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BER Performance in Digital Video Broadcasting-Terrestrial for Inner and outer Interleaving Using 64 QAM

HIMANI CHUGH

Department of Electronics and Communication Engineering, Chitkara University, Himachal Pradesh

Email: Himani.chugh@chitkarauniversity.edu.in

Abstract Digital video broadcasting-terrestrial (DVB-T) was developed by the DVB Project that was first broadcast in the UK in 1997. The compressed digital audio, video and other data in Moving Picture Expert Group (MPEG) transport stream, using orthogonal frequency-division multiplexing (OFDM) modulation is transmitted by this system. In order to analyze how an MPEG transport stream at the input of a DVB-T modulator is turned into a DVB-T signal, the channel coding and modulation technique must be considered. DVB-T offers three different modulation schemes (QPSK, 16QAM, 64QAM). This paper analyzes the performance of the system for the stationary reception. The aim was to implement all the functional blocks as specified in the DVB-T specification and analyze the BER performance of the system. Thus, this paper deals with a MATLAB application being developed to simulate DVB-T system for selected QAM. This work deals with the MATLAB code to establish a system level simulation environment and use this system simulation model to evaluate the system performance hence provide the result in evaluating the performance of DVB-T with 64QAM. This system is able to measure and analyze the performance of bit error rate (BER) versus energy per bit to noise power spectral density ratio (Eb/No) for 64 QAM.

Keywords: Digital Video Broadcasting DVB-T/H, FEC Channel coding, Interleaving, BER

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I. INTRODUCTION

The DVB-T (Digital Video Broadcasting – Terrestrial) of European digital television for the terrestrial broadcasting transmission is used in fixed and portable mobile receivers. ETSI EN 300 744 V1.5.1 (2004-11) The DVB-T Standard specifies the framing structure, channel coding and modulation for digital terrestrial broadcasting. The system is fully compatible with MPEG-2 coded TV signals ISO/IEC 13818 and has several similarities of channel coding with DVB-S (Digital Video Broadcasting – Satellite) and DVB-C (Digital Video Broadcasting – Cable) standards. The block diagram for a DVB-T transmitter is shown in Figure 1. Source data, consisting of video, audio, and data, is multiplexed into MPEG transport stream (TS) packets. Each packet is 188 bytes long with 184 bytes for data and 4 bytes for header information, such as sync and packet ID bytes. The system is defined as the functional block of equipment performing the adaptation of the baseband TV signals from the output of the MPEG-2 transport multiplexer, to the terrestrial channel characteristics. The following processes shall be applied to the data stream in both DVB-T (Digital video broadcasting –Terrestrial) ETSI EN 300 744 V1.5.1 (2004-11) or DVB-H (Digital video broadcasting –Handheld) ISO/IEC 13818 by the following processing:

- Transport multiplex adaption and random transport multiplex adaptation and randomization for energy dispersal;
- Outer coding (i.e. Reed-Solomon code);
- Outer interleaving (i.e. convolutional interleaving);
- Inner coding (i.e. punctured convolutional code);
- Mapping and modulation;
- Orthogonal Frequency Division Multiplexing (OFDM) transmission.

The system is directly compatible with MPEG-2 coded TV signals ISO/IEC 13818.

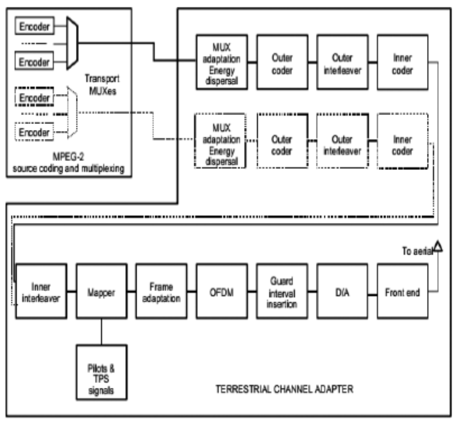


Figure 1. Functional block diagram of the system

II. CHANNEL CODING AND MODULATION

These processes (except for OFDM) are performed in Channel coder with the configurations depicted in Figure 2.

