Analyzing Digital Video Broadcasting Terrestrial System Using Basic Transmission Model (Gaussian, Ricean and Rayleigh Channel)

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Abstract – This paper analyzes the Digital Video Broadcasting – Terrestrial, DVB-T system. All basic transmission channel model (Gaussian, Ricean and Rayleigh) are examined. MATLAB techniques are presented with the transmission parameters setup. These parameters are bit error rate (BER) before Viterbi Decoder and after Viterbi Decoder, with varying Signal to Noise ratio (S/N ratio). The simulation results of actual DVB-T transmission and reception performance using 2K OFDM multi carrier with modulation level of 64 QAM using various transmission channel are graphically compared. These results are then compared to the theoretical value of DVB-T specification.

Keywords : DVB-T system; Gaussian Channel; Ricean Channel; Rayleigh Channel; 2K OFDM Carrier

1. Introduction

1.1 Digital Video Broadcasting

Digital Video Broadcasting –Terrestrial (DVB-T) is a technical standard developed by the DVB Project that specifies the framing structure, channel encoding and modulation for Digital Terrestrial Television (DTT) broadcasting [1]. This paper contains the preliminary step of research using MATLAB application which allows the simulation of a DVB-T transmission in Gaussian Channel, Ricean Channel and Rayleigh Channel in order to obtain Bit Error Rate (BER) depending on channel type, its parameters and its performance on 2K OFDM multicarrier.

1.2 Gaussian Channel (AWGN)

Gaussian Channel model is the reception condition where the coverage area is based on a direct signal path from transmitter to receiver. It can be considered as direct Line of Sight transmission with no multipath interference during reception. However, it is corrupted by additive white Gaussian noise. This channel is mainly produced in the receiver itself, which is overlaid with additive white Gaussian noise (AWGN) [2].

1.3 Ricean Channel

Ricean Channel has a dominant incoming signal with lower delayed or multipath signal and thermal noise. TV transmission to a roof top directional antenna is considered as fixed reception and is an example of a Ricean channel.

1.4 Rayleigh Channel

Rayleigh Channel has several statistically independent incoming signals with different delays, which none of it is dominant. TV transmission to a mobile or handheld unit is an example of a Rayleigh channel. There is also frequency selective fading combined with Doppler frequency shift and spread. These conditions impose stringent requirements on transmission parameters such as coding.[3]

1.5 2K Orthogonal Frequency Division Multiplex (OFDM)

Matlab and Simulink have a DVB-T demo model incorporated in their software which can be modified to support research into new coding techniques [4]. Figure 1 showed DVB-T Simulation Model using 2K OFDM multi carrier with modulation level of 64 QAM using Gaussian Channel.

