INVESTIGATION OF FWM EFFECT ON BER IN WDM OPTICAL COMMUNICATION SYSTEM WITH BINARY AND DUOBINARY MODULATION FORMAT

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ABSTRACT

This paper simulates two channel WDM optical communication system to investigate the effect of FWM on Bit Error Rate for Duo-binary & binary modulation like NRZ Rectangular at different dispersion value ,core effective area of fiber & channel spacing for 100km long optical communication system. BER got improved with duobinary modulation format & by increasing core effective area which will offer a significant performance benefit in digital systems.

KEYWORDS

Dense wavelength division multiplexing (DWDM), Four wave mixing (FWM), Bit error rate (BER), Erbium doped fiber amplifier (EDFA).

1. INTRODUCTION

In order to meet the huge capacity demands imposed on the core transmission network by the explosive growth in data communications the number of optical channels in dense-WDM optical networks is being increased. Since the gain bandwidth of EDFAs is limited, these requirements for a very large number of channels mean that the channel spacing will have to be small. The current ITU grid specifies 100 GHz channel spacing, but systems are being considered with 50 GHz to 25GHz channel spacing. At these spacing, the non-linear effects of the optical fibre can induce serious system impairments and modulation schemes are now being developed which are robust to both the linear and non-linear behaviour of fibre. Duobinary modulation techniques are known to compress the optical spectrum, thereby facilitating the tighter packing of channels into the EDFA gain window. It has also been reported that the 2-level variant of duobinary signalling [1, 2] almost eliminates the impact of SBS since the optical carrier component is suppressed [3]. Four-Wave-Mixing (FWM) is another non linear effect [14] that can limit the performance of WDM systems [4, 5, 8, 9].For long distance light wave communication larger information transmission capacity and longer repeater-less distance are required formers requires high bit rate and wavelength division multiplexing for increasing bit rate. When high power optical signal is launched into a fiber linearity of optical response is lost. Four wave mixing is due to changes in the refractive index with optical power called optical Kerr effect. In FWM effect, two co-propagating wave produce two new optical sideband wave at different frequencies. When new frequencies fall in the transmission window of original frequency it causes severe cross talk between channels propagating through an optical fiber. Degradation becomes very severe for large number of WDM channels with small spacing. Optical duobinary modulation has attracted much attention as a transmission technique that can mitigate fiber chromatic-dispersion effects in high capacity optical transmission system [10 -

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12]. The technique was first described by Lender in 1963 [13]. The simulation setup is validated using simulation software Optsim.

2. SIMULATION SET UP

A model of optical communication link is simulated in (fig.1).Here optical fiber of 100km long is used & two CW semiconductor lasers externally modulated by Duo-binary & binary modulation format like NRZ Rectangular. CW laser 1 have central emission frequency 193.41449 THz (1550nm), optical power 3dBm & FWHM line width 10 MHz. CW Laser 2 have central emission frequency 193.45817 THz (1549.65nm), optical power 3dBm & FWHM line width 10 MHz .Data source generate data of Bit rate 10 Gbps. The duo binary encoder used consists of a one-bit delay line. The output of the delay line is added to the original signal to generate a zero mean, three-level signal. Here external modulation is carried out by amplitude dual arm Mach Zehnder modulator .Mach Zehnder modulator [15] has maximum transmissivity offset voltage of 0.5V & extinction ratio of 20dB. Same external modulator is used for both duobinary & binary signal with same parameter as mentioned above. Duobinary modulation format is obtained by driving an external dual arm modulator with opposite phase signal. The simulation set up is shown in figure 1.Two externally modulated duobinary signal or binary signal can be combined using optical combiner having attenuation on each output -0.0dB .The optical signal is amplified by optical amplifier which has output power 7dBm, maximum small signal gain 35 & noise figure 4.5 dB. The signals are then transmitted over 100km of optical fiber having loss 0.2 dB & reference wavelength for dispersion is 1550nm.Optical filter raised cosine is followed by 100km optical fiber.

