MATLAB Simulation of the DVB-S Channel Coding and Decoding

Tejas S. Chavan, V. S. Jadhav

MAEER'S Maharashtra Institute of Technology, Kothrud, Pune, India
Department of Electronics & Telecommunication,Pune University, Pune, India

Abstract - **The paper deals with the Matlab implementation and simulation of channel coding and modulation of DVB-S (Digital Video Broadcasting – Satellite). Transport stream multiplex adaptation and randomization for energy dispersal, outer coding and interleaving, inner coding and interleaving, constellation and mapping blocks of encoder and decoder are implemented. Channel encoder and decoder follow European Standard ETSI EN 300 748 for digital satellite television and provide utilization of different convolutional encoder code rates, inner modulation modes scheme for OFDM (Orthogonal Frequency Division Multiplexing).**

Keywords − **DVB-S, code rates, modulation schemes, OFDM.**

I. INTRODUCTION

The DVB-S (Digital Video Broadcasting – Satellite) is ETSI EN 300 748 standard of European digital television for the satellite transmission to fixed, portable and mobile receivers. The DVB-S Standard specifies the framing structure, channel coding and modulation for digital satellite broadcasting. The system is fully compatible with MPEG-2 coded TV signals ISO/IEC 13818 and has several similarities of channel coding with DVB-T (Digital Video Broadcasting – Terrestrial) and DVB-C (Digital Video Broadcasting – Cable) standards.

II. METHODOLOGY

The system is composed of functional blocks performing the adaptation of the baseband TV signals from the output of the MPEG-2 transport multiplexer to the satellite channel characteristics. The system input data stream is organized in fixed length 188 bytes MPEG-2 packets.[1][2]

The following processes are applied to the data stream:

1) Transport Multiplex Adaptation and Randomization for Energy Dispersal;
2) Outer Coding (i.e. Reed-Solomon code);
3) Outer Interleaving (i.e Convolutional Interleaving);
4) Inner Coding (i.e. punctured convolutional code);
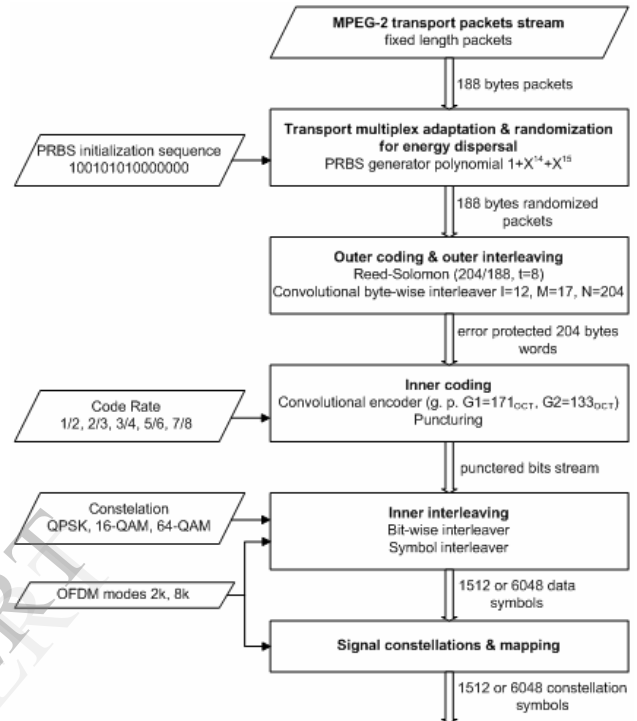5) Inner Interleaving;
6) Mapping and Modulation Schemes;

Fig 1. Flow Chart for the Encoder

A. Energy Dispersal:

The data of the input are randomized to ensure adequate binary transitions. The polynomial for the PRBS (Pseudo Random Binary Sequence) generator is equal to $1 + X_{14} + X_{15}$. To achieve energy dispersal, PRBS is first generated and then mixed with the data stream by means of an XOR (Exclusive OR) operation which breaks up long sequence of ones or zeros. If this energy-dispersed data stream is mixed again with the same PRBS at the receiving end, the dispersal is cancelled again.

B. Outer Coding:

The next stage contains the outer encoder, the Reed-Solomon FEC (Forward Error Correction). To obtain optimisation of the DVB-S system Reed Solomon(204,188) will be used.

C. Outer Interleaving:

An outer interleaver is a convolutional interleaver with interleaving depth of $I = 15$ and the block length is 255

bytes. Interleaving is realized by writing bytes into the matrix by columns and reading them out by rows.

D. Inner Coding:

The outer interleaver is followed by a convolutional encoder, with the basic code rate 1/2. The generator polynomials are $G_1 = 1 + X_3 + X_4 + X_5 + X_6$ and $G_2 = 1 + X_1 + X_3 + X_4 + X_6$. Possible puncturated code rates are, according to DVB specification, 2/3, 3/4, 5/6 and 7/8.

