Investigation of Cascaded Optical All Pass Filter at 10Gb/s

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Abstract—The purpose of this paper is to by experimentation study cascaded Optical All Pass Filters (p-OAPF) and optimize the worth of distance of origin from poles (r). Exploitation the worth of transfer function of optical all pass filter that is of second order we tend to found the issue of dividend and divisor. The chromatic dispersion (CD) that occurs in single mode fibres (SMFs) is a consequential issue that requires to be addressed in long-haul optical communication links. The effect of CD is pulse spreading which in turn leads to inter-symbol interference, thus resulting in the deterioration of the bit error rate (BER) performance of the system. An alternative CD emolument technique that utilises a parallel optical all pass filter (p-OAPF) is presented, where the p-OAPF design is predicated on the inverse phase replication of the SMF. The p-OAPF is predicated on a class of all-pass filter. Simulation results of the proposed technique show an incrimination in the repeater-less length of a point-to-point optical communication system by up to three and four times utilizing a non-return-to-zero data format with a rectangular and Gaussian pulse shape, respectively, at error-free condition (BER < 10^6). The results additionally show that the p-OAPF is robust in performing dispersion equalization at a wide range of SMF lengths to procure error-free communication

Keywords— Single Mode Fiber, chromatic dispersion, four wave mixing, dispersion compensation, optical communication

INTRODUCTION

All Pass filters are used to compensate the chromatic dispersion in wavelength division multiplexed (WDM) optical fiber communication system . Optical fiber communication is a way of transmitting the information from one place to another place with the information signal. All-pass filters (APFs) are devices that allow phase correction or equalization without introducing any amplitude distortion. An optical implementation of such devices is very attractive since they can be used for dispersion compensation. All pass filters are linear systems having variable phase response and constant amplitude response. The variable phase response of the APFs makes them to be used as the phase equalizers to compensate the chromatic dispersion. Chromatic Dispersion (CD) can be compensated through Single Mode Fiber. Where it will result in spreading the pulses and also causes for Intersymbol Interferences (ISI). However, Chromatic Dispersion (CD) is made up to Material Dispersion (MD) and Waveguide Dispersion (WD). Material Dispersion can be defined as the phenomenon of different wavelengths travelling at different speeds due to the variation of Refractive Index through which the light will also travel to the proportion in cladding of SMF, which has a different Refractive Index as compared to core and introducing an effect known as Waveguide Dispersion.

Both of these phenomena occurs because all of the optical signals have a finite spectral width and also have different spectral components which will propagate at different speeds along with the length of the fiber. One cause of its velocity difference that is the index of refraction of the core of fiber that is different for their different wavelengths called material dispersion and it is the dominant source of chromatic dispersion in single-mode fibers. Another cause of dispersion is the cross-sectional distribution of light where the fiber may also changes for different wavelengths. Shorter wavelengths are more completely confined to the fiber core, while a larger portion of the optical power at longer wavelengths propagates in the cladding. So that the index of the core is greater than the index of the cladding, this difference in spatial distribution causes a change in propagation velocity. OAPFs have the potential to provide the third order dispersion compensation that causes extremely in transmission optical fiber systems.

Its performance could be improved by increasing the quantity and quality of stages where it planning accordingly the poles and zeros of OAPF nearer to unit circle. However, the trade- offs between the most of cluster delay and its information could measureable because of FSR. As well posses sensible drawback like enlarged in fiber quantity, unacceptable losses and unacceptable ripple of GVD that OAPF produces. OAPF may target using many stages area for finite insertion loss in a device that is sensible and that must be be lossless. Here all frequencies should be unit linear for their unity magnitude values so that the OAPFs varies with frequency as resulting by magnitude response that is constant price of one. The transfer function perform of OAPF can be written as,

$$H_{OAPF}(\omega) = exp^{[j\varphi(\omega)]} \qquad (1)$$

By the transfer function of OAPF can make arbitrary equal to any desired phase response by shifting the coefficients of the transfer function of an OAPF in z domain. The delay in lower frequencies of pulse through large amount as comparable to high frequencies is the basic mean of CD compensation. The phase response of an OAPF can be designed to cancel the phase delay of the SMF . The second order APF in Z domain transfer function can be written as,

$$H(Z) = = \frac{(Z-\frac{1}{r}e^{j\omega_0})(Z-\frac{1}{r}e^{-j\omega_0})}{(Z-re^{j\omega_0})(Z-re^{-j\omega_0})} \qquad (2)$$

Where r and w_0 are the parameters used to check the phase shift. Where the phase response can be written as, $\emptyset_{OAPF}(\omega)$ equals to,

$$tan^{-1}[\frac{\frac{1}{r}2cos\omega_0 sin\omega T-\frac{1}{r^2}sin2\omega T}{1-\frac{1}{r}2cos\omega T\, cos\omega_0+\frac{1}{r^2}cos\omega_0}] - tan^{-1}[\frac{2rcos\omega_0 sin\omega T-r^2 sin2\omega T}{1-2rcos\omega T cos\omega_0+r^2 cos2\omega_0}] \quad (3)$$

