Demonstrating a Millimeter wave band DPSK Radio Over Fiber System and Minimizing Effects of Chromatic Dispersion

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Abstract— **A sub-carrier multiplexed differential phase shift keying using radio over fiber system for different channel frequencies that lie in the C-band is realized. Here, undoubtedly C-band is chosen for transmission because of its supremacy over other bands for minimizing signal attenuation in dB/km and increasing the range of transmission. In this work various dispersion compensation techniques like pre-compensation, post-compensation and fiber bragg grating component are taken into account in order to minimize the fiber chromatic dispersion which is seen in most of the radio frequency propagation systems. These techniques are compared in terms of Quality factor, RF received power and accumulated dispersion. Optisystem 11 is used as the software for designing the layout for our system.**

Keywords: **radio over fiber, differential phase shift keying, dispersion compensating fiber, EDFA, Mach Zehnder Interferometer.**

I. INTRODUCTION

The wireless technologies are playing a prerequisite role in today's time by providing end-users in local wireless access networks with broadband services in order to fulfill their day-to- day needs. As Radio Frequency bands are allocated a limited available frequency band, the overall technology is switching towards the fourth generation that makes use of millimeter wave bands [1]. The millimeter-wave region corresponds to an electromagnetic spectrum band of frequencies with a lower limit of 30 GHz that extends to 300 GHz frequency range. Thus a sub-carrier multiplexed differential phase shift keying Radio over Fiber technology is demonstrated as it is deemed to provide the customers with much higher bandwidth and support long haul transmission as it works on phase variations rather than amplitude modulation. The basic building blocks in millimeter wave-band transmission are as following: A central station (CS) linked to antenna units placed at remote places [2].

II. LITERATURE REVIEW

Recently Joseph Zacharias, Nithyamol V R and Vijayakumar Narayanan in the year 2013 demonstrated Millimeter Wave Link using photons of light and a frequency of 60 GHz taking into consideration a distance of 10 m and employing phase shift keying. This was a short-Range Experiment System. In December 2010 Shangyuan Li, Xiaoping Zheng, Hanyi Zhang, and Bingkun Zhou introduced a Radio-Over-Fiber Set-up Incorporating Mach–Zehnder Modulator. In December 2004 Gang Zhou introduced a two-way transmission system in which a bandwidth of 30 GHz was used for ROF transmission. The system performance is investigated by utilizing novel techniques such as OTTSB, SCM, Frequency down-shifting techniques and DWDM. In 2013, an ASK radio over fiber was developed. The work is basically focused on Radio over fiber technology using DPSK system.

III. SET-UP FOR PROPOSED SYSTEM

In this work, a SCM-DPSK ROF system for two channel frequencies initially set to 193.1THz and 193.2 THz has been observed. This is a one-way transmission system layout incorporating an optical generation along with ROF transmission. For achieving external modulation, a Mach–Zehnder modulator utilizes the concept of Single Sideband subcarriers that has an advantage over Double Side-Band signals in saving the bandwidth. Thus it avoids bandwidth wastage and overcomes the short-comings of frequency chirp.

Here in this proposed system wavelengths lying in C-Band, which is also known as "conventional" or "erbium window" are taken that is 1510-1565 nm. This window is used here as the loss of signal quality due to attenuation is minimum in this range [3]. This concept is justified in figure 3.

Differential phase–shift keying helps in recording the changes in the binary stream of data and uses the concept of change in phase of the incoming signal.

Inspite of this it has been observed that a Radio over fiber signal suffers from fiber chromatic dispersion whenever propagated over a long fiber link especially in the C-band. So, how dispersion compensation schemes affect the overall system performance is examined here. System specifications are shown in table 1 while figure 1 shows the layout of proposed system.

