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Effective BER performance for Spectrum- and Energy- Efficient OFDM Based Wi-MAX System

M. Rajani Devi
Associate Professor/Department of ECE
Vardhaman college, Shamshabad, India

Gopanbai Shwetha
PG Scholar/Department of ECE
Vardhaman college, Shamshabad

***Abstract*—TDS-OFDM is an effective multi carrier modulation scheme to improve the spectrum efficiency. For TDS-OFDM systems, the TS and the OFDM information block inside of each TDS-OFDM symbol will acquaint mutual interference with one another. So consider Orthogonal Frequency Division Multiplexing (OFDM) based WiMAX (Worldwide Interoperability for Microwave Access) is the result in this direction which guarantees to tackle the last mile access innovation to give rapid web access in the private and also little and medium estimated venture parts. In this paper Bit Error Rate (BER) execution of the WiMAX Physical layer baseband have investigated which is fitting in with the parameters built up by IEEE 802.16 benchmarks under distinctive Guard time intervals between OFDM symbols. The performance was also extended for different length in digital modulation schemes. For Wi-MAX extension considering 100 OFDM symbols with ¼ th cyclic prefix so getting good performance on BER (Bit Error Rate) and MSE (Mean Square Error) of the OFDM channel.**

***Index terms*- Interference cancellation, spectrum and energy efficiency, TDS-OFDM, Wi- MAX, BER (Bit Error Rate), MSE (Mean Square Error).**

I. INTRODUCTION

OFDM has as of now been broadly received by various wireless communication systems like DVB-T, WiMAX, LTE, WiFi, and so forth, and it is additionally generally perceived as a conspicuous balance method for future remote communication systems [1], [2].

Fundamentally, there are three sorts of OFDM [3]: cyclic prefix OFDM (CP-OFDM), zero cushioning OFDM (ZP-OFDM), and time space synchronous OFDM (TDS-OFDM). The well known CP-OFDM uses a CP as a watchman interim to lighten Inter Block- Interference (IBI) in multipath channels [4]. The CP is supplanted by a ZP in ZP-OFDM to handle the channel transmission zeros issue. TDS-OFDM embraces a known pseudorandom Noise (PN) succession as a gatekeeper interim and also a training sequence (TS) for synchronization and channel estimation, so the generally utilized recurrence space pilots are a bit much anymore and in like manner the spectrum efficiency can be progressed. TDS-OFDM is the key innovation of one universal computerized TV standard called digital terrestrial multimedia/television broadcasting (DTMB) [5], which has been effectively sent in China, Laos, Cuba, and some different nations [6]. Then again, in multipath channels, the shared obstructions between the PN grouping and the OFDM information square set aside a few minutes space channel estimation and recurrence area information demodulation commonly contingent, so an iterative interference calculation [3], [7] must be executed, which tragically can't uproot the interference totally. Like the pilot boosting procedure [8] in CP-OFDM, the DTMB standard expands the force of the PN arrangement in TDS-OFDM to lighten the obstruction and after that enhance the channel estimation execution. Such power boosting procedure won't diminish the energy efficiency, yet experiences decreased energy efficiency, particularly when the guard interval length ought to be long in broadcasting systems with the scope span up to many kilometers or considerably bigger.

WiMAX is based upon IEEE 802.16e-2005, endorsed in December 2005. It is a supplement to the thus the real standard is 802.16-2004 as corrected by 802.16e-2005. The first form of the standard on which WiMAX is based determined a physical layer working in the 10 to 66 GHz range. 802.16a overhauled in 2004 to 802.16-2004, included particulars range. 802.16-2004 was upgraded by 802.16e-2005 in 2005 and utilizes scalable orthogonal frequency-division multiple access (SOFDMA) which is a technique encoding digital data on multiple carrier frequencies. OFDM has formed into a prominent plan for wideband computerized correspondence, whether remote alternately over copper wires, utilized as a part of uses, for example, advanced TV and sound TV. SOFDMA instead of fixed orthogonal frequency - division multiplexing (OFDM) form with 256 sub- carriers (of which 200 are utilized) in 802.16d. More propelled forms, including 802.16e, multiple antenna support through MIMO (multiple input multiple output). This gets potential advantages terms of scope, self establishment, power utilization, recurrence reuse and data transfer capacity effectiveness. WiMAX is the most vitality proficient pre-4G method among LTE and HSPA+.

