REDUCING SRS AND FWM IN DWDM SYSTEMS

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ABSTRACT:

Optical communication in case of WDM systems is progressing at an astonishing rate due to high transmission capacity. But this transmission is often effected by effects like SRS (Stimulated Raman Scattering) and FWM (Four Wave Mixing) due to non-linear properties of fiber.

These effects affect our transmission and give rise to large variation in output power levels along with distortion and large noises present in output signals. This project aims to eliminate such problems to a maximum extent to recover our original input signal by lowering input power, unequal channel spacing and increasing dispersion. The effect of output signals with and without such changes is observed at bit rate of 10 GB/s and 1 GB/s. Eye diagram and spectrum analyzer input and output are compared and observed for each case and analysis is drawn from the same.

Keywords: WDM, SRS, FWM, Channel spacing, Dispersion, Power level

INTRODUCTION:

Wavelength Division Multiplexed (WDM) systems consist of two or more wavelengths being carried together in a single fiber at the same time. These channels are separated by specific channel wavelengths to avoid interference. The throughput of WDM systems is often limited due to various fiber nonlinearities such as FWM and SRS.

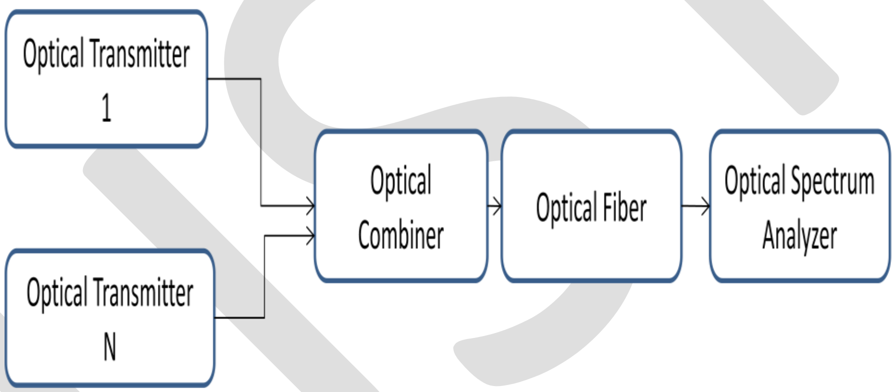
SRS (Stimulated Raman Scattering) is present in fibers due to equal channel spacing among various wavelengths. This mainly occurs when there is scattering of inelastic photon to a lower energy photon. This energy difference is often absorbed by phonons or molecular vibrations present in the medium. This transfer of optical power among different modes degrades the signal strength and often gives rise to SRS. Due to equal channels spacing, SRS couples different channels together which often leads to crosstalk. This depends on optical power level, number of channels, channel spacing etc.

FWM (Four Wave Mixing) is often the result of SRS. Basically, FWM occurs when light of different wavelengths is launched into fiber. These wavelengths often interact with each other and give rise introduction o new wavelength which is different from the input wavelengths. This produces additional noise and degrades system performance. The effect of FWM can be mitigated by introducing dispersion, in both equal and unequal channel spacing, in the fiber.

Power Tilt factor is used to measure the amount of power variation among various wavelengths in a fiber. This factor reduces and dispersion increases and unequal channel spacing is introduced.

BLOCK DIAGRAM:

Figure 1.



Optical Transmitters taken depend on number of channels considered for WDM. Here, we have considered a 4-channel WDM system.

Optical combiner is used to combine all wavelengths together and input it together onto a single fiber.

