Implementation of WIMAX IEEE802.16d Baseband Transceiver on Multi-Core Software-Defined Radio Platform

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Abstract: IEEE 802.16d was developed for WIMAX wireless communication, which is based on orthogonal frequency division multiplexing (OFDM) technology, to enable advancement towards 4G The last decade have seen growing importance place on research in wireless communication system. A recent surge of research on WIMAX has given us opportunities and challenges. In this paper, we describe the implementation of WIMAX baseband transceiver on multi-core Software-defined radio (SDR) platform. This work presents a new approach to the adaptation of WIMAX technology on the basis of SFF SDR development platform. The proposed WIMAX system was modelled-tested, and its performance was found to comply with Stanford University Interim (SUI) Channel Models that have been elected for the wireless channel in the simulation process. The performance results of the simulated on different modulation systems were also compared among themselves.

Key-Words: - WIMAX, SFF SDR, OFDM, RS, Coding, SUI, AWGN.

1- Introduction

Broadband access technology has significant influences in the telecommunication industry. It does not only provide faster web surfing but also quicker file downloads, several multimedia applications and reliable voice communications. Today broadband users are restricted to digital subscriber line (DSL) technology, which provides broadband over twisted-pair wires and cable modem technology which delivers over coaxial cable. Both of these wire line infrastructures are highly expensive and time consuming to be deployed compared to the wireless technology. Another way of getting broadband access is through satellite service but it is costly and there is a half second delay between the data transmission and reception. Wireless technology has also clear advantage in rural areas and developing countries which lacks wire infrastructures for broadband services. Worldwide interoperability for microwave access (WIMAX) is a broadband wireless technology which brings broadband experience to a Wireless context. There are two different types of broadband wireless services. One is fixed wireless broadband which is similar to the traditional fixed line broadband access technology like DSL or cable modem but using wireless as a medium of transmission. Another type is broadband wireless, also known as mobile broadband which has additional functionality of portability, mobility and nomadicity. WIMAX promises to solve the last mile problem which refers to the expense and time needed to connect individual homes and offices to trunk route for communications. WIMAX also offers higher peak data rates and greater flexibility than 3G networks [1]. For this purpose, the Software Define Radio (SDR) technology is used at present. SDR allows coexistence of different independent standards, protocols, and services. This signal processing approach is broadly spreading given that reprogramming and reconfiguring of mobile and fixed devices is of great importance. Due to the availability of SDR in the device architecture, a user can update and replace necessary services without changing the hardware.

2-WIMAX 802.16-2004

Earlier version known as 802.16a that was updated to 802.16-2004 (also known as 802.16d) is a WIMAX standard that supports fixed non-line of sight (NLOS) wireless internet services thus forming a point to multipoint deployment scenario. The basic goal of 802.16-2004 standard was to provide a stationary wireless transmission with data rates higher than those provided by DSL and T1, this feature makes fixed WIMAX an alternative for cable, DSL and T1. 802.16-2004 uses Orthogonal Frequency Division Multiplexing (OFDM) for transmission of data thus serving a large number of users in time division manner in round robin fashion. Some of the silent features of 802.16-2004 standards are [2]:

- Designed to provide Fixed NLOS broadband services to Fixed, Nomadic and Portable users
- 256 OFDM PHY with 64QAM, 16QAM, QPSK, and BPSK modulation techniques.
- Support for Advance antenna and Adaptive modulation & coding techniques.
- Facilitates the use of point-to-multipoint mesh topology
- Low latency for delay sensitive services, thus improving on QoS parameters
- Support for both: Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD)

3. SFF SDR Development Platforms

The SFF SDR Development Platform consists of three distinct hardware modules that offer flexible development capabilities: the digital processing, data conversion, and RF module. The digital processing module uses a Virtex-4 FPGA and a DM6446 SoC to offer developers the necessary performance for implementing custom IP and acceleration functions with varying requirements from one protocol to another supported on the same hardware. The data conversion module is equipped with dual-channel analog-to-digital and digital-to-analog converters. The RF module covers a variety of frequency ranges in transmission and reception, allowing it to support a wide range of applications [3].

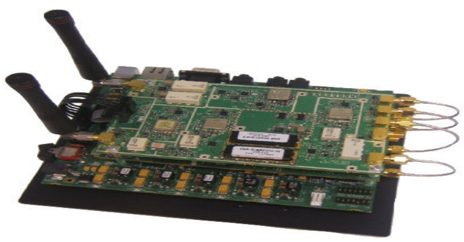

Fig .1. SFF SDR Development Platform[3]

3.1 System performance analysis and optimization target

MathWorks and Texas Instruments (TI), the two companies responsible for the development of Matlab/Simulink, are currently working on the development of a DSP development tool that users can use through Simulink. The object modules, designed to meet their own needs, the programming system, which is implemented through Real- Time Workshop, and the S-function with the TLC (Target Language Compiler) Function of the system design, when completed, can be directly converted to the most commonly used DSP programming language. The DSP, in conjunction with the TI software, Code Composer Studio, is completed in combination with the DSP hardware. Thus, through this development tool, users can work together to complete the design and simulation on the Simulink; however, it cannot provide the convenience of design that could increase the set count on the efficiency.

