International Journal of Advance Research in Science and Engineering
Volume No.06, Issue No. 10, October 2017
www.ijarse.com
IJARSE
ISSN: 2319-8354

Orthogonal Frequency Division Multiplexed Optical Systems at Different Data Rates

Simranjit Kaur, Mr.Vishal Walia

[1]*M.Tech (ECE),Rayat Institute of Engineering and Information Technology, Railmajra, Punjab (India)*

[2]*Associate Professor, Rayat Institute of Engineering and Information Technology, Railmajra, Punjab(144533)*

ABSTRACT

It is useful to improve the performance of optical communication system if we implement Quadrature Amplitude Modulation with Orthogonal Frequency Division Multiplexing in optical communication. Optisystem software version 13 offered by optiwave is used to simulate the components of the system.The system was for a transmission distance of 50 km over standard single mode fiber.System performance is analysed in terms of dispersion,Bit error rate,Q Factor. Dispersion compensation schemes like pre-compensation,post-compensation and symmetric compensation to compensate the dispersion in optical fiber. The impact of non-linear effects is also studied in optical fiber's performance.Different types of fibres like LEAF, TWRS and NDSF are employed to implement QAM-OFDM system at different data rates of 10 Gbps, 20 Gbps, 40 Gbps, 40 Gbps, 60 Gbps and 100 Gbps.

Keywords: OFDM,QAM,LEAF,NDSF,TWRS,Q Factor.

I. INTRODUCTION

Orthogonal Division Multiplexing(OFDM) is gaining importance in optical communications as a major technology because of its flexibility and robustness.Optical OFDM provides robustness against chromatic dispersion and polarization mode dispersion[1][3].

Now need for greater bit rate for high speed transfer of data is increasing in communication systems. OFDM is emerging as new trend to work at high data rates of 100 Gbps in optical systems[5]. Optical fibres have greater capacity and immunity to cross-talk .In this thesis, we have demonstrated the implementation of Quadrature Amplitude Modulation(QAM) with Orthogonal Division Multiplexing(OFDM) at data rates of 10,20,40,60 and 100 Gbps. In modern communication systems, QAM systems are used to get maximum throughput with limited bandwidth requirements. Thus QAM systems are prominent mean to increase the spectral efficiency in optical communication systems[4].

To simulate the components of QAM-OFDM system we have used optiwave software developed by optiwave. We evaluated the optical signal sent over the system. The communication system employed a fiber of length of 50 km and signal is transmitted in 20 loops and hence a distance of 1000 km is covered. The performance of the system is checked by changing CW laser's input power.Q-factor value is observed to check the reliability of the system.

Firstly analysis of system is done at different data rates. The dispersion compensation schemes like pre compensation,post compensation and symmetric compensation are employed to compensate dispersion in optical fibre at different data rates.

Different types of fibre like Long Effective Area Fibre(LEAF) ,Non Dispersioin Shifted Fibre(NDSF),True Wave Reduced Slope Fibre(TWRS) are used to examine the performance of the system.The comparison between the performance of different types of fibre is made at different data rates of 10.20,40,60 and 100 Gbps.It is observed that LEAF fiber gives better performance over all fibres.

QAM

Quadrature amplitude modulation QAM can be both analog and digital modulation scheme. In QAM,the two carrier waves with same frequency 90° out of phase from each other and are named as quadrature carriers.The one carrier is known as I signal and other is known as Q signal. The modulated waves are added and the resultant end waveform is a combination of amplitude phase shift keying (ASK) and phase shift keying (PSK) . A straight amplitude modulated signal is a motivation for utilization of QAM because with suppressed carrier double sideband gives twice the bandwidth of modulating signal[6]. With QAM, likelihood of occurrence of errors is reduced because constellation diagrams are optimized to achieve greatest distance between elements, hence reducing the mixing of one element with another.QAM is communication systems due to its bandwidth conserving abilities[2]. High spectral efficiencies can be achieved with QAM.

The I and Q signals can be represented as:

$I = Acos(\varphi)$ and $Q = Bcos(\varphi)$

I and Q components are represented by sine and cosine waves.