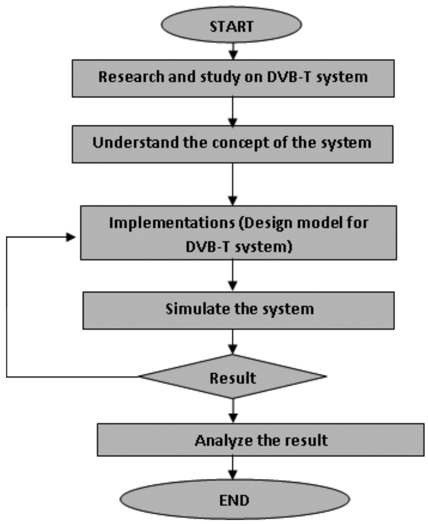


Figure 2. Flow-chart of channel coding in DVB-T (implemented in Matlab)

Transport multiplex adaptation and randomization, outer coding and outer interleaving are common with the Satellite DVB-S baseline specification ETSI EN 300 421 and Cable DVBC baseline specifications ETSI EN 300 429 and the inner coding is common with the Satellite baseline specification. Detailed description of DVB-T channel coder blocks can be found in ETSI EN 300 744 V1.5.1 (2004-11).

Following section describes possible implementation of channel coding/ modulation and decoding/demodulation for DVB-T in accordance with European Standard ETSI EN 300 744 for digital terrestrial television.

A. Transport multiplex adaptation and randomization for energy Dispersal

The System input stream shall be organized in fixed length packets (see figure 3), following the MPEG-2 transport multiplexer. The total packet length of the MPEG-2 transport multiplex (MUX) packet is 188 bytes. This includes 1 sync-word byte (i.e. 47HEX). The processing order at the transmitting side shall always start from the MSB (i.e. "0") of the sync-word byte (i.e. 01 000 111). In order to ensure adequate binary transitions, the data of the input MPEG-2 multiplex shall be randomized in accordance with the configurations depicted in figure 2 ETSI EN 300 744 V1.5.1 (2004-11)

The polynomial for the Pseudo Random Binary Sequence (PRBS) generator shall be 1 + X14 + X15

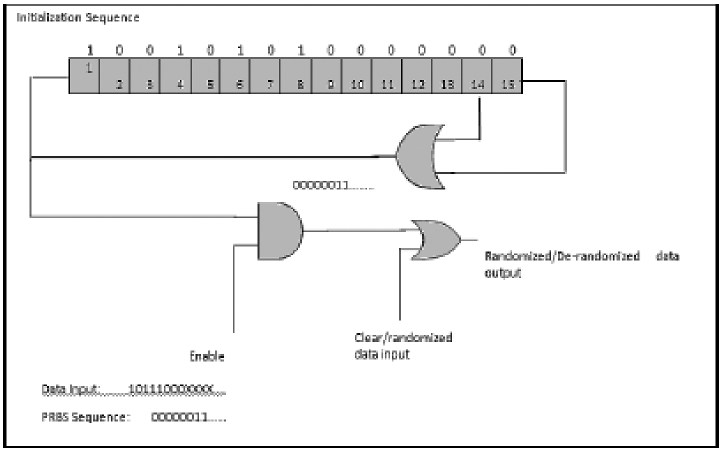


Figure 3. Scramble or Descrambler Schematic Diagram

Initialization sequence “100101010000000” is loaded to the PRBS registers at the beginning of every eight transport packets – once per frame composed by 8 packets. The first synchronization byte word of every frame is bit wise inverted to provide an initialization for descrambler. Synchronization byte words are not randomized

B. Outer coding and outer interleaving

The outer coding and interleaving is performed on the randomized 188 bytes transport packets structure. Reed-Solomon RS (204, 188, t = 8) shortened code is derived from the original systematic RS (255, 239, t = 8) and may be implemented by adding 51 bytes, all set to zero, before the information bytes at the input of an RS (255, 239, t = 8) encoder. These null bytes shall be discarded after the RS encoding procedure, leading to a RS code word of N = 204 bytes.

