IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 14, Issue 6, Ser. I (Nov.-Dec. 2019), PP 40-44
www.iosrjournals.org

Minimizing Four Wave Mixing Effectsin WDM Radio over Fiber System Using Hybrid Modulator, Dispersion Compensating Fiber, and Optical Rectangular Filter

B. K. Karmaker[1], Md. Rayhanul Haque[2]
[1]*(Assistant Professor, EEE, Jatiya Kabi Kazi Nazrul Islam University, Bangladesh)*
[2]*(Assistant Network Engineer,Bangladesh Computer Council)*

Abstract: *Fiber nonlinearities deteriorate the system performance substantially since they compromise fast, robust, and error-free characteristics of an optical network. Some nonlinear features- SBM, SRS, XPM, SPM, and FWM- influence the overall network performance of a wavelength division multiplex (WDM) radio over fiber (RoF) system. Among the nonlinearities, FWM can cause severe performance degradation of the RoF wavelength division multiplex system. In this research article, we analyzed the performance of the WDM RoF system that uses a Hybrid modulator, Dispersion Compensating fiber, and Optical rectangular filters. The method with 50-200 Km fiber span comprises eight channels, each carrying NRZ modulated data with a channel capacity of 5 Gbps, and the first channel operates at 193.0 THz center frequency. The proposed model can cut down FWM effect considerably.*

Keywords: *Radio-over Fiber (RoF), Wavelength Division Multiplexing (WDM), Four Wave Mixing (FWM), Mach-Zehnder modulator (MZM).*

Date of Submission: 18-12-2019 Date of Acceptance: 01-01-2020

I. Introduction

Nowadays, the demand for wireless network is increasing day by day because of its ability to provide connection seamlessly- move anywhere within the coverage area. But a wireless network can't offer higher data rate over a long distance because at high-frequency electromagnetic wave experiences high attenuation. Radio over fiber (RoF), which is an integration of wireless and optical networks, can be implemented to overcome this issue.RoF uses highly linear optical fiber- has enormous bandwidth and supports high data rates- links to transmit and distribute radio frequency (RF) signals to remote antenna units (RAUs) from a central base station and allows the RAUs to be extremely simple since they only need to contain optoelectronic conversion devices and amplifiers. In a WDM system, optical fiber suffers from some undesirable effects- nonlinearities. The nonlinear effects occur either due to inelastic-scattering phenomenon or intensity dependence of the refractive index of the medium [1, 2]. Nonlinear effects waste the energy of the information carrying channels [2, 3] by distorting the output signal. Four wave mixing (FWM) causes sharp crosstalk and spill power from one channel to another that leads to increase bit error rate (BER) and thus degrade the system performance [4]. Various factors- channel spacing, channel power, dispersion, number of channels, and distance of the link- contribute to FWM. Several methods applied to minimize FWM effects. In this paper, we used combined techniques- hybrid modulator, dispersion compensating fiber, and optical rectangular filters to minimize FWM effects of WDM RoF system. The performance of the proposed system is measured in terms of (BER) and Quality (Q) factor while the length of the link varied from 50 to 200 km.

II. System Design

In this analysis Optisystem 7.0 simulation software is used. The system setup comprising eight channels each with a data rate of 5 Gbps shown in figure 1 consists of WDM transmitter, WDM multiplexer, Single Mode Fiber (SMF), Optical Amplifier, WDM demultiplexer, Optical power splitter and power combiner, Optical rectangular filters, Optical receiver and BER analyzer, and Optical spectrum analyzer. The transmitter (Tx) consists of a pseudo-random sequence generator, a pulse generator (NRZ), CW laser source and hybrid modulators. The bits are converted into pulses by pulse generator using Non-return-to zero modulation format. The hybrid modulator consists of optical PM modulator followed by dual drive Mach-Zehnder and AM modulator [5, 6]. The input power of the CW laser source is 5 dBm. The channel consists of single mode fiber, erbium doped fiber amplifier (EDFAs) and dispersion compensation fiber. EDFAs are used to boost the optical signal as signal strength decreases with distance. Dispersion compensation fiber is used to avoid the chromatic dispersion. DCF has negative dispersion. At the receiving end, an optical receiver is used. The optical receiver consists of a PIN photodiode, Low pass Bessel filter and 3-R generator. A BER analyzer is used to observe the bit-error-rate, Quality factor, and eye pattern [8]. The input signals with a bandwidth of 5 GHz are passed through the WDM multiplexer and de-multiplexer. The centre frequency of the channel starts at 193.0 THz with a channel spacing of 100 GHz among them. The optical rectangular filter is a sinc function that eliminates all frequencies above the cut-off frequency. Optical filters have a bandwidth of 10 GHz. The power splitter split the power equally among all the filters through which individual signal pass to the rectangular filter having a specific cut-off frequency. Power combiner combines individual signals [7].