Various techniques to limit the chromatic dispersion are:

a). Pre compensation

b). Post-compensation

c). Introduction of Ideal Fiber Bragg Grating Component

TABLE I : System Specifications

PARAMETERS	VALUES
Bit Rate	40 Gbps
Length of Sequence	128 Bits
Samples Per Bit	32
Number of Samples	4096
Resolution	0.1nm

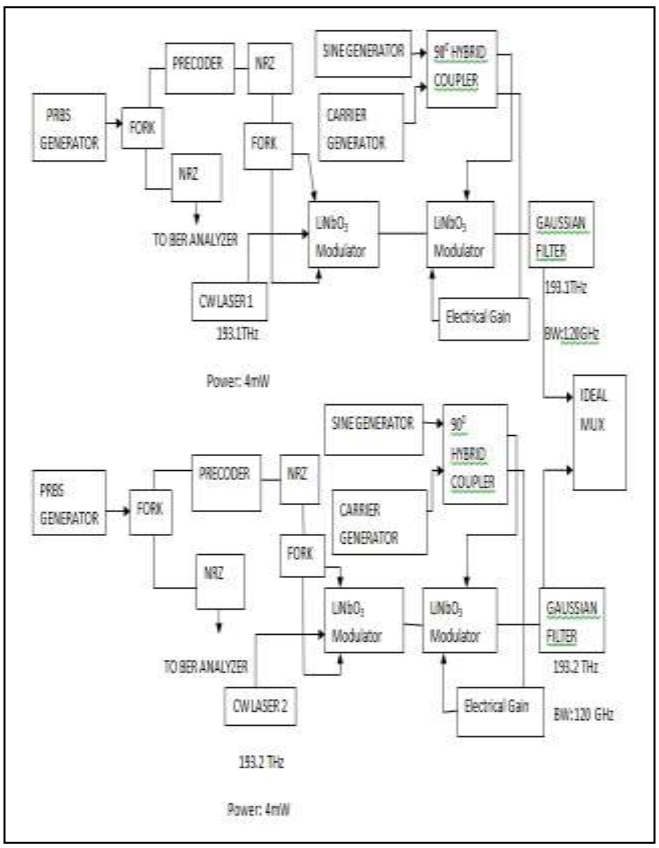

Figure 1: DPSK ROF Transmitter for 2-channels

In this, the signal first undergoes DPSK modulation and is afterwards modulated with carrier signal using MZM. This is to generate Non-Return to Zero-DPSK modulated signal. The modulated signal is transmitted through 50 km SMF and finally given to mach-zender interferometer.

A. TRANSMISSION LINK MODEL:

A transmission link model is designed by using ideal multiplexer and de-multiplexer linked through single mode fiber of length 50 Km and a DCF of length 10 Km. EDFA is providing a gain of 15 dB. The transmission link is shown in figure 2 and the attenuation is expressed as:

$$Attenuation = -(10/L)log_{10}(power\ out/power\ in) \quad (1)$$

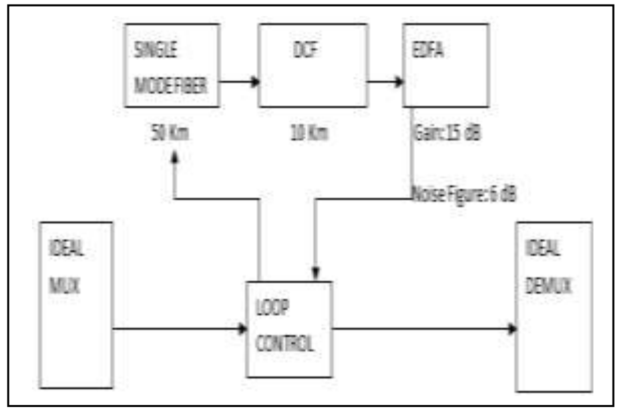

Figure 2: Transmission Link

Erbium Doped Fiber Amplifier (EDFA) in the link encounters the attenuation and dispersion and uses erbium ions which produce photons of light that results in stimulated emission. Also it uses the concept of pump lasers working at 980nm or 1480 nm to boost the signal level required for some applications. Therefore EDFA is deployed in long haul communication systems. Specifications for EDFA and SMF are specified in table 2 and table 3 respectively.
Figure 3 shows attenuation as a function of different wavelengths.