3.1.1 System integration and implementation of workflow

In the development and testing of IEEE 802.16d Wireless MAN-OFDM PHY, the specifications of communication transfer have varying systems, which are based on our needs under Simulink mentioned in the proposed system for WIMAX IEEE 802.16d. For our study, we used the standard communication system box with a map provided by Matlab, which contains the following: Internal Communications Blockset, Signal processing Blockset, and Simulink Blockset. These correspond to our use of the hardware development platform for SFF SDR DP Blockset. The overall WIMAX PHY system construction is opened in the Simulink interface and Matlab is used to communicate the internal functions of RTW and TLC. We intend to build a finished system into a module, in accordance with the code of each block. Through this, we can perform the compilation and completion that will be automatically compiled in Matlab CCS connecting knot. The CCS establishes a corresponding module under the file name "Project." We then correct the generated C code and conduct compilation, debugging, and analysis. We then download our work into to the DSP. The overall system workflow is shown in Figure 3. The figure shows the system built based on the Simulink-established IEEE 802.16d Wireless MAN-OFDM PHY standard modules. The first step is the configuration by Simulink of the parameters interface and development platform into the conduct of the connecting node configuration. Information will be set to leave the bulk form of a fixed number of patterns, and the RTW system development module is set to be transferred and replaced by C language. Meanwhile, the TLC file option SDR development of modules and the set up Simulink system development are scheduled for DSP link module by an external module through the executive. Configuration of the IEEE 802.16d Wireless MAN-

OFDM PHY may be achieved through the DSP Options Block Simulink to develop interfaces connecting node, development platform, and CCS. The use of the DSP Options Block and the Compiler Options allow us to optimize the system and the executive profit use. Moreover, future compiler optimization can be conducted through the Block. In the SFF SDR Development Platform of the DSP configuration, three kinds of memory are used: L1DRAM (8 KB), L2RAM (64 KB), and SDRAM (8 MB). The L1DRAM and L2RAM are used for the internal memory, while the SDRAM is used for the external memory. Due to the retention of internal memory, the speeds become quicker; thus, if information is to be placed in the internal memory in the system as a whole, the speeds and the executive would enhance performance Thus, the CMD File Generator Block for Development Platform can be conducted into the memory settings [3].

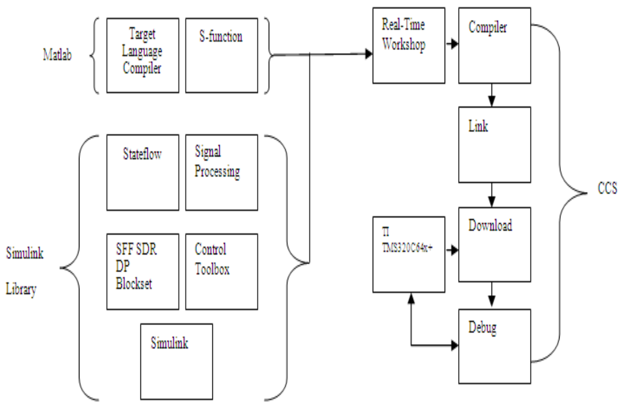

Fig .2. Schematic diagram of the system workflow actions [3].

3.1.2 TLC and RTW

Target Language Compiler (TLC) is a Matlab program that uses syntax. Developers using the RTW tool can use the TLC to create self-designed C syntax language code by adding to the executive after the RTW-generated C language code or design. The use the S-function in the input and output of the set can design its own system for C programming and create Simulink objects in the box to use; however, RTW is only responsible for producing the C language program yards. It will not check the correct use of grammar; thus, performing actions or debugging code requires conducting C into the editor. Moreover, in the design of TLC, all of the program features in metropolis are the function of the type, as shown in Figure 3. Thus, the designer can use the RTW to generate the required developer as long as the C program is appropriately used together with the TLC syntax. The source code, TLC, and RTW program application flowchart is shown in Figure 4 [4].

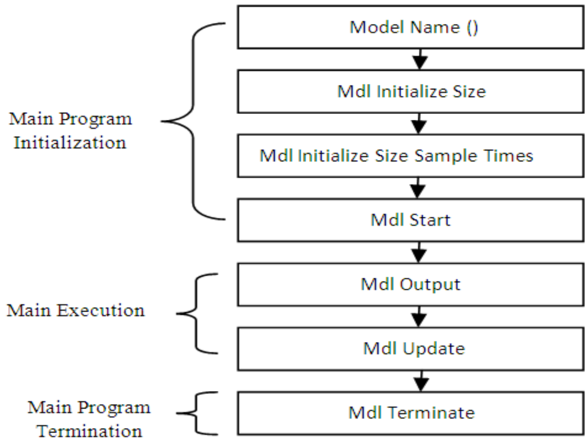

Fig.3.Target Language Compiler grammatical structure [4].

