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Performance Analysis Of Dispersion Compensation Of Optical Fiber Using EDFA

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Abstract

We have investigated the performance analysis of dispersion compensation in WDM network using EDFA. In this the variation of Q-factor and Bit error rate with respect to the system length is analysed. This simulation is done for 8-channel and 16-channel transmitter at 10Gbps and 30Gbps data rate and various dispersion compensation schemes are analyzed for defining the optimum results.

"1. Introduction"

WDM (wavelength division multiplexing) optical networks have revolutionized the data transmission in communication system because of low loss, high speed, better bandwidth and high gain [1]. Optical amplifiers are the backbone of optical network as they directly amplify the weak signal without going through electronic process. But it also amplifies the signals which occur due to the fiber losses and many other noise sources. There are various amplifiers like SOA (Semiconductor Optical Amplifier), RAMAN and EDFA (Erbium Doped Fiber Amplifier) etc. But EDFA is the optical amplifier which is the most used amplifier because of its high capacity and low pump power. So EDFA behaviour in a WDM network needs to be studied. [2]

Fiber also suffers from dispersion due to fiber material nonlinearities, cut-bands in the fiber and the distance that signal travels inside the fiber. So this dispersion has to be minimized by some methods. Installing the DCF (Dispersion Compensation Fiber) is one of the methods to compensate the dispersion due to the SMF (Single Mode Fiber).

Malekmohammadi and M.A. Malek show the EDFA gain optimization for 32X10 Gbps WDM systems. In this paper how to optimize the gain for 32 channel WDM system with data rate of 10Gbps is shown. [3]

Y. Namihira, T. Kawazawa And H. Wakabayashi gives "Polarization Mode Dispersion Measurements in 1520 Km EDFA system" which limit the use of ultrahigh bit rate long haul optical amplifier systems, especially when the chromatic dispersion effects become very small by tuning the signal wavelength near the zero-chromatic dispersion wavelength. [4]

G. Yan, Z. Ruixia, D. Weifeng, and C. Xiaorong give the idea to create a WDM network using optisystem. It also shows the SMF and DCF dispersion values. We get a good idea of creating a 32X40 Gbps network using optisystem. [5]

KamhikoAikawa, Takaaki Suzuki, Kuniharu Himeno, Akira Wada gives "New dispersion-flattened hybrid optical fiber link composed of medium-dispersion large-effective-area fiber and negative dispersion fiber" in which a new dispersion-flattened hybrid optical fiber link composed of a medium-dispersion large-effective-area fiber and a negative dispersion fiber is presented. The hybrid fiber link showed a very low and flat dispersion in the C-band. [6]

I. Kang, S. Chadrasekhar, M. Rasras, X. Liu, M. Cappuzzo, L. T. Gomez, Y. F. Chen, L. Buhl, S. Cabot, J. Jaques gives "Transmission of 35-Gb/s all-optical OFDM signal over an all-EDFA 1980-km recirculation loop consisting of SSMF and DCF without using tunable dispersion compensation" in which they demonstrate long-haul transmission of 35-Gb/s (7 x 5 Gb/s NRZ-OOK) all-optical OFDM signal. They achieve bit error ratio of 3.3x10-3 for transmission over 1980-km span consisting of SSMF and DCF without using tunable dispersion compensation. [7]

