Performance Evaluation of DVB-T Based OFDM over Wireless Communication Channels

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***Abstract*—Video Broadcasting is playing a key role in communication arenas. In this paper DVB-T (terrestrial based digital video broadcasting) based OFDM is analyzed in terms of various parameters over different communication channels. DVB-T 2K and 8K mode carriers are transmitted over AWGN, Rician and Rayleigh Channel, the received signal is thus corrupted. The corrupted signal is then manipulated in terms of different values of SNR (ranging from 0db to 16dB) and modulation schemes (4 QAM, 16 QAM and 64 QAM). A comparison is also made in terms of BER performance of different modulation schemes and for various values of SNR in order to find the optimized parameters for 2k and 8k mode carriers.**

***Index Terms*— Digital video broadcasting, DVB-T, Fading channels, OFDM, Performance evaluation.**

I. Introduction

IN the communication world of today, high data rate information transmission along with high capacity and reliability are just some of the requirements which modern system have to meet in order to provide a good quality of service to the end user.

The arenas where wireless communication systems are deployed, signals usually suffer phenomenon like multipath delay, fading and Inter Symbol Interference (ISI) [5] due to the frequency selectivity of the channel at the receiver side, the result of which is the poor performance and high probability of errors. In order to overcome the above mentioned issues channel coding and equalization techniques are implemented. But due to the cost of hardware and various technical issues like delays in coding and equalization process, it is not feasible to employ these techniques where desired bit rates and the reliability of data expectations are quiet high.

The solution of this issue is to implement an effective scheme like OFDM where the high bit rate over the frequency selective channel is guaranteed to some extent. Currently OFDM is a widely used scheme in almost all communication system ranging from ADSL (Asymmetric Digital Subscriber Line) to WLAN (Wireless Local Area Network). In OFDM the channel is sub-divided into multiple channels known as sub channelization, which are transmitted in parallel fashion and which ultimately increases the symbol duration and decreases ISI [1]. In the past few years OFDM has been standardized for use in Digital Audio and Video Broadcasting known as DAB and DVB respectively. In Europe, terrestrial based video broadcasting has already been implemented under the standard known as Digital Video Broadcasting-Terrestrial [2].

In this paper the performance evaluation of OFDM is done by sending the DVB-T based OFDM signal through AWGN [3], Rician and Rayleigh channel. For simplification purpose, the simulation is modeled for only one path between the transmitter and receiver and no multipath effect is taken into account for each of the considered channel. DVB-T 2k and 8k mode are analyzed over different values of SNR and by changing different modulation schemes (4 QAM, 16 QAM and 64QAM) and a conclusion is drawn based on the analysis.

II. Block Diagram

The modeling for the implementation of OFDM system by using DVB-T parameters can be best understood with the help of figure 1. Discrete signal is generated by using Matlab codes and the signal is then mapped in QAM fashion (4QAM, 16QAM and 64QAM variations). An IFFT is performed to translate the signal in time domain and a guard interval is inserted. After passing the signal from filter, an UP conversion is performed; the output signal is then passed through three different channels (AWGN, Rayleigh and Rician) where they were analyzed to find the optimal performance parameters for 2k, and 8k mode.

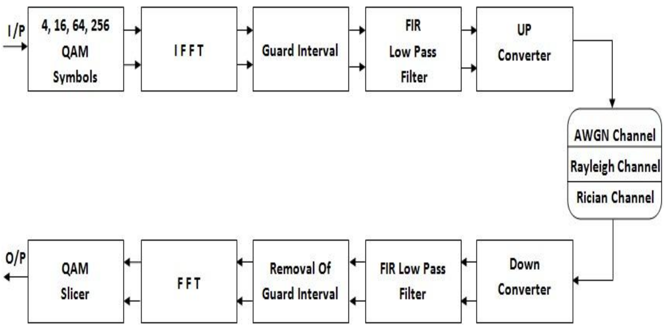

Fig. 1. Block diagram of the model

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At the receiver side the inverse process is performed to retrieve the signal back to the original shape, thus down conversion, filtering, removal of guard interval, FFT and QAM slicing is performed respectively. As it is discussed that different channels have different capabilities in terms of adding noise, so the key point of this paper is to investigate these issues and propose a solution so that the problems can be eliminated in practical scenario of video broadcasting in order to perform optimized transmission and reception.