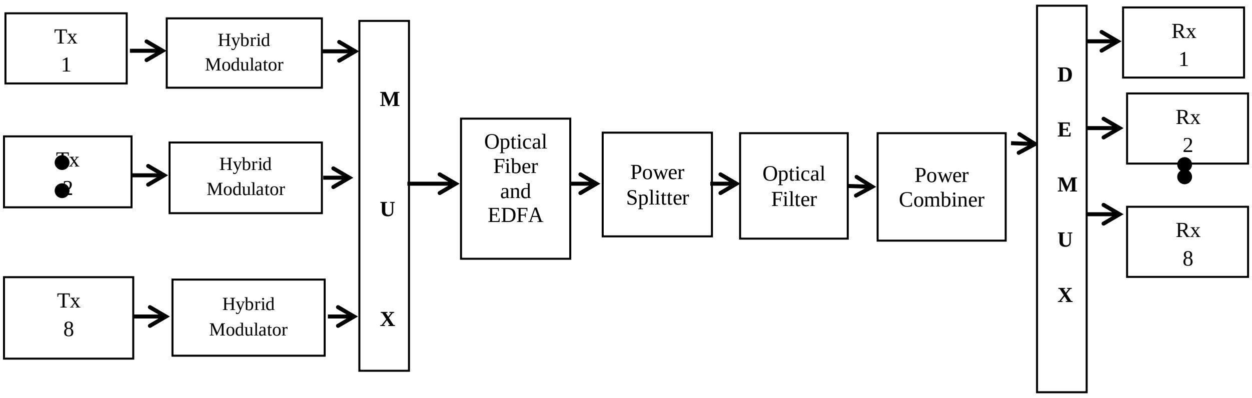

Figure 1: Block Diagram of a 5 Gbps WDM system

Table 1: The following table contains the system parameters.

Parameters	Values	Units
Data rate	5	Gbps
Attenuation	0.2	dB/km
Amplifier gain	15	dB
Amplifier noise figure	4	dB
No. of channels	8	
Filter bandwidth	10	GHz
Dispersion	16.75	Ps/nm.km

III. Result and Discussion

BER and Q factor are two crucial parameters to evaluate the performance of a system. A widely used experimental technique to determine the goodness of the received signal is the eye diagram [4]. In eye diagram analyzer, the morefull the eye, the better the performance and BER of the signal. BER is the rate at which transmitted bits are received in errors and calculated in comparison of erroneously received bits to the number of transmitted bits. Figure 2 shows the spectrum of the signal at the transmitting end. Figure 3, represents the spectrum of the received signal that is distorted substantially due to the adverse effect of FWM, while figure 4, correspond to the spectrum of the received signal in which the effect of FWM has been reduced considerably by the proposed system.

