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Optimizing the Wavelength Spacing in WDM

Sabapathi T, Aarthi R and Madhu Mitha K
Department of ECE,
Mepco Schlenk Engineering College, Sivakasi,
Tamilnadu, India.

***Abstract*-Telecommunication systems have been revolutionized by Fiber optic communication. This has led to the need for optimized transmission capacity. As the optical signal propagates from the transmitter towards receiver, due to physical layer impairments of the network the quality and efficiency degrades. Moreover channel spacing is an important phenomena that has to be taken in consideration when designing a Fiber Optical communication system. FWM suppression are obtained based on Odd-Even Channels (OEC) arrangement strategy and analysis on Cross Phase Modulation(XPM) are evaluated using OptiSystem Software in this paper.The proposed setup provides an effective way of minimizing non linearity in fiber.. In this paper, the effect of Cross Phase Modulation is analyzed with respect to channel spacing and input power variation.**

Keywords-WDM ,Channel Spacing,Non-Linearities, FWM, XPM, Q Factor, BER

I.INTRODUCTION

Fiber optic communication transmits the information from one point to another with the help of infrared light within a fiber stran*d*. . Using this optical fiber cable information can be transmitted over long distances with low loss of data and has higher data rates. In the earlier days of communication there occured a need for transmitting data more and also in a faster way. For these the coaxial cables were engaged in several channels to be transmitted over the same cable. For this optical fiber were started to be investigated. Data rates has been improved and also the performance has been improved for enabling greater distances. As an indication of this improvement the speed which can be achieved through the fiber optic system exceeds 10 TBps. The transmission capacity in optical communication are significantly improved using wavelength division multiplexing.Wavelength-division multiplexing (WDM) transmits multiple channels of information through a single optical fiber by sending multiple beam of lights of different wavelengths through the fiber. Each wavelength is modulated with a separate information channel, allows the available capacity of optical fibers to be multiplied. Under WDM the optical transmission spectrum is set up into number of non-overlapping frequency bands,with each wavelength supporting a single channel which is operated at the required rate.To implement the WDM some devices are required such as to combine together,distribute ,isolate and amplify optical power at different wavelengths. factors of Non Linearity arise due to transmission length, data transfer speed, number of wave lengths that are passed as input to the fiber and optical power. The non linearities are further classified as Non-linear refractive Index and the Inelastic scattering effects.

II. FOUR WAVE MIXING

The concept of four wave mixing is that when three wavelengths are made to allow through the fiber the fourth signals gets added to that message or data which is unwanted signals. In brief they can be defined when more than two wave lengths are allowed to pass through the fiber then there occurs intermodulation. The signal that gets added to the original is classified as Out band signal and In band signal. The Out band signal can be easily filtered using the band pass filter and the In band is undifferentiated form the base band signal and are difficult to process them. So our project is to reduce the efficiency of the FWM using Odd-Even Channel Arrangement. Here the Polarization Controller and the optical fiber arrangement play a significant role.

$$FWM\ power \propto No. of\ channels$$

$$FWM\ power \propto \frac{1}{L}$$

$$Number\ of\ FWM\ terms = \frac{(N^3 - N^2)}{2}$$

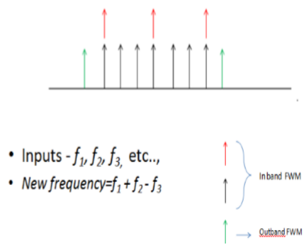

Fig. 1 Four Wave Mixing.

III. CROSS PHASE MODULATION:

Cross-Phase Modulation (XPM) is a nonlinear optical impact where one wavelength of light can influence the period of another wavelength of light through the optical Kerr impact. At the point when the optical power from a wavelength impacts the refractive index, the effect of the new refractive on another wavelength is known as XPM. Cross-stage modulation can be utilized as a system for adding data to a light stream by altering the period of an intelligible optical with another wavelength through collaborations indirect medium. This system is connected to fiber optic correspondences.In fact, XPM converts power fluctuations in a particular wavelength channel to phase fluctuations in other copropagating channels. The dependency of XPM on input power and channel spacing has been analyzed in the simulation setup . Results show that increasing the input power leads to growing XPM effect at constant channel spacing.

