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OPTICAL LINK DESIGN USING MULTIPLE MODULATION TECHNIQUES

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Abstract- In this paper, we have demonstrated 8 channel WDM system in orthogonal frequency division multiplexing using pre, post and symmetric compensation at the data rate of 100 Gbps The performance of OFDM system was analyzed by increasing the input power. Software simulator is implemented for the analyzation part. Optisystem software version 7 offered by optiwave is used to simulate the components for testing the WDM system. The performance of the OFDM system is analyzed by varying the input power. In OFDM system, the Q factor goes on improving with the higher data rates of 100 Gbps and by increasing the transmission distance in order to get relevant performance. Thus OFDM at higher data rates proves to be beneficial for long- haul transmission with higher spectral efficiency and low bandwidth requirement. So, we can conclude from the result that OFDM performs better at higher data rates and helps to eliminate inter symbol interference and has the tendency to overcome the signal at higher levels. Thus, OFDM is preferred as compared to single carrier systems.

Key Words- OFDM, WDM, OOK, LAN, MAN, WAN, Q Factor.

1 INTRODUCTION-

The process of connecting two or more computer devices for the purpose of sharing the information and data through the hardware and software arrangement is called networking. The phenomena of transmitting information from source to the destination through the use of optical fiber by sending light pulse is known as optical fiber communication. The light pulse is converted into electromagnetic wave and is modulated for carrying any information.

The means of transmitting information among several nodes of network that will encode signal onto light is referred to as optical network. The optical network is operated for a short range of LAN or over a WAN which crosses MAN all the region to national and international distances. Nowadays, the capacity of the WDM system has shown tremendous growth to 100 Gb/s on each wavelength channel. The advantage of using optical fiber in WDM system is its high bandwidth, low noise and less interference.

OFDM- Today's communication system uses large number of bit rates to transfer high speed of data extended up to 100 Gbps. Recently, OFDM is established to meet the increasing requirements. It is a process whereby a signal is divided into several channels. It is a modulation technique to transfer single stream of data over less rate orthogonal sub carriers. Because of its tendency to overcome the signal and eliminates ISI, OFDM is preferred as compared to single carrier systems.

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The orthogonality of sub carriers will make the signals received at the receiver without any noise and inter carrier interference. Major benefit of using OFDM is its ability to protect channel against co channel interference. Basically, OFDM is the combination of two process known as modulation and multiplexing. Modulation is a technique in which information is mapped when changing the carrier frequency, phase, amplitude or the combination. Whereas, multiplexing is a process in which each independent channels share the bandwidth.

WDM- In optical communication, WDM is a process of multiplexing carrier signals over a single fiber with the use of different wavelengths. This technique provides bi directional transmission of signal or information over a single optical fiber. WDM system has a transmitter that uses multiplexer to combine the signals and the receiver has de multiplexer which will apart the signals. By using the right choice of the fiber, the device can be made possible that will work both simultaneously and function as optical add drop multiplexer. Earlier WDM systems were very expensive and hard to run. Moreover, the recent modification and prior understanding of WDM system have made it less expensive.

WDM is one of the technique that meets the requirement of high data rate, wider bandwidth over higher speed of data network. Wavelength division multiplexing is one of the efficient method in telecommunication system that increases the tolerance of the dispersion, so as to increase the spectral efficiency and reduce the non linear effects. Optical fiber communication uses WDM for transmitting information among various channels having different wavelengths. So, optical link capacity can be made larger so that it is just not beneficial for the fiber itself but also for the amplifiers used in the fiber. Pre, post and symmetric compensation have to be well managed in order to achieve maximum performance.

Organization of the paper- The rest of the paper is discussed as follows. In Section 2, we introduced the designing of OFDM system. Section 3 discussed the WDM and simulation set up parameters and Section 4 shows the result and finally conclusion part is included in section 5.