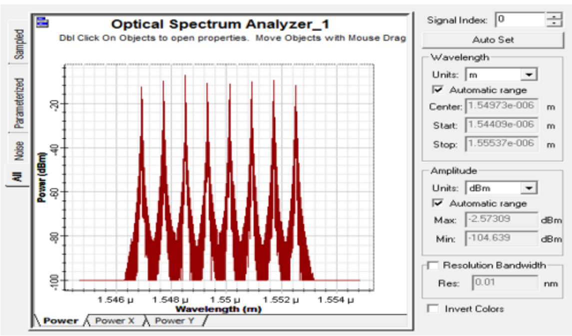

Figure 2: Spectrum at the transmitting end

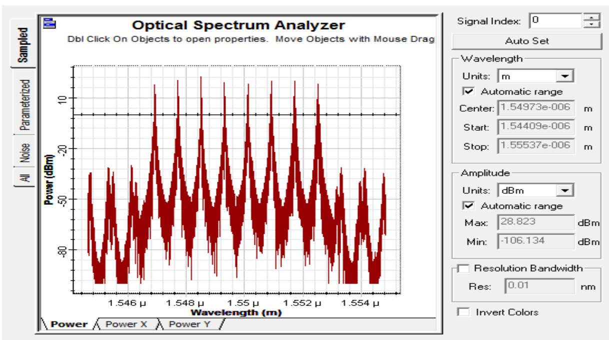

Figure 3: Spectrum with FWM effect

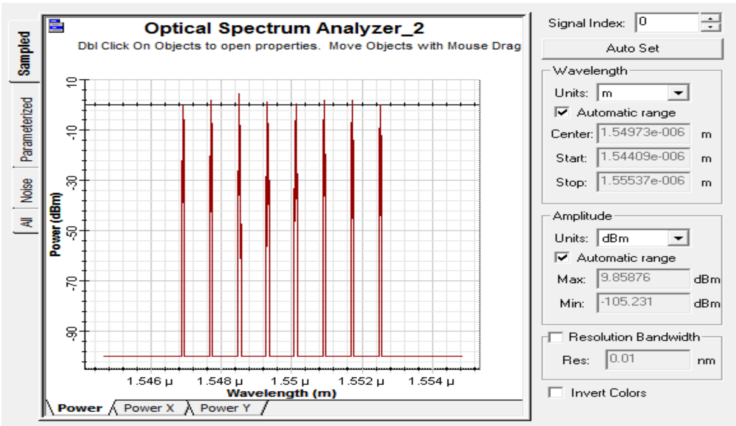

Figure 4: Spectrum after reduction of FWM effect

Fiber length 50 km (49 km SMF+1 km DCF):

For49 km fiber length, we used 1 km DCF with -820.75 ps/nm.km. The figure 5 shows the eye diagram forchannel 1 and figure 6 shows the eye diagram for channel 8.

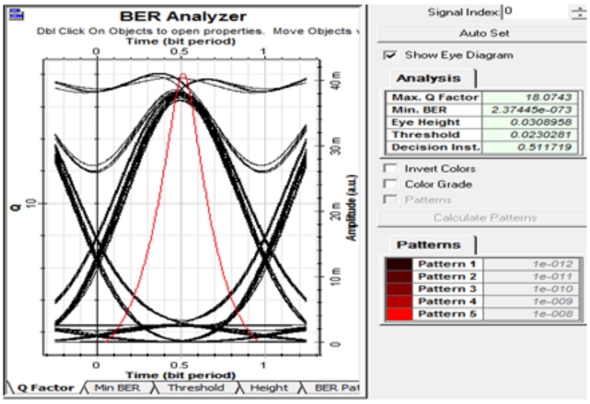

Figure 5: Eye diagram for channel 1

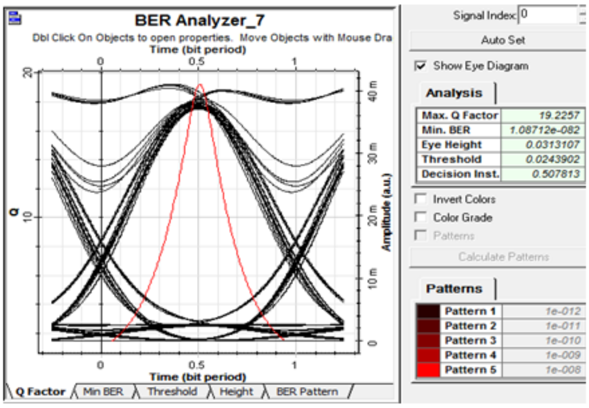

Figure 6: Eye diagram for channel 8

Table 2: The values of Q factor and BER for channel 1 through 8 for 50 km is shown.

Channels	Q factor	BER
Channel 1	18.07	10^{-72}
Channel 2	21.93	10^{-107}
Channel 3	17.86	10^{-72}
Channel 4	18.21	10^{-74}
Channel 5	18.59	10^{-77}
Channel 6	16.48	10^{-61}
Channel 7	18.95	10^{-80}
Channel 8	19.22	10^{-81}

Here the maximum Q factor is 21.93 and minimum BER is 10^{-107}.

