PERFORMANCE ANALYSIS OF COST EFFECTIVE DISPERSION COMPENSATION JOINT MODULE IN ROF SYSTEMS.

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***Abstract* –** With the ever-increasing expansion as well as requirements for high capacity in internet based applications, high speed optical fiber communication has in recent times turn out to be a necessary part of information communications. The high speed augments the spectral employment which outcome into improved system capacity as well as reduces overall cost. Fiber optic reliant systems are used for the prolonged reach transmission systems. To release the full potential of optical systems as well as attain higher transmission capacity, numerous researches on dispersed managed systems have been reported. The objective of a fiber optic communication system is to send the maximum number of bits per second over the maximum possible distance with the lesser errors. This work proposes a high speed ROF system employing economical dispersion compensation module.

***Keywords* – optical fibre communication, radio over fibre system, dispersion, signal.**

I. INTRODUCTION

Optical fiber have brought a new era in the telecommunication field. The reason behind such success of the optical fiber is due to its various properties like low transmission loss, high optical damage threshold and low optical nonlinearity [1]. All of these properties complied has enabled to achieve long distance transmission of the signals. However, no matter how much the optical fiber are efficient, like all matters of technology they are also limited by the effects of dispersion. Dispersion leads to pulse broadening of the signals as they travel across the fiber leading to overlapping of the signal. This creates errors at the receiver output which is known as inter symbol interference (ISI) [2].The concept of Fibre Bragg Gratings was introduced in the 1980s and till now it is a widely used technique for compensating dispersion in optical fiber. It is a rather cost effective technique compared to the Dispersion Compensating Fiber. The efficiencies of both the techniques are to be seen separately as well as combined [3]. Moreover, the advance pulse shaping techniques are to be used as an effective way of maintaining dispersion.

The aim of this work is to do a complete analysis of the dispersion compensation techniques and find out the one which is the most effective. The parameters are studied to achieve efficient dispersion compensation scheme. Also, a comparative analysis will be done by changing the components used in the simulation optical model design and finding out what will be the parameter constraints. The idea is to use the dispersion compensation scheme in designs where the frequency spacing is very small. Moreover, advance pulse shaping methods will be seen to combat dispersion at high data rates.

II. BACKGROUND

Hu et al. (2010) demonstrates the use of dispersion compensating fiber. The schemes of pre-compensation, mix-compensation and post compensation are studied for the dispersion effect The simulation is done with the help of the OptiSystem software. Two factors such as the Q factor and the BER are analyzed. The non linear effects are reduced to an extent by the mix-compensation scheme. It is seen that effect of laser power is less in this scheme. The transmission code used here is the DPSK scheme. The transmission rate was kept at 40 Gbps using the WDM system. A moderate increase in the laser power leads to better BER improving the system response [4].

Arora et al. (2011) demonstrated the performance of optical fiber at high speed with the help of dispersion compensating module. The dispersion combat techniques used for the symmetrical configurations are the pre-compensation and the post compensation, which gives the optimum results. Here, a single channel is taken for test operating at a speed of 10 Gbps at the wavelength 1550 nm. The operating distance is 120 km and the compensating fibers are used for 24 km, 30 km and 35 km. The NRZ format is used here for the modulation. The software used is OptiSystem to evaluate the Q factor and BER [5].