4 QAM is M-ary scheme with M=2^L .L is number of levels in each of I and Q channels. For QAM,M=4 and L=2.

QAM is used in optical communications to operate at high data rates

OFDM

There has been rapid increase in need for high speed communications.High speeds upto 100 Gbps can be provided by optical networks.OFDM has emerged as most attractive technique in optical communication to work at high data rates and combat the dispersion effects in optical fiber.OFDM utilizes multiple carrier signals at distinct frequencies and transmits some of bits on each channel.Single stream of data can be transmitted over lower rate orthogonal subcarriers[4].Due to elimination of ISI and reduction in fading,OFDM is the most prominent technique used in optical communication.

Due to orthogonality among subcarriers,interference between adjacent subcarriers is minimu and hence can be packed tightly.Also.multiplexing and modulation processes are combined in OFDM.Multiplexing is a process in which bandwidth of a communication link is subdivided into number of channels of distinct frequencies,each occupying a signal at same time.On other hand,modulation is a process of adding information to optical carrier signal.Information can be added by changing its phase,frequency ,amplitude and polarization.Each subcarrier’s peak of power spectral density occurs at a point where other subcarrier’s power is zero.Subcarriers are sine and cosine waves.Let a and b be frequencies of sine and cosine waves respectively.

Where ‘a’ and ‘b’ are integers .Hence area under them will be be:

$$F(t) = sina\omega t * sinb\omega t$$

IJARSE
ISSN: 2319-8354

We would get if multiply sine wave with its different harmonic.

Division of bandwidth into number of subcarriers is main idea behind OFDM.All subcarriers must be orthogonal to each other.The condition to make subcarriers orthogonal is that frequency separation between subcarriers must be 1/R Hz,where R= signal interval duration.Transmission speed is increased by OFDM over optical fiber networks.

OFDM system has ability to combat the problem of Intersymbol Interference(ISI).On higher data rates,ISI has more effect because distance between symbol is less.But with OFDM data rate is reduced due to division into subcarriers and hence symbol increases.OFDM provides the excellent protection against impulsive parasitic noise and co-channel interference and provides high speed communication.

II. SIMULATION MODEL

Figure 1 shows the simulation model for direct-detection QAM –OFDM system designed to analyse the performance in terms of BER, Q factor (dB) .Different fibers are used to examine the system performance.

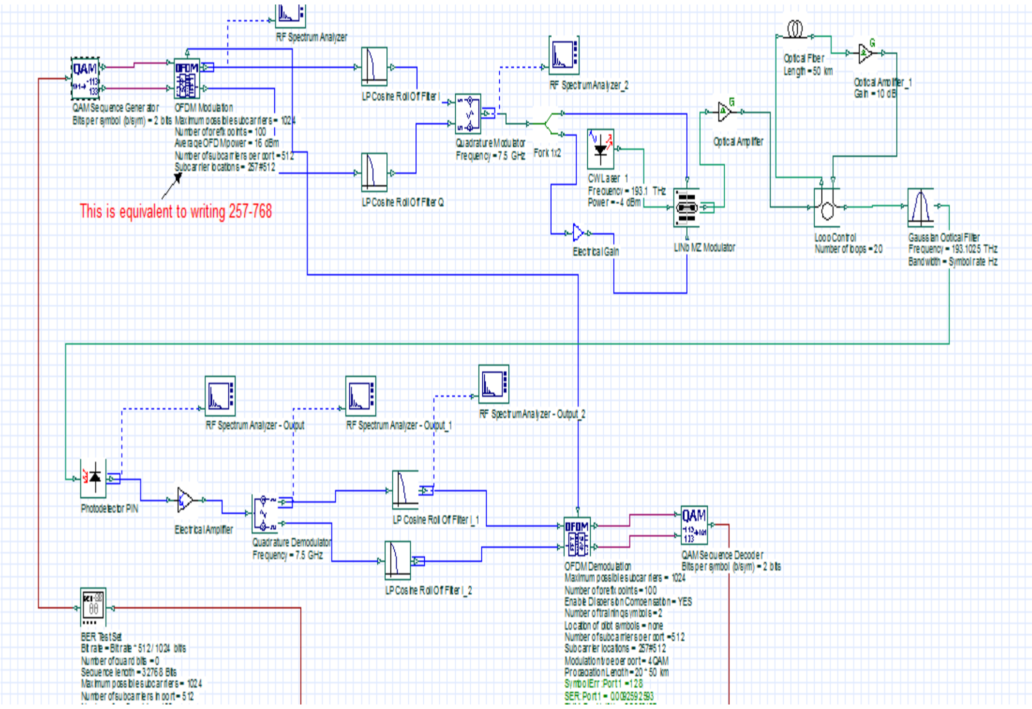

fig:2(a) Simulation Set Up for Direct-Detection Optical-OFDM System implementation with QAM

The transmitter section consists of QAM generator,OFDM modulator and quadrature modulator. In the simulation model of an QAM-OFDM system, the Mach–Zehnder modulator (MZM) is used to convert electrical signals to optical signals. At the receiverside, of a PIN photodiode is used to convert optical signals into electrical signals.

