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Design and Performance Analysis of Digital Modulation Techniques in Optical Fibre Communication

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ABSTRACT

Main objective of this paper is to design and analyze the simulation model of Various Digital Modulation techniques in Optical Fiber Communication System using simulation tool OptiSystem 16. Here laser transmitter with (1310nm) and (1550nm) wavelengths has taken as input power (dBm) and Single mode optical fiber cable and Multimode optical fiber cable used as channel whose length is in km. In this paper, it is designed, simulated and analyzed the digital modulation techniques namely ASK, PSK, FSK with bit rate of 2.5 Gbps, 40 Gbps, 100Gbps, 200Gbps, 400Gbps & 1000Gbps respectively and compared the various parameters.

Keywords:—*TIR, Digital Modulation, Optical fiber cable, OptiSystem simulation tool, single mode and multimode fiber, step-index and Graded index fiber, ASK, FSK, PSK, RZ Pulse Generator, Pseudo-Random Bit Sequence Generator, Eye Diagram .*

I. INTRODUCTION

In optical fiber communication system, optical fiber is the guided channel. Before the optical communication, the most of the communication was in radio and microwave domain which has a frequency range orders of magnitude lower than the optical. For a good communication, system needs High Bandwidth (BW) and Good Signal to Noise Ratio (SNR). Other than these advantages, Optical fiber communication gives no EMI response, light in weight, ease of handling, low manufacturing cost etc. Presently attenuation loss is 0.2 dB/Km. In optical fiber communication attenuation caused by mainly absorption, scattering and dispersion which limits the data bandwidth. The basic block diagram of optical fiber communication system is shown below and it mainly includes:

- Transmitter
- Optical fiber (channel)
- Receiver

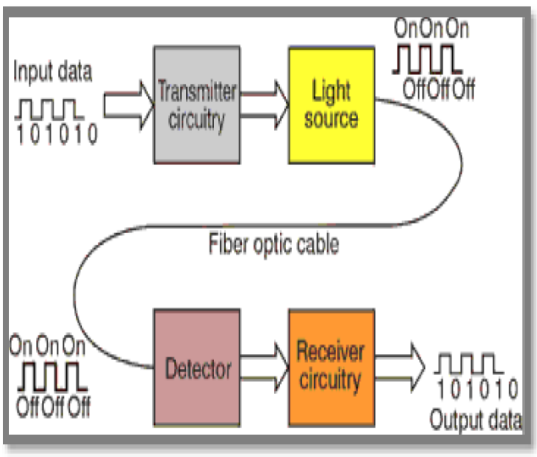

Figure : The Basic Fiber Communication System

II. Digital Modulation Techniques

Modulation is the process of imposing carrier signal in to message by changing the characteristics of carrier signal of amplitude, frequency and phase. A carrier signal is one with a steady waveform constant height or amplitude and frequency. In digital modulation techniques message signal is in form of binary format and carrier signal is the sinusoidal signal. Description of some digital modulation techniques which are analyzed in this paper here as followed:

ASK:

In ASK, message signal which is in binary format multiplied by a carrier signal, so the resultant output waveform has found which is anlog in nature.

Waveform of binary input, carrier and output of ASK format are shown below. This modulation technique is very simple.

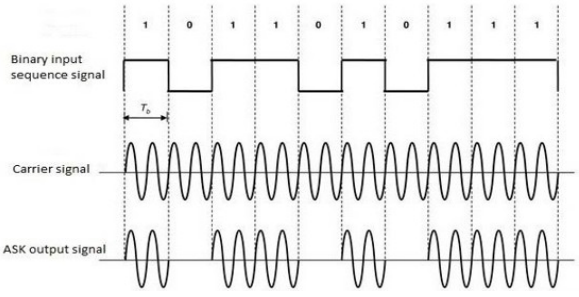

Figure 2 : Waveform Binary input and ASK output

PSK:

In PSK, phase of the carrier signal is changed with respect to the message signal instantaneously. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.PSK is of two types, depending upon the phases the signal gets shifted. These are BPSK and QPSK. In this paper performance of BPSK is analyzed. Waveforms are shown below.

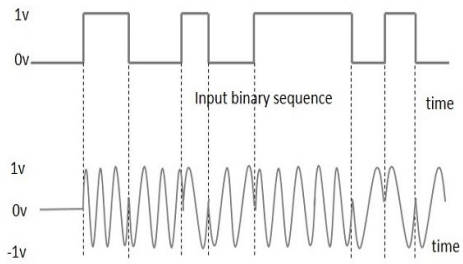

Figure : BPSK Modulated output wave

FSK (Frequency Shift Keying)

In FSK frequency of the carrier signal is varied according to the message. Output of a FSK modulated wave is high in frequency for a binary High input and is low in frequency for a binary Low input. The binary **1s** and **0s** are called Mark and Space frequencies .The total bandwidth of a FSK signal is given approximately by 2Δf+2B where B is the bit rate.

