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Performance Evaluation Of Ocdma Communication System Under The Effect Of Jitter

Deepinder Singh[1], Jagtar Singh[2]
[1]Student, M.tech Electronics and Communication Section, YCOE, Talwandi Sabo, Guru Kashi Punjabi University Campus, Patiala
[2]Associate Prof., Electronics and Communication Section, YCOE, Talwandi Sabo, Guru Kashi Punjabi University Campus, Patiala

Abstract

This paper focuses on the effect on BER, Q-Factor for a four user OCDMA communication system with varying Jitter. Performance of the OCDMA communication system has been evaluated in terms of bit error rate and Q factor with jitter varying from 0 pico-seconds to 3.0 pico-seconds in steps of 0.5 pico-seconds. Simulations were carried out using commercially available simulator from Rsoft, OPTSIM.

Key Terms: BER, Jitter, OCDMA, OPTSIM, Q-Factor.

I. INTRODUCTION

OCDMA is a technology which supports multiple simultaneous transmissions in the same timeslot and the same frequency to realize multiplexing transmission and multiple accesses by coding in the optical domain. Besides OTDM and WDM and a potentially promising technique for optical networks in the future, and especially, due to its easy access and flexible network structure, it is very applicable to the access network, it is another technology of multiplexing and multiple accesses. To verify the feasibility to implement incoherent OCDMA system by encoding in the time domain in 1986, Prucnal, Santoro and Fan proposed to realize the fiber-optic LAN by using optical signal processing[5, 6], and used prime codes to carry out the experiment of electronic encoding and fiber-optic delay line decoding. In 1988, Weiner, Heritage and Salehi [1] demonstrated how to spread the femto-second optical pulse into pico second-duration pseudo noise bursts. By encoding the light spectrum into pseudo random binary phase the spread frequency was achieved and then by decoding the spectrum phase encoded to recover the original pulse. The coherent ultra-short pulse coding and decoding could be applied to the fast reconfigurable OCDMA communication networks was proposed by them. Both breakthrough studies were milestones for the development of OCDMA. Optical encoding and decoding for incoherent OCDMA uses unipolar codes whereas the bipolar codes used in radio frequency code division multiple access (RF CDMA) have poor performance in OCDMA system and cannot be used. Therefore, unipolar codes with good system performance need to be developed. As a result, in the earlier years, the research on incoherent OCDMA focused on looking for and obtaining unipolar codes with good auto-and cross-correlations, such as optical orthogonal/pseudo-orthogonal codes (OOC) [7], prime codes (PC) [6, 8], quadratic congruence codes (QCC), etc. Extended prime codes (EPC) [9], modified prime codes (MPC) [10] and extended quadratic congruence codes (EQCC) [11] have been proposed again In order to improve the performances of PC and QCC. OOC has the best performance among these one-dimensional codes but its construction is complicated, compared with those of other codes. Even though one-dimensional OOC possesses the ideal auto- and cross correlations, and its cardinality, that is, the number of code words, is the largest, the number of users is inversely proportional to the data rate for single user in one-dimensional incoherent OCDMA systems because the cardinality of codes is proportional to the length of time-spread. While, the data rate for a single user is inversely proportional to the length of the time-spread. In the meantime, the cardinality of code is approximately inversely proportional to the square of the code-weight. The smaller the code-weight becomes, the more the error probability increases. In order to meet the requirement of bit-error-rate, the simultaneous number of active users in the network must be reduced. The application of one-dimensional codes to incoherent OCDMA system is limited due to the reasons mentioned above. Unipolar codes with larger capacity need to be designed in order to increase the number of users. Therefore, starting around 1990, researchers transferred their interests from the study on one-dimensional codes to 2D OOCs [12-14], which enormously increases the capacity of the system and improves the performance.