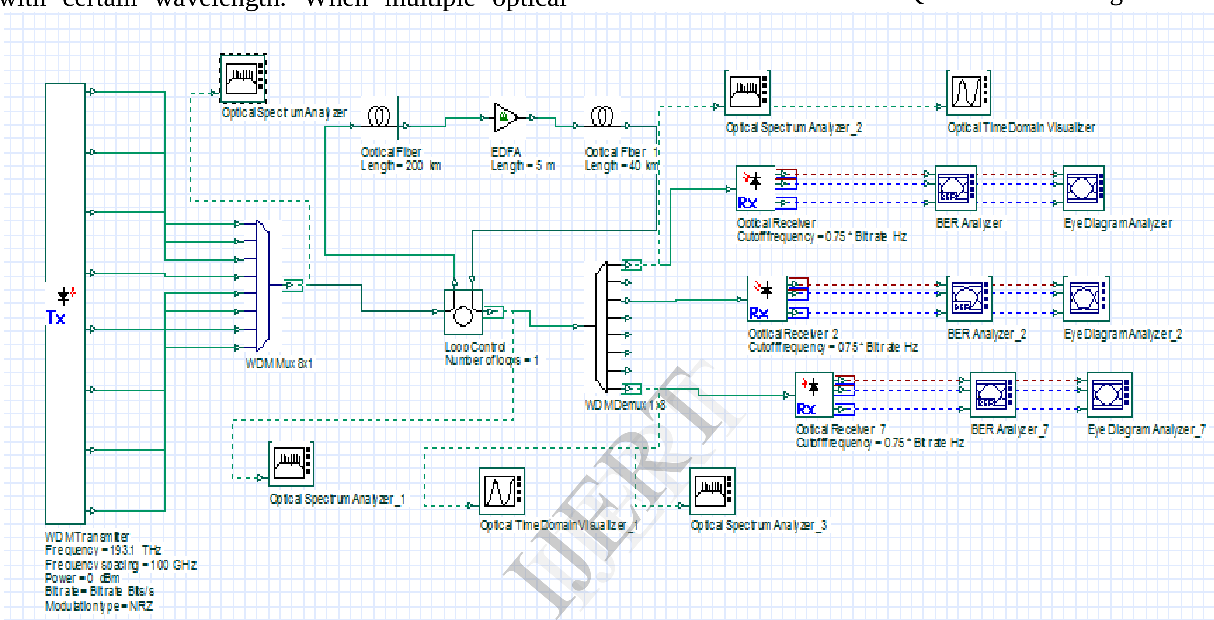
Yu-Siang Huang, Ching-Hung Chang, Wen-Yi Lin, Wen-Jeng Ho, and Hai-Han Lu gives "10Gb/s Bidirectional Long Reach WDM-PON with Dispersion Compensating Raman/EDFA Hybrid Amplifier and Colorless ONUs" in which The hybrid amplifier is proposed and employed in bi-directional long-reach WDM-PON system to boost up power budget for both downstream and upstream signals. A 10Gbit/s symmetrical signal is modulated and demodulated in colorless ONU. [8]

WDM systems are analysed using EDFA and it is attempted to minimize the dispersion for 8 and 16 channel WDM system at data rates of 10 and 30 Gbps and various dispersion compensation schemes are analyzed for defining the optimum results.

"2. Simulation Model"

To investigate the effect of dispersion on the 8-channel and 16-channel WDM system at the speed of 10Gbps and 30Gbps the following model is used as shown in fig 1.

The transmitter section consists of data source, Laser source and Mach-Zehnder modulator. The data source is then converted to Non-Return to Zero (NRZ) format. The Data source and laser signal are fed to the Mach-Zehnder modulator, where the inputs generated from data source are modulated with the laser signal are transmitted. The output from the modulator is now an optical signal with certain wavelength. When multiple optical signals are transmitted in a fiber they are multiplexed with wavelength division multiplexer. The multiplexed signal is then passed through the SMF fiber, then through the optical amplifier (EDFA) and then through the DCF fiber to the detector. In the detector section the de-multiplexer is used to get the different optical signals with different wavelengths which were multiplexed at the transmitter side. The Receiver side consists of photo-detector, low-pass filter and the BER analyser. The photo-detector detects the optical signal and then the signal is passed through a low pass filter. The BER analyser is used to check the Bit Error rate and the Q-factor of each signal.



"Figure1. Simulation diagram of 8 channel system"

"3. Results"

In this the variation of Q-factor and Bit error rate with respect to the system length is analysed. This simulation is done for 8-channel and 16-channel transmitter at 10Gbps and 30Gbps data rate. The wavelength range for the 8-channel transmitter is 1546.9nm to 1552.6nm with the wavelength spacing of 0.8nm between channels. The wavelength range for the 16- channel transmitter is 1540.5nm to 1552.6nm with the wavelength spacing of 0.8nm between channels. The input power per channel is -10dBm. The SMF length is taken as 100Km and DCF length is 20Km. The EDFA is placed between the SMF and DCF. EDFA length is 5m and is forward pumped at 980nm with 100mwatt pump power.

