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Implementation of Improved Coherent OFDM System Using Digital Signal Processing

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Abstract— The Coherent detection is one of the active research areas for the development of high speed, high spectral efficient optical communication network. Digital signal processing (DSP) is the important technique for compensating the fiber transmission impairments because of number of advantages such as signal can be amplified, delayed, splitted and manipulated without degrading the signal quality. In this paper we developed of Improved Coherent OFDM System Using Digital Signal Processing. The performance parameters like EVM, Symbol Error Rate, Constellation diagram, Q factor etc. The experiment work is done on OptiSystem software & DSP unit for the Coherent optical OFDM system is it observed that for 4 QAM modulation EVM is ~8.81 % and it is reduced ~7.25% in-case of DSP SER and BER reduce from~ 9.3E-11 to ~ 7.58E-11 and ~ 3.07E-11~ 3.03 E-11 respectively whereas the Q factor & output SNR increase form ~ 26 dB to ~ 45dB and from ~ 137.84dB to ~ 190.18 dB respectively. For 16 QAM modulation EVM is ~6.93 % and it is reduced ~ 6.31% in-case of DSP SER and BER reduce from ~ -0.141 to ~ -0.0986 and ~ -0.394 to QAM ~ -0.566 respectively whereas the Q factor & output SNR increase form ~ 0.0894 dB to ~ 0.191 dB and from ~ 209.58 dB to ~ 250.469 dB respectively. For 64 QAM modulation EVM is ~ 16.1% and it trim down ~9.8% in-case of DSP SER and BER decrease from ~ -0.078to ~ -0.079 and ~ 0.315 to ~ 0.316 respectively whereas the Q factor & output SNR increase form ~ - 0.069 dB to ~ 1dB and from ~ 36.21 dB dB to ~ 103.7 dB respectively.

Keywords— OFDM, Coherent, DSP, EVM, BER, Q factor, SER

I. INTRODUCTION

Coherent detection employing multilevel modulation format has become one of the most promising technologies for next generation high-speed transmission system due to the high power and spectral efficiencies [1-3]. With the powerful DSP, coherent optical receivers allow the significant equalization of chromatic dispersion (CD), polarization mode dispersion (PMD), phase noise (PN) and nonlinear effects in the electrical domain[4]. Single-mode fibers support the transmission of two polarization-modes that are orthogonal to each other. Thus change in the states-of-polarization is also responsible of distortion because temperature fluctuations and random birefringence due to mechanical stress cause the (SOP) and, therefore, the group velocity to vary with time and across the full length of the fiber [5-6].The nonlinear impairments are self phase modulation (SPM) and stimulated Brillouin scattering (SBS)The symbiotic combination of Digital Signal Processing, coherent detection, and spectrally efficient modulation formats has resulted in the digital coherent optical receiver. Coherent detection employing multilevel modulation format has become one of the most promising technologies for next generation high-speed transmission system due to the high power and spectral efficiencies[7-8]. With the powerful DSP, coherent optical receivers allow the significant equalization of chromatic dispersion (CD), polarization mode dispersion (PMD), phase noise (PN) and nonlinear effects in the electrical domain [9-11].

II. DIGITAL SIGNAL PROCESSING

Digital signal processing is used at the receiver for compensation of fiber impairments [12]. Digital compensation can be done at the receiver after the optical signal has been converted to electric signal. If the baseband signal is sampled above the Nyquist rate, digitized signal represents the full content of analog electric signal, which enables digital signal processing compensation[13-17]. DSP has advantages, such as signals can be delayed, split, amplified and manipulated without degradation in signal quality.

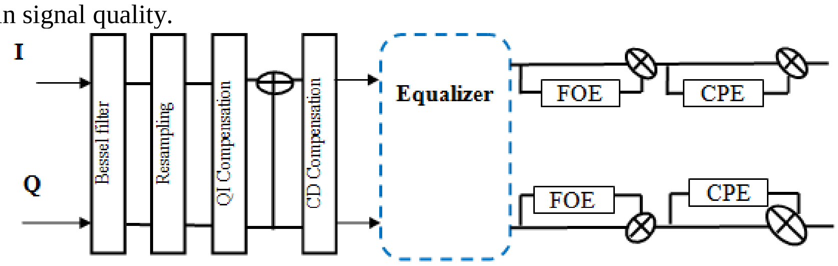


Fig.1 Different Stages of Digital Signal Processing

The electronic signal-processing techniques can be broadly classified as adaptive equalization at the receiver, predistortion at the transmitter, and electric-field domain signal processing. The Electronic Dispersion Compensation (EDC) at the receiver can be most conveniently designed to be fully adaptive and, due to its ease of use and attractive economics, this approach will be emphasized [18-22].