Zhu et al. (2012) Radio over fibre (RoF) systems are simplified in terms of implementation and cost by the usage of a high frequency 40-60 GHz millimeter wave. However, the generation of such optical mm-waves is a limitation due to fibre chromatic dispersion. The use of dual Mach-Zehnder Modulator helps in overcoming the chromatic dispersion to some extent to generate optical carrier suppression However, the repetitive frequency of the optical mm-wave is only two times frequency of the local oscillator (LO) signal, it still requires expensive electrical equipments to generate 40–60 GHz mm wave. The paper's approach is to generate quadrupling frequency optical mm-wave by using a dual drive MZM. The phase difference in the two modulation arms of MZM is adjusted properly along with other parameters, to remove the optical carrier while the output signal contains two second order sidebands and modulation of data is done on one sideband only. This helps in exclusion of time shifts of the codes due to chromatic dispersion and the second order sidebands (as they are not carrying any information) carries the upstream data of duplex RoF system. Simulation of the approach is done on the OptiSystem software where the eye diagram is analyzed and the parameters are compared to check the effect of chromatic dispersion on the generation of the 40 GHz mm wave. The repetitive frequency of the RF signal is reduced and use of one dual drive MZM is included. Comparative analysis with the conventional method of generation of quadrupling frequency mm-wave (OCS- optical carrier suppressed) is done and results show that the effect of chromatic dispersion is less in the later case [6].

Mori et al. (2013) presented that modal dispersion is compensated with the help of adaptive equalization in multimode fibres. Enlarging the effective area (A_{eff}) of optical fibres is a practical way of reducing nonlinearity and increasing the fibre fuse threshold power. Increasing the effective area leads to difficulties in maintaining the single mode operation and bending loss tends to increase. Modal dispersion, as the name suggests, creates more trouble in multimode fibres. There are two ideas to curb modal dispersion. The first method suggests a signal light which is launched into the centre of the core of a multimode fibre to prevent the occurrence of the higher order mode (HOM). The second idea is to filter the mode which will remove the HOM in the receiver side by using a modal filter. Directly using a digital signal processor with an electric adaptive equalizer degrades the signal at the receiver side. Here, a digital coherent receiver with an adaptive multi mode fibre for curbing modal dispersion is used. Also, the quality of transmitted signal compensation in the case of mode conversions created by axial deviations is studied. Experimental studies shown over here the realization of signal travelling till 20 km uncompensated even when axial deviations occur. The experimental set up consists of introducing an adaptive filter adjusted to an adaptive algorithm prior to the receiver at the end of the multimode fibre. The higher order modes are first excited with the help of mode excitation unit so that modal dispersion occurs. The signal travelling from the end of a single mode fibre is coupled into a GI MMF based on the standard ITU-T G.651. Numerical aperture, focal length of the lens is predefined. Mapping of the SMF to the MMF is done in the mode excitation unit. The signal is degraded by introducing modal dispersion to check the performance of the digital coherent receiver. The received signal is combined by the light from a continuous wave local oscillator in a 90 degree optical hybrid. The polarization is adjusted in a way so that optical power of the signal at the output of optical hybrid is maximum. The decision directed detector is used to compensate the noise. A digital filter with the taps of the symbol space to reduce the tap number is used. Thus, digital signal processing to recover a signal distorted by MPI in an MMF transmission is used [7].

Choudhary et al. (2014) the DWDM technique is analyzed here. It is an effective technique for faster data rates and has such has become a key player in optical communication. However, when the data rate is less than 10 Gbps per channel than dispersion and non linearity creeps into the system degrading the performance of the system. Therefore, methods are required to alleviate such effects. The dispersion compensating technique used over here is dispersion compensating fibre. Positive dispersion is counteracted by negative dispersion effect. Different modulation formats are used to find the system performance for long distance preferably in the range of 1500 km. 16 channels of DWDM are analysed in a comparative manner to find out the best modulation format out of (NRZ, Carrier suppressed return-to-zero, Duo binary return-to-zero and Modified duo binary return-to-zero) and compensation schemes (Pre, Post and Mix compensation) at different bit rates (10Gbps, 20Gbps and 40Gbps) with standard and dispersion compensated fibre on the basis of Q-factor, eye-diagram and bit error rate for fixed gain EDFA and length for both types of fibre. The software used over here for the simulation model is OptiSystem software. From the simulation results for the different modulation formats, it has been found that MDRZ modulation shows a relatively faithful performance for long distance communication [8].