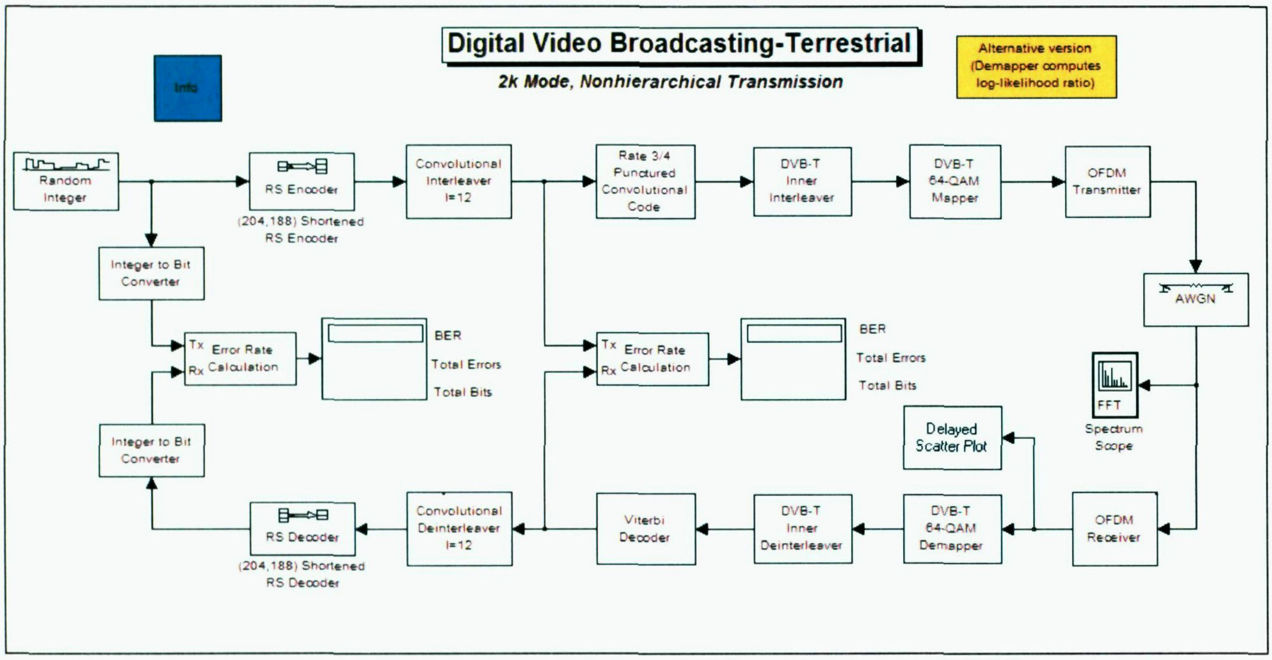

Figure 1 : DVB-T Simulation Model using RS (204,188) Codes [4]

1.6 Bit Error Rate, BER And Reception Performance

The Bit Error Rate (BER) was measured before and after the Viterbi Decoder and non-hierarchical modulation was used as was similarly done with the Simulink models.

The simulation results of actual DVB-T transmission and reception performance using 2K OFDM multi carrier with modulation level of 64 QAM using various transmission channel (Gaussian, Ricean and Rayleigh Channel) in this experiments will be compared to the theoretical value.

2. Methodology

Computer simulation of simplified DVB system over Gaussian (AWGN), Ricean and Rayleigh channels were done to determine the performance of the proposed designs. Study obtained from the simulation results of actual DVB-T transmission and reception performance using 2K OFDM multi carrier with modulation level of 64 QAM using Gaussian, Ricean and Rayleigh Channel in this experiments will be treated separately for easier discussion and compared to the theoretical value.

The flow of this study will include some important steps like designing , simulation and analyzing DVB-T Model, as shown in the following flow chart at Figure 2.

2.1 Flow Chart

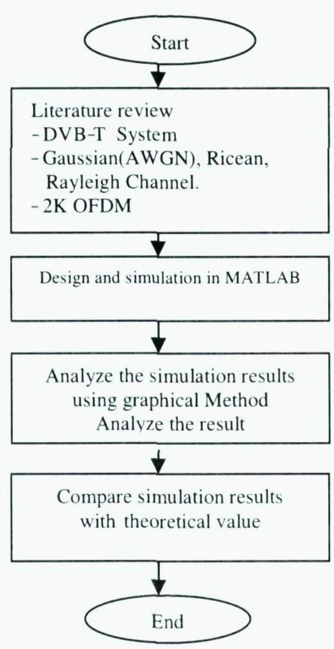

Figure 2 : Flow Chart Process

3. Result and Discussion

3.1 Theoretical

Figure 3 below show published simulation results of actual DVB-T transmission and reception performance using 2K OFDM multicarrier with modulation level of 64 QAM.

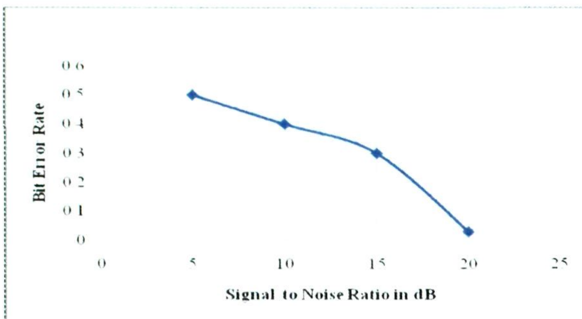

Figure 3: Bit Error Rate Performance of DVB-T in Gaussian Channel Condition [5]

The Bit Error Rate (BER) was measured before the Viterbi decoder and non-hierarchical modulation was used as was similarly done with the Simulink models. The graph obtained shows that as signal/ noise value increases from 5 to 10 dB there is a gradual decrease in BER, until at a certain point after 15 dB the BER falls steeply [5].

