Journal of Engg. Research ICAPIE Special Issue pp. 177-184 DOI:10.36909/jer.ICAPIE.15033

Performance Improvement Using DCSRZ at 10 GHz OCDMA Transmission Link

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ABSTRACT

In this paper, a method based upon combination of duo-binary (DB) and carrier suppressed return-to-zero (CSRZ) format has been proposed that has significantly improved the performance of optical code division multiple access (OCDMA) system by means of two dimensional (2D) codes based on two parameters; wavelength and time. The various investigations divulge that highest Q2 (dB) of minimum and maximum value [18,23]; [14,17]; [9,12] and [1,6] has been obtained at a power variation of -10 to 20 dBm for DCRZ, DB, CSRZ and RZ modulation formats respectively for a communication distance of 80 kilometers. It has also been identified that maximum OSNR of [37-29] dB is obtained by using DCSRZ modulation format for the same distance. The maximum opening of eye for DCSRZ format has further proved its robustness to suppress the channel impairments at a high-power level of 20 dBm for 10 GHz optical CDMA systems.

Keywords: Optical Code Division Multiple Access (OCDMA); Duo-binary Carrier Suppressed RZ (DCSRZ); Two-dimensional codes; OSNR.

INTRODUCTION

OCDMA is an emerging technology based on spread spectrum technique. This technique was introduced into the field of optical communication in the middle of 80's, when all the processing of signal in system is done in optical domain. It is a multiple access technique where users are separated using a unique code instead of wavelength or time-slot to transmit information [1-5]. However, the transmission of signals in OCDMA systems for long haul distances is influenced by linear and non-linear impairments. Both these effects including dispersion are more severe at higher power levels and longer transmission lengths. However, these effects can be mitigated using some suitable modulation format for the signal transmitted. The mostly utilized formats are return-to-zero (RZ) and non return-to-zero (NRZ) that can diminish dispersion and other non-linear limitations to some amount [6, 7]. These modulation formats modulates the optical phases without carrying any useful information [8-10]. Using duo-binary (DB) and carrier suppressed RZ (CSRZ) modulation format improves the performance of optical communication system by increasing the optical signal to noise ratio of the system [11]. Also it has been proved that combination of duo-binary with CSRZ modulation format offers better result for various optical communication systems [12]. It provides an effective solution to relieve signal degradation originating from various fibre non linear effects with increase in the transmission length of the system. Therefore, through this manuscript an effort has been made to get better quality of transmission and increase the distance of transmission through combination of duo-binary and CSRZ format for OCDMA by means of two dimensional (2D) codes based on wavelength and time [13-16]. The characteristics of the new generated DCSRZ format for OCDMA system are compared with duo-binary, CSRZ and RZ modulation by means of simulations.

The manuscript is structured in the subsequent mode. Section 2, of the paper introduces the methodology to generate DCSRZ modulation format after a brief introduction in section 1. Section 3 is dedicated to the system description. Section 4 throws light on the results and discussions part and finally paper is concluded in section 5.

METHODS TO GENERATE DCSRZ SIGNAL

The DB and CSRZ modulation formats are combined together to form a duo-binary carrier suppressed return-to-zero (DCSRZ) modulation format. Generation of DCSRZ modulation format from CSRZ and duo binary formats is as shown in the figure 1. A pseudorandom bit sequence (PRBS) generator is used to produce the data bits sequence that is further encoded using a NRZ coder and is transferred to the data encoder then for encoding purpose. EX-OR circuit is used as an optical encoder for DCSRZ system to encode the electrical NRZ signals. Then the encoded signals are passed to duo-binary filter for band limiting. To reduce the spectrum of signal, the electrical pulses are band limited. This phenomenon of reduction in spectrum is dependent mainly upon the filter type used. The optimum filter type for reduction in spectrum can be an ideal rectangular filter; instead a duo binary filter is used in the system here as the practical realization of rectangular filter is more complicated. The low pass filter in the system behaves as an analog converter that converts the signal from binary level to duo-binary and cut off the high frequency components in the duo-binary spectrum of signal [17-20]. Then the signal level is passed to mach-zehnder modulator driven by duo-binary carrier suppressed RZ signal. A continuous wave (CW) laser produces light at 1.55 μm wavelength is also send to modulator that acts as carrier. At the receiver end, direct detection is used to detect the transmitted signals. The photodiode at the receiver end is used to change the optical duo-binary signal to the binary signal [21-25]. The reduction in the spectrum of modulation signal is the main cause for its better tolerance to dispersion as compared to other modulation formats and provides an improved efficiency for the OCDMA system.