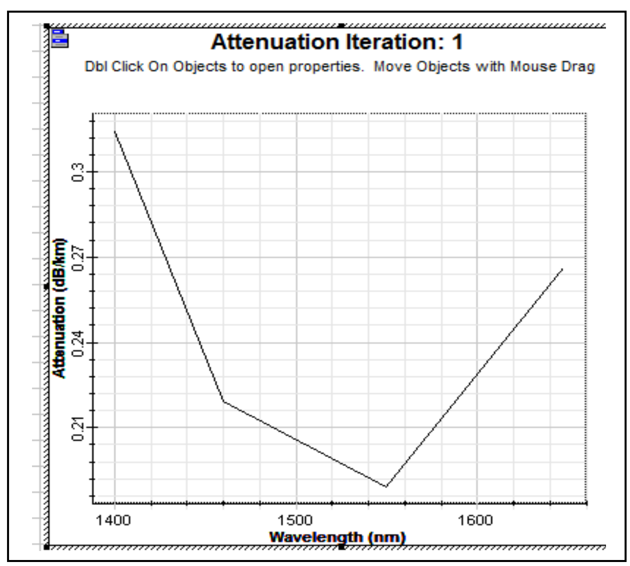

Figure 3: Attenuation at different wavelengths

TABLE II: Erbium Doped Fiber Amplifier Specifications

System Parameters For Ideal EDFA	Values
Operation Mode	Gain Control
Gain	15 db
Noise Figure	6 db

TABLE III: Specifications For SMF

PARAMETERS	VALUES
Length	50 Km
Attenuation	0.2dB/km
Dispersion	17ps/nm/km
Dispersion Slope	0.075ps/nm^2/k
Differential Group Delay	0.2ps/km

B. RECEIVER MODEL:

Figure 4 shows the DPSK receiver model for a two channel system.

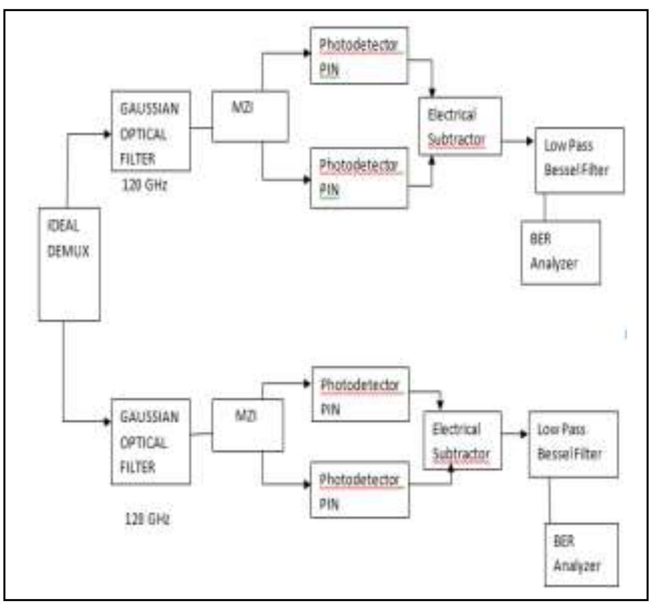

Figure 4: DPSK Receiver Section for 2-channels

In the receiver systems using DPSK modulation introducing MZI results in an amplitude variations with input being a phase modulated signal [5,6]. An optical receiver has PIN Photo detector which uses an intrinsic layer to gather light and accomplishes the task of converting light into electricity.

