

# Investigate the Characteristics of Ultrashort Pulses in OCDMA System

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**ABSTRACT:** The main focus of this paper is to investigate the characteristics of ultrashort pulses and analyse the application on Optical Code Division Multiple Access (OCDMA) system. Ultrashort pulses are often called as Ultra fast events are electromagnetic pulses with time period in the order of picoseconds ( $10^{-12}$  second) or less. There are many applications of these ultrashort pulses such as Single carrier, Optical Code Division Multiple Access, Wavelength Division Multiplexing, Optical Time Division Multiplexing. These applications depend upon the various characteristics of the ultrashort pulse. The characteristics include Bit Error Rate (BER), Q value, Pulse Repetition Rate, Pulse width, Peak Power. We investigate these using OPTSIM Rsoft tool.

**KEYWORDS:** Ultrashort pulses, Optical code division multiple access, Bit error rate, Eye diagram and OPTSIM tool.

## I. INTRODUCTION

An optical code division multiple access, where the users share the same transmission medium by assigning a unique pseudo-random sequence optical code (PRBS), is attractive for the next generation of broadband access networks due to its features allowing fully asynchronous transmission with low delay access, soft capacity on demand, protocol transparency, as well as increased flexibility of QoS control.

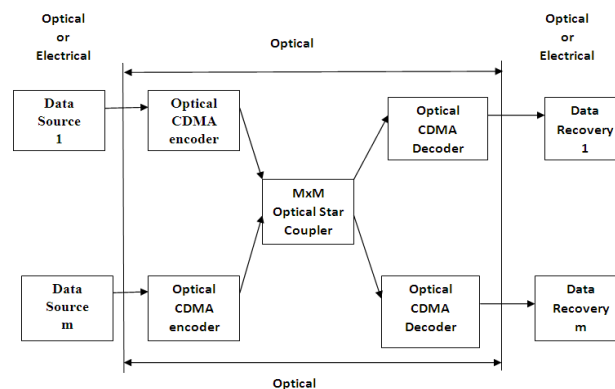


Fig. 1. Block diagram of an optical code division multiple-access

In Fig.1.shows the block diagram of an OCDMA. In fiber optic CDMA, users communicate by imprinting their message bits which in turn depends upon their own single Pseudo random code, which they transmit asynchronously

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(with respect to the other transmitters) over a common channel. In receiver side a matched filter ensures that the data is been detected only when they are present on their proper code sequence (see Fig. 1). This approach is to allow transmission without delay and also handles multi access interference (contention) which is an integral part of the multiplexing scheme.

Optical network of next generation can support for various emerging broadband applications as well as copy many kinds of bequest services using the same infrastructure, with minimal investment. With the boost in demand of broadband services, channel complication has been increased. Therefore it has become essential to monitor the performance of optical networks. Bit error rate monitoring is very vital tool to condense the number of errors in the transmission of bits. When one talks about QoS, BER is the factor which desires to be monitored. The formula used to calculate BER is,

$$\text{BER} = \frac{\text{Total no of Errors}}{\text{Total no of bits transmitted}}$$

During past decades, a normal optical pulse which is a result of LASER is used to diminish the BER value in all optical communications. But, now a day we use ultrashort pulses to diminish the BER value. When ultra short pulse is used the BER value is very least when compared to other optical pulse. But Ultra short pulses cannot be generated or propagated by conventional electrical resources. Extremely short optical pulses can be produced by mode locked lasers, which readily provide pulse widths of picoseconds or less, repetition rates from megahertz to hundreds of gigahertz, and reasonably high powers.