Digital signal processing in optical communication systems is enabled by high speed digital-to-analog converter (DAC) and analog-to-digital converter (ADC) technology operating at billions of samples per second. Fiber chromatic dispersion can be effectively mitigated through electronic dispersion compensation (EDC) at the transmitter or at the receiver [23].

III. EXPERIMENT SETUP

The experiment setup include OFDM transmitter; which consists of random data generator and corresponding QAM sequence generator. The OFDM Modulator working on M-ary pulse thus an additional subsystem is designed for M-ary pulse generator. This sub system also connected with visualizer. The In- Phase (I) and Quadrature Phase (Q) Signal fed to OFDM modulator. The output of OFDM modulator followed by a Low Pass Filter with gain of 10 dB separately for I & Q signals and combined with power combiner.

To perfect recovery of transmitted signals require the perfect receiver. The design layout of OFDM receiver is given in figure 4.4. It consists of OFDM demodulator, QAM decoder, and subsystem and NRZ pulse generator with different analyzing tools. The proposed methodology is coherent detection thus the coherent system is used at receiving end. There are four PIN diode with 90 degree phase shift used at detector. To avoid the optical isolation the optical null device is connected at the coupler. One local oscillator of 193.1 THz frequency with -2dBm is used to provide the synchronization. The line width & phase of laser for local oscillator same as the transmitter laser source. The performance of the receiver can be observed by the constellation diagram, BER and output SNR.

Order of modulation is increase then order on nonlinearity is also increase due to no. of bit per symbol in increase. The 2 bit per symbol for 4 QAM, 4 bit per symbol for 16 QAM and 6 bit per symbol for 64 QAM is taken for the different modulation scheme. The data rate is ~10Gbs .

The Digital signal processing is used at the receiver for compensation of fiber impairments. Digital compensation can be done at the receiver after the optical signal has been converted to electric signal. If the baseband signal is sampled above the Nyquist rate, digitized signal represents the full content of analog electric signal, which enables digital signal processing compensation. DSP has advantages, such as signals can be delayed, split, amplified and manipulated without degradation in signal quality.

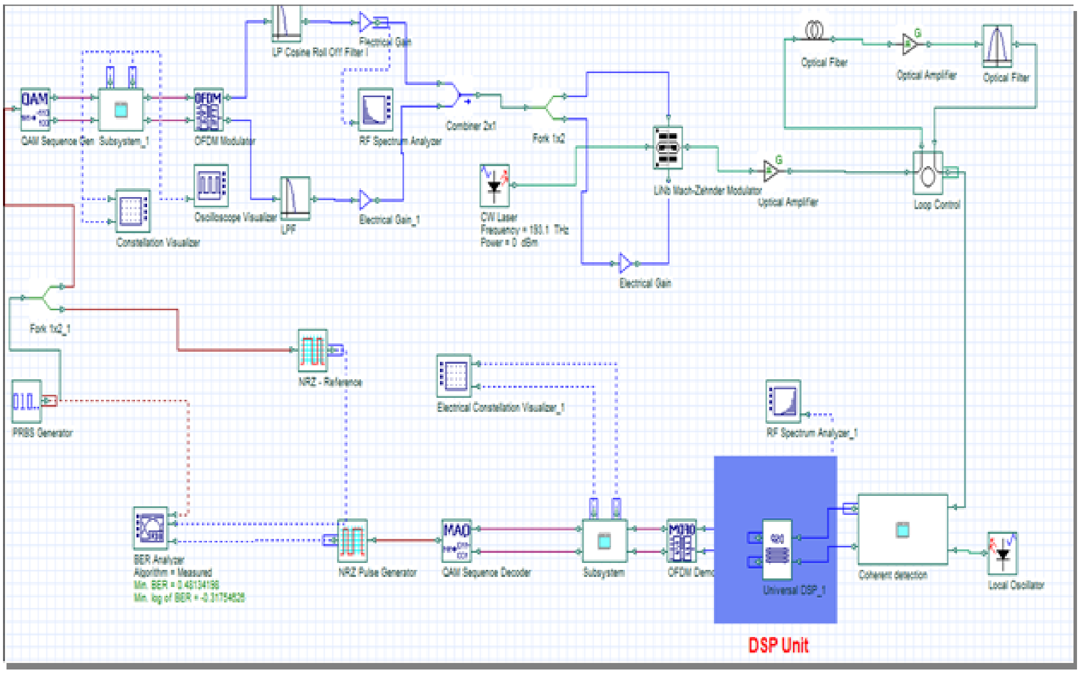
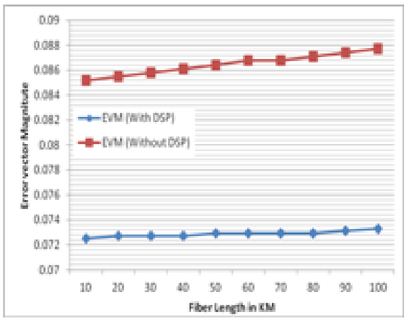


