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OPTIMUM OPTICAL LINK DESIGNING USING DIFFERENTIAL CODING

Maninder Kaur

M.Tech (ECE)

Rayat Institute of Engineering and Information Technology, Railmajra, Punjab(144533)

Maninder Singh (Associate Professor)

Rayat Institute of Engineering and Information Technology, Railmajra

Abstract- **The increasing demand of high capacity optical network for transmission of data rate at 40 Gbps or beyond with required signal quality research is carried out to meet new modulation and multiplexing techniques. Channel dispersion or spacing becomes the prominent factor for various transmissions at given fiber length, as the data rate increases beyond 40 Gbps. This paper shows the transmitter and receiver design with linear and non linear effects. Pre, post and symmetric link designing was used and the result is achieved for output quality factor for different channels. We discuss the high spectral efficiency in long haul transmission and describes the theory behind multi level modulation technique i.e. differential quadrature phase shift keying (DQPSK) and explain in detail how to implement it in experimental setup at 100 Gbps. The value of input power ranges from 0 to 10 dbm and more which generates the required Q factor graphs at the output. The graph clearly shows as we increase the value of power, q factor decreases and vice versa. It is clear from the result that DQPSK performs better at 100 Gbps.**

Keywords- WDM, DQPSK, OOK, CD, MAN, WAN, PMD, Optical Network.

I INTRODUCTION-

Telecom networks are made of using various communication mediums like twisted pair cable, coaxial cable, optical fiber etc. Optical fibers are like thin glass cylinders that carry signals as light (optical signal). Optical networks are widely used with bandwidth of 50 tera-bits per second. Or we can say, we can send 50*10^12 bits per second for single fiber. When multiple signals are operated on same fiber it is called WDM. The carrier frequency of optical fiber is of 10^15 hertz. Optical fiber uses low loss of 1.3 um and 1.55 um bands. The optical fiber even have high capacity and bandwidth. They are immune to noise and interference and can be easily upgraded using WDM.

DQPSK- DQPSK detects the phase change but not the phase value which avoids the use of local carrier at the receiver. The phase change of symbol is encoded to next symbol period but not the absolute value of phase. DQPSK can detect the signal without using any local carrier whereas the previous modulated signal affects the phase of initial modulated signal. DQPSK allows the transmission of information at four different levels 00, 01, 11, 10. It has high dispersion, more channel spacing and offers narrower spectrum efficiency. It is a technique that operates 40 Gb/s data rate at 50 GHZ channel spacing. To have the same data rate it uses half the transmission rate.

It offers high spectral efficiency, polarization mode dispersion and even used in long transmission. With the increasing capacity of optical systems at the data rate of 40 Gbps and more various research is held to generate new modulation, multiplexing and optical signals.It transmits different phase code in two bits of group known as symbols (00, 01 ,11, 10). As the symbol rate is half that of the bit rate therefore the bandwidth required for the bit rate is ¼ which reduces the system complexity. Its advantage is that it has lower spectral width.

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WDM- In WDM, the channel bandwidth is splitted into different channels and every channel has its frequency spectrum and these channels are known as wavelength. It is so called because every channel operate at different frequency and wavelength. It is a device that transfers various optical signals on a single optical fiber. Multiplexers are used at the transmitters to combine signals and de multiplexers at receiver to split them. In WDM, the bandwidth is divided into number of channels and various data streams are emitted to same fiber at same time.

In WDM two signals having same wavelength does not move down in same fiber. It has bandwidth of around 30 to 40 optical wavelengths. Without any extra fiber WDM can upgrade the capacity of fiber networks. Any transmission format can be made by optical channels.. The first WDM uses two wavelengths i.e. 1310 nm and 1510 nm.

Organization of the paper- This paper has been organized as follows. Section II gives the description of DQPSK modulation format. Wdm parameters is designed in section III. The result is shown in section IV and finally the conclusions are drawn in section V.

