

MATLAB SIMULATION OF DVB-H TRANSMISSION UNDER DIFFERENT TRANSMISSION CONDITIONS

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Abstract

This paper deals with the simulation of the transmission of the DVB-H standard in fading channels. The results of the DVB-H broadcasting over Gaussian channel, Ricean and Rayleigh fading channels are presented. Application for this simulation was developed in Matlab. Dependences of BER on C/N ratio before and after Viterbi decoding in all tested channel conditions were graphically expressed. Finally, obtained results are evaluated and discussed.

1 Introduction

DVB-H (Digital Video Broadcasting - Handheld) is a technical specification for the transmission of digital TV to the handheld receivers such as mobile telephones and PDAs. It was published as a formal standard (EN 302 304) by ETSI in November 2004. DVB-H has been developed from the DVB-T (Terrestrial) standard that is used in many countries mainly around the Europe. The documents for the physical layer were ratified in 2004, and the upper layers were defined in 2005 [1], [2].

The focus of this paper is a simulation of the transmission of data stream of DVB-H over fading channels. The appropriate algorithm which is capable to simulate the impact of different noises to transmission was developed in Matlab. Created application is divided into several independent functions. Each function represents one block of the DVB-H system (see Fig. 1) and the simulation is described in the first part of this paper. The second part is focused on the description of the created GUI application in Matlab and on the dependences of BER (Bit Error Ratio) before Viterbi and after Viterbi decoding on C/N (Carrier-to-Noise Ratio). Finally, results of these dependences are graphically expressed, compared and discussed.

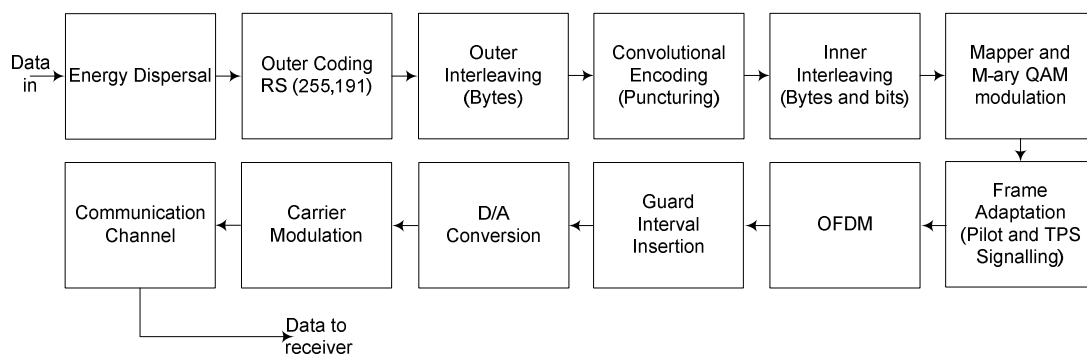


Figure 1: Block diagram of the DVB-H transmitter.

2 Description of the block diagram of the DVB-H Transmitter

In the first step it is necessary to order a number of bits for the input sequence generation. In the simulation presented below there was used a number of 100 kilobits.

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 $X^{15} + X^{14} + 1$. 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.

The next stage contains the outer encoder, the Reed-Solomon FEC (Forward Error Correction). This encoder RS (255,191) adds 64 correction bytes to 191 input bytes and it is able to correct up to 32 erroneous bytes [3].

However, frequently burst errors occur during a transmission. If this results in more than 32 errors in a packet protected by Reed-Solomon coding the block error protection fails. Therefore, the data are interleaved. An outer interleaver is a convolutional interleaver with interleaving depth of $I = 15$ [3].

The next function block in the Fig. 1 is the outer interleaver. The outer interleaver is followed by a convolutional encoder. The generator polynomials are $G_1=171OCT$ and $G_2=133OCT$. If necessary, the error protection can be controlled by puncturing, e.g. the data rate can be lowered again by selectively omitting bits [3].

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.

The input stream is demultiplexed (mapped to output modulation symbols) into ν sub-streams, depending of the modulation used: $\nu = 2$ for QPSK, $\nu = 4$ for 16QAM and $\nu = 6$ for 64QAM. Each sub-stream from the demultiplexer is then interleaved in the interleaver with own interleaving sequence called permutation function.