This phenomenon is popularly referred to in technical literature as a 'waterfall curve'. Further increase in Signal Noise Ratio, S/N value does not provide any visible improvement in BER as the maximum point has been reached. In practice, increasing the S/N means increasing transmitter power without improving receiver performance. This is rather contrary to analog TV transmission where increase in transmitter power will increase reception quality especially at distant areas from the transmitter tower .

3.2 Measured Value

The graphical expression of the BER dependence on the S/N ratio before Viterbi error correction and after Viterbi error correction can be seen in Figure 4.a,b,c for Gaussian, Ricean and Rayleigh Channel respectively.

The results obtained are compared with actual DVB-T performance results as shown in Figure 3. The actual results have a more pronounced `waterfall curve' where as the Simulink models results show curves that drop more gradually as the S/N value increases.

We can see a gradual decrease in BER as signal to noise ratio increases from 10 to 15 dB in Gaussian Channel and after 15 dB the BER falls steeply in Figure 4.a. Figure 4.c showed the worse performance of Rayleigh Channel when compared to the Gaussian Channel or even Ricean Channel in Figure 4.a and 4.b respectively.

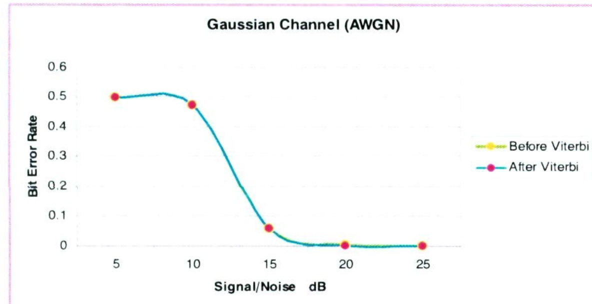

Figure 4.a

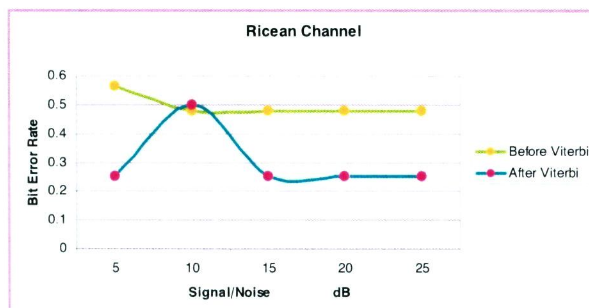

Figure 4.b

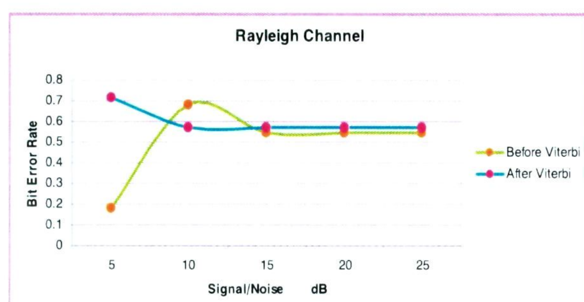

Figure 4.c

Figure 4.a,b,c : BER using 2K OFDM in Different Channel Condition

Other parameters such as the 2K OFDM Frequency Spectrum Plot for DVB-T Transmission Model and 64 QAM Constellation Plot for DVB-T (Reception performance) in Gaussian, Ricean and

Rayleigh Channel are shown in Figure 5.a,b,c and Figure 6.a,b,c respectively.

The Spectrum Scope that shown in Figure 5.a, 5.b and 5.c indicate that a correct 7 MHz RF bandwidth as specified by the DVB standards is being used for the OFDM signal in all the models. The signal within the wanted DVB-T channel is flat overall but with tiny ripples caused by the peaks of the OFDM subcarriers [5].

