Comparative analysis between RZ-DPSK and NRZ-DPSK at 10Gb/s in optical communication system by using DCF

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Abstract--In this paper, the performance ofRZ-DPSK and NRZ-DPSK modulation techniques with/without dispersion compensating fiberin optical communication system has been analyzed. Dispersion compensating fibers are developingvery fast to gain the dispersion compensation of real value and perfect coupling to fibers to sustainwavelength stability. A effort is shown to improve the performance of the system in terms of bit error rate (BER) and Q-value by proposing a combination of fibre length by using SMF-DCF for RZ-DPSK and NRZ-DPSK modulation techniques. The combination of SMF-DCF improves the optical distance. The BER and Q-value are observed for RZ-DPSK and NRZ-DPSK at the transmission rate of 10 Gb/s.

Keywords--Dispersion compensation, BER, Q-value, DCF, SMF, RZ-DPSK and NRZ-DPSK.

1. Introduction

Superior spectral efficiency (SE) and ultra-high speed WDM transmission owing to their inherent 3-dB better receiver sensitivity have helped the Differential Phase Shift Keying (DPSK) modulation formats remain in forefront in the recent days. It has attracted much attention from researchers and industry alike. The direct detection of these phase coded formats has a significant dependency on the design of Mach-Zehnder delay interferometer. The performance of optical communication systems can be significantly improved by using the technique of Differential Phase Shift Keying format. Phase of the optical carrier signal is used to carry the information in the DPSK modulation format. The appearance of optical power in a DPSK signal is observed in each bit slot. The binary data is encoded as either a π or 0 optical phase shift in between adjacent bits. The entire bit slot can be occupied by the optical power in NRZ-DPSK (Non Return To ZeroDifferential Phase Shift Keying). In RZ-DPSK (Return To Zero Differential Phase Shift Keying), an optical pulse represents the optical power of transmission. A DPSK modulator, in combination with an RZ pulse carver, can be used to implement an NRZ-DPSK.

DPSK signals are found to have high receiver sensitivity due to the ~3dB lower OSNR (Optical Signal To Noise Ratio)which is required to achieve a given BER(Bit Error Rate). Reducing the optical power requirements, extending the transmission distance and relaxing component specifications are some cogent uses of DPSK.

2. RZ-DPSK and NRZ-DPSK

On the transmission rate of 10 Gb/s, RZ-DPSK and NRZ-DPSK modulation techniques are being used in the optical communication system. The graph is plotted between the optical distance and BER shown in Figure 1. Optical length varies from 40 to 160 Km. The NRZ-DPSK performs better in terms of BER, as it gives 10^{-10} BER for 105 Km distance. The RZ-DPSK performs only up to 100 Km for the BER of 10^{-10} at the transmission rate of 10 Gb/s.
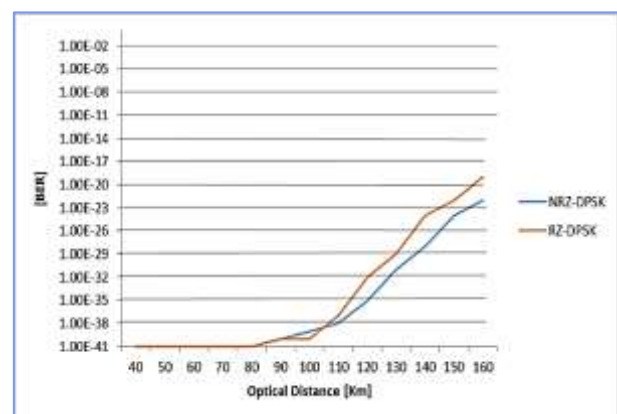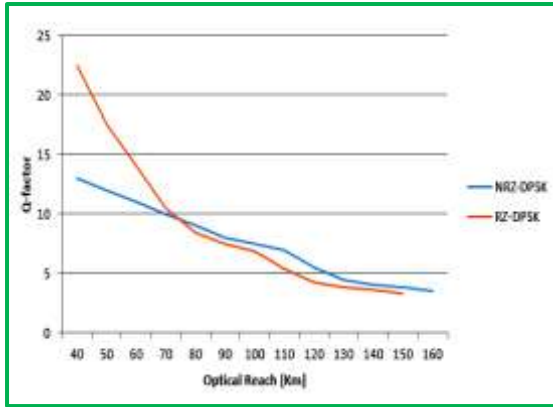

Figure 1: BER for 10 Gb/s systems with different fibre length

In Figure 2, the graph is plotted between optical distance and Q-factor for 10 Gb/s transmission rate. The optical distance varies from 40 Km to 160 Km. It can be seen from the graph below that RZ-DPSK gives higher Q value than the NRZ-DPSK.

