Data transmission with OFDM technique using soliton carriers

Tarnveer Kaur[1], Kamaljit Singh Bhatia[2] , Harsimrat Kaur[3], Saranjeet Kaur[4]

Abstract **-** OFDM provides both high data rate and symbol duration with overlapping sub carriers without causing inter carrier interference using frequency division multiplexing (FDM) over multi sub carriers within one channel. On the other hand solitons are famous for retaining their shape over a long distance so providing good transmission rate over long distance. Then for multiuser structures, the initial laser phase values of various solitons pulse generators at transmitter, plays efficacious role on the performance (in terms of Q-values, jitter and BER at the receiver) of the transmission. Besides that jitter is an effect that results in undesirable causes in the system, hence very important to be minimized. We proposed a new for transmission of data with orthogonal frequency division multiplexing technique for communication network using solitons as carriers with minimized jitter. Here multiple soliton carriers are multiplexed and modulated using an OFDM technique. It will result in boosting capacity of data transmission over long range communication systems with improved speed.

Keywords- OFDM, Soliton, QAM, FFT

I. INTRODUCTION

OFDM is aggregate of modulation and multiplexing [1-3]. Modulation refers to the technique of varying the carrier phase, frequency, amplitude or their combination with a signal which typically contains information to be transmitted and called modulating signal [4]. The target of multiplexing is to share a given bandwidth [5-6]. A process that modulates information onto only one carrier is known as Single carrier modulation [7]. The main obstacle in this technology is to fulfill the need for high bandwidth in fixed spectrum limits of one single carrier [8]. High symbol rate is achieved by high data rate in one carrier [9]. The decrease in the duration of one symbol or bit results in the system that becomes more susceptible to loss of information from impulse noise, reflections of signal and other impairments [10]. These impairments can clog the capability to recover information sent [11].An increase in the bandwidth used by a single carrier system increases the susceptibility to interference from other continuous signal sources [12]. This type of interference is commonly introduced as a carrier wave (CW) or frequency interference [13]. The basic principle of OFDM is that channel is split into many sub-channels and the digital symbols are transmitted in parallel over these sub-channels , it is labeled as parallelization [14]. OFDM serves both high data rate and symbol duration over multi subcarriers within one channel using frequency division multiplexing (FDM) [15]. OFDM uses subcarriers which are orthogonal to each other [16]. Bandwidth can be divided into some sub-channels in traditional parallel data-stream where a fixed channel spacing between them is there to eliminate inter carrier interference (ICI) [17]. Traditional technique result in wastage of exiting spectrum, but OFDM uses overlapping sub carriers without causing ICI [18]. To gain this goal, in OFDM sub-carrier are orthogonal to each other [19]. A conversion system can be used for signal security using temporal dark-bright solitons via an add/drop filter [20]. Bright soliton with central frequency of 50 GHz and power of 1 W is introduced into the first ring resonator using an optical add- drop filter [21]. In our previous studies we investigated the compensation of Optical Telecommunication Channels for Optical OFDM System by using Optical Add Drop Multiplexers [22]. By using coded signals Peak-to-average power ratio is reduced in optical-orthogonal frequency division multiplexing systems [23]. Optical-ofdm systems and a coded direct detection optical orthogonal frequency division multiplex (OFDM) system was also developed [24-25]. A Simulative analysis of integrated DWDM and Multiple input multiple output- orthogonal frequency division multiplexing (MIMO-OFDM) system using Optical Add Drop Multiplexers had also been done [26]. Modeling and simulative performance analysis of Optical Add Drop Multiplexers for Optical-OFDM system that is hybrid multiplexed [27]. The combination of soiltons with this OFDM technology is still untouched (according to our knowledge) , So here we described successful Soliton-OFDM technology.

Tarnveer Kaur[1] , [1]Department of Electronics Engineering, Sri Guru Granth Sahib World University, Fatehgarh Sahib, India.

Dr. Kamaljit Singh Bhatia[2] , [2]Department of Electronics Engineering, Sri Guru Granth Sahib World University, Fatehgarh Sahib, India.