In Fig 2 & Fig 3 the variation of Q-factor with system length for 8-channel transmitter is shown. The system length is varied from 10Km to 100Km and the Q-Factor for 1546nm and 1552nm channel at 10Gbps and 30Gbps is observed.

In the Fig 2 it is observed that Max Q-factor decreases with increase in system length due to dispersion. At 10 Gbps max value of Q factor is 5 at 10 km length for high input signal wavelength 1552nm. But as the wavelength decreases max value of Q-factor also decreases.

In Fig 3 Max Q-factor value with respect to system length of 10 km at 1551 nm is 2.6 which decrease due to increase in data rate to 30 Gbps. In this graph it is observed that Q-factor increases with system length due to better dispersion compensation.

In Fig 5 & Fig 6 the variation of Q-factor with system length for 16-channel transmitter is shown. The system length is varied from 10Km to 100Km and the Q-Factor for 1546nm and 1552nm channel at 10Gbps and 30Gbps is observed.

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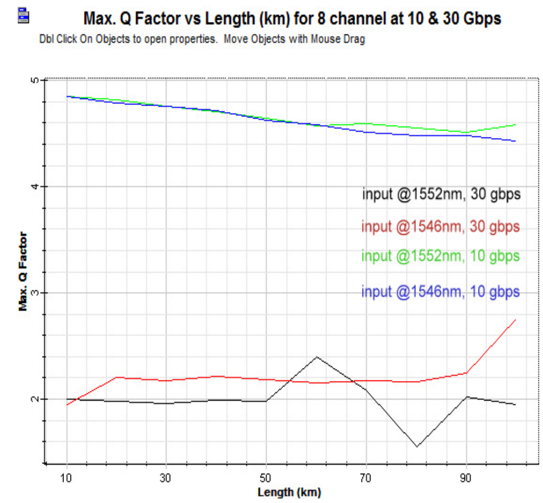
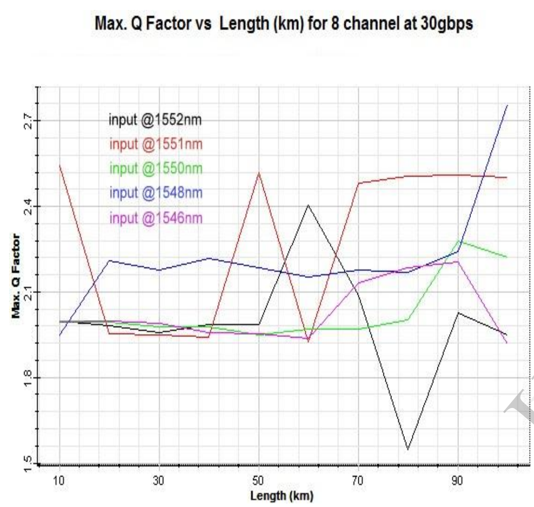
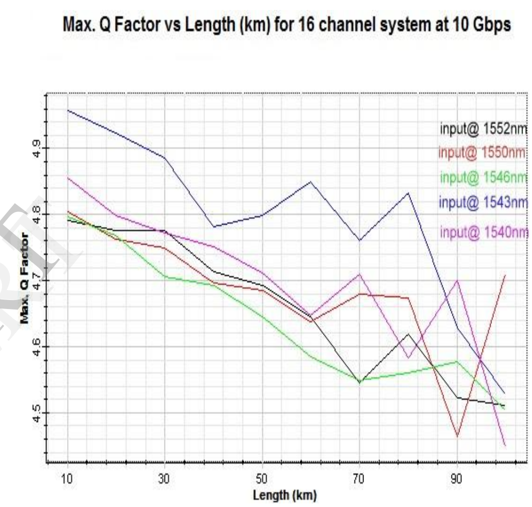
“Figure 2 Variation of Q Factor with system Length at 10 Gbps for 8 channel system”



“Figure 4 Variation of Q Factor with system Length for 8 channel system”



“Figure 3 Variation of Q Factor with system Length at 30 Gbps for 8 channel system”



“Figure 5 Variation of Q Factor with system Length at 10 Gbps for 16 channel system”

In Fig 5 it is observed that Max Q-factor decreases with increase in system length due to dispersion. At 10 Gbps max value of Q factor is 5.5 at 10 km length for input signal wavelength 1543nm. But as the wavelength decreases max value of Q-factor also decreases.