Receiver section consists of QAM sequence detector and OFDM demodulator.

III. PERFORMANCE ANALYSIS of OFDM SYSTEM

The system performance is analysed in terms of Q- Factor at different data rates of 10 Gbps, 20 Gbps,40 Gbps and 60 Gbps. Dispersion compensation is also done using pre,post and symmetric compensation techniques at different data rates to eliminate effects of dispersion.The system performance is also evaluated without considering impact of nonlinear effects and it is observed that Bit error rate is reduced and hence system performs better.

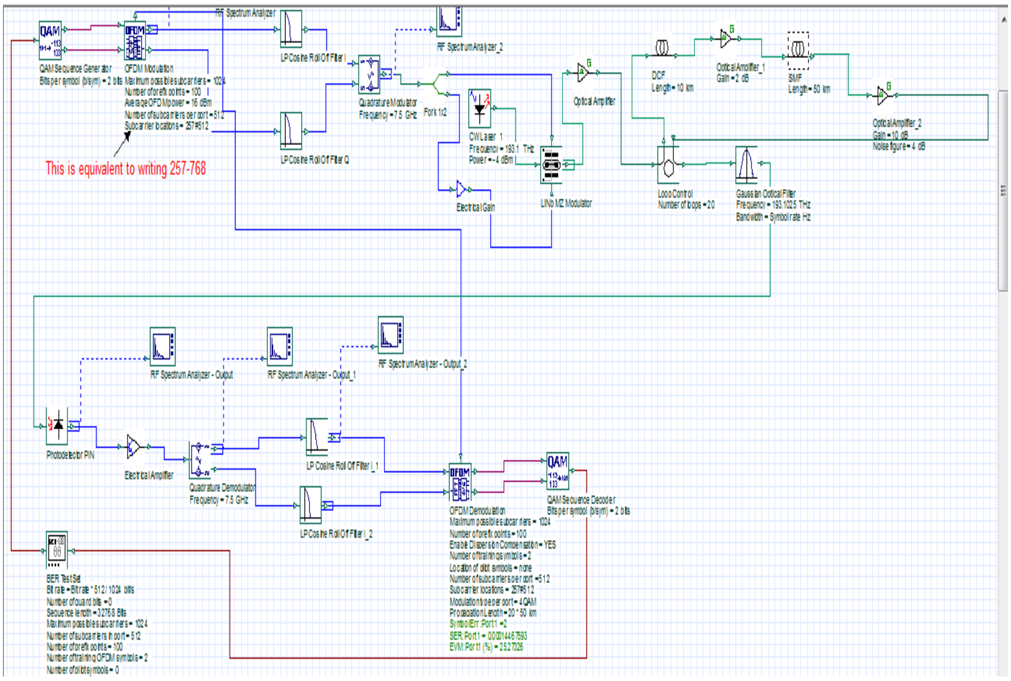

fig.3(a):Implementation of Pre-Compensation

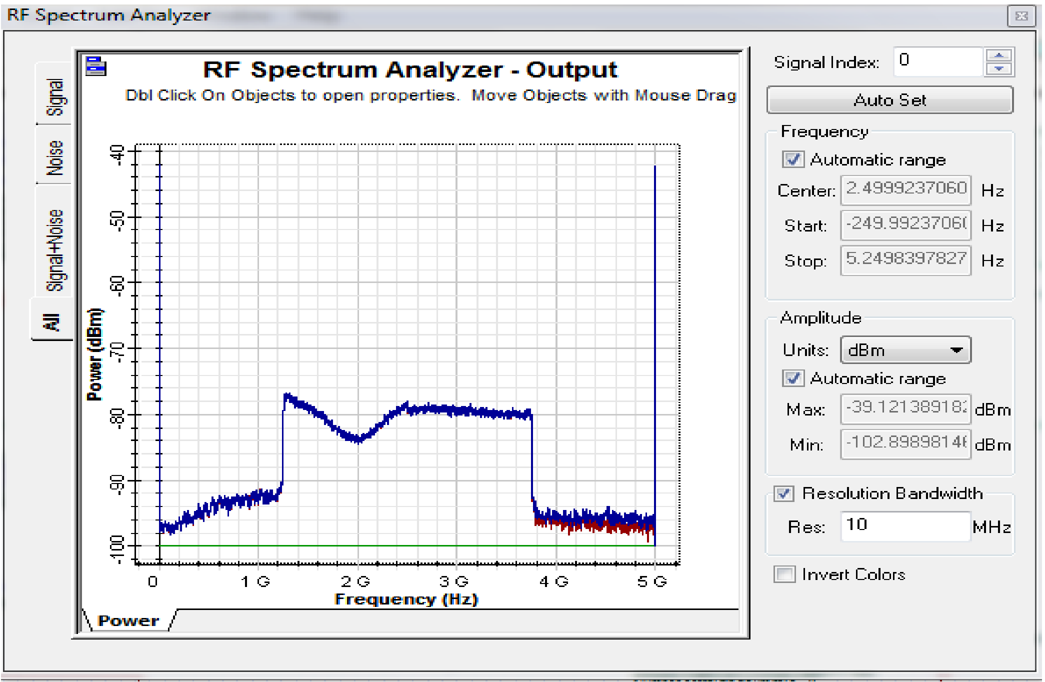

fig.3(b):RF spectrum analyzer

IV. PERFORMANCE ANALYSIS WITH DIFFERENT FIBER TYPES

SMF's can be of different types like LEAF(Long Effective Area Fiber),NDSF (Non Dispersion Shifted Fiber)and TWRS (True Wave Reduced Slope Fiber)and all these differ from each other in optical propagation