SYSTEM DISCRIPTION

OCDMA system is implemented and simulated using commercial optical simulation software, OptisystemTM version 11 using two dimensional (2D) coding techniques. The system is analyzed for different modulation formats. The simulation set up is shown in the figure 2. At the transmitter end, an array that consists of eight continuous wave lasers as source, PRBS generator, duo-binary carrier suppressed return-to-zero pulse generator and optical modulator are used. To implement the system, eight different CW lasers representing eight wavelengths are utilized to generate multi frequency source to make a carrier signal.

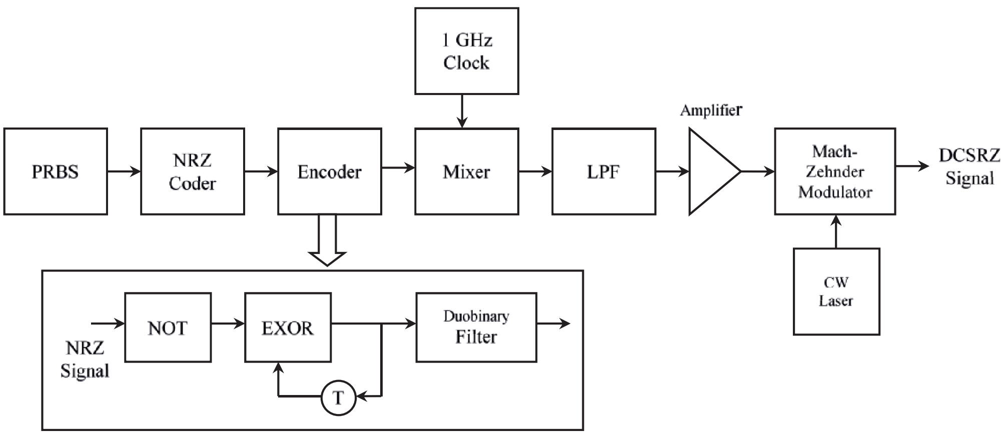


Figure 1. Structure of DCSRZ formation.

The wavelength from 1549.2 nm to 1554.8 nm range having 0.8 nm space in between and input power variations from -10 to 20 dBm are used. The light produced by the source is modulated by the pseudo random sequence generator of each user. The pulse is generated by using combination of duo binary and DCSRZ with a pre coder of delay 1 ns. Then with the help of a de-multiplexer the signal is passed to optical encoder. Optical encoder comprises of optical filters and different delay lines to impart the wavelength and time slots to each user respectively. Each wavelength is divided (power) into different paths, independent to each other by the use of optical filter (bandwidth 10 GHz) and then the signals are passed through different delay lines that depend upon the code generated. After that by using a power combiner the signals are combined.

The combined signal from all the encoders is then multiplexed and transferred into an optical channel that consists of a single mode fibre including a dispersion compensating fibre and erbium doped fibre amplifier (EDFA). An EDFA having gain of 10dB and noise figure of 4 dB is used in the system to enhance the optical signal to the desired power level. The parameters of SSMF and DCF are shown in table 1.

At receiver, transmitted signal is splitted using a power splitter and decoded with respect to the code of each user. In decoder inverted delay lines are used for each user that decodes the signal. The decoded signal is then converted to electrical form with the help of a photo detector possessing 10 nm dark current and a low pass Bessel filter possessing 8 GHz cut off frequency.