In this paper, TDS-OFDM and WiMAX transceiver system has been developed for this BER and MSE performance results to shown the betterment between existing and proposed system.

Whatever is left of this paper is organized as follows. Segment II presents the system model. Segment III locations the proposed TDS-OFDM taking into account SCS, WiMAX scheme analysis and performance evaluation are given in Section IV and Section V given simulation results, separately. At last, conclusions are made in Section VI.

II. RELATED WORK

Spectrum and energy efficiency are of great importance for present and future wireless communication systems. OFDM has already been extensively adopted by numerous wireless communication systems. Thus, developing spectrum- and energy-efficient OFDM scheme is essential to achieve high transmission efficiency and low energy consumption. One direct way to increase the OFDM system spectrum efficiency is to use higher order of modulations. Wimax scheme also discussed below.

Due to the robustness to the frequency-selective multipath channel and the low complexity of the frequency domain equalizer, orthogonal frequency division multiplexing (OFDM) has been widely recognized as one of the key techniques for the next generation broadband wireless communication (BWC) systems.

A. Problem Outline:

Time domain synchronous OFDM (TDS-OFDM) have an energy efficiency and higher spectrum than standard cyclic prefix OFDM (CP-OFDM) by replacing the known pseudo random noise (PN) sequence in place of unknown CP. However, due to mutual interference between the OFDM data block and the PN sequence, TDS-OFDM could not support high-order modulation scheme such as 256QAM in realistic static channels with large delay spread or high-definition television (HDTV) delivery in fast fading channels.

B. Simultaneous multi-channel reconstruction based on A-SOMP

Several signal reconstruction algorithms in customary CS theory are extended to the SCS framework to realize put together distributed signals reconstruction. Among them, SOMP derived from the well-known OMP scheme has drawn in depth attention because of its satisfying reconstruction quality. The key plan of SOMP is to search out solution by consecutive choosing a small set of column vectors of to approximate the observation matrix in an reiterative manner.

However, SOMP needs before the familiar sparsity level and therefore the range of observations, each of which can be variable and unavailable in sensible applications. Moreover, since matrix inversion is needed in every iteration step, SOMP includes a high procedure quality for hardware implementation. To avoid these issues of SOMP, used adaptive SOMP (A-SOMP) algorithmic rule supported the fundamental principle of SOMP, whereby the precise options of TDS-OFDM are also exploited to get partial priori info of the channel, which incorporates the estimated sparsity level, CIR length, and partial support of the channel. These info is employed by the A-SOMP algorithmic rule to cut back the procedure quality also on create it adaptive to the channel variation. Supported the fundamental principle of well-known sparse signal recovery algorithmic rule SOMP, we have a tendency to used the adaptive SOMP(A-SOMP) algorithm, that is adaptive to variable channel conditions.

C. IEEE 802.16 WiMAX PHY Layer

This segment examines about the OFDM based IEEE 802.16 PHY layer which can be utilized with the MAC layer to give a solid end-to-end link. Orthogonal Frequency-Division Multiplexing (OFDM) is the key improvement in the WiMAX PHY layer that make it impervious to multipath fading effects and inter symbol interference (ISI). Addition of cyclic prefix is the key operation for ISI removal. OFDM is gotten from the way that the high serial bit stream information was transmitted over large (parallel) number sub- carriers (acquired by partitioning the available bandwidth), each of an alternate frequency and these carriers were orthogonal to one another. OFDM changes over frequency selective fading channel into N flat fading channels, where N is the number of sub-carriers. Othogonality is kept up by keeping the carrier spacing multiple of $1/T_s$ by utilizing Fourier transform methods, where T_s is the symbol duration. Since channel coding is applied prior to OFDM symbol generation which represents the term `coded' in COFDM. Fig. 1 beneath presents the point by point block diagram of an OFDM Transceiver.