## II. RELATED WORK

In this paper we investigated the characteristics of ultrashort pulses and their applications in communication system. In particular we analysed the BER performance and Q-value in OCDMA networks by using ultrashort pulses with the help of OPTSIM tool. This tool can be used to find Pseudo-noise bursts generated by ultrashort pulses and also to examine the temporal and statistical behavior of pseudo noise bursts generated by spectral phase coding of ultrashort pulse as mentioned in [1]. Then this result can be applied to perform a BER analysis of the proposed USP CDMA

Bit Error Rate is calculated for 1m and 3m fiber cable through experimental readings and formula respectively. The Bit error rate is been noticed that it have got varied with respect to Receiver Power [2]. The technique used here is cost effective, accurate and economical Simulations have been considered in OPTSIM.

The performance of 2-D encoding OCDMA system and Spectral Phase Encoding OCDMA System is compared in time domain at 2.5Gb/s for 60 km length. SPE O-CDMA systems results specify major enhancement in term of Bit Error Rate (BER) and very high excellence factor in the form of Quality of Service (QoS) at -18dBm received power. The simulations are accepted out using OptSim (RSOFT) [3].

The consequence on BER, Q-Factor for a four user OCDMA communication system with varying Jitter and recital of the OCDMA communication system has been evaluated in terms of bit error rate and Q factor with jitter unreliable from 0 to 3.0 pico-seconds in order of 0.5 pico-seconds. Simulations were carried out using normally existing simulator from Rsoft, OPTSIM as mentioned in [4].

The academic and new studies on the propagation of ultrashort pulses all the way through fiber Bragg gratings are studied in [5]. It also considers more than a few applications in optical communications by accumulating ultrashort pulses and fiber Bragg gratings: a multi wavelength source for wavelength division- multiplexed systems and a means for implementing optical code-division multiple access.

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As mentioned in [6], the various modulation procedural schemes are recommended for development of BER in fiber optic communications. This developed scheme has been experienced on optical fiber systems working with a non-return-to-zero (NRZ) format at relaying rates of up to 10Gbps. Statistical simulations have shown a obvious advance of the system BER after optimization of the suggested processing utility on the detected electrical signals at central wavelengths in the region of 1310 nm.

Many properties of an optically consistent system can be enhanced using the mode locked LASER. The short pulse duration, wide spectral bandwidth, high peak power and low timing jitter of such a LASER lead to these benefits. Timing compensation includes basic synchronization transversely large chip areas, receiver latency fall, and data resynchronization. Lower power debauchery may be obtained throughout improved receiver sensitivity. Further applications of short optical pulses include time-division multiplexing, single-source wavelength-division multiplexing, and precise time-domain testing of circuits as discussed in [6].

### III. NUMERICAL SIMULATION

The principle of this paper is to design a optical code division multiple access (OCDMA) using optical components such as mode-lock LASER, PRBS generator, Electrical signal generator, external modulator, non-linear fiber, BER estimator, Eye-diagram analyser etc in OPTSIM. After designing the OCDMA we analyse the eye diagram and evaluate the performance of bit error rate and Q-value in OPTSIM.

The BER analysis of OCDMA networks constitutes of four steps namely OCDMA design, Input generation, Design of optical fiber length and BER Analysis.