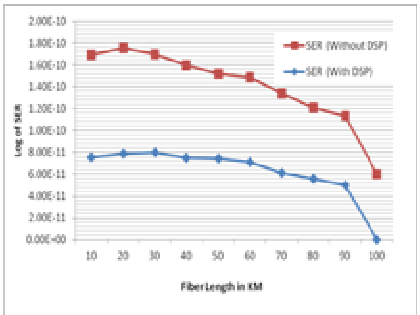
Fig. 1 Implementation of DSP unit for Coherent OFDM System

IV. RESULTS

The demand for high speed and large bandwidth for mobile wireless communications has rapidly increased in recent years. Optical orthogonal frequency division multiplexing (OOFDM), which is an advanced modulation technique, has recently been considered as a viable option to satisfy the increasing demand for high data rates and large capacity. OOFDM is being introduced as a promising scheme for supporting large capacity and high spectral efficiency for the advanced optical fiber communication networks. In this thesis, the design and simulation of OOFDM, studied and investigated. First, the design of a 4-QAM-OOFDM data rate of 10Gbps and a transmission distance of 10 km SMF is simulated then it is simulated for different length of fiber & high order of modulation like 16 QAM & 64 QAM. Further is modifying with DSP unit to improve the performance. The system performance is investigated by measuring the signal to noise ratio (SNR), BER, SER, Q factor & EVM and by studying the constellation diagram.

The proposed methodology implement as per activity chart, after the successfully implementation the results is shown in table I.





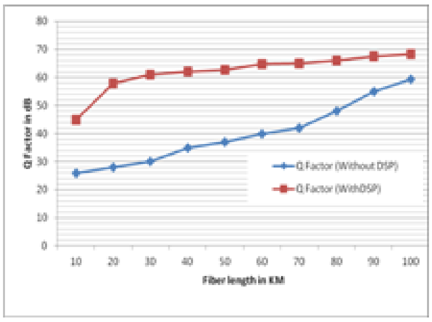
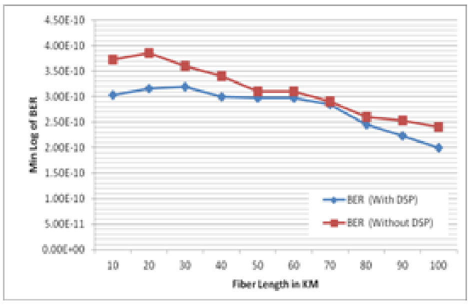
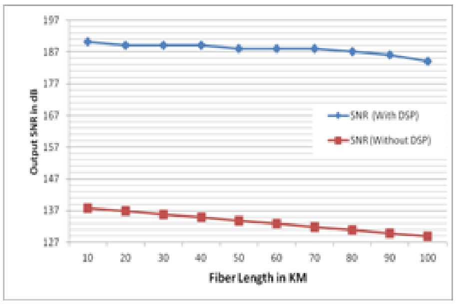


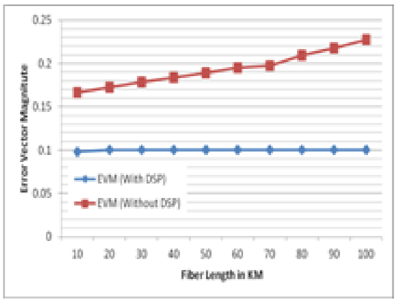
Figure 5.4 Graph for (a) EVM vs Fiber Length (b) SER vs Fiber Length (c) Q factor vs Fiber Length