In Fig 6 Max Q-factor value with respect to system length of 10 km at 1550 nm is 2.8 which decrease due to increase in data rate to 30 Gbps. In this graph it is observed that Q-factor increases with system length due to better dispersion compensation. But at some particular length Q factor become zero i.e. for input wavelength of 1546nm at system length between 70-80km Q-factor become zero.

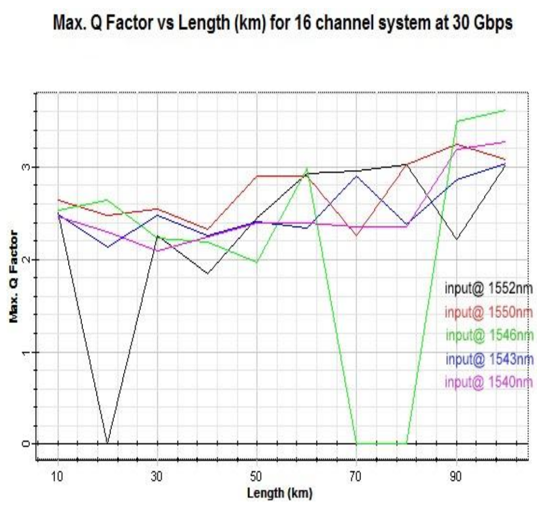
In Fig 4 & Fig 7 it is clearly observed that Q-factor decreases as data rate increases. So in comparison between 8 channel and 16 channel system Q factor is better for 8 channel system as no of channel increases Q factor decreases.

Here in Fig 8 it can be seen that for 8 channel transmitter the Q-Factor for 1552nm signal at 100 km is 4.65 and at 180 km is 2.62 at 10Gbps. So the Q-Factor is very much acceptable for this system for a 180 km distance optical network. The observed Q-factor for 8 channel transmitter for 1546nm at 100 km is 4.82 and at 180 km is 2.80. Beyond 200 km distance the Q-factor is 0. This Q-factor is good till 200 km but is not suitable beyond 200 km distance.

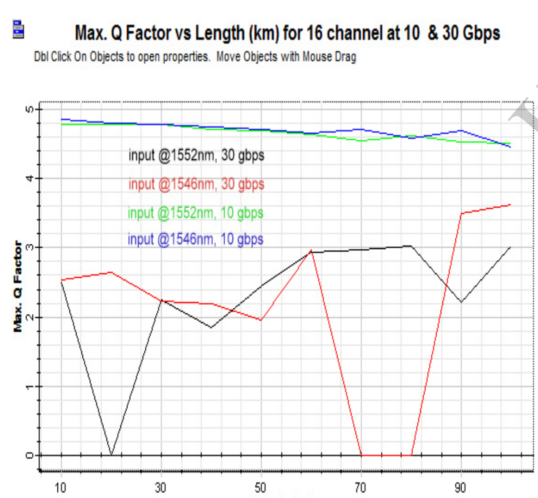
When the same observation was done for 30Gbps data rate network, for 1552nm signal the Q- factor at 100km distance is 1.98 and at 150 km distance it is found to be zero. Hence it can be observed that for the current system is not suitable for 30Gbps data rate for 1550nm signal. For 1546nm signal at

100 km distance Q-Factor is 2.50 and at 150 km Q-factor is 2.10 which is acceptable. So this system is good for signal detection up to 150 km distance.