#### A. OCDMA Design

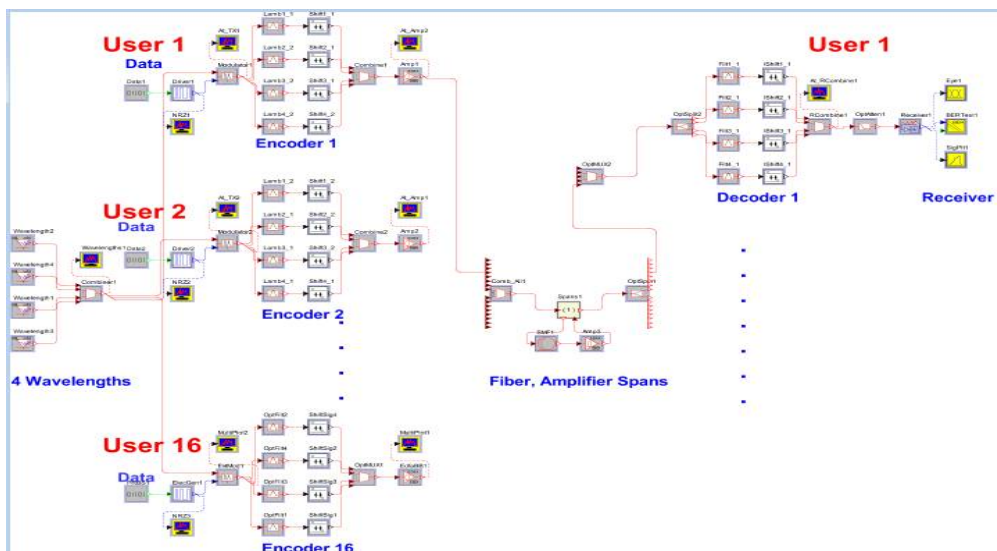


Fig. 2.Design of OCDMA for 16-users.

This Fig. 2.design of block diagram shows that the 16 user-OCDMA. Data access security and ability to support asynchronous, bursty data transmission are two of the main driving forces behind a lot of interest in the OCDMA techniques. On the other hand, the poor spectral efficiency of OCDMA systems demand appropriate choice of coding

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techniques and multi-access interference (MAI) is often a limiting factor. It consists of variety of components such as wavelength, encoder, data, fiber, amplifier spans, decoder, and receiver.

It also consists of several components such as mode lock laser, is nothing but one of the laser source generating the ultrashort pulses. Generating the short pulse we must need peak power, wavelength, pulse width, pulse repetition rate. Combiner can be used to combining the multiple values and produce output to other blocks. PRBS is one of the digital sources to generate the data into electrical signal generator. Electrical signal generator converts the digital data (PRBS) into electrical signal. However we are using optical fiber cable.

Modulator is a semiconductor device. It is used for modulating the intensity of a laser beam via a electrical voltage. It is used for controlling the amplitude of an optical value. EDFA is nothing but Erbium Doped Fiber Amplifier. Erbium doped fiber amplifier have attracted most because they operate in the wavelength region near 1.55Mm. Non linear fiber has different length. The main objective is to analyse the BER performance depends upon the changing the optical fiber cable length.

In telecommunication, an eye pattern, also known as an eye diagram, is an oscilloscope display in which a digital signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. The BER performance analysis is very important. Because in optical communication the BER is widely used. So in our paper analyse the performance of BER by using ultrashort pulse in OCDMA technique.

## B. Input generation

Ultrashort pulses have a broadband optical spectrum, and can be created by using mode lock laser. The important parameters of the mode lock laser are Wavelength, Pulse width, Pulse repetition rate and Peak power which are shown in the following table:

Parameter	Value	Units	Range	Std. Dev.	Distribution
pattern	"Multiple"				
type	"sech"				
peakPower	625	Watts	[ 0, 1e+032 ]	0.0	None
wavelength	1.55e-6	meters	[ 0, 1e+018 ]	0.0	None
mode	"Single"				
multiNodeOutput	"NO"				
noSources	10	none	[ 1, 1000 ]		
deltaFreq	1.0E11	meters or Hz	[ 0, 1e+018 ]	0.0	None
filename	--				
azimuth	0.0	degrees	[ -90, 90 ]	0.0	None
ellipticity	0.0	degrees	[ -45, 45 ]	0.0	None
force_Ey	"no"				

Fig . 3. Parameter of Mode Lock laser

Different wavelengths are represents in  $\lambda_1, \lambda_2, \lambda_3$  etc... Normally the wavelengths are 850nm, 1310nm, 1550nm have been obtained. Here we are using the wavelength range between 1550, 1550.4, 1550.8 and 1550.12nm.

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The distance between two maximas gives the pulse width which is a major parameter considered over here in this paper. The range of pulse is 0.1607e-12 Ps.