III. Methodology

An OFDM signal, which is generated at the transmitter end by using DVB-T [2k and 8k mode] carriers, is transmitted over noisy communication channels [i.e. AWGN, Rayleigh and Rician]. By changing the modulation schemes [i.e. 4 QAM, 16 QAM and 64 QAM] the output will be observed at different values of SNR, and BER is evaluated for the performance of OFDM signal for the above mentioned channels. The diagrammatic approach of the above mentioned scenario is demonstrated in Figure 2.

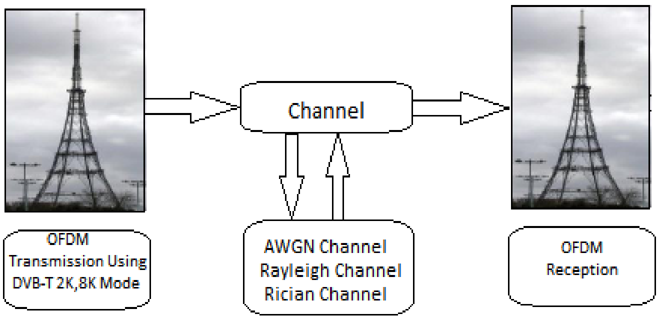

Fig. 2. Transmission and reception of DVB-T based OFDM signal through various channels.

Some of the basic facts which were taken into account during the analysis and the simulation of the DVB-T based OFDM system in Matlab are discussed below:

1) The OFDM symbols transmitted, is first organized in frames which has the duration T_f. Four frames constitutes one super frame and 1 super frame can accommodate 272 symbols [i.e. 1 frame = 68 symbols]. Each symbol has a duration of TS [TS=GI + TU], where GI is guard interval and TU is useful symbol period [2].

2) Number of IFFT/ FFT length according to the specifications of DVB-T standards is kept as 4096 for 2k mode and 8192 for 8k mode.

3) The bandwidth for the transmit filter is kept minimum in order to minimize the error in transmission.

4) Further parameters for DVB-T based 2K and 8K mode are mentioned in the Table 1.

TABLE I
DVB-T PARAMETRES FOR 2K AND 8K MODE

Parameters	2K Mode	8K Mode
No of carriers K	1705	6817
Value of carrier number Kmin	0	0
Value of carrier number Kmax	1704	6816
Duration Tu	224uS	896us
Carrier Spacing 1/Tu	4464 Hz	1116 Hz
Spacing between carriers Kmin and Kmax (K-1)/ Tu	7.61 MHz	7.61 Hz

IV. Simulation and Analysis

A. *Analysis for 2K mode*

The simulations performed are intended for the 4 QAM, 16QAM and 64QAM schemes where the SNR is varied in between 0 to 16 dB and the signal is analyzed at three channels which are AWGN, Rician and Rayleigh. In each of the figures below, the comparison between the three channels in question are shown. It is evident from the figure 3a, which is representing received constellation of 4QAM signal that the most affected path in terms of noise is Rayleigh channel as the received constellation points are at a large distance as compare to AWGN and Rician received constellation points. In comparison with figure 3b it is observed that the transmitted symbol is not received correctly due to large distance between the points representing the symbol. The modulation scheme used in this scenario is 16 QAM, so the number of bits representing one symbol will be 4. While from figure 3c, it is observed that the worst affected received signal appears in Rayleigh channel where it is difficult to even differentiate between the constellation points and such type of effects usually ends up in making a wrong decision by the receiver.