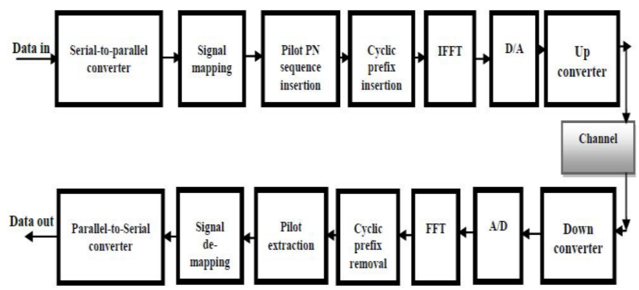

Figure 1. Block diagram of an OFDM Transceiver

III. SCS-AIDED TDS-OFDM SCHEME

As demonstrated in Fig. 2, in this area propose a dependable and energy-efficient TDS-OFDM transmission scheme with lessened guard interval power taking into account the hypothesis of SCS. The relating investigation of the execution bound and the computational many-sided quality are likewise provided.

A. Channel Sparsity and Inter-Channel Correlation

Numerous hypothetical examinations and exploratory results have affirmed that the wireless channels are sparse in nature particularly in broadband wireless communications [15]. More specifically, the CIR $\mathbf{h}i = [hi, 0, hi,1, \ldots, hi,L-1]T$ comprising of Si resolvable propagation paths can be modeled as

$$h_{i,n}=\sum_{l=0}^{si-1} \alpha_{i,l}\delta\left[n-T_{i,l}\right], 0 \leq n \leq L-1, \ldots(1)$$

where αi,l is the addition of the lth way, τi,l is the deferral of the lth way standardized to the testing period at the beneficiary, and the way postpone set Di is characterized as Di = {τi,0, τi,1, ..., τi,Si−1}. Channel sparsity implies Si _ L. In addition, time-differing remote channel has the property of between channel relationship because of the way that the way defers change much slower than the way picks up [10], e.g., regardless of the fact that the way picks up are fluctuating altogether starting with one image then onto the next image, the way defers amid a few progressive TDS-OFDM images commonly stay unaltered. The reason is that, the intelligibility time of the quick time-differing way picks up is contrarily relatively to the framework's working bearer recurrence, while the way postpone variety is conversely relatively to the sign data transmission, and as a rule the signal bandwidth is much littler than the carrier frequency.

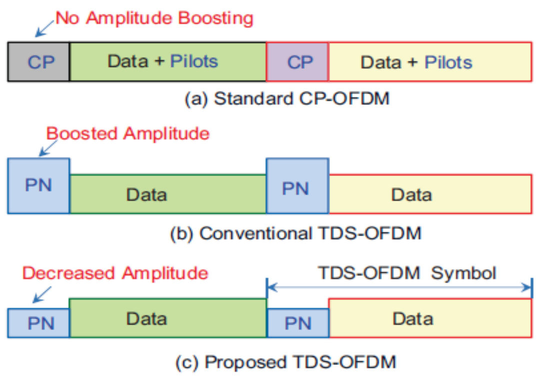

Figure 2. Comparison of the guard interval power: (a) No power boosting in CP-OFDM; (b) Boosted power in conventional TDS-OFDM with iterative interference cancellation; (c) Decreased power in the proposed TDS-OFDM based on SCS.

All the more particularly, the CIR segment vectors in R consecutive TDS-OFDM symbols can be expected to have the same sparsity pattern.i.e.,

$$\begin{cases} S_i = S_{i+1} = \cdots = S_{i+R-1} = S, \\ D_i = D_{i+1} = \cdots = D_{i+R-1} = D, \\ \tau_{i,l} = \tau_{i+1,l} = \cdots = \tau_{i+R-1,l} = \tau_l, \end{cases} \quad \ldots(2)$$

$$\mathrm{H} = [\mathrm{h}_i, \mathrm{h}_{i+1}, \ldots, \mathrm{h}_{i+R-1}], \quad \ldots(3)$$

which was said to be jointly *S*-sparse, i.e., **H** has *S* nonzero rows with indices *D* in (3).

Exploit these channel properties, which were not considered in conventional TDS-OFDM systems, to realize accurate channel estimation.