The convolutional interleaving process shall be based on the Forney approach which is compatible with the Ramsey type III approach, with I = 12. The interleaved data bytes shall be composed of error protected packets and shall be delimited by inverted or non-inverted MPEG-2 sync bytes (preserving the periodicity of 204bytes).The interleaver may be composed of I = 12 branches, cyclically connected to the input byte-stream by the input switch. Each branch j shall be a First-In, First-Out (FIFO) shift register, with depth j × M cells where M = 17 = N/I, N = 204.The cells of the FIFO shall contain 1 byte, and the input and output switches shall be synchronized

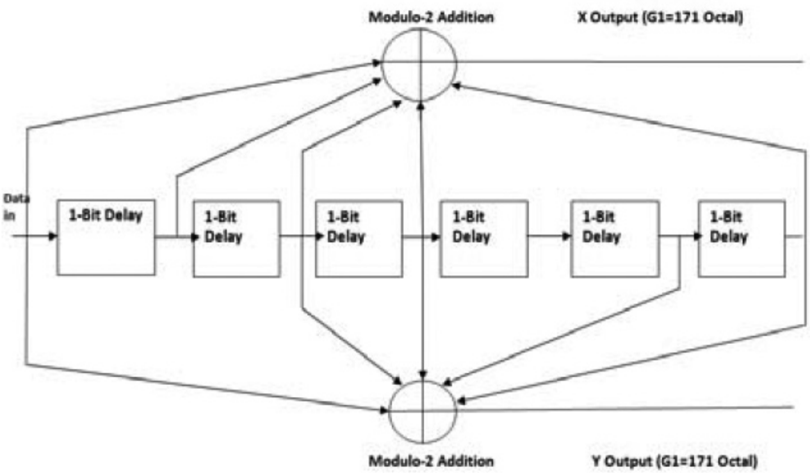


Figure 4. The mother convolutional code of rate ½

C. Inner Coding and Inner Interleaving

Inner coding is based on ½ convolutional code with constraint length 7 and generator polynomial 171_{Oct}, 133_{Oct}. This mother code is used to produce several punctured codes with different coding rates (Y.Yasuda et al., 1984)

Table1. Puncturing Patterns and transmitting sequence

Rate	Pattern	Transmitted sequence
½	11	x1 x2
2/3	1101	x1 x2 x4
¾	110110	x1 x2 x4 x5
5/6	1101100110	x1 x2 x4 x5 x8 x9
7/8	11010101100110	x1 x2 x4 x6 x8 x9 x12 x13

Inner interleaving specifies a combination of bit and symbol interleaving. Bit wise interleaving is followed by symbol interleaving. Both the processes are block-based. The input is demultiplexed into v-sub streams where v=4 for 16-QAM and v=6 for 64-QAM.

For each bit interleaver, the input bit vector is defined by [10]:

$$B(e) = (b_{e,0}, b_{e,1}, b_{e,2}, ...b_{e,125})$$

Where e ranges from 0 to v-1

The interleaved output vector

$$A(e) = (a_{e,0}, a_{e,1}, a_{e,2}, ...a_{e,125})$$ is defined by.

$$a_{e,w} = b_{e,He(w)} w = 0,1,2.........,125$$

He (w) is defined as follows for each interleaver :

$$I0: H_0 \ (w) = w$$

$$I1: H_1 \ (w) = (w + 63) \bmod 126$$

$$I2: H_2 \ (w) = (w + 105) \bmod 126$$

$$I3: H_3 \ (w) = (w + 42) \bmod 126$$

$$I4: H_4 \ (w) = (w + 21) \bmod 126$$

$$I5: H_5 \ (w) = (w + 84) \bmod 126$$

the output from the bit-wise interleaver is a v bit word y' that has the output of I0 as its most significant bit, i.e.:

$$y_w = a_{o,w,} a_{1,w}, ...a_{v-1,w}$$

126 data words from the bit interleaver are read sequentially into a vector

$$Y' = (y'_0, y'_1, y'_2, ...y'_{1511})$$

The interleaved vector $Y = (y_0, y_1, y_2, ...y_{Nmax-1})$ is defined by[10]:

$y_{H(q)} = y'_q$ For even symbols for q = 0, 1, 2,....., Nmax-1

$y_q = y'_{H(q)}$ For odd symbols for q = 0, 1, 2,....., Nmax-1

The demultiplexing is defined as a mapping of the input bits, xdi onto the output bits be, do.

In non-hierarchical mode:

xdi = b[di(mod)v](div)(v/2)+2[di(mod)(v/2)],di(div)v

In hierarchical mode:

xdi = bdi(mod)2,di(div)2

x"di = b[di(mod)(v-2)](div)((v-2)/2)+2[di(mod)((v- 2)/2)]+2,di(div)(v-2)

The purpose of the symbol interleaver is to map v bit words onto the 1512 (2K mode) or 6048 (8K mode) active carriers per OFDM symbol. The symbol interleaver acts on blocks of 1512 (2K mode) or 6048 (8K mode) data symbols

D. Digital Modulation

The system uses Orthogonal Frequency Division Multiplex (OFDM) transmission. All data carriers in one OFDM frame are modulated using QPSK, 16-QAM, 64-QAM, non-uniform 16-QAM or non-uniform 64-QAM constellations ETSI EN 300 744 V1.5.1 (2004-11)

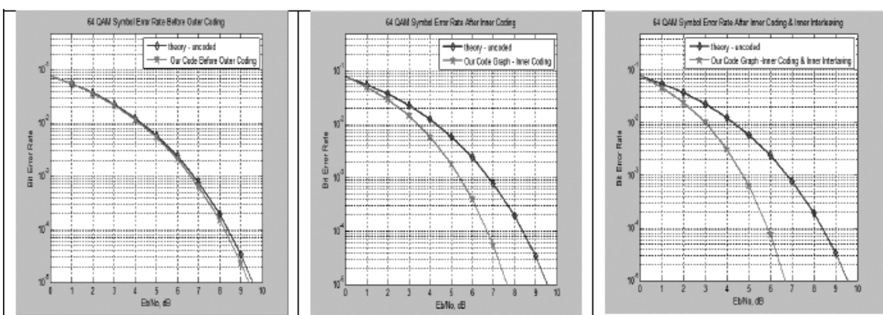
The constellation is divided in clusters that are further divided in sub-clusters.

III IMPLEMENTATION OF CHANNEL CODER IN 64QAM

DVB-T channel coder has been implemented in MATLAB. Initially a data signal is generated first on which both outer coding and interleaving and inner coding and interleaving is implemented to improve the Bit error ratio. Code rate of ½ and mode 8k is used for simulations. The following graphs show the improved symbol error rate.

The following Tables A, B & C shows various BER for 64 QAM with increasing E_B/N_o values. Table C shows the exact values for the improved BER in 64 QAM after inner coding and inner interleaving. As we can see from the table that every time as the signal to noise ratio is increasing the BER for 64QAM is improving with respect to 16 QAM. The amount of calculated percentage is also calculated and is shown in the table.

The results from fig 5 shows that as we are going with different simulations of inner and outer coding and interleaving processes the bit error ratio is improving.



