MODULATION FORMATS IN OPTICAL COMMUNICATION SYSTEM

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ABSTRACT

The objective of this study is to analyse the performance of dispersed managed RZ system, different modulation formats and to study the different compensation techniques at high bit rate. The dispersed managed system is a promising way to transmit data in optical communication networks. The performance of 10 Gbps optical communication system with the dispersion managed return-to-zero (RZ) pulse has been reported The return-to-zero (RZ) pulse is efficient for long-distance, high-bit-rate, wavelength division multiplexed (WDM) transmission dispersion-managed systems. In RZ pulse, the power is transmitted only for fraction of bit period. In this thesis, predictions are made by varying the dispersion parameter of single mode fiber in optical communication system. It has been reported that the performance of the system is improved with increase in the value of dispersion parameter. Using the different types of modulation formats, it is predicted that the novel modulation formats enhance the overall performance of the optical communication systems at high bit rate. The performance of non-return-to-zero (NRZ), carrier suppressed return-to-zero (CSRZ) and do binary modulation format at 10 Gb/s for the optical communication system is analyzed.

I INTRODUCTION

Fiber-optic communication is a method of transmitting information from one place to another by sending light through an optical fiber. Fiber-optic communication systems have revolutionized the telecommunications industry and played a major role in the advent of the Information Age. Because of its advantages over electrical transmission, the use of optical fiber has largely replaced copper wire communications in the developed world. Optical fiber is the most common type of channel for optical communications; however, other types of optical waveguides are used within communications gear, and have even formed the channel of very short distance (e.g. chip-to-chip) links in laboratory trials.

The main benefits of fiber are its exceptionally low loss, allowing long distances between amplifiers or repeaters and its inherently high data-carrying capacity, such that thousands of electrical links would be required to replace a single high bandwidth fiber. Another benefit of fiber is that even when are alongside each other for long distances, fiber cables experience effectively no crosstalk, in contrast to some types of electrical transmission lines With the explosive growth in demand for capacity in national, regional, and even metropolitan optical networks, high bit rate fiber transmission have recently become an essential part of state-of-the-art communications. Modern optical networks a re now primarily based on 2.5 Gb/s and 10 Gb/s channels. 40 Gb/s channels have begun to be implemented in new product offerings [1]. In addition to increases in data rate per channel, the number of channels per fiber is also increased through wavelength division multiplexing (WDM) or dense WDM (DWDM) to further improve overall capacity .High-bit rate transmission is attractive for several reasons. First, it potentially enables lower capital expenditure by sharing transmitter/receiver cost between more data sources or users. Second, it eases wavelength management by reducing the number of WDM channels. Wavelength management, such as reconfigurable optical add/drop multiplexing, is essential to making optical networks transparent, scalable, and flexible, which ultimately reduces the operational expenditure of such networks. Thirdly, high spectral efficiency can be achieved in a WDM system that has a common channel grid through the use of high bit rate

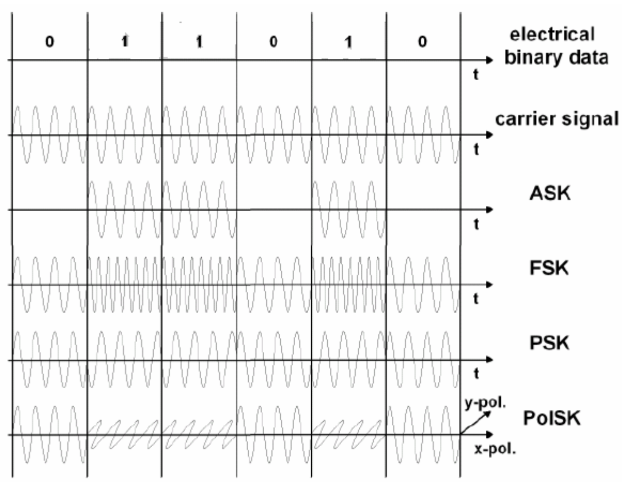


Figure : *Principle of optical signal modulation*

Amplitude Shift keying

Amplitude-Shift-Keying (ASK) known as"On-Off"-keying (OOK) is the technique of modulating the intensity of the carrier signal is shown in figure. In the simplest form, a source is switched between on and off states. The ASK modulation is characterized by the relation between the signal levels in on and off states called extinction ratio (ER). The ER value is dependent on the approach used for the signal generation: direct or external modulation of the laser source. In case of external modulation, the ER is limited by the extinction ratio of the external modulator. Typical ER values vary between 8-12 dB depending on the signal bit rate in use. The ASK-based modulation formats are characterized by simple signal generation and detection, due to which all currently deployed optical transmission systems employ ASK-based modulation formats. In the following section various ASK-based modulation formats is discussed. Due to the use of different modulation methods for generation of these formats, they posses different signal shapes (e.g. return-to-zero or non return-to-zero) and spectral characteristics, resulting in different transmission.