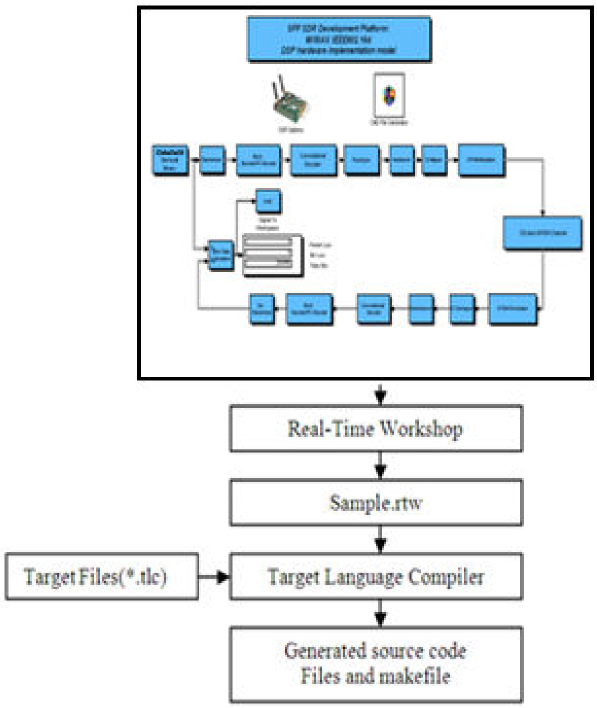

Fig .4. TLC and the RTW program application flowchart.

4-Block Diagram

The Block diagram in figure 5 represents the whole system model or the signal chain at the base band. The block system is divided into 3 main sections namely the transmitter, receiver and the channel. The model has been tested with and without the channel coding (part in doted box representing the channel coding and decoding). The bit error rate

(BER) plots have been obtained for at least 2000 errors to get a good confidence limit.

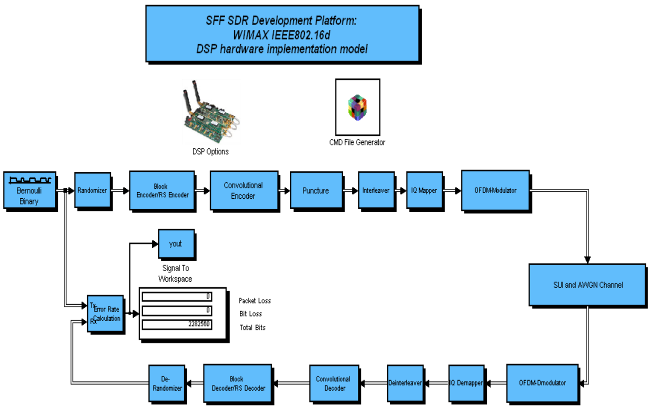

Fig .5. WIMAX IEEE802.16d Software defined radio DSP hardware implementation

4.1-Transmitter model

Figure 5 shows how the transmitted signal is generated and the functions of the sub-modules are briefly described below.

4.1.1 Data Generation:

The data is generated from a random source, consists of a series of ones and zeros. Since the transmission is done block wise, when forward error correction (FEC) is used, the size of the data generated depends on the block size used, modulation scheme used to map the bits to symbols (QPSK, 16QAM), and whether FEC is used or not [5]. The generated data is passed on to the next stage, either to the FEC block or directly to the symbol mapping if FEC is not used.

4.1.2 Forward error correction:

In case error correcting codes are used, the data generated is randomized so as to avoid long run of zeros or ones, the result is ease in carrier recovery at the receiver. The randomized data is encoded where the encoding process consists of a concatenation of an outer Reed-Solomon (RS) code the implemented RS encoder is derived from a systematic RS (N=255, K=239, T=8) code using field generator GF (2^8) [2]. And an inner convolutional code (CC) as a FEC scheme. This means that the first data passes in block format through the RS encoder, and then, it goes across the convolutional encoder. It is a flexible coding process due to the puncturing of the signal, and allows different coding rates. The last part of the encoder is a process of interleaving to avoid long error bursts. Using tail biting convolutional codes (CC) with a coding rate of ½ (puncturing of codes is provided in the standard. Finally interleaving is done by two stage permutation, first to avoid mapping of adjacent coded bits on adjacent subcarriers and the second permutation insures that adjacent coded bits are mapped alternately onto less or more significant bits of the constellation, thus avoiding long runs of lowly reliable bits.

4.1.3 Symbol mapping:

The coded bits (uncoded, if FEC not used) are then mapped to form symbols. Modulation scheme used is BPSK, QPSK, 16QAM and 64QAM unless with gray coding in the constellation map. In any case the symbol is normalized so that the average power is unity, irrespective of the modulation scheme used [5].

4.1.4OFDM Symbol Description

The IEEE 802.16d PHY layer is based on OFDM modulation. OFDM wave form is created by Inverse Fast Fourier transforming: this time duration is referred to as useful symbol time [6]. A copy of the last of the useful symbol period, termed CP, is used to collect multipath, while maintaining the orthogonality of the codes. Data is sent in the form of OFDM symbols. The basic structure of an OFDM symbol is represented in frequency domain. Generally the OFDM symbol is made up from carriers, the number of these carriers determine the FFT to be used. Three sub carrier types are used [6]:
A-Data subcarriers: For data transmission
B-Pilot subcarriers: For various estimation purposes
C- Null subcarriers: no transmission at all, for guard bands and DC carrier
The purpose of the guard bands is to enable the signals to naturally decay and create the FFT 'brick wall' shaping. [6]. It can also be used for canceling the Inter-channel interference.

4.1.4 IFFT and cyclic prefix:

The t-th time domain sample at the n-th subcarrier at the output of IFFT is given by

$$X_t = \sum_{n=0}^{N-1} X_n e^{j\frac{2\pi tn}{N}} \quad 0 \le t \le N-1 \quad (1)$$

Where N is the number of subcarriers and is the data symbol on the n-th subcarrier. From the equation it can inferred that this is equivalent to generation of OFDM symbol. An efficient way of implementing

IDFT is by inverse fast Fourier transform (IFFT). Hence IFFT is used in generation of OFDM symbol. The addition of cyclic prefix is done on the time domain symbol obtained after IFFT. The IFFT size ('N' value) is considered as 256 in simulations. This data is fed to the two channels AWGN and SUI which represents Stanford University Interim Channel Models and also implements multipath as shown in Figure 5,[7].