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IV. PRPOSED METHOD

The presence of the non-linearities reduces the performances of the system.To reduce the power level of Four Wave Mixing, ODD-EVEN Channel Arrangement strategy is used.And also when the channel spacing is increased it reduces further.

For this simulation setup WDM of 8-channels are used.Different channel spacings used here are 200GHz,300GHz and 400GHz.

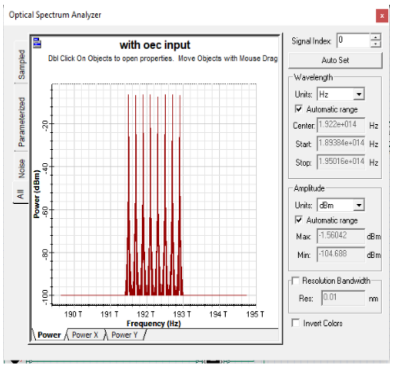

Fig 2. Input Spectrum at 200 GHz.

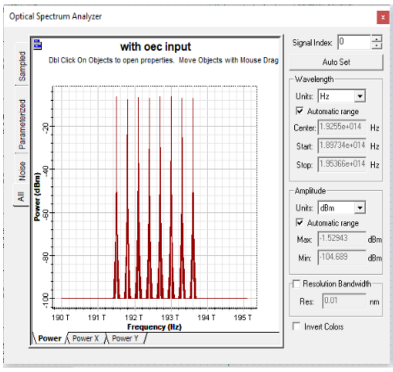

Fig 3. Input Spectrum at 300 GHz.

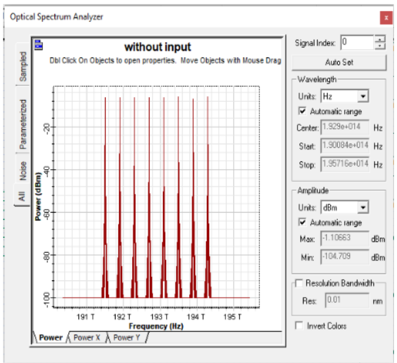

Fig 4. Input Spectrum at 400 GHz.

When the channel spacing is increased then the power level of FWM at the output spectrum gets reduced when compared with other channel spacings.When the frequency is set at the input side,the input spectrum consists of only the spectrum of the frequency given.The output spectrum consists of the FWM which is due to the combination of the other waves.The power level of the FWM with the OEC arrangement for 200 GHz spacing is obtained as -41 dBm.

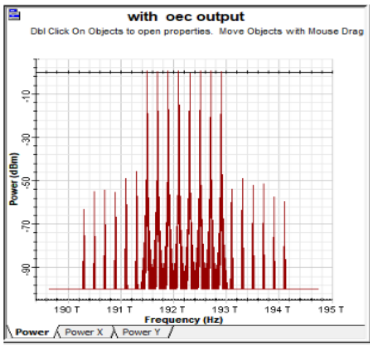

Fig 5. Output Spectrum at 200 GHz with OEC.

Without the use of OEC arrangement the FWM power level for the same channel spacing is found to be reduced to -45 dBm.

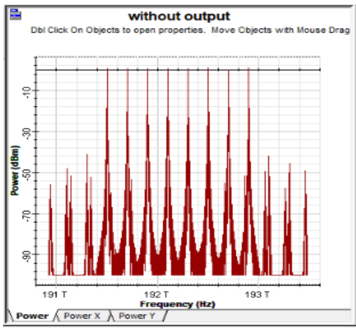

Fig 6. Output Spectrum at 200 GHz without OEC.

With the channel spacing of 300 GHz ,the FWM power level with the OEC is found to be -50dBm.

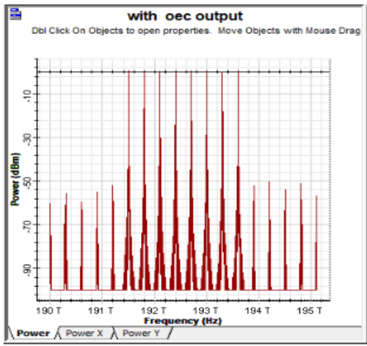

Fig 7. Output Spectrum at 300 GHz with OEC.