A low pass Bessel filter of frequency 0.75 * bit rate is used. The eye-diagram representation for proposed frequencies can be illustrated by figure 5a and figure 5b.

a). OUTPUT OF BER ANALYZER:

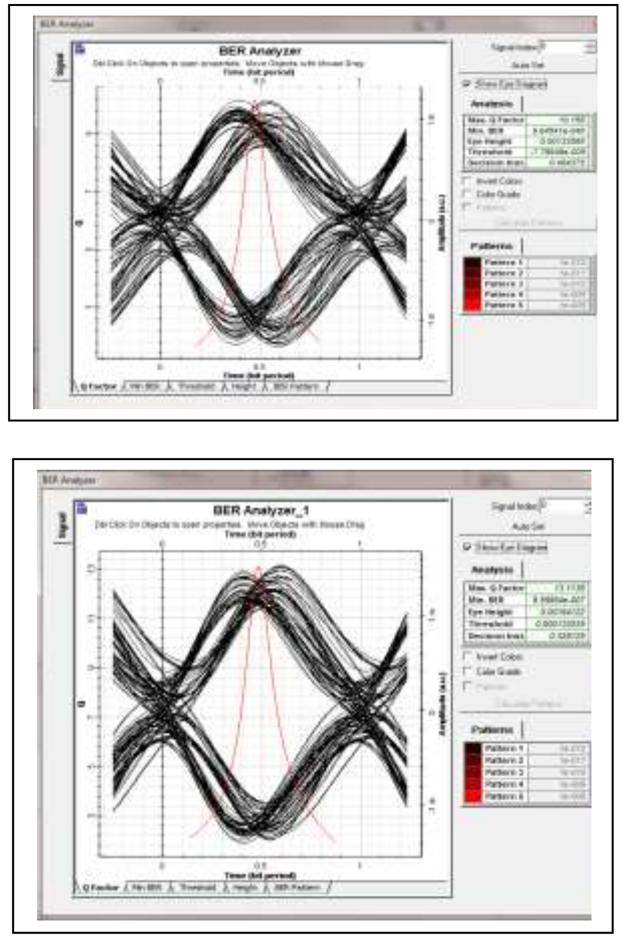

Figure 5: Eye-Diagrams for 193.1THz and 193.2THz

IV. CHROMATIC DISPERSION IN RADIO OVER FIBER SYSTEMS:

When DSB signals are transmitted via fiber link, fiber chromatic dispersion hinders and disturbs the successful signal transmission as each frequency component experiences different phase shifts.

$$P_{RF} \propto \cos[\pi L D \lambda_c{}^2 f_{RF}{}^2 / c] \qquad (2)$$

Where P_{RF} is the received RF power, λ_c denotes the wavelength of the optical carrier and f_{RF} is the frequency of the Radio signal.

This broadening is a function of distance travelled as well as dispersion parameter D. The dispersion parameter is given in ps/nm/km and it is observed that dispersion increases as we move towards higher wavelengths. This concept is illustrated as seen in figure 6.

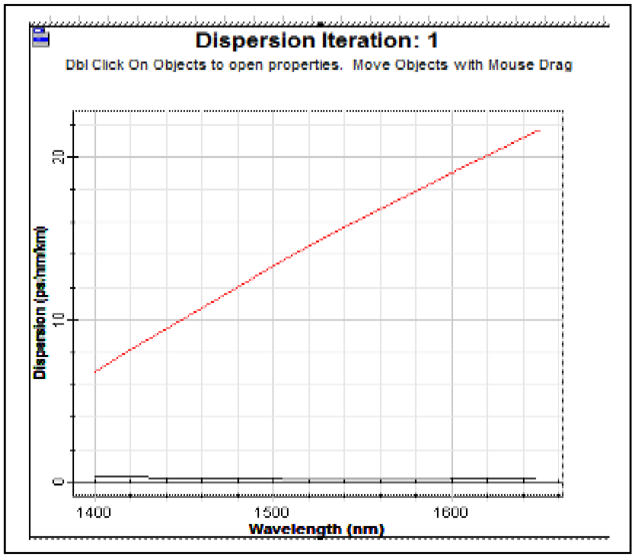

Figure 6: Dispersion as a function of wavelengths

V. DISPERSION COMPENSATION TECHNIQUES:

These schemes are as follows:

A. The proposed system: Pre-compensation

Here a Dispersion Compensating Fiber (DCF) of fixed length has been demonstrated as shown in figure 7. D is taken as 17 ps/nm/km in the wavelength range of 1.55 µm for a standard single mode fiber (SMF). Quality factor is plotted against dispersion as shown in figure 8. Table 4 gives specifications for DCF.