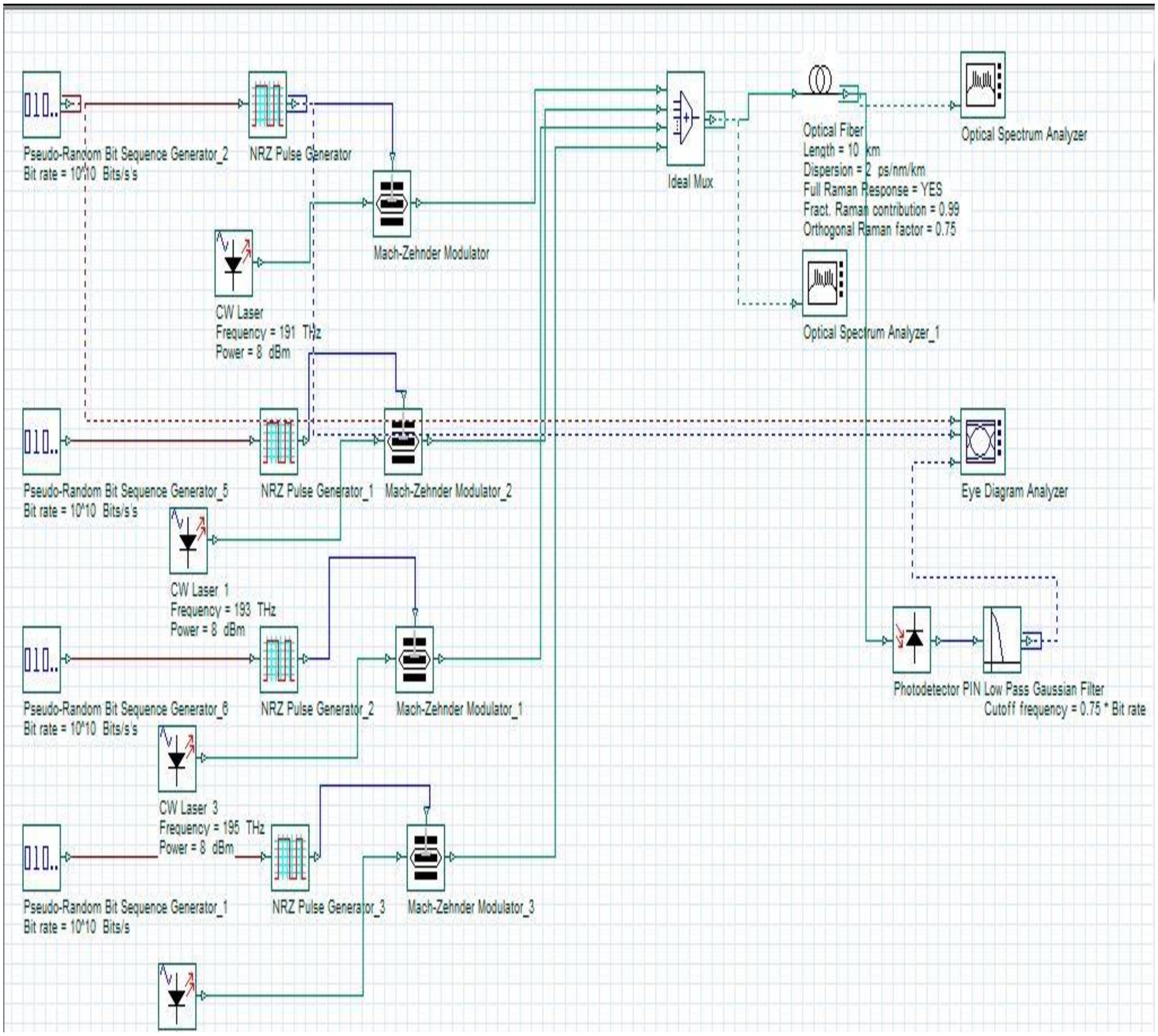
A non –linear optical Fiber is considered exhibiting Raman effects. Dispersion values of the same are changed according to different cases.

An optical Spectrum Analyzer is used to view an optical signal output and used to measure Power Tilt factor and observe FWM effects.

An eye diagram analyzer is also used to view the FWM effects on fiber and how the pattern changes in each case. It is used to view all 4 channels at the same time and shows where logic high or low is present for all 4 simultaneously transmitted bits. If the eye diagram is unclear and not open like an eye, it shows distortion due to various non-linear effects.