Table 1. Fiber parameter.

Parameters	SSMF	DCF
Fibre Dispersion	16	-80
Attenuation of Fibre	0.2	0.4
Distance (km)	80	16
Dispersion Slope	0.07	-0.30
Effective area (μm^2)	80	35
Non-linear coefficient	$12e^{-20}$	$50e^{-20}$

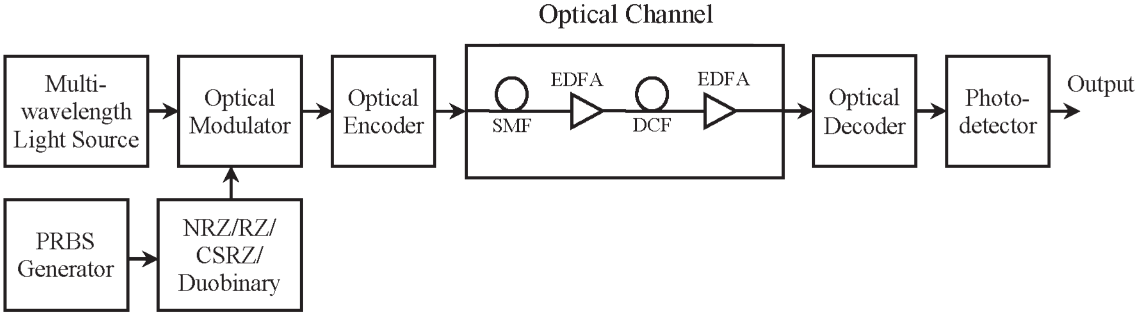


Figure 2. System set up.

The system is demonstrated and implemented by using optical simulator. The results are reported by means of optical spectrum analyzer and BER analyzer in system. The demonstrated system is analyzed for diverse number of active users.

RESULTS AND DISCUSSIONS

OCDMA system was analyzed with DCSRZ modulation format by using simulation designs at 10GHz. To analyze the system a variety of performance measuring parameters like quality factor and bit error rate (BER) are used for varying input power with respect to the length of fiber. The DCSRZ is compared with duo-binary (DB) and CSRZ formats in a 80km transmission link. The results are shown in figure 3 (a) and (b).

It is clear from the graphs that till 6dBm, the effect of power is almost constant on the behavior of OCDMA system with different modulation formats.

