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ANALYZING THE PERFORMANCE OF OPTICAL SYSTEM USING DIFFERENT MODULATION TECHNIQUES

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Abstract: *Couple of years from now, the optical fiber will have totally replaced the copper fiber due to its points of interest over the later one, for example, greater bandwidth, higher security, flexibility, immunity to electrical interface, more reliability, ease of design and Cost of material. The interest for the larger noise free information is expanding step by step and the information transmission limit is still not coordinating up with it. Transmission limit is influenced due to distinctive scattering issues and non-linearities existing in optical fiber. It results in lower transmission rate. Expanding the transmission separation and the transmission rate additionally influences extremely to the Q-value. Thus in this paper, work is done in this field to build the transmission rate over long separation and to acquire enhanced Q-value and BER rate. Return-to-zero signals and duobinary signals are used to check the performance of the optical network at 40Gbps bit rate upto a distance of 900km.*

Keywords: *Optical, Return-to-zero, Duobinary signals, Nonlinearities, Q-factor, Bit Error Rate.*

I. INTRODUCTION

The continuing demand of more and more bandwidth and data rates is the major challenge faced by today's communication industry. Optical Fiber network is a fascinating solution to fulfill the worldwide rising requirement for transmission capacity in the next generation. But the presence of non-linear effects and dispersion in the optical fiber communication system adversely affects the communication between two receiving ends. Nonlinearities and dispersion are the major barrier in optical field. Dispersion is of two ways: Chromatic dispersion and Polarized Mode Dispersion. Chromatic dispersion can be eliminated by implementing Fiber Bragg Grating (FBG) or by placing Dispersion Compensating Fiber (DCF) in between single mode optical fiber links. Here, we have used DCF for compensating dispersion.

Now there are several nonlinear effects in optical links, such as Self-Phase Modulation (SPM), Cross Phase Modulation (XPM), Stimulated Raman Scattering (SRS), Stimulated Brillouin Scattering (SBS), and Four-Wave Mixing (FWM). Out of which SBS and SPM is inspected in single channel link whereas SRS, XPM and FWM is introduced in multi-channel link. The description of all this nonlinearities is as below:

1.1 Self Phase Modulation: Within a single pulse of light in the fiber, there is difference in the RIs at the leading edge in the middle and at the trailing edge. This changes the phase and the frequency and hence the pulse is broadened. SPM creates a "chirp" i.e., a gradual shift in frequency over the whole duration of a pulse.

1.2 Cross Phase Modulation: XPM is caused by multiple pulses travel in the fiber as in WDM communication system and their overlapping. Distortion & pulse broadening is caused by cross phase modulation.

1.3 Stimulated Raman Scattering: SRS occurs when intense beam of light of high power level propagates in the optical fiber, then interaction between vibration of molecules of Sio2 and light takes place. It affects the power distribution of the input data channels & lead to channel to channel crosstalk.

1.4 Stimulated Brillouin Scattering: SBS is a scattering of light backwards towards the transmitter which is caused by mechanical vibrations in the transmission medium (fiber). SBS is caused by the presence of the optical signal itself.

1.5 Four Wave Mixing: FWM effect occur if three or more light pulses having different wavelength & travelling through single fiber interact together to generate a new pulse.

This paper depicts the investigation of the effect of nonlinear impacts on the execution of an optical system utilizing Return-to-Zero (RZ) signals and duobinary signals.

II. SIMULATION SETUP

The simulation is done using OptiSystem Simulation Software. OptiSystem is a thorough programming outline suite that empowers to arrange, test, and rebuild optical connections in cutting edge optical systems. Propose algorithm comprises of a transmitter with RZ signals and duobinary signals, optical fiber with an Erbium Doped Fiber Amplifier (EDFA) which is put after every length of fiber such that the misfortunes are adjusted, optical receiver consisting of PIN photodetector, Bessel filter and BER analyzer to analyze the yield result. So as to investigate the effect of nonlinearities on the optical fiber communication system, the transmission distance of the optical system is differed. The length of the optical Single Mode Fiber (SMF) is differed and in agreement with it the length of Dispersion Compensating Fiber (DCF) is additionally changed individually as indicated by the equation,

$$D_{SMF} \text{ X } L_{SMF} + D_{DCF} \text{ X } L_{DCF} = 0_{[5]}$$

Where, D_{SMF} = Dispersion Coefficient of Single Mode Fiber
L_{SMF} = Length of Single Mode Fiber
D_{DCF} = Dispersion Coefficient of Dispersion
L_{DCF} = Length of Dispersion Compensating Fiber

To produce the optical signs we have utilized a CW laser source, Mach-Zehnder modulators, NRZ signal generator and a sinusoidal electrical sign generator. Moreover, we have utilized a duobinary precoder for the duobinary signals with a specific end goal to maintain a strategic distance from recursive interpreting in the recipient.

