DVB-T SIMULATION IN GAUSSIAN CHANNEL

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ABSTRACT

This paper deals with a Matlab application currently being developed to simulate DVB-T transmission in various transmission channels. The application structure and its functions are described. The aim was to implement all the functional blocks as specified in the DVB-T specification. Dependence of BER on C/N ratio as a result of the simulation in the Gaussian channel is graphically expressed and compared to the results of the laboratory measurement. The reference measurement was performed using Rohde & Schwarz SFU (broadcast test system) unit as the transmitter and Kathrein MSK-33 DVB-T test receiver. Finally, obtained results are discussed.

1. INTRODUCTION

The DVB-T is subject to implementation in recent years not only in the Czech Republic. The aim of presented research is to develop application which will be able to simulate DVB-T transmission in various transmission conditions. The resulting *BER* (Bit Error Rate) of the transmission using various settings of the DVB-T system parameters can be evaluated. Application is being developed in Matlab, using its Communication Toolbox. This toolbox includes many functions, which can be easily implemented and they are performance is optimized. User-friendly graphical interface GUI was also created to make the use of the application and changing settings easier.

2. APPLICATION DESCRIPTION

Main window of the Matlab application can be seen in Fig. 1. The application is composed of several independent functional blocks. The structure of the transmitter basically follows common DVB-T transmitter block diagram, as shown in Fig. 2. Each block is represented by one m-file function. Where it is possible, block parameters can be set to the various transmission parameters defined by DVB-T specification [1]. The receiver is programmed as inverted transmitter, just channel estimation and channel correction block was added to correct multipath propagation influence on the received signal.

User can choose the type of the channel (Gaussian, Rice and Rayleigh) and set up to 20 independent paths of multipath propagation. The paths settings are available in the separated window. Gain and delay of each path can be set as defined in [1] or set by user.

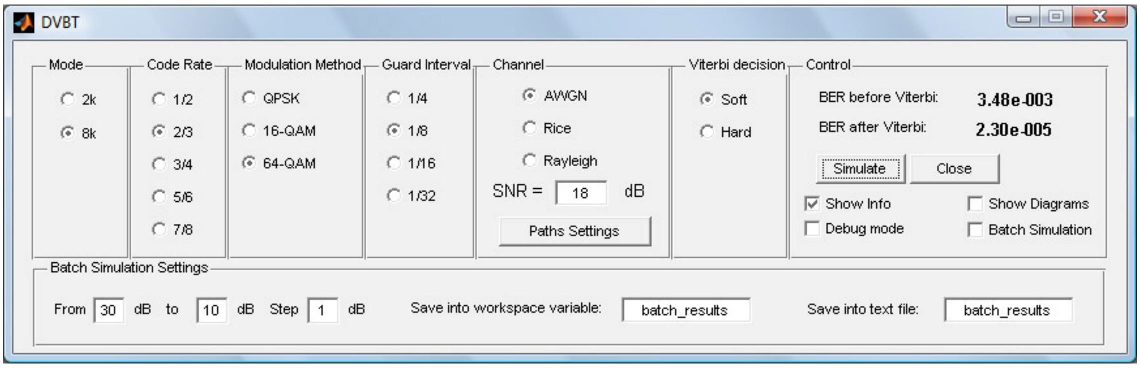

Figure 1: Main window of the Matlab application for the DVB-T simulation.

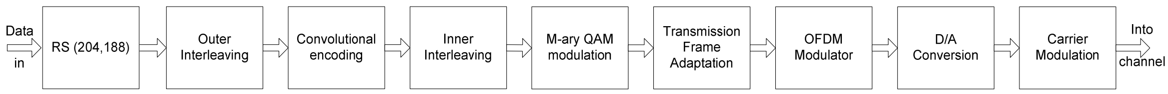

Figure 2: Block diagram of the DVB-T transmitter modulator.

Application is currently utilizing channel simulator function included in Communication Toolbox. The noise ratio *C*/*N* (Carrier-to-Noise ratio) can be also set in the range of 5 to 50 dB. *BER* before and after Viterbi decoding is computed after successful simulation and output to the application window.

The “Show Info” option enables displaying of a current status of the simulation as well as each function processing time in the Matlab command line. The “Show Diagrams” option displays constellation diagrams of transmitted signal, received signal and received signal after channel correction. The “Debug mode” can be turned on for application debugging purposes. Each processing step is stored into workspace variable, allowing evaluation of each block inner function and its output results.

As a greater number of simulations has to be performed to construct a graphical representation of *BER* dependence on *C*/*N* ratio, the “Batch Simulation” option was implemented. User can set start and end *C*/*N* ratio as well as the step. Results, including settings used are stored into the user defined text file or Matlab workspace variable.