B. Spectrum Efficiency

The normalized spectrum efficiency of the thought of OFDM themes compared with the ideal OFDM scheme with none overhead (i.e., no time-domain guard interval and no frequency-domain pilots).

$$\gamma_0 = \frac{N_{data}}{N_{data} + N_{pilot}} \times \frac{N}{N+M} \times 100, \quad \ldots(4)$$

where and denote the amount of knowledge subcarriers and pilot subcarriers, severally. Table one compares the spectrum efficiency of the proposed theme with the traditional OFDM schemes in typical wireless broadcasting applications with the 4K mode once an equivalent constellation is employed. It's clear that the proposed theme has the best spectrum efficiency just like that of the traditional TDS-OFDM theme, and outperforms CP-OFDM by over 10 percent in typical applications. Additionally, as are going to be incontestable later in this Section that the proposed SCS-aided TDS-OFDM theme will support 256QAM in realistic static channels with massive delay unfold, whereas the traditional TDS-OFDM theme will solely support 64QAM in such eventualities, we are able to acquire a better spectrum efficiency by concerning 30% than this TDS-OFDM based mostly DTMB customary while not dynamical the signal structure. As mentioned in on top of Section that within the extreme case that the particular CIR length equals the guard interval length, we are able to extend the TS within the planned TDS-OFDM theme so Associate in Nursing IBI-free region will be still provided. Note that such TS extension can scale back the spectrum potency. This may be additional quantified later in that solely Associate in Nursing IBI-free region of length twenty five is spare to produce correct multi-channel reconstruction once , which suggests that the original length-256 TS ought to be extended by only twenty five samples to get the mandatory IBI-free region. The corresponding spectrum efficiency will going to be reduced from 94.12% to 93.58%, that corresponds to a negligible spectrum efficiency penalty as little as 0.54%.

Table. 1. Spectrual effecency comparision

	CP – OFDM	TDS-OFDM	Spectrum and Energy efficient - OFDM	Proposed Wimax scheme
M=N/4	70.97	80.00	80.00	80.00
M=N/8	78.85	88.89	88.89	88.89
M=N/16	83.49	94.12	94.12	94.12

C. Energy Efficiency

The energy efficiency of practical OFDM systems is

$$\eta_0 = \frac{N_{data}}{N_{data} + \beta^2 N_{pilot}} \times \frac{N}{N+\alpha^2 M} \times 100\% \quad \ldots(5)$$

where *β* and *α* denotes the amplitude factor imposed on the frequency-domain pilots and time-domain guard interval, respectively. For example, $\beta = 4/3$ in CP-OFDM has been specified by the DVB-T2 standard, and similarly, $\alpha = \sqrt{2}$ in conventional TDS-OFDM has been specified by the DTMB standard. On the contrary, the proposed scheme can reduce the guard interval power by relying on the powerful SCS theory to significantly improve the channel estimation performance.

When the amplitude factor $\alpha = 1/\sqrt{2}$ is considered for the proposed scheme, Table 2 summaries the energy efficiency comparison of different OFDM transmission systems. It is clear that in typical single frequency network (SFN) applications when $M = N/4$, the conventional TDS-OFDM has very similar energy efficiency as standard CP-OFDM. However, the proposed SCS-aided TDS-OFDM scheme has a 23.66% higher energy efficiency than standard CP-OFDM. Although such improvement becomes slightly smaller when the guard interval length is decreased, more than 20% higher energy efficiency1 can be still achieved when $M = N/8$ or $M = N/16$.

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Table. 2. Energy efficiency comparison

	CP – OFDM	TDS-OFDM	Spectrum and Energy efficient - OFDM	Proposed Wimax scheme
M=N/4	65.23	66.67	88.89	90.00
M=N/8	72.48	80.00	94.12	97.87
M=N/16	76.75	88.89	96.97	98.45

IV. PROPOSED METHODOLOGY

The process of Wi-Max technology is going to give fast communication between user and server. The IEEE 802.16 standard, commonly known as WiMAX, was the latest technology that has promised to offer broadband wireless access over long distance. Since 2001 WiMAX have evolved from 802.16 to 802.16d for fixed wireless access, and to the new IEEE 802.16e standard with mobility support.

In this paper, a novel, low-complexity, high-speed, and resource-efficient address generator for the channel de-inter leaver used in the WiMAX transreceiver eliminating the requirement of floor function is proposed. As compared with the complicated and lengthy expressions, particularly for 64-QAM and 256-QAM, due to the 2-D translation, a compact and user-friendly mathematical representation and subsequent algorithm is proposed.