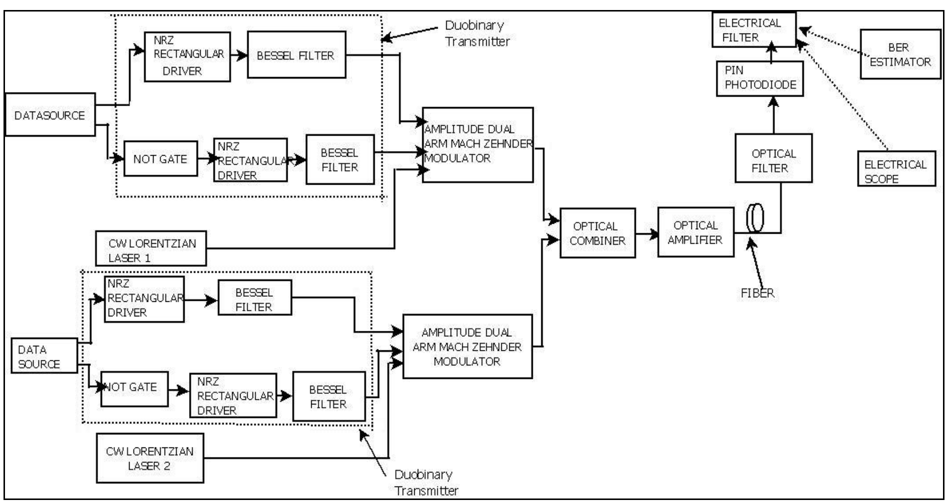

Figure 1. The Simulation setup

This optical filter has band pass type , center wavelength 1550nm,-3dB two sided bandwidth 52 GHz.PIN Photodiode is used at receiver side to convert optical signal into electrical signal .This PIN Photodiode having reference wavelength as 1550 nm, quantum efficiency 0.7, -3dB Bandwidth as 40GHz & dark current 0.1nA . Bessel electrical filter is followed by PIN Photodiode. Bessel electrical filter is low pass type, having number of poles 5, -3dB bandwidth as 8 GHz. In additions, the optimum configuration of duobinary transmitters & receiver has been extensively studied [18]. Here four simulations are conducted for both duobinary & binary modulation format; one is to determine the Variation in BER with channel spacing keeping constant dispersion = 17ps/nm/km, core effective area =80µm; second is to determine the variation in BER with channel spacing for different core effective area (20µm,40µm,60µm,80µm),keeping dispersion = 17ps/nm/km; third is to determine the variation in BER with dispersion for constant core effective area 80µm; fourth is to determine the variation in BER with dispersion for different core effective area .The spectrum after propagation through the fiber is viewed on an optical spectrum analyser (OSA). Power is kept as constant as practicable for all of the simulation. At receiver side, electrical scope is connected to electrical filter output to view eye diagram, to calculate BER, Q factor .In some simulation model , I am using fiber with dispersion 17ps/nm/km & core effective area 80µm.

Input variable:

Dispersion= 0 - 12ps/nm/km

Core effective area = 20-80 µm

3. RESULTS

Total transmission capacity can be enhanced by increasing the number of multiplexed DWDM channels. This can be carried out by reducing channel spacing .we know that for DWDM transmission channel spacing between two adjacent channel for 10Gbps should not be less than 37.5 GHz [6]. Here first simulation is carried out for binary & duobinary modulation format to determine variation in BER with channel spacing between adjacent channels for constant dispersion=17 ps/nm/km & core effective area =80µm.In figure.2a variation in BER with channel spacing for binary & duobinary modulation is shown.

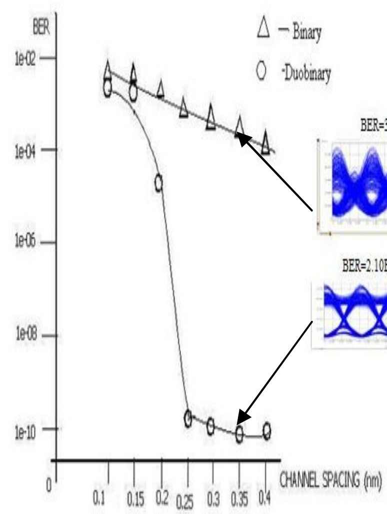

Figure.2a BER vs Channel Spacing

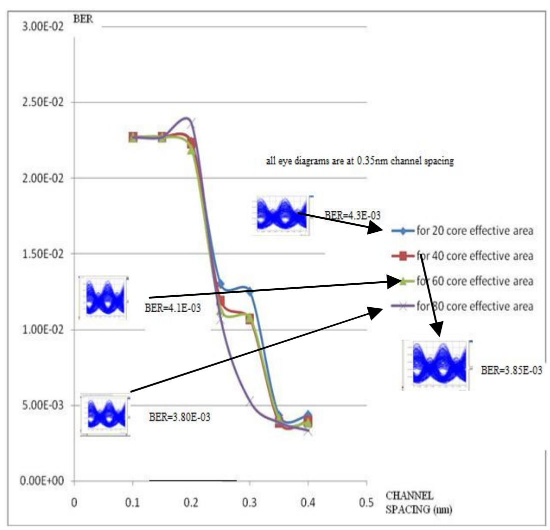

Figure.2b BER vs Channel Spacing for Binary modulation

As we increase channel spacing between adjacent channels the BER reduces for both duobinary & binary modulation format. When we compare reduction in BER for both duobinary & binary then we come to know that reduction in BER for duobinary modulation is greater. As shown in figure.2a at 0.35nm channel spacing between adjacent channels the BER for duobinary & binary modulation format are 2.10E-11 & 3.86E-03 respectively. The eye opening for duobinary &

binary modulation format are 0.267E-04 & 0.539E-05 respectively. I have taken 0.35 nm as channel spacing between adjacent channels to get better eye diagram & less BER which plays an important role to improve DWDM system performance. The second simulation is conducted for both duobinary & binary modulation format in order to investigate the variation in BER with channel spacing for constant dispersion = 17 ps/nm/km & variable core effective area (20µm, 40µm, 60µm, 80µm).