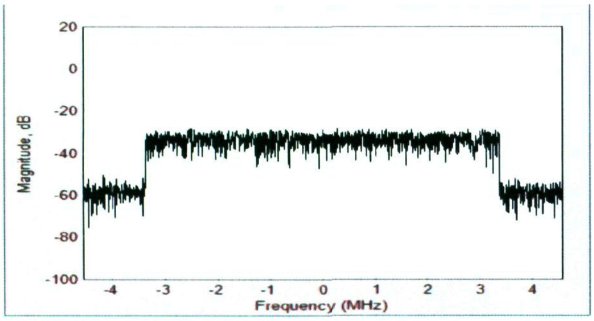

Figure 5.a: 2K OFDM Spectrum Plot for DVB-T Transmission Model in AWGN Channel

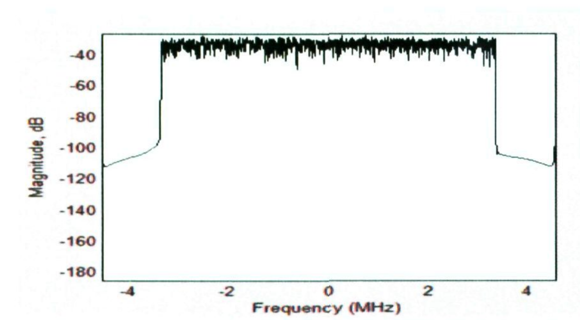

Figure 5.b: 2K OFDM Spectrum Plot for DVB-T Transmission Model in Ricean Channel

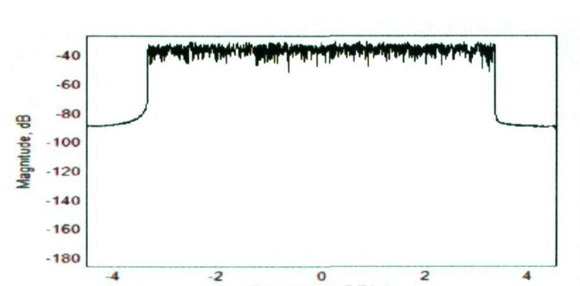

Figure 5.c: 2K OFDM Spectrum Plot for DVB-T Transmission Model in Rayleigh Channel

The Scatterplot shown in Figure 6.a, 6.c, and 6.e are the location of the 64 QAM constellation points at 25dB SNR, and the location of the 64 QAM constellation points at 5dB SNR are shown in the Scatterplot at Figure 6.b, 6.d and 6.f for Gaussian, Ricean and Rayleigh Channel respectively.

Gaussian Channel, AWGN leads to cloud shaped constellation points which become larger as the noise increases. To put it otherwise, the smaller the constellation point, the better the signal quality. The Matlab models indicate that the constellation points become larger when the SNR is lowered [3]. It also becomes larger when the channel is changed from AWGN to Ricean or Rayleigh indicating that more noise is present [5].

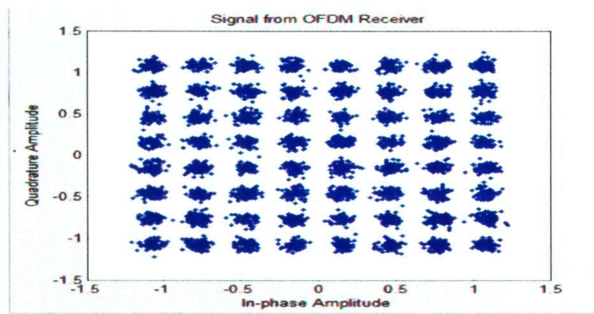

Figure 6.a: 64 QAM Constellation Plot for DVB-T in AWGN Channel (Reception performance at 25dB SNR)

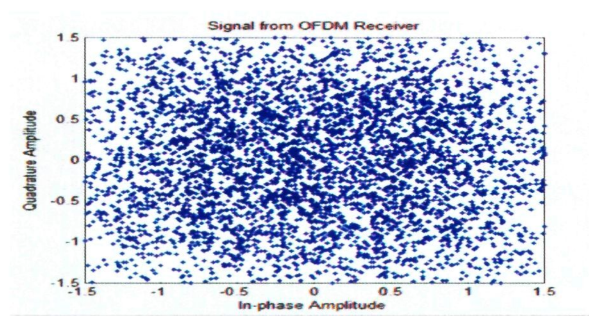

Figure 6.b: 64 QAM Constellation Plot for DVB-T in AWGN Channel (Reception performance at 5dB SNR)