Figure 2: Q-factor for 10 Gb/s systems with different fibre length

3. RZ-DPSK andNRZ-DPSK with dispersion compensation fibre technique

In the dispersion compensated link, which comprises of a standard SMF (Single Mode Fibre) and a DCF (Dispersion Compensation fibre) the sequence takes place like as mentioned. The input pulses initially expand due to the propagation through the SMF and then subsequently it recompress to its original shape due to the propagation through the DCF. The DCF must have the dispersion coefficient parameter of opposite sign to that of SMF, for this pattern to be exercised in the process of the propagation of a pulse through the fibre.The group velocity dispersion (GVD) acts to change the frequency of transmission across the pulse. This is often referred to as frequency chirp also. The chirp primarily depends on the sign of the dispersion parameters. The two chirp contributions cancel each other however the broadening rate decreases progressively during propagation in the fibre with positive dispersion coefficient parameter. The study of dispersion management technique employed to compare and reduce the chirping highlights and the comparison with the DCF pulse propagation. Consider the situation in which each optical pulse propagates through two fibre segments, the second of which is DCF. The equation for perfect dispersion compensation is:

$$D_1 L_1 + D_2 L_2 = 0 \qquad \ldots\ldots 1$$

i.e., its length should be chosen to satisfy

$$L_2 = -(D_1/D_2) L_1 \qquad \ldots\ldots 2$$

where D_1 and D_2 are the fibre dispersions of SMF and DCF respectively. For practical reasons, L_2 is kept be as small as possible. The condition is fulfilled only if the DCF has a large negative value

of D_2 in the equation stated above. The case demonstrated here consists of 120 Km fibre span which consists of two segments, SMF of length L_1 Km and DCF of length L_2 Km. L_1 and L_2 are kept variables for the demonstration of clear difference in parameters of both the types of modulation. The optical signal is fed into the fibre and the fibre parameters are adjusted in accordance to the simulation environment. In this particular work demonstration, the transmission link is composed of SMF of length L_1 and DCF of length L_2. The input power is scaled at 1dbm to analyse the effects of SMF and DCF on the parameters of signal received.

In Table 1.2, the SMF length L_1 varied from 120 to 85 Km and DCF length L_2 varied from 0 to 35 Km. The BER and Q value for the L_1=100 and L_2= 20 Km indicates its superior system performance at this combination.
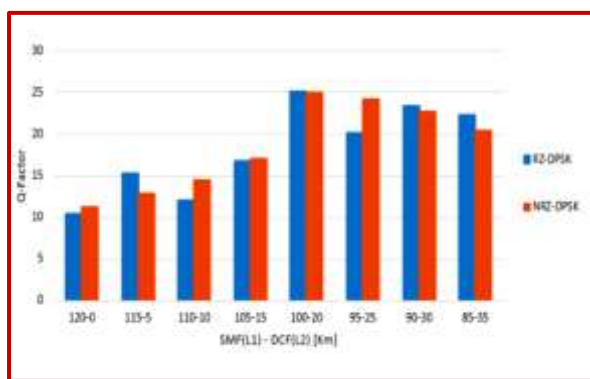
Table 1.2 Combination of SMF and DCF lengths

S. No.	SMF (L1) Km	DCF (L2) Km	Remark
1	120	0	Without DCF
2	115	5	With DCF
3	110	10	With DCF
4	105	15	With DCF
5	100	20	With DCF
6	95	25	With DCF
7	90	30	With DCF
8	85	35	With DCF

The length of fibre is varied in accordance with combination of SMF and DCF. As it can be seen from above Table that value of the SMF varies from 120 Km to 85 Km and DCF varies from 0 Km to 35 Km. The value of BER and Q are also varied with the different combination of the SMF and DCF. The lowest BER and higher Q value shows the best combination of the SMF–DCF.
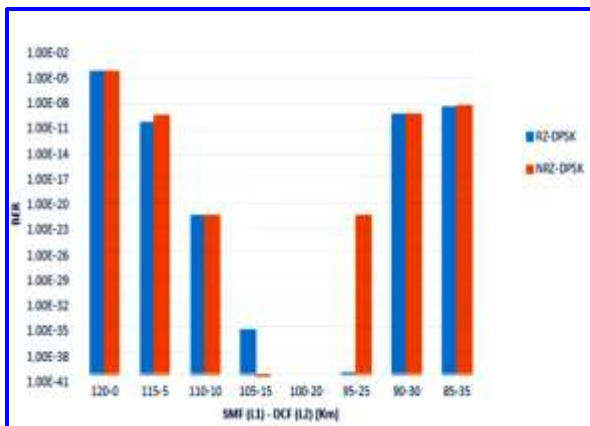
Figure 1.3Variation of BER with SMF DClength for RZ-DPSK and NRZ-DPSK

Figure 1.4 Variation of Q with SMF-DCF length for RZ-DPSK and NRZ-DPSK

4.Conclusions

A dispersion compensation fibre is used with proper length which compensates the dispersion of the signal. RZ-DPSK, NRZ-DPSK modulation techniques are analyzed with the combination of SMF and DCF. The length of DCF is varied with the length of SMF and a proper combination of both on which the value of BER and Q gives the best result. These results show that RZ-DPSK gives higher Q value than NRZ-DPSK modulation technique.

The combination of SMF with DCF varies for every BER and Q value. The SMF varying from 120 Km to 85Km and with this DCF is also varying. First SMF has taken of 120Km which is without any DCF and it gives the worst result of BER and Q. As a DCF is combined with the SMF, BER starts decreasing and the Q value improves. For various combinations of SMF-DCF, the value of BER and Q are noted down. It is observed from Figure 1.3 and 1.4 that at the combination of SMF-120Km and DCF-20Km the BER and Q have their best values. When both modulation techniques are

compared on the basis of BER and Q value, RZ-DPSK performs better. The value of BER and Q has minor differences between these two modulation techniques. If DCF is present with the SMF than only it can perform better up to a certain optical reach. As it gives the lowest BER and high value of Q but optical reach limits the performance of RZ-DPSK.

5. References

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