Harsimrat Kaur[3] , [3]Department of Electronics and communication Engineering, CTIEMT Jalandhar

Saranjeet Kaur[4] , [4]Department of computer Application, Lovely professional university, Jalandhar

II. FRAMEWORK

We introduced our proposed system that generates Soliton pulses before sequence generator. Graphically the topology is divided in two horizontal levels, the upper one corresponding to the transmitter section and the lower one corresponding to the receiver section .N number of subcarriers is introduced with cyclic prefix of 0.25. At the OFDM transmitter part of system, the data sequence undergoes serial-to-parallel (S/P) conversion so that it can be stacked into one OFDM symbol [30]-[31]. Then, *N*-points inverse fast-Fourier transform (IFFT) produces the *N* dimensional signal in the time domain [32].

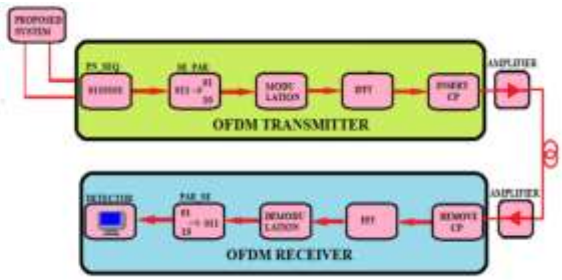

Fig.1 Conceptual diagram of Soliton based OFDM transmission

A single 10 Gbit/s preudo-random bit sequence is converted into a number of lower rate bit sequences controlled by the symbol QAM_bit_number .So, conversion of frequency selective channel into *N* parallel frequency-flat sub-channels occurs [33].3db average power reduction due to modulation is taken. Hence the subcarriers are orthogonal to each other, enhancement in bandwidth efficiency is done because of overlapping of the signal spectra corresponding to the different subcarriers [34]. The multiplicity of the serial-to-parallel conversion corresponds to the number of bits used by block to encode one QAM symbol. Therefore the *N* dimensional signal is converted parallel-to-serial (P/S). Orthogonality of the subcarriers is preserved by a cyclic prefix (CP) [35]. The resultant symbol is sent over the channel after applying it to a power amplifier [36]. At the OFDM receiver part, the CP is removed from the symbol, and S/P conversion is done[37]. Then, before P/S conversion takes place fast Fourier transform (FFT) is applied to the symbol [38]. The symbol so received is then equalized and detected to try to retrieve the original transmitted symbol. As a result we can say that OFDM can provide both high data rate and symbol duration using frequency division multiplexing (FDM) over multi subcarriers within one channel [39]. An intermediate binary to Gray-code conversion is used in the modulation process .S/P convertor and some modulations such QAM, PSK are used to convert Stream of binary digits to many parallel data symbol streams [40].

III. RESULTS

Orthogonal frequency division multiplexing (OFDM) modulation uses orthogonal carriers to transport the phase and amplitude information of multiple low-rate bit sequences modulated using BPSK, QPSK or QAM. Serial-to-parallel and parallel-to-serial conversions enable to transmit and receive a single high-rate bit stream. The signal is monitored at each stage of the modulation process for ideal study of the modulation behavior details. Figure 2 shows the constellation diagram at the output of the QAM modulator. Then the model IFFTOFDM converts the QAM symbols in OFDM symbols with an IFFT operation using a number of subcarriers controlled by the subcarriers_number, returning on output baseband in-phase and in-quadrature signals. The soliton pulses are used widely in securing optical communication as carrier signals in which the information is input into the signals and finally retrieved by using suitable filtering systems.

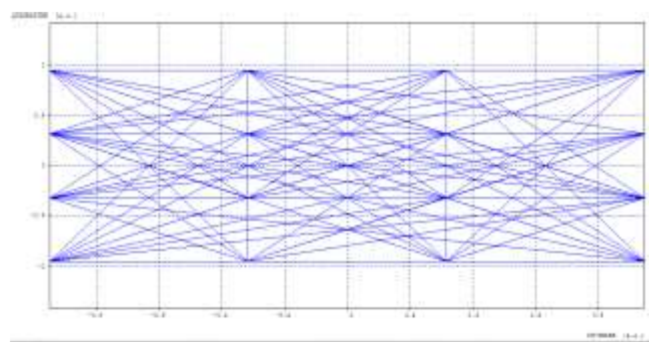

Fig. 2 Constellation diagram at the output of the QAM modulator

The OFDM signal at baseband is RF modulated with a quadrature mixing up conversion. Fig,3 shows the OFDM signal RF-modulated.

