International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Absolute Polar Duty Cycle Division Multiplexing: A Spectrally Efficient Multiplexing method

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Abstract: ***Absolute Polar Duty Cycle Division Multiplexing (AP-DCDM) is a new multiplexing technique, which is based on absolute Polar Return-to-Zero (RZ) duty cycles, that increases the channel count from the conventional multiplexing techniques. Absolute Polar Duty Cycle Division Multiplexing over Wavelength Division Multiplexing (WDM) is a multiplexing technique which promises better spectral efficiency. It faces nonlinearities such as Self Phase Modulation, Cross Phase Modulation and FourWave Mixing, which affects the spectral efficiency. FWM is the prominent nonlinearity faced by AP-DCDM system. RZ and NRZ modulation schemes are used to evaluate the performance parameters of AP-DCDM system. The RZ format would be beneficial for systems with few channels but would require NRZ as the number of channels increase. The RZ format has better baseline receiver sensitivity when the average power into the fiber is kept constant. Since an RZ pulse has a wider optical bandwidth than an NRZ pulse, it is more affected by dispersion. In AP-DCDM system, with the change in duty cycles and polarity of each RZ pulses, error detection and correction is possible at the receiver side. AP-DCDM system has high spectral efficiency and tolerance towards dispersion due to its reduced spectral bandwidth. The performance analysis of the system is done by using Optisystem 12.0 software.***

Keywords: Absolute Polar Duty Cycle Division Multiplexing (AP-DCDM), WDM,FWM Q factor, Bit rate

1. Introduction

After mid of 20th century, the invention of lasers in 1960 gave an opening for the achievement of high capacity and faster data rate at the same time as efforts were made to make it possible that lasers could be used for optical communication and optical communication became once again focus for future communication system. Optical communication uses light wave carriers of very high frequencies usually in THz which are near visible or infrared region of electromagnetic spectrum. Fiber optic communication systems were practically used in 1980s. As they say, nothing comes free, since then efforts are made continuously from time to time to make the optical communication more efficient as losses are linked when fiber optic communication systems are designed. To use the available bandwidth in optical communication systems different multiplexing techniques are adopted, so that multiple users can access and use the bandwidth efficiently.

The most common techniques are frequency division multiplexing, time division multiplexing, optical code division multiplexing, wave length division multiplexing and dense wavelength division multiplexing. In FDM, users share the bandwidth according to the frequencies allotted to them, therefore, for a given bandwidth the number of users to access the bandwidth and use for communication are limited. TDM allows users to share bandwidth according to the time slots allotted to them. This is an efficient technique but the electronic devices required for multiplexing and demultiplexing channels become bottleneck. WDM allows the users to share bandwidth according to the wavelengths assigned to them. This technique has been used for long and is one the most common techniques for optical communication, but it has low spectral efficiency as it uses wide range of wavelengths.

To give enough bandwidth to each user and to accommodate more users sharing bandwidth at one time is one of the major issues. Absolute Polar Duty Cycle Division Multiplexing (AP-DCDM) is a new multiplexing technique, which is based on absolute Polar return-to-zero (RZ) duty cycles, that increases the channel count from the conventional existing systems. APDCDM technique reduces the spectral width and it has small spectral width, due to this fact, has greater spectral efficiency and tolerance towards dispersion. In this work the performance of Absolute Polar Duty Cycle Division Multiplexing is compared with other multiplexing techniques. Phase Shift Keying (PSK) and Quadrature Amplitude Modulation (QAM) are used as modulation schemes to evaluate various parameters. Absolute Polar Duty Cycle Division Multiplexing over WDM is a multiplexing technique which promises better spectral efficiency. The system faces nonlinearities such as self-phase modulation, cross phase modulation, four wave mixing etc. as like the other conventional system which affects the spectral efficiency. The performance analysis of the system can be obtained by using Optisystem 12.0 software.

2. Overview of AP DCDM System

AP-DCDM technique can be used with guard bands as well as without guard bands as per requirement. Also this technique is different from other conventional techniques due to the fact that users share the same transmission medium, in same time period with same carrier wavelength but using different duty cycles, which results in uniqueness. AP-DCDM can become an alternative multiplexing technique in wireless communications. The new technique allows for better error detection, correction, clock recovery and more efficient use of time slots as well as spectrum. AP-DCDM has better performance than TDM for supporting higher number of multiplexing users and bit rate.