Fiber length 150 km (146 km SMF+4 km DCF):

For 146 km fiber length, we used 4 km DCF with -600 ps/nm.km. The figure 7 shows the eye diagram for channel 1 and figure 8 shows the eye diagram for channel 8.

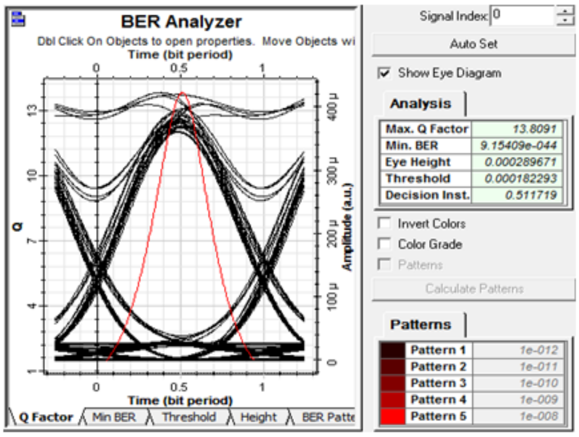

Figure 7: Eye diagram forchannel 1

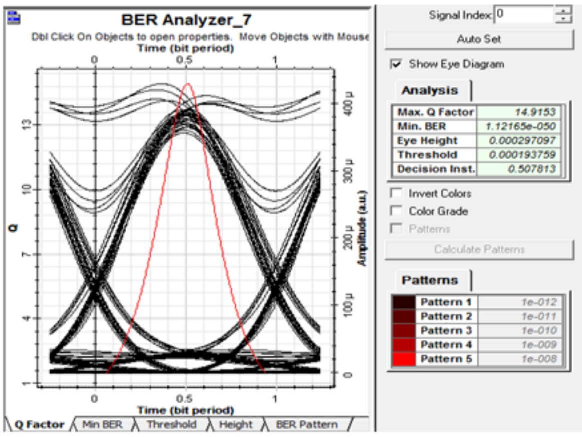

Figure 8: Eye diagram forchannel 8

Table 3: The values of Q factor and BER for channel 1 through 8 for 150 km is shown

Channels	Q factor	BER
Channel 1	13.81	10^{-43}
Channel 2	16.73	10^{-63}
Channel 3	16.0	10^{-58}
Channel 4	13.83	10^{-44}
Channel 5	16.23	10^{-59}
Channel 6	15.76	10^{-56}
Channel 7	15.94	10^{-57}
Channel 8	14.91	10^{-49}

Here maximum Q factor is 16.73 and minimum BER is 10^{-63} .

Fiber length 200 km (195 km SMF+5 km DCF):

For195 km fiber length, we used 5 km DCF with -653.25 PS/nm.km. The figure 9 shows eye diagram for channel 1 and figure 10 shows the eye diagram for channel 8.

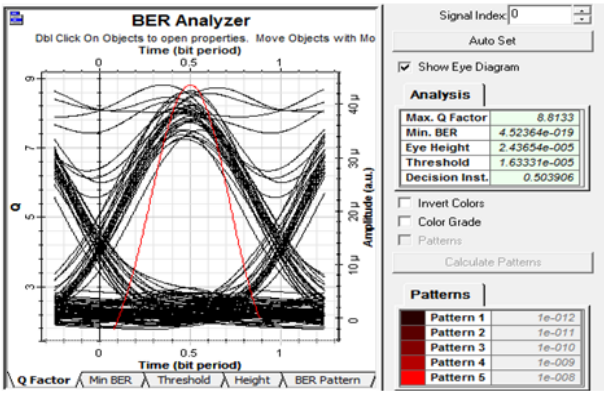

Figure 9: Eye diagram forchannel 1

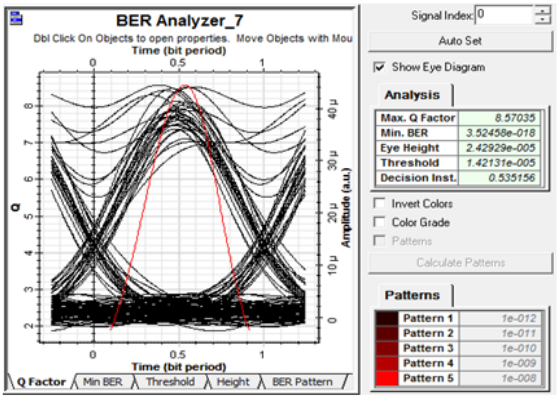

Figure 10: Eye diagram for channels 8

Table 4: The values of Q factor and BER for channel 1 through 8 for 200 km is shown