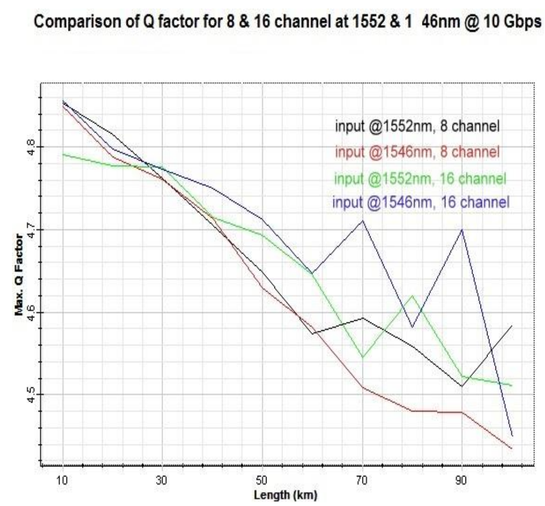
The same observation was done for 16 channel transmitter. It is found that for 10Gbps data rate and 1546nm signal, Q-factor at 100 km is 4.70 and at 180 km is 2.80. For 1552nm signal Q-factor at 100 km is 4.60 and at 180 km is 0.24. For 30Gbps data rate and 1546nm the Q-factor at 100 km is 2.75 and at 150 km is 0.50. For 1552nm signal at 30Gbps Q-factor is 1.98 at 100 km and 0.15 at 175 km system distance



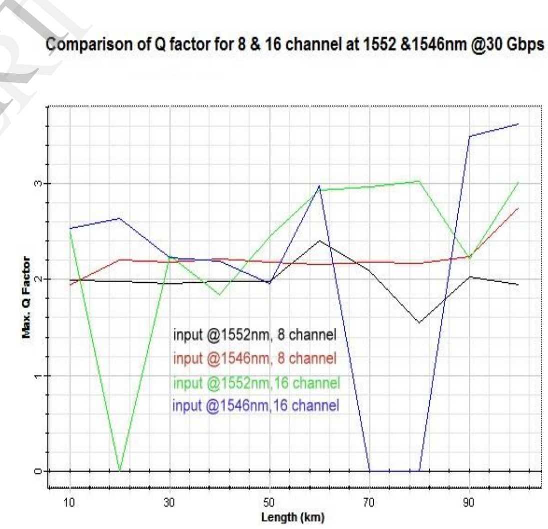
"Figure 6 Variation of Q Factor with system Length at 30 Gbps for 16 channel system"



"Figure 7 Variation of Q Factor with system Length for 16 channel system"



"Figure 8 Comparison of Q factor for 8 & 16 channel system at 10Gbps"



"Figure 9 Comparison of Q factor for 8 & 16 channel system at 30Gbps"

"4. New Proposed Model"

In this we proposed the various latest dispersion compensation schemes to improve the Q factor for long distance haul fiber.

4.1 Post Dispersion Scheme

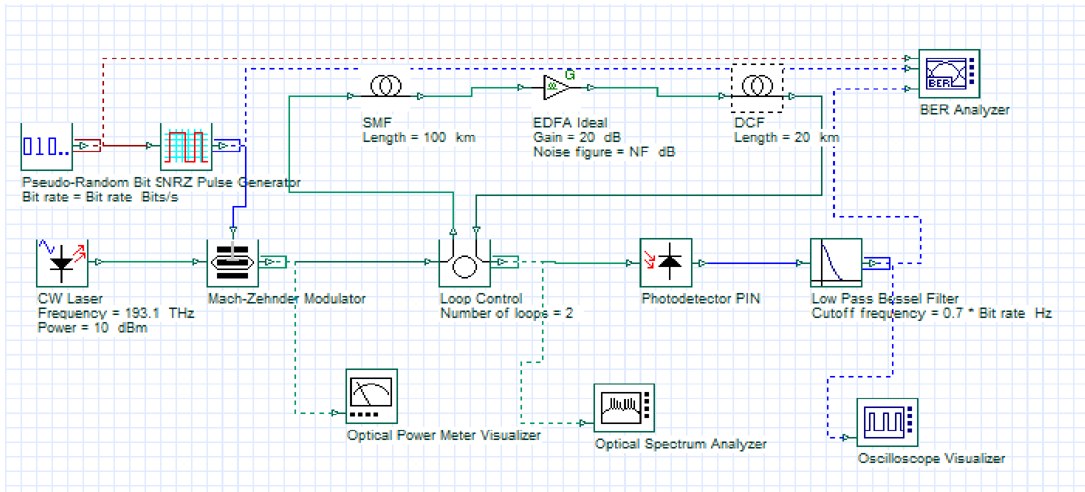
In this scheme firstly Single mode fiber (SMF) is used then signal is amplified using EDFA and then dispersion compensated fiber (DCF) is used to compensate the dispersion of optical signal.