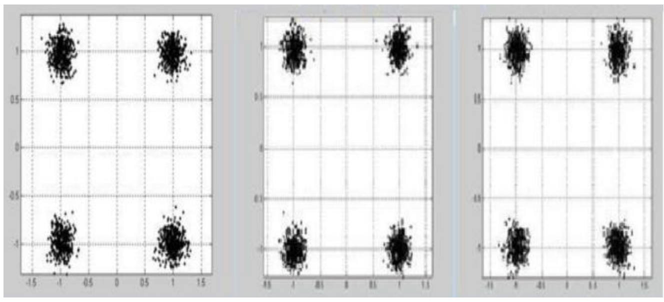

Fig. 3a. Received constellation of 4QAM Signal at 6dB SNR via AWGN, Rician and Rayleigh channel, respectively.

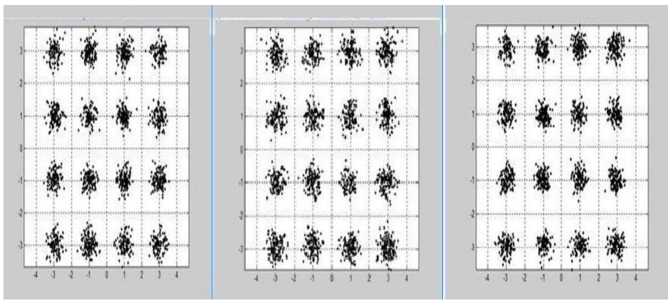

Fig. 3b. Received Constellation of 16 QAM Signal at 6dB SNR via Rayleigh, AWGN and Rician Channel

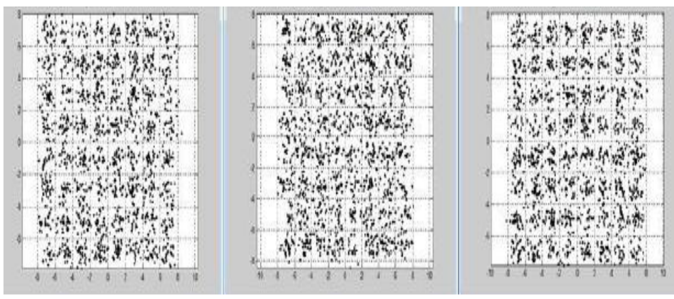

Fig. 3c. Received Constellation of 64 QAM Signal at 6dB via Rayleigh, AWGN and Rician Channel.

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In addition to this as the modulation scheme increases, the chances for the error is also increased because of the reason of decreasing period of symbol and high data rate will lead towards the problem like ISI which is also shown in terms of comparison between bit error rates of 4QAM and 16QAM signal which passes through AWGN channel as shown in 3d.

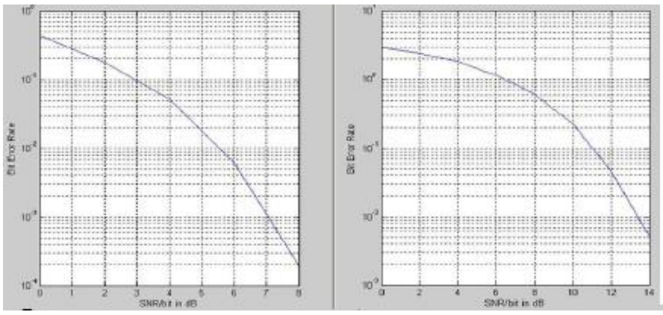

Fig. 3d. Comparison between 4 QAM and 16 QAM BER for AWGN Channel.

Furthermore in terms of bit error rate, the maximum path affected by the noise is again the Rayleigh due to the fact already been discussed that the Rayleigh path has high multipath fading [4] and which is why the ratio of error was high in Rayleigh and lowest in Rician channel which is shown in figure 3e.