Where T is the Time Delay. As well it's Minimum Mean Square Error can be used to minimize the error. The transfer function of OAPF can be written in Z- domain as:

$$H_{OAPF}(Z)=\frac{1-\frac{2}{r}Z^{-1}\cos(\omega_0)+\frac{1}{r^2}Z^{-1}}{1-2rZ^{-1}\cos(\omega_0)+r^2Z^{-2}}=\frac{y(z)}{x(z)} \quad (4)$$

The broadening of light pulses is called dispersion in a critical factor that limiting the quality factor of signal transmission over optical links. The Dispersion is a consequence of the physical properties of the transmission medium. Single-mode fibers are used for high-speed optical networks, those are subjected to Chromatic Dispersion (CD) that causes the pulse broadening that depending on a wavelength and Polarization Mode Dispersion (PMD) is also there that causes pulse broadening depending on polarization. The Excessive spreading will cause a bit to "overflow" their intended time slots and overlap adjacent bits.

PREVIOUS WORK

In previous year, the distance of 111km was chosen although the eye pattern was fully closed with that. But furthermore, the distance was finally chosen at the maximum length of 140 km where it gets the higher probability of bit error rate (BER<10^{-9}) and quality factor of 6.2 at that bit error rate without taking the values of r=.80 and w0=.30 pie. Taken bit rate at 10 Gb/s at wavelength of 1.55 µm and attenuation of .2 dB/km.

RESULTS AND DISCUSSION

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Here we are showing the results at different lengths with the help of Tables:

Table 1: BER and Q-Factor for Channel 1

S. No.	Fiber Length	Channel 1 without equalizer		Channel 1 with equalizer	
		Q-FACTOR	BER	Q- Factor	BER
1	140 km	4.99	2.29* 10^{-7}	11.06	9.42*10^{-29}
2	160 km	0	1	8.42	1.81*10^{-17}
3	180 km	0	1	6.70	9.49*10^{-12}
4	200 km	0	1	6.41	6.85*10^{-11}
5	240 km	0	1	4.75	9.21*10^{-7}

The Table 1, describes the performance parametric values of Channel 1 at different Lengths i.e., the values of BER and Q-Factor. Both the parameters are analyzed with equalizer and without equalizer.

Table 2: BER and Q-Factor for Channel 2.

Sr. No.	Fiber Length	Channel 3 without equalizer		Channel 3 with equalizer	
		Q-FACTOR	BER	Q-Factor	BER
1	140 km	5.46	2.03* 10^{-8}	11.54	4.25*10^{-31}
2	160 km	0	1	8.71	1.39*10^{-18}
3	180 km	0	1	6.84	3.55*10^{-12}
4	200 km	0	1	6.49	3.96*10^{-11}
5	240 km	0	1	4.92	4.02*10^{-7}

The Table 2, describes the performance parametric values of Channel 2 at different Lengths i.e., the values of BER and Q-Factor. Both the parameters are analyzed with equalizer and without equalizer.

Table 3: BER and Q-Factor for Channel 3.

Sr. No.	Fiber Length	Channel 3 without equalizer		Channel 3 with equalizer	
		Q-FACTOR	BER	Q-FACTOR	BER
1	140 km	4.65	$1.31*10^{-6}$	11.64	$1.36*10^{-31}$
2	160 km	0	1	8.69	$1.85*10^{-18}$
3	180 km	0	1	6.94	$1.94*10^{-12}$
4	200 km	0	1	6.60	$2.07*10^{-11}$
5	240 km	0	1	4.98	$3.04*10^{-7}$

The Table 3, describes the performance parametric values of Channel 3 at different Lengths i.e., the values of BER and Q-Factor. Both the parameters are analyzed with equalizer and without equalizer.

Table 4: BER and Q-Factor for Channel 4.

Sr. No.	Fiber Length	Channel 1 without equalizer		Channel 1 with equalizer	
		Q-Factor	BER	Q-Factor	BER
1	140 km	4.41	$3.86*10^{-6}$	12.06	$8.92*10^{-34}$
2	160 km	0	1	9.11	$3.90*10^{-20}$
3	180 km	0	1	7.14	$4.30*10^{-13}$
4	200 km	0	1	6.78	$5.85*10^{-12}$
5	240 km	0	1	5.03	$2.25*10^{-7}$

The Table 4, describes the performance parametric values of Channel 4 at different Lengths i.e., the values of BER and Q-Factor. Both the parameters are analyzed with equalizer and without equalizer.

CONCLUSION

This paper has presented the Chromatic Dispersion in cascaded parallel OAPF at 10 Gb/s in Optical Communication Systems. Results show the capability and equality of two different parameters. Here the BER and Q factor is improving by using a repeater-less distance by four to five times using Gaussian pulses shapes respectively. Four wave Channels are using here to optimize the BER. Where the performances can shorten the effect of compensated pulses and improve the BER using a parallel structure with different lengths. And results are shown then with or without equalizer at lengths. The minimum BER value (10^{-7}) is shown at the length of 240 km where the proper value is achieved for the parameters.

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