CIRCUIT SCHEMATIC:

Figure 2.



Here, a Pseudo-Random Sequence Generator is used to generate sequences at a bit rate of 1GB/s and 10GB/s. This sequence along with CW Laser input with a center frequency of 1550nm is passed onto a Mach-Zehnder Modulator.

Issue 4 volume 4, July-August 2014
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All inputs from different channels are together modulated onto a 4:1 Multiplexer. This output is then passed onto a non-linear optical fiber of length 10 km and attenuation 0.2 db/km with dispersion values of 2 ps/nm-km and 25 ps/nm-km for both the cases.

An optical spectrum analyzer is attached to input and output of fiber to analyze their power levels. An eye diagram analyzer along with a photo detector and a filter, to convert optical signal to electrical signal, are also attached to observe FWM.

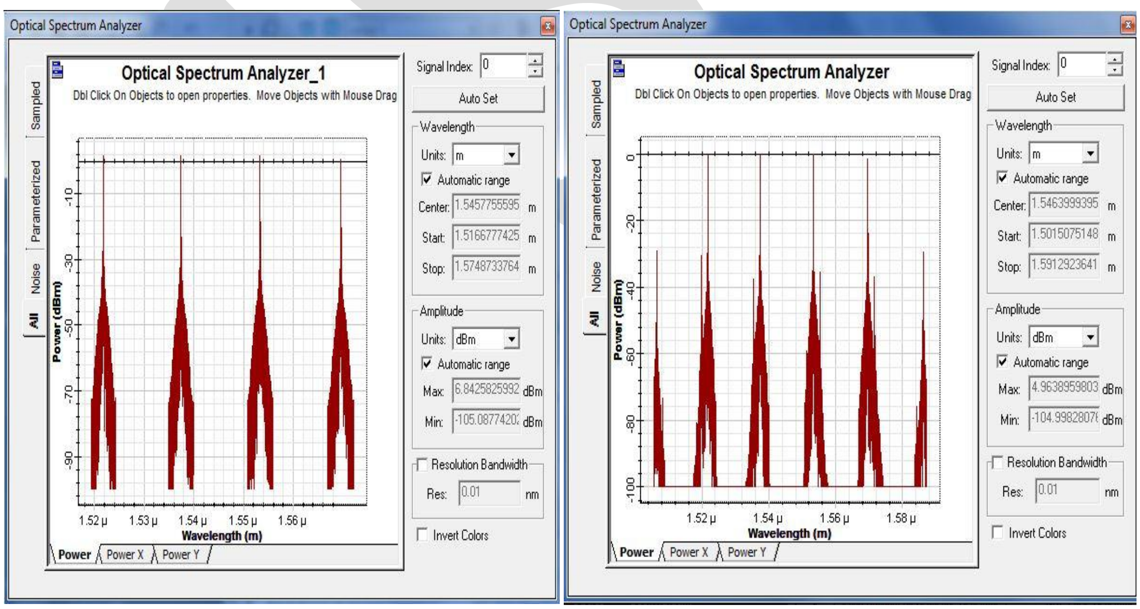
RESULTS AND DISCUSSION:

The above circuit was simulated in OPTISYSTEM 10.

(a) EQUAL CHANNEL SPACING:

A 4-channel WDM system is considered with equal channel spacing. The frequency of CW Lasers is as 191 THZ, 193 THZ, 195 THZ and 197 THZ with a center wavelength of 1550 nm. The input power level is 8 dbm and the bit rate for pseudo random bit sequence generator considered is 10 GB/s. Non-linear Fiber properties such as Raman crosstalk are enabled and the Dispersion value considered is 2 ps/nm/km.

Figure 3.Input and output power spectra for equal channel spacing with bit rate of 10 GB/s



The left side of Figure 3 shows equally spaced input power spectrum of different channel wavelengths. The right side shows equal spacing but addition of new wavelengths different from the input wavelengths. This is due to the presence of FWM in fibers and low dispersion values.

