SIMUALTION OF THE DVB-SH-A/B TRANSMISSION IN MATLAB

Ladislav Polák

Doctoral Degree Programme (3), FEEC BUT

E-mail: xpolak18@stud.feec.vutbr.cz

Supervised by: Tomáš Kratochvíl

E-mail: kratot@feec.vutbr.cz

Abstract: In recent research, thank to the innovations of signal processing, DVB-SH (Digital Video Broadcasting – Satellite services to Handhelds) standard is considered as a reference for the next generation mobile TV standard DVB-NGH (DVB-Next Generation for Handhelds). This paper deals with a MATLAB application that is currently developed for simulation of the DVB-SH (includes both modes DVB-SH-A and DVB-SH-B) transmission in Gaussian and fading transmission channels. The application structure and its function for both transmission modes are described. Dependences of *BER* (Bit Error Ratio) on *C/N* (Carrier-to-Noise Ratio) after turbo decoding as a result of the simulation in Gaussian and fading channels are graphically expressed and evaluated. Finally, obtained results are discussed.

Keywords: DVB-SH, Turbo encoding and decoding, number of decoding iterations, BER.

1. INTRODUCTION

The number of applications and their possibilities, which are integrated in present mobile phone terminals, has been significantly increased over time. Nowadays, personal mobile telephones, beyond the transmission of classical voice, text and data services, offer many multimedia services [1]. In an era of digital TV broadcasting there exist several types of DVB (Digital Video Broadcasting) standards, which propose broadcasting with high transmission capacity for video and audio services. In case of mobile TV, behind the DVB-H (DVB-Handhelds) standard [2], the DVB-SH (DVB-Satellite to Handhelds) standard has been developed [2]-[5].

DVB-SH [2], [3] is a relatively new standard provides an efficient and flexible mean of carrying broadcast services over the hybrid satellite and terrestrial infrastructure ,operating in S-band, (2.17 - 2.2) GHz, to a variety of portable, mobile and fixed terminals having compact antennas with very limited or almost no directivity. Target terminals include handheld defined as light-weight and battery-powered apparatus (e.g. PDAs, mobile phones), vehicle-mounted, nomadic (e.g. laptops, palmtops, etc.) and stationary terminals (set-top-boxes). Standard DVB-SH complements and improves the existing DVB-H (mainly the physical layer) standard. This improvement pushes the limits on the possibilities of DVB broadcasting to handheld terminals. It allows mobile TV transmission in two principle modes: OFDM (Orthogonal Frequency Division Multiplexing) for satellite and terrestrial mode and TDM (Time Division Multiplexing) for satellite mode.

This paper contains results of recent development of MATLAB application, which allows simulates transmission of the DVB-SH standard (in both mentioned modes) in Gaussian (AWGN) and fading channels. 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* (Bit Error Ratio) after turbo decoding and *MER* (Modulation Error Ratio). Finally, results of the *BER* ratio dependences on the *C/N* (Carrier-to-Noise Ratio) ratio in Gaussian and fading transmission channels are graphically expressed and compared.

2. BLOCK DIAGRAM OF THE DVB-SH-A AND DVB-SH-B
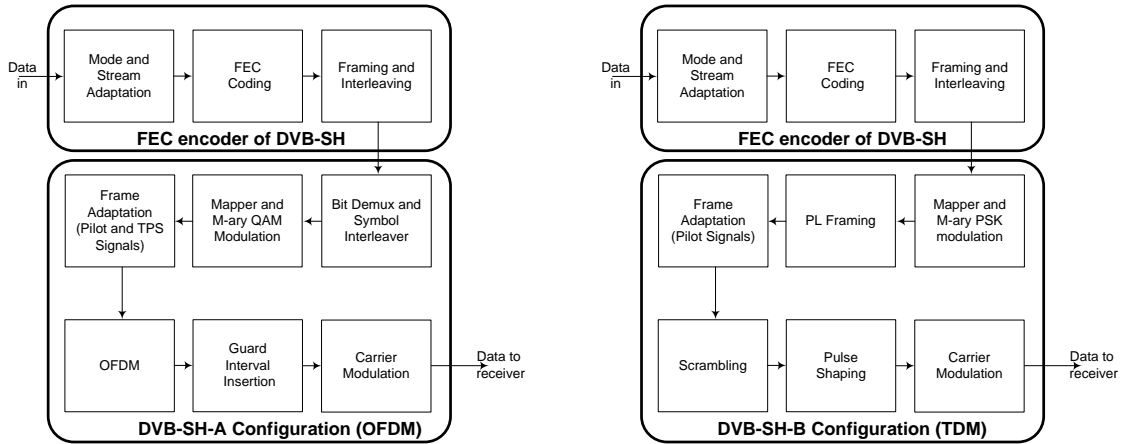
a) Block diagram of the DVB-SH-A transmitter   b) Block diagram of the DVB-SH-B transmitter

Fig. 1: Block diagram of the DVB-SH transmitter: a) DVB-SH-A (terrestrial configuration with OFDM) b) DVB-SH-B (satellite configuration with TDM).