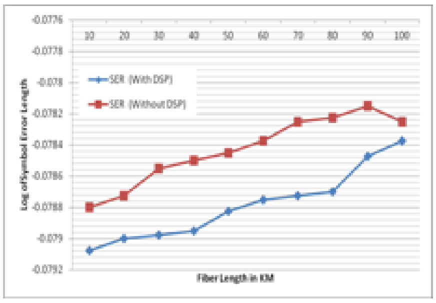


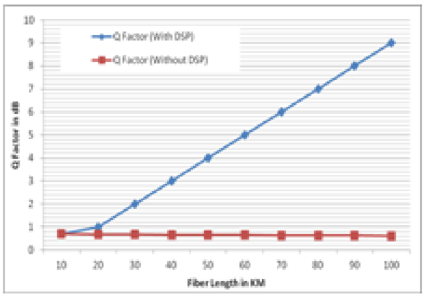


(d) BER vs Fiber Length (e) SNRvs Fiber Length

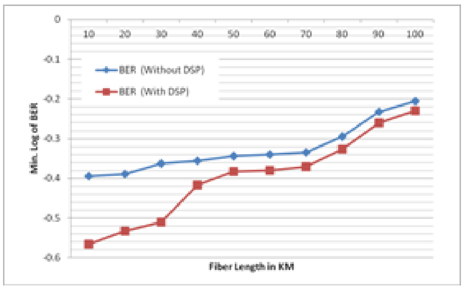
Figure 3: Performance analysis for 4 QAM Modulation With & Without DSP Unit

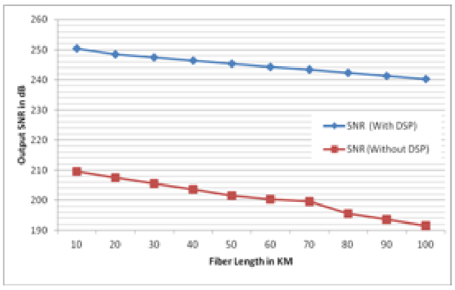






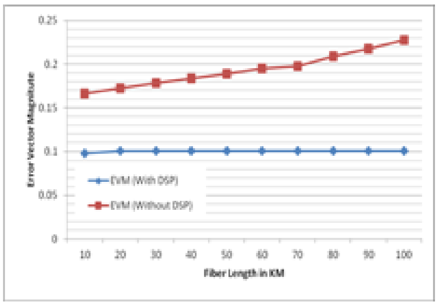
(a) EVM vs Fiber Length (b) SER vs Fiber Length (c) Q factor vs Fiber Length

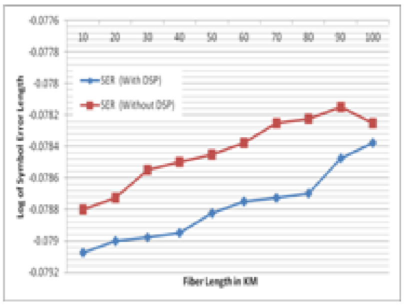


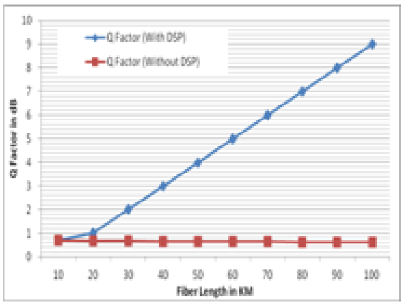


(d) BER vs Fiber Length (e) SNRvs Fiber Length

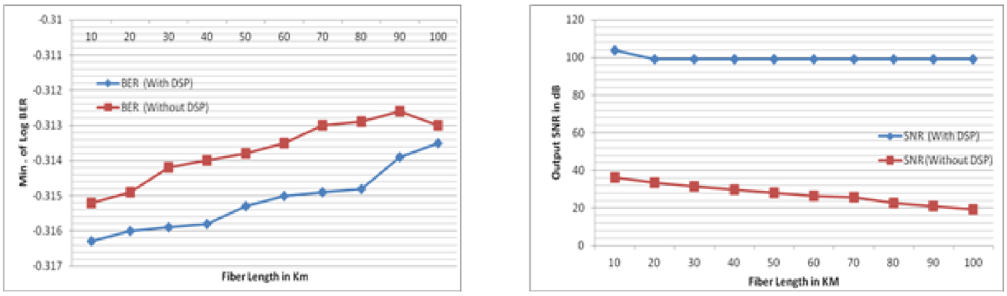
Figure 4: Performance analysis for 16 QAM Modulation With & Without DSP Unit