II DQPSK DESIGNING-

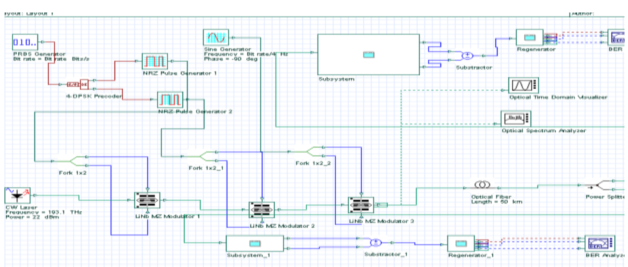

Fig 2: Illustration of DQPSK SYSTEM

Our objective is to modulate the signal at NRZ format. In order to get the optical signal we have used CW laser, Mach zehnder modulator, NRZ pulse generator and sinusoidal signal generator .Duobinary is made by combining NRZ signal with pre coder and pulse generator. This generator passes through mach zehnder and then combines with another mach zehnder that is linked by sinusoidal signals. Then these three mach zehnder combines to generate DQPSK signal at receiver. The working of DQPSK receiver is same as that of QPSK system whereas the output to low pass filter is decoded to receive the information. Basement signal is sampled at the low pass filter part and then compared with previous signal. To have same data rate, DQPSK uses half the transmission rate (20 Gbps system for 40 Gbps data rate).

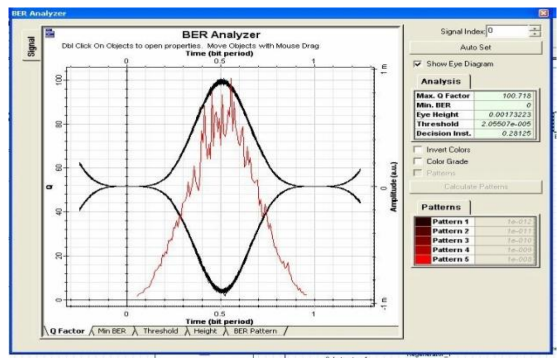

Fig 2(a): Q factor and eye pattern of DQPSK

DQPSK generates the above graph with perfectly shown eye pattern having Q factor 100.718 at power 10 dbm.

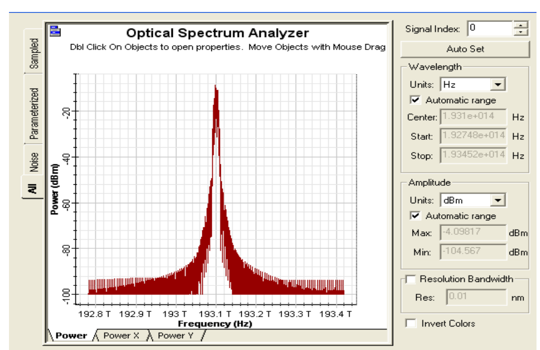

Fig 2(b): optical spectrum analyzer

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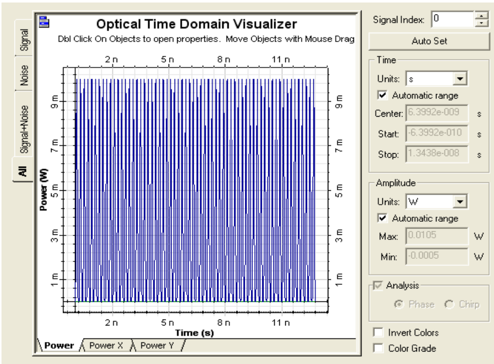

Fig 2(c): time domain visualizer

DQPSK technique has an alternate as it, like QPSK the symbol period is half that of the bit rate with less complexity of system as it transmits two bits per symbol. On the contrary, DQPSK is more tolerable to chromatic dispersion, PMD and increasing spectral efficiency and more oftenly used in long transmissions.