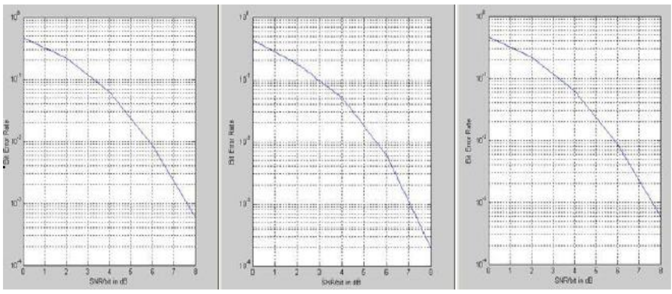

Fig. 3e. BER of 4QAM Signal via AWGN, Rician and Rayleigh Channel @ SNR 0 to 16 db

While utilizing 16QAM in 2K mode carrier, the BER graph shows that at an SNR of 0db the percentage of received bit in error Rayleigh channel is almost 90 percent while there is 80percent chance that the received bits will be in error while in Rician channel this error percentage is reduced remarkably to 20 percent because of the reason that one or some of the wave are in strong line of sight. The percentages of error in received bits can be reduced by simply increasing the SNR value. Rician has proved to have the ability to tackle in fading environment as it is shown in figure 3f that for 16 QAM signal by increasing the value of SNR the error rate is decreasing. It can be observed in fig 3g by the calculation of BER that the Rician channel has the lowest BER as compare to Rayleigh and AWGN.

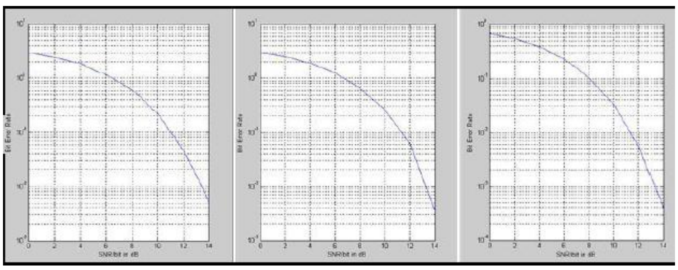

Fig. 3f. BER of 16 QAM Signal via AWGN, Rician and Rayleigh Channel @ SNR 0 to 16db.

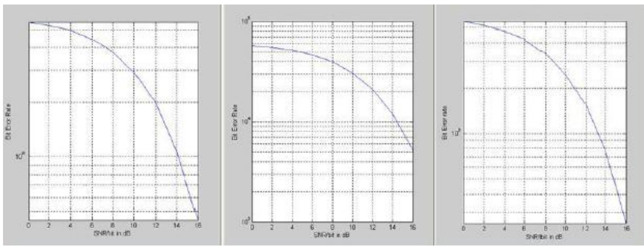

Fig. 3g. BER of 64 QAM Signal via AWGN, Rician and Rayleigh @ SNR 0 to 16db.

This concludes that the schemes which have higher data rates are more prone to error than the schemes with lower data rates, the performance of different schemes can be made acceptable by increasing the SNR but only to a certain limited extent. The performance of the Rician channel is remarkable and it is the least effected channel, so there must be a balance between the SNR and the modulation scheme that we are using for DVB-T based transmission so that the originally transmitted data can be recovered as it is quite evident from the graphs of the different schemes and channels that if we increase the data rate the bit error rate also increases even the SNR value failed to effect the reception at very high data rates like 64 QAM or 256 QAM. So the effective modulation scheme found for the DVB-T is 16 QAM for 2k mode at the level of SNR 6db.

B. Analysis for 8k Mode

The simulation performed in figure 4a is totally intended for DVB-T 8k mode using 4QAM symbol, a large number of constellation point representing one symbol, is because of the increase in number of carrier which are closed to each other and since the bandwidth is limited means that the sub carrier will be closely placed to each other and which can produce ISI so the receiver will be more prone to error in detecting the correct result because of the reason that the chances for bit in error increases as the number of carrier increases.