4.2 Stanford University Interim (SUI) Channel Models

SUI channel models are an extension of the earlier work by AT&T Wireless and Ercegetal [8]. In this model a set of six channels was selected to address three different terrain types that are typical of the continental US [9]. This model can be used for simulations, design, development and testing of technologies suitable for fixed broadband wireless applications [10]. The parameters for the model were selected based upon some statistical models. The tables below depict the parametric view of the six SUI channels.

Table 1: Terrain type for SUI channel

Terrain Type	SUI Channels
C (Mostly flat terrain with light tree densities)	SUI1, SUI2
B (Hilly terrain with light tree density or flat terrain with moderate to heavy tree density)	SUI3, SUI4
A (Hilly terrain with moderate to heavy tree density)	SUI5, SUI6

Table 2: General characteristics of SUI channels

Doppler	Low delay spread	Moderate delay spread	High delay spread
Low	SUI1,2 (High K Factor) SUI3		SUI5
High		SUI4	SUI6

We assume the scenario [11] with the following parameters:

- Cell Size: 7Km
- BTS antenna height: 30 m
- Receive antenna height: 6m
- BTS antenna beamwidth: 120^0
- Receive antenna beamwidth: Omni directional
- Polarization: Vertical only
- 90% cell coverage with 99.9% reliability at each location covered

For the above scenario, the SUI channel parameters are tabulated in Table 3, 4 and 5 according to [11]

Table 3: Delay spread of SUI channels

Channel model	Tap1	Tap2	Tap3	Rms delay spread
	µs			
SUI-1	0	0.4	0.9	0.111
SUI-2	0	0.4	1.1	0.202
SUI-3	0	0.4	0.9	0.264
SUI-4	0	1.5	4	1.257
SUI-5	0	4	10	2.842
SUI-6	0	14	20	5.240

Table 4: Tap power (Omni directional antenna) of SUI channels

Channel model	Tap1	Tap2	Tap3
	dB		
SUI-1	0	-15	-20
SUI-2	0	-12	-15
SUI-3	0	-5	-10
SUI-4	0	-4	-8
SUI-5	0	-5	-10
SUI-6	0	-10	-14

Table 5: 90% K factor (Omni directional antenna) of SUI channels

Channel model	Tap1	Tap2	Tap3
	dB		
SUI-1	4	0	-20
SUI-2	2	0	-15
SUI-3	1	0	-10
SUI-4	0	0	-8
SUI-5	0	0	-10
SUI-6	0	0	-14

In the next section we will discuss about how these parameters have been incorporated to implement SUI channel model for proposed design.

4.2.1 SUI Channel model Simulation

This model can be used for simulations, design, and development and testing of technologies suitable for fixed broadband wireless applications [11]. The parameters for the model were selected based upon some statistical models the channel can be setup to simulate channel coefficients.

A- Power Distribution

To generate channel coefficients with specified distribution and spectral power distribution, the method of filtered noise is used. For each tap a set of complex zero-mean Gaussian distributed numbers is generated with a variance of 0.5 for the real and imaginary part, so the total average power of this distribution is one This way a normalized Raleigh distribution (equivalent to Rice with k=0) is achieved for the magnitude of the complex coefficients. In case of Rician distribution (K>0 implied), a constant path component m has to be added to the Rayleigh set of coefficients. The K factor implies the ratio of the power between the constant part and variable part. The distribution of power is shown below. The total power of each tap is given as [11]:

$$P = |m|^2 + \sigma^2 \tag{2}$$

Where "m" is the complex constant and the variance of complex Gaussian set. 2σ the ratio of powers is:

$$K = |m|^2 / \sigma^2 \tag{3}$$

In equation 2 and 3, the power of the complex Gaussian is given as

$$\sigma^2 = P\frac{1}{K+1} \tag{4}$$

And the power of the constant part is given as

$$|m|^2 = P\frac{K}{K+1} \tag{5}$$

B- Doppler Spectrum

The power spectral density (PSD) functions for these scatter component channel coefficients is given by:

$$S(f) = \begin{cases} 1 - 1.72fo^2 + 0.785fo^4 & |fo| \leq 1 \\ 0 & |fo| \rangle 1 \end{cases} \tag{6}$$

Where, the function is parameterized by a maximum Doppler frequency f_m and $f_{0=1/f_m}$ to generate a set of channel coefficients with this PSD function, the original coefficients are correlated with a filter which amplitude frequency response is:

$$H(f) = \sqrt{S(f)} \tag{7}$$

A non recursive filter and frequency-domain overlap method has been used. Since there are no frequency components higher than, the channel can be represented with a minimum sampling frequency of according to the Nyquist theorem. It is considered that coefficients are sampled at a frequency of and the power of the filter is also normalized to 1 [11].

