SIMULATION OF THE DVB-H TRANSMISSION IN MATLAB

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ABSTRACT

This paper deals with a Matlab application that is currently being developed for simulation of the DVB-H transmission in Gaussian and Ricean transmission channel. The application structure and its functions are described. Channel encoder and decoder were implemented in Matlab as it is specified in the DVB-H standard. Dependence of *BER* (Bit Error Ratio) on *C/N* (Carrier-to-Noise Ratio) as a result of the simulation in the Gaussian and Ricean channel is graphically expressed and it is compared with each other. The OFDM (Orthogonal Frequency Division Multiplexing) modulation was not implemented yet. Finally, obtained results are discussed.

1. INTRODUCTION

DVB-H (Handhelds) is a technical specification for the transmission of digital TV to handheld receivers such as mobile telephones and PDAs. 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]. It is an extension of DVB-T with some backwards compatibility, i.e., it can share the same multiplex with DVB-T. A non-proprietary open standard, DVB-H has broad support across the industry and services are now on air in more than ten countries, with more due to launch in 2009 and 2010.

This paper contains results of recent development of Matlab application which allows simulates transmission of the DVB-H standard in Gaussian channel and Ricean static frequency-flat channel. Resources for the simulation of transmission and signal processing are included in Matlab in packet of Communication Toolbox. This toolbox also includes models of a different type of transmission channels with many adjustable parameters. These functions were used, as they are optimized and simple to implement. GUI (Graphical User Interface) was also created to make the use of the application and changing settings easier. At the end of this simulation it can show *BER* before Viterbi decoding and *BER* after Viterbi decoding. Finally, results of these dependences in Gaussian and Rice transmission channels are graphically expressed compared.

2. TYPE OF TESTED TRANSMISSION CHANNELS

2.1. GAUSSIAN CHANNEL

Model of the Gaussian channel describes a case, which is based on a direct signal path from transmitter to receiver only. In this case the received signal is only attenuated and includes a definite level of noise. This channel is overlaid with AWGN (Additive White Gaussian Noise), which is mainly produced in the receiver itself. The best condition for the received data is defined as Gaussian channel.

2.2. RICEAN CHANNEL

When reflected signals are added to a direct signal then the quality of the reception get worse. Multipath propagation of the signals makes a variance of signal intensity and causes ISI (Inter Symbol Interferences). On this variance the signal is also influenced with the movement of the receiver and changes of the environment. These situations are modeled in channel, which is defined as a Rice channel. In this type of channel the Gaussian channel and its characteristics also exists. The signal is completed with reflection of signals from different ways. A case like this is in real conditions most frequent. The Rice factor *K* denotes the ratio of the signal in the direct path to the sum in all echo paths (1):

$$K = \frac{\rho_0^2}{\sum_{i=0}^{N_e} \rho_i^2}, \tag{1}$$

where ρ_0 is the attenuation in the direct signal path, N_e is the certain number of echoes and ρ_i is the attenuation in echo path *i* [3].

Rice channel has higher requirements for the compensation of multipath propagation effects than Gaussian channel. Methods of signal propagation in both mentioned and described cases are illustrated in Fig. 1.

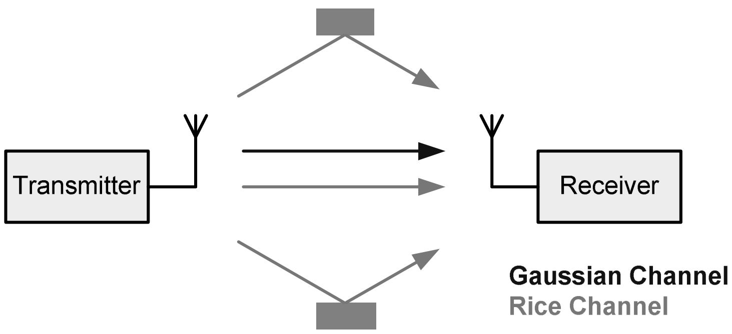


Fig. 1. Propagation of the signal in Gaussian and Rice channel.

3. APPLICATION DESCRIPTION

The structure of the transmitter follows common DVB-H transmitter block diagram, as shown in Fig. 2. Each block is represented by one m-file function. The receiver is programmed as inverted transmitter. Main window of the Matlab application can be seen in Fig. 3.