II. JITTER AND ITS EFFECTS

Transmitting and receiving a signal through a medium or channel is the essence of communication. An early mathematical model for communication may be tracked back to Claude Shannon's famous 1948 [15]. Communication systems are grouped into three basic categories Depending on what kind of medium is used to transmit and receive a signal: fiber, copper, and wireless (or free space) . The bandwidths typically are a few THz for fiber and a few GHZ for copper media. Attenuation, and cost, fiber-based communication is often used for long-distance (> 1 km), high-data-rate (up to > 100 Gb/s per channel) communication, considering the constraints of bandwidth.Copper-based communication is used for medium-distance (< 1 km) and medium-high data rates (1 Mb/s to a few Gb/s per channel). Wireless is used for medium distance (~ km) and medium data rates (up to ~100 Mb/s). The choice of a communication medium is largely determined by cost and application requirements. Fiber has the highest intrinsic bandwidth, so it can deliver the highest data rate possible for a single channel.

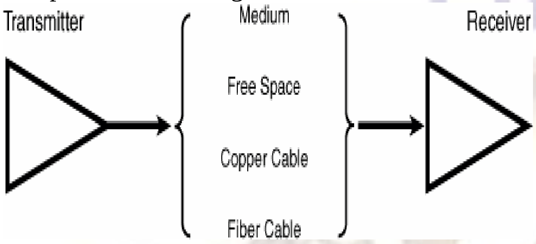

Fig.1 A Simple Communication System, Including Three Basic Building Blocks: Transmitter, Medium, And Receiver.[16]

A physical process called noise is always associated with it when a signal is transmitted and received. Noise is basically any undesired signals added to the ideal signal. The information is encoded in logical bits of 1 and 0 in the context of digital communication. An ideal signal may be represented by a trapezoid wave with a finite 0 to 1 rise time or 1 to 0 fall time. In the presence of noise, it is the sum of ideal signal, with the noise giving rise to the "net" or actual signal waveform. The actual signal is identical to the ideal signal waveform if no noise is added. As shown in Figure2 the actual signal is deviated from the ideal signal if the noise is added.

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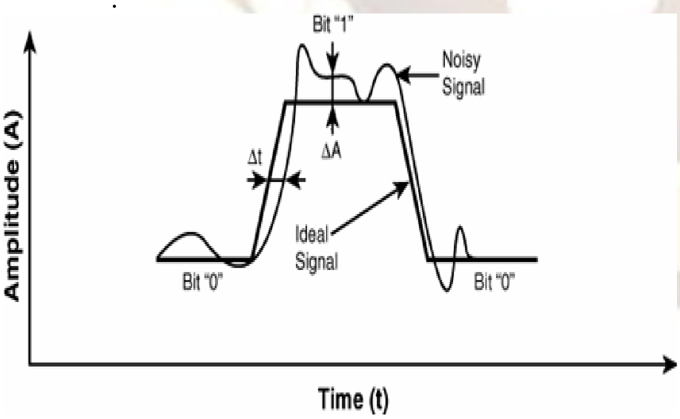

Fig.2 An Ideal Signal Versus A Noisy Signal For A Digital Waveform.[16]

From two aspects the deviation of a noisy signal from its ideal can be viewed: timing deviation and amplitude deviation. The amplitude of the digital signal for a copper-based system is the voltage, and for a fiber-based or radio frequency (RF) wireless system it is the power. The deviation of the signal amplitude (ΔA) is defined as the amplitude noise (or just noise), and the deviation of time (Δt) is defined as the timing jitter (or just jitter). Though the impacts of timing jitter and amplitude noise are not symmetrical. Amplitude noise is a constant function and can affect system performance all the time. Timing jitter affects system performance only when an edge transition exists. Any deviation from ideal waveform is defined as the Signal integrity generally. Signal integrity contains both amplitude noise and timing jitter in a broad sense. But, certain signal integrity signatures such as overshoot, undershoot, and ringing may not be well covered by either noise or jitter alone.