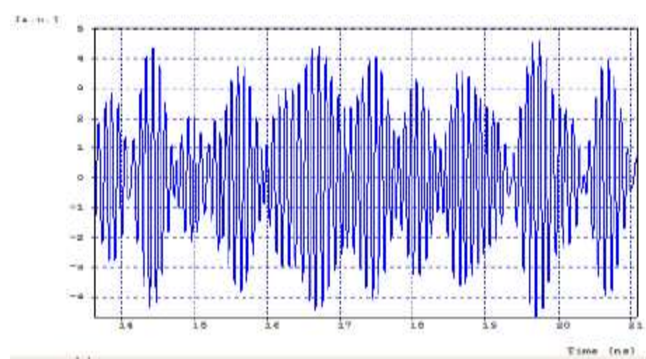

Fig. 3 OFDM signal with proposed system generating solitons RF-modulated transmitted

At the receiver section the RF signal is translated to baseband with a quadrature mixing down conversion. Filtering of the replica at twice the carrier frequency which is produced by the down conversion process is done. Here two 7-pole low-pass Bessel filters centered at the 10 GHz carrier frequency is used. Finally the FFTOFDM extracts the transmitted QAM symbols from the OFDM signal at baseband with an FFT operation. The OFDM modulation is very sensitive to the sampling instant at the receiver, So it is very important to sample the

OFDM symbol at the optimum sampling instant for good system performance. At FFTOFDM block the amplitude and phase of the original QAM symbols is also recovered therefore facilitating the demodulation into bit streams of the received QAM signal. We observed that soliton signals as single or multiple carriers can be multiplexed and modulated using an OFDM technique in order to transmit the data via a wired/wireless network system. Therefore, transmitted signals can be received and de-multiplexed at the end of the transmission Link. At parallel-to-serial *PAR_SE* the received QAM symbols are converted into single high-rate bit sequence and low-rate parallel bit streams.

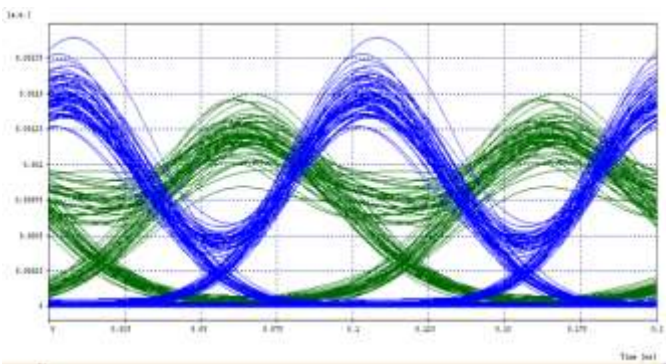

Fig. 4 Eye diagram at receiver with Soliton-OFDM transmission

Using higher optical frequency high bit rate transmission of optical soliton can be performed credit goes to shape preserving nature of solitons. Figure 4 shows eye pattern received at the end with Q-value of 21.3542db having BER of $5.21e^{-032}$ and timing jitter of 0.00156ns. Undesired effect jitter is very important to be minimized in the system. Various channels (32) that are spaced at 100 GHz are used to examine jitter values. The input signal spectrum occupies a bandwidth of 3.2 THz. As shown in fig.5 we observed jitter values at different channels (1, 8, 17, 24, and 32) channels at the end bear less jitter as compared to the mid ones. After jitter minimization, viewing electrical spectrums of some channels gives outputs as shown in figure 6,7 and 8. Figure 6 shows the electrical spectrum of a channel, where using various Soliton generators multiple Solitons are generated and transmitted onto fiber using OFDM technique. Different Soliton pulses are transmitted together in order to utilize bandwidth as shown in time domain visualizer.

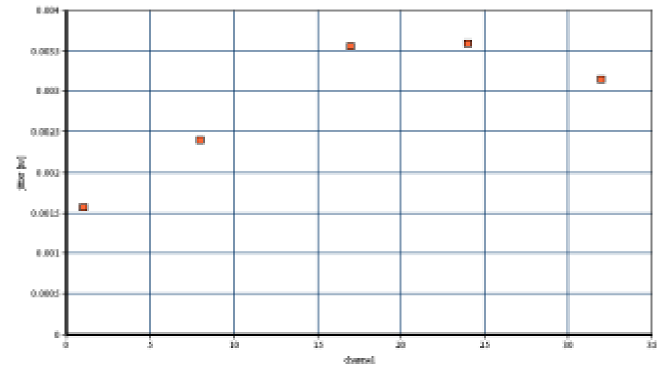

Fig. 5 Variation of jitter with various channels

In Fig.7 16 QAM constellation diagram at the receiver section of Soliton based OFDM system is shown. Here sampling instant is taken greater than the optimal one by 10% of bit period and variation in the constellation diagram can be seen by comparing it with that of fig.2 constellation diagram at the output of the QAM modulator which is at the transmitter section.In fig.8 we showed electrical spectrum of the same system with proposed Soliton generator embedded at the starting of transmitter section.