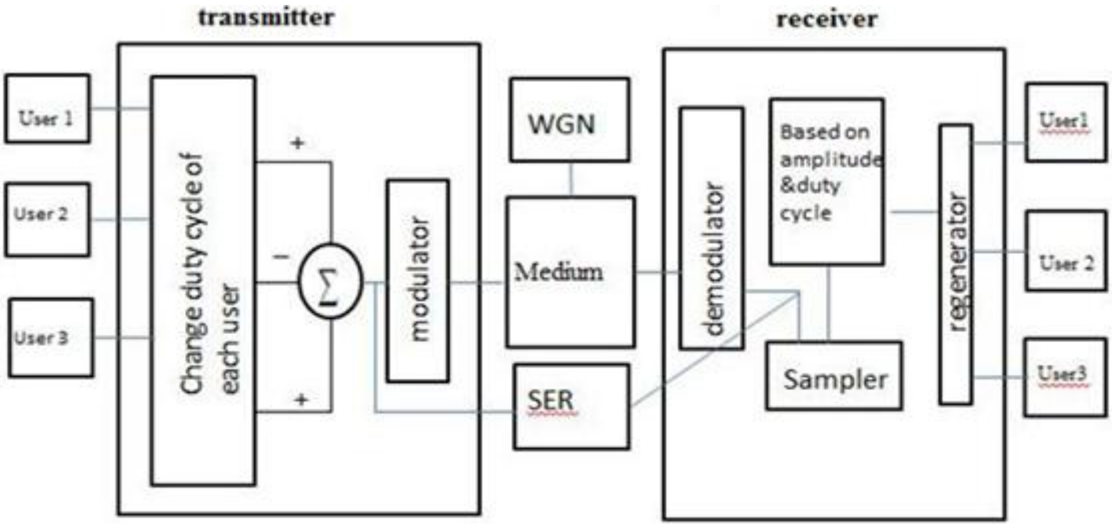


Figure 1: AP-DCDM System

AP- DCDM technique is implemented in a high speed optical communication link with the setup uses only a single wavelength channel; the system can be easily duplicated for other wavelength to represent a WDM system. Researchers have examined multilevel signaling as a way of increasing the capacity of optical communication systems. Four level signaling has an intrinsic signal to noise ratio penalty due to the fragmentation of the main eye to three smaller eyes. There are other methods employed to provide more transmission capacity such as optical polarization multiplexing, so that more than one channel can be transmitted in single wavelength. However these methods are not economical and are difficult to realize. Realizing these problems in this paper the authors introduced AP-DCDM based on return-to-zero duty cycles which is allows signal multiplexing to be performed economically in the electrical domain. By using return-to-zero modulation format and simple amplitude modulation the capacity of 30 Gb/s per optical channel is achieved using 10 Gb/s transmitter and receiver. This achievement shows that AP-DCDM can become a potential alternative to increase the transmission capacity tremendously. The absolute polar duty cycle division multiplexing is based on having each channel modulated with a unique RZ duty cycle. In this technique each multiplexing user transmits bit ’0’ with zero volts and for the case of bit one, the odd users transmit with +A volts and the even users transmitted with -A volts. Based on the linear distribution of duty cycle, the multiplexing user transmits bit I within a time period. In AP-DCDM technique, all users show almost similar behavior at positive and negative chromatic dispersion. Users with 25, 50 and 75 percentage duty cycles are used here.

3. System Modelling

The Pseudo-Random Bit Sequence Generator is a device which works on an algorithm to generate random sequence of bits. The RZ Pulse Generator performs the coding of signal as discusses earlier. CW Laser emits the optical signals. The wavelength selected for the setup here is 1550 nm and has a line width of 10 MHz. Amplitude Modulator takes in the electrical signal from RZ Pulse Generator and optical signal from CW Laser and gives result to a modulated signal which is optical in nature.

Erbium Doped Fiber Amplifiers are used with pre-defined gain of 20 db and ,noise Figure of 4 dB for the purpose of amplifying the signal. Optical Attenuator is used to attenuate the signal at different values in sweep mode to give the estimate of receiver sensitivity for different attenuation levels. A Photodetector PIN is used to convert the optical signal to electrical signal. A low Pass Gaussian Filter is used with a cut off frequency of 2* 0.75 * Bit Rate to work efficiently for RZ.Bit Error Analyzer comes under visualizers category in Optisystem, which calculates and displays the bit error rate and also shows the eye diagram.

