Implementation of Next generation DVB-T based OFDM in Modern Wireless Technology

Rohit Kumar (M.Tech. Student), Asst. Professor Arvinder Pal Singh Kalsi

Abstract— Now-a-days, life in the 24*365, in communication arenas video broadcasting is acting a key role. However, it is analyzed in terms of various wireless communication channels. Thus there is a need for development of next generation DVB-T. In OFDM the data is transmitted into parallel fashion by dividing high rate serial data into low rate sub-streams. By dividing the data into parallel streams the data rate is reduces, which results the increase of the length of symbol duration. The robustness of the channel and high data rates make OFDM as an efficient scheme for all the DVB-T applications and others applications too. So, we use one of the proposed OFDM signals of the Digital Video Broadcasting (DVB) standard which is now used for the European terrestrial digital television (DTV) service. In this paper, the advanced and proposed module of DVB-T system model is mentioned, based on the analysis of some parameters, which will discuss later in this paper, on the basis of FFT via different channels, time and frequency synchronization.

Key Words— OFDM, FFT, Channels, DVB-T, Proposed Model of DVB-T.

1 Introduction

In modern communication world, there is a need for high data rate information with high capacity and better reliability system. Wireless channels system phenomena like multipath delay, fading and Inter symbol Interference (ISI) also PAPR are occurred due to the frequency selectivity of the channel at the receiver side, this gives the result as the low performance and highly probability of errors. To overcome from such illness we uses channel coding and equalization techniques. But such techniques are costly therefore we use OFDM techniques to get high bit rate over selected frequency channels. This paper emphasizes about proposed DVB-T system model which is based on the analysis of OFDM on the basis of FFT and other parameters via different channels, time and frequency analysis. Orthogonal Frequency Division Multiplexing (OFDM) is implemented in the wireless communication systems where the high bit rate over the frequency selective channel is guaranteed to some extent. OFDM is a multi-carrier modulation technique where data symbols modulate a sub-carrier which is taken from orthogonally separated subcarriers with a separation of frequency (f_k) within each sub-carrier. The spectra of sub-carrier are overlapped in case of OFDM and the sub-carriers are also orthogonal to each other so by which the bandwidth utilization is more efficient with comparing other modulation schemes. To avoid Inter Carrier Interference (ICI) and maintain the orthogonality, separation between the sub-carriers should be (f_k). OFDM is used to convert a frequency selective channel into a parallel collection of frequency flat sub-channels by choosing the sub-carrier spacing properly in accordance with the channel coherence bandwidth. OFDM uses the discrete Fourier transform (DFT) or the fast Fourier transform (FFT) with a cyclic prefix that makes the system free from interference and make them robust.

2 OFDM [4], [5], [6], [7], [8], [9], [10].

It is a multicarrier transmission technique, proposed in 1960 which divides the available spectrum into many subcarriers, each one being modulated by a low data stream. It is viewed as either a modulation technique or a multiplex technique. It relates to the input to the output signal and called modulation technique. Another technique is seen by the output signal which is the linear sum of the modulated signals.

ISSN 2229-5518

2.1 Signal Characteristics: OFDM consists of N orthogonal subcarrier modulated by N parallel data streams. Each baseband subcarriers are in the form, as given by

$\emptyset_{k=e^{2\pi f_k t}}$……………………………………………...….. (1)

Where f_k = frequency of k-subcarrier. Then one baseband OFDM symbol multiplies N-modulated subcarriers, i.e.

$s(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} x_k(t)$ ………………..……….....… (2)

Where X_k is K^{th} complex data symbol for 0< t< N_t and taken as PSK or QAM fashion.

$S(nT) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} X_k e^{j2\pi kn/N}$; For $0 \le n \le n-1$ ……………………………………………………...….. (3)

This orthogonal technique is defined by following condition

$S_i(t) = \frac{2Es}{Ts}\cos[\pi/Ts\ (n_c + i)\ t]$ when $0 \le t \le T_s$ ….…………………………………………………… (4)

Where i = 1, 2, 3.….. M; $f_c = n_c / 2Ts$, for some fixed integer (n_c) , M= transmitted signals, making the signals orthogonal to one another. For coherent M-array FSK, the optimum receiver consists of a bank of M co-realtors', or matched filters. The average probability of error is given by

$P_e \le (M-1)Q\left(\sqrt{E_b \log_2 M / N_0}\right)$ ………………... (5)