2.1: DQPSK IN WDM FOR 8 CHANNEL AT 100 Gbps

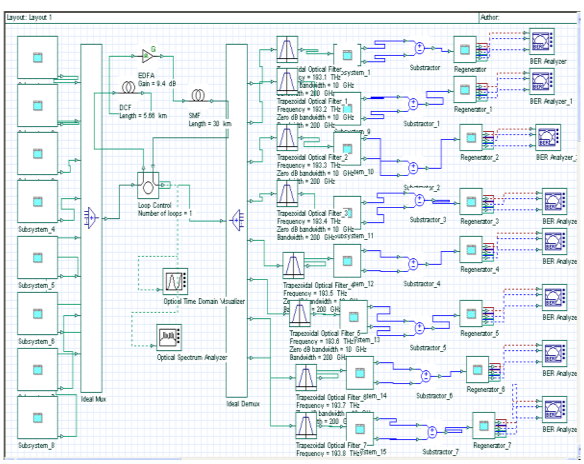

Fig 2.1(a): Implementation of pre compensation DQPSK in WDM at 100 Gbps

Link design consists of pre, post and symmetric compensation at 100Gbps. DCF is one of the simplest and prominent approach for the optical designed links made of SMF. The designing consists of DCF, SMF and EDFA. The purpose of using the EDFA after SMF or DCF is that it provides the periodic amplification.

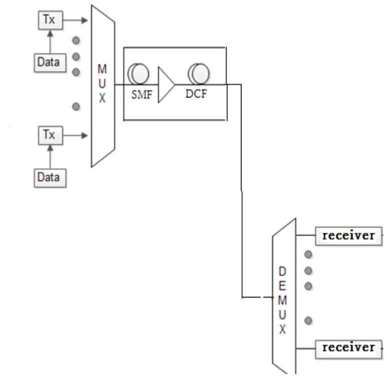

Fig 2.1(b): implementation of post compensation DQPSK in WDM at 100 Gbps

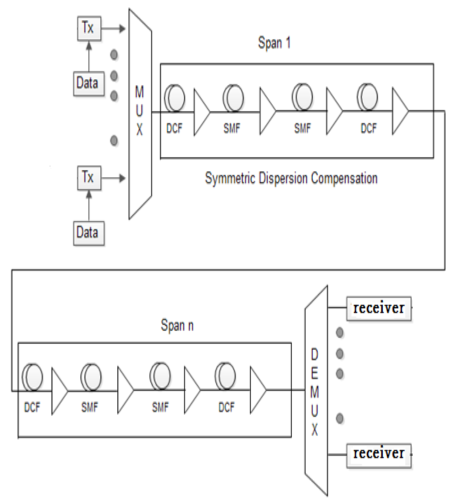

Fig 2.1(c): Implementation of symmetric compensation DQPSK in WDM at 100 Gbps

EDFA is used to compensate the 100 % power loss. The input power of DCF should be less than -27 dpm/channel. In pre compensation, DCF is placed before SMF. In post compensation, DCF is placed after SMF. In symmetric compensation, DCF is placed before SMF and the amount of pre compensation generated by DCF is completely compensated in SMF. Then the attenuation through the EDFA, make the signal or the light path to move to another SMF. Now, the attenuation produced in SMF is post compensation at next DCF placed after second SMF. Therefore, the second DCF generates post compensation in every optical span. On the contrary, if we place one DCF having negative dispersion after SMF having positive dispersion, then the resulting dispersion is zero.

Moreover, the dispersion tolerance is inversely proportional to data rate. The signal bandwidth decreases due to which non linearity's increases and vice versa. DCF and SMF are beneficial for long haul transmission. SMF has high capacity, long optical fiber and incredible bandwidth. Dispersion causes pulse broadening and pulse distortion. DCF offers reduced insertion loss, reduced PMD, and high chromatic dispersion. The length of DCF is 5.66 km and dispersion is -90 ps/nm/km. whereas, the SMF length is 30 km and dispersion is 17 ps/nm/km. EDFA has the gain of 9.4 db and noise figure of 4 db.

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

POWER	QFA1	QFA2	QFA3	QFA4	QFA5	QFA6	QFA7	QFA8
-4	27	32	31	36	42	34	32	28
-1	33	35	35	38	41	36	33	32
0	32	31	33	34	36	33	32	32
2	25	25	23	23	23	23	24	24
3	21	20	19	18	18	18	19	19
6	15	14	14	15	13	12	11	11
8	6	6	5	5	5	4	6	6

Table 2.1(a): pre compensation DQPSK in WDM at 100 Gbps

POWER	QFA1	QFA2	QFA3	QFA4	QFA5	QFA6	QFA7	QFA8
-4	25	32	34	37	40	39	34	29
-1	35	45	47	51	57	56	46	42
0	42	49	52	54	58	59	48	46
2	48	53	57	64	63	64	52	55
4	50	52	55	57	59	57	49	54
7	38	37	39	35	36	36	38	32
10	19	18	17	17	16	16	17	18