After successful completion of the task for 10 Gbps for RZ, it was modified later and the bit rate from 10 Gbps was changed to 40 Gbps and the changes that were made to the optical attenuator values range from 43 to 52 dB, from which important results were achieved. The design was then tested for NRZ just by replacing the RZ Pulse Generator with NRZ Pulse Generator to produce the NRZ line coding and the filters cut off frequency set to 0.75 * Bit Rate. Simulate the system for the same attenuator values. To compare the bandwith and spectral efficiency, it is important to analyse the RZ and NRZ spectrum.

Here 2 channel, 4 channel and 8 channel with RZ-WDM Systems are obtained. Simulations are made with a channel spacing of 0.8 nm between each channel. The length of the single mode fiber was kept 25 km. The sequence length is 1024 bits. The bandwidth of the multiplexer and demultiplexer are set to 50 GHz. After testing it for 5 Gbps, the bit rate was changed to 10 Gbps and 40 Gbps, and the values of Optical Attenuator parameter ranges from 43 to 52 dB.

Receiver sensitivity was tested for AP-DCDM design. The AP-DCDM system is shown in Fig.2. As it is clear,four RZ pulse generator are combined by an electric adder, then the signal passes through an absolute circuit to make the signal absolute polar. Then the optical signal from CW laser and the absolute polar electric signals are modulated by an AM modulator. Duty cycle of 25, 50, 75 and 100 percentage are used from first to till last RZ pulse generator while the amplitude of first and third is 1 and -1 for others. This is how the setup for AP-DCDM without guard bands. Without guard bands are used here to prevent the interference between each channels.

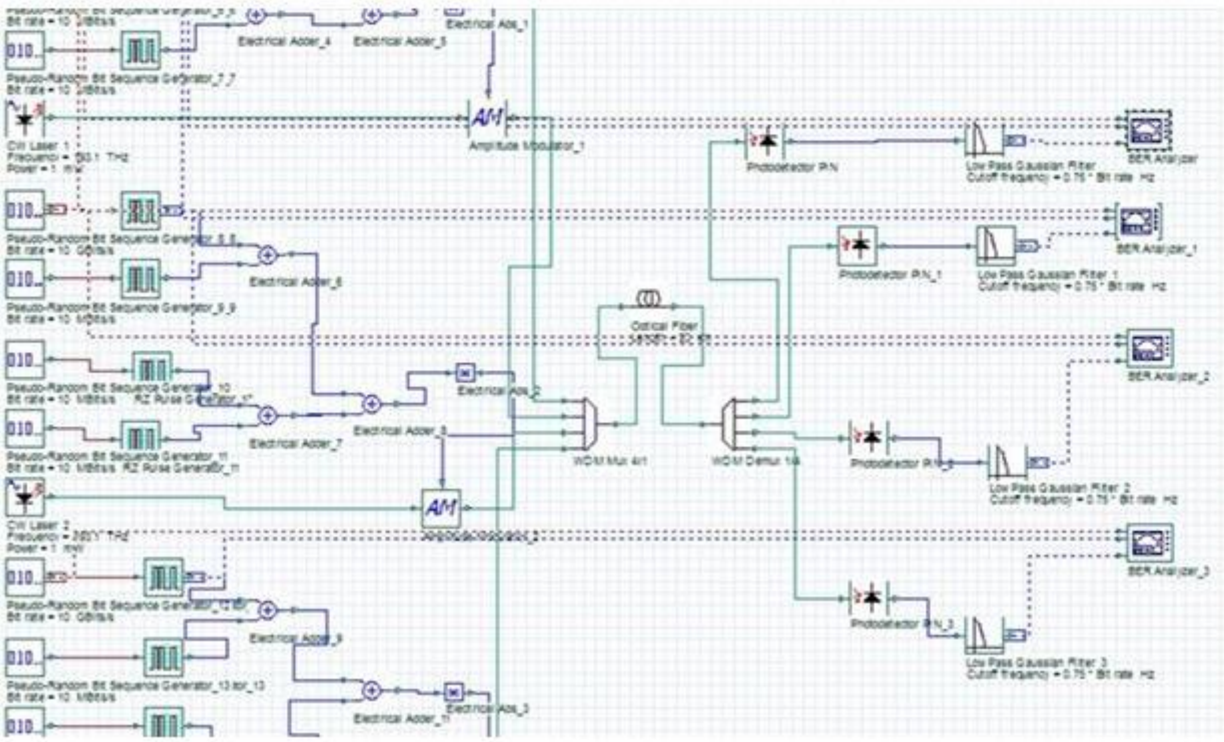


Figure 2: Simulation of 4 channel AP-DCDM WDM System

4. Results and Discussions

As the WDM channels on AP-DCDM system increases, the BER also increases. Very high data rate can be transmitted efficiently through this system. As dispersion increases the Bit error rate is also increases. By comparing RZ-WDM system with AP-DCDM WDM, it is obtained that, the effect of dispersion is reduced in AP-DCDM WDM for a fixed dispersion coefficient. It is because of the reduced bandwidth of AP-DCDM. It is possible in this system to accommodate more than two users per WDM channel with aggregate bit of 40 Gbps. Figure 3 shows the output eye diagram obtained for 2 channel and 4 channel RZ-WDM and AP-DCDM WDM system.