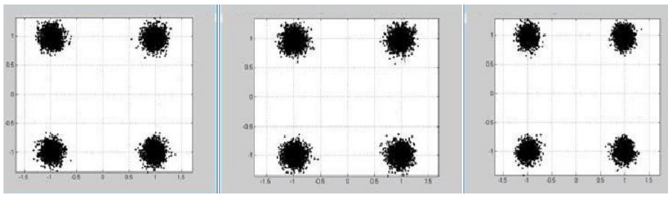

Fig. 4a. Received Constellation of 4 QAM Signal at 6dB SNR via Rayleigh, AWGN and Rician Channel

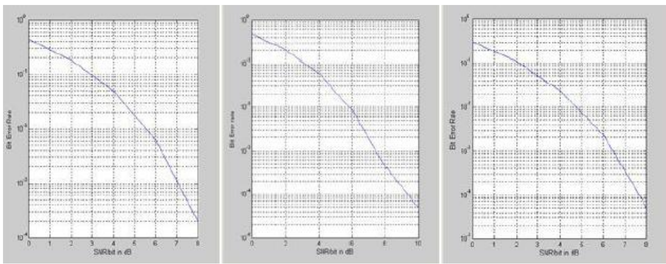

Fig. 4b. BER of 4 QAM Signal via AWGN, Rayleigh and Rician Channel @ SNR 0 to 16dB

Furthermore it can be observed from the figure 4b that the highest bit error rate is present in Rayleigh channel , at the low value of SNR, the signal seems to be similar for AWGN and Rayleigh channel while as the value of SNR increases,

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the percentage for error greatly reduced in Rayleigh as compare to AWGN channel and which can be analyzed that at an SNR level of 8 db the percentage of error bits in error are approaches to 40 percent in AWGN while it is 45 percent in Rayleigh channel and for Rician channel it is the lowest which shows again the promising nature of Rician channel against multipath fading.

The scenario simulated in figure 4c below shows that the modulation considered is 16 QAM while the carrier is kept as 8K, from a technical point of view this is not a viable solution because 8K carriers will lead us to have more errors while increasing the size of the modulation. It can also be observed that the signal pass through AWGN has less error in terms of received constellation points as compared to Rayleigh channel while the least distortion between the constellation points among the three paths is found in the Rician channel.

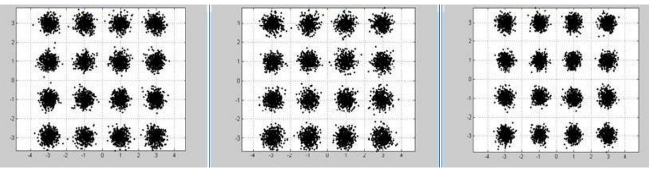

Fig. 4c. Received Constellation of 16 QAM Signal at 6dB SNR via AWGN, Rayleigh and Rician Channel

Bit error rate error is found to be high in Rayleigh channel and AWGN channel while it was minimum in Rician channel which is approx 0.001 at a level of 14 db of SNR while in AWGN and Rayleigh similar result was achieved at the level of 16 db as shown in figure 4d.

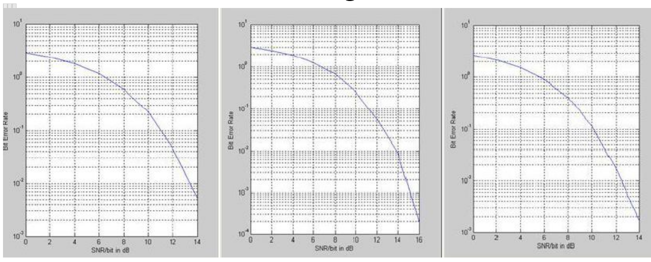

Fig 4d. BER of 16 QAM Signal via AWGN, Rayleigh and Rician Channel @ SNR 0 to 16dB

The received symbols in terms of constellation diagram is shown in figure 4e.By observing the diagram, It is very difficult to judge the worst affected received signal in terms of constellation points as it is already been discussed that by increasing the modulation scheme, the data rate also increases, which creates problem like ISI, in the above mentioned simulation for 8k mode, due to high number of carrier the received signal are closed enough to produce a wrong decision. While in term of BER, it is also shown in figure 4f that the percentage of the error introduced in the symbols is very high which is approaching to 100 percent, so after analyzing this situation, one can conclude that there is no feasibility in using 64 QAM while utilizing DVB-T 8k mode, which only result in the complexity and unreliability of the results.