For non – coherent detection using matched filters followed by envelope detectors. The average probability of errors is given by,

$$P_e = \sum_{k=1}^{M-1} [(-1)^{k+1}] \begin{bmatrix} M-1 \\ k \end{bmatrix} \exp\left[-kE_s / (k+1)N_0\right]$$

……………………………………………………… (6)

Now, the probability of error can be bounded as,

$P_e < \frac{M-1}{2}\exp\left(-E_s / 2N_0\right)$ ………………………… (7)

Now, calculate the channel bandwidth of a coherent M-ary FSK signal as,

$B = \frac{R_b(M+3)}{2\log_2 M}$ ……………………..…………...…… (8)

Also for non-coherent MFSK can be defined as,

$B = \frac{R_b M}{2\log_2 M}$ ……………………..…………………... (9)

This shows that the bandwidth efficiency of an M-ary FSK signal decreases with increasing M. Since all the M signals are orthogonal, there is no crowding in the signal space and hence the power efficiency increases.

2.2 Subcarrier generations using IFFT:

An OFDM signal consists of a sum of subcarriers, that are modulated by using PSK or QPSK, if the complex are QAM symbols, Ns is the number of subcarriers, t is the symbol duration and f_c is the carrier frequency, then one OFDM symbol starting at t=Ts, can be written as;

$S(t) = \sum_{N_s/2}^{\frac{N_s}{2}-1} d_i + N_s.\exp[j.2.\pi.i(t-t_s)\,T]$; $t_s \le t \le t_s + T$ …………………………………………………….…..... (10)

$S(t) = 0; t \le t_s \,\&\, t \ge t_s + T$…………………….…. (11)

3 DVB [1], [2], [3], [11], [13].

DVB-T stands for Digital Video Broadcasting Terrestrial; Digital Video Broadcasting (DVB) is a European standard for broadcasting Digital Television over Satellites, cables and thorough terrestrial (wireless) transmission. DVB was standardized by the ETSI in 1997. This system transmits a compressed digital audio/video stream, using OFDM modulation with concatenated channel coding (i.e. COFDM). This system transmits a compressed digital audio/video stream, using OFDM modulation with concatenated channel coding (i.e. COFDM). The methods for source coding are MPEG-2, Source encoding and MPEG-2 multiplexing. The Compressed video, audio and data streams are multiplexed into Data Streams (DS).One or more DSs are joined together into an MPEG-2 Transport Stream (MPEG-2 TS), this is the basic digital stream which is being transmitted and received by home Set Top Boxes (STB).

4 Channels [5], [6], [7].

ISSN 2229-5518

4.1 Gaussian Channel AWGN: The terminology 'Additive' means, it is added self to any noise because it is self-built in wireless communication system, 'White' means the idea that it is uniform power across the frequency band for the wireless communication system. As a white color contains all types of color, hence it is an analogy of white color which has uniform emissions at all frequencies in the visible color spectrum; 'Gaussian' means that, it has a normal distribution or constant power distribution w.r.to the time with an average value of zero.

4.2 Rician Channel: This channel has the property of Line Of Sight (LOS). This is also responsible for reduce the delay spread and decrease the fading depth. Moreover the envelope of a received signal is described by this kind of channel. This channel is defined in DVB-T for describing the fixed, outdoor antenna reception for proposed system.

4.3 Rayleigh Channel: This Channel does not follow LOS property also all paths are relatively equal, i.e., in room no signal but outside of room we get signal. The distribution function is as given,

$$p(x) = \frac{x}{\sigma^2} e^{-\left(x^2/2\sigma^2\right)}; x \geq 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (12)$$

Where σ is the scale parameter of distribution function and $x \in [0, \infty]$.

5 The Proposed Model [1], [2], [3], [4], [6], [7], [11], [12], [13].

This model of DTT system gives higher rate of data transmission, techniques to reduce the PAPR in order to reduce the cost of transmission. It also provides the flexibility of BW and frequency along with the mechanism for providing the robustness of the specific service. DVB-T standard is based upon MPEG-2 techniques based upon MUX techniques. This model provides some extra features, like, extra inter-leaver, external and internal channel coding. May be all these blocks contains many phenomena which are shown by shadow blocks behind the main blocks in the given figure after these blocks DVB-T has map-per, frame adaptation, frame builder, IFFT, GI, D/A convertor and

