BER and Q-Value Performance Analysis of WDM Network Using DPSK Modulation Format
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Abstract: In this paper a novel and simple non-return-to-zero differential phase shift keying (NRZ-DPSK) wavelength division multiplexing (WDM) system is investigated using OPTSIM. It has been analyzed Bit Error Rate (BER) and Q-value performance for WDM system using Differential Phase Shift Keying (DPSK) modulation scheme. we study the BER as well as Q-value performance for different system parameters such as fiber length, gain, number of amplifier and channel spacing. With the aid of analysis and simulation results it is demonstrated that the influence of different system parameters on the BER and Q-value performance of an Optical system using differential modulation schemes.

Keywords — Optical Communication, WDM, BER, DPSK, Fiber Length, Q-value, Fiber Gain.

I. INTRODUCTION

The bandwidth-distance product is a figure-of-merit in optical communication systems. Increase in data-rate per channel and tighter channel spacing in the main factors to increase the capacity of optical communication systems. Tight channel spacing and a 40 Gbps and higher data rate of a WDM system are the possible solutions.

A WDM system uses the Wavelength Division Multiplexing technique to communicate the channels with very low channel spacing so that they do not interfere so much and the receiver is capable to receive a good quality signal. A WDM network provides an effective telecommunication infrastructure over which a variety of services can be delivered[1].

To improve the quality of the received signal and to minimize both the linear and the nonlinear impairments over the transmission fiber, an optimal modulation format is needed[3]. A modulation format with a narrow optical spectrum improves the spectral efficiency and tolerance to chromatic dispersion. A modulation format with constant optical power can be less susceptible to SPM and XPM[4]. Modulation format with multiple signal levels will carry more information than binary signals and its longer symbol duration will reduce the distortion induced by chromatic dispersion and polarization mode dispersion[11].

Use of low noise optical amplifiers, advanced optical fibers and forward error correction techniques, are crucial to realize high spectral efficiency, and hence high-capacity optical transmission networks. Constant intensity formats like DPSK and DQPSK, although have relatively complex transmitter and receiver setups still proved their strong candidacy for high data-rate and spectral efficient DWDM systems. These constant intensity formats have inherent 3-dB better receiver sensitivity by using balanced detection[12].

II. SIMULATION TOOL (OPTSIM)

This simulation tool (OPTSIM) provides support for multiple parameter-scans-based optimizations. It is the only design tool with multiple engines implementing both the Time Domain Split Step and the Frequency Domain Split Step for the most accurate and efficient simulation of any optical link architecture. MATLAB interface makes it easy to develop custom user models using the m-file language and/or the Simulink modeling environment. Interfaces with laboratory test equipment such as Agilent and Luna to merge simulation with experiment. Interfaces with device-level design tools such as Beam PROP and Laser MOD provide a powerful mixed-level design flow for optoelectronic circuits and systems. Application Programming Interface (API) for programming languages such as C/C++ for the development of custom user models. Best Fit Laser Toolkit™ makes customizing powerful rate-equation laser model parameters to fit desired performance characteristics easily. Extensive library of predefined manufacturer components makes it easy to model commercially available devices. Intuitive and flexible measurement post-processing graphical interface acts like a virtual laboratory instrument.

III. SYSTEM MODEL

Block diagram of a WDM system that is implemented for simulation is shown in Fig. 1. In this work DPSK transmitter and receivers are used in a WDM system for Optical fiber communication. The DPSK transmitter and receiver are first designed as a compound component and then called in the schematic.

![Fig.1 Shows the Block Diagram of a WDM System](image-url)
Various measurement tools such as Electroscope, BER estimator and BER calculator can be used to take the measurement of different performance parameters such as BER, Q-value etc.

IV. SIMULATION RESULTS

Here simulation results showing BER performance and Q-value performance of a WDM optical system using DPSK modulation scheme are presented. In the following subsections we discuss the effect of three key parameters along with the transmitter power on BER and Q-value performances at three channels; channel 1, channel 8 and channel 16 of a 16-channel WDM system.