4.3 Receiver model

The process starts with the removal of the cyclic prefix that was initially added to the transmitted signal as earlier on explained in the transmitter module. After cyclic prefix removal, the data was converted back into frequency domain from the time domain using the FFT. Once the data conversion is completed the data is passed to the De-Modulator where the data is De-modulated according to modulation schemes applied on the data during the transmission. The De-modulation of the data marks the end of the receiver module where the data obtained from De-modulator was compared to original data in the form of Bit Error Rate (BER).

5. System parameters

The reference model specifies a number of parameters that can be found in Table (6, 7)

Table (6) system parameters

BW	1.75MHz
N used	200
n-sampling factor	8/7
Δf -subcarrier spacing	7.8KHz
Tb-useful symbol time	12.8ms
Tg-cyclic prefix time	1/4
Ts-OFDM symbol time	16ms

Table (7) system parameters

Modulation	NCPC	NCBPS
BPSK	1	192
QPSK	2	384
16-QAM	4	768
64-QAM	6	115

6. Simulation Results

In this section the simulation results along with the underlying assumptions are presented. The basic aim of this work is to study the physical layer of WIMAX 802.16d and the corresponding results. First the performance of the system is investigated by using AWGN channel and then SUI channel [11]. The worst performance of the SUI channel is due to multipath effect, delay spread and Doppler effects. Although the impact of the delay spread and the Doppler effect is low so that the major degradation in the performance is due to the multipath effects. There are various methods to reduce the multipath effect. In this model the simulation of the system is repeated and the number of transmitted bits and bit errors are calculated for each simulation. In the end BER rate is estimated as the ratio of the total number of observed errors and the total number of transmitted bits. Let us consider the case system using BPSK, QPSK, 16-QAMand 64-QAM as a modulation scheme and AWGN as a channel. The total number of transmitted bits for 3 OFDM symbols is 1152 bits. If the simulation is repeated 500 times then the total number of transmitted bits is 576000 and the total numbers of bits that are in error are 62768. In the end BER rate is estimated from the above calculations. Same method is adopted for each simulation considered in this system model. The parameters that can be set are number of simulated OFDM symbols, modulation scheme, channel type and range of SNR (Eb/No (Bit Energy-to-Noise Density) values.

6.1 Performance in AWGN Channel

Performance of the system model tested using different modulation schemes i.e. BPSK, QPSK, and 16QAM and 64QAM with an AWGN channel which is considered as an ideal communication channel. Figures 6 show a comparison of the simulation results for BPSK, QPSK, 16-QAM and 64-QAM. It has been concluded from these simulation results that BPSK BER is good accordance with other modulation.

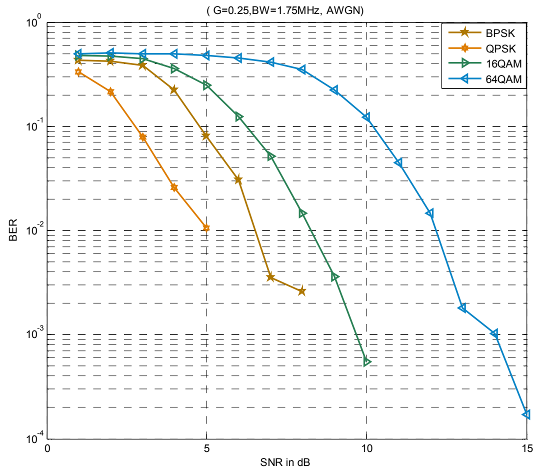

Fig.6. BER of the received symbols (GP=1/4, BW=1.75MHz, AWGN Channel).

6.2 Performance in SUI Channel.

Now the performance of the system model tested using different modulation schemes i.e. BPSK, QPSK, 16QAM and 64QAM with an SUI channels. When the incoming signal is passed through the SUI channel, then the performance of the system degrades due to fading effect and Doppler spread. According to the In this section we have presented various BER vs. SNR plots for all the mandatory modulation and coding profiles as specified in the standard on same channel models.. It can be seen from this figures that the lower modulation and coding scheme provides better performance with less SNR. This can be easily visualized if we look at their constellation mapping; larger distance between adjacent points can tolerate larger noise (which makes the point shift from the original place) at the cost of coding rate. By setting threshold SNR, adaptive modulation schemes can be used to attain highest transmission speed with a target BER. SNR required to attain BER level at 103characteristics of the SUI channel, Rician distribution is used here. So the channel has three paths consisting of un faded LOS path and two Rayleigh components. The required signal is corrupted by the previous multipath model and AWGN. The next Figurers show the performance on SUI1, 2,3,4,5 and 6 respectively, the simulation results for BPSK, QPSK 16QAM and 64QAM with GP=1/4, BW=1.75MHz constant for all simulation.

Table (8) SNR required to attain BER level at $10^{-0.8}$

Modulation	BPSK	QPSK	16QAM	64QAM
Channel	SNR (dB) BER level $10^{-0.8}$			
AWGN	3.2	1.2	4.5	8
SUI1	4	2	5.5	8.2
SUI2	3.5	1.5	4.5	8.5
SUI3	4.2	3.2	6.5	10.5
SUI4	5.5	4.2	7.8	10.1
SUI5	6	6.2	9	10.2
SUI6	5.5	5	8.2	10.5

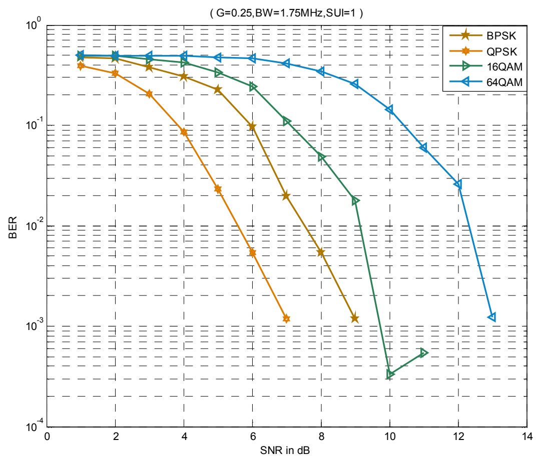

Fig.7.BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=1 Channel).

