Analysis and Simulation of the Transmission Distortions of the Mobile Digital Television DVB-SH

Part 1: Terrestrial Mode DVB-SH-A with OFDM

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Abstract. *This paper deals with the latest digital TV standard DVB-SH (Digital Video Broadcasting - Satellite to Handhelds) with focus on utilization of its advantages for the next generation of mobile TV broadcasting. The whole paper consists of two parts. In this first part, after the brief introduction to DVB-SH and related last works review, the simulation model of DVB-SH-A, which is using terrestrial configuration with OFDM transmission mode, is presented. The work is especially focused on the description of new type of forward error correction and system configuration of the DVB-SH-A mode. For the analysis and simulation of the transmission, the original scheme of turbo encoder was modified in this paper. Application for simulation of the transmission in mobile and portable fading transmission channels was developed in MATLAB. Dependences of BER on C/N ratio for all types of payload modulation are compared with focus on mobile TV services availability. Finally, the achieved results are evaluated and clearly discussed.*

Keywords

Digital television, mobile TV, DVB-SH-A, turbo coding, portable reception, mobile reception, BER.

1. Introduction

The number of applications and their possibilities, which are integrated in present mobile phone terminals, has been increased significantly over time. Nowadays, personal mobile telephones, beyond the transmission of classical voice, text and data services, offer many multimedia services (mainly audio and internet applications). It is, therefore, expected that mobile TV services will be offered on these devices very soon. Access to TV and multimedia services on mobile terminals is already possible via a UMTS (Universal Mobile Telecommunication Systems) connection. Unfortunately, after a certain time it was shown that this solution has many disadvantages (problems with video image quality and mobile network architecture and capacity) [1], [2], [3]. Generally, mobile TV users want to watch their favorite TV shows on small handheld devices mainly while travelling. Therefore, a more efficient solution, than the UMTS, is to transfer the video data to the terminals via a classical broadcast terrestrial television network. 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, the standards DVB-H (Handhelds) and DVB-SH (Satellite to Handhelds) have been developed.

DVB-H [4] is still the leading global technology standard for the transmission of digital TV to handheld receivers such as mobile and smart phones, terminals and PDAs. Nowadays, mobile TV is already booming on existing cellular infrastructures in point-to-point mode. Therefore, in areas where the reception and availability of the mobile TV is bad, especially in urban areas, the classical DVB-H does not represent the optimal solution. Moreover, the possibilities of improvements in the area of mobile cellular infrastructure and data transmission are limited. For these situations the data stream, transmitted in DVB-SH system, is better suited.

DVB-SH [5], [6] as 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. In the last decade, several works have dealt with the research and development in area of standard DVB-SH. It allows mobile TV transmission in two principle modes: OFDM (for satellite and terrestrial mode) and TDM (for satellite mode). Therefore, it is very necessary in order to have sufficient information about the satellite/terrestrial signal propagation and its gain. Field measurements of a DVB-SH network with both satellite and terrestrial transmitters are done and the obtained results were published in [7], [8].

In the DVB-SH standard a classical, so called, non hierarchical modulations are used. However, a hierarchical modulation is also adopted as an "alternative" modulation technique. Hierarchical modulation is particularly used to mitigate the cliff-off effect in digital television broadcasting, particularly mobile TV, by providing a lower quality fallback signal in case of weak conditions of the reception, allowing graceful degradation instead of complete signal loss. It has been widely proven and included in various standards, such as DVB-T/H and it is under study for DVB-SH. The first obtained results and their evaluation from this area were presented in [9], [10].

The S-Band is very demanding in terms of signal coverage. For achieving a good signal quality, it is required a dense terrestrial repeater network in urban areas. The cost of this network can be reduced if the *C/N* (Carrier-to-Noise-Ratio), required for stable reception, is low. This requirement in DVB-SH is met by the high frequency band, in which it operates and it is compensated by a selection of tools that enhance the signal robustness. Therefore, the correct and robust FEC (Forward Error Correction) of the transmitted mobile TV service is necessary. In DVB-SH standard, the turbo code is used as a FEC encoder. The advantages and disadvantages and very brief implementation notes were presented in several papers [11], [12] and [13]. In these papers the alternative solutions (modification of the original turbo code, which is preferred in DVB-SH standard) were presented too.