E. Inner Interleaving:

The inner interleaving is divided into two steps: bit and symbol interleaving. Both the bit-wise interleaving and the symbol interleaving processes are block-based.[3][4]

F. Modulation Schemes:

After previously mentioned FEC blocks, symbols from output inner interleaver are ready to modulate into QPSK, 16QAM or 64QAM constellations. Matlab provides some cases for the modulation and demodulation. OFDM is implemented using DVB-S parameters.
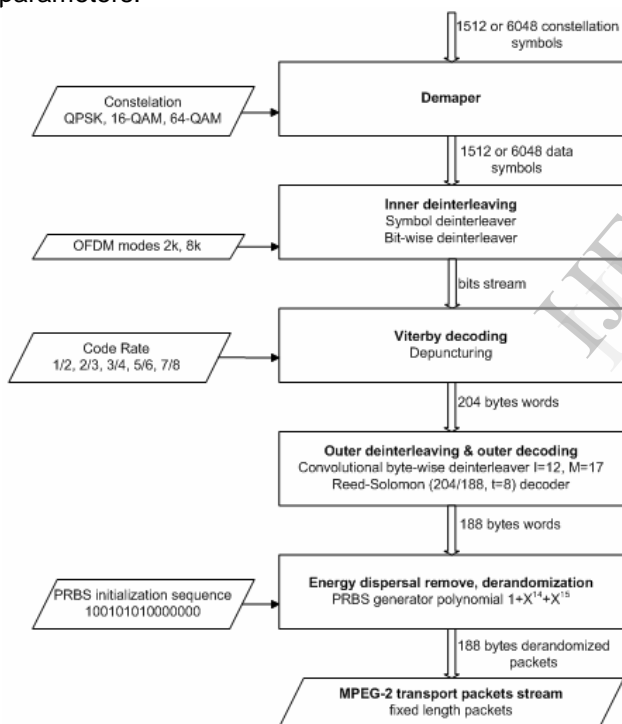

Fig 2. Flow Chart for the Decoder

In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-channels or subcarriers, transmitted in parallel, divide the available transmission bandwidth.[3]

The simulations will focus in the 2k mode of the DVB-S standard. This particular mode is intended for mobile reception of standard definition DTV. The transmitted OFDM signal is organized in frames. Each frame has a duration of T_F, and consists of 68 OFDM symbols. Four frames constitute one super-frame. Each symbol is

constituted by a set of K=1,705 carriers in the 2k mode and transmitted with a duration T_S. A useful part with duration T_U and a guard interval with a duration Δ compose T_S.[4][5]