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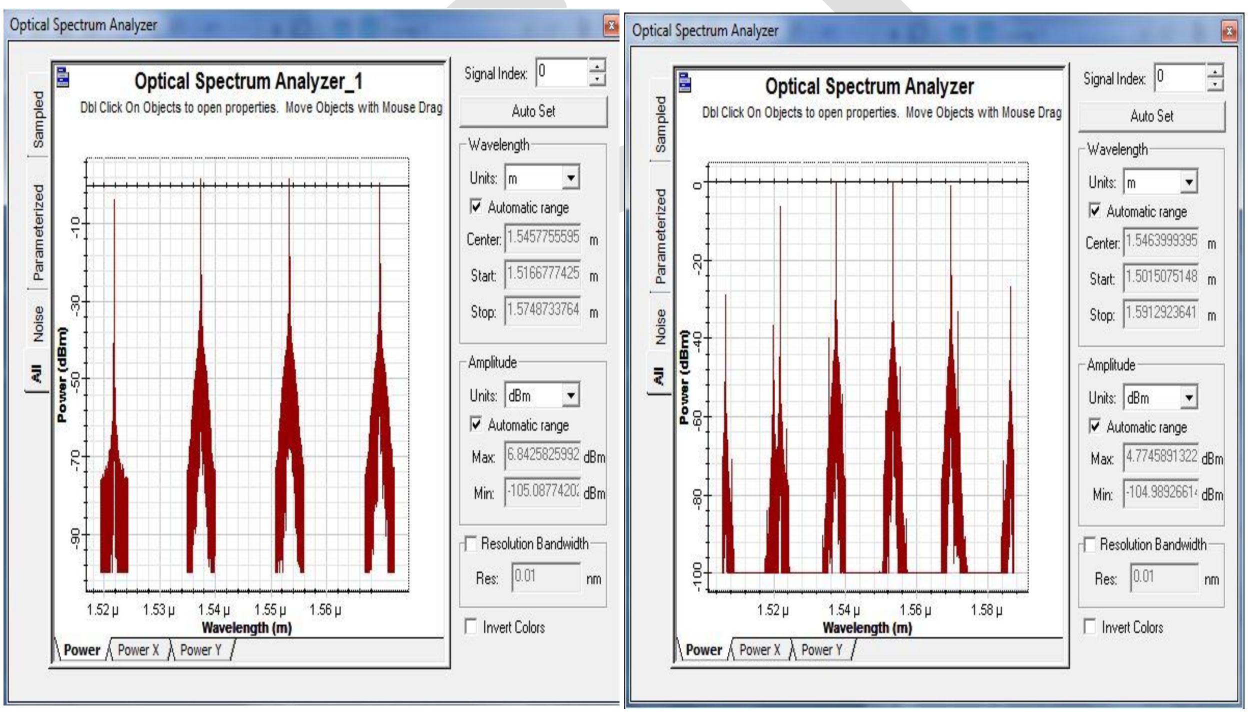
Table 1.