Table2.1(b): post compensation DQPSK in WDM at 100 Gbps

POWER	QFA1	QFA2	QFA3	QFA4	QFA5	QFA6	QFA7	QFA8
-4	27	33	33	37	39	36	33	28
-1	35	46	45	50	54	46	46	41
0	39	51	54	51	59	54	52	51
2	45	64	62	65	68	60	63	48
4	52	60	65	60	63	60	62	51
8	28	27	25	26	25	24	22	18
11	15	14	15	15	13	13	12	11

Table2.1(c): symmetrical compensation of DQPSK in WDM at 100 Gbps

III WDM PARAMETERS-

The WDM system parameters are shown in below table. The frequency's used are 193.1 thz, 193.2 thz, 193.3 thz___ 193.8 thz. The attenuation for SMF is 0.22db/km and for DCF is 5.6 db/km. SMF shows the attenuation at 17ps/nm/km and DCF at -90ps/nm/km.

	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	0.18
DCF	5.6	0.5	-90	30	0.2	30e^-30	0.18

Table 3(a): WDM system parameters

SIMULATION PARAMETERS-

The bit rate of DQPSK used in this thesis work is 8*100 = 800 Gbps. The length of SMF is 30 km and that of DCF is 5.66 km. The SMF has the dispersion of order 17 ps/nm/km and of DCF is -90 ps/nm/km. The attenuation of SMF is 0.22 db/km and DCF uses attenuation of 0.5 db/km. affective area of SMF is 80 um^2 and DCF is 30 um^2. The gain of in line EDFA after SMF and DCF is 9.4 db. Noise figure is of the order 4 db.

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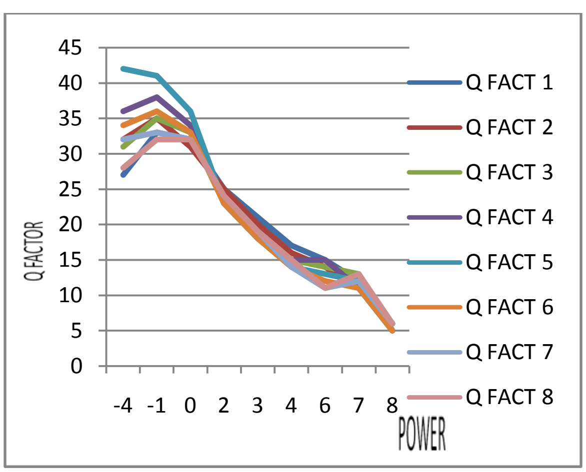
PARAMETERS	VALUES
Bit rate	8*100 Gbps = 800 Gbps
Length of SMF	30 km
Length of DCF	5.66 km
Dispersion of SMF	17 ps/nm/km
Dispersion of DCF	-90 ps/nm/km
Attenuation of SMF	0.22 db/km
Attenuation of DCF	0.5 db/km
Affective area of SMF	80 um^2
Affective area of DCF	30 um^2
Gain of in line EDFA after SMF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