There are several issues when simulating DVB-T transmission. Common problem is that real transmission is continuous in contrast to the simulation, where finite data amount is transmitted. This fact results in need to check block input divisibility, as the processing is performed by data blocks. For example, Reed-Solomon coder acts on blocks of 188 input bytes. If the input data amount is not divisible with 188, zeros are added to ensure divisibility. Number if zeros added in the transmitter side is stored into a variable and they are removed on the receiver side. Inner function of some blocks had to be programmed differently than in the case of real transmission, for example the convolutional interleaver. Convolutional interleaver utilizes shift registers, but when simulating finite transmission, first bytes are interleaved with initial zeros stored in the registers, and last bytes remain in the registers. So the interleaving is realized simply by writing bytes into the matrix by columns and reading them out by rows instead of using Matlab in-built function for convolutional interleaver.

3. RESULTS

The simulation was performed using the same settings as the measurement. Parameters were chosen as they are typical for the DVB-T transmission in the Czech Republic:

- mode 8k,
- convolutional code rate 2/3,
- inner modulation 64-QAM,
- guard interval 1/8,
- non-hierarchical modulation.

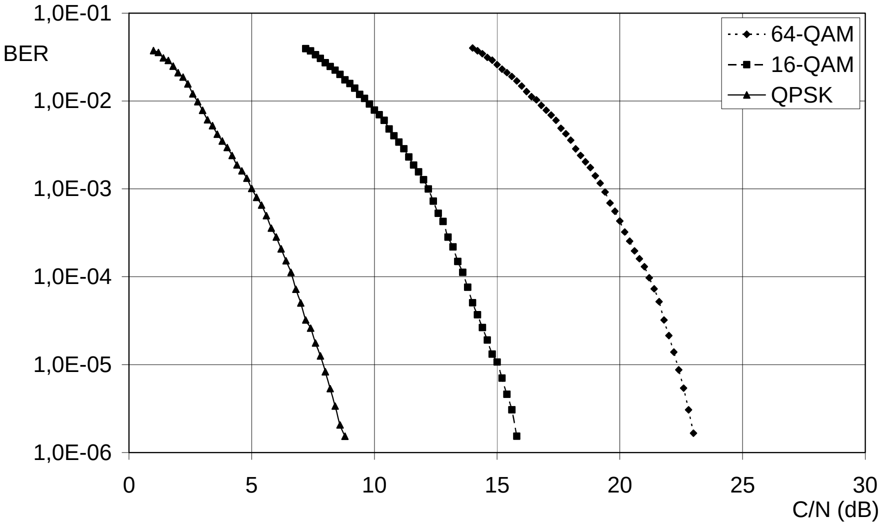

Figure 3: Simulated dependence of BER before Viterbi decoding on Carrier-to-Noise ratio.

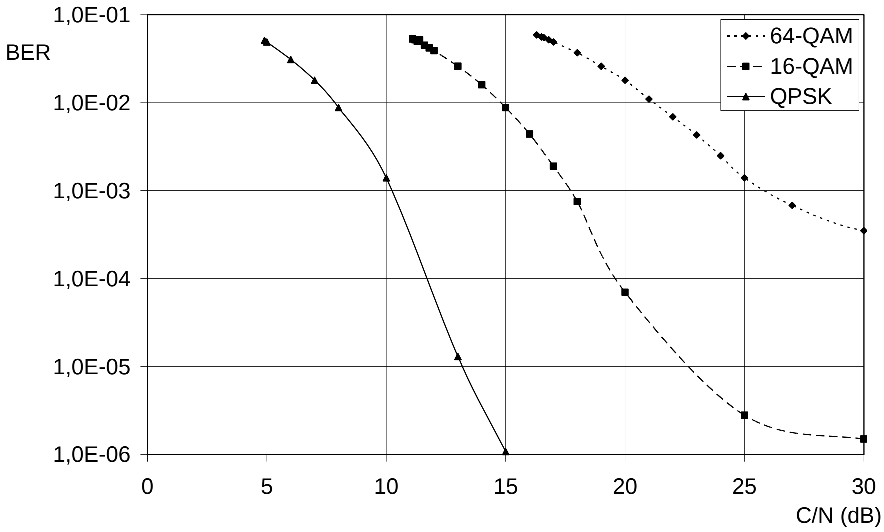

Figure 4: Measured dependence of *BER* before Viterbi decoding on Carrier-to-Noise ratio.