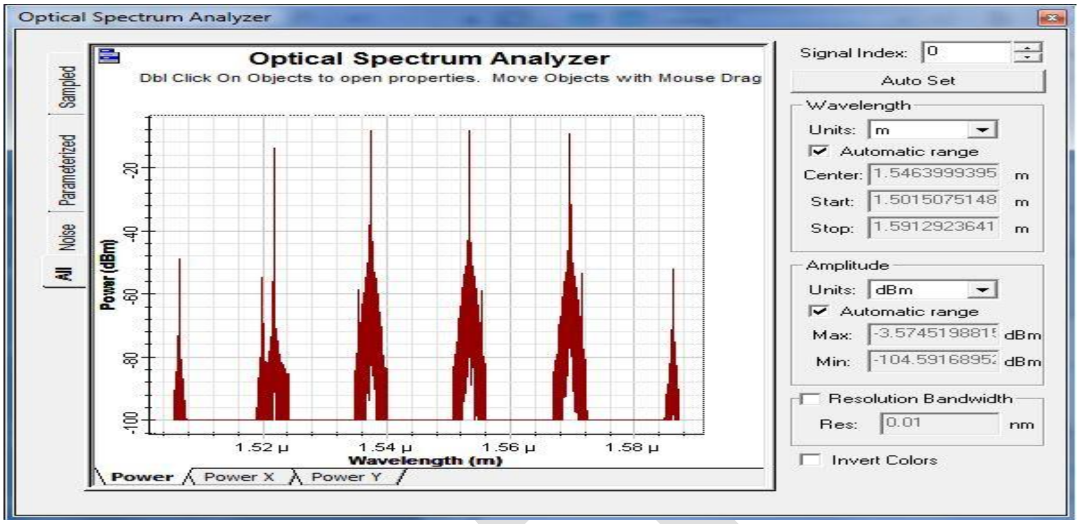
S.NO.	DISPERSION	BIT RATE	POWER TILT
1.	2 ps/nm-km	10 GB/s	0.33 dbm
2.	2 ps/nm-km	1 GB/s	7.8 dbm

Figure 4.Input and output power spectra for equal channel spacing with bit rate of 1 GB/s



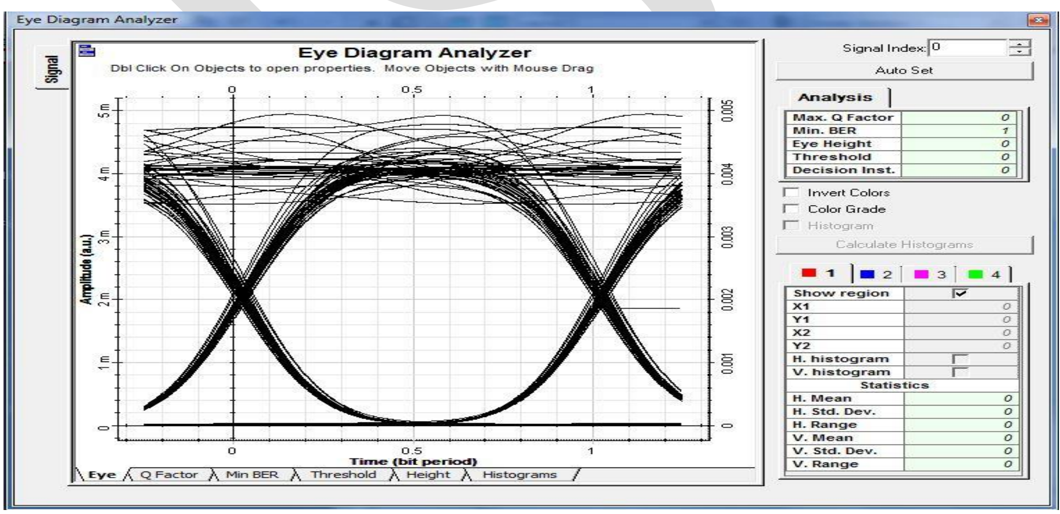
Right side of Figure 4 exhibits output power spectra for bit rate of 1GB/s. The addition of extra wavelengths is due to FWM. Also, there is an increase in Power Tilt factor. Hence, from the output power spectra of Figure 3 and Figure 4, we observe power tilt factor increases with decrease in bit rate.

Figure5. Output power Spectra for input power of 0dbm



This is the output power spectra for bit rate of 1GB/s and input power of 0 dbm. Here, Power Tilt comes out to be 7 dbm and power levels of extraneous wavelengths comes down from -28 dbm to -48 dbm. Hence, as power reduces, Power Tilt factor and FWM reduces.