characteristics and hence their performance is demonstrated on OFDM-QAM system.TWRS and LEAF fibres have smaller value of dispersion parameters than the NDSF fiber and hence provides better performance.

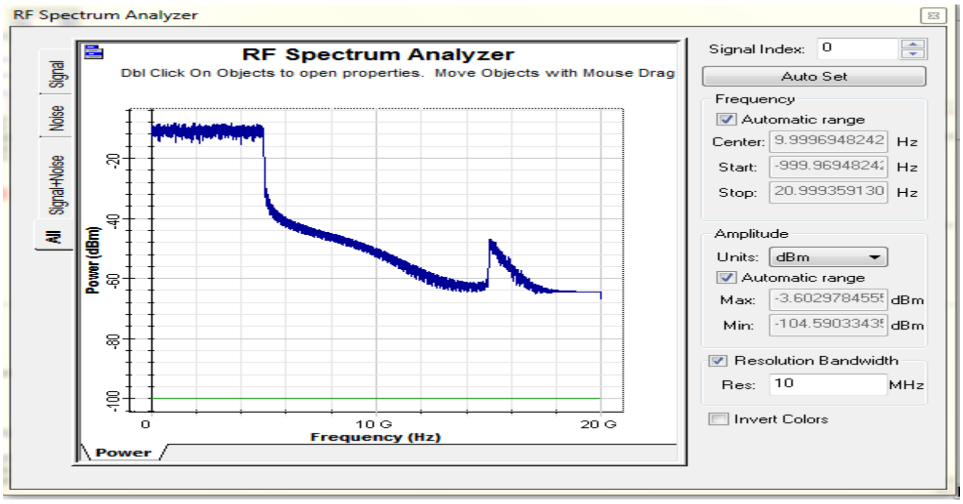

fig.:4(a):RF spectrum analyzer

V. SIMULATION SET UP

The parameters for different types of fibers are shown below.

Fiber	LEAF	NDSF	TWRS
Length	100 Km	100 Km	100 Km
Effective area	72.5 μm2	80 μm2	55 μm2
Dispersion parameter	7.68 ps/km /nm	17.0 ps/km /nm	4.24 ps/km/ nm
Dispersion slope	0.082 ps/km nm	0.07 ps/km nm	0.05 ps/km/ nm
loss	0.21 dB/km	0.20 dB/km	0.21 dB/km

Table4(a): simulation set up parameters for different types of fibre

The bit rates used are 10 Gbps,20 Gbps,40 Gbps and 60 Gbps.The length of SMF is 50 Km and number of loops is 20 and hence distance covered is 1000 Km.The length of DCF is 10 Km .Dispersion parameter for SMF and DCF is 16.75 and -83.7 respectively.The affective area of SMF and DCF 80 um^2und 30 um^2.