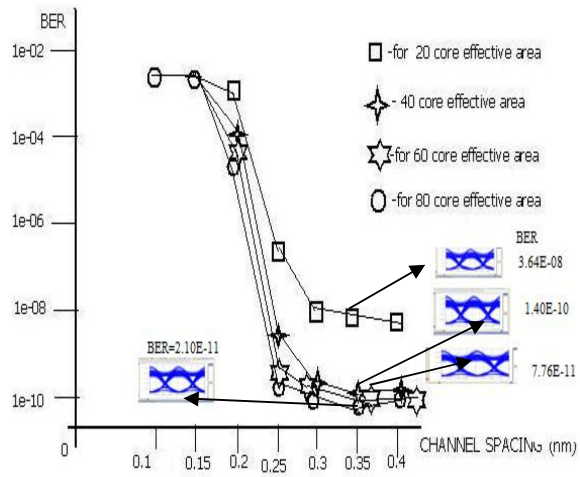

Figure.2c BER vs Channel Spacing for duobinary modulation

In figure.2b variation in BER with channel spacing for different core effective area & for constant dispersion =17ps/nm/km is shown. It is observed that at 0.1nm & 0.2nm channel spacing the BER is constant for all core effective area. There is variation in BER for all core effective area after 0.2nm channel spacing. In figure.2b it is observed that BER reduces with the increase in core effective area. In figure.2b & figure.2c eye diagrams with BER are shown for all core effective area at 0.35nm channel spacing for duobinary & binary. Of course it is found that the reduction in BER is more in Duobinary modulation than binary modulation.

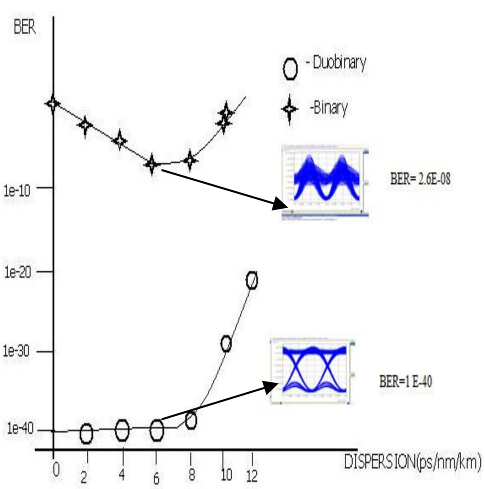

Figure.3a BER vs Dispersion

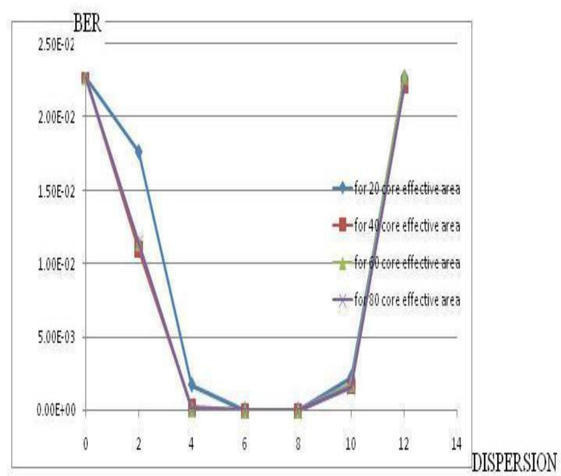

Figure.3b BER vs Dispersion for binary

Modulation format

The third simulation is conducted for both binary & duobinary modulation format to investigate the variation in BER with dispersion for constant core effective area =80μm & channel spacing =0.35nm.In figure.3a the variation in BER with dispersion for constant core effective area=8μm & channel spacing=0.35nm for duobinary & binary modulation format is shown. As we know that less dispersion means all signals are in phase [7] .when signals are in phase then there is interaction between signal & it produces FWM product. FWM product result in increase in BER which affect WDM optical communication system [7]. In figure.3a it is found that for binary modulation BER reduce with dispersion up to dispersion=6ps/nm/km. there is increase in BER after dispersion = 6ps/nm/km. In case of duobinary modulation it is found that the BER is 1E-40 constant for dispersion=0, 2, 4, 6 ps/nm/km.BER increases after dispersion = 6 ps/nm/km. when we compare increment in BER for both duobinary & binary modulation format after dispersion=6ps/nm/km then we found that the increment in BER is greater for binary modulation format. In figure.3a eye diagrams with BER are shown for both modulation format at dispersion=6ps/nm/km.