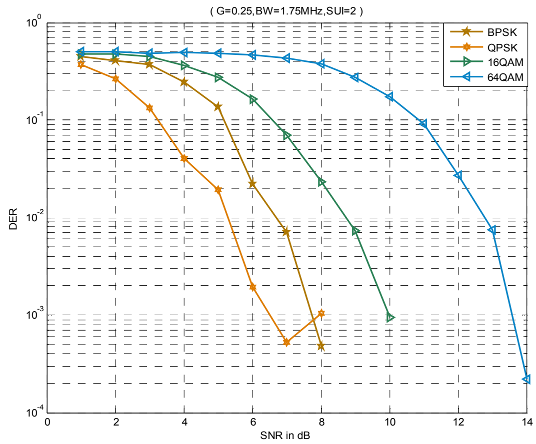

Fig.8. BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=2 Channel)

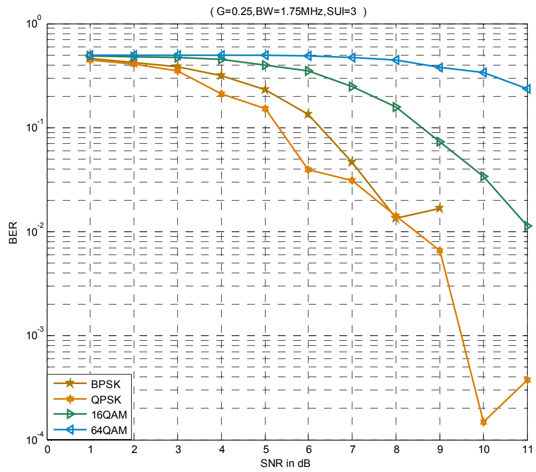

Fig.9. BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=3 Channel).

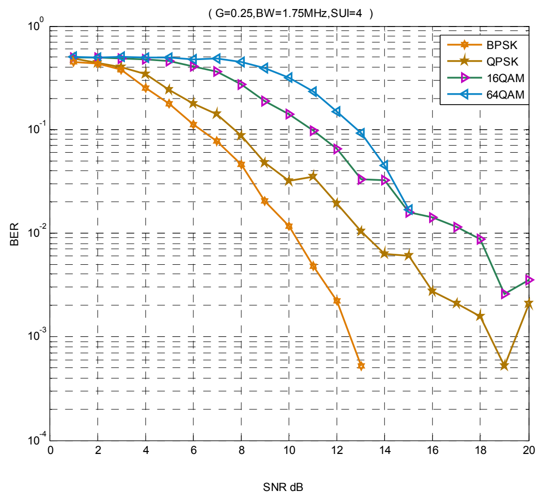

Fig.10. BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=4 Channel).

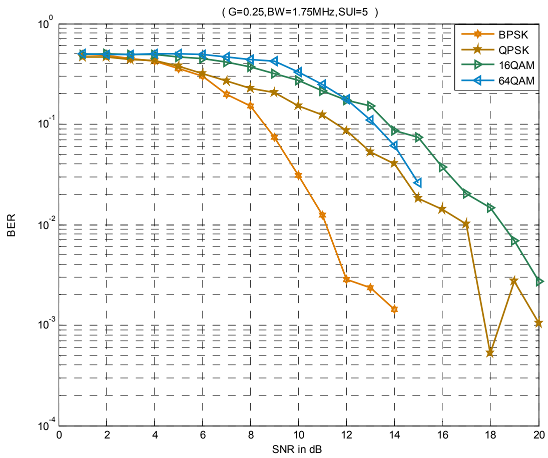

Fig.11. BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=5 Channel).

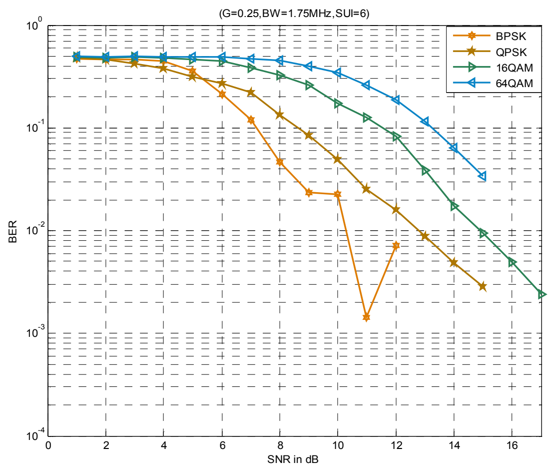

Fig.12. BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=6 Channel).