5.1.1 Frame Structure: A super frame of Proposed DVB-T is made by many DVB-T simple frames. Every simple DVB-T signal information is passes to the frame adaptor block by the pilot and Transmission Parameter signaling (TPS) signal block The multiplexed MPEG-2 coded data is transmitted into fixed size packets, and then goes to external channel coding and external inter-leaver blocks. The coding is done by LDPC coding. Then the map-per maps the bits to constellation points based on the chosen modulation schemes. Now, frame adaptor ready for OFDM frame by organized data, scattered pilots, continual pilots and Transmission Parameter Signaling (TPS). Each OFDM frame has fixed number of symbol and 4 frames which mean one super frame and then the carriers are divided into cells, where each cell corresponds to one carrier modulated with either data or pilots or TPS during one symbol. After the frame builder blocks finishes to creating frame, then IFFT is performed to convert the signal from frequency to time domain then GI is inserted in front of each frame which is a cyclic continuation of the useful part of frame. Finally these frames go via D/A convertor and ready for transmission.

5.1 Proposed DVB-T System Explanation: The explanation of major block diagram of this system is as given.

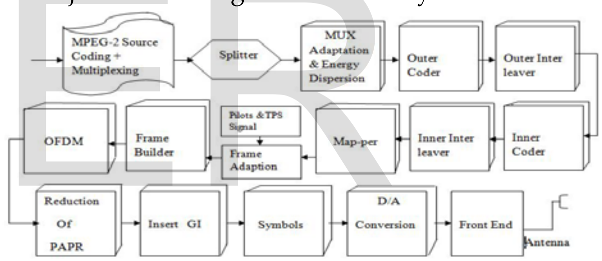

Figure 1 Proposed DVB-T Diagram [1], [2], [3], [12].

There can be multiple copies of sub-modules depends upon the number of Physical Layer Pipes (PLP) and may be some extra feature which shows behind the sub-modules blocks in the figure. The implementation is done by following table.

Parameters	Proposed Model
BW	10MHz
Constellation	256 QAM
Carrier	10K
GI	1/32
FFT size	5204
Kmax	3410
Kmin	0
OFDM Symbol Period Tu	442e-8
Baseband Elementary Period T	Tu/3208

Table 1 Parameter for Implementation.

ISSN 2229-5518

frames starts with a symbol, chased by another number of symbols for a signaling block, which followed by data symbols.

Frame 1	Frame 2	Frame 3	Frame 4
No. of Symbols	No. of Symbols	No. of Symbols	No. of Symbols

Figure 2 Frame Structure.

5.1.2 The IFFT/FFT: This is used in model for convert the signal from frequency domain to time domain and vice-versa when OFDM is used as modulation technique in proposed DVB-T system.

5.1.3 The Guard Interval: The GI is to introduce immunity propagation delays, echoes and reflections, by dividing the input data stream into 'N' subcarriers, the symbol duration becomes N times smaller, which also reduces the relative multipath delay spread, relatively to symbol time, by the same factor. Also to remove inter symbol interference completely; a guard time is introduced for each OFDM symbol. Note that, the guard time is chosen larger than the expected delay spread, such that multipath components from one symbol cannot interfere with the other or next symbol. These delayed replicas of the OFDM symbol are always being an integer number of cycles within the FFT interval. As long as the delay is smaller than the guard time, as a result, the multipath signals with delays smaller than the guard time does not cause the ICI.

5.2 System Model (DVB-T Example): For one OFDM symbol, according to [4], [6], [7] and [10] the mathematical model is as given.

$$S(t) = \mathrm{Re}\left[\sum_{i=\frac{N_s}{2}}^{\frac{N_s}{2}-1} d_i + \frac{N_s}{2} \cdot \exp\left[j \cdot 2\pi\left\{f_c - \frac{i+0.5}{T}\right\}\{t - t_s\}\right]\right]$$ ……………………………………………………… (13)

$t_s \leq t \leq t_s + T$ And $S(t) = 0, t < t_s$ $\& t > t_s + T$ ………………………………………………… (14)

Where d_i is the complex modulation symbols, N_s is the number of subcarriers, T is the symbol duration, and f_c be the carrier frequency. The particular form of (equ.12) is given in the proposed DVB-T standard as for the signal S (t) is given below

$$S(t)=\mathrm{Re}\left[(e^{\theta}\right) \sum_{m=0}^{\infty} \sum_{I=0}^{N} \sum_{k=K_{min}}^{Kmax} . C_{m,i,k}. \Psi_{m,I,k}(t)$$ ……… (15)

Where $\Psi_{m,I,k}(t) = \{e^{j.2.\pi.\frac{k'}{T_u}}(t - \Delta - l \cdot T_s - (N+1) \cdot m \cdot T_s)$ ………………………………………………… (16)