Symbol interleaving is performed as bit-wise interleaved substream. The purpose of the symbol interleaver is to map ν bit words onto the 1512 (2k mode), 3024 (4k mode) or 6048 (8k mode) active carriers per OFDM symbol. The symbol interleaver acts on blocks of 1512, 3024 or 6048 data symbols. After previously mentioned FEC blocks, symbols from output inner interleaver are ready to modulate into QPSK, 16QAM or 64QAM constellations [3].

Transmission frame adaptation block has to divide modulated stream, carrying useful data, into OFDM symbols are add the TPS, scattered, pilot and zero carriers. This block is simple, as the only purpose is to rearrange the data and insert special carriers on their defined positions. Once we have OFDM symbols assembled, guard interval can be inserted. According to the DVB-H specification, options are 1/4, 1/8, 1/16 and 1/32 of the symbol period. End part of each symbol is copied to its end.

Now the complete OFDM signal in the frequency domain is transferred into the time domain using IFFT (Inverse Fast Fourier Transformation). Real $Re(t)$ as well as imaginary $Im(t)$ part of the OFDM signal is upsampled and filtered with Raised Cosine filter with roll-off factor equals to 0.35.

At this point we have now prepared DVB-H signal, which can be transmitted. This paper shows a feature of three types of channels: Gaussian, Ricean and Rayleigh.

3 MATLAB Application Description

Main window of the Matlab application can be seen in Fig. 2.

In the first step, it is necessary to order a number of bits for the input sequence generation. Created application allows selecting between two options. In the first case the user can specify the number of bits for generating input bit sequence. This number the user can write to table *Number of bits*. When checkbox *Picture* is active, that presented the second option. In this case the created program is loaded the *DVBH.bmp* (see Fig. 2) picture and converted it into a sequence of ones and zeroes. In the simulations presented below, there was used the first case.

The *Code Rate* option allows control of the error protection of the transmitted data, e.g. the data rate can be lowered again by selectively omitting bits. Possible punctuated code rates are, according to DVB specification, 1/2 (no puncturing), 2/3, 3/4, 5/6 and 7/8 (minimum error protection).

The *Type of Modulation* and *OFDM mode* options enable choose of type of modulation (QPSK, 16QAM and 64QAM) and OFDM modes (2k, 4k and 8k), which used in standard DVB-H.

The option *Guard Interval* enables set values as are defined in [6]: 1/4, 1/8, 1/16 and 1/32.

The *Type of Channel* allows choose the type of communication environment, in which it is possible to simulate the transmission of DVB-H data. This application enables to choose between the *Gaussian* channel and *Multipath* channels.