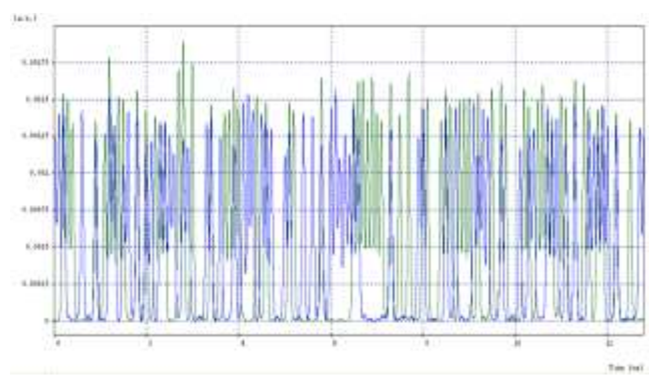

Fig. 6 Electrical signal at receiver with Soliton-OFDM transmission

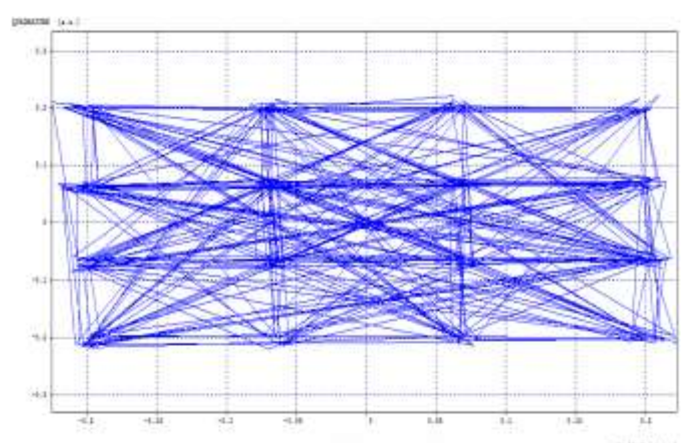

Fig.7 16- QAM received constellation with sampling instant greater than the optimal one by 10% of the bit period

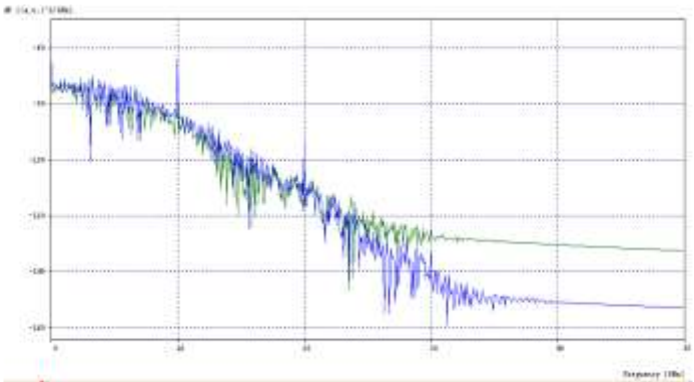

Fig. 8 Electrical spectrum at receiver with Soliton-OFDM transmission

IV. Conclusion

Solitons and OFDM independently are such fields that are successful in providing high data rate transmission. So, combination of both of these can satisfactorily solve bandwidth limitation problem with speedy transmission of data for long distance communication. In our paper we proposed a system with our Soliton generated proposed system in transmitter section and so generating multiple Soliton pulses. These multiple Soliton pulses are transmitted with OFDM scheme. Minimization of jitter with different channels has also been studied with same Soliton based OFDM system.

References

[1]. Bolcskei, H., Gesbert, D., and Paulraj, A. J. “On the capacity of OFDM-based spatial multiplexing systems”, Communications, IEEE Transactions on, vol. 50, pp. 225-234, 2002.

[2]. Attar, A. , et al. “Interference-limited resource allocation for cognitive radio in orthogonal frequency-division multiplexing networks”, Communications, IET, vol. 2, pp. 806-814, 2008.