When the laser is running in pulsed mode the quantity of pulses per second or frequency of pulses is known as the Pulse Repetition rate (PRR). The term PRR and pulse frequency are frequently used. In our Paper the pulse repetition rate is 2.5Gbp/s. pulse repetition rate is in many ways like 1Gbp/s and 1.5Gbp/s.

The peak power of an optical pulse is the maximum occurring optical power. Due to the tiny pulse durations which are possible with optical pulses, peak powers can become very high even for moderately energetic pulses. They are different peak power for different cases. The formula for to calculate the peak power is defined  $Peak = E_{tot} \times 1.763/2 * FWHM$ .

Before calculate the peak power we must know energy of the pulse ( $E_{tot}$ ) and full width half maximum (FWHM). The peak power is found to be 625 Watts.

### C. Design of optical fiber length

The non linear fiber has different lengths. The main objective is to analyse the BER performance which depends upon the change in cable length such as 1km, 5km, 50km. The length of the fiber have some important parameters which have to be considered such as, Loss of the fiber and Dispersion of the fiber.

These losses are definite to geometry and handling of the fibers and are not functions of the fiber material itself. There are three basic types namely bending losses, launching losses, connector losses

For single mode fiber, the loss is about 0.5 dB per km for 1310 nm sources, 0.4 dB per km for 1550 nm. (1.0 dB/km for premise/0.5 dB/km at either wavelength for outside plant max per EIA/TIA 568). These approximately translate into a loss of 0.1 dB per 600 (200m) feet for 1310 nm, 0.1 dB per 750 feet (250m) for 1300 nm.

In optics, dispersion is the event in which the phase velocity of a wave depends on its frequency. Media having these common goods may be termed dispersive media. Sometimes the term chromatic dispersion is used for specificity.

Length of the fiber (km)	Fiber loss (dB)	Dispersion (ps/nm.km)
1	0.4	17
5	2.0	85
50	20	850

Table 1 Fiber loss and dispersion.

The above tabulation representing the different optical fiber cable length in km, fiber loss in db and dispersion of the fiber in ps/km.nm correspondings to the fiber length.

### D. BER Analysis

In Eye diagram analysis, an eye pattern, also well-known as an eye diagram, is an oscilloscope display in which a digital signal from a receiver is repetitively sampled and applied to the vertical input.

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Several system performance measures can be derived by analysing the display. If the signals are excessively long, too short, poorly synchronized with the system clock, too high, too low, too noisy, or too slow to change, or have moreover much undershoot or overshoot, this can be observed from the eye diagram. A release eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform due to inter-symbol interference and noise appears as closure of the eye pattern.

The fig.4. shows the eye diagram analysis which is obtained in optsim considering the parameters like length of the fiber and input that is used to find and analyse the BER of different fiber lengths.

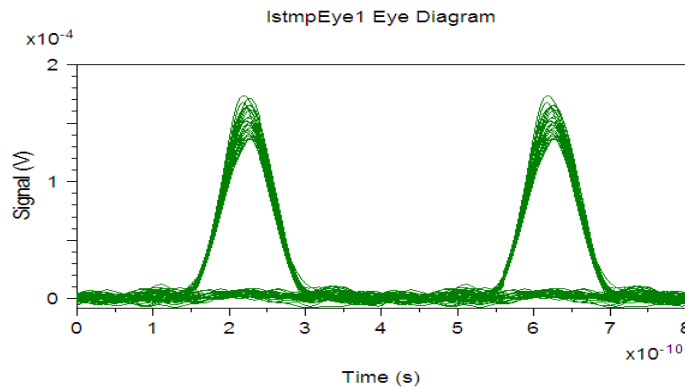


Fig. 4. Eye Diagram Analysis

In, BER study the bit error rate (BER) is the number of bit errors per unit time. Bit error rate is the number of bit errors divided by the total number of transferred bits during a calculated time interval. BER is a part less performance measure, often expressed as a percentage.