For $T_s \leq t \leq (l + (N+1) \cdot m)(l + (N+1) \cdot m + 1) \cdot T_s$ ………………………………………………… (17)

And $\Psi_{m,I,k}(t) = 0$; Anywhere ………………… (18)

$$S(t) = \mathrm{Rl}\left\{e^{\theta} \sum_{K_{min}}^{K_{max}} C_{0,0,k}.e^{\theta'/T_u}\right\}$$ ………………… (19)

Where $\theta = j.2.\pi.f_c.t$ and $\theta' = j.2.\pi.k'.(t - \Delta)/T_u$ Also with $k' = k - K'/2$ and $K' = (K_{max} + K_{min})$ ………………………………………………………… (20)

5.3 Transmission of Proposed Model: Let consider an OFDM spectrum which is centered at carrier frequency, now consider the symbol duration T_u with IFFT (N-point), thus we can use IFFT= 2N.Now generation of one OFDM symbol as shown below by block diagram.

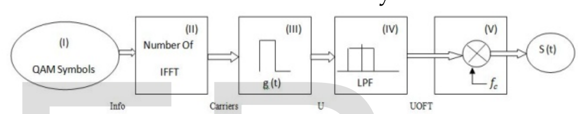

Figure 3 Proposed Transmission Model.

Here elementary period for a baseband signal is T, but for simulating a pass band signal; relates it to a time period, 1/Rs, that consider at least twice the carrier frequency which gives a carrier frequency , in the range of a VHF channel, which can applicable for a TV channel in any terrestrial area. This is explain as; add {FFT Length (FS) – K_max} zeros to the signal info to achieve over-sampling, and to center the spectrum. The result of this operation that is the signal carrier uses T/2 as its time period, this shown in figure (3.1) and (3.2); we can also get the observation that, the carriers are discrete time baseband signal, we can also use this signal in baseband discrete-time domain simulations, but the drawbacks of OFDM can be occur in the continuous-time domain; so that to overcome such issues, we provide a simulation tool. Therefore, the first step is to generate a continuous time signal by using a filter g (t), to the complex signal carriers. In Figure (3.3), the pulse or impulse response of g (t), filter response is shown in figure (3.4).

In Figure (3.5), (3.6), (3.7) and (3.8) is in the time and frequency-domain. The frequency response of these figures are periodic as required of the frequency response of a discrete-time system , and the bandwidth of the spectrum in this figure is given by 2/T, and if we uses an N-IFFT, then it requires a very sharp reel-off, hence occurs high complexity, in the reconstruction filter to avoid aliasing. The proposed reconstruction or D/A filter response is shown in figure (3.4), the cut-off frequency of this filter is approx 1/T. Now another step is to perform the quadrature multiplex double-sideband amplitude modulation of {uoft (t)}. In this scheme, an in-phase and a quadrature signal be modulated using by given formula.

$$s(t) = \left[\{m_{In}(t)[\cos 2\pi f_c t\} + \{m_{Quad}(t)[\sin 2\pi f_c t\}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

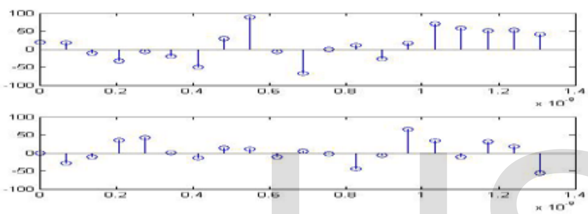

Figure 3.1 Time Response of signal carrier.

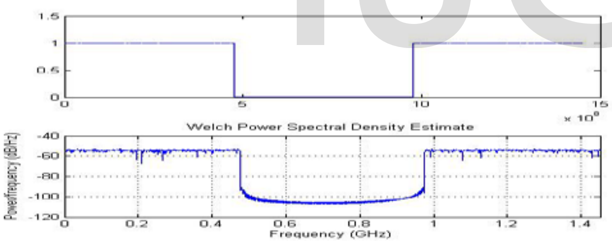

Figure 3.2 Frequency Responses.

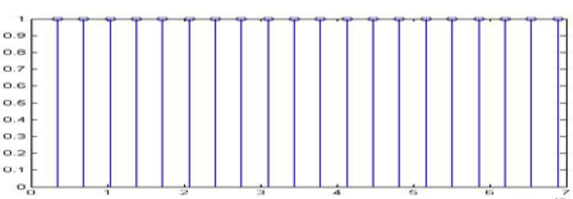

Figure 3.3 Pulse Shape.