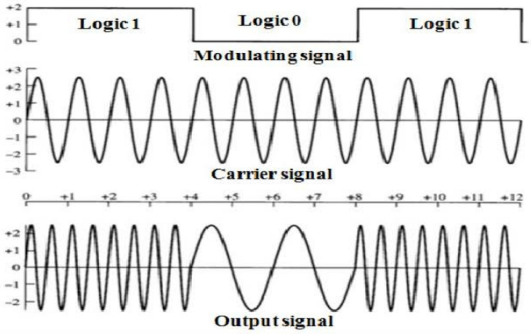

Figure 3: FSK waveform output

III. Simulation Software

OptiSystem

OptiSystem is a simulation tool for the design, testing, and optimization of any type of optical link virtually. OptiSystem is compatible with Optiwave's OptiAmplifier design tools. OptiSystem serves a wide range of applications like WDM network design, transmitter, channel, amplifier, and receiver section. By using this software, circuit is designed for ASK, FSK and PSK and then their Eye diagrams are observed. These are shown below:

ASK Modulation in OptiSystem

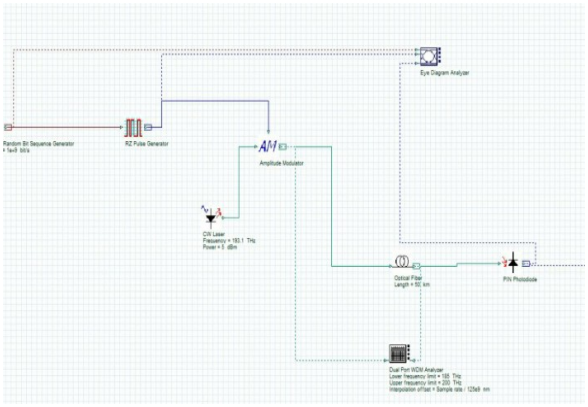

Figure 4: ASK Modulation circuit diagram

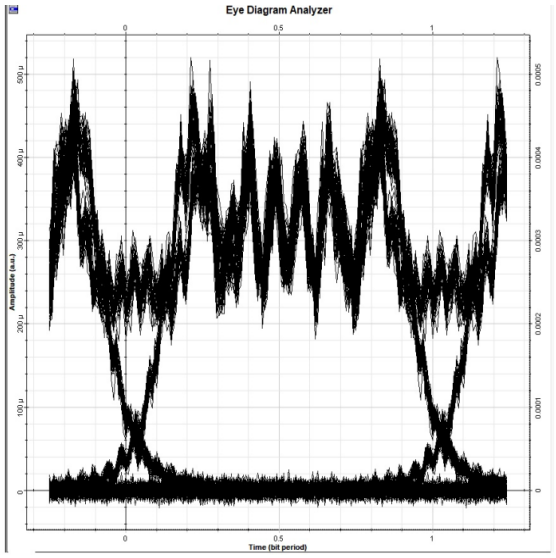

Figure 5: ASK Modulation eye diagram

PSK Modulation in Optisystem

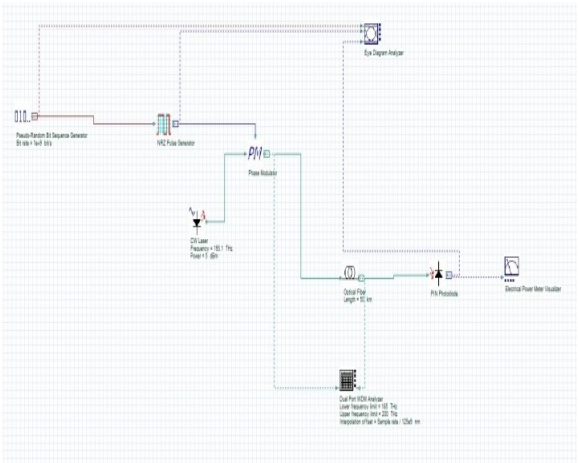

Figure 6: PSK Modulation circuit diagram

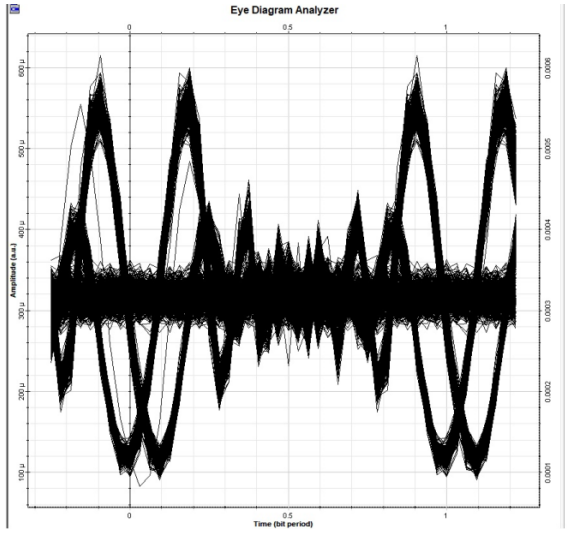

Figure : 7 PSK Modulation eye diagram

FSK Modulation in Optisystem

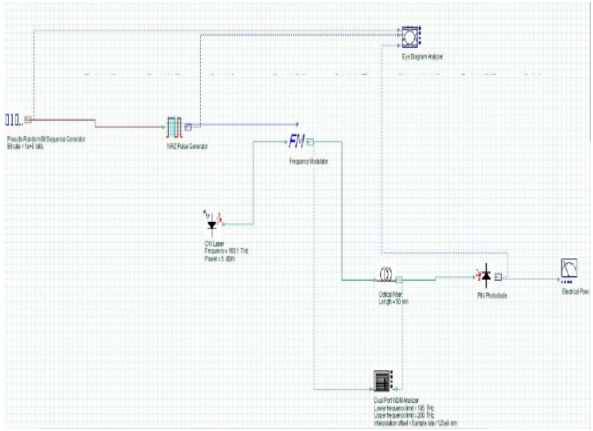

Figure 8: FSK Modulation circuit diagram

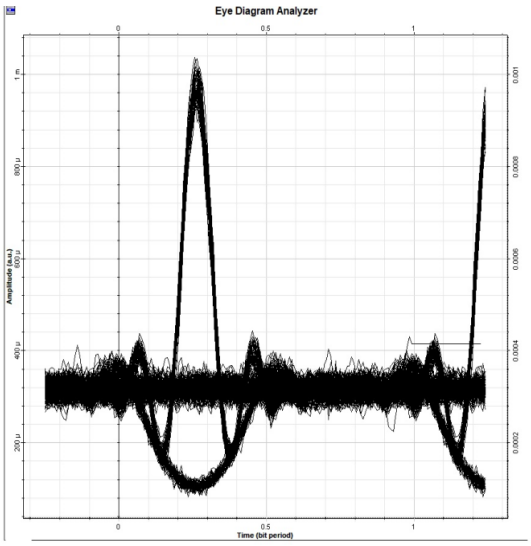

Figure 9: FSK Modulation eye diagram

IV. RESULTS

Observation 1:

Table 1 : Result for Input Parameter

Sl. No.	MODULTION TECHNIQUE	INPUT SIGNAL (dB)	INPUT NOISE (dBm)	INPUT SNR (dBm)	INPUT NOISE 0.1 nm (dB)	INPUT OSNR (dB)
1	ASK	0.5337	-37.7788	38.3125	-39.8200	40.3537
2	PSK	4.9739	-30.9838	35.9577	-33.0250	37.9989
3	FSK	4.9903	-48.6765	53.6669	-50.7177	55.7081

Table 2 : Result for Output Parameter

Sl. No.	MODULTION TECHNIQUE	OUTPUT SIGNAL (dB)	OUTPUTNOISE (dBm)	OUTPUT SNR (dBm)	OUTPUT NOISE 0.1 nm (dB)	OUTPUT OSNR (dB)
1	ASK	-9.4663	-47.7918	38.3255	-49.8330	40.3666
2	PSK	-5.0275	-40.9572	35.9296	-42.9984	37.9708
3	FSK	-5.0104	-58.6654	53.6550	-60.7066	55.6962

Observation 2:

Now the type of fiber is changed for these three modulation techniques ASK, PSK and FSK and then calculate the losses. So the result shown below:

Table 3 : Optical Losses with Respective Fiber

Fiber		Optical loss (dB/km)			
Size(μ)	Type	780 nm	850 nm	1300 nm	1550 nm
9/125	SM	3.0	2.5	0.5-0.8	0.2-0.4
50/125	MM	3.5-7.0	2.5-6.0	0.7-4.0	0.6-3.5
62.5/125		4.0-8.0	3.0-7.0	1.0-4.0	1.0-5.0
100/140		4.5-8.0	3.5-7.0	1.5-5.0	1.5-5.0
110/125			15		
200/230			12		

So on the basis of these two observations, it is concluded that PSK modulation is best suitable modulation techniques because of its best SNR and least probability of error and also the suitable for the operating wavelength of 1550nm where attenuation loss is low.

V. CONCLUSION

Digital Modulation techniques ASK, PSK and FSK are designed and analyzed by using the software OptiSystem 16. Performance is also analyzed on types of fiber and on various lengths (in km) by keeping the bit rate of 2.5 Gbps, 40 Gbps, 100Gbps, 200Gbps, 400Gbps &1000Gbps respectively.

VI. FUTURE SCOPE

In future, polarization angle and wavelength division Multiplexing (WDM) can be added on the analysis. After analyzing all the results, it can be said that suitability of a particular modulation technique for a short and long optical fiber length and also the type of fiber (single mode or Multimode) depending upon the provided conditions.

ABOUT AUTHOR

Mrs. Pragati Patharia received the B.E. degree in Electronics & Telecommunications From Jabalpur Engineering College, Jabalpur, (India) and M. Tech Degrees in Opto Electronics from SGSITS, Indore, (India) in 2005 and 2009, respectively. She has been teaching various subjects like Digital Electronics, Basic Electronics, Microprocessor, Analog & Digital Communication, and Optical Fiber Communication in different Institutes from 2009. Her Research interest is an application of Soliton Communication system in a data network.

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