Hessainiaa et al. (2014) discussed the effect of different taper profiles on dispersion slope compensation in optical fibre links. FBGs are the spectral filters which are based on the principle of Bragg wavelength of different apodization factors of the chirped FBGs have been studied to check their effects on high speed systems. Importance is bestowed on the tapered FBGs under strain or stress. Results indicate that linearly tapered FBGs display nonlinear group delay under strain, which means that the linearly tapered FBGs can be used in dispersion slope compensation. This paper aims to numerically computate the dispersion and dispersion slope cancellation characteristics of two types of tapered FBGs having exponential–linear and parabolic profiles. The numerical analysis is done on Matlab and it is seen that apodization factors optimize reflection spectra and also diminishes the ripples and side lobes. This further helps to prevent cross talk in the channels and as a result, can be used in the WDM systems. Linear tapered FBG shows a better performance [9].

Nazmi A. Mohamad et al. (2014) proposed a system by using standard values for single channel and equipment to investigate the pulse pulse width reduction performance of some dispersion compensation methods. The results revealed that among the three different chirping profiles of FBG, linear chirping provided best results. The investigation showed that the length of the grating should be optimized to provide assurance of acceptable pulse width reduction behavior. The DCF technique yields a good dispersion compensation unit, but it was costly for the standard link in the system under examination. The DCF, together with the optimized linearly chirped tanh FBG, achieves remarkable dispersion compensation [10].

III. PROPOSED TECHNIQUE

This section describes research methodology used to implement proposed technique. First and foremost, a timeline literature survey will be done for better understanding of dispersion compensation and Radio over fiber communication systems. Also it enables to identify the concept more accurately. The second step will be designing and simulation of the Raio over fiber system with DCF and FBG. After this more work will be done on the system for better results. This will be done by using Optisystem software. Firstly the study about software will be done.

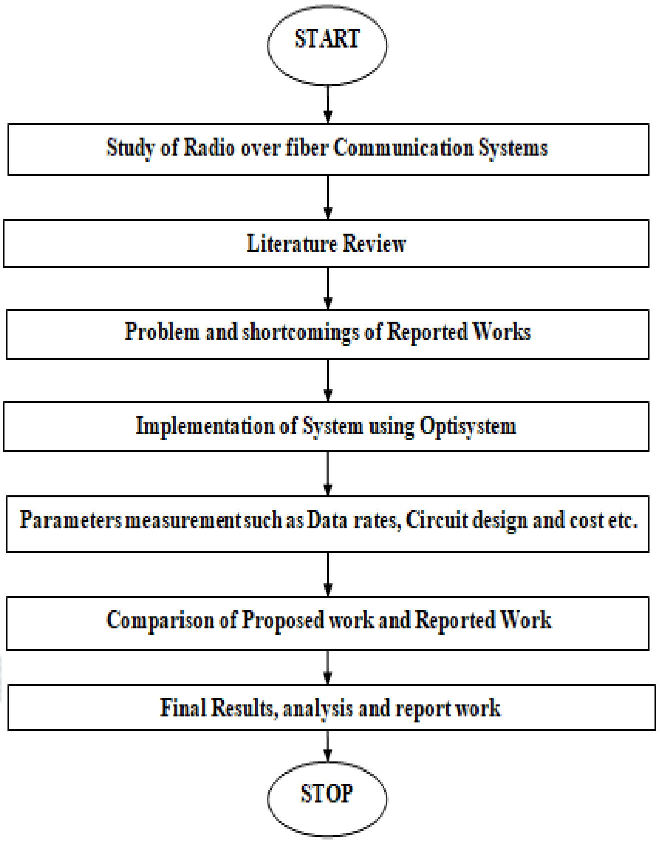

Figure 1: Flowchart of Proposed Technique

IV. EXPERIMENTAL RESULTS

Investigation of proposed radio over fiber system is carried out for different signal detection cases such as FBG+DCF+PIN module, FBG+DCF+APD module, only PIN without any dispersion compensation, and only APD without any compensation. Main goal of this analysis is to find optimal receiver arrangement for radio over fiber systems. FBG and DCF joint module is realized as explained in chapter 4. First and foremost, optical spectrum of carrier signal is analyzed. It represents the carrier signal and also power at the signal. Center frequency/wavelength in this work is 1553.8 nm as depicted in Figure 2 CW laser is a component which provides carrier signal and power is set to 0 dBm.