(a) EVM vs Fiber Length (b) SER vs Fiber Length (c) Q factor vs Fiber Length



(d) BER vs Fiber Length (e) SNRvs Fiber Length

Figure 5: Performance analysis for 16 QAM Modulation With & Without DSP Unit

TABLE I SUMMERED RESULTS FOR M- QAM MODULATION WITH & WITHOUT DSP UNIT

Parameter	**Without DSP Unit**	**With DSP Unit**
EVM	4QAM ~8.81 % 16 QAM ~6.93% 64 QAM ~ 16.1%	4QAM ~7.25% 16 QAM ~ 6.31% 64 QAM ~9.8%
Symbol Error Rate	4QAM ~ 9.3E-11 16 QAM ~ -0.141 64 QAM ~ -0.078	4QAM ~ 7.58E-11 16 QAM ~ -0.0986 64 QAM ~ -0.079
Q Factor	4QAM ~ 26 dB 16 QAM ~ 0.0894 dB 64 QAM ~ - 0.069 dB	4QAM ~ 45dB 16 QAM ~ 0.191 dB 64 QAM ~ 1dB
Min log of BER	4QAM ~ 3.07E-11 16 QAM ~ -0.394 64 QAM ~ 0.315	4QAM ~ 3.03 E-11 16 QAM ~ -0.566 64 QAM ~ 0.316
Output SNR	4QAM ~ 137.84dB 16 QAM ~ 209.58 dB 64 QAM ~ 36.21 dB	4QAM ~ 190.18dB 16 QAM ~ 250.469 dB 64 QAM ~ 103.7 dB

V. CONCLUSIONS

After the successfully implementation of DSP unit for the Coherent optical OFDM system is it observed that for 4 QAM modulation EVM is ~8.81 % and it is reduced ~7.25% in-case of DSP SER and BER reduce from~ 9.3E-11 to ~ 7.58E-11 and ~ 3.07E-11~ 3.03 E-11 respectively whereas the Q factor & output SNR increase form ~ 26 dB to ~ 45dB and from ~ 137.84dB to ~ 190.18 dB respectively. For 16 QAM modulation EVM is ~6.93 % and it is reduced ~ 6.31% in-case of DSP SER and BER reduce from ~ -0.141 to ~ -0.0986 and ~ -0.394 to QAM ~ -0.566 respectively whereas the Q factor & output SNR increase form ~ 0.0894 dB to ~ 0.191 dB and from ~ 209.58 dB to ~ 250.469 dB respectively. For 64 QAM modulation EVM is ~ 16.1% and it trim down ~9.8% in-case of DSP SER and BER decrease from ~ -0.078to ~ -0.079 and ~ 0.315 to ~ 0.316 respectively whereas the Q factor & output SNR increase form ~ - 0.069 dB to ~ 1dB and from ~ 36.21 dB dB to ~ 103.7 dB respectively.

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REFERENCES

[1] Ayhan, Y. and Cavdar, I.H., "Optimum link distance determination for a constant signal to noise ratio in M-ary PSK modulated coherent optical OFDM systems", in Telecommunication Systems, August, 2013.

[2] Ali Y. Fattah, ZainabFaydh Mohammed, "Electronic Signal Processing for Cancelation of Optical Systems Impairments", IJCCCE, 13(2), 2013, pp 55-71.

[3] I. Tomkos, B. Hallock, I. Roudas, R. Hesse, A. Boskovic, J. Nakano, and R. Vodhanel, 10-Gb/s transmission of 1.55-_m directly modulated signal over 100 km of negative dispersion _ber," IEEE Photon. Technol. Lett., vol. 13, pp. 735- 737,2001

[4] J. McNicol, M. OSullivan, K. Roberts, A. Comeau, D. McGhan, and L. Strawczynski, Electrical domain compensation of optical dispersion," Proc. Conf. Opt. Fiber Communication paper OThJ3, 2005.

[5] L. Gruner-Nielson, S. N. Knudsen, B. Edvold, T. Veng, D. Magnussen, C. C. Larsen, and H. Damsgaard, Design and manufacture of dispersion compensating fibre for simultaneous compensation of dispersion and dispersion slope," Proc. Conf. Opt. Fiber Commun., vol. 2, pp. 232-234, 1999.