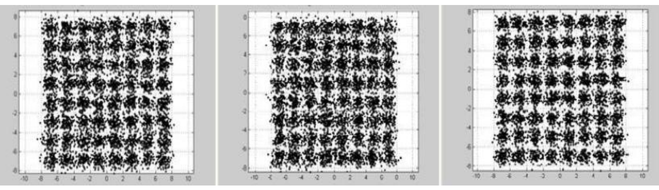

Fig 4e. Received Constellation of 64 QAM signal at 6dB SNR via Rayleigh, AWGN and Rician Channel

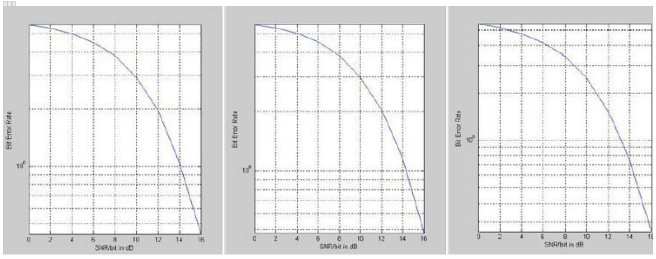

Fig. 4f. BER of 64 QAM symbols via Rician, AWGN and Rayleigh Channel @ SNR 0 to 16dB

C. Performance evaluation of 2K and 8K Mode

The simulation presented above was targeted for DVB-T 2k and 8k mode where the performance of DVB-T was analyzed by using the parameters given by ETSI standard, According to simulation it is found that 2k modes are less prone to errors but as the modulation scheme is increased, it starts to effect the performance of system by introducing more errors due to the fact that higher modulation schemes have higher ratio of errors which actually comply with the theory of the OFDM studies. For 2k mode video broadcasting, the scheme which was found reliable and robust was 16 QAM over the SNR of 6db. However it should be taken into account that the performance evaluated here does not included any error protection scheme or synchronization process. In addition to this, the simulation performed for 8k mode shows a high number of error and ISI when applying the modulation scheme of 16 QAM or higher, so the best modulation scheme found for 8k mode carrier is 4 QAM over the SNR of 16 db. By increasing the modulation scheme yields the high probability of error and produce undesirable signal as the receiver is unable to make the decision correctly.

In a nutshell, it is not useful to apply higher modulation schemes without the error correction schemes, DVB-T has certain error correction method which when mixed with the higher modulation scheme can only be useful in that circumstances, which is for 2k it can support up to 64 QAM modulation scheme and for 8k it can support up to 16 QAM modulation scheme as long as the proper error correction coding is implemented.

V. Conclusion

The combination of high data capacity, high spectral efficiency, and resilience to interference as a result of multi-path effects means OFDM is ideal for the high data applications that are becoming a common factor in today’s communication scene. It has thus gained a significant presence in the wireless market of today. The paper investigated the performance of OFDM and the effect of different multipath channels, namely Rayleigh, Rician and AWGN. The results which were obtained verify that Rayleigh is the least suitable and most affected multipath environment due to its non line of sight communication and delay characteristics, whereas Rician shows the most promising result, while the AWGN performance lies in between these two. Different modulation schemes were also applied for the DVB-T based OFDM transmission and reception and it was found that as the modulation scheme increases from 4 QAM to 64 QAM, the chances for error (for example ISI) also increases because of the reason that high data rates has high probabilities of error due to less symbol period. Furthermore if the number of carrier is increased, the chance for error also goes high and the receiver will not be able to properly recover the signal and it may end up in making wrong decision.

The simulation results infer that the suitable modulation scheme for 2k mode is 16 QAM, at an SNR of 6 dB. In addition to this the 4 QAM modulation scheme was found optimum for 8k mode while keeping the level of SNR at 6dB, although DVB-T can support the SNR up to a 50db, but as the number of carrier is increased, the chances for error is also increased which was observed in the form of bit error rate. So after the performance evaluation, it is concluded that the performance of 2k mode was better as compare to 8k mode and is suitable to use in the video broadcasting because of less number of errors.

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