Thank to the new features and innovations, which DVB-SH incorporates in comparison with DVB-H, it can be one of the favorite standards for mobile TV broadcasting in the future. DVB-SH has many innovations in FEC, especially turbo coding and a very flexible channel interleaver. These innovations are the main reasons, why very low C/N is needed for achieving a good signal quality and mobile TV service availability. However, the study of sufficient signal strength and quality, represented by *C/N* vs. *BER* (Bit Error Ratio) is not finished in DVB-SH.

To finish the introduction, this paper deals with the analysis and simulation of the transmission distortions of the mobile TV in DVB-SH standard. The paper is especially focused on the model DVB-SH-A, which is using configuration with OFDM (Orthogonal Frequency Division Multiplexing) transmission mode. To explore the performance of DVB-SH-A and its transmission distortions, AWGN (as a reference) and mobile fading transmission channels (with Doppler shift) and their models were used.

The rest of the paper is organized as follows. Section 2 briefly describes the functional block diagram of the transmitter DVB-SH-A. Attention is devoted mainly on the advanced FEC scheme and its implementation in MATLAB. The parameters and typical scenarios for the analysis and simulation are presented in Section 3. Section 4 contains graphical dependences of the *BER* after turbo decoding on *C/N* ratio for the DVB-SH-A performance analysis in mobile TV fading channels. Finally, the results are evaluated and discussed in Section 5.

2. Block Diagram of the DVB-SH-A

The structure of the transmitter follows common DVB-SH-A transmitter block diagram, as shown in Fig. 1. Details of the following blocks are briefly described below, including simulation notes for MATLAB application.

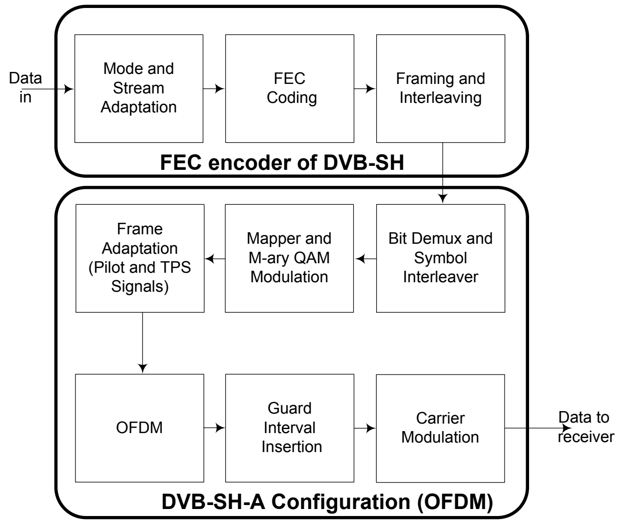


Fig. 1. Block diagram of the DVB-SH-A transmitter (terrestrial configuration with OFDM).

2.1 Mode and Stream Adaptation

How it can be seen in Fig. 1, the first functional block is the Mode and Stream Adaptation. Mode Adaptation consists of CRC (Cyclic Redundancy Check) encoding, to provide detection of MPEG packets. Stream Adaptation provides padding to complete a constant length of one transmitted frame and performs scrambling. Function of the scrambling (and its process) is the same that was used in standard DVB-H [4].

In the real broadcasting the scrambling (and it breaks up the long sequences of "ones" and "zeros") of data sequences is very important in terms of synchronization in the receiver. However, for the simulation of the data transmission, this block is omitted, because the scrambling of input data stream has not significant effect on the error correction. The MATLAB application in the first step is generating the (random) input data sequence for the simulation.