[3]. Hung, H. L. and Huang, Y. F. “Peak-to-average power ratio reduction in orthogonal frequency division multiplexing system using differential evolution-based partial transmit sequences scheme,” IET Communications, vol. 6, p. 1483, 2012.

[4]. Power, A. C., et al., “AON APD ARPU ASE ASN. 1 AWGN”, Next Generation Wireless Communications Using Radio over Fiber, 2012.

[5]. Ma, Y., et al., “1-Tb/s single-channel coherent optical OFDM transmission with orthogonal-band multiplexing and sub wavelength bandwidth access”, Lightwave Technology, Journal of, vol. 28, pp. 308-315, 2010.

[6]. Shen, G. and Zukerman, M., “Spectrum-efficient and agile CO-OFDM optical transport networks: architecture, design, and operation”, Communications Magazine, IEEE, vol. 50, pp. 82-89, 2012.

[7]. Shukla, P. K. and Singh R., “Optimization of power in optical ofdm system”, vol. 3, pp. 171-174, 2012.

[8]. Benvenuto, N., et al., “Single carrier modulation with nonlinear frequency domain equalization: an idea whose time has come—again”, Proceedings of the IEEE, vol. 98, pp. 69-96, 2010.

[9]. Odenwalder, J. P., et al., "High-data-rate supplemental channel for CDMA telecommunications systems," ed: EP Patent 2,288,062, 2011.

[10]. Kim, Y., Bae, J. N., and Kim, J. Y. , “Performance of power line communication systems with noise reduction scheme for smart grid applications”, Consumer Electronics, IEEE Transactions on, vol. 57, pp. 46-52, 2011.

[11]. Tabach, M. E., et al., “Coded OFDM and OFDM/OQAM for Intensity Modulated Optical Wireless Systems”, Journal of Communications, vol. 4, pp. 555-564, 2009.

[12]. Sreekanth, N. and GiriPrasad, M., “BER analysis of mitigation of ici through ici self-cancellation scheme in ofdm systems”, vol. 2, 2012.

[13]. Balaei, A. T., Dempster, A. G., and Presti, L. L. , “Characterization of the effects of CW and pulse CW interference on the GPS signal quality”, Aerospace and Electronic Systems, IEEE Transactions on, vol. 45, pp. 1418-1431, 2009.

[14]. Raajan, N., et al., "Improved OFDM system using inter symbol pilot aided synchronization in asynchronous mode of transmission," 2012, pp. 652-656.

[15]. Zhu, J., et al., “Robust low-complexity joint space-time-frequency channel estimation with transmit diversity in mobile wireless channels”, AEU-International Journal of Electronics and Communications, vol. 64, pp. 570-578, 2010.

[16]. Chrabieh, R., Soliman, S. S., and Dural, O., "Adaptive loading for orthogonal frequency division multiplex (ofdm) communication systems," ed: EP Patent 2,371,080, 2011.

[17]. Wang, C. “Beyond 3G Techniques of Orthogonal Frequency Division Multiplexing and Performance Analysis via Simulation” , (IJAPUC), vol. 3, pp. 1-13, 2011.

[18]. Wilhelmsson, L., "Doppler dependent power control and sub-carrier allocation in OFDM multiple access systems," ed: EP Patent 1,732,244, 2011.

[19]. Khan, A., Imran, M., and Evans, B. “Iterative turbo beam forming for orthogonal frequency division multiplexing-based hybrid terrestrial-satellite mobile system”, IET, vol. 6, pp. 157-164, 2012.

[20]. Siririth, W., et al., “A novel temporal dark-bright solitons conversion system via an add/drop filter for signal security use”, Optic- Journal for Light and Electron Optics, vol. 121, pp. 1955-1958, 2010.

[21]. Mitatha, S., et al., “Soliton spin manipulations using an optical add-drop filter”, Microwave and Optical Technology Letters, vol. 54, pp. 1100-1103, 2012.

[22]. Kamaljit Singh Bhatia, R. S. Kaler, T. S. Kamal and Rajneesh Kaler, “Monitoring and Compensation of Optical Telecommunication Channels by using Optical Add Drop Multiplexers for Optical OFDM System” Copyright © 2012 De Gruyter. DOI 10.1515/joc-2012-0001

[23]. K. Singh Bhatia ,T.S. Kamal, R.S. Kaler, “Peak-to-average power ratio reduction using coded signal in optical-orthogonal frequency division multiplexing systems” IET Optoelectronic., Elsevier Science. (2012), Vol. 6, Iss. 5, pp. 250–254, doi: 10.1049/iet-opt.2011.0089.

