,” IEEE Trans. Commun., vol. 59, no. 5, pp. 1368–1377, May 2011.

[4] K. P. Peppas and C. K. Datsikas, “Average symbol error probability of general-order rectangular quadrature amplitude modulation of optical wireless communication systems over atmospheric turbulence channels,” J. Opt. Commun. Netw., vol. 2, no. 2, pp. 102–110, Feb. 2010.

[5] M. Z. Hassan, X. Song, and J. Cheng, “Subcarrier intensity modulated wireless optical communications with rectangular QAM,” J. Opt. Commun. Netw., vol. 4, no. 6, pp. 522–532, June 2012.

[6] M Al Naboulsi and H Sizun, Fog attenuation prediction for optical and infrared waves, Optical Engineering, 23, 319–329, 2004

[7] S. J. Dolinar, J. Hamkins, B. E. Moision, and V. A. Vilnrotter. 2006. “Optical modulation and coding in Deep Space Optical Communications”, Wiley Interscience.

[8] Sugianto Trisno. “Design and analysis of advanced free space optical communication systems”, Ph.d thesis, University of Maryland, 2006.