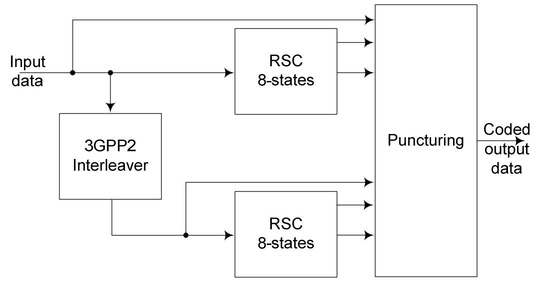


Fig. 2. Block diagram of the 3GGP2 turbo encoder.

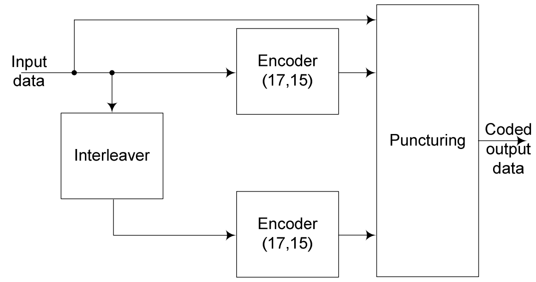


Fig. 3. Block diagram of the PCCC turbo encoder.

2.2 FEC in the DVB-SH

The next stage contains the turbo encoder and puncturing. The turbo code as it was standardized by the 3GPP2 (3^{rd} 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.

A block diagram of the 3GGP2 turbo encoder is shown in Fig. 2. This type of turbo encoder, as well as general turbo encoders, employs two RSC (Recursive Systematic Convolutional) encoders connected in parallel. These encoders are used to code the same input bits, but a special interleaver (so called 3GPP2 interleaver) [6] is placed between the encoders. Each of the encoders produces an output of three bits. After an output symbol sequence is generated, puncturing is applied. Within a puncturing pattern, a “0” means that that the symbol shall be deleted and a “1” means that a symbol shall be passed [5], [6], [12].

In the introduction, it was mentioned that nowadays, several papers are focused on the usage of alternative types of turbo encoders. These reasons are based mainly on the disadvantages of 3GGP2 turbo encoder (complexity, complicated turbo interleaver, ambiguous description of the turbo decoding processing) from the perspective of simulation. Therefore, our simulation scripts use another, but very similar type turbo encoder, so called PCCC (Parallel Concatenated Convolutional Code) [14]. A block diagram of PCCC turbo encoder is shown in Fig. 3.

The PCCC turbo encoder, as well as the 3GPP2 turbo encoder, consists of two RSC encoders too [15]. Their structures are defined by generator polynomials $G_1 = 17_{OCT}$ and $G_2 = 15_{OCT}$. The input data bit stream is divided into two parts. Both parts are then independently encoded by PCCC encoders. One of the main differences between the 3GPP2 and PCCC turbo encoder is that in the PCCC turbo encoder the systematic bits are transmitted only once. It is very important in terms of time consumption of the effective simulation. And again, after an output symbol sequence is generated, puncturing is applied [6].

How it was mentioned, in the 3GPP2 turbo encoder, a special type of interleaver (so called 3GPP2 interleaver) is used. The process and function of this interleaver is described in [6]. Pseudo random interleaver is used to permute the data encoded by the second RSC encoder.

Unfortunately, the output (interleaving) address calculation procedure and its algorithm implementation from the perspective of simulation are not effective [16]. Therefore, instead of the mentioned interleaver, a semi random (so called s-random) interleaver was used for the simulation.

S-random interleaver from the perspective of structure is placed between a random interleaver and interleaver with fixed structure. Each randomly selected integer is compared with S previously selected random integers. If the difference between the current selection and S previous selections is smaller than S, the random integer is rejected. This process is repeated until N distinct integers have been selected [17], [18].