4.2 Pre Dispersion Scheme

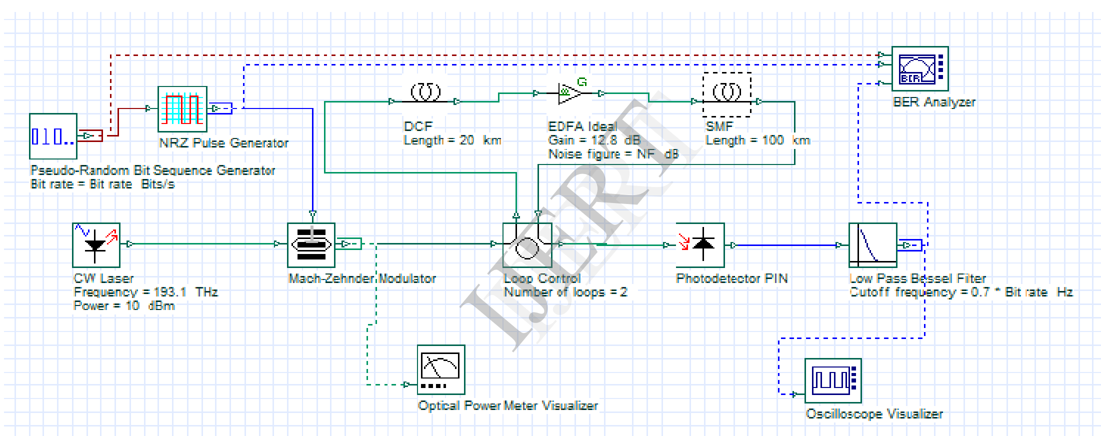
In this scheme firstly dispersion compensated fiber is used to disperse the optical signal negatively then this signal is amplified using EDFA and then single mode fiber (SMF) is used to compensate the dispersion of optical signal.

4.3 Symmetrical Dispersion Scheme

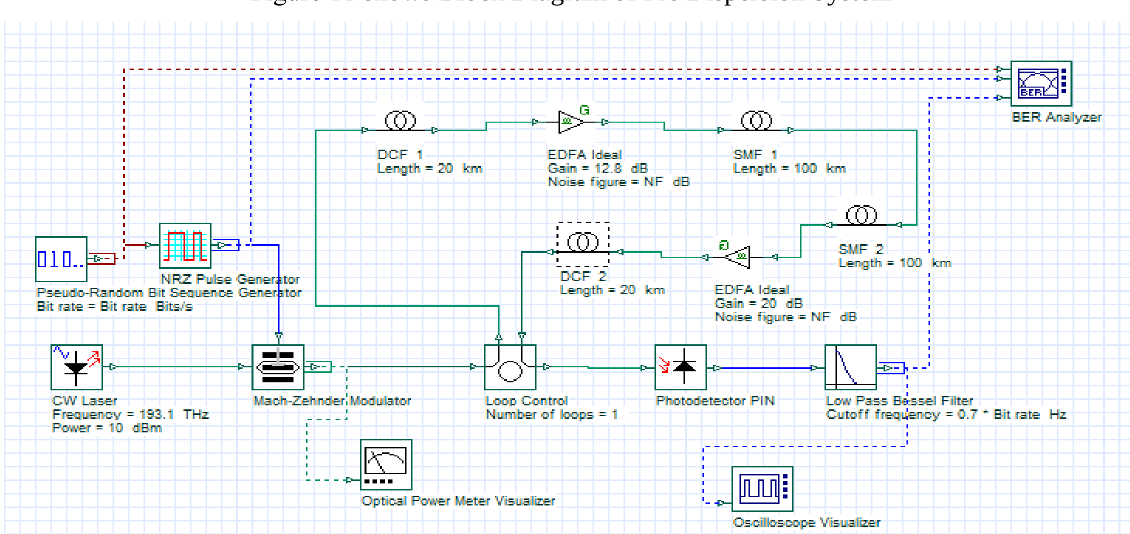
In this scheme basically combination of both i.e. pre compensation followed by post compensation is used. Firstly signal is negatively compensated using DCF then passes through pair of SMF & EDFA is used to amplify the signal and finally over all signal at last is dispersion compensated using DCF.