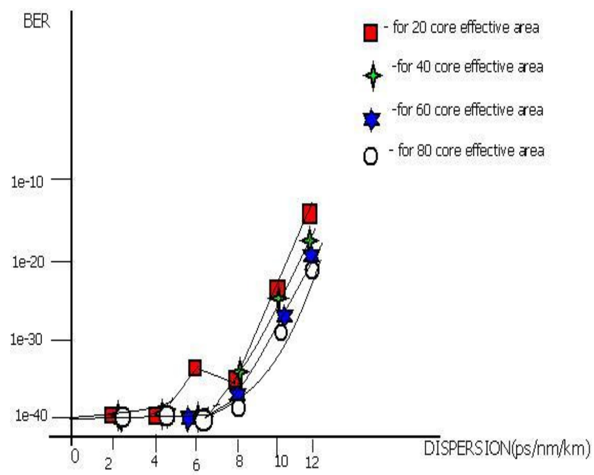

Figure. 3c BER vs Dispersion for duobinary modulation

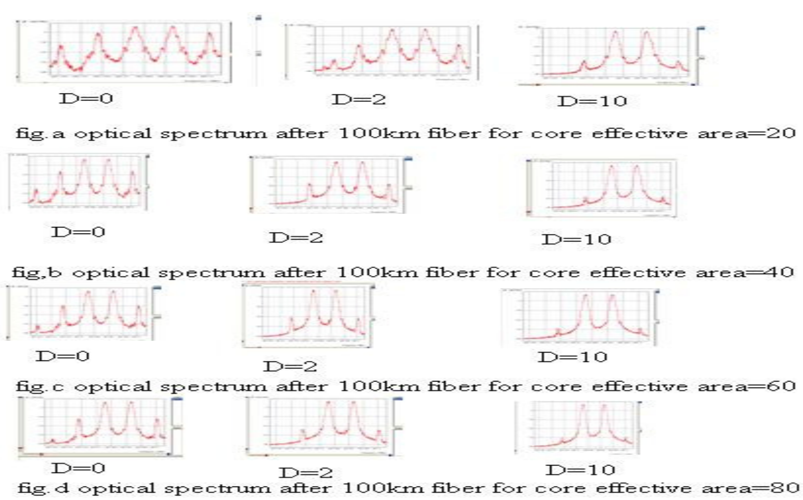

Figure.3d Optical spectrum after 100km fiber for duobinary modulation

The fourth simulation is conducted for both duobinary & binary modulation format in order to investigate the variation in BER with dispersion for constant channel spacing =0.35nm & variable core effective area (20µm,40µm,60µm,80µm).In figure.3b variation in BER with dispersion for binary modulation for different core effective area is shown. In figure.3b it is found that reduction in BER is possible up to dispersion=8ps/nm/km. There is increment in BER from dispersion= 8ps/nm/km. The minimum BER value for binary modulation is 2.66E-08.In figure.3c variation in BER with dispersion for duobinary modulation for different value of core effective value is shown. In figure.3c it is observed that the BER is constant up to dispersion value=4ps/nm/km for all core effective area. The minimum BER value for duobinary modulation is 1E-40. In figure.3b & 3c it is clear that the minimum BER value for binary modulation is maximum BER value for duobinary modulation. In figure.3d the nature of optical spectrum after 100km fiber for different dispersion value & core effective value & constant channel spacing 0.35nm is shown. In figure.3d it is clear that for minimum dispersion value & minimum core effective area the FWM effect is great & whatever FWM products [16,17] are formed having large power. When we increase dispersion value & core effective area then there is decrement in power of FWM product. Figure.3c shows that due to increase in dispersion value the BER is increased .It is also observed that BER is more reduced by using duobinary modulation as compared to binary modulation.

4. CONCLUSIONS

This paper simulates WDM optical communication system using optsim. This simulation provides verification that the use of a duobinary encoding scheme can reduce significantly the level of four-wave mixing products. The reduction in BER is more for Duobinary modulation than binary modulation with channel spacing for constant dispersion value=17ps/nm/km & constant core effective area =80µm.second thing which is observed is that the reduction in BER is more for duobinary modulation for variable core effective area & constant dispersion value=17ps/nm/km. Further BER is reduced by increasing core effective area. BER is increased with increase in dispersion value after 6ps/nm/km but the increment in BER is very less as compare to binary modulation. Thus duobinary becomes a very attractive encoding method.

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