Unfortunately, Communication Toolbox of MATLAB does not contain any resources or functions for the turbo encoding. Therefore, for the PCCC turbo encoding and s-random interleaving, a custom algorithm was used. To describe the simulation very clearly (in comparison with the other papers) and in advance for possible reference, the final code for the modeling and simulation of PCCC turbo encoding is given below:

```
% PCCC Turbo Encoder (17,15)

% Definition of the input parameters
D1 = 0; % set the shift registers
D2 = 0;
D3 = 0;

Y1 = zeros (1,length(I)); % parity bits
Y2 = zeros (1,length(I)); % (I is an interleaved sequence)

L=length(X); % X is the input bit sequence

% Turbo Encoding
for i=1:L

        Turbo_Encoding=mod(X(i)+D1+D3,2);
        Y1(i)=mod(Turbo_Encoding+D2+D3,2);
        D3=D2;
        D2=D1;
        D1=Turbo_Encoding;

end

for i=L+1:L+m             % m is a number of shift registers

    if mod(D1+D3,2) == 0

        X(i)=0;
    else

        X(i)=1;
    end

        Turbo_Encoding=mod(X(i)+D1+D3,2);
        Y1(i)=mod(Turbo_Encoding+D2+D3,2);

        D3=D2;
        D2=D1;
        D1=Turbo_Encoding;

end

X_interleaved = X(I); % interleaved input bits
                      % I-output of the S-random interleaver
```

```
for i=1:length(X_interleaved)

        Turbo_Encoding=mod(X_interleaved(i)+D1+D3,2);
        Y2(i)=mod(Turbo_Encoding+D2+D3,2);
        D3=D2;
        D2=D1;
        D1=Turbo_Encoding;

end
```

2.3 Framing and Channel Interleaver

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.

In the DVB-SH standard (in contrast to DVB-T/H), the channel is composed of two cascades of elementary interleavers. A block bit-wise interleaver works on individual coded words at the output of the encoder and a convolutional time interleaver works on IUs (Interleaving Units) of 126 bits [6]. The output of the turbo encoder shall be bit interleaved using a block interleaver. The values for block interleaving are given in [6] and each code rate has its own bit-wise interleaver function.

The function of the time interleaver is to interleave coded words and bits over time using a convolutional interleaver. The detail description of its function is available again in [6]. Communication Toolbox of MATLAB contains function `convintrlv` for this purpose. However, this function was not used, as it uses shift registers and the simulated stream is finite. This causes problems with initial zeros stored in the registers and interleaved with payload data of Mobile TV[19]. Therefore, a simple `randintrlv` function was used.

To this point, the advanced FEC scheme was presented. The described process of FEC is common for both DVB-SH modes (SH-A and SH-B). The first part of this work is focused on the mode SH-A (OFDM mode) only, therefore, the brief description of the OFDM configuration is presented below.

2.4 Bit Demux and Symbol Interleaver

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. In contrast with DVB-T/H, the modulation 64QAM is not used in DVB-SH-A.

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. As it can be seen, DVB-SH is using more types of the OFDM modes in comparison with DVB-H. This new mode called 1k was added to support higher speeds of the mobile TV receiver and/or smaller bandwidths [5], [6] than in classical TV broadcasting bands [20].

In the code presented below the example is focused on the implementation of the input parameters (bit permutation table, permutation function algorithm) for the 2K mode:

```
% Permutation function algorithm

% Definition of the input parameters (1K OFDM mode)
permutation_table = [0 7 5 1 8 2 6 9 3 4];
Number_of_useful_carriers = 1512;
Number_of_global_carriers = 2048;

% Equation of addition parameters
Nr = log2(Number_of_global_carriers);
Hq = zeros(Number_of_useful_carriers,1); % perm. function
q = 0;

for i = 0:Number_of_global_carriers - 1

    switch i        % R´i bit position

        case 0

            R1 = zeros (1, Nr-1);

        case 1

            R1 = zeros (1, Nr-1);

        case 2

            R1 = zeros (1, Nr-1);
            R1(1) = 1;

        otherwise

            if modOFDM == 2 % in the mode 2K

                R1 = [R1(2:Nr-1) , xor(R1(1+0), R1(1+3))];

            end

     end

     r = zeros(1, Nr-1); % initialize the matrix r

    % Algorithm for the perm. function H(q) calculation
     for k = 0:Nr-2

         r(1+permutaion_table(1+k)) = R1(1+k);

     end

     Hq(1+q) = rem(i,2) * 2^(Nr-1);

     for j = 0:Nr-2

         Hq(1+q) = Hq(1+q) + r(1+j) * 2^j;

     end

     if Hq(1+q) < Number_of_useful_carriers

         q = q + 1;

     end

end
```

2.5 M-ary QAM Modulation

MATLAB functions and tools support some cases for the modulation and demodulation. In the developed application the `modem.qammod (M)` function was used from Communication Toolbox. This function also enables a set up of which symbols are to be mapped. However, the symbol order does not match the mapping in the DVB-SH specification. The solution of this problem was described in [22] and it was applied in this application, too.