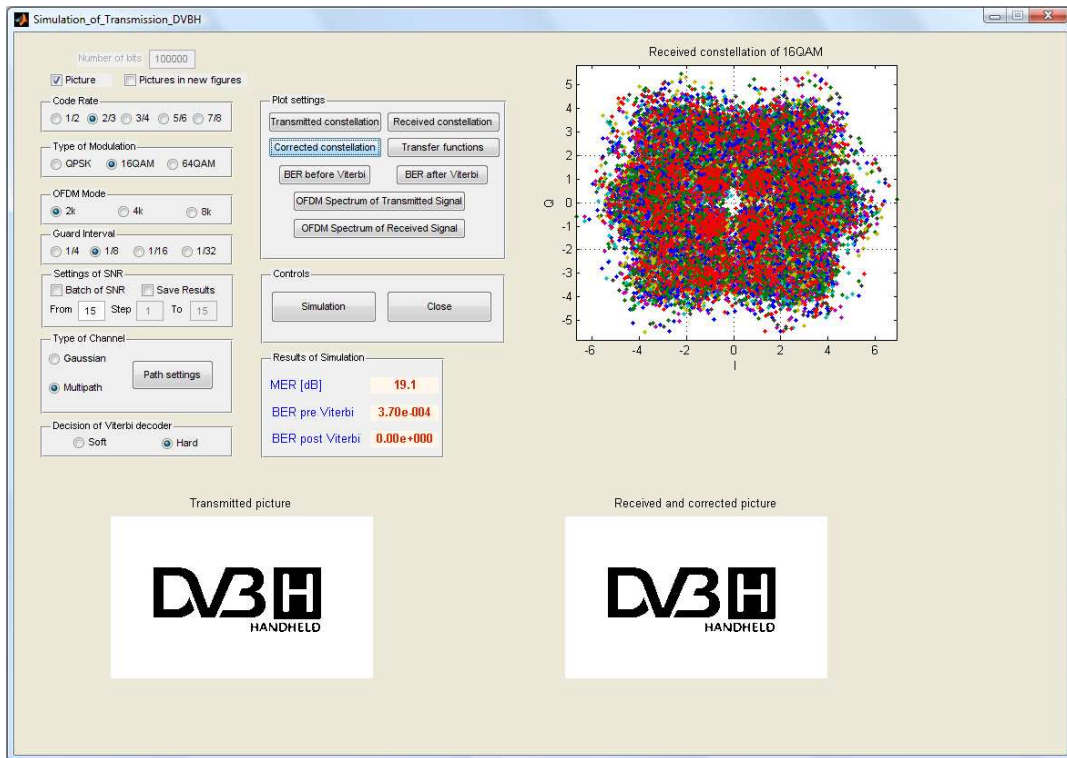


Figure 2: Main window of the MATLAB application for the DVB-H simulation.

It is visible in the Fig 3. that in table *Settings of SNR* it is given the value of the Signal-to-Noise Ratio in dB. Resources for the simulation of the transmission and signal processing are included in Matlab in functions of the Communication Toolbox. This toolbox also includes models of different types of transmission channels with many adjustable parameters. In Matlab, the transmission channel with fading can be applied to the signal with filtering using functions `ricianchan` and `rayleighchan`. But for using these Matlab functions it is necessary to use a filter, which is also in this case, with low sampling very slow. Moreover, these functions do not enter the phase shift of paths, which is defined in the standard [6]. Therefore, the modeling of channel environments with fading that was used is a custom algorithm based on equations [5], [6].

Option *Decision of Viterbi Decoder* allows choosing of the type of decision in Viterbi decoding process. Here exist two cases: soft decision and hard decision.

After the set-up of all parameters the simulation can be started. The results of simulation are shown in Fig. 3. These are constellation diagram of received signal, *MER* (Modulation Error Ratio) in dB, *BER* before and *BER* after Viterbi decoding.

4 Simulation parameters

Application for the simulation of the transmission of DVB-H has been implemented in Matlab. For the simulation of the DVB-H transmission was used following settings:

- mode: 2k (used mobile reception)
- code ratio: 1/2 (presents robust transmission)
- inner modulation: QPSK, 16QAM, 64QAM (variable)
- guard interval: 1/32 (used in small DVB-H networks)
- transmission channel: Gaussian (AWGN), Ricean (ETSI model RC 20 ANX B), Rayleigh (ETSI model RL 20 ANX B)
- K-Factor: 10 (factor used in Ricean channels)
- Viterbi decoding decision: soft.