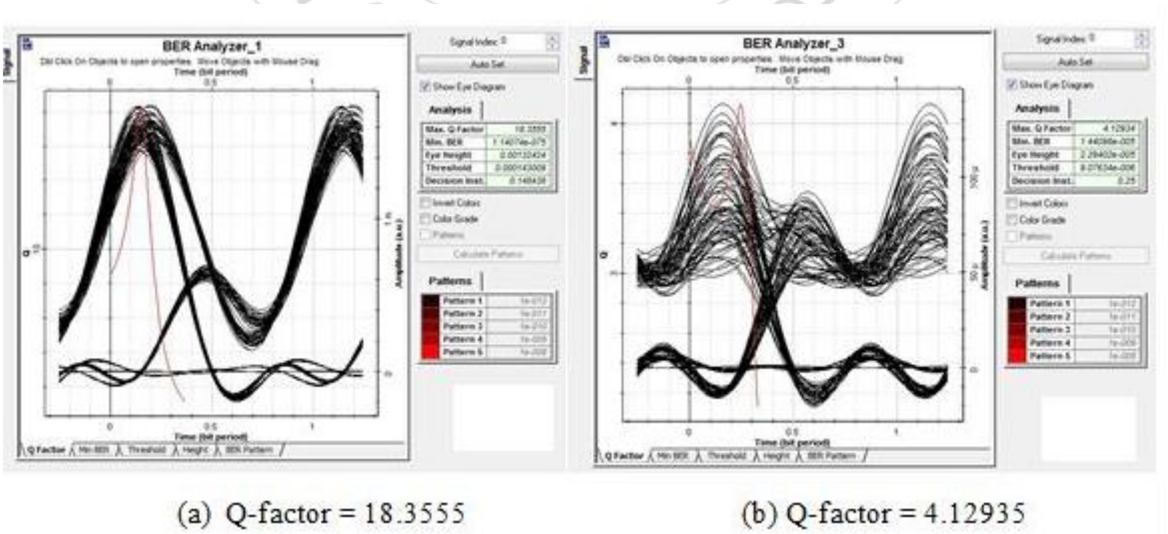


Figure 3: Output Eye diagram of 2 channel and 4 channel AP-DCDM WDM

As the number of channels increases the Q factor decreases and Bit Error rate increases. The effect of dispersion for RZ-WDM and AP-DCDM WDM system is shown in figure 4.

Figure 5 shows the spectrum obtained in case of 2 channel RZ-WDM and AP-DCDM WDM.10Gbps data rate spectrum is shown here. In a 2 channel RZ WDM, the total of 20 Gbps bits are transmitted. The bandwidth obtained is 20 GHz. In a

2 channel AP-DCDM WDM ,each AP-DCDM channel consists of four RZ pulse generator having 10 Gbps data rates.

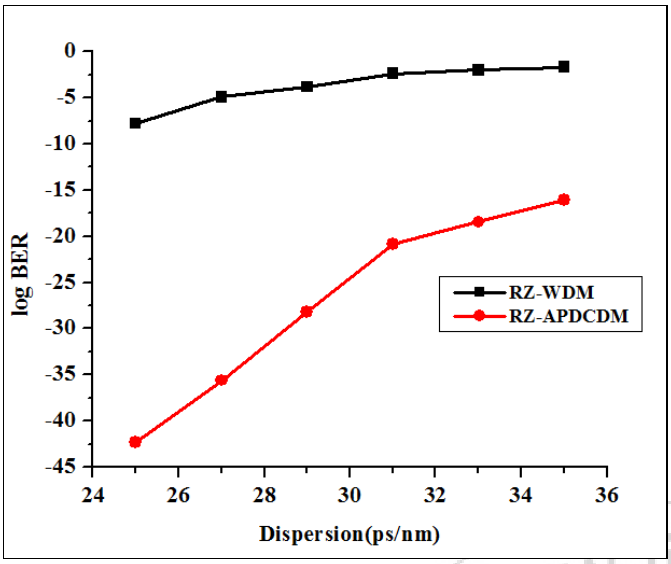
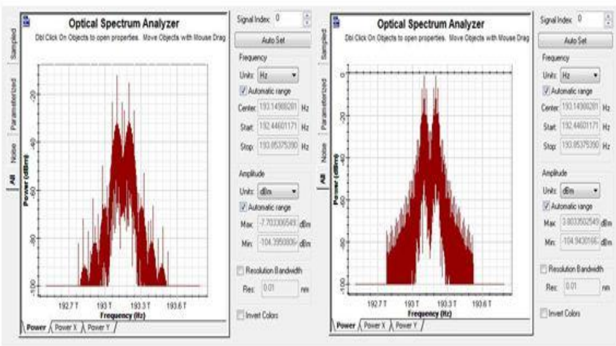