The structure of the transmitter follows common DVB-SH-A transmitter block diagram, as shown in Fig. 1 a). Mode Adaptation and Stream Adaptation provide padding to complete a constant length of one transmitted frame and performs scrambling. The next stage contains the turbo encoder and puncturing. The turbo code as it was standardized by the 3GPP2 (3rd Generation Partnership Project 2) organization shall be used in the real implementation. The turbo code is used for the FEC encoding of the input data stream. The interleavers are introduced to enhance the resistance of the waveform to short-term fading and medium-term shadowing impairments in satellite and terrestrial channel. The output of the channel interleaver is demultiplexed into v sub-streams (depending on the modulation scheme), where v is equal to 2 for QPSK and 4 for 16QAM. The purpose of the symbol interleaver is to map v bit words onto the 756 (1K mode), 1 512 (2K mode), 3 024 (4K mode) or 6 048 (8K mode) active carriers per OFDM symbol. After the M-ary QAM modulation the transmitted mobile TV signal is organized in frames. Transmission frame adaptation block has to divide modulated stream, carrying useful data, into OFDM symbols and adds the zero, TPS, fixed and scattered pilots. After transformation from frequency to time domain (IFFT operation) guard interval can be inserted. At the end, the carrier modulation is the last process.

The structure of the block diagram of the DVB-SH-B transmitter (which used in case of the SH-B mode) is shown in Fig. 1 b). As it can be seen, the FEC part of the DVB-SH transmitter is same for both modes (SH-A and SH-B). In contrast with DVB-SH-A, QAM modulations are not used in DVB-SH-B mode. Instead of QAM, PSK (Phase Shift Keying) modulations are preferred. DVB-SH-B mode used QPSK, 8PSK and 16APSK modulations. The transmitted mobile TV is organized in frames. The SH frame to be transmitted in TDM mode consists of a number of PL (Physical Layer) slots of length $L_{TOT} = 2176$ symbols, each of them comprising of 2 (QPSK), 3 (8PSK) or 4 (16APSK) CU (Capacity Units) of 2 016 bits. Prior to modulation, each PL slot including the PF (Pilot Field), shall be randomized for energy dispersal by multiplying for each PL slot of length L_{TOT} the I and Q modulated baseband signal symbol samples by a unique complex randomization sequence. In the DVB-SH-B, concretely in TDM mode, the scrambling code sequence shall be constructed by combining two real m-sequences into a complex sequence. In this case, the Gold sequences are used. Now, complete SH frame (in TDM mode) is available in the time domain. After the carrier modulation (RRC filtering and IQ modulation), DVB-SH signal is prepared and it can be transmitted in broadcasting network. More details can be found in [1]-[5].
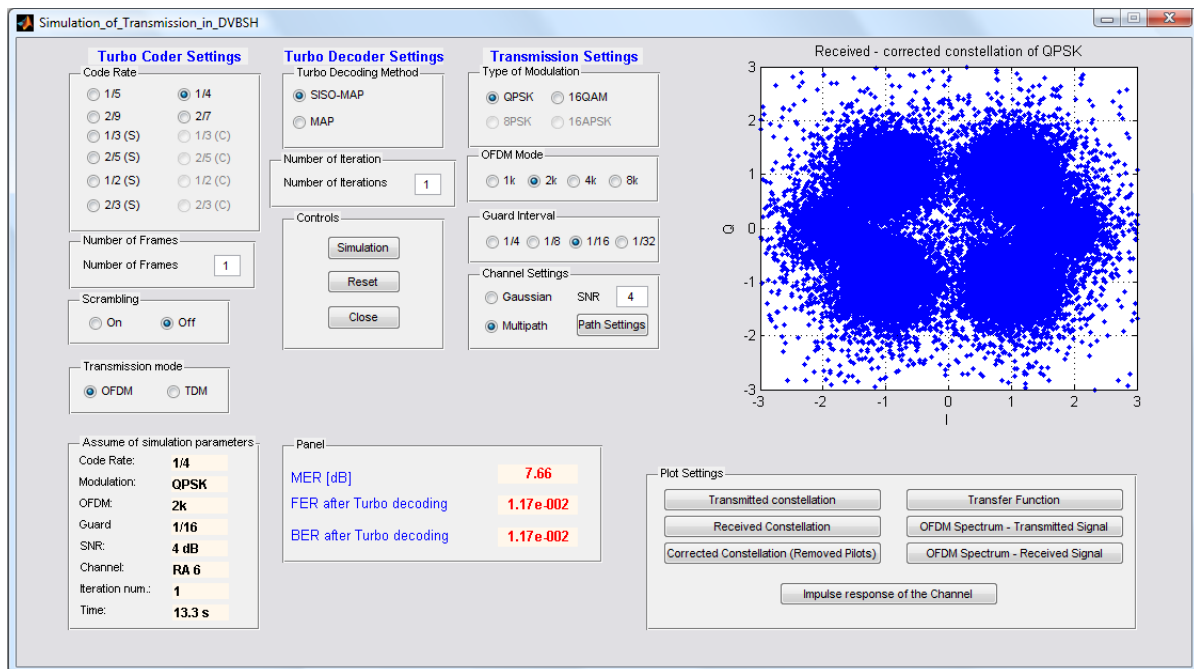
3. APPLICATION IN MATLAB