Channels	Q factor	BER
Channel 1	8.81	10^{-18}
Channel 2	8.44	10^{-17}
Channel 3	7.77	10^{-15}
Channel 4	6.97	10^{-13}
Channel 5	8.17	10^{-17}
Channel 6	8.61	10^{-17}
Channel 7	7.95	10^{-16}
Channel 8	8.57	10^{-17}

Here the maximum Q factor is 8.81 and minimum BER is 10^{-18} .
The above results show that with an increase in the transmission length, the value of the Q factor decreases, but BER value increases. This phenomenon occurs because the adverse effects of FWM become more pronounced at longer distance.

IV. Conclusion

In this research work, we investigated the combined effect of a Hybrid modulator, DCF, and optical rectangular filter in minimizing the adverse effects of FWM in a WDM RoF system. Our simulation was carried out considering the distance of the transmission link. The maximum achievableQ factor and minimum BER for 50 km transmissionlength is 21.93 and 10^{-107}, while for 100 km,they are 16.73 and 10^{-63}. For 200 km fiber length, the Q factor and BER decreasesto 8.81 and 10^{-18} . Output of spectrum analyzer shows the reduction of four-wave mixing at the receiver end. It can be concluded that by using theproposed model the detrimental effects of FWM can be reduced substantially,and transmission is possible within the distance of 50-200 km with usable Q factor and BER value. So, the proposed system may be handy for engineers in designing RoF network.

References

[1]. S. P.Singh and N.Singh, Nonlinear Effects in Optical fibers: Origin, Management and Application, Progress in Electromagnetics Research, PIER 73, 249–275, 2007.
[2]. Haider J. Abd, M.H. Al-Mansoori, N. M. Din, F. Abdullah, and H. A. Fadhil, Priority-based parameter optimization strategy for reducing the effects of four-wave mixing on WDM system, Optik, vol. 125, pp. 25-30, 2014.
[3]. H. J Abed, N. M. Din, M.H. AL-Mansoori, H. A Fadhil, and F. Abdullah, Recent four-wave mixing suppression methods, Optik, vol. 124, pp. 2214-2218, 2013.
[4]. Karanjot Singh, and Harmandar Kaur, Simulative Analysis of 40 Gbps DWDM System Using Combination of Hybrid Modulators and Optical Filters for Suppression of Four-Wave Mixing, International Journal of Signal Processing, Image Processing and Pattern Recognition Vol.9, No.7 (2016), pp.213-220.
[5]. Iftikhar Rasheed, Muhammad Abdullah, Qazi Md, Hamza Mansoor, and Zia-ur-Rehman, Novel Approaches for Suppression of Four Wave Mixing in WDM System using Concocted Modulation Techniques, International Conferenceon Frontiers of Information Technology, 2012.
[6]. Iftikhar Rasheed, Muhammad Abdullah, Shahid Mehmood, and Mahwish Chaudhary, Analysing the Non-Linear effects at various power levels and channel counts on the performance of DWDM based Optical fiber communication system, 978- 1-4673-4451-7/12, IEEE, 2012.
[7]. Rajiv Ramaswami, Kumar N. Sivarajan Galen, and H. Sasaki, Optical Networks A Practical Perspective, Third Edition, page-257.
[8]. Gurleen Kaur and Gurinder Singh,Analysis to find the best Hybrid ModulationTechnique for Suppression of Four Wave Mixing, Proc. of 2015 RAECS UIET Panjab University Chandigarh 21-22nd December 2015.
[9]. F. Ramos, J. Marti, and V. Polo, Compensation of Chromatic Dispersion Effects inMicrowave/Millimeter-Wave Optical Systems Using Four-Wave-Mixing Induced in Dispersion-Shifted Fibers, IEEE PHOTONICS TECHNOLOGY LETTERS, Vol. 11, No. 9, Sept. 1999.

B. K. Karmaker. "Minimizing Four Wave Mixing Effectsin WDM Radio over Fiber System Using Hybrid Modulator, Dispersion Compensating Fiber, and Optical Rectangular Filter." IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) 14.6 (2019): 40-44.