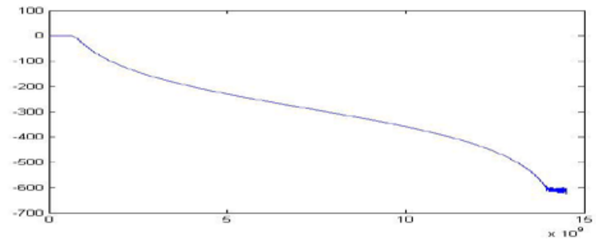

Figure 3.4 Filter Responses.

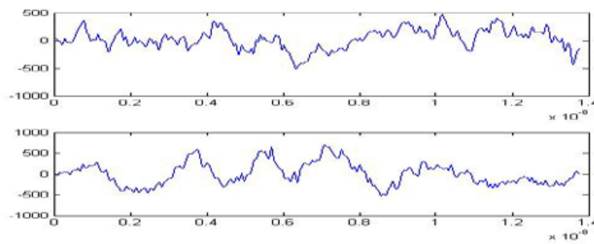

Figure3.5 Time Response

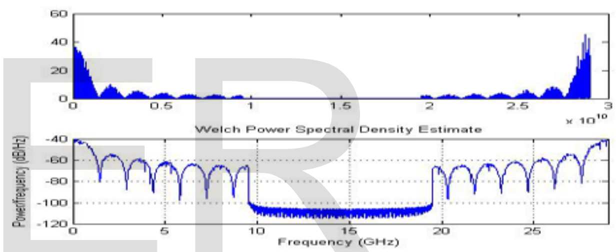

Figure 3.6 Frequency Responses.

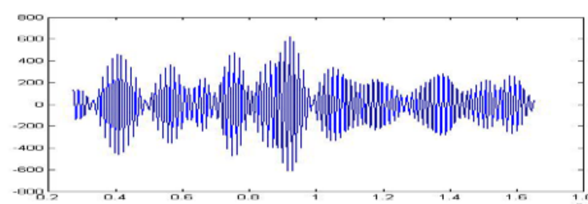

Figure 3.7 Time response

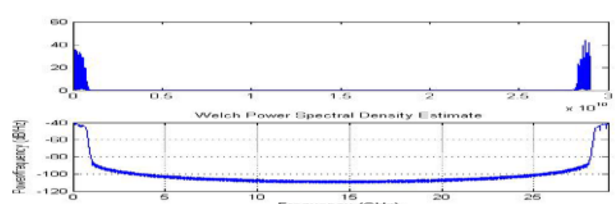

Figure 3.8 Frequency Responses.

ISSN 2229-5518

5.4 Proposed DVB Reception

Most of the modifications and implementations are done at the receiver side, e. g; the frequency sensitivity drawback is a main transmission channel issue, which is occur at the receiver side; therefore, we will simply present a basic receiver structure in this paper; as shown below.

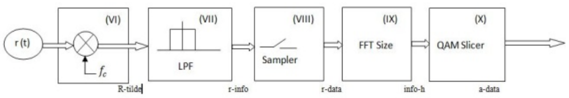

Figure 4 Proposed DVB-T Receivers.

The results of this model are shown in figures (4.1) to (4.3) as shown below.