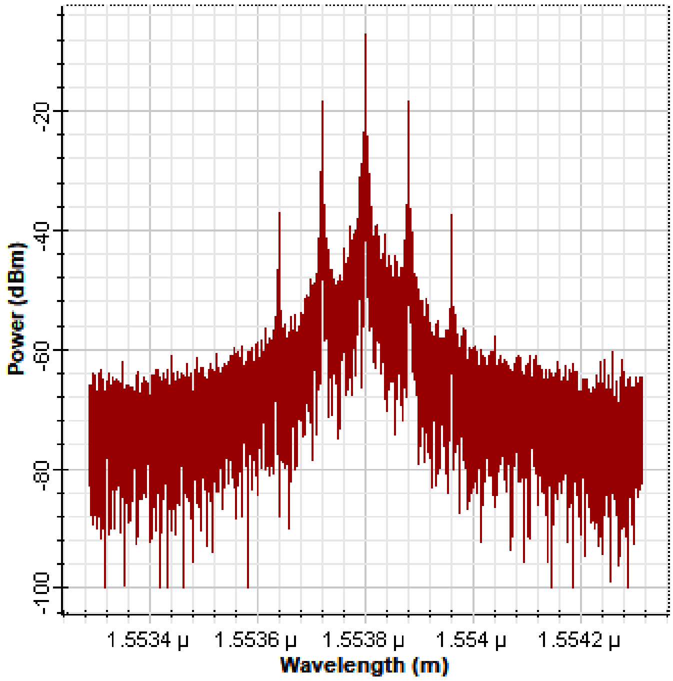

Figure 2: Representation of optical spectrum of carrier signal

Carrier is surrounded by some other low power carriers which are due to radio signal sine generator frequency. These are basically sidebands of the carrier signal.

Figure 3 depicts the optical time domain visualizer's and output diagram which provide us time slot of each bit and also amplitude of bits. This OTDV is essential to check time period of the pulse and it is also evident that transmitted pulse is 0.05 ns. Also in the depiction, radio signal is shown on the OTDV with time in seconds and power in watts. Time is considered upto 3 ns for the better representation.