2 OFDM SYSTEM DESIGNING-

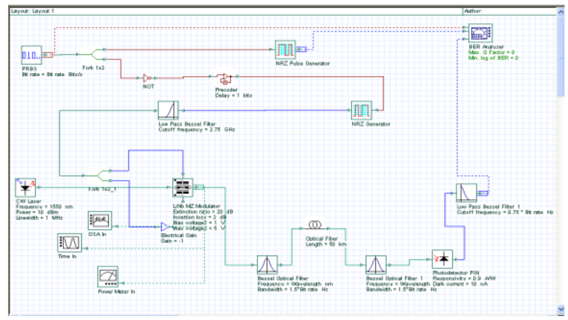


Fig 2.1 : Implementation of OFDM

With the use of NRZ modulation the pulses are placed in between the bit slots where the NRZ amplitude are not two or more consecutive bits. As we change the bit pattern, the pulse width changes. Advantage of using NRZ in optical fiber communication is its simple configuration for the transmitter and receiver design, low bandwidth requirement as compared to RZ pattern, not sensitive to laser noise and less cost. For large number of channels, NRZ is beneficial. High spectral efficiency and dispersion tolerance is provided by optical duo binary systems. Because of its easy fabrication and more prone to dispersion duo binary modulation is supposed to be superior.

The signal at the BER analyzer is used as a visualizer to get the graphs and other specific readings

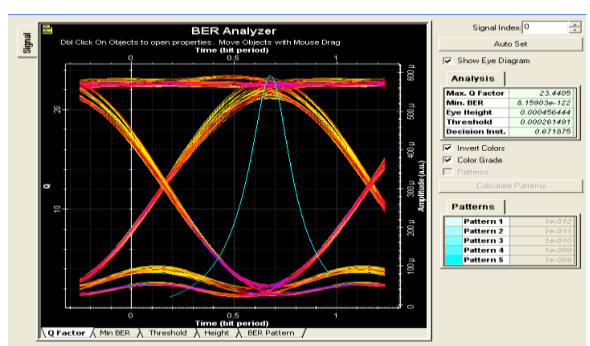


Fig 2(a): Q Factor and eye pattern

The eye pattern and Q factor is achieved at high powers having maximum Q factor of 23.44 with minimum log of BER.

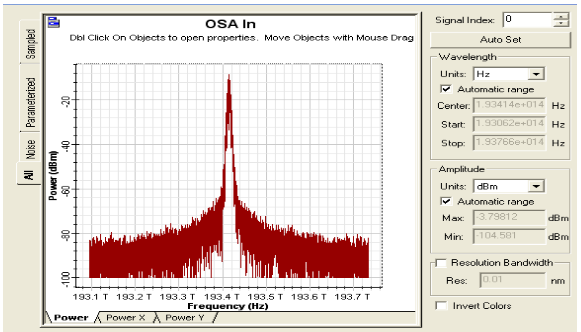


Fig 2(b): Optical Spectrum Analyzer

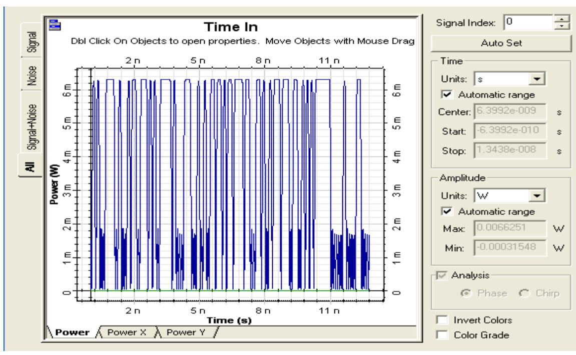


Fig 2(c): Time Domain Visualizer

The spectrum shows that NRZ has narrow pulse width and moreover the transmission bandwidth required by NRZ is less as compared to RZ pattern.