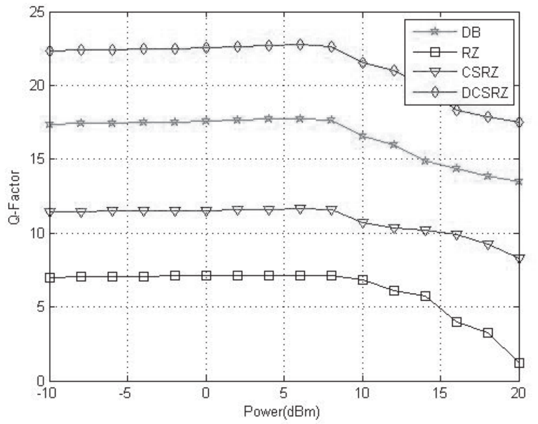


Figure 3. (a) Q-factor vs. power

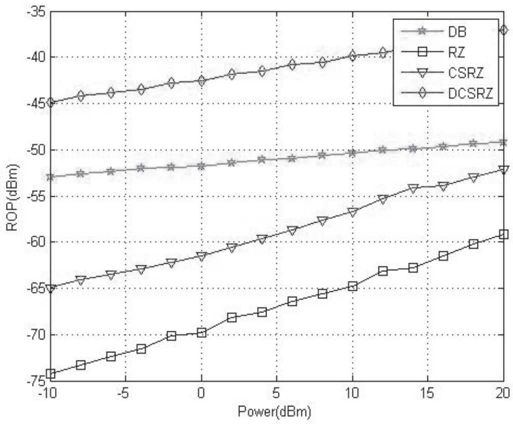


Figure 3. (b) ROP vs. power

The DCSRZ modulation format is the top preference format at 10 GHz for OCDMA system. Use of DCSRZ modulation enhances Q-factor to 22.30 at -10 dBm power and to 17.52 at a elevated power level of 20 dBm in comparison to duo-binary (DB) possessing Q- factor value of 17.34 at -10 dBm and 13.5 at 20 dBm and CSRZ with Q-factor value of 11.43 dBm at -10 dBm and 8.31 at 20 dBm. As compare to basic RZ modulation format, DCSRZ format shows improvement by a factor of 3. Further, the highest communication distance of 50 kilometers reported by various researchers has been improved by a distance of 80 km using this modulation format at 10 Gbps for 25 numbers of users in an OCDMA transmission link.

In figure 3(b), ROP, optical power received versus transmitted different modulations is presented. The ROP varies from [-45 to-37], [-65 to -52], [-53 to -49] and [-74 to -59] dBm for DCSRZ, CSRZ, DB and RZ modulation formats respectively at varying input power from -10 to 20 dBm. Consequently, DCSRZ format appreciably enhances the highest output power versus input power for the system.

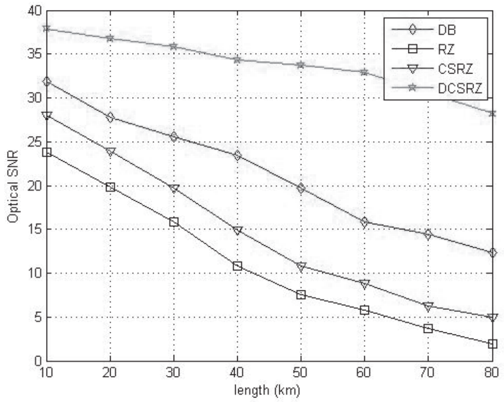


Figure 4. (a) Optical SNR vs. Length

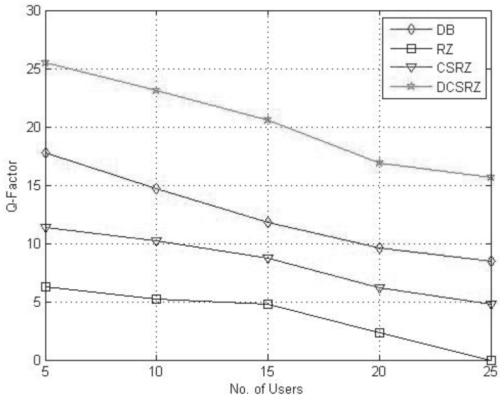
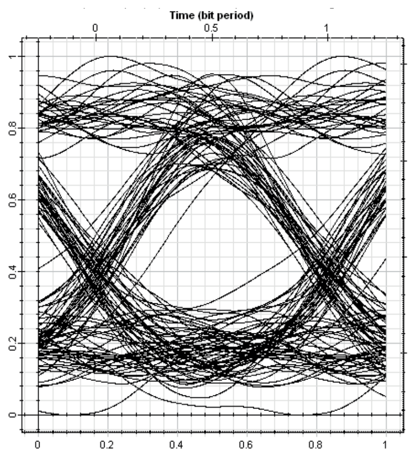


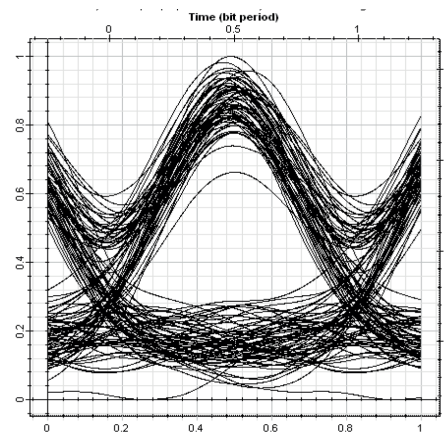
Figure 4. (b) Q-factor vs. Number of users