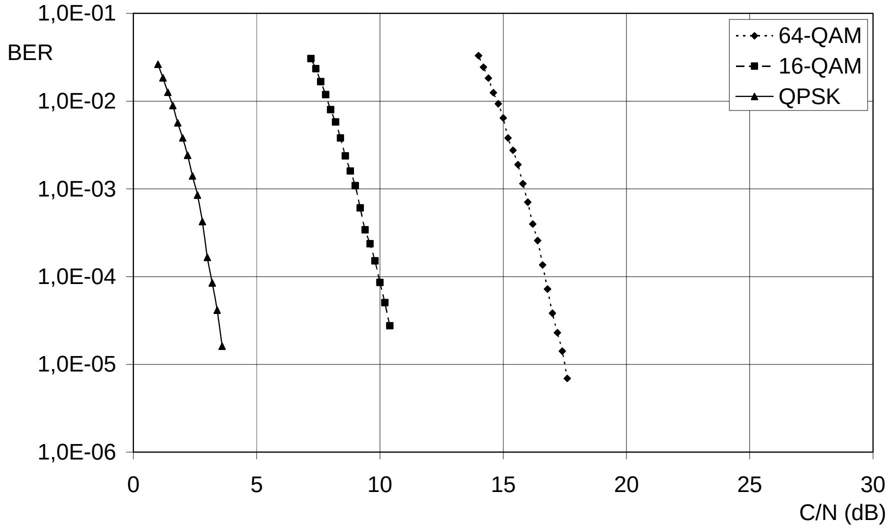

Figure 5: Simulated dependence of BER after Viterbi decoding on Carrier-to-Noise ratio.

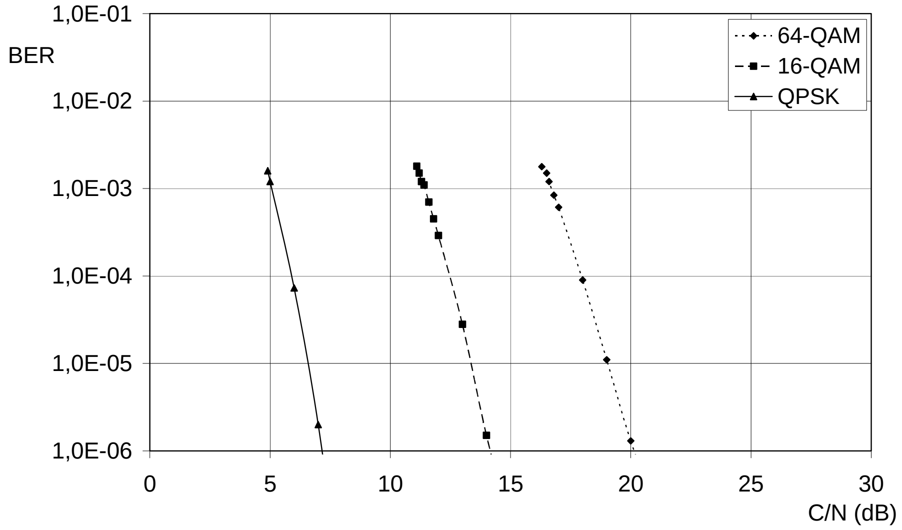

Figure 6: Measured dependence of BER after Viterbi decoding on Carrier-to-Noise ratio.

Transmission of 800 kbits of the data was simulated for varying *C*/*N* ratio in the Gaussian channel (AWGN). Dependence of the *BER* on the *C*/*N* ratio before Viterbi decoding can be seen in Fig. 3 and it can be compared with the measured dependence in Fig. 4. The same dependence can be seen in Fig. 5 and Fig. 6 for *BER* after Viterbi decoding. Details about comparative measurement can be found in [2]. Experimental simulations in Rice and Rayleigh fading channels with use of channel estimation block were also performed. Rice channel with 6 paths was simulated. Noise *C*/*N* ratio was set to 30 dB in the transmission channel. Resulting *BER* was 1.3E-2 before Viterbi decoding and 8.2E-4 after Viterbi decoding. The entire sequence was error-free after all error corrections (de-interleaving and Reed-Solomon decoding). Such a high error rate after Viterbi decoding, even with such high C/N ratio was caused by simple channel estimation algorithm, temporally used. Therefore simulations of Rice and Rayleigh channel are not presented yet.

4. CONCLUSIONS

Presented application allowing simulation of the DVB-T transmission, including error correction was described and obtained results were presented. Simulated and measured dependencies slightly differ. This is probably caused by noise produced by real transmitter and receiver system which was not taken into account during the simulation.

Future work will be focused on a channel estimation block to provide reliable simulation results in Rice and Rayleigh fading channels as they are defined in [1]. Attention will be also paid on speeding up the whole simulation, mainly carrier modulation/demodulation blocks, which are the slowest in the whole system simulation. Finally, work on including DVB-T2 system parameters [3] will be started, as the specification is currently available in the form of a DVB BlueBook [4].

ACKNOWLEDGEMENTS

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