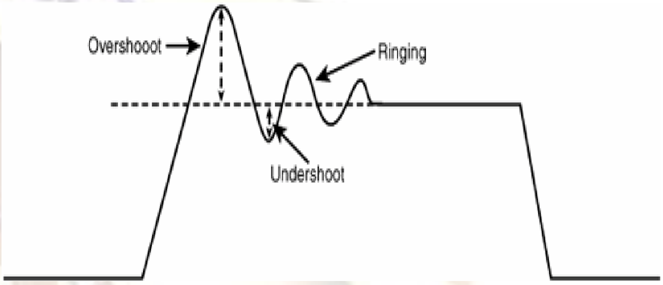

Fig. 3 Some Signal Integrity Key Signatures.[16]

The quality of a communication system is affected by jitter, noise, and signal integrity. The following sections discuss and illustrate how jitter and noise cause a bit error and under what conditions this bit error occurs. Then the metric that is commonly used to quantify the bit error rate in a communication system is discussed.

III. SIMULATION OF FOUR USER OCDMA SYSTEM

Simulation set-up for four user OCDMA System has been developed using Rsoft Optsim tool as shown in Figure 4.

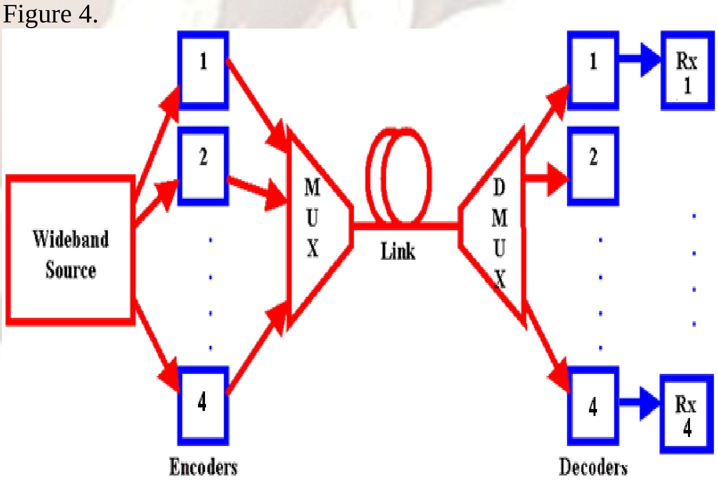

Fig. 4 Block Diagram of Four User OCDMA Network

Each user has a transmitter and a receiver and star network topology has been used. Star coupler collects the power sent by the transmitters and distributes it equally among all receivers.