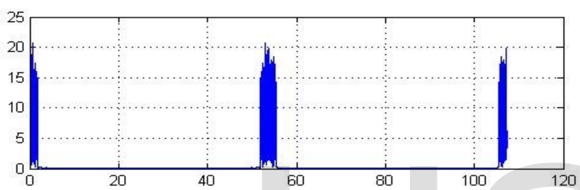

Figure 4.1 Frequency Response

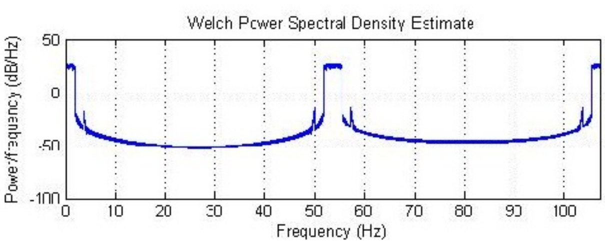

Figure 4.2 Frequency Response

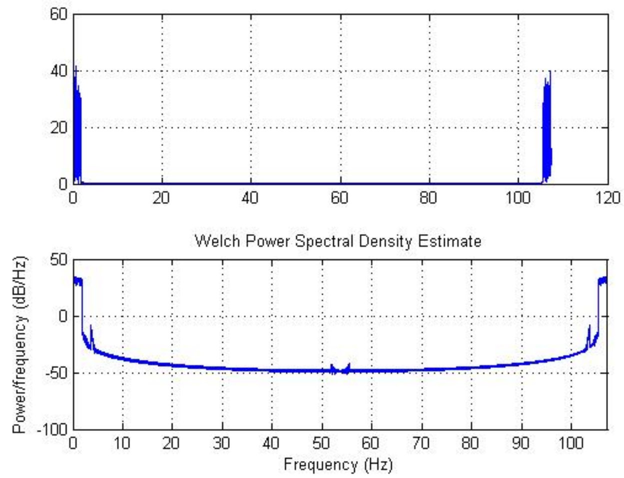

Figure 4.3 Frequency Responses.

6 Conclusions

There are many advantages in OFDM, but there are still many complex problems to solve. The motto of this paper is to provide better data transmission and reception facility via basic simulation tool (Mat Lab).The modulation schemes and other parameters are used in this paper provides more BW efficiency, reduction of system complexity and interferences. So far, the model and the techniques used in this paper are more efficient than the past DVB-T module. I hope that by using the specifications as a working system, as an example of DTT System, provides better explanation of the OFDM; Thank You.

7 References

[1] ETS 300 744, "Digital broadcasting systems for television, sound and data services; framing structure, channel coding, and modulation for digital terrestrial television", European Telecommunication Standard, Doc. 300 744, 1997.

[2] ETSI EN 300 744, "Digital Video Broadcasting (DVB): Framing Structure, Channel Coding and modulation for digital terrestrial television", European Standard (Telecommunication series), V1.5.1 (2004-06).

[3] ETSI EN 300 744, "Digital Video Broadcasting (DVB): Framing structure, channel coding and modulation for digital terrestrial television", European Standard (Telecommunications series), V1.6.1 (2009-01).

[4] Richard van Nee and Ram jee Prasad, OFDM for wireless multimedia communications Artech House, and Inc. Norwood, MA, USA ©2000 ISBN: 0890065306.

[5] Wireless Communication: Principle and Practice, 2/E, Rapp port Theodore S, Pearson Education India, 2010, ISBN: 8131731863, 9788131731864.

[6] Digital communication, John G. Proakis, 4th Edition, Mc Graw Hill.

[7] OFDM: Principles and Challenges, Nicola Marchetti, Sanjay Kumar, and Ramjee Prasad, Center for Tele-In-Frastruktur (CTIF), Aalborg University, Denmark, Muhammad Imadur Rahman, Ericsson Research, Kista, Sweden, V. Tarokh (ed.), New Directions in Wireless Communications Research, DOI 10.1007/978-1-4419-0673-1 2, © Springer Science + Business Media, LLC 2009.

[8] OFDM and Its Wireless Applications: A Survey, Taewon Hwang, Chenyang Yang, Senior Member, IEEE, Gang Wu, Member, IEEE, Shaoqian Li, and Geoffrey Ye Li, Fellow, IEEE, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 58, NO. 4, MAY 2009.

[9] ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING FOR WIRELESS CHANNELS, Leonard J. Cimini, Jr., AT&T Labs – Research , 100 Schulz Dr., Rm. 4-146 , Red Bank, NJ 07701-7033, USA, Ye (Geoffrey) Li , AT&T Labs – Research, 100 Schulz Dr., Rm. 4-152, Red Bank, NJ 07701-7033, USA.

[10] Orthogonal Frequency Division Multiplex (OFDM) Tutorial: Intuitive Guide to Principles of Communications, www.complextoreal.com.

[11] Digital Terrestrial Television, DVB Fact Sheet - August 2012.

[12] Companding Techniques for PAPR Reduction in DVB-T Systems, Biserka Petrovska, Student Member, IEEE, Liljana Gavrilovska, Senior Member, IEEE, and Valentin Rakovic, Student Member, IEEE.

[13] www.digitag.org.

Rohit Kumar (M.Tech Student), School of Electronic and Communication Engineering, Lovely Professional University, Punjab, India.PH.8284904313E-mail: rohit.mailrps.kumar@gmail.com

Mr. Amrinder Pal Singh Kalsi, (Assist. Professor), School of Electronic and Communication Engineering, Lovely Professional University, Punjab, India.PH. 7696443544 E-mail: arvinder.17120@lpu.co.in

s