Figure 4: Relationship between Dispersion (ps/nm) and log BER



(a) RZ-WDM (b) AP-DCDM WDM

Figure 5: Spectrum of RZ-WDM and AP-DCDM WDM

Such a way in a 2 Channel AP-DCDM WDM, a total of 80 Gbps bits are trasmitted. Here the bandwidth is 24 GHz.By comparing the two spectrum, it is clear that AP-DCDM system has more spectral efficiency and it reduces the effect of dispersion. Due to the change in duty cycles and polarity of each signals in AP-DCDM system, the output is easily distinguishable at the receiver side by using a clock and data recovery unit. Because of this reason the system provides better clock recovery and error correction.

5. Conclusion

Absolute Polar Duty Cycle Division Multiplexing (AP-DCDM) is a multiplexing technique, which is based on absolute Polar return-to-zero (RZ) duty cycles, that increases the channel count from the conventional multiplexing techniques. From the receiver sensitivity, it was observed that when the attenuation parameter is increased the BER gets bad. The system working under 10 Gbps has more tolerance toward attenuation than the system which is working under higher bit rate. Comparing the results of AP-DCDM-WDM system, with RZ-WDM and NRZ-WDM system, it is clear that AP-DCDM-WDM has more spectral efficiency, while on the other hand NRZ-WDM system is better in performance than RZ-WDM system where the criteria of performance is receiver sensitivity and effect of dispersion. AP-DCDM reduces the effect of dispersion.

References

[1] Farman Ullah, Khalid Ibrahim Qureshi, Amir Khan, Kashif Hesham Khan and Shafqat Ali Shad “Effect of four wave mixing on AP-DCDM-WDM fiber optic system at different channel spacing” Sci.Int.(Lahore),26(2),2014

[2] M.K.Abdullah, G.A.Mahdiraji, A.F.Abas, “Absolute Polar Duty Cycle Division Multiplexing: An Economical and Spectral Efficient Multiplexing Technique”,978-1-4244-1980-7/08/ 2008 IEEE.

[3] Farman Ullah, Aamir Khan, Nadia N Qadri, Muhammad Masood Sarfraz “Effect of Four Wave Mixing on AP-DCDM-WDM Fiber Optic System with Different Power per Channe”,I.J. Information Engineering and Electronic Business, 2013, 3, 11-21

[4] Amin Malekmohamadi, Mohamad Khazani Abdullah, “Experimental 20 Gbit/S Absolute Polar Duty Cycle Division Multiplexing Polarization Division Multiplexing transmission”, Dept. Research and Development, Significant Technologies, Sdn, Bhd 2012 @Malaysia

[5] Amin Malek mohammadi, Mohammed Hayder Al-Mansoori, Ghafour Amouzad Mahdiraji ,Ahma Fauzi Abas, Mohamad Khazani Abdullah “Performance enhancement of Absolute Polar Duty Cycle Division Multiplexing with Dual Drive MachZehnder Modulator in 40 Gbit/s optical fiber Communication systems”, A.Malekmohammadi et al./Optics Communications 283 (2010)

[6] Amin Malekmohammadi, Member, IEEE, M. K. Abdullah, Member, IEEE, A. F. Abas,“Performance Enhancement of AP-DCDM over WDM with Dual Drive Mach-Zehnder- Modulator in 1.28 Tbit/s Optical Fiber Communication Systems”, WCE 2010, June 30-July 2, 2010, Lond on, UK

[7] Amin Malekmohammadi, M.Khazani Abd- ullah, G.A Mahdiraji , A.F.Abas, Member IEEE , and M. Mokhtar, Member IEEE ,“30Gb/s Absolute Polar Duty Cycle Division Multiplexing In Dispersion Uncompensated Optical Systems”, IEEE 2008 2nd Malaysia conference on photonics,26-28 August 2008.