Figure 4(a) plots OSNR at varying fiber lengths for different formats. From the plot, it is apparent that for each format, optical SNR decreases with fiber length. As we increase transmission distance, the optical SNR reduces due to the dispersion and other channel impairments. The optical SNR varies from [37-29], [28-5], [32-12] and [24-2] for DCSRZ, CSRZ, DB and RZ modulation formats respectively for a transmission distance of 80 km. The figure 4(b) demonstrates Q-factor versus number of active users accommodated at a time for different formats. Commencing the investigation, it is observed that Q-factor decrease with the boost in number of active users. As increment in active number of users concurrently using the system leads to multiple access interference. For DCSRZ, the system preserve Q-factor at value of 13 for 25 users and is declining to 7, 3 and finally to zero for DB, CSRZ and RZ formats correspondingly. Further enhancement in Q-factor for growing number of users can be obtained using optimized filtering techniques. Figure 5 demonstrates maximum eye opening for all CSRZ, RZ, DB and DCSRZ modulations. Now, the maximum opening of eye in DCSRZ as compared to RZ, CSRZ and DB modulation formats clarifies its robustness to the system.



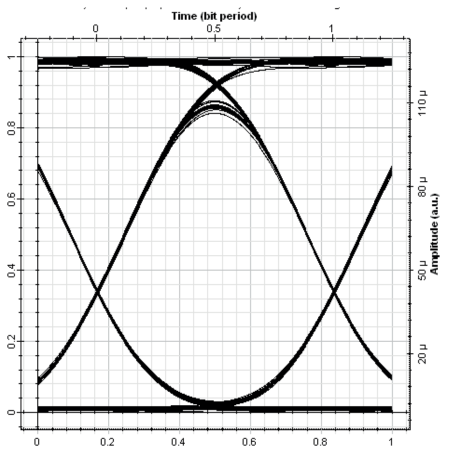
(a)

Figure 5. Eye diagrams for (a)



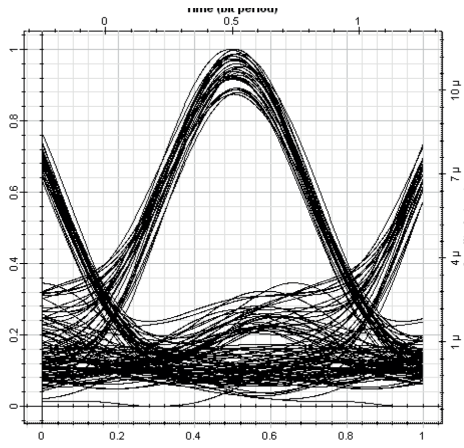
(b)

Figure 5. RZ (b)



(c)

Figure 5. CSRZ (c)



(d)

Figure 5. DCSRZ (d) duo- binary

CONCLUSION

Through this manuscript, the author has proposed and demonstrated the utilization of duo-binary carrier suppressed RZ (DCSRZ) modulation format to reduce the dispersion and improve the performance of system in a 10 GHz OCDMA transmission link. Then the performance of DCSRZ modulation is compared with CSRZ, RZ and DB modulation formats to demonstrate its robustness. The results from various simulations divulge that Q-factor can be appreciably enhanced to 23 and highest output power is achieved up to -43 dBm at -10 dBm at a transmission distance of 80 km by applying DCSRZ modulation. Also highest optical SNR of [37-29] dB has been achieved for this communication distance. The investigations proves that DCSRZ modulation is best suitable for OCDMA system that has further been justified by maximum opening of eye as compared to CSRZ, RZ and DB modulations. Results recommend that the DCSRZ format can be a capable contender for upcoming high speed and high capacity optical communication networks.

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