Fig. 2: Main window of the created MATLAB application for the DVB-SH.

Main window of the created application in MATLAB for the simulation of complete transmission in DVB-SH standard can be seen in Fig. 2.

Before the simulation, it must be defined the input parameters of the system configuration. Firstly, the user must define the mode of transmission: OFDM (SH-A mode) or TDM (SH-B). Moreover, it is also possible controlled the *scrambling* process (*on/off*) and the number of generated frames (*Number of Frames*).

The *Code Rate* option allows control the error protection of the transmitted data. It can be choice between twelve code rates (according to DVB-SH-A/B specification). Codes rates with *"S"* abbreviation are used, when the OFDM mode (SH-A mode) was selected. Codes rates with *"C"* abbreviation are used for the TDM (SH-B mode). Other code rates without abbreviation are common for both modes. More details can be found in [3].

The *Type of Modulation* and *OFDM mode* options enable choose of modulation. DVB-SH-A standard defines two types of modulations: QPSK and 16QAM. User can set the following OFDM modes: 1K, 2K, 4K and 8K. The option *Guard Interval* enables set values as are defined in [3]: ¼ (longest), 1/8, 1/16 and 1/32 (shortest). In case of TDM mode, there are possible choose between modulations QPSK, 8PSK and 16APSK. Of course, *OFDM mode* and *Guard Interval* modes are not available in this case.

It is visible in the Fig 2. that in table *Channel Settings* it is possible set the type of transmission environment. It gives a choice for a user selected between the *Gaussian* (AWGN) and *Multipath* channel. The button *Path settings* enables set up different types of fading channels. In this part it is also possible given the value of the Signal-to-Noise Ratio in dB.

Option *Turbo Decoding Method* allows choosing the type of turbo decoding process. Here exist two cases: SISO-MAP (Soft Input Soft Output - Maximum A Posteriori) and MAP. In this paper the first one was used. As a last it is important to define the number of the decoding process, so called *Number of iterations*. In this field it can be set the number of decoding process. In this paper the number of decoding is equal to 8, as recommended in [3].

After the setting of all parameters first case the user can click on the *Simulation* button for the start of simulation.

The table *Results of simulation* shows the *MER* (Modulation Error Ratio), *FER* (Frame Error Ratio) *after Turbo decoding and BER* (Bit Error Ratio) *after Turbo decoding*. The outputs of each simulation are also the constellation diagrams. Application shows the received and corrected (after equalization) constellation diagram. Of course, user can show these diagrams in separate windows. For this step serves buttons in the table *Plot Settings*.

4. SIMULATION

Application for the simulation of the transmission of DVB-SH-A/B has been implemented in MATLAB. For the simulation of the DVB-SH-A/B transmission was used following settings:

Settings	DVB-SH-A	DVB-SH-B
FEC Coding	1/4 (robust)	1/4 (robust)
Modulation	QPSK (mobile)	QPSK, 8PSK, 16APSK (all fixed)
Transmission Mode	OFDM (2K mode)	TDM
Guard Interval	1/16	-
Channel Models	AWGN RA6, TU6	AWGN RC20
Method of decoding	SISO-MAP	SISO-MAP
Number of iterations	8	8