Figure6. Eye Diagram for bit rate of 10 GB/s

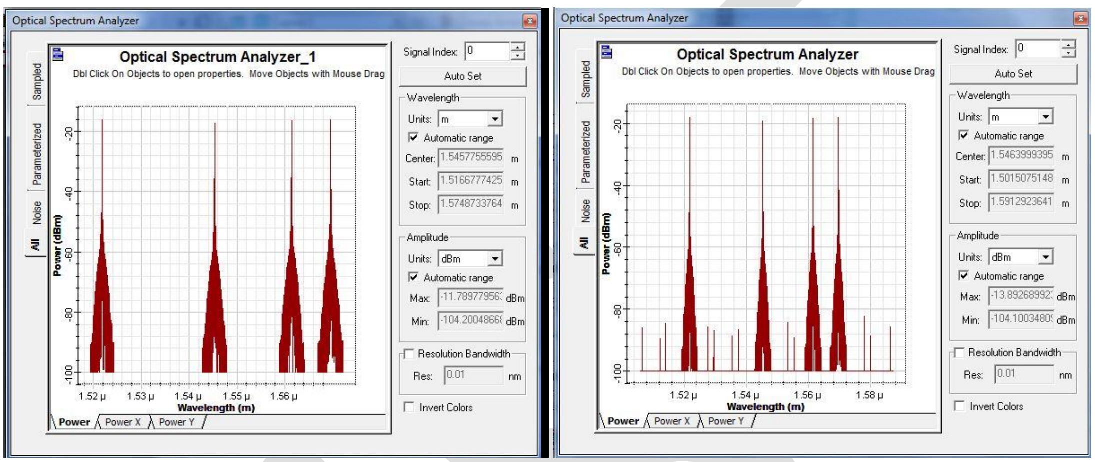


When there is equal channel spacing and various compensation measures have not been taken, it can be seen from Figure 6 that the results of serious distortion of the signal and the receiver cannot determine the received signal and communication lines are not available coming from the cumulative effect of FWM and SRS which causes spreading among various optical signal and thus, inter-symbol interference and noise model.

(b)UNEQUAL CHANNEL SPACING:

A 4-channel WDM system is considered with unequal channel spacing. The frequency of CW Lasers is as 191 THZ, 192 THZ, 194 THZ and 197 THZ with a center wavelength of 1550 nm. The input power level is -10 dbm and the bit rate for pseudo random bit sequence generator considered is 10 GB/s. Non-linear Fiber properties such as Raman crosstalk are enabled and the Dispersion value considered is 25 ps/nm-km.

Figure7. Input and output power spectra for unequal channel spacing with bit rate of 10 GB/s



The left side of Figure 7 shows unequally spaced input power spectrum of different channel wavelengths. The right side shows unequal spacing but addition of new wavelengths due to FWM. But, the output power of these extraneous wavelengths is -85 dbm which significantly reduces from the previous cases. Hence, lowering of input power, unequal channel spacing and high dispersion leads to decrease in FWM effects.

Table 2

S.NO.	DISPERSION	BIT RATE	POWER TILT
1.	25 ps/nm-km	10 GB/s	0.30 dbm
2.	25 ps/nm-km	1 GB/s	6 dbm