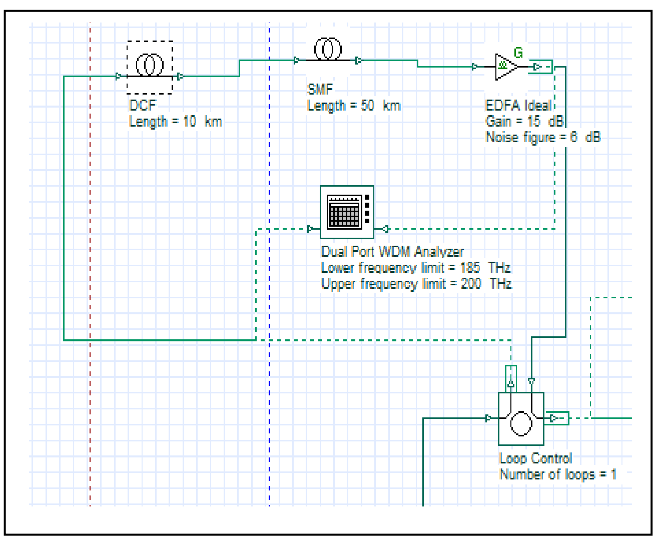

Figure 7: Transmission Link showing Pre-compensation

TABLE IV: Specifications For Dispersion Compensating Fiber

PARAMETERS OF DCF	VALUES
Length	10 km
Dispersion slope	-0.3ps/nm/2^/k
Attenuation Factor	0.5db/km
Dispersion	-85ps/nm/km

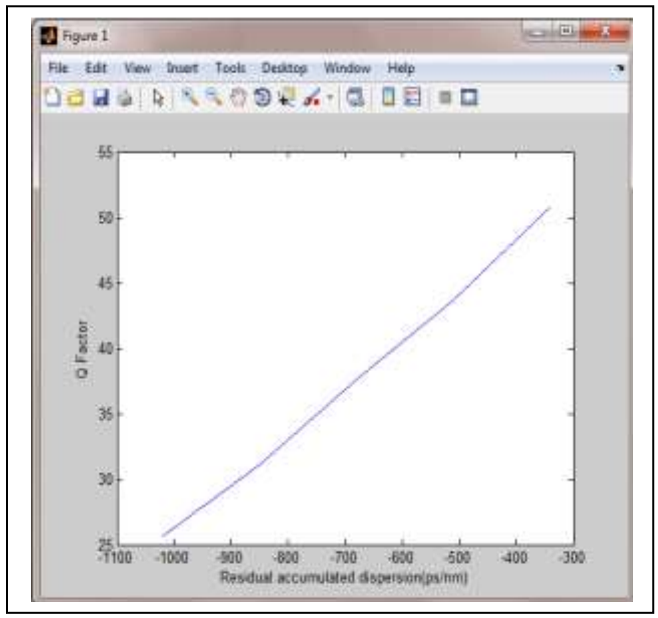

Figure 8: Q-factor in dB as a function of residual accumulated dispersion(ps/nm) for pre-compensation

B. System configuration and design for post-compensation:

For depreciating the short-comings of this spreading of light pulse known as material or chromatic dispersion, a dispersion compensating fiber is used after the single mode fiber as shown in figure 9 while figure 10 depicts relation between the factor that decides the quality of signal transmission and the residual accumulated dispersion.