6.3 Uncoded and Coded BER Plots:

Uncoded and coded BER vs. SNR plot for the different modulation schemes have been presented. Uncoded and coded BER considered here uncoded and coded streams with Reed-Solomon (RS) code with rate (½)tail biting convolutional code (G1 = 171; G2 = 133). Are available in output and BER rate curves as function of SNR are plotted. First using only AWGN channel and then with SUI-1, 2, 3, 4,5and 6 channel. It has been concluded that lower modulation schemes provides better performance with less SNR as shown in table 9

Table (9) SNR required to attain BER level at 10^{-1}

Modulation	BPSK		QPSK		16QAM		64QAM	
	uncoded	coded	uncoded	coded	uncoded	coded	uncoded	coded
Channel	SNR (dB) BER level 10^{-1}							
AWGN	5.5	9	2.7	1	6.5	3	10.3	6.5
SUI1	5	8.5	3	0.9	7	3.5	10.1	6
SUI2	4.8	8	3.5	3.4	11	4	10	2.5
SUI3	7.5	10.5	5.5	1.5	12	5.7	10.5	6
SUI4	8.5	11.1	6.5	2	9.7	4	11.8	7
SUI5	7.5	10.7	7.8	2.5	7.5	3.7	14.1	8.5
SUI6	5.2	9	7	3.2	6.7	3.1	12	7.7

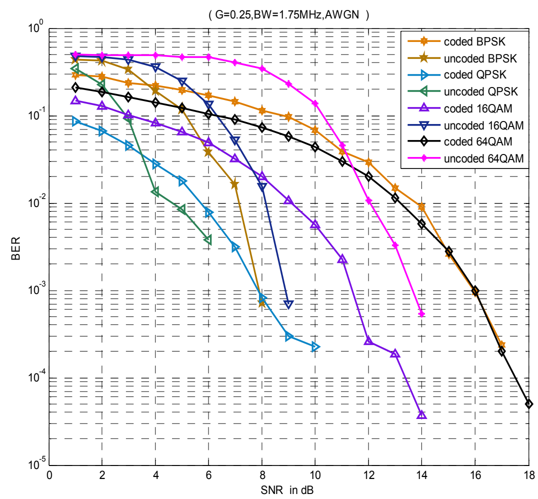

Fig.13 coded and uncoded BER of the received symbols (GP=1/4, BW=1.75MHz, AWGN Channel).

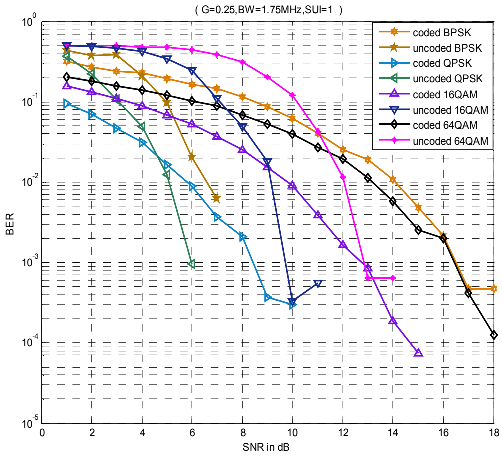

Fig.14. coded and uncoded BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=1 Channel).

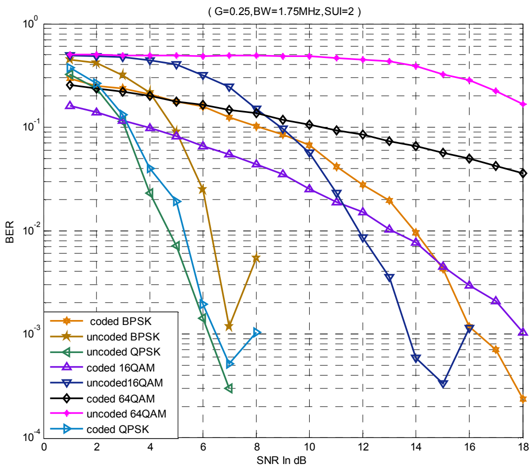

Fig.15. coded and uncoded BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=2 Channel).

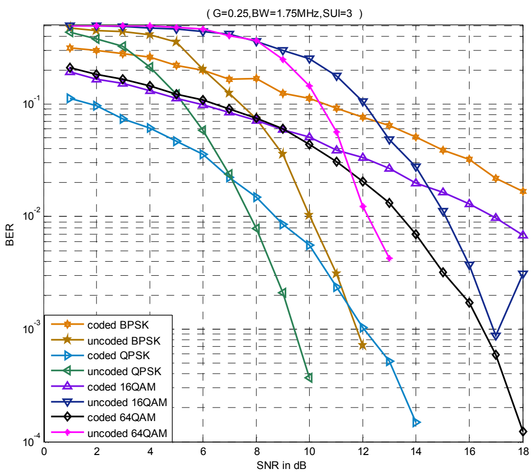

Fig.16. coded and uncoded BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=3 Channel).

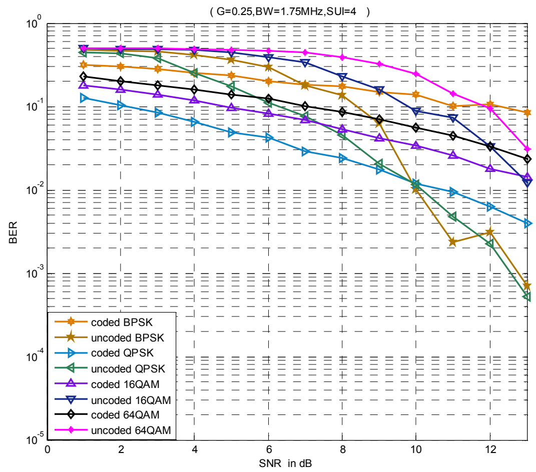

Fig.17. coded and uncoded BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=4 Channel).