A. OFDM based Wi-Max system

This section examines the simulation model executed by us in MATLAB environment to assess BER performance analysis of IEEE 802.16 OFDM based WiMAX system fitting in with the parameters as indicated by proposed system. The useful pieces of baseband WiMAX handset is delineated in Fig. 4. In the transmitter part the information from the source is randomized first and after that subjected to forward error correction (FEC) Encoder utilizing punctured convolutional codes with variable code rates. The coded information is then mapped into QPSK/QAM symbols. Beforehand, multi-carrier systems were implemented through the use of separate local oscillator. This was both inefficient and expensive. With the appearance of shoddy effective DSP processors, the sub-carriers can now be executed by the fast Fourier transform algorithms (FFT) which keep sub-transporters orthogonal with one another. The image is regulated onto sub bearers by applying the Inverse Fast Fourier Transform (IFFT). The yield is changed over to serial data and a cyclic prefix is added to make the system robust to inter-symbol interference (ISI). In channel, additive white Gaussian noise characteristics are brought alongside the fading Rayleigh channel. The receiver performs the converse operations of the transmitter. The vital blocks of the simulation model is discussed in detail as follows:

1. Randomizer

To stay away from long sequence of continuous ones and zeros the data bits is randomized before the transmission. This guarantees suitable vitality dispersal in the transmitted signal minimizes the possibility of transmissions of non-modulated sub carriers. This is actualized with a Pseudo Random Binary Sequence (PRBS) generator which utilizes a 15- stage shift register with a generator polynomial of $1 + x_{14} + x_{15}$ with XOR gates in feedback as demonstrated in Fig. 3.

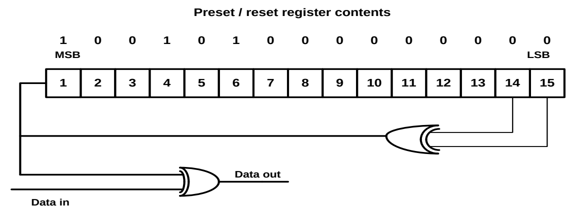

Figure 3. Randomizer.

2. FEC Encoder

This FEC encoder block comprises of a connecting of an external Reed Solomon (RS) code and an internal convolutional code (CC) as a FEC scheme. The last block of the encoder is an interleaver to keep away from long burst errors. The RS encoder executed is a systematic RS code utilizing 100 OFDM symbols. After the RS encoding process, the data bits are further encoded by a binary Convolutional encoder, which has a mother code rate of 1/4 and a rate_id of 1.

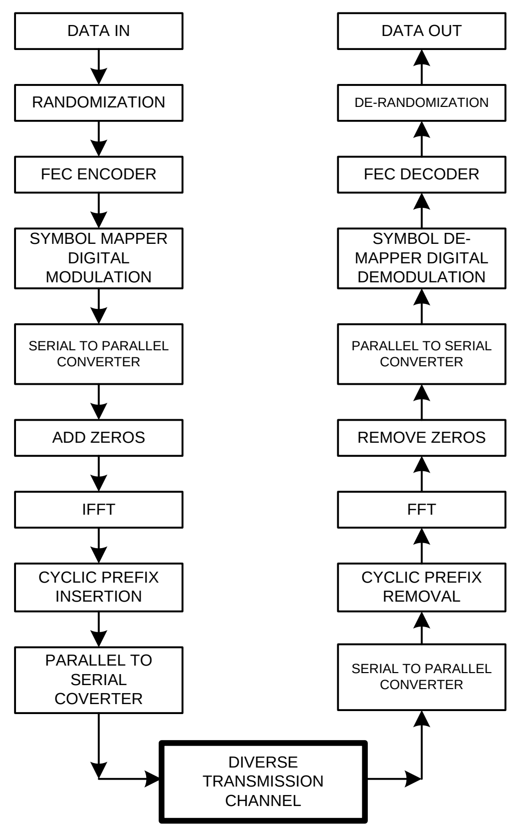

Figure 4. Simulation model of WiMAX-PHY layer.

3. Digital Modulation Mapper

In this part, after interleaving data and channel coding are then entered serially to the digital modulation mapper that support grey- mapped BPSK, QPSK, 64-QAM, and 256-QAM as specified in the standard.

The bits are mapped to a subcarrier stage and plentifulness, which was represented by complex quadrature-phase (IQ) and in-phase vector. The IQ plot for a QAM modulation scheme demonstrating the transmitted vector for all information word blends. Dim coding has been utilized for this allotment so that nearby focuses in the group of stars just contrast by a solitary bit. This coding serves to minimize the general bit error rate as it lessens the possibility of multiple bit errors occurring from a single symbol error.