2.1 OFDM in WDM 8 Channel at 100 Gbps-

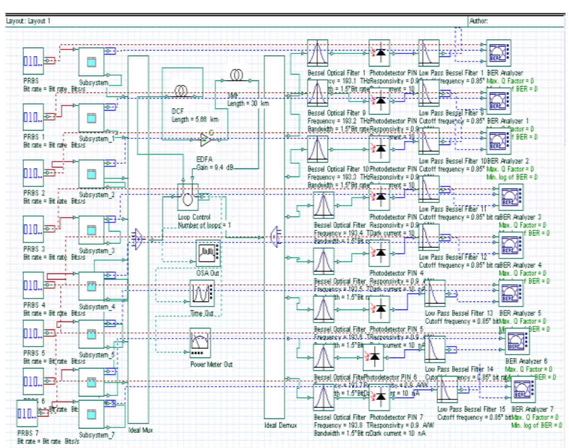


Fig: 2.1(a) Implementation of Pre Compensation OFDM in WDM at 100 Gbps

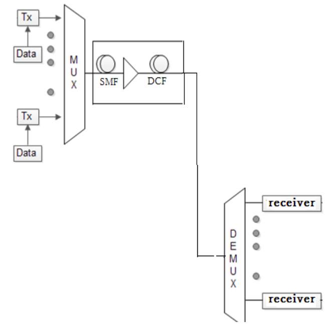


Fig2.1(b): Implementation of Post Compensation OFDM in WDM at 100 Gbps

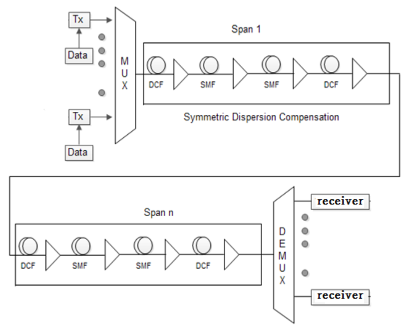


Fig 2.1(c): Implementation of Symmetric Compensation OFDM in WDM at 100 Gbps

The implementation consists of 8 channel WDM system in OFDM modulation technique transmitting data at 100 Gbps of data rate per channel. The 100 Gbps of the data stream is developed using PRBS generator at 64 samples per bit. The frequency range is set from 193.1 to 193.8 THZ. The CW laser generates the optical carrier wave and is then modulated by MZ modulator that is used to generate NRZ, RZ and duo binary data which largely depends on the pulse generator used.

The power used is varied from -4 to 10 dbm per channel. The transmitter is used to filter the eight channels by using optical filters and is further multiplexed for transmission on a single fiber link. Erbium- doped fiber is used to boost up the signal before it is received by the PIN photo diode. Then, Bessel filter amplifies the signal. At the end part of WDM, BER analyzer is used to generate Q factor and bit error rate.

In order to attain high capacity and high speed of WDM transmission, it is necessary to compensate the single-mode fiber. So, for this designing we must use dispersion compensation scheme in the link.. Three dispersion compensation techniques are used- pre, post and symmetric compensation. These schemes are compared with respect to Q factor and bit error rate. The link set up is designed by using DCF and SMF such that the dispersion is compensated. To compensate the losses of the fiber we have used EDFA. Noise figure is kept at 4 db.

In pre compensation, the negative dispersion of DCF is placed before SMF to compensate the fiber of positive dispersion. In post compensation the negative dispersion of DCF is placed after SMF to compensate the fiber. And in symmetric compensation, the negative dispersion of DCF is kept before and after SMF to compensate the fiber link. The set up consists of three parts- transmitter, fiber and receiver. The transmitter consists of CW laser, modulator and multiplexer. The signal from modulator is fed to the 8 input ports of multiplexer. At the receiver end, the signal is de multiplexed by PIN detector and then passes to the filter. The filtered signal is directly connected to the BER analyzer which generate Q factor, BER, eye opening etc.