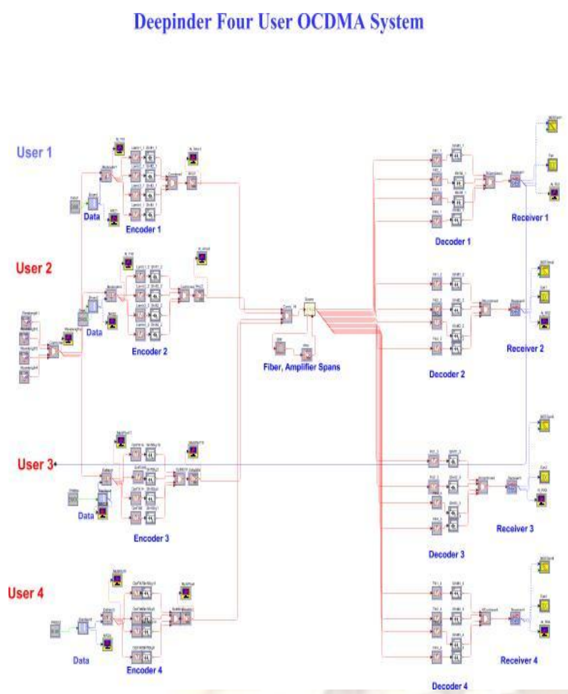

Fig. 5 Screen Shot of Four User OCDMA Network

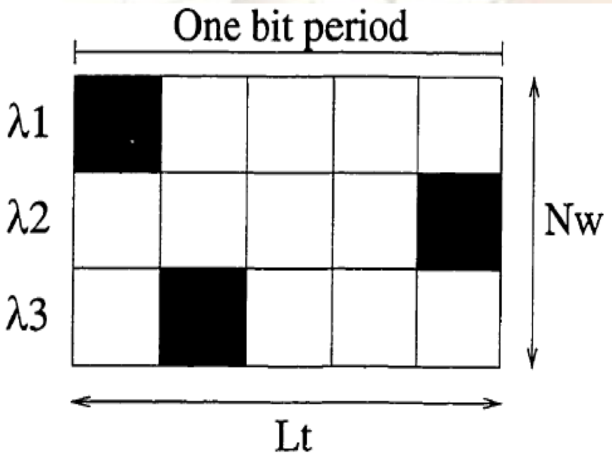

Fig. 6 OCDMA Code using three wavelengths of λ_1= 850 nm, λ_2=1310 nm, λ_3=1550 nm

The construction of OCDMA code is shown in Figure 4.2. Simultaneous use of both time and wavelength results in 2-D coding space. The number of wavelength channels used is denoted by N_w, which is the number of rows used in the code. In each wavelength channel, one bit period is divided into L_t time slots. L_t is the temporal length of the code since it indicates the number of chips available in a bit period per wavelength. The coding area D is the product of N_w and L_t, which also gives the total number of available chips. The weight W of the code is the number of chips in which a light pulse is present. These are called the '1' chips of the code. The density of the code is the ratio of code weight to coding area.

IV. RESULTS AND DISCUSSIONS

Table 1 : Variation of BER with Jitter for Different Fibers with Different Lengths

Bit Error Rate (BER)								
Jitter (ps)	10 Km		30 Km		50 Km		70 Km	
	Corningleaf Fiber	Lucentallwave Fiber	Corningleaf Fiber	Lucentallwave Fiber	Corningleaf Fiber	Lucentallwave Fiber	Corningleaf Fiber	Lucentallwave Fiber
0	2.11E-02	0.00E+00	2.11E-02	6.15E-07	0	0	6.42E-02	2.18E-165
0.5	6.65E-03	0.00E+00	6.65E-03	9.11E-03	2.03E-04	9.13E-03	1.14E-02	5.27E-03
1	1.10E-02	8.52E-76	1.10E-02	1.95E-02	8.22E-04	2.54E-02	1.06E-02	1.01E-02
1.5	1.23E-02	3.00E-88	1.23E-02	3.63E-02	8.39E-03	2.87E-02	1.02E-02	6.80E-03
2	4.34E-03	5.80E-111	4.34E-03	1.93E-02	9.04E-03	9.65E-03	1.11E-02	1.06E-04
2.5	3.47E-02	6.95E-126	3.47E-02	1.06E-03	7.63E-04	4.79E-02	9.50E-03	3.11E-03
3	1.71E-02	1.09E-29	1.71E-02	7.76E-03	4.15E-04	2.89E-03	1.29E-03	8.88E-03