4. Channel

At long last to assess the execution of the created WiMAX communication system, the transmitted signal is presented to three paths fading channels. The wireless channel composed utilize the impact of Multipath delay spread, Path loss(including shadowing), Doppler spread, Fading characteristics, Co channel and nearby channel interference.

5. Guard Time

However, it is clear that a reliable PN-based channel estimation requires a correctly demodulated previous OFDM data block as well as accurate channel information to remove the interference imposed on the received PN sequence. Similarly, a correct data demodulation requires accurate channel information to remove the interference on the OFDM data block caused by the previous PN sequence. That is to say, the coupled channel estimation and data demodulation are mutually conditional due to the mutual interference. Therefore, the classical iterative interference cancellation algorithm has been proposed to refine channel estimation and data demodulation iteratively.

V. SIMULATION RESULTS

Simulation was done on MATLAB R2012a, the results were demonstrated that the Extensive recreations have been completed to explore and accept the execution of the SCS-aided TDS-OFDM scheme based on simultaneous multi-channel reconstruction. The reproduction setup is arranged by regular remote broadcasting systems.

Figs. 5 and 6 present the MSE and BER performance comparison in a fast block fading channel with a velocity of 120 km/h with proposed scheme. Let observe that the performance of MSE is degraded for all considered schemes, especially for conventional TDS-OFDM scheme where the mutual interference severely deteriorates the system performance in fast time-varying channels. However, compared with conventional TDS-OFDM and DPN-OFDM schemes, the proposed solution still has a SNR gain of more than 5 dB in this case, and the MSE is as small as when the receiver SNR is 20 dB.

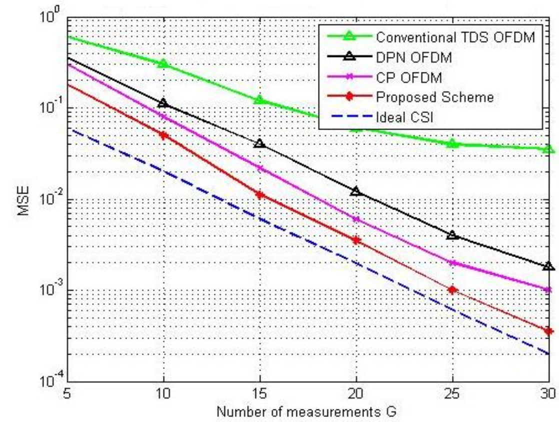

Figure 5. Channel estimation comparison in previous and proposed scheme.

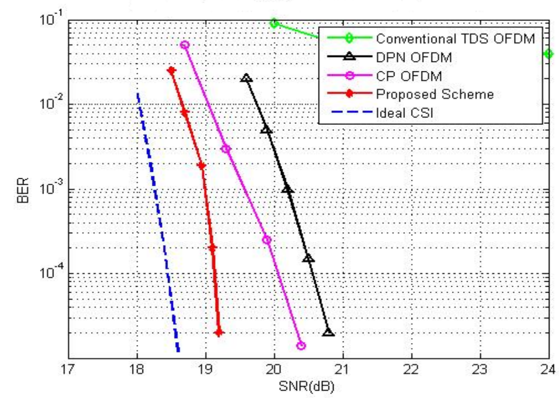

Figure 6. BER performance comparison when HDTV is delivered (64QAM together with the LDPC code rate of 0.6) in a fast fading Vehicular B channel with a velocity of 120 km/h.

Fig. 7 looks at the coded BER performance when 256QAM is embraced in a static channel. The BER performance with the perfect channel state information (CSI) is additionally included as the benchmark for comparison. Watched that the routine TDS-OFDM method can't bolster 256QAM in light of the fact that the shared impedance between the TS and OFDM information piece can't be uprooted well. On the other hand, the proposed SCS helped TDS-OFDM method can bolster 256QAM dependably, since exceptionally exact channel estimation as showed by Fig.8 can be utilized to proficiently evacuate the common obstruction. In addition, inferable from the decoupling of the time-domain channel estimation and frequency-domain data detection, and also the high channel estimation precision, the proposed scheme additionally has a superior BER execution than DPN-OFDM and CP-OFDM with a SNR gain of around 0.5 dB and 0.2 dB at a BER of, separately.