### III. RESULTS

The simulation of the DVB-S system was carried out for different code rates. The code rates used are ½, 2/3, ¾, 5/6 and 7/8. The bit error rates(BER) at each stage were calculated and noted down. Different Modulation Error rates (MER) were also used. The MER used are 30dB, 24dB, 20dB, 17dB, 15dB and 13 dB. BER1 denotes the error rate for QAM-64 demapping, BER2 denotes error rate for symbol deinterleaving, BER3 denotes error rate for inner interleaving, BER4 for inner decoding, BER5 for outer deinterleaving and BER6 for outer decoding.
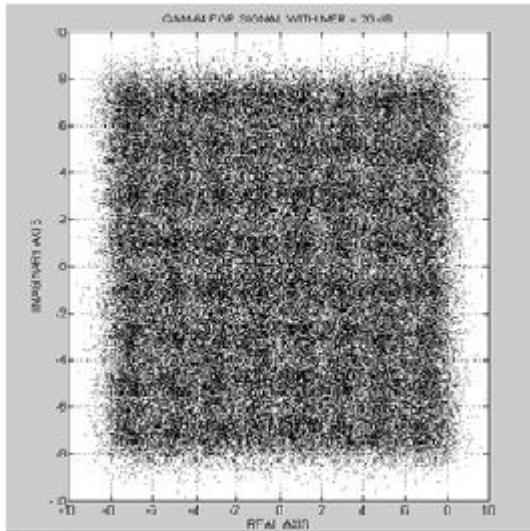
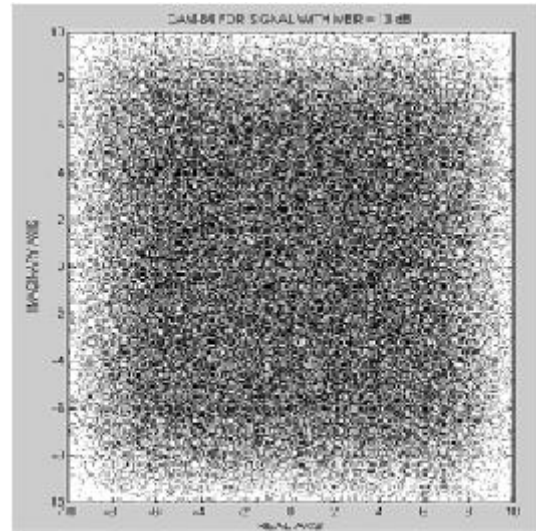The following diagrams show the constellation mappings for QAM-64 for different MER and code rate of 2/3.
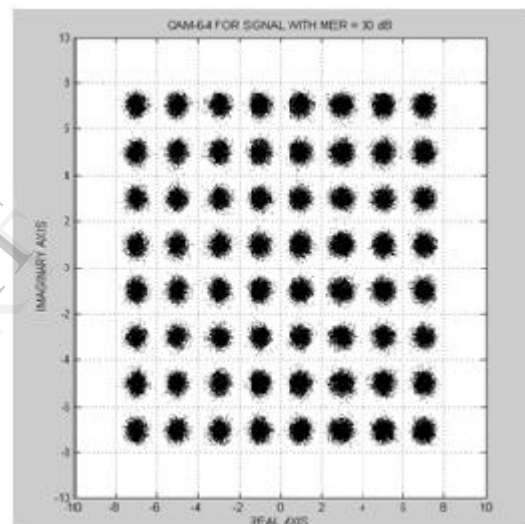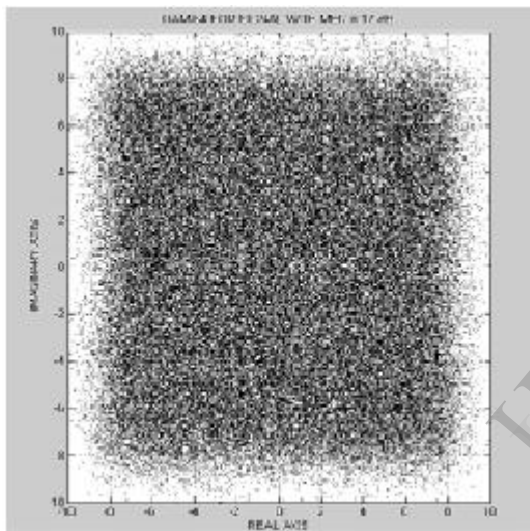

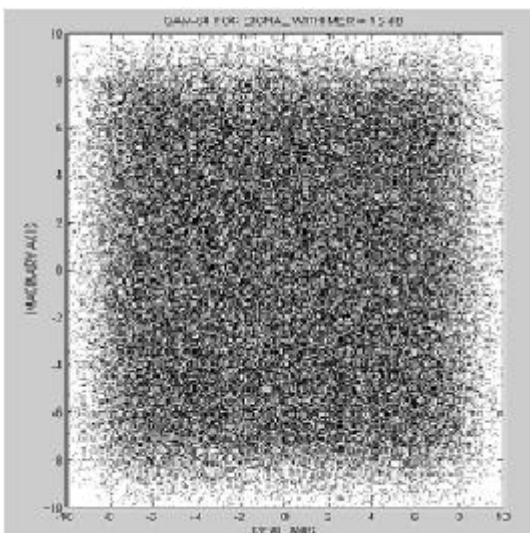a) 64-QAM symbols with MER = 30dB
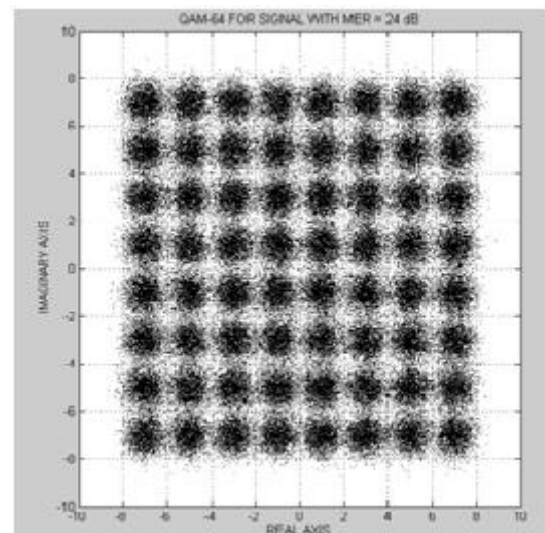
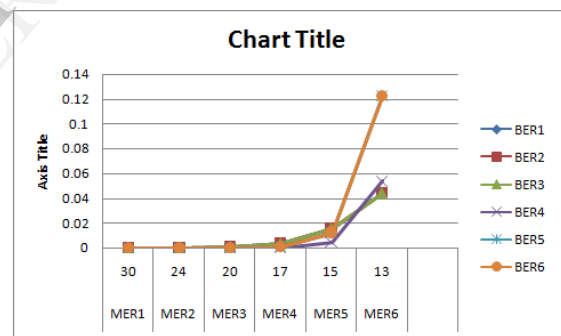

b) 64- QAM symbols with MER = 24dB

c) 64- QAM symbols with MER=20dB

f) 64-QAM symbols with MER=13dB

The bit error rate(BER) at each stage was caclculated and plotted against the Modulation error rate used.