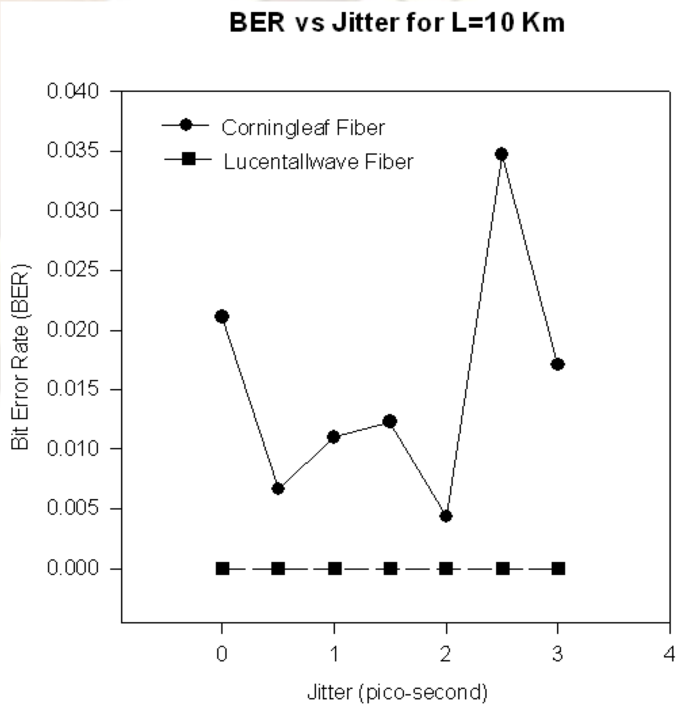

Fig.7 Variation of BER with Jitter for L=10 Km

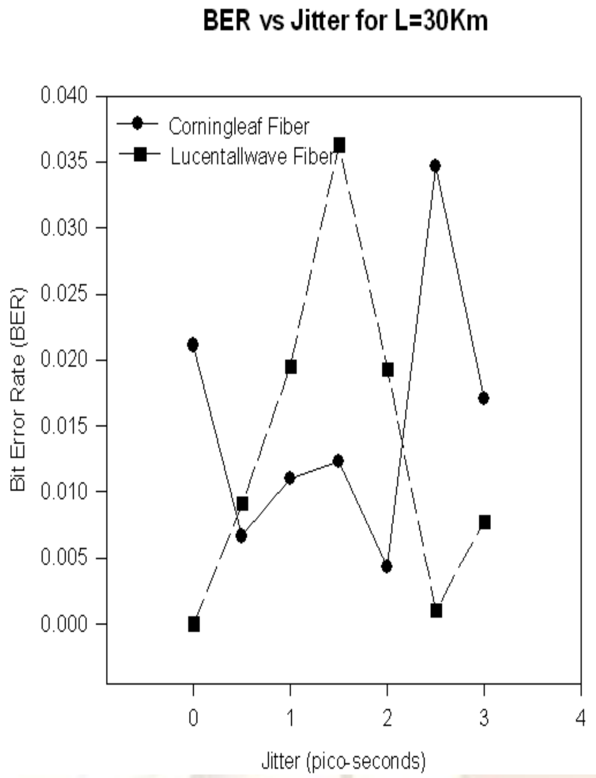

Fig.8 Variation of BER with Jitter for L=30 Km

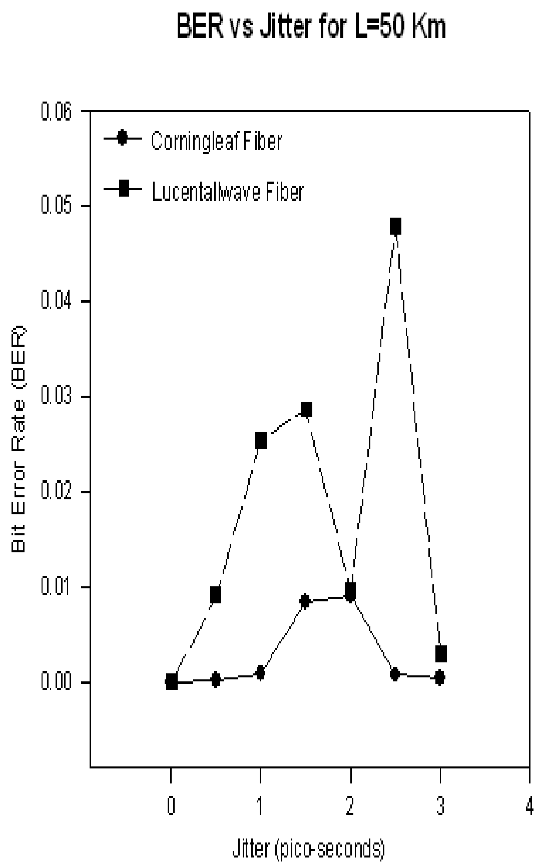

Fig.9 Variation of BER with Jitter for L=50 Km

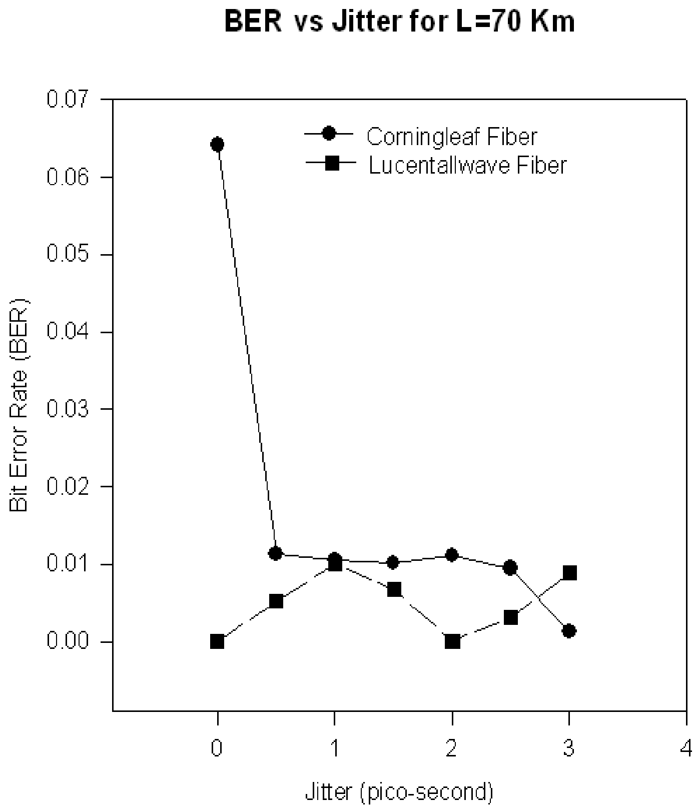

Fig.10 Variation of BER with Jitter for L=70 Km

From Figures 7-10 and Table 1 as the value of Jitter is increased from 0 pico-second to 3.0 pico-second, the value of BER varies from 2.11E-02 to 1.71E-02 and 0 to 1.09E-29 for L = 10 Km, from 2.11E-02 to 1.71E-02 and 6.15E-07 to 7.76E-03 for L = 30 Km, varies from 0 to 4.15E-04 and 0 to 2.89E-03 for L = 50 Km and from 6.42E-02to 1.29E-03 and 2.18E-165 to 8.88E-03 for L = 70 Km for Corningleaf Fiber and Lucentallawave Fiber respectively.