When the simulation is done without OEC at 300 GHZ the FWM power level is found to be -44 dBm.

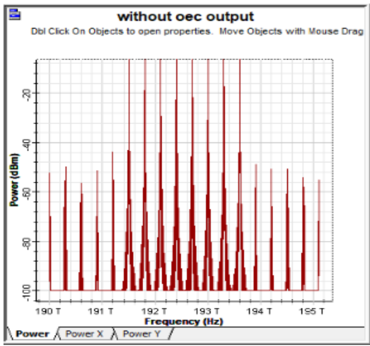

Fig 8. Output Spectrum at 300 GHz without OEC.

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For the 400GHz channel spacing the FWM power level with OEC is obtained as -62 dBm and without the OEC the power level of FWM is reduced to -57 dBm.

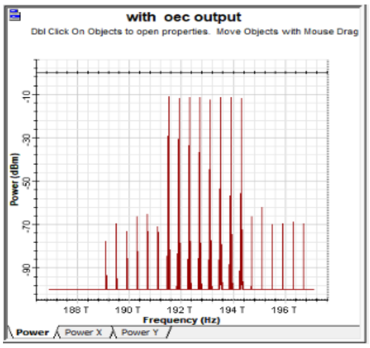

Fig 9. Output Spectrum at 400 GHz with OEC.

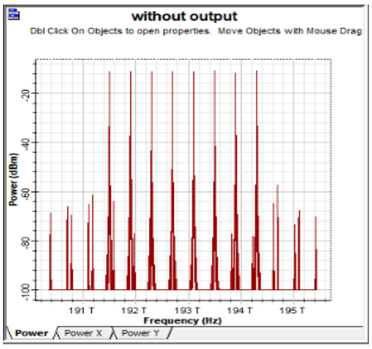

Fig 10. Output Spectrum at 400 GHz without OEC

Here the FWM power level is found to be reducing by the use of ODD-EVEN Channel Arrangement Strategy.Here the power level is reduced to a particular dBm ,further more is reduced when the channel spacing is increased more. The WDM consists of many channels and when the spacing between the channels increases the FWM Power level is reduced.

TABLE 1:VARIATION OF FWM POWER LEVEL

CHANNEL SPACING	With OEC	Without OEC
200 GHz	-45dBm	-41 dBm
300 GHz	-50 dBm	-44 dBm
400 GHz	-62 dBm	-57 dBm

V. XPM ANALYSIS SETUP:

WDM Transmitter is placed in the input side. The channel spacing values are varied to 50GHz, 150GHz and 250GHz.Here the data rate are fixed at the range of 5 GBps. The input frequency is 193.1 THz . The input power is varied from 0dBm to 12dBm. NRZ Modulation type is used.The input channels are send to multiplexers and the optical signals are sent to the optical fiber. The optical fiber consists of Single Mode Fiber (SMF) and Dispersion Compensation Fiber (DCF) followed by Erbium-doped fiber amplifier (EDFA). The dispersion of 100 km SMF is 16 ps/nm-km and its effective area is 72 square microns. The dispersion of DCF is -80 ps/nm-km. A 20 km DCF is used to totally compensate the dispersion. The effective area of DCF is 30 square microns. SMF and DCF losses are compensated by an EDFA with 25 dB gain and its Noise figure is 4 dB.In order to have the effect of practical attenuation factors the value is set to 0.2 dB/km for SMF and 0.5 dB/km for DCF.

The Output Spectrum analysis for each channel spacing are given as follows:

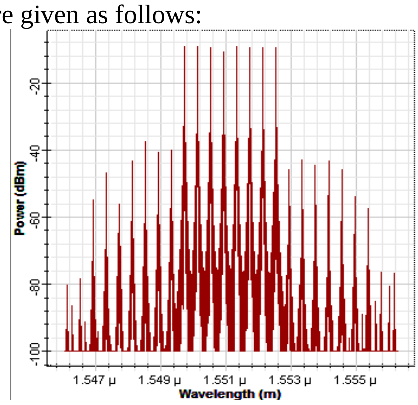

Fig 11.Output Spectrum of 0 dBm at 50 GHz.