[6] N. Q. Ngo, S. Y. Li, R. T. Zheng, S. C. Tjin, and P. Shum, Electrically tunable dispersion compensator with fixed center wavelength using fiber bragg grating," IEEE J. Lightwave Technology, vol. 21, pp. 1568-1575, 2003.

[7] Y. Jiang, X. Tang, J. C. Cartledge, and K. Roberts, Electronic pre-compensation of narrow optical filtering for OOK, DPSK and DQPSK modulation formats," IEEE J. Lightwave Technol., vol. 27, pp. 3689-3698, 2009.

[8] [I. Fatadin, S. J. Savory, and D. Ives, “Compensation of Quadrature Imbalance in an Optical QPSK Coherent Receiver”, IEEE Photonics Technology Letters, Vol. 20, No. 20, pp. 1733- 1735, Oct 15, 2008.

[9] S. J. Savory, “Digital filters for coherent optical receivers”, Optics Express, Vol. 16, No. 2, Jan21 2008.

[10] M. Oerder and H. Meyr, “Digital Filter and Square Timing Recovery”, IEEE transactions on communications, Vol. 36, No. 5, pp. 605-612, May 1988.

[11] D. N. Godard, “Self-Recovering Equalization and Carrier Tracking in Two-Dimensional Data Communication Systems”, IEEE Transactions on Communications, Vol. COM-28, No. 11, pp.1867-1875, Nov 1980.

[12] W. A. Sethares, G. A. Rey, C. R. Johnson, “Approaches to blind equalization of signals with multiple modulus,” in Proc. Int. Conf. Acoust., Speech, Signal Process., Vol. 2, pp. 972-975 May 1989(ICASSP).

[13] P. Ciblat and L. Vandendorpe, “Blind carrier frequency offset estimation for non-circular constellation based transmission”, IEEE Transactions on Signal Processing, vol. 51, no. 5, pp1378-1389, May 2003.

[14] M. Morelli and U. Mengali, “Feedforward Frequency Estimation for PSK: a Tutorial Review,”IEEE Transactions on Communications, Vol. 9, No. 2, pp. 103-116, 1988.

[15] T. Pfau, S. Hoffmann, and R. Noe, “Hardware-Efficient Coherent Digital Receiver Concept WithFeed-forward Carrier Recovery for M-QAM Constellations”, Journal of Lightwave Technology,Vol. 27, No. 8, pp. 989-999, Apr 15, 2009.

[16] Liang B. Du and Arthur J. Lowery , “Improved single channel back propagation for intra-channelfiber nonlinearity compensation in long-haul optical communication systems”, Optics Express,vol. 18, no. 16, pp. 17075-17088, 2010.

[17] K. Kikuchi, M. Fukase, and S.-Y. Kim, “Electronic post-compensation for nonlinear phase noisein a 1000-km20-Gbit/s optical QPSK transmission system using the homodyne receiver with digital signal processing,” in Optical Fiber Communication Conference (Optical Society of America, Anaheim, California, 2007

[18] A. J. Lowery, “Fiber nonlinearity mitigation in optical links that use OFDM for dispersioncompensation,” IEEE Photon. Technol. Lett. 19(19), pp1556-1558, 2007.

[19] Capoglu, I. R., Li, Y., & Swami, A. Effect of Doppler Spread in OFDM Based. IEEE Transactions on Wireless Communications, pp.2559-2567.2005

[20] Hanzo, L. L., Ng, S. X., Keller, T., & Webb , W. (2004). Quadrature Amplitude Modulation: From Basics to Adaptive Trellis-Coded, Turbo-Equalised and Space-Time Coded OFDM, CDMA and MC-CDMA Systems. New York: Wiley-IEEE Press., 2004.

[21] Wei, J. Intensity Modulation of Optical OFDM Signals Using Low-cost Semiconductor Laser Devices for Next-generation PONs . Bangor: Bangor University Electronic Engineering.2010.

[22] R, C. I., Li, Y., & A, S. Effect of Doppler spread in OFDM-based UWB systems. IEEE Transactions on Wireless Communications, pp.2559-2567, 2005.

[23] Tang, M. J., Lane, P. M., & Shore, K. A. “High-Speed Transmission of Adaptively Modulated Optical OFDM Signals over Multimode Fibers Using Directly Modulated DFBs”. IEEE Journal of Lightwave Technology, pp.429-441.2006