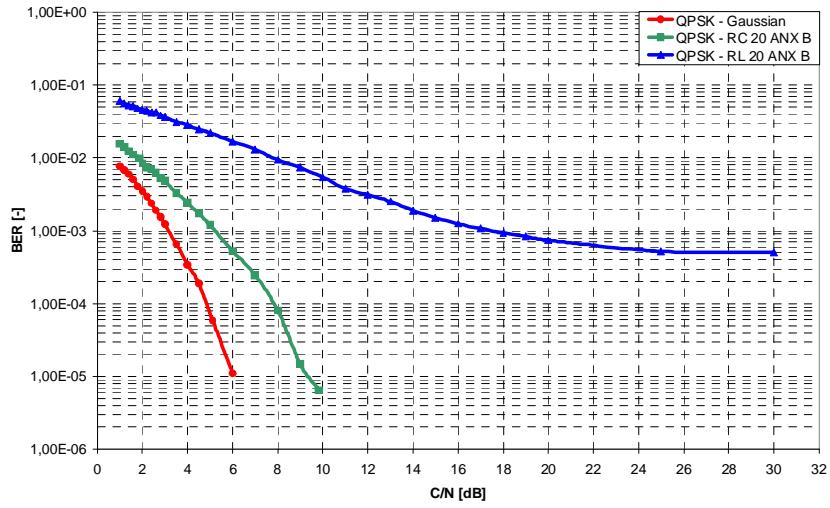


Figure 3: *BER* before Viterbi decoding as a function of *C/N* ratio in the Gaussian channel and in the fading channels “RC 20 ANX B”, “RL 20 ANX B” (mode 2k – inner modulation QPSK).

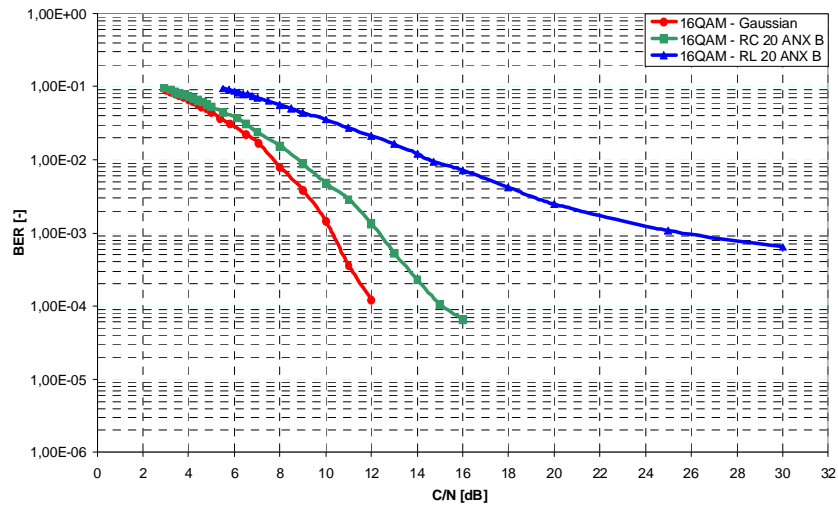


Figure 4: *BER* before Viterbi decoding as a function of *C/N* ratio in the Gaussian channel and in the fading channels “RC 20 ANX B”, “RL 20 ANX B” (mode 2k - inner modulation 16-QAM).

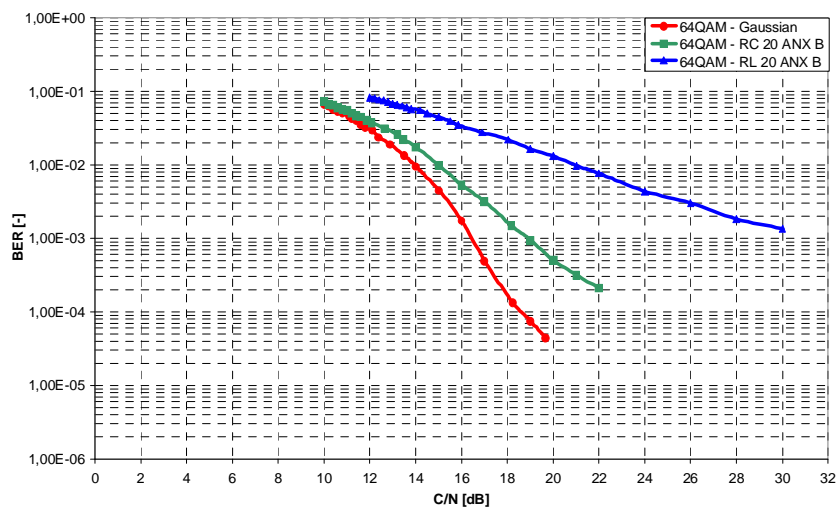


Figure 5: *BER* before Viterbi decoding as a function of *C/N* ratio in the Gaussian channel and in the fading channels “RC 20 ANX B”, “RL 20 ANX B” (mode 2k - inner modulation 64-QAM).