[24]. Kamaljit Singh Bhatia, R.S. Kaler, T.S. Kamal, “Design and Simulation of optical-ofdm systems” Journal of Russian Laser Research, Springer Science+ Business Media (2012), Volume 33, Number 5, pp. 202-208,

[25]. K.S. Bhatia, T.S. Kamal, R.S. Kaler, “An adaptive compensation scheme-based coded direct detection optical–orthogonal frequency division multiplex (OFDM) system” Computers and Electrical Engineering 38, Elsevier Science (2012) 1573–1578,

[26]. Kamaljit Singh Bhatia, R.S. Kaler, T.S. Kamal, Rajneesh Randhawa, “Simulative analysis of integrated DWDM and MIMO-OFDM system with OADM” Optik 124, Elsevier Science (2013) 117– 121,

[27]. Kamaljit Singh Bhatia, T.S. Kamal, “Modeling and simulative performance analysis of OADM for hybrid multiplexed Optical-OFDM system” , In Press Optik, Elsevier Science (2013), http://dx.doi.org/10.1016/j.ijleo.2012.05.036, Impact Factor-0.5,

[28]. Tarnveer Kaur and Kamaljit Singh Bhatia, “Impact of Initial Laser Phase Values on Soliton Transmission”, J. Opt. Commun.. Volume 0, Issue 0, Pages 1–4, DOI: 10.1515/joc-2013-0044, October 2013

[29]. Tarnveer Kaur and Kamaljit Singh bhatia, “effect of line coding on jitter and initial laser phase on q value in soliton transmission” optik - International Journal for Light and Electron Optics,Volume 125, Issue 2, January 2014, Pages 805–809

[30]. Kikuchi, K. and Osaki, M., "Highly-sensitive coherent optical detection of M-ary frequency-shift keying signal," 2011.

[31]. Ahmed, E., et al.:'Channel Estimation for OFDM System using Training Sequence Algorithms,' Advances in Electrical Engineering Systems, vol. 1, pp. 140-145, 2012.

[32]. Ahmed, M., et al.:'OFDM Based on Low Complexity Transform to Increase Multipath Resilience and Reduce PAPR,' Signal Processing, IEEE Transactions on, pp. 1-1, 2011.

[33]. Roy, T. K.:'Comparative BER Performance Analysis of OFDM System using BPSK Modulation Technique over AWGN and Rayleigh Fading

Channel,' International Journal of Applied Research in Computer Science and Information Technology, vol. 1, 2012.

[34]. Kaur, S. and Bharti, G.:'Orthogonal Frequency Division Multiplexing in Wireless Communication Systems: A Review,' International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), vol. 1, pp. pp: 125-129, 2012.

[35]. Lowery, A. J.:'Inserting a cyclic prefix using arrayed-waveguide grating routers in all-optical OFDM transmitters,' Optics Express, vol. 20, pp. 9742-9754, 2012.

[36]. Ren, G., et al.:'OFDM-Based Precise Ranging Technique in Space Applications,' Aerospace and Electronic Systems, IEEE s on, vol. 47, pp. 2217-2221, 2011.

[37]. Cao, S., Yu, C., and Kam, P. Y.:'Decision-Aided Joint Compensation of Transmitter IQ Mismatch and Phase Noise for Coherent Optical OFDM,' Photonics Technology Letters, IEEE, vol. 24, pp. 1066-1068, 2012.

[38]. Bouziane, R., et al.:'Optimising FFT Precision in Optical OFDM Transceivers,' Photonics Technology Letters, IEEE, pp. 1-1, 2011.

[39]. Ghosh, S. and Bass, A.:'Implementation of Digital Video Broadcasting-Terrestrial (DVB-T) using Orthogonal Frequency Division Multiplexing (OFDM) on Physical Media Dependent Sub layer,' International Journal of Computer Applications, vol. 44, pp. 20-25, 2012.

[40]. Tang, Z.:'The Application of Fast Fourier Transform Algorithm in WiMAX Communications System,' Education Management, Education Theory and Education Application, pp. 711-719, 2012.

Dr. K. S. Bhatia is an Academician, Researcher and learner in the field of Optical-OFDM. There are about 65 research publications in International Journals/Conferences into his credit.