The duobinary was produced by first making a NRZ doubinary signal utilizing a precoder and a duobinary pulse generator. The generator drives the first MZM, and afterward connects this modulator with a second modulator that is driven by a sinusoidal electrical sign with the frequency of 40 GHz. The duobinary precoder utilized here was made out of an exclusive-or gate with a delayed feedback path. The considered simulation parameters are shown in below table:

Table 1: Simulation Parameters

Parameters	**Values**
Bit Rate	40 Gbps
Modulation	RZ, Duobinary
Distance	50xn km (n=2, 4, 6, 8,10, 12, 14, 16, 18)
Power	4 mw
Length of SMF	50 km
Dispersion coefficient of SMF	17 ps/nm/km
Length of DCF	10km
Dispersion coefficient of DCF	-85 ps/nm/km

III. RESULTS

We have simulated the optical link working at 40 Gbps. For the compensation of dispersion, DCF in symmetrical design is utilized. The non-linear effects with this dispersion compensation configuration utilizing RZ and duobinary modulation have been analyzed at different transmission distance. The nonlinear effects are analyzed in terms Q Factor, BER with the use of Eye Diagrams. Following table shows the impact of nonlinear effects on the Q-factor in accordance to the increase in transmission distance for Duobinary and RZ modulation.

Table: 2 Q-factor vs. Distance

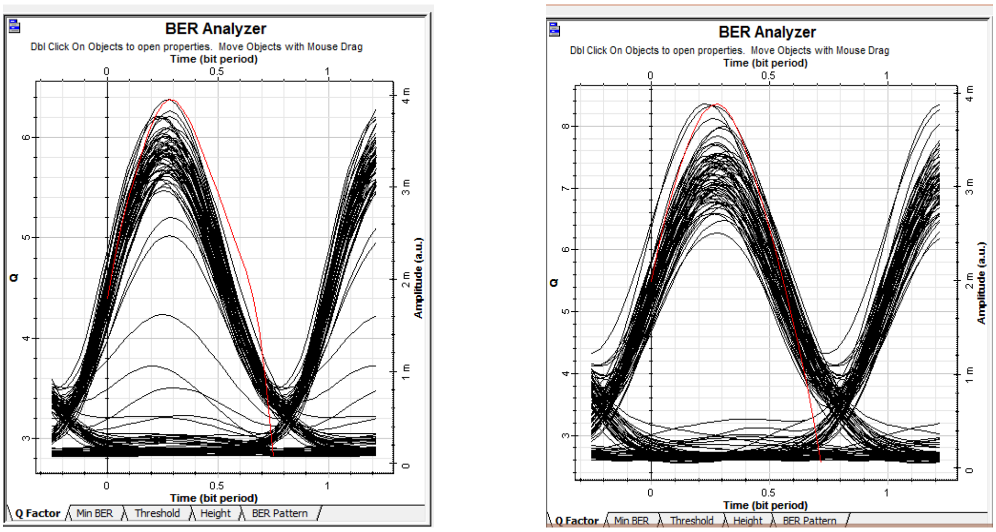
Modulation	Distance (km)								
	100	200	300	400	500	600	700	800	900
Return-to-zero	61.44	41.08	29.32	21.04	15.73	11.96	9.39	7.63	6.38
Duobinary	58.22	39.40	30.61	24.83	20.18	16.14	12.80	10.23	8,35

As seen from the table for shorter distance range nearly about 200km RZ shows better performance compare to duobinary but for longer distance Duobinary signals is more preferable. The Bit Error Rate table for the two signals is also shown below.

Table: 3 BER vs. Distance

Modulation	Distance (km)								
	100	200	300	400	500	600	700	800	900
Return-to-zero	0	0	2.3E-189	1.4E-98	4.5E-56	2.8E-33	3.0E-21	1.5E-14	8.8E-11
Duobinary	0	0	2.7E-206	1.6E-136	5.5E-91	5.5E-59	6.5E-38	5.9E-25	2.7E-17

Eye diagram of the two signals at 900km having 40 Gbps bit rate is shown below. From eye pattern it can be seen that Duobinary signals has more eye opening compared to RZ signal.



(a) Return-to-Zero (RZ) **(b) Duobinary Signal**

Figure 1: Eye Pattern for (a) Return-to-Zero (RZ) and (b) Duobinary signals

IV. CONCLUSION

In this paper, two signals are utilized for the compensation of impact of nonlinear effect on optical fiber system. It can be concluded that for longer distance at higher bit rate duobinary signals gives better compensation compared to RZ signal. Here, the system is simulated at 40 Gbps, and the system gets 2.7E-17 BER using duobinary signal at 900 km of transmission distance. From the table of q factor it s seen that as the distance increases the effect of nonlinearities increases which impacts the overall system performance, also Q factor decreases.

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