Table2 : Variation of Q-Factor with Jitter for Different Fibers with Different Lengths

Jitter (ps)	Q-Factor							
	10 Km		30 Km		50 Km		70 Km	
	Corningleaf Fiber	Lucentallawave Fiber	Corningleaf Fiber	Lucentallawave Fiber	Corningleaf Fiber	Lucentallawave Fiber	Corningleaf Fiber	Lucentallawave Fiber
0	2.03E+00	1.41E+03	2.03E+00	4.85E+00	1.41E+03	1.36E+01	1.52E+00	2.74E+01
0.5	2.48E+00	1.41E+03	2.48E+00	2.36E+00	3.54E+00	2.36E+00	2.28E+00	2.56E+00
1	2.29E+00	1.84E+01	2.29E+00	2.06E+00	3.15E+00	1.95E+00	2.31E+00	2.32E+00
1.5	2.25E+00	1.99E+01	2.25E+00	1.80E+00	2.39E+00	1.90E+00	2.32E+00	2.47E+00
2	2.62E+00	2.24E+01	2.62E+00	2.07E+00	2.36E+00	2.34E+00	2.29E+00	3.71E+00
2.5	1.82E+00	2.38E+01	1.82E+00	3.07E+00	3.17E+00	1.67E+00	2.35E+00	2.74E+00
3	2.12E+00	1.13E+01	2.12E+00	2.42E+00	3.34E+00	1.36E+01	3.01E+00	2.37E+00