MER	BER1	BER2	BER3	BER4	BER5	BER6
30	0	0	0	0	0	0
24	0	0	0	0	0	0
20	0.00051	0.00051	0.00052	0.00006	0.00002	0.00002
17	0.00324	0.00324	0.00325	0.0002	0.0008	0.0008
15	0.0152	0.0152	0.0153	0.0043	0.0122	0.0122
13	0.0437	0.0437	0.0438	0.0536	0.1223	0.1223

a) BER vs MER for code rate=1/2

d) 64-QAM symbols with MER=17dB

e) 64-QAM symbols with MER=15dB

MER	BER1	BER2	BER3	BER4	BER5	BER6
30	0	0	0	0	0	0
24	0	0	0	0	0	0
20	0.00051	0.00051	0.00052	0.00006	0.00002	0.00002
17	0.00324	0.00324	0.00325	0.0002	0.0008	0.0008
15	0.0152	0.0152	0.0153	0.0043	0.0122	0.0122
13	0.0437	0.0437	0.0438	0.0536	0.1223	0.1223

MER	BER1	BER2	BER3	BER4	BER5	BER6
30	0	0	0	0	0	0
24	0	0	0	0	0	0
20	0.000077	0.000077	0.000077	0	0	0
17	0.00302	0.00302	0.00303	0.00028	0.00098	0.00098
15	0.01528	0.01528	0.01529	0.0036	0.01033	0.01033
13	0.04351	0.04351	0.04357	0.05244	0.12085	0.12085

b)   BER vs MER for code rate=2/3.
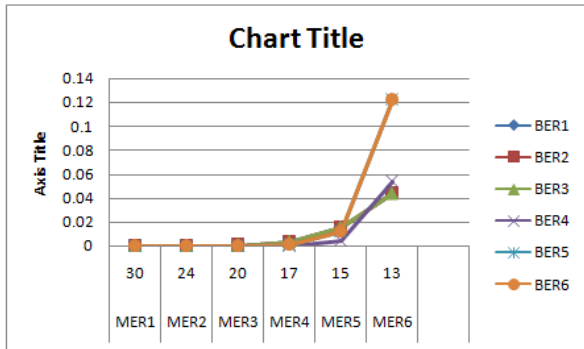
e)   BER vs MER for code rate=7/8.

MER	BER1	BER2	BER3	BER4	BER5	BER6
30	0	0	0	0	0	0
24	0	0	0	0	0	0
20	0.000067	0.000067	0.000067	0.000069	0.0002	0.0002
17	0.003216	0.003216	0.00322	0.000179	0.00068	0.00068
15	0.01497	0.01497	0.01499	0.0036	0.01027	0.01027
13	0.04353	0.04353	0.04357	0.0546	0.12464	0.12464

IV. CONCLUSION

The DVB-S system is successfully simulated using MATLAB. All major components of the DVB-S system are covered. Some of the challenges in developing this DVB-S simulation program were carefully matching steps in modulator and demodulator, keeping track of data format and data size throughout all the processes of the whole simulation, designing an appropriate frame detector for the receiver, and debugging the MATLAB codes.

The DVB-S system is implemented for different Modulation error rates(MER) and code rates. The bit error rate(BER) was calculated at each stage and the graphs were plotted against MER for different code rates. As seen from the graphs, the BER increases for different code rates. As code rate increase, the BER also increases.the symbols for 64-QAM are also plotted for different MER. As seen from the plots, as MER increases the symbols get dispersed.

c)   BER vs MER for code rate=3/4.

MER	BER1	BER2	BER3	BER4	BER5	BER6
30	0	0	0	0	0	0
24	0	0	0	0	0	0
20	0.000067	0.000067	0.000067	0.000069	0.0002	0.0002
17	0.00321	0.00321	0.00322	0.000179	0.000682	0.000682
15	0.01534	0.01534	0.01536	0.00387	0.01066	0.01066
13	0.04314	0.04314	0.043175	0.051	0.1176	0.1176

Presented implementation of DVB-T channel coder and decoder and results of its simulation in Matlab are in general in accordance with assumptions of *MER* relation and error rates after corresponding error correction. However, simulated error rates are influenced by finite data length in opposite to continuous data stream in real digital television broadcast.

d)   BER vs MER for code rate=5/6.

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