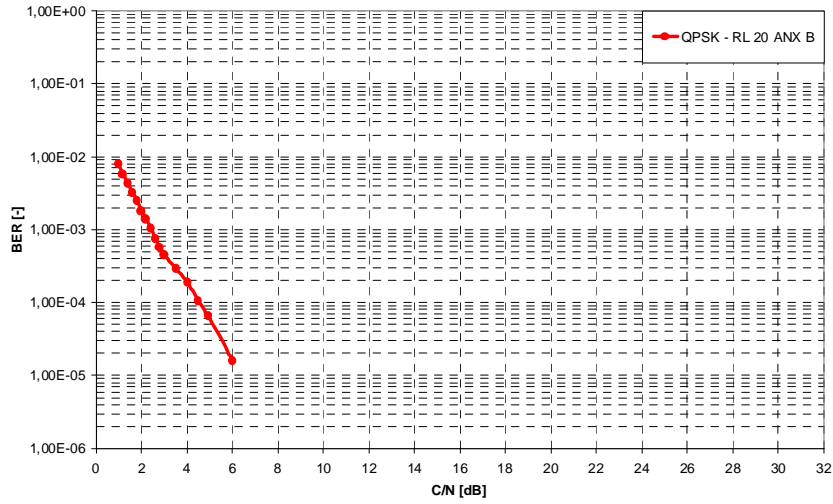


Figure 6: *BER* after Viterbi decoding as a function of *C/N* ratio in the Gaussian channel and in the fading channels “RC 20 ANX B”, “RL 20 ANX B” (mode 2k – inner modulation QPSK).

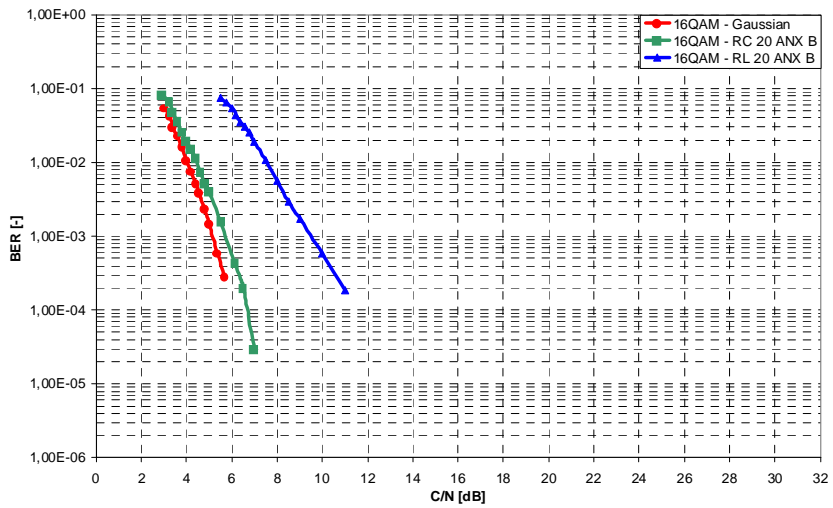


Figure 7: *BER* after Viterbi decoding as a function of *C/N* ratio in the Gaussian channel and in the fading channels “RC 20 ANX B”, “RL 20 ANX B” (mode 2k – inner modulation 16-QAM).