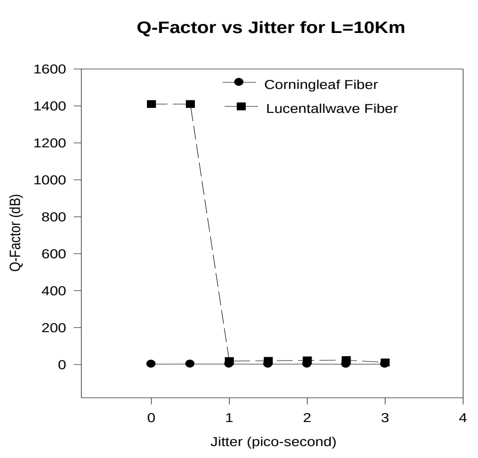

Fig.11 Variation of Q-Factor with Jitter for L=10 Km

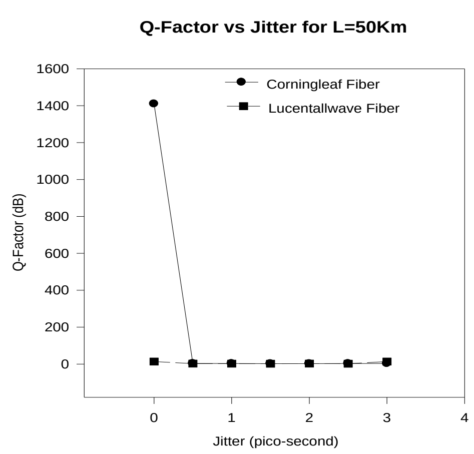

Fig.13 Variation of Q-Factor with Jitter for L=50 Km

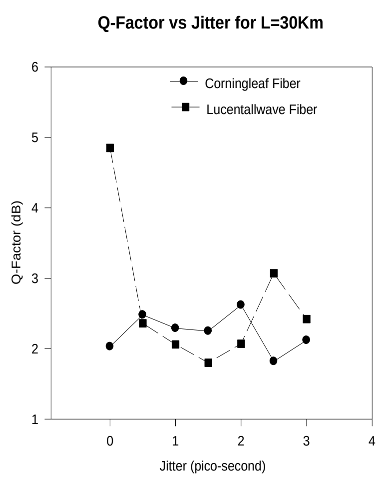

Fig.12 Variation of Q-Factor with Jitter for L=30 Km

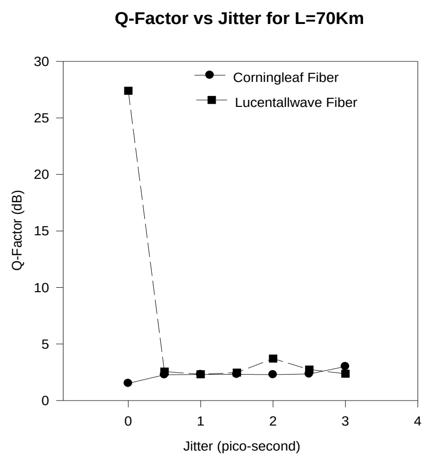

Fig.14 Variation of Q-Factor with Jitter for L=70 Km

From Figures 11-14 and Table 2 it can be concluded that as the value of Jitter is increased from 0 pico-second to 3.0 pico-second, the value of Q-Factor varies from 2.03dB to 2.12 dB and 1.41E+03 dB to 1.13E+01 dB for fiber of L= 10 Km, from 2.03 dB to -2.12 dB and 4.85 dB to 2.42 dB for fiber of L= 30 Km, from 1.41E+03dB to 3.34 dB and 1.36E+01 dB to 1.36E+01dB for fiber of L= 50 Km and from 1.52 dB to 3.01 dB and 2.74E+01dB to 2.37 dB for fiber of L= 70 Km for Corningleaf Fiber and Lucentallawave Fiber respectively. Thus from comparison of the overall performance of both the fibers, it can be concluded that although in some cases Corningleaf Fiber show better results but overall Lucentallawave Fiber shows more consistent performance.

V. CONCLUSION

With advantages like ability to increase the transmission capacity of an optical fiber optical code division multiple access (OCDMA) has been recognized as one of the most important technologies for supporting many simultaneous users in shared media. Jitter is an important factor, which degrades the overall performance of OCDMA system. In this paper performance of the OCDMA communication system has been evaluated by jitter varying from 0 pico-seconds to 3.0 pico-seconds in steps of 0.5 pico-seconds. From simulation results it has been concluded that although in some cases Corningleaf Fiber show better results but overall Lucentallawave Fiber shows more consistent performance.

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