The readings of OFDM in WDM 8 channel system is shown in the table given below-

POWER	QF 1	QF 2	QF 3	QF 4	QF 5	QF 6	QF 7	QF 8
-4	6	10	11	12	12	11	11	6
-3	6	12	13	14	14	13	13	7
-2	8	14	15	17	16	15	15	8
-1	9	16	18	19	18	17	17	9
0	11	18	20	22	20	20	19	10
1	14	19	21	23	21	20	19	10
2	13	19	21	22	21	20	19	12
3	11	16	18	20	19	18	16	10
4	9	15	16	17	16	15	14	8
5	4	6	6	5	4	7	6	5

Table2.1(a): Pre Compensation OFDM in WDM at 100 Gbps.

POWER	QF 1	QF 2	QF 3	QF 4	QF 5	QF 6	QF 7	QF 8
-4	5	10	10	11	12	11	11	6
-3	6	12	13	14	14	13	13	7
-2	8	14	15	16	17	16	16	8
-1	9	20	18	19	19	19	19	9
0	11	20	21	23	23	22	21	10
1	12	23	24	25	27	25	24	14
2	13	26	22	28	30	29	26	12
3	14	27	26	25	26	25	18	14
4	14	27	29	21	19	21	14	11
5	11	17	19	22	17	18	11	10
6	9	11	15	13	12	11	9	7
7	4	9	6	8	2	4	6	2

Table2.1(b): Post Compensation OFDM in WDM at 100 Gbps.

POWER	QF 1	QF 2	QF 3	QF 4	QF 5	QF 6	QF 7	QF 8
-4	5	10	10	11	12	11	11	6
-3	6	12	13	14	14	13	13	7
-2	8	14	15	17	17	16	15	8
-1	9	22	18	22	20	22	21	9
0	10	18	21	22	19	24	24	10
1	11	14	24	20	19	22	22	11
2	12	13	22	17	20	19	18	12
3	14	13	19	15	16	18	15	13
4	15	12	15	11	14	15	12	14
5	10	9	11	14	12	12	10	10
6	9	6	9	11	12	11	9	7
7	4	3	6	8	2	4	3	2

Table2.1(c): Symmetric Compensation OFDM in WDM at 100 Gbps.

2 WDM Parameters-

	Length(km)	Att.(db/km)	Disp.(ps/nm/km)	Aeff(um^2)	DGD (m^2/W)	n2(m^2/W)	FRC
SMF	30	0.22	17	80	0.2	26e^-21	.18
DCF	5.6	0.5	-90	30	0.2	30e^-30	.18

Table 3(a): WDM system parameters.

SIMULATION SET UP-

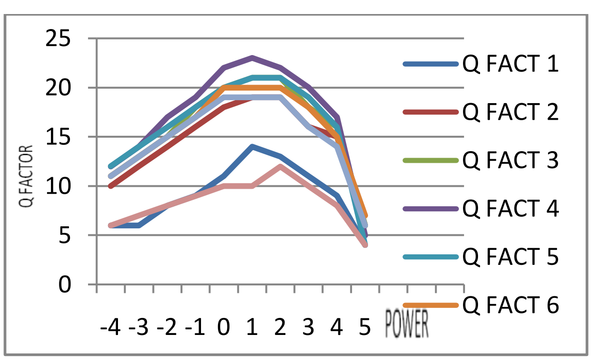
PARAMETERS	VALUES
Bit rate	8*100 Gbps = 800 Gbps
Length of SMF	30 km
Length of DCF	5.66 km
Dispersion of SMF	17 ps/nm/km
Dispersion of DCF	-90 ps/nm/km
Attenuation of SMF	0.22 db/km
Attenuation of DCF	0.5 db/km
Affective area of SMF	80 um^2
Affective area of DCF	30 um^2
Gain of in line EDFA after SMF and DCF	9.4 db
Noise figure	4 db

Table 3(b): Simulation Set Up.