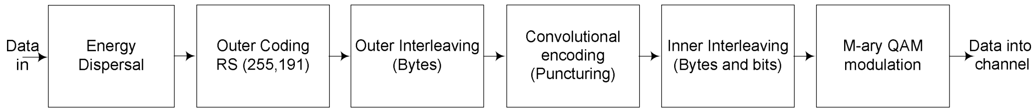


Fig. 2. Block diagram of the DVB-H transmitter.

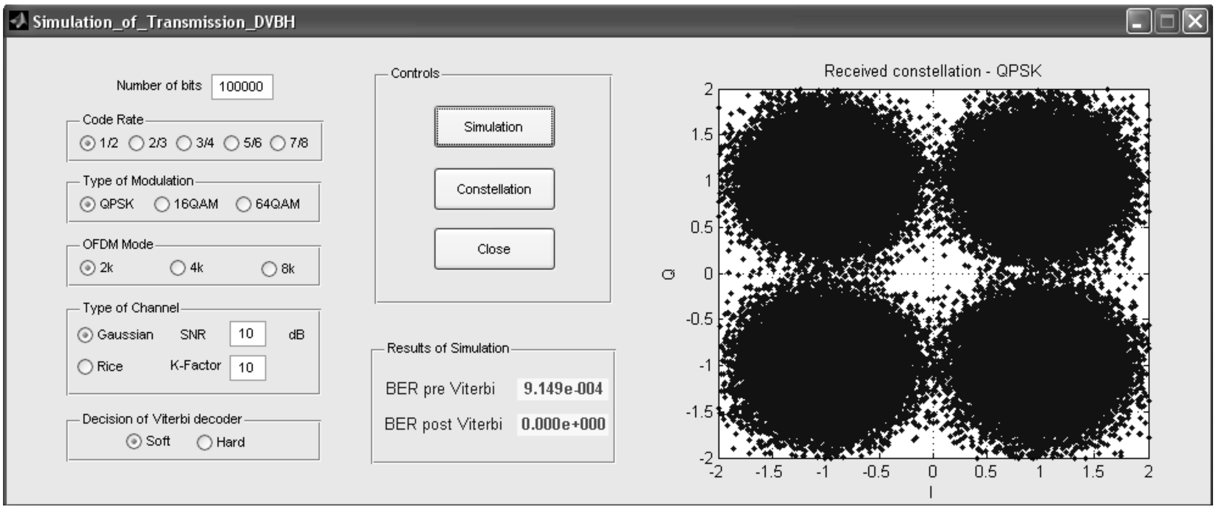


Fig. 3. Main window of the Matlab application for the DVB-H simulation.

In the first step it is necessary to order a number of bits for the input sequence generation. This number, the user can to write to table *Number of bits*. In the simulation presented below there were used a number of 100000 bits.

The *Code Rate* option allows controlled 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. In the developed application OFDM modes define variables (vector of interleaving, permutation function) which will be used in the block inner interleaving.

The *Type of Channel* in window of GUI allows choose the type of communication environment, in which it is possible to simulate behavior of the transmitted data. This application enables to choose two types of channels: Gaussian and Rice. It is visible in the Fig 3. the table *SNR* is given the value of the Signal-to-Noise Ratio in dB. Table *K-Factor* allows setting of parameter *K* in case of Rice channel simulation. For the simulation of the Rice channel was used the `ricianchan` Matlab function. This function models a static frequency-flat channel with zero Doppler's shift.

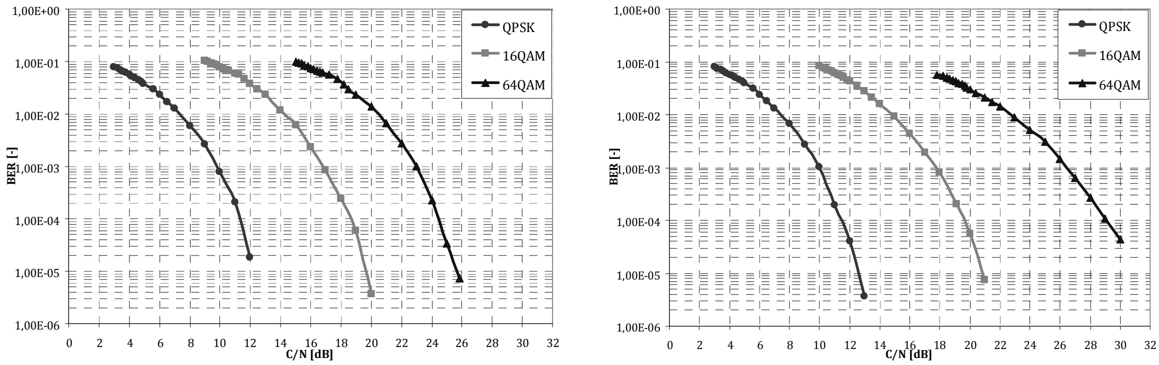
Option *Decision of Viterbi Decoder* allows chooses the type of decision in Viterbi decoding process. Here exits to cases: soft decision and hard decision.