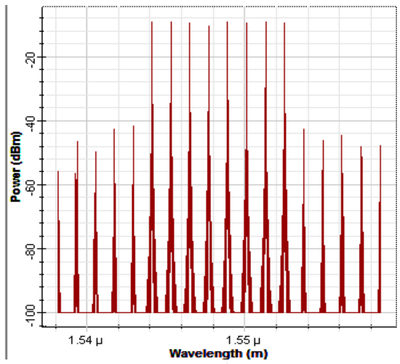

Fig 12.Output Spectrum of 0 dBm at 150 GHz.

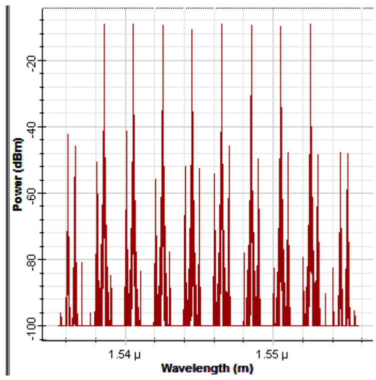

Fig 13.Output Spectrum of 0 dBm at 250 GHz.

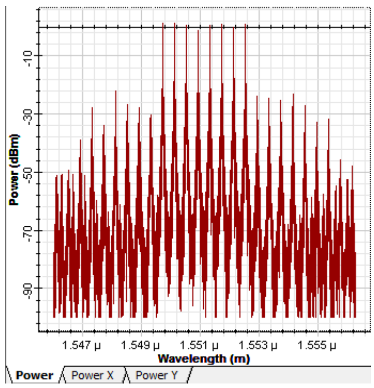

Fig 14.Output Spectrum of 12 dBm at 50 GHz.

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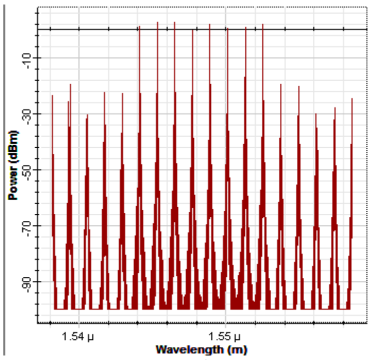

Fig 15.Output Spectrum of 12 dBm at 150 GHz.

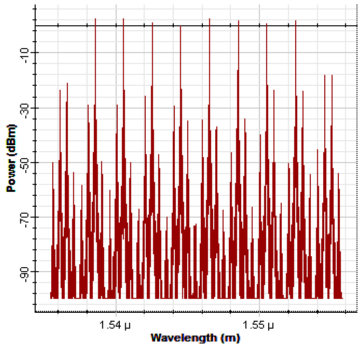

Fig 16.Output Spectrum of 12 dBm at 250 GHz.

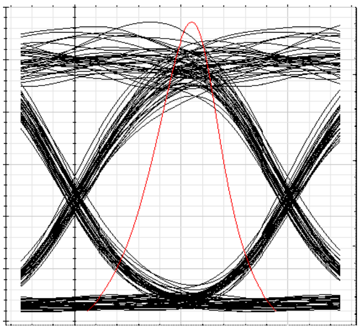

Fig 17. BER of 0 dBm at 50 GHz.

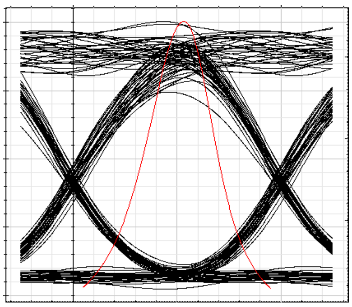

Fig 18. BER of 0 dBm at 150 GHz.

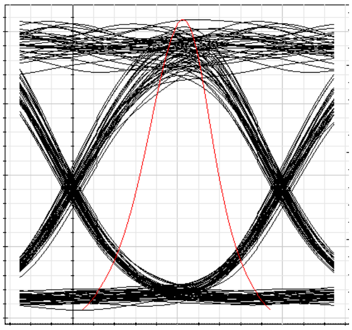

Fig 19. BER of 0 dBm at 250 GHz.