PARAMETRES	VALUES
Length of SMF	50 km
Length of DCF	10 km
Dispersion of SMF	16.75 ps/(km.nm)
Dispersion of DCF	-83.7ps(km.nm)
Affective area of SMF	80 um^2
Affective area of DCF	30 um^2
Gain of line EDFA after SMF	10 dB
Gain of line EDFA after DCF	2 dB
Noise figure	4 dB

Table 4(b) OFDM system parametres

VI.RESULT

We have implemented QAM in combination with OFDM technique at different data rates.QAM system have advantage of bandwidth convergence.here we have taken symbol rate equal to half of the bit rate.We have implemented different dispersion compensation schemes at data rates of 10 Gbps,20 Gbps,40 Gbps and 60 Gbps.Different fibres are used on the optical link like TWRS ,NDSF and LEAF at multiple data rates to observe the system performance.The graphs for dispersion compensation and different fibers are shown:

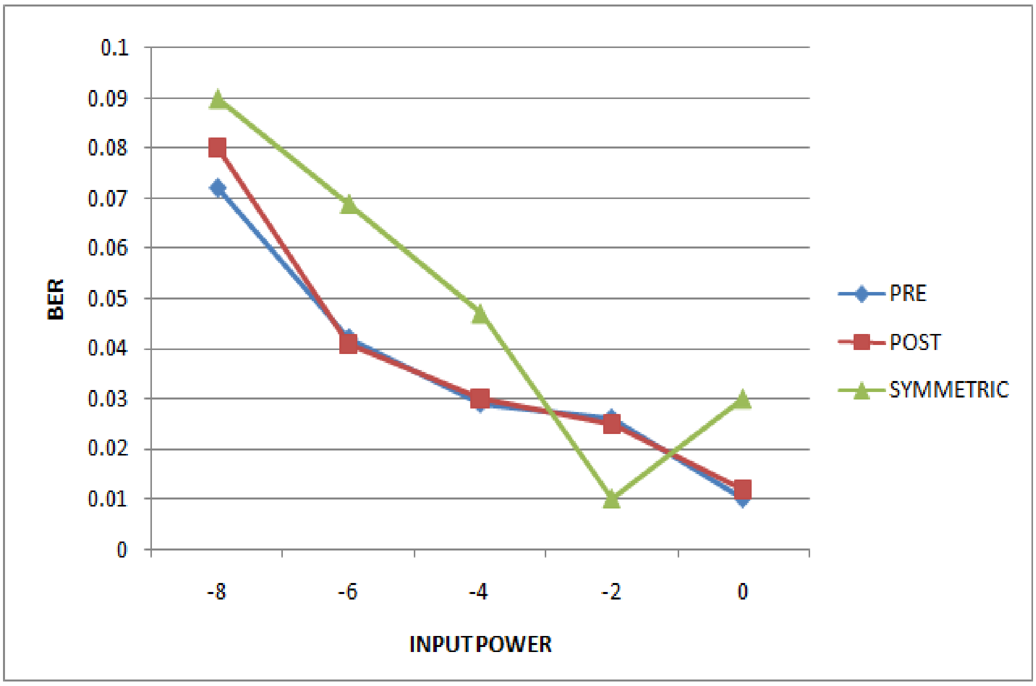

fig.5(a) Dispersion compensation

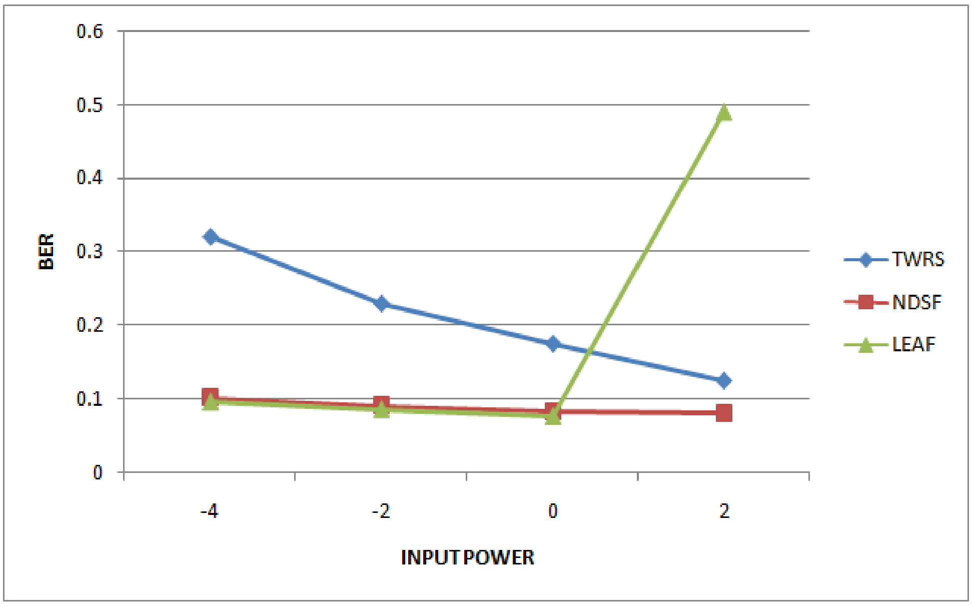

fig. 5(b) Different fiber types

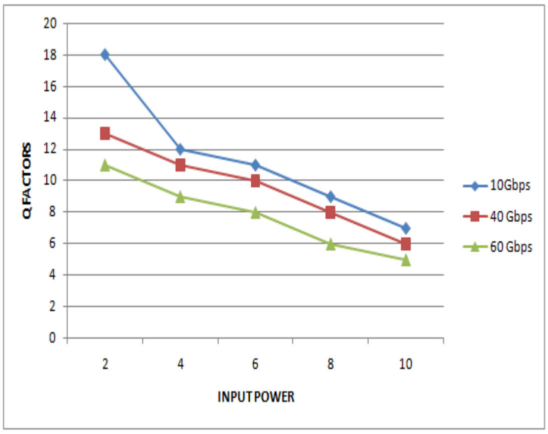

fig.5(c) Q factor analysis at different data rates

VII. CONCLUSION

In this paper we have discussed QAM implementation with OFDM scheme and also with dispersion compensation techniques like pre,post and symmetric compensation at different data rates.Theoptical signal sent over the fiber is analyzed by changing the input power values.

QAM implementation with OFDM provides better performance at low input power.The signal is sent over a 50 Km single mode fiber in 20 loops and hence distance of 1000 Km is covered.The bit error rate goes on increasing as the input power increases. This increase in bit error rate is due to the fact