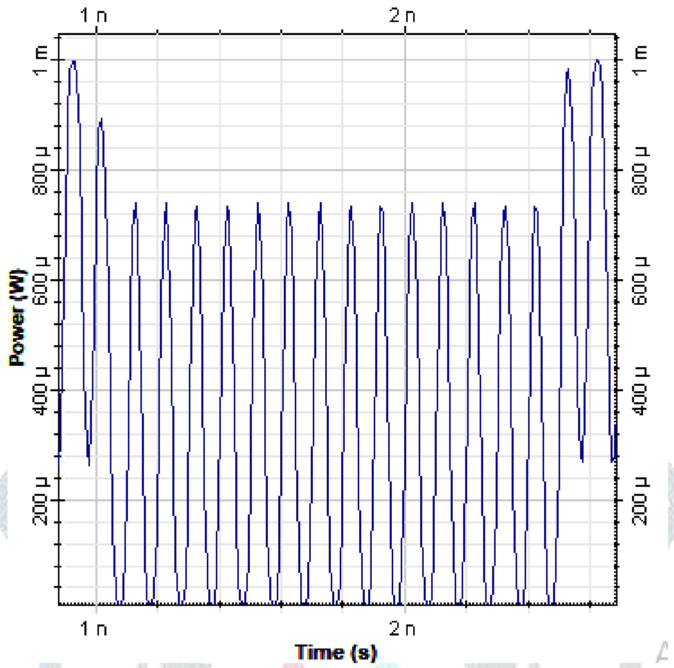

Figure 3: Optical time domain visualizer's output

Further system is analyzed for diverse launched power levels and results of all the 4 different reception techniques are investigated. Input power is varied from laser from 0 dBm to 4 dBm with the difference of 1 dBm. Distance of the optical fiber is fixed to100 km and all the linear as well as nonlinear factors are considered. Results are evaluated in terms of Q factor as well as BER for all the cases. It is evident from the Figure 4 that as the power coupling increases into fiber, more Q factor of the signal is received in all cases. But it is noteworthy that system having dispersion compensation module, performs better than without dispersion compensation systems. Moreover it is also perceived that in proposed system of ROF, joint dispersion compensation module of linearly chirped FBG and dispersion compensation fiber with PIN photo-detector provide best Q factor over all power levels. Also, it is also important to note that for dispersion compensation of 100 km signal which travel and through optical fiber, requires 20 km DCF according to the equation (4). However, joint module which consists of linearly chirped FBG and DCF requires less DCF fiber for the optimal dispersion compensation. By changing the values of DCF in joint module, provide us a value of 17.1 km for best dispersion compensation and Q factor. Thus we have saved 2.9 km DCF fiber and in turn save 8.7$. PIN photodetector is also cheaper than the APD photodetector and thus joint module with PIN is a economical and efficient module for proposed ROF system. Performance FBG+DCF+PIN is followed by other module FBG+DCF+APD at varied power levels. Least Q factor is emerged in case of APD detection alone without any dispersion compensation. Values of Q factor at varied power levels are given in Table 1.

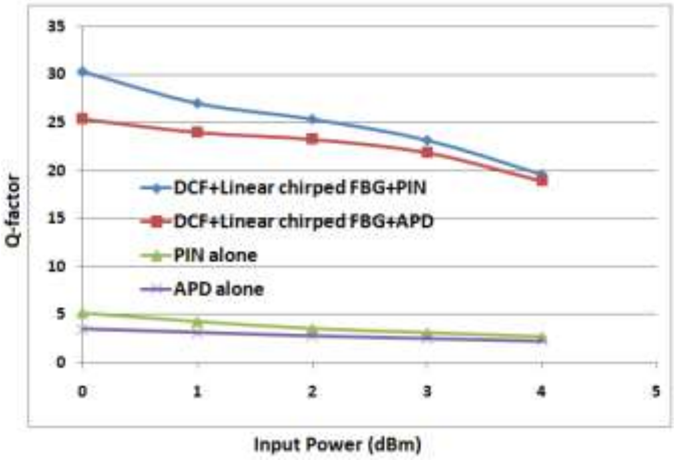

Figure 4: Input power versus Q factor of different cases in ROF system

Moreover system is analyzed again for diverse launched power levels for different reception techniques. Input power is varied from laser from 0 dBm to 4 dBm with the difference of 1 dBm. Distance of the optical fiber is fixed to100 km and all the linear as well as nonlinear factors are considered. Results are evaluated in terms of Log BER for all the cases. It is evident from the Figure 5 that as the power coupling increases into fiber, less Log BER of the signal is received in all cases. But it is perceived that system having dispersion compensation module, performs better than without dispersion compensation systems. Moreover it is also perceived that in proposed system of ROF, joint dispersion compensation module of linearly chirped FBG and dispersion compensation fiber with PIN photo-detector provide enhanced BER over all power levels. Also, it is also important to note that for dispersion compensation of 100 km signal which travel and through optical fiber, requires 20 km DCF according to the equation (4). However, joint module which consists of linearly chirped FBG and DCF requires less DCF fiber for the optimal dispersion compensation.
Performance of FBG+DCF+PIN in terms of Log BER is best and is followed by other module FBG+DCF+APD at varied power levels. Highest Log BER is observed in case of APD detection without any dispersion compensation. Values of Log BER at varied power levels are given in Table 2. Values are given at each power levels and it is also observed from Table 2 that APD is worst performing and joint dispersion compensation mule with PIN photodetector is best performing.