A. Effect of Booster Gain

1) BER Performance

From the graph shown in fig. 2, 3 and 4 it is observed that the BER for WDM system at all the channels decreases as the transmitter power increases. It is also demonstrated that as the booster gain increases the BER value decreases. Hence, the system performance increases with increase in the booster gain for all channels in a WDM system. The effect of booster gain variation is greater at channel 8 compared to channel 1 and channel 16 i.e effect is greater near to the central frequency of the WDM system and decreases towards ends. Rate of decrement is more towards the higher frequency end compared to the other lower frequency end. Thus by increasing the transmitter power we can improve the system performance.
2) Q-Value Performance

Fig. 5, 6 and 7 shows the Q-value performance of a 16 channel WDM system at channel 1, 8 and 16. Here the Q-value vs. transmitter power is plotted for various values of booster gain.

Fig. 5 Q-value vs. Transmitter Power in dBm at Channel 1 for different Booster Gains

Fig. 6 Q-value vs. Transmitter Power in dBm at Channel 8 for different Booster Gains

Fig. 7 Q-value vs. Transmitter Power in dBm at Channel 16 for different Booster Gains

The booster gain effect increases as the transmitter power decreases thus we need higher values of booster gain with low transmitter powers to get the better performances.

B. Effect of number of Inline-Amplifiers

1) BER Performance

Fig. 8 BER vs. Transmitter Power in dBm at Channel 1 for different number of Inline Amplifiers
Fig. 8, 9 and 10 illustrates the graphs showing the BER performance of a WDM system for various number of inline amplifier. It is observed that as we install the inline amplifier in the network the BER performance improves drastically. From the graphs it is clear that the BER performance is best among all these for N=4 for 100 km of fiber length where inline amplifiers are installed after each fiber span of 25 km. this fiber span length depends on the total distance for communication and the value of the BER that must be required for the successful transmission of a signal. The gain of inline amplifier is fixed by analyzing the fiber cable properties such as dispersion and polarization within in the fiber cable used for the transmission purpose.

Fig. 11, 12 and 13 illustrates the graphs showing the Q-value performance of the WDM system for various number of inline amplifier. The graph demonstrates that the Q-value of a WDM system increases as the transmitter power increases.

From the BER performance graphs and Q-value performance graphs it is clear that the Q-value varies approximately inversely proportional to the BER value.

2) Q – Value Performance
C. Effect of Fiber Length

1) BER Performance

Fig.12 Q-value vs. Transmitter Power in dBm at Channel 8 for different number of inline Amplifiers

Fig.13 Q-value vs. Transmitter Power in dBm at Channel 16 for different number of Inline Amplifiers

Fig.14 BER vs. Transmitter Power in dBm at Channel 1 for different Fiber Lengths

Fig.15 BER vs. Transmitter Power in dBm at Channel 8 for different Fiber Lengths
2) \textit{Q – Value Performance}

Fig.16 BER vs. Transmitter Power in dBm at Channel 16 for different Fiber Lengths

Fig.17 Q-value vs. Transmitter Power in dBm at Channel 1 for different Fiber Lengths

Fig.18 Q-value vs. Transmitter Power in dBm at Channel 8 for different Fiber Lengths

Fig.19 Q-value vs. Transmitter Power in dBm at Channel 16 for different Fiber Lengths
Fig. 14, 15 and 16 illustrates the BER performance graphs at three different channels channel 1, 8 and 16 of a 16-channel WDM system. As the length of the fiber decreases the losses associated with the fiber also decreases and hence the BER value of the communication system decreases and the Q-value increases as demonstrated by the graphs shown in fig. 17, 18 and 19.

V. CONCLUSION

From the above discussion on simulation results of WDM system performances for various parameters we conclude that a WDM system provides its best performances at the channel nearer to the central frequency of the WDM system. It also concludes that the effect of parameters is also greater nearer to the central transmission frequency. The value of BER decreases with the use of the inline amplifiers. And hence improves the Q-value performance. Thus we concludes that the WDM system Q-value and BER performance improves as the booster gain increases and fiber length span decreases and hence help in increasing the transmission distance for the same transmitter parameters.

VI. REFERENCES


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