The fig 5 gives the corresponding BER analysis of the Eye diagram given in fig 4. For instance only one user is taken into consideration for performing the eye diagram analysis and BER analysis which can be further extended upto User 16 in multiples of 2.

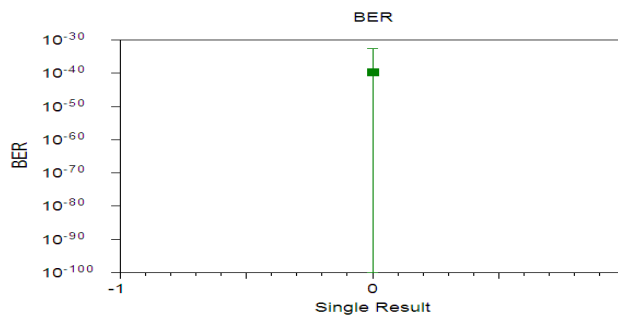


Fig. 5. BER Analysis

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## IV. RESULTS AND DISCUSSION

Based on the Numerical simulation given in section II, the performance of BER and Q-value is found out using the Optsim Rsoft tool. The various input parameters to find the BER performance and the Q-value is mentioned in Table.2.

<b>Peak power (w)</b>	625		
<b>Wavelength (nm)</b>	1550		
<b>Pulse width (ps)</b>	0.1607		
<b>Fiber length (km)</b>	1	5	50
<b>Fiber loss (dB)</b>	0.4	2.0	20
<b>Dispersion (ps/nm.km)</b>	17	85	850

Table 2 Input

Thus the simulation is done using the input parameters mentioned above and corresponding output is obtained for various cases taking various lengths into consideration. The various length which are used here are 1km, 5 km and 50km. The relationship between the no of Users, performance of BER and Q-value is as given below.

$$No. of Users \propto \frac{BER}{Q - value}$$

User	BER	Q-value(dB)
1	8.6182e-39	2.2261e1
2	1.3057e-38	2.2240e1
4	3.9497e-34	2.1673e1
8	9.0834e-3	7.4663e0
16	5.4082e-2	4.1176e0

Table 3 Output values for 1 km



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The above table 3 describes the output values for 1km. In user 1 the BER is 8.6182e-39 and its corresponding Q-value is 2.2261e1, followed by BER of user 16 is 5.4082e-2 and Q-value is 4.1176e0. So this table shows that the BER is increases and the corresponding Q-value is decreases when the user is increases.

User	BER	Q-value(dB)
1	8.7002e-39	2.2249e1
2	1.4339e-38	2.2235e1
4	4.2158e-34	2.1669e1
8	9.0901e-3	7.4653e0
16	5.4080e-2	4.1177e0

Table 4 Output values for 5km

The above table 4 describes the output values for 5km. In user 1 the BER is 8.7002e-39 and its corresponding Q-value is 2.2249e1, followed by BER of user 16 is 5.4080e-2 and Q-value is 4.1177e0. So this table shows that the BER is increases and the corresponding Q-value is decreases when the user is increases.

User	BER	Q-value(dB)
1	8.1176e-2	2.9092e0
2	8.1202e-2	2.9041e0
4	8.1229e-2	2.9030e0
8	1.0235e-1	2.0642e0
16	1.0236e-1	2.0640e0

Table 5 Output values for 50km

The above table 5 describes the output values for 1km. In user 1 the BER is 8.1176e-2 and its corresponding Q-value is 2.9092e0, followed by BER of user 16 is 1.0236e-1 and Q-value is 2.0640e0. So this table shows that the BER is increases and the corresponding Q-value is decreases when the user is increases.



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### A. Graph analysis:

The following graph analyses the relation between BER and Q value (dB). Based on the results and discussions is given in the section III.