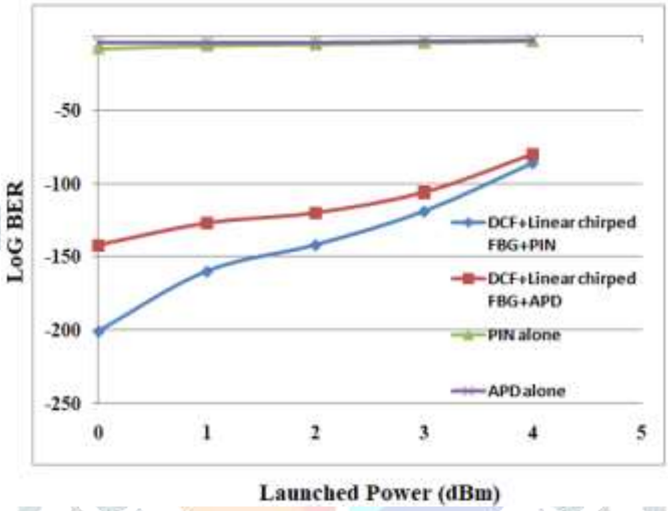

Figure 5: Input power versus Log BER of different cases in ROF system

Table 1: Values of Q factor at varied power levels

Input Power (dBm)	DCF+Linear chirped FBG+PIN	DCF+Linear chirped FBG+APD	PIN alone	APD alone
0	30.27	25.36	5.24	3.51
1	26.98	23.98	4.34	3.16
2	25.33	23.26	3.6	2.81
3	23.14	21.89	3.16	2.56
4	19.58	18.96	2.73	2.29

Table 2: Values of Log BER at varied power levels

Input Power (dBm)	DCF+Linear chirped FBG+PIN	DCF+Linear chirped FBG+APD	PIN alone	APD alone

0	-201	-142	-8	-4
1	-160	-127	-6	-4
2	-142	-120	-5	-4
3	-119	-106	-4	-3
4	-86	-80	-3	-2

V. CONCLUSION

In this work, a cost effective dispersion compensation scheme is demonstrated by utilizing a linear chirped fiber bragg gratings with combination of dispersion compensation fiber in radio over fiber system at 20 Gbps data rate over 100 km optical fiber. Four diverse cases are studied such as FBG+DCF+PIN module, FBG+DCF+APD module, only PIN without any dispersion compensation, and only APD without any compensation. Main goal of this analysis is to find optimal receiver arrangement for radio over fiber systems. Results are investigated on different power levels and evaluated in terms of Q factor and Log BER. It is noteworthy that system having dispersion compensation module, performs better than without dispersion compensation systems. Moreover it is also perceived that in proposed system of ROF, joint dispersion compensation module of linearly chirped FBG and dispersion compensation fiber with PIN photo-detector provide best performance. Also, it is also important to note that for dispersion compensation of 100 km signal which travel and through optical fiber, requires 20 km DCF in conventional systems. However, joint module which consists of linearly chirped FBG and DCF requires less DCF fiber for the optimal dispersion compensation. By changing the values of DCF in joint module, provide us a value of 17.1 km for best dispersion compensation and Q factor. Thus we have saved 2.9 km DCF fiber and in turn save 8.7$. PIN photodetector is also cheaper than the APD photodetector and thus joint module with PIN is a economical and efficient module for proposed ROF system. This work limited to the single channel only. Further work can be done on the multiple ROF channels. Use of Broadband amplifier like HOA can be used for the further analysis of this system for C+L band to effect of amplification and dispersion.

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