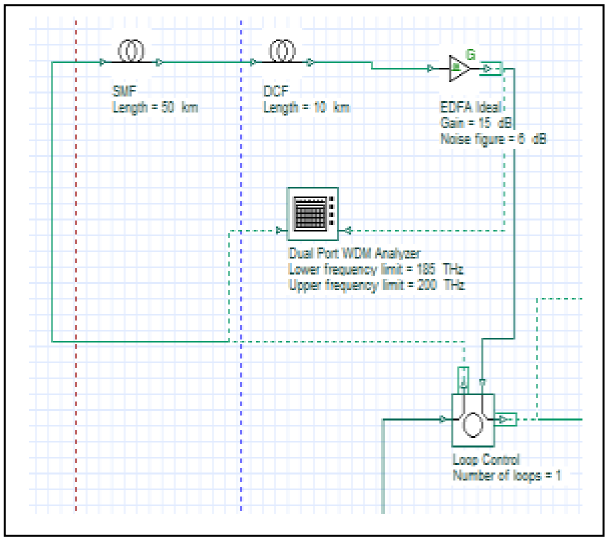

Figure9:Transmission Link showing Post- compensation

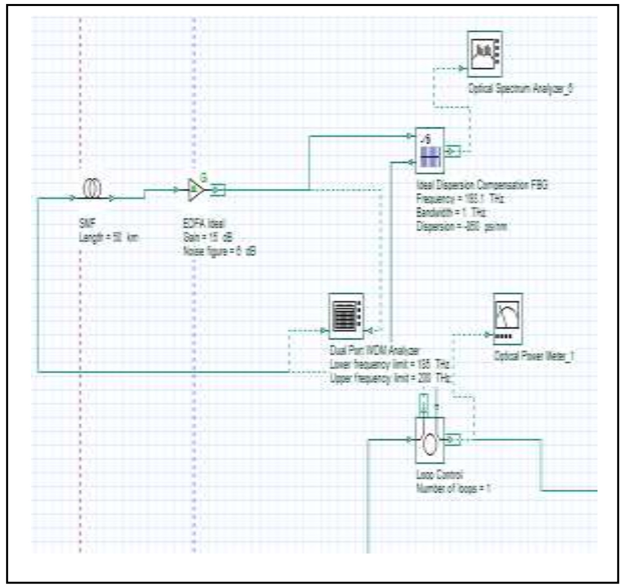

Figure 11: FBG Component incorporated in link

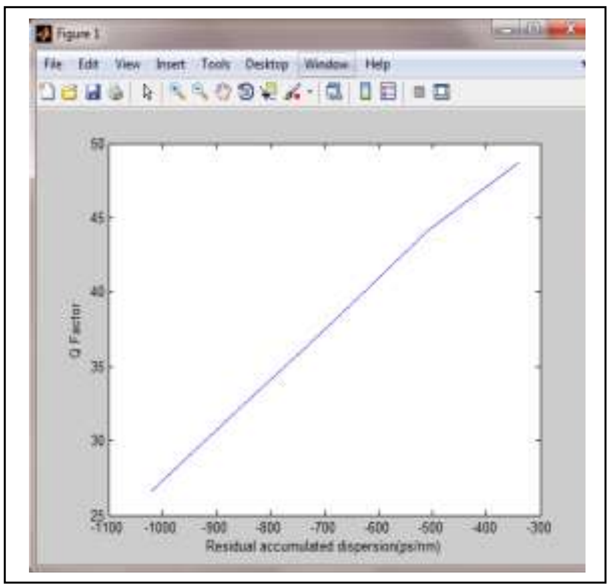

Figure 10: Q-factor and residual accumulated dispersion(ps/nm) for post-compensation

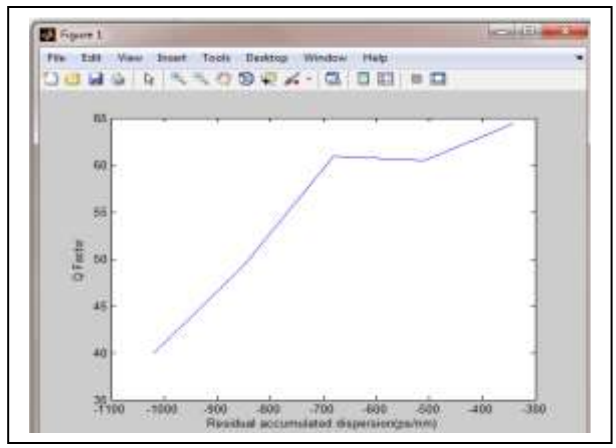

Figure 12: Q-factor in dB as a function of residual accumulated dispersion(ps/nm) for fiber dispersion component

C. Using Ideal Fiber Bragg Grating Component:

The studies reveal that FBG provides both positive and negative dispersion and has special features for reflection and transmission of light signals [7,8].