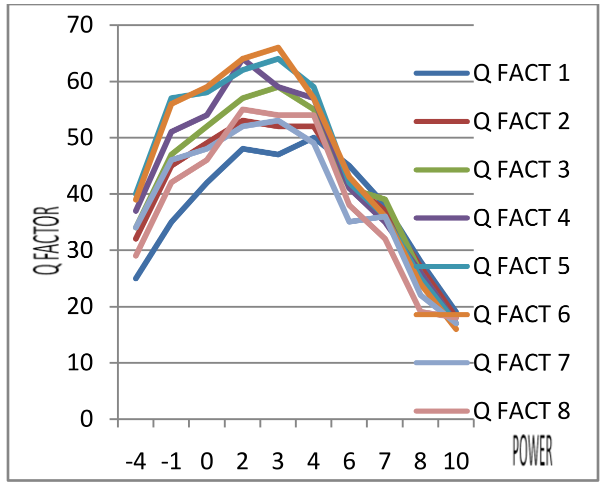
Table 3(b): WDM system parameters

IV RESULT-

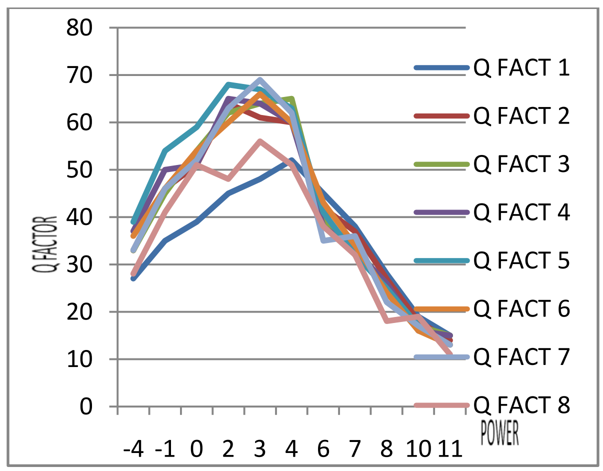
We have implemented the modulation techniques i.e. DQPSK at data rate of 100 Gbps. We have also established DQPSK in WDM at 8 channels and finally have drawn many conclusions and resuts. DQPSK offers high spectral efficiency, polarization mode dispersion and even used in long transmission. It transmits different phase code in two bits of group known as symbols (00,01,11,10). As the symbol rate is half that of the bit rate therefore the bandwidth required for the bit rate is ¼ which reduces the system complexity. Its advantage is that it has lower spectral width. The result shows the graphs for pre, post and symmetric compensations.



Pre Compensation

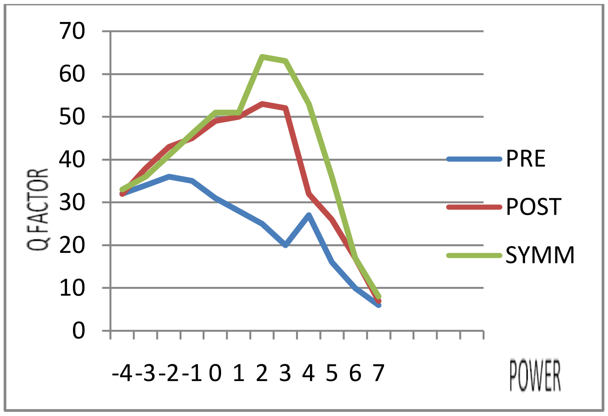


Post Compensation



Symmetric Compensation

We obtain different Q factors at various powers shown above. It is clear from graphs, as we increase the power the Q factor goes on decreasing and vice versa. And after the certain point it gradually declines. The reason to it is, at very high powers, wavelengths tend to overlap each other thus reducing the non- linear effects and further decreases the Q value. The result shows that the signal is recovered at the receiver with less noise impairments.



DQPSK in WDM using pre, post and symmetric compensation at 100 Gbps

In the above graph, we have compared DQPSK in WDM using pre, post and symmetric compensation at 100 Gbps. In this case, symmetric compensation performs best than other two compensations. The value of Q factor in this case is 73.241 which offers lower bit rate. DQPSK offers high high spectral efficiency and is widely used in long haul transmissions.

V CONCLUSION-

We have discussed the usability of 100 Gbps optical network for large spectral efficiencies using the modulation technique DQPSK. The result shows that the modern technology enhance the optical network for every channel of bit rate of 100 bit per sec. DQPSK allows the transmission at high data rates in WDM channels. DQPSK is proven better for long transmission with good tolerance to chromatic dispersion, PMD and increasing spectral efficiency. The increasing demand of available components in market makes this DQPSK possible. Transmitter and receiver deigning shows linear and non linear effects at different data rates. Pre, post and symmetrical designing is carried out and obtain the result for output quality factor at different channels. From the above graphs we can say that input power is inversely proportional to quality factor. DQPSK offers good performance at higher data rates of 100 Gbps.

This paper work clearly shows DQPSK offers good performance at higher data rates of 100 Gbps and is proven better for long transmission with good tolerance to chromatic dispersion, PMD and increasing spectral efficiency.

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