Frequency Shift Keying

Frequency Shift Keying (FSK) is realized by switching the laser light frequency between two frequency values as shown in figure. In FSK, the optical signal envelope remains unchanged and the complexity of signal generation and detection increases compared to ASK modulation. FSK modulation is characterized by the modulation index. By the variation of modulation index, different FSK based modulation format can be realized. The differences between FSK formats are reflected in the optical signal spectra, whereby a smaller modulation index enables more compact optical spectra. The FSK-based formats are not used in already deployed transmission systems because of complex signal detection. More recently, FSK-based modulation known as Dispersion Supported Transmission (DST) format was intensively investigated for the implementation in MAN networks. The main drawback of this new technique is that the transmitter and receiver parameters have to precisely match the characteristics of the transmission line.

Phase Shift Keying

Phase Shift Keying (PSK) uses the phase of the signal to encode information. Optical PSK signals posses a narrow spectrum and a constant signal envelope as shown in figure, which enables improved nonlinear tolerance, but on the other hand the PSK signals are sensitive to a phase modulation induced by multi-channel effects, which can result in decoding errors at the receiver side. At the same time, PSK-based modulation enables improved receiver sensitivity (up to 6 dB) compared to ASK-formats. Especially interesting method of PSK modulation is differential PSK (DPSK). In DPSK signals, the information is encoded in the phase change between two successive bits. Basically, PSK signals only allow coherent detection, which require a local oscillator at the receiver to compare the phase of transmitted with the phase of the local signal, making the feasibility of this modulation more difficult. Also, a phase-locked-loop (PLL) is required to synchronize the local oscillator to the received signal. Pure PSK modulation is rather inapplicable for the system implementation, but some special binary and multilevel variants of PSK like DPSK or differential quaternary PSK (DQPSK) allow the use of direct detection methods. DQPSK enables a further improvement of the code efficiency using 4 different phases, where the signal symbol rate is half of that in DPSK case. The DQPSK bit stream must be differentially encoded using a digital pre-coder. The signal detection in DPSK formats can be made using MZI interferometer based configurations which enable a reduced detection complexity compared to coherent detection. In spite of increased realization complexity of PSK modulation, recently presented DPSK and DQPSK system are as good lternatives to ASK-based modulation formats in future high speed WDM systems.

Polarization Shift Keying

Polarization Shift Keying (PolSK) is the most exotic modulation format among all already presented. The optical PolSK signals are generated by switching the signal polarization between two orthogonal states of polarization. The PolSK is characterized by a Constant signal envelope enabling an improved nonlinear tolerance, an improved sensitivity (3 dB) compared to ASK-based modulation, and enable a better utilization of the system bandwidth by the use of orthogonal polarization as an additional degree of freedom. The drawbacks of PolSK are an increased complexity of signal generation and detection, as well as, the sensitivity to polarization disturbances in the transmission line, whose impact increases with an increased channel data rate.

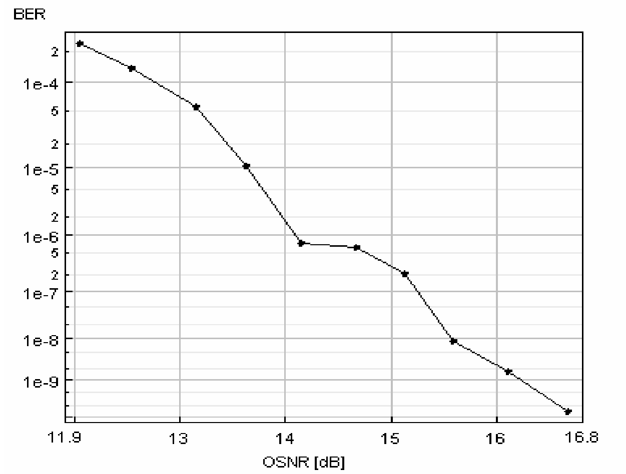
II PERFORMANCE OF OPTICAL SYSTEM WITH DIFFERENT MODULATION FORMATS