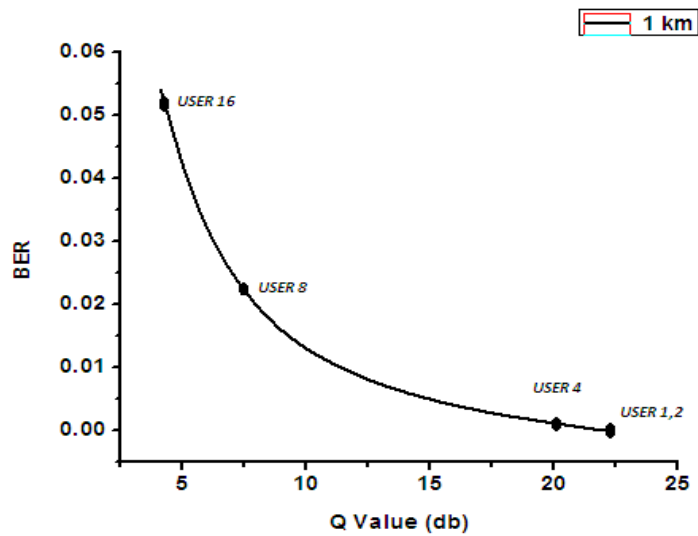


Fig. 6. Relationship between BER vs Q-value(dB)

This fig. 6. Shows that the relationship between BER vs Q-Value. For 1 km, User 1 BER is 8.6182e-39 and Q-Value is 2.2261e1. Similarly User 16 BER is 5.4082e-2 and Q-value is 4.1176e0 . So the above graph shows that BER value exponentially decreases when the Q-value increases.

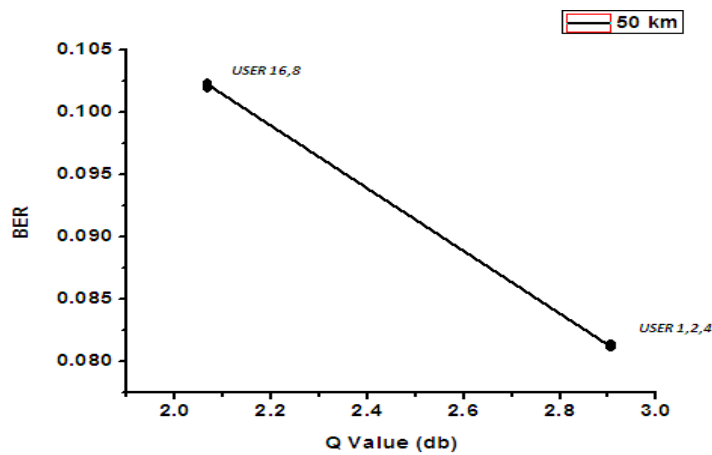


Fig.7. Relationship between BER vs Q-value(dB)

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This fig. 7. Shows that the relationship between BER vs Q-Value. For 50 km, User 1 BER is  $8.1176 \times 10^{-2}$  and Q-Value is  $2.9092 \times 10^0$ . Similarly User 16 BER is  $1.0236 \times 10^{-1}$  and Q-value is  $2.0640 \times 10^0$ . So the above graph shows that BER value linearly decreases when the Q-value increases.

## V. CONCLUSION

The characteristics and applications of ultrashort pulses are successfully investigated for different length and different users. In particular we discussed OCDMA, performance of BER using OPTSIM. For 1 Km, BER of User 1 is  $8.6182 \times 10^{-39}$  and Q-Value is 22.2261 likewise the BER of User 16 is  $5.4082 \times 10^{-2}$  and Q-value is 4.1176. It terminated the no. of users is directly proportional to BER and inversely proportional to Q-Value. Similarly same for both 5 km and 50 km. Thus the result is analysed and compared with fiber length, bit error rate and Q value by using various graph. Furthermore we study and design the other applications such as wavelength division multiplexing (WDM), Optical time division multiplexing (OTDM) using OPTSIM tool.

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