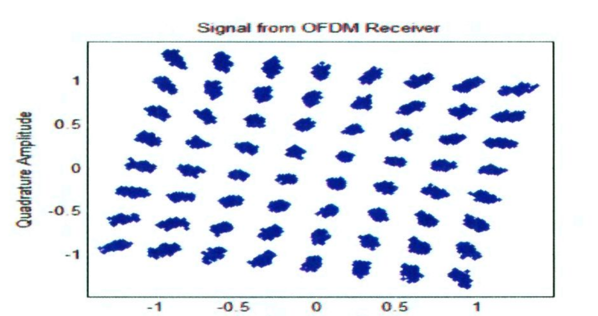

Fig 6.c: 64 QAM Constellation Plot for DVB-T in Ricean Channel (Reception performance at 25 dB SNR)

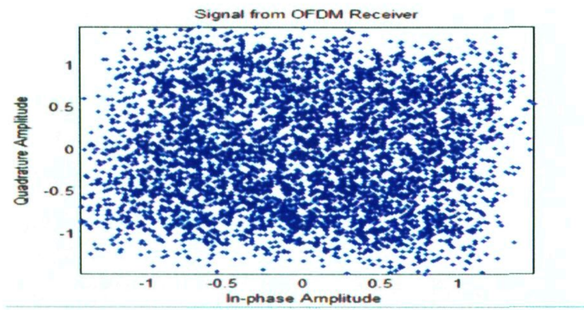

Fig 6.d: 64 QAM Constellation Plot for DVB-T in Ricean Channel (Reception performance at 5 dB SNR)

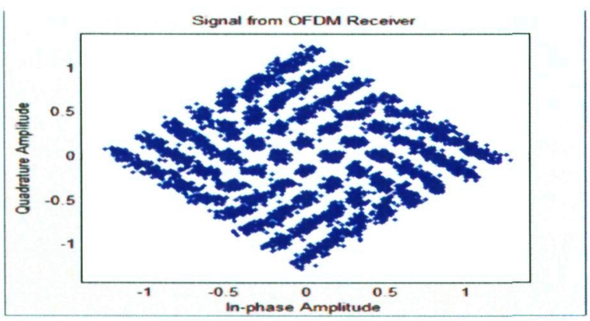

Fig 6.e: 64 QAM Constellation Plot for DVB-T in Rayleigh Channel (Reception performance at 25dB SNR)

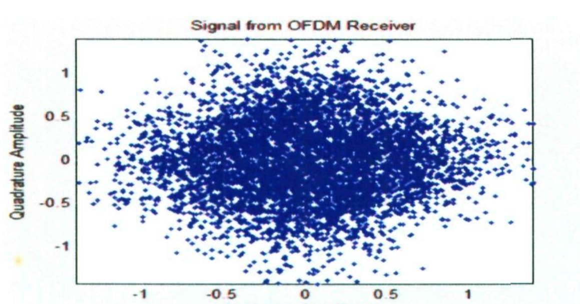

Fig 6.f: 64 QAM Constellation Plot for DVB-T in Rayleigh Channel (Reception performance at 5dB SNR)

An additional effect observed in the Matlab models is that the constellation diagram tends to rotate slowly when the Ricean and Rayleigh channels are chosen. This is caused by the channel induced carrier phase rotation but it is not a problem as non coherent detection can be applied for carrier recovery [5]. It can be shown in Figure 6.a that the AWGN channel models do not show any rotation.

4. Conclusion

All measured result were expected. The Basic Transmission Model, AWGN channel, the Ricean and Rayleigh channel models are used to examine the performance of DVBT signals. When the Ricean channel is compared to the AWGN channel, the BER is found to have increased. When the Rayleigh channel model is compared to the Ricean and AWGN model, there are even further increases in BER. The Rayleigh channel imposes more stringent conditions on propagation as it does not have a Line of Sight (LOS) path and severe multipath fading occurs. The overall result have showed that the reception and performance using 2K OFDM multi carrier with modulation level of 64 QAM using Gaussian Channel, AWGN is the best compared to Ricean Channel and Rayleigh Channel.

5. Future Development

In future, one should continue with different RS Code such as RS (238,188), RS (256,188) under the Gaussian, Ricean and Rayleigh Channel conditions with different modulation levels especially 256 QAM.

In fact, 256 QAM mode which is less robust but can carry a higher payload is now offered with DVB T2. It must be emphasized here that it is not possible to use 256 QAM with the first generation DVB-T to improve performance [6].

6. References

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