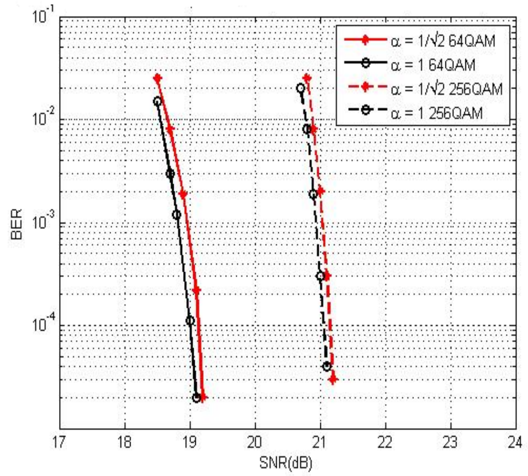

Figure 7. The impact of decreased amplitude of the guard interval on the system BER performance.

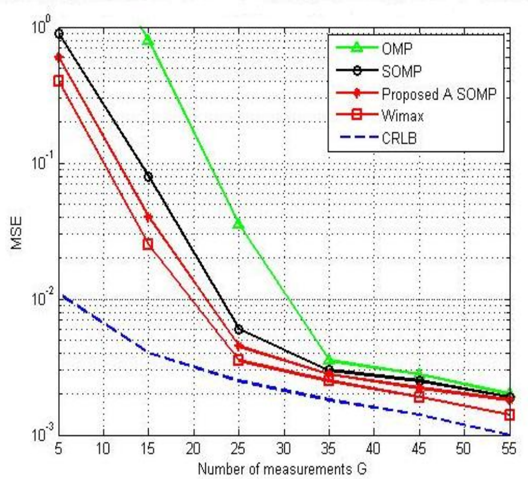

Figure 8. MSE performance using WiMAX in a Vehicular channel

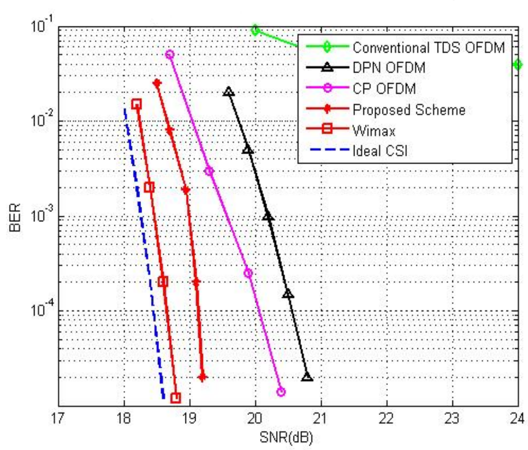

Figure 9. BER performance comparison for convolutional and proposed Wimax schemes

VI. CONCLUSION

In this paper, more spectrum and energy-efficient distinct option for the standard CP-OFDM scheme has been developed, whereby the hypothesis of SCS is abused to empower TDS-OFDM to support high-order modulation schemes, for example, 256QAM in realistic static channel with huge delay spread and HDTV delivery in fast fading channels. The key commitment of this paper was the execution PHY layer of IEEE 802.16 OFDM based WiMAX system to assess BER execution under 1/4th Guard time interval. It was demonstrated that watch time of ¼ th gives better resistant to inters symbol interference (ISI). The implemented PHY layer supports all the coding schemes and modulation characterized in the standard. Contrasted with past systems Wi-Max technique MSE and BER execution is better which is demonstrated in figure 9 and 10.

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Authors Profile

M. Rajani Devi received the **B.Tech** degree in electronics and communication engineering from Bapatla Engineering College, Bapatla, Nagarjuna University, Andhrapradesh, India, in 2004. received the **M.Tech** in Digital Communications from Kakatiya University, Warangal, India. Her research interest includes wireless communication (**WiFi,WiMax**), Communication networks

Gopanbai Shwetha received the **B.Tech.** degree in Electronics and Communication engineering from the Mallareddy Engineering College for women, JNTU University, Hyderabad, India, in 2013. Currently doing **M.Tech.** in electronics and communication engineering (Digital electronics and communication systems) in Vardhaman College of Engineering, Shamshabad, India. Her research interest includes wireless communication.