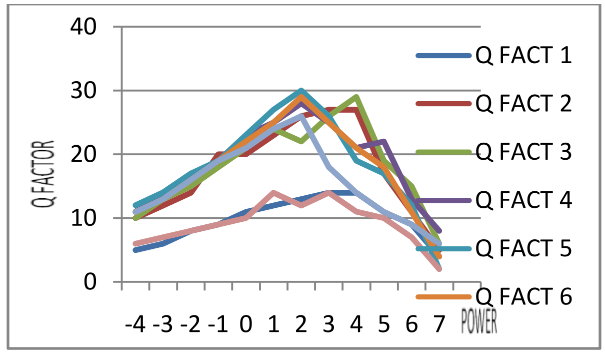
The parameters used in the designing of OFDM system at different data rates are shown above. The bit rate used is 100 Gbps. The length of SMF and DCF are kept at 30 km and 5.66 km respectively. Dispersion of SMF used is 17 ps/nm/km and that of DCF is -90 ps/nm/km. The attenuation of SMF is set at 0.22 db/km and DCF is 0.5 db/km. affective area of DCF used is 30 um^2 and that of SMF is 80 um^2. Gain of in line EDFA used in compensation schemes is 9.4 db. Noise figure of EDFA is set at 4 db.

4 RESULT-

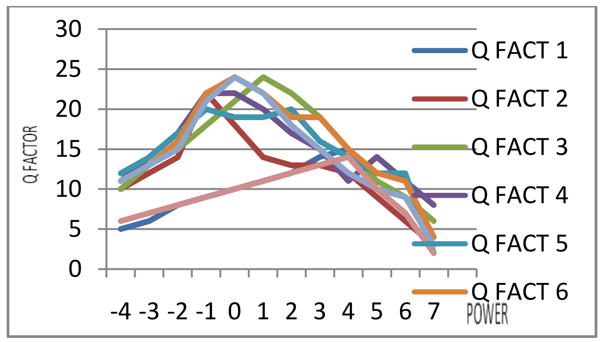
In this paper, the comparison and the performance of the modulation format OFDM in optical fiber communication is done. The performance was restricted to 100 Gbps of bit rate. The graph shows the Q factor verses input power.



Pre Compensation.



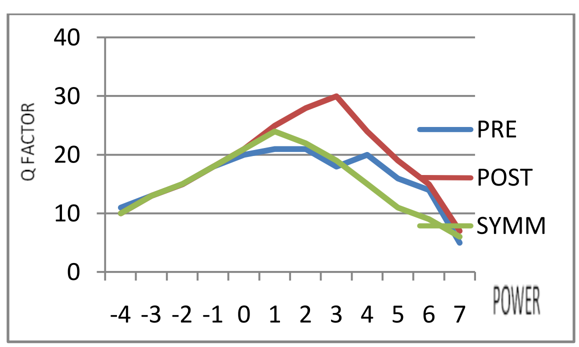
Post Compensation.



Symmetric Compensation.

The graphs of pre, post and symmetric compensations at 100 Gbps of data rate are drawn.

The result shows that as we increase the input power Q factor also increases initially and then reaches at the peak value. But further as we increase the input power, the q factor starts to show a decline. So the point where it starts to show decline gives up the peak value. The reason behind this is that at very high powers, wavelengths start to overlap each other thus reducing non- linear effects and further lead to decrease in the value of q factor.



Comparison of pre, post and symmetric compensation is drawn in the graph. The post compensation comes out to be superior because it has less nonlinearities and good spectral efficiency as compared to the other two.

5 Conclusion-

In this paper, we have discussed the modulation techniques like OFDM in WDM system at 8 channels using pre, post and symmetric compensation at the data rate of 100 Gbps. The optical signal transmitted over the OFDM systems have been evaluated. The performance of OFDM system was analyzed by increasing the input power. Moreover, the input laser power for the reception of signal is observed and was found that initially when we increase the input power the output signal is good at certain level, but further as we increase the power, signal at the receiver is destroyed due to non linear effects and the graph shows the decline. It was observed that Q factor goes on improving with the bit rate and the transmission distance. So, OFDM performs better at higher data rates and helps to eliminate inter symbol interference and has the tendency to overcome the signal at higher levels. Thus, OFDM is preferred as compared to single carrier systems. By using this modulation technique we came to the conclusion that OFDM has higher bit rate and good spectral efficiency.

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