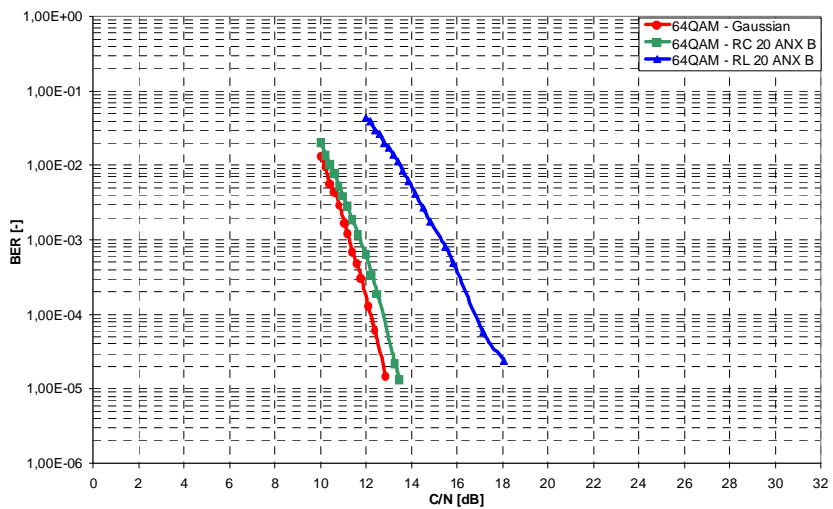


Figure 8: *BER* after Viterbi decoding as a function of *C/N* ratio in the Gaussian channel and in the fading channels “RC 20 ANX B”, “RL 20 ANX B” (mode 2k – inner modulation 64-QAM).

5 Simulation Results

Transmission of 100 kilobits of the data was simulated for varying C/N ratio in the Gaussian channel (AWGN) and in the fading channels - Ricean (type RC 20 ANX B) and Rayleigh (type RL 20 ANX B). The QEF (Quasi Error-Free) reception is defined as a bit error rate after Viterbi decoding less or equal to $2 \cdot 10^{-4}$ [7]. Then the BER ratio after Reed-Solomon decoding is less or equal to $2 \cdot 10^{-11}$. The Fig. 3 to Fig. 8 illustrates BER before Viterbi decoding in Gaussian and two fading channel models.

The Fig. 4 shows the dependence of the BER after Viterbi decoding on C/N ratio in case of the QPSK modulation. How it can be seen in the Fig. 3, there were obtained three BER curves: one for the Gaussian channel, one for the Ricean channel and one for the Rayleigh channel. After Viterbi decoding, just one BER curve has been obtained and only for the Rayleigh channel. This is because the modulation QPSK is the most robustness to fadings. It can be seen that for QEF in Rayleigh channel and 2k mode, minimum of C/N equal to 4 dB is needed [8].

Results of the simulation by using 16QAM modulation for the transmission via Gaussian, Ricean and Rayleigh channel are shown in the Fig. 4 and Fig. 7. It is visible in Fig. 4, as well as at influence of noise in all tested channel models, that lower number of states in multistate modulations (in this case 16QAM) leads to a lower BER . That means that the higher number of states in multistate modulations are needed for higher achievement and higher C/N produces lesser BER . According to the results of the simulations it is possible to conclude, that in case of Ricean channel and QEF it is needed to increase value of C/N by 1dB in comparison with values in the Gaussian channel (see Fig. 7). In Rayleigh channel there is needed increase of C/N by 7 dB [8].

The same results, but in case of 64QAM modulation in all mentioned channel environments, are shown in Fig. 5 and Fig. 8. By using 64QAM modulation for the transmission, the data stream volume is the larger one. But the resistance of transmitted data to errors in fading channels is much worst. Therefore for achieving the QEF in Ricean channel it is needed 13.0 dB and 16.2 dB for the Rayleigh channel [8].

6 Conclusion

Presented application allows simulation of the DVB-H transmission in OFDM mode 2k with error correction. Dependences of the BER before and after Viterbi decoding on C/N ratio was explored for the Gaussian channel as the reference and for two main fading channels introduced in the [6].

Differences between the results in Gaussian and Ricean channel are not too large. This is because that in Ricean channel direct signal path already exists. For achieving a good reception quality in Rayleigh channel it is needed to increase C/N ratio. It is simply because the direct path in this case is fully attenuated.

Presented results can be used for the transmission distortion analysis and evaluation of the DVB-H system parameters influence on transmitted signal of the mobile TV.

Acknowledgement

This contribution was supported by the grant project of Research programme of Brno University of Technology MSM0021630513 "Electronic Communication Systems and New Generation Technology (ELKOM)" and grant projects of the Czech Science Foundation no. 102/08/H027 "Advanced methods, structures and components of the electronic wireless communication", no. 102/08/P295 "Analysis and Simulation of the Transmission Distortions of the Digital Television DVB-T/H" and no. 102/10/1320 "Research and modeling of advanced methods of image quality evaluation".

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