After set-up of all parameters the simulation can be started. The results of simulation are shown in Fig. 3: constellation diagram of received signal, *BER* before and *BER* after Viterbi decoding.

4. SIMULATION

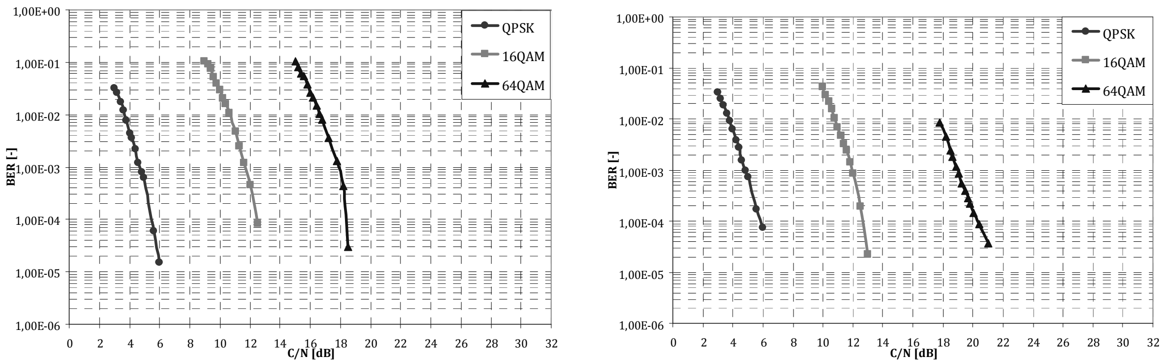
Application for the simulation of the transmission of DVB-H has been implemented in Matlab. For the simulation of the DVB-H transmission was used following settings:

- mode: 2k (mobile reception)
- code ratio: 1/2 (robust transmission)
- modulation: QPSK, 16QAM, 64QAM
- transmission channel: Gaussian (AWGN), Ricean (static frequency-flat)
- K-Factor: 10 (Ricean channel)
- Viterbi decoding decision: soft.



a) AWGN channel   b) Ricean channel with K-Factor = 10

Fig. 4. Simulated dependence of BER before Viterbi decoding on C/N ratio in AWGN and Ricean channel (mode 2k).



a) AWGN channel   b) Ricean channel with K-Factor = 10

Fig. 5. Simulated dependence of BER after Viterbi decoding on C/N ratio in AWGN and Ricean channel (mode 2k).

5. RESULTS

Dependence of the *BER* on *C/N* ratio as a result of the simulation in the Gaussian channel and Rice frequency-flat channel is graphically expressed. The Fig. 4 a) and b) illustrate *BER* ratio before Viterbi decoding. From the results it is easy to see that the multistate modulations with less number of states are more robust than the modulation with higher number of states. The *BER* in the Ricean channel is worse because in this type of channel reflected signals already exist. For achieving the same *BER* ratio for the various types of modulation as in Gaussian channel we need increased the value of *C/N*.

6. CONCLUSIONS

Presented application allowing simulation of the DVB-H transmission with error correction was described and obtained results are presented. Gaussian channel and Rice channel with K-Factor = 10 as a static frequency-flat channel was simulated. We can see how much worse performance has the Rice channel compared to the Gaussian channel (Fig 4. a) and b)). This is caused by reflected signals which are added to the direct signal. Graphical expression of the *BER* dependence on the *C/N* ratio after Viterbi decoding in Gaussian and Rice channel can be seen in Fig. 5 a) and b).

The created application with appropriate algorithm in Matlab is capable to simulate the DVB-H transmission and show the main results of parameters of transmission. Created application with user-friend GUI is can be used for study purposes.

Future work will be focused on a channel estimation block to provide reliable simulation results in Rice and Rayleigh fading channels. This work will be also continuing to developed OFDM modulator.

ACKNOWLEDGMENTS

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