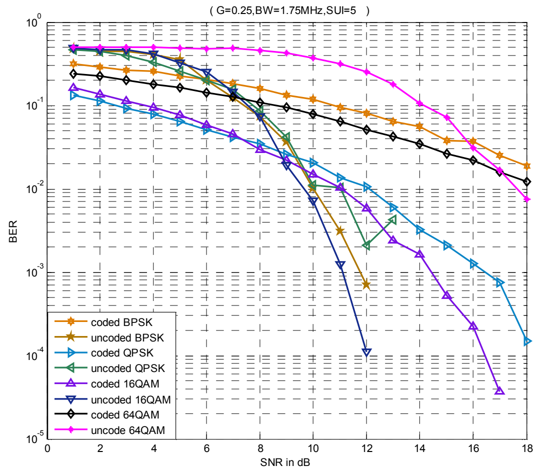

Fig.18. coded and uncoded BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=5 Channel).

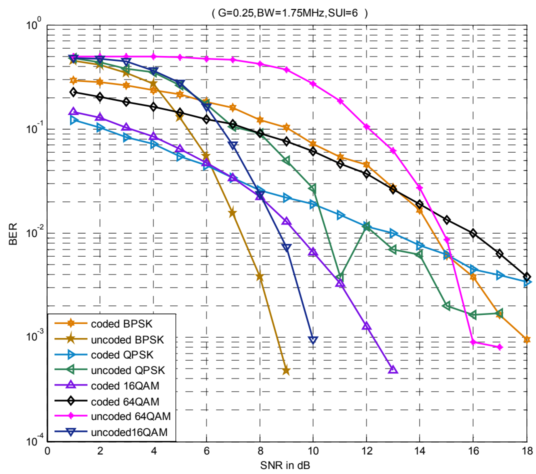

Fig.19. coded and uncoded BER of the received symbols (GP=1/4, BW=1.75MHz, SUI=5 Channel).

7. Conclusions

The Small Form Factor (SFF), Software-Defined Radio (SDR) Development Platform is a unique new product that addresses the special, portable SDR needs of the military, public safety, and commercial markets. It was designed around the latest DSP and FPGA technology – Lyrtech's area of expertise – as a low-cost, off-the-shelf, integrated hardware and software development solution. The DSP and FPGA of the SFF SDR Development Platform are completely integrated to the model-based design flow, which integrates MATLAB, Simulink, and Real-Time Workshop from The MathWorks. The SFF SCA Development Platform optional package allows SCA waveform development and implementation the key contribution of this paper was the implementation of the IEEE 802.16d PHY layer using MATLAB in order to evaluate the PHY layer performance under reference different channel model. The implemented PHY layer supports all the modulation and coding schemes as well as CP lengths defined in the specification. To keep matters simple we avoided doing oversampling of the data samples before using the AWGN and different SUI channel model. Though, that can be implemented by minor modifications. On the receiver side. The developed Simulator can be easily modified to implement new features in order to enhance the PHY layer performance. Simulation was the methodology used to investigate the PHY layer performance. The performance evaluation method was mainly concentrated on the effect of channel coding on the PHY layer. The overall system performance was also evaluated under different channel conditions.. A key performance measure of a wireless communication system is the BER the BER curves were used to compare the performance of different modulation and coding scheme used. The effects of the FEC and interleaving were also evaluated in the form of BER. These provided us with a comprehensive evaluation of the performance of the OFDM physical layer for different states of the wireless channel.

References

1. Wireless MAN Group. IEEE standard for local and metropolitan area networks. Technical Report IEEE Std 802.16-2001, wirelessMAN.org, 2001. Part 16, Air Interface for Fixed Broadband Wireless Access Systems

2. Book, Jeffrey G.Andrews, Arunabha Ghosh, Rias Muhamed, Fundamentals of WIMAX, Prentice Hall Communications Engineering and Emerging Technology Series.

3. Small Form Factor SDR Evaluation Module/ Development Platform User'sGuide

4. Math Works express, Target Language Compiler. 2002.

5. IEEE Standard for Local and metropolitan area networks, "Part 16: Air Interface for Fixed Broadband Wireless Access Systems, IEEE Std 802.16™-2004", 1 Oct 2004.

6. Wireless MAN Group. IEEE standard for local and metropolitan area networks. Technical Report IEEE Std 802.16-2001, wirelessMAN.org, 2001. Part 16, Air Interface for Fixed Broadband Wireless Access Systems

7. R. Nee and R. Prasad, OFDM for Wireless Multimedia Communications, Artech House, 2000

8. Bernard Sklar, "Digital Communications: Fundamentals and Applications, 2nd Edition," January 11, 2001

9. V. Erceg et. al, "An empirically based path loss model for wireless channels in suburban environments," IEEE JSAC, vol. 17, no. 7, July 1999, pp. 12051211.

10.Fixed, nomadic, portable and mobile applications for 802.162004and 802.16e WIMAX networks

11. V. Erceg, K.V.S. Hari, M.S. Smith, D.S. Baum et al, "Channel Models for Fixed Wireless Applications", IEEE 802.16.3 Task Group Contributions 2001, Feb. 01