Here. a post compensation scheme using an ideal dispersion compensating fiber bragg grating is chosen. It minimizes chromatic dispersion while improving power output as well as given in figure 11.

In the similar way a graph is plotted for q-factor as a function of dispersion in figure 12. Figure 13 justifies the above statement.

(a) Power meter value with DCF

(b) Power meter value when FBG is used

Figure 13: Optical Power Meter Values

VI. RESULTS AND DISCUSSION:

Comparison of three techniques in order to reduce power fading:

With reference to the results of evaluating system performance on the basis of quality factor, it has been investigated that post-compensation gives better results than pre-compensation for different values of fiber lengths as shown in figure 14.

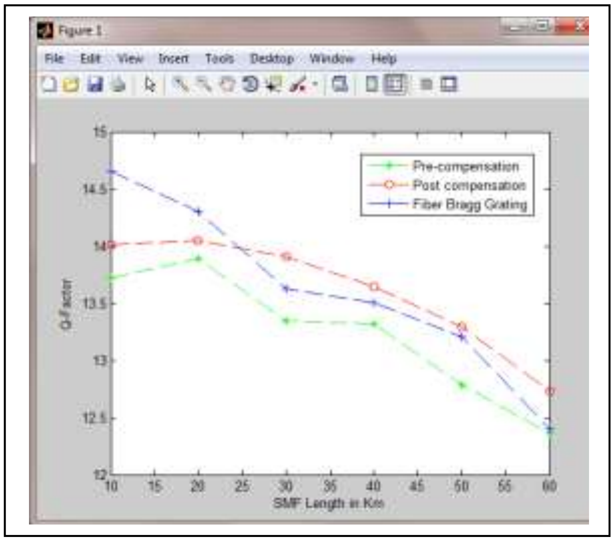

Figure 14: Q-factor in dB vs SMF length for different compensation techniques

Secondly RF received power is plotted against SMF length in figure 15. It is ascertained that RF received power for 10 GHz is less as compared to 20GHz and 40 GHz.

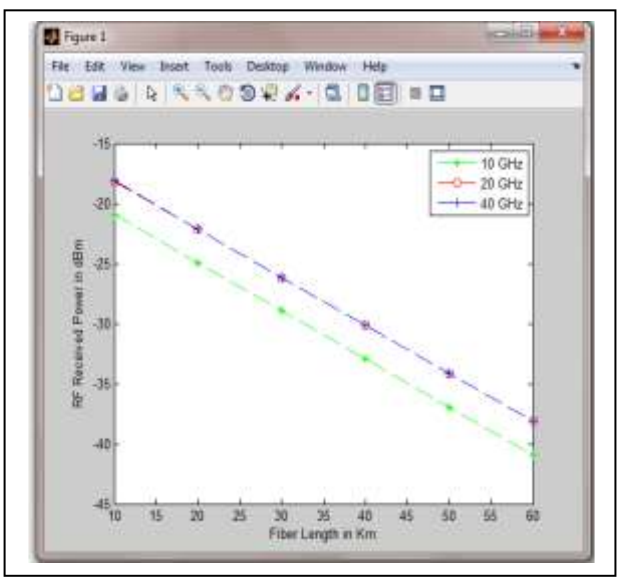

Figure 15: RF received power in dBm is plotted against SMF length in Km

EYE DIAGRAM COMPARISON:

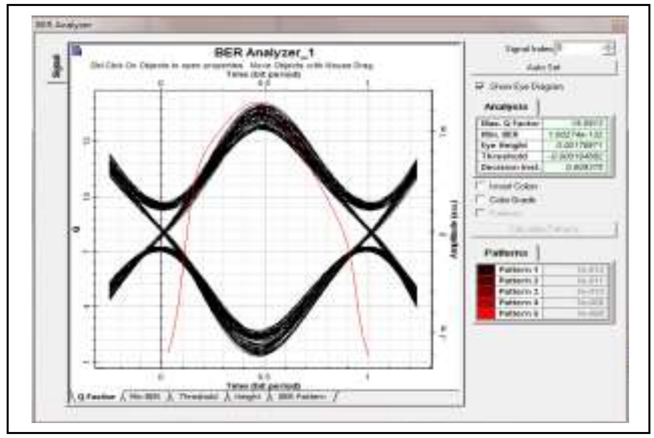

Figure 16: Q-factor for 10 GHz

Here, it is seen that the maximum Q-factor comes out to be 15.0913 for 10 GHz bandwidth. Now if the bandwidth is manipulated and changed to 20 GHz and the result is displayed in figure 17 where Q-Factor comes out to be 27.4368.

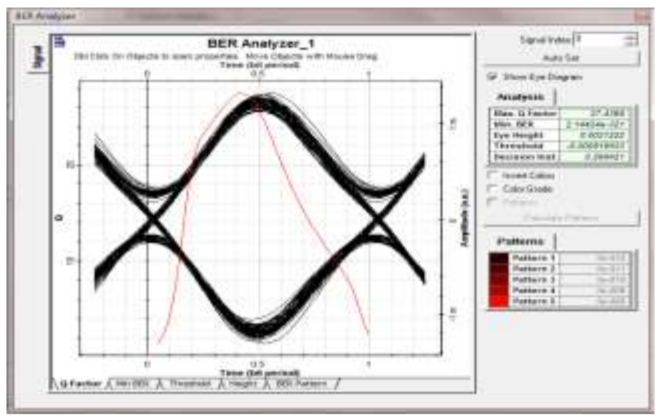

Figure 17: Q-factor for 20 GHz

But for 40 GHz the quality factor is reduced to 7.5109.

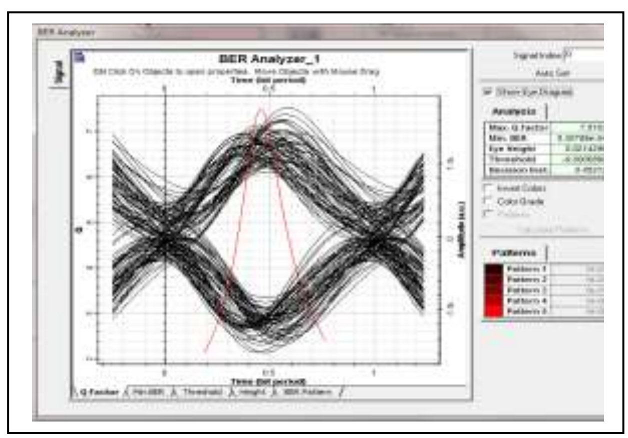

Figure 18: Q-factor for 40 GHz

VII. FUTURE SCOPE:

Radio Over Fiber systems are presently employed in Europe in metro stations to send signals by combining wireless and fiber technology. So, in order to cope up with the increasing demand of bandwidth in the near future, Radio over fiber technology incorporating these dispersion compensating techniques can prove to be an ultimate solution. Moreover it helps in combating the effect of chromatic dispersion to some level and improving the quality factor as well.

VIII. CONCLUSION:

Thus the work is basically focused on implementing differential phase shift keying in ROF systems. Secondly the overall performance of system can be improved by utilizing various dispersion compensation techniques and it is analyzed that post-compensation gives better results than pre-compensation when they are evaluated on the basis of quality factor. Also FBG Component acts as a dispersion compensating device and improves power as well.

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