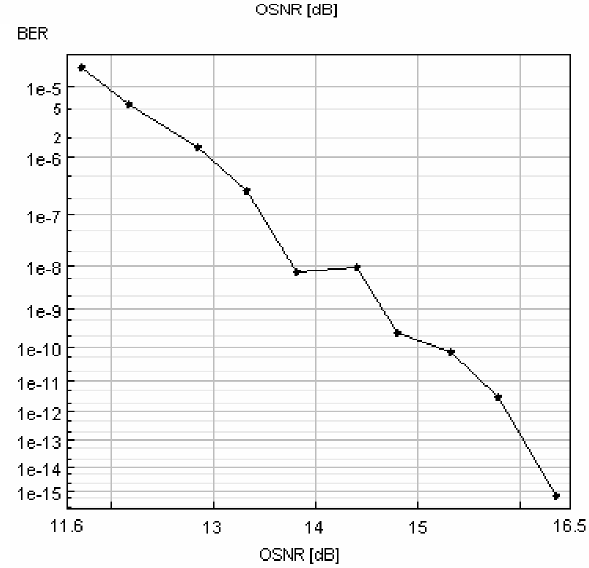
The performance of NRZ, CSRZ and doubinary modulation format at 10 Gb/s for the optical communication system at 10 Gb/s is analyzed. The performance evaluation of the modulation format has been analyzed in terms of the bit error rate against the accumulate dispersion and optical signal to noise ratio. The dispersion tolerance of the modulation formats has been analyzed. It is observed that doubinary modulation format provides the maximum dispersion tolerance. It is shown that CSRZ has the lowest bit error rate BER value. It is reported that CSRZ modulation format has the edge over NRZ and doubinary modulation format. The performance of the NRZ, CSRZ and doubinary has been observed which shows that CSRZ is better for long optical communication system at 10 Gb/s. The analysis indicates that the AGV is a bottleneck for the flexible manufacturing cell. There are on average a large number of parts waiting for transport by the AGV. Currently AGV utilization is 100%. The addition of a second AGV is a logical solution to the problem of excessive utilization, but due to cost inefficiencies it was not considered as a viable alternative.

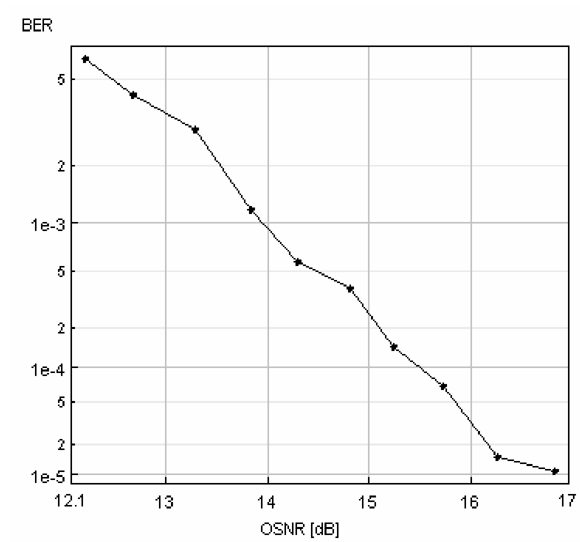
The optical communication systems are used as high speed long haul communication system. Due to high data rates, limitation due to dispersion and nonlinearities in the optical communication system has been of great concern as these parameters limits the overall efficiency of the system. An optical modulation format is the method used to impress data on an optical carrier wave for transmission over optical fiber. The ideal modulation format for long haul, high speed and WDM transmission links is the one that has a narrow spectral width, low susceptibility to fiber nonlinearity, large dispersion tolerance and good transmission performance and has a simple and cost-effective configuration for generation. In Inensity-modulated direct-detection (IM/DD) systems, there are two possible modulation formats, non return-to-zero (NRZ), tin which a constant power is transmitted during the entire bit period, and return-to-zero (RZ), in which power is transmitted only for a fraction of the bit period. Most commercial systems use the NRZ modulation format The non-return-to-zero (NRZ) has been the most dominant modulation format in intensity modulated-direct detection fiber-optical communication systems for the last years. The reasons for using the NRZ in the early days of fiber-optical communication as it is not sensitive to laser phase noise, requires a relatively low electrical bandwidth for transmitter and receivers compare with the RZ and the simplest configuration of transmitter and receiver. The NRZ pulses has a narrow optical spectrum .The reduced spectrum width improves the dispersion tolerance but it has the effect of intersymbol interference. The RZ pulse occupies just a part of the bit slot, so it has a duty cycle smaller than 1 and a broad spectrum. The RZ pulse shape enables an increased robustness to fiber nonlinear effects and to the effect of polarization mode dispersion (PMD). Due to its broader spectrum, the RZ pulse has a reduced dispersion tolerance and spectral efficiency. The RZ achieves a 1-2 dB advantage in optically pre-amplified receiver sensitivity compared to the NRZ .Carrier suppressed RZ pulse is a special form of the RZ pulse where the carrier is suppressed. The difference between the CSRZ and conventional RZ is that the CSRZ signal has a p phase shift between adjacent bits. The CSRZ signal is far less sensitive to fiber nonlinear effects and provides better robustness against transmission impairments. Optical duobinary format s a very interesting modulation format, which offers high spectral efficiency and chromatic dispersion tolerance. In the duobinary format, the optical phases of “1” bits that are separated by an odd number of “0s” differ by p radians. The optical spectrum of the duobinary signal is very compressed as compared to many other binary formats. The LPF duobinary has recently received significant attention. One reason for this is that duobinary can be easily created using simple low-cost techniques. So different types of modulation techniques are used these days to enhance the performance of optical communication system. Each modulation format has its own advantages and disadvantages. Depending upon the required application, the modulation format is used.