A. Symbol error rate before outer coding

B. Symbol error rate after Inner coding

C. Symbol error rate after Inner coding and inner interleaving

Figure 5: 64QAM Symbol error rate

TABLE II: Bit error rate performance before Outer coding

Eb/No	Theoretical BER for 64 QAM	BER for 64QAM Before Outer Coding	Percentage improvement in BER of 64QAM w.r.t 16QAM
4	0.01217	0.01183	2.8%
5	0.005711	0.00547	4.2%
6	0.002245	0.002106	6.19%
7	0.0007067	0.0006442	8.8%
8	0.0001682	0.0001474	12.3%
9	2.82E-05	2.34E-05	17.02%

TABLE III: Bit error rate performance after Inner coding.

Eb/No	Theoretical BER for 16 & 64 QAM	BER for 64QAM After Inner Coding	Percentage improvement in BER of 64QAM w.r.t 16QAM
1	0.05628	0.05122	5.14%
2	0.03751	0.02966	12.4%
3	0.02288	0.01471	22.4%
4	0.0125	0.005954	35%
5	0.005954	0.001841	49.8%
6	0.002388	0.0003988	65.5%

TABLE IV. Bit error rate performance after Inner coding and Inner Interleaving

Eb/No	Theoretical BER for 64 QAM	BER for 64QAM After Inner Coding and Inner Interleaving	Percentage improvement in BER of 64QAM w.r.t 16QAM
1	0.05628	0.04775	9.37%
2	0.03751	0.0247	22.4%
3	0.02288	0.01027	39.1%
4	0.0125	0.003163	58%
5	0.005954	0.0006442	76%
6	0.002388	7.42E-05	89.6%

IV. CONCLUSIONS

MATLAB plays an important role throughout my work and it takes some time to be familiar with MATLAB functions such as performing mathematical operations, plotting data, manipulating data structures using MATLAB communication tools. After analyzing the result, it is concluded that after each step through the process of DVB-T the experimented values of bit error rate of 64 QAM are improved from the theoretical values before outer coding, after inner coding and inner interleaving. Also there is a comparative analysis on 16 and 64 QAM which show the percentage improvement in BER of 64QAM with respect to 16QAM.At the end it is being analysed that BER is improved by 17% before outer coding, 65. 5% after inner coding and is finally improved by 89.6% after inner coding and interleaving process. Thus before transmission as bit error rate is improved burst errors will be removed which will increase the efficiency.

V. REFERENCES

ETSI EN 300 744 V1.5.1 (2004-11). Digital Video Broadcasting (DVB); Framing structure,channel coding and modulation for digital terrestrial television. ETSI, 11/2004. [Online]Available:http://pda.etsi.org/pda/queryform.asp

ISO/IEC 13818 (Part 1to3): Information technology - Genericcoding of moving picturesand associated audio information.ISO/IEC. [Online]Available:h http://neuron2.net/library/mpeg2

ETSI EN 300 421 V1.1.2 (1997-08). Digital Video Broadcasting (DVB); Framing structure,channel coding and modulation for 11/12 GHz satellite services. ETSI, 08/1997. [Online]Available:http://pda.etsi.org/pda/queryform.asp

ETSI EN 300 429 V1.2.1 (1998-04). Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems. ETSI, 04/1998. [Online] Available: http://pda.etsi.org/pda/queryform.asp

Y. Yasuda, K.Kashiki, Y.hirata (1984). ‘High-Rate Punctured Convolutional Codes for Soft decision Viterbi Decoding’, IEEE Trans. On Communications, vol. COM-32,no. 3,pp:315-317, March 1984

Md. Dulal Haque et al., (2008). “Performance evaluation of a wireless orthogonal Frequency Division Multiplexing system under various concatenated FEC channel-coding schemes” Proc. IEEE(ICCET 2008) pp.25-27Dec 2008.

Stukavec, R. et al., (2009). “Matlab simulation of the DVB-T transmission”Proc.IEEE Radioelektronika, 2009. RADIOELEKTRONIKA ‘09. 19th International Conference pp. 315 - 318 April 2009.

Huttl, O. Kratochvíl, T. (2010). “Comparison of native and In-depth Symbol interleaving used in DVB-T/H channel coding” Proc.IEEE pp1-4,April 2010