Table 1: Settings Used for The Mobile TV Transmission
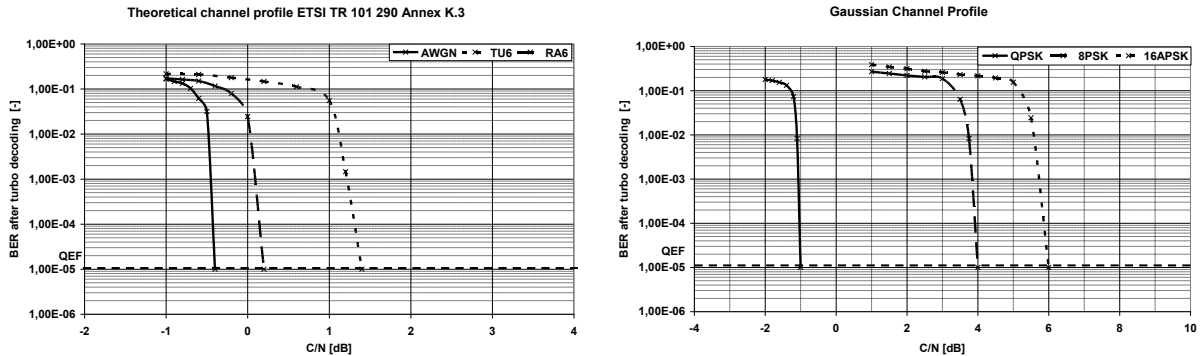
a) Mobile reception scenario (QPSK, mode 2K, CR 1/4 and GI 1/16) and DVB-SH-A performance (*BER* after turbo decoding with 8 iterations as a function of *C/N* ratio) in typical mobile TV channel profiles.

b) Satellite reception scenario (QPSK, 8PSK, 16APSK, mode TDM, CR 1/4) and DVB-SH-B performance (*BER* after turbo decoding with 8 iterations as a function of *C/N* ratio) in the Gaussian channel.

Fig. 3: Dependences of the *BER* after turbo decoding on the *C/N* ratio in the typical mobile TV channel profiles (mode DVB-SH-A) and in the Gaussian channel (DVB-SH-B mode).

5. RESULTS

Simulation results of the mobile TV transmission in the DVB-SH-A standard for a varying *C/N* ratio in the Gaussian channel (AWGN) and mobile environment (RA6, TU6), represented by the fading channels and their models are in the Fig. 3 a), where *BER* after turbo decoding vs. *C/N* ratio in Gaussian and two fading channel models is illustrated. The simulation parameters and configuration for the mobile reception scenario (mode SH-A) has been chosen with respect to mobile channel model parameters.

For the data transmission in the mobile scenario, 2k OFDM mode and QPSK modulation was used (for the mobile reception and minimization of the frequency shift). Both channel profiles, RA6 (Rural Area) and TU6 (Typical Urban), are generally different [4]. Channel RA6 consists of one direct path and five reflected (echo) paths. Moreover, in the RA6 the expected speed of the receiver is equal to 100 km/h, so the Doppler shift is two times higher than in TU6 (50 km/h). Of course, in case of QPSK modulation, for achieving the minimum *BER* it is needed small value of the *C/N* ratio. This is because the modulation QPSK is the most robust to noise and fading. For *BER* = 1.10^{-5} [3] in case of QPSK modulation in RA6 mobile fading channel it is needed *C/N* = 0.2 dB in 2K OFDM mode. In TU6 channel it is needed *C/N* = 1.4 dB.

Simulation results of the satellite TV transmission in the DVB-SH-B standard for a varying *C/N* ratio in the Gaussian channel (AWGN) is in the Fig. 3 b), where *BER* after turbo decoding vs. *C/N* ratio in Gaussian channel is illustrated. There were obtained three curves: one for QPSK, 8PSK and for the 16APSK modulation. How it can be seen, modulation QPSK is the most robustness to noises. For the achieving of very low *BER* ratio it is needed a very low value of *C/N*. In case of 8PSK and 16APSK modulations for the achieving of QEF is needed a higher *C/N* ratio. The *BER* = 1.10^{-5} can be achieved at 4.0 dB in case of 8PSK and at 6.0 dB in case of 16APSK modulation.

6. CONCLUSION

The application that allows simulation of the complete DVB-SH standard (modes DVB-SH-A and DVB-SH-B) transmission was developed and described. Dependence of the Bit Error Rate on Carrier-to-Noise Ratio after turbo decoding was explored. Differences between both DVB-SH modes in turbo decoding processing were also investigated and discussed. Results for all type of DVB-SH modulations were obtained and evaluated.

ACKNOWLEDGEMENT

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