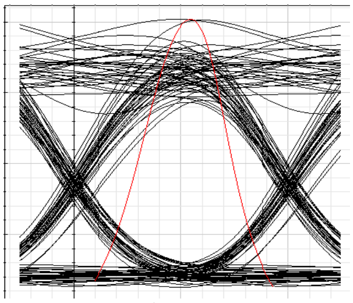

Fig 20. BER of 12 dBm at 50 GHz.

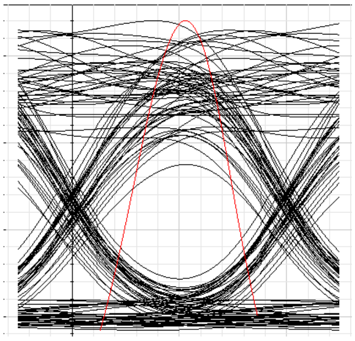

Fig 21. BER of 12 dBm at 150 GHz.

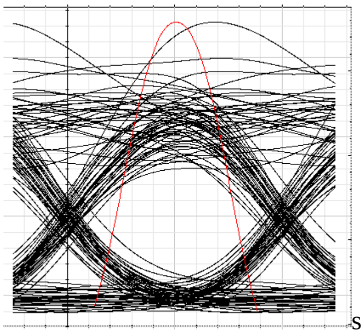

Fig 22. BER of 12 dBm at 250 GHz.

The output of the optical signal from the fiber is fed into demultiplexer and the PIN photodetector converts the optical signal to electrical signal and connected to Bessel filter. The output spectrum is viewed in BER analyzer.

TABLE 2:Q FACTOR AND BER AT 0 dBm

Channel Spacing (GHz)	Power (dBm)	Q Factor	BER
50	0	12.4325	7.8622E-036
150	0	13.0353	3.3223E-039
250	0	13.5006	6.77621E-042

TABLE 3:Q FACTOR AND BER AT 12 dBm

Channel Spacing (GHz)	Power (dBm)	Q Factor	BER
50	12	9.0741	5.0413E-036
150	12	5.4496	2.1826E-008
250	12	5.4379	2.9688E-008

VI.RESULT AND ANALYSIS:

FWM:

The FWM can be reduced when the channel spacing is increased .The different channel spacing simulated here are

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200GHz,300GHz and 400GHz.With the increase in channel spacing FWM reduces.With the Odd-Even channel arrangement the power level of the FWM is much reduced when compared with the channels without the OEC arrangement. From the above table we can analyze that the power level of the FWM reduces and also by increased channel spacing.

XPM:

Effect of input power variation:

In this simulation, the pump power values supplied at input are 0 dBm and 12 dBm. Data rate is set to 5 Gb/s and channel spacing is varied as 50GHz, 150GHz, 250GHz.

By observing the table, it is clear that BER increases with increasing pump power while the Q-factor decreases with power. Hence it can be concluded that XPM effect increases with increase in input power and this degrades the system performance.

Effect of channel spacing variartion:

In the simulation, channel spacing are varied to 50GHz, 150GHz and 250GHz. With Power at 0dBm, the Q factor obtained at 50 GHz channel spacing is 12.4325 and BER is7.8622E-036, Q factor obtained at 150 GHz channel spacing is 13.0353and BER is 3.3223E-039 and the Q factor obtained at 250 GHz channel spacing is 13.5006 and BER is 6.77621E-042.

Thus, Q factor increases and BER decreases with increase in the channel spacing. Hence it is concluded that reducing the channel spacing results in increasing XPM and degrading the signals.

VII.CONCLUSION

The simulation results of Odd-Even Arrangement with 8 channels has reduced FWM to a great extend and the efficiency of the output signal is significant. FWM power reduces when channel spacing is increased. Simulation results of Cross Phase Modulation with 8 channels have been analyzed. When input power is increased the Q factor decreases and BER increases which is due to Cross Phase Modulation. Moreover, when channel spacing is increased Q factor increases and BER decreases thereby improving the efficiency of output signal. The future work can be done by extending the number of WDM channels and the efficiency of FWM have be analyzed by increasing the optical fiber length and also by increasing the data rate and to find an optimum solution to further reduce the Cross Phase Modulation.

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