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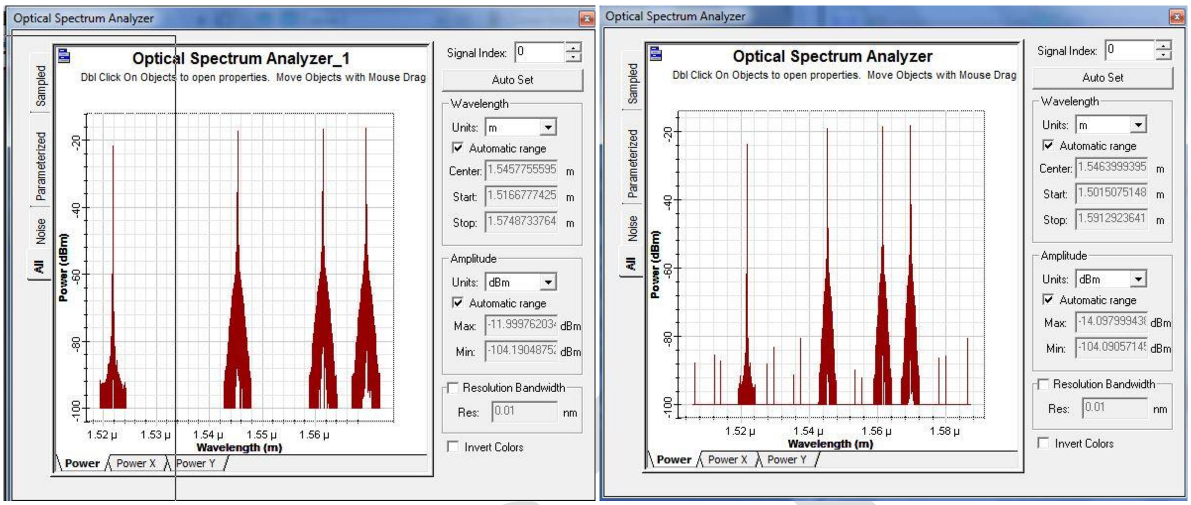
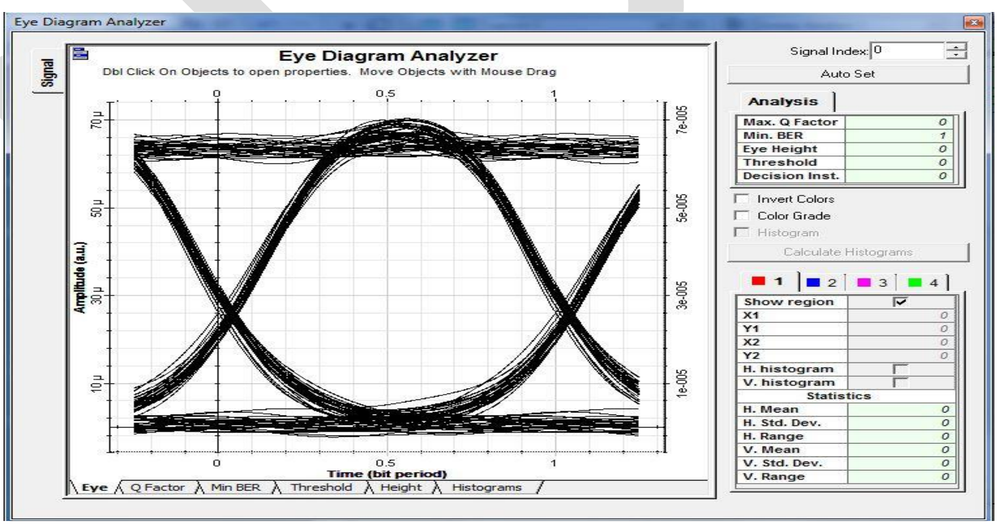
Figure8. Input and output power spectra for unequal channel spacing with bit rate of 1 GB/s



Right side of Figure 8 exhibits output power spectra for bit rate of 1GB/s. The addition of extra wavelengths is due to FWM. Also, there is an increase in Power Tilt factor. Hence, from the output power spectra of Figure7 and Figure8, we observe power tilt factor decrease with increase in bit rate.

Figure9. Eye Diagram for bit rate of 10 GB/s



The above figure shows distortion less opening of eye. Hence, here received signal is easy to infer and there is less distortion as compared to Figure6 of previous case.

CONCLUSION:

The effect of various factors like equal and unequal channel spacing, input power levels, bit rates and dispersion values have been analyzed using OPTISYSTEM layout.

It has been found that Power Tilt factor increases with decrease in bit rate. Also, FWM effects decrease as input power level decreases. It has also been noted that, high dispersion values and unequal channel spacing give better results than equal channel spacing with low dispersion value.

Hence, to combat the effects of SRS and FWM,

- Unequal channel spacing
- Low input power level
- High input bit rate
- High dispersion values

should be used.

But high dispersion can make the signal go some power overshoot at initial stages. Hence dispersion value should be chosen with careful consideration.

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