"Figure 10 shows Block Diagram of Post Dispersion System"



"Figure 11 shows Block Diagram of Pre Dispersion System"



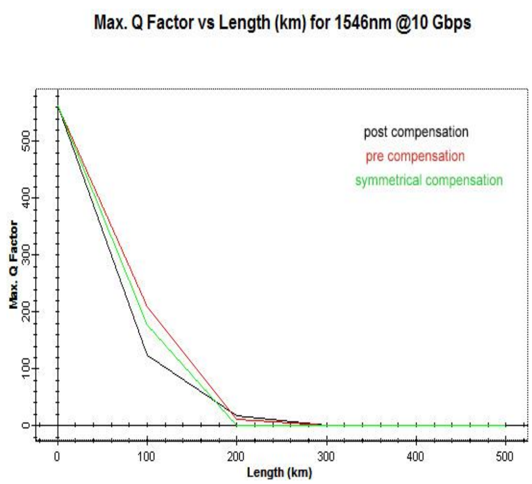
"Figure 12 shows Block Diagram of Symmetrical System"

"5. New Model Simulation & Results"

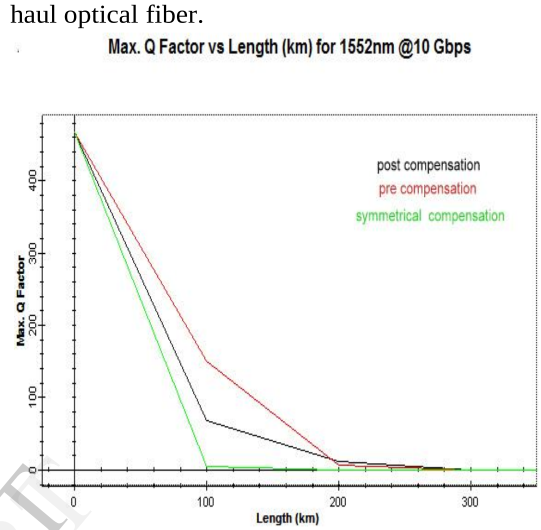
In this new model we can use various dispersion schemes along with standard measured EDFA with input power of -10dBm. The pumping technique is forward pumping with pumping power of 100mW & pumping wavelength of 980nm. The Gain of first EDFA is 20 dB and second EDFA is 12.5dB.

Here in Fig 13 it can be seen that Q factor for 1546nm signal at 100 km for post compensation is 120 and at 200 km it is 15.50. But for pre compensation value of Q factor at 100 km is 215 and at 200 km its value is 1.25 which is not acceptable. So this system is acceptable up to 150 km. Now for symmetrical system Q factor at 100 km is 175 which is better than post compensation.

Here in Fig 14 it can be seen that Q factor for 1552nm signal at 100 km is 170 and at 200 km it is 5.30 but value for symmetrical compensation at 100 km is 2.30 which is very less so symmetrical compensation at 1552nm is not acceptable for long haul optical fiber.



"Figure 13 Comparison of different compensation schemes for 1546nm @10 Gbps"



"Figure 14 Comparison of different compensation schemes for 1552nm @10 Gbps"

"6. Conclusion"

Here in this the effect due to dispersion and its compensation is studied. The DCF was used to compensate the dispersion loss. The Q factor for 8 channels and 16 channels was compared at data rate of 10 Gbps and 30 Gbps. It was found that Q factor for 8 channel systems is greater than 16 channel systems. For 10 Gbps data rate is high as compare to 30 Gbps data rate. The comparison of different dispersion compensation scheme was done and it was found that at 1546nm pre compensation scheme is best for distance up to 180 km but for large distance &good Q factor post scheme is preferred. Now at 1552 nm best scheme is pre compensation. Now at high data rate dispersion is more due to more pulse broadening. So for longer data transmission effect due to polarization mode dispersion needs to be compensated.

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