III RESULT AND DISCUSSION

In previous section, various component and parameters used in simulation setup are discussed. Using some of these components, the bit error rate (BER), optical signal to noise ratio and eye-diagrams is measured at the receiver end is measured. The measurement component used are Q estimator to measure Q-factor, average eye opening values and timing jitters, BER estimator to measure to measure bit error rate (BER), electrical scope to measure eye diagrams and optical probe to measure optical spectrums the performance of NRZ, CSRZ and doubinary modulation format at 10 Gb/s for the optical communication system at 10 Gb/s is analyzed. The performance evaluation of the modulation format has been analyzed in terms of the bit error rate against the accumulate dispersion and optical signal to noise ratio. The dispersion tolerance of the modulation formats has been analyzed. It is observed that doubinary modulation format provides the maximum dispersion tolerance. It is shown that CSRZ has the lowest bit error rate BER value. It is reported that CSRZ modulation format has the edge over NRZ and doubinary modulation format. The performance of the NRZ, CSRZ and doubinary has been observed which shows that CSRZ is better for long optical communication system at 10 Gb/s. The optical communication systems are used as high speed long haul communication system. Due to high data rates, limitation due to dispersion and nonlinearities in the optical communication system has been of great concern as these parameters limits the overall efficiency of the system. An optical modulation format is the method used to impress data on an optical carrier wave for transmission over optical fiber. The ideal modulation format for long haul, high speed and WDM transmission links is the one that has a narrow spectral width, low susceptibility to fiber nonlinearity, large dispersion tolerance and good transmission performance and has a simple and cost-effective configuration for generation. In Intensity-modulated direct-detection (IM/DD) systems, there are two possible modulation formats, non return-to-zero (NRZ), in which a constant power is transmitted during the entire bit period, and return-to-zero (RZ), in which power is transmitted only for a fraction of the bit period. Most commercial systems use the NRZ modulation format. The non-return-to-zero (NRZ) has been the most dominant modulation format in intensity modulated-direct detection fiber-optical communication systems for the last years. The reasons for using the NRZ in the early days of fiber-optical communication as it is not sensitive to laser phase noise, requires a relatively low electrical bandwidth for transmitter and receivers compare with the RZ and the simplest configuration of transmitter and receiver. The NRZ pulses has a narrow optical spectrum .The reduced spectrum width improves the dispersion tolerance but it has the effect of intersymbol interference. The RZ pulse occupies just a part of the bit slot, so it has a duty cycle smaller than 1 and a broad spectrum. The RZ pulse shape enables an increased robustness to fiber nonlinear effects and to the effect of polarization mode dispersion (PMD). Due to its broader spectrum, the RZ pulse has a reduced dispersion tolerance and spectral efficiency







The above figures show the graphs for BER vs. OSNR for the NRZ, CSRZ and doubinary modulation format. It can be seen from all the three graphs that the value of BER is decreased with increase in the OSNR value. The value of BER for the NRZ, CSRZ doubinary modulation format at OSNR value of 16 is 91e−,141e−,51e− respectively. The CSRZ modulation format has the best BER value from the entire different modulation format at. a given value of OSNR where as doubinary has the worst BER value. Hence the doubinary system requires a high input power to achieve the desired BER value which limits the performance of the doubinary modulation format to some extent. It is observed that the CSRZ provides a good performance at high bit rate. The CSRZ modulation can be used for long distance communication system at high bit rates.

IV CONCLUSION

In this chapter, the performance of NRZ, CSRZ and doubinary modulation format at 10 Gb/s for the optical communication system is analyzed. It is observed that the CSRZ modulation format has the edge over the NRZ and doubinary modulation format. It is shown that the CSRZ has the lowest BER value. It is reported that the Doubinary modulation format provides the higher dispersion tolerance among the three modulation formats. The doubinary modulation format can be recommended for long distance communication systems at high bit rates but its performance are limited by the low OSNR value. It is observed that the NRZ modulation format has the worst performance in terms of dispersion tolerance. It is reported that the NRZ modulation format has a better OSNR value than the doubinary modulation format. The NRZ modulation format can be used for small distance communication system a high bit rates. It is concluded that the CSRZ modulation format is best for the long distance optical communication system due to its low value of BER and tolerance to the dispersion at high bit rates. That is, production output is maximized, long-term percentage mixes are met, and the average time a part spends in the manufacturing cell is minimized.

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