that nonlinear effects increase as the power increases.Then sytem is also evaluated without considering nonlinear effects and lower bit rate values are obtained measns system reliability increases slightly.Different fibers like LEAF,NDSF and TWRS are employed at different data rates.LEAF and TWRS have smaller value of dispersion parameter than the NDSF and hence provides better performance that means lower values of BER are obtained in case of LEAF and NDSF fibres than NDSF.

REFERENCES

Journal Papers:

[1] Maninder Singh,M.L.Singh .A novel algorithm to integrate synchronous digital hierarchy networks into Optical Transport Network using mixed line rates, . Optik-International Journal for Light and ElectronOptics, 125(22):6739{6745, 2014.

[2] Lei Deng_; Xiaodan Pang_; _; Ming Tang_, "Experimental Demonstration of Nonlinearity and Phase Noise Tolerant 16-QAM OFDM W-Band (75–110 GHz) Signal Over Fiber System(2014)",in Journal of Lightwave Technology, 32(8), pp1442 } 1448, April15, 2014.

[3]M.Singh.M.L.Singh and S.Luengar.Routing multiple services in optical transport network environment using mixed line rates,In Advances in Computing ,Communications and informatics(ICACCI,2014 International Conference on pages 44{49 sept,2014.

IJARSE
ISSN: 2319-8354

[4 John V. Badding ; Pier J.A. Sazio ; Venkatraman Gopalan " Integration of optical fiber and optoelectronic devices", in Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC), 2013.

[5] K. Roberts et al., "100G and beyond with digital coherent signal processing," IEEE Commun. Mag. pp62–69.(2010).

Books:

[6] G. P. Agrawal, Nonlinear Fibre Optics, 2nd ed. New York: Academic,1995.