2.6 Frame Adaptation, OFDM and Guard Interval Insertion

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.

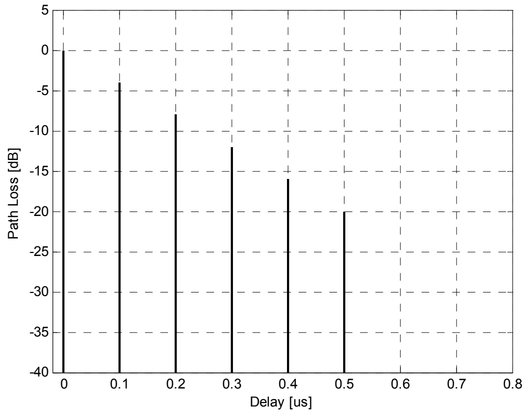


Fig. 4. Impulse response of the RA6 (Rural Area) channel.

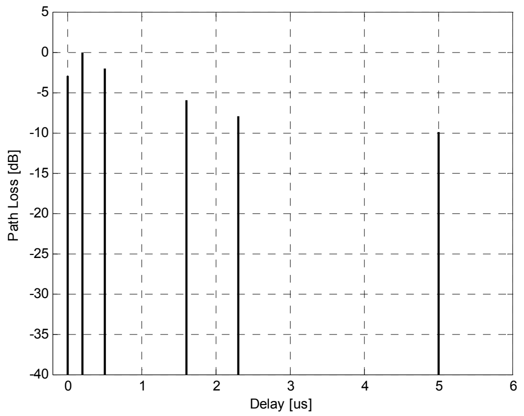


Fig. 5. Impulse response of the TU6 (Typical Urban) channel.

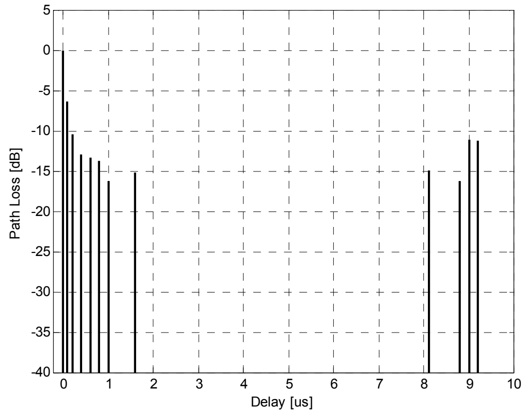


Fig. 6. Impulse response of the PI (Pedestrian Indoor) channel.

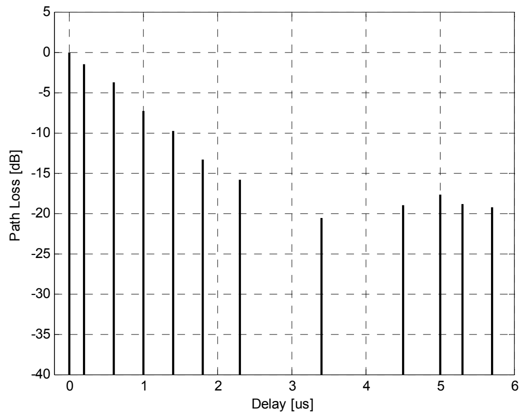


Fig. 7. Impulse response of the PO (Pedestrian Outdoor) channel.

This block is simple, as the only purpose is to rearrange the data and insert special carriers on their defined positions. The pilots can be used for frame, frequency and time synchronization, channel estimation, transmission mode identification and can also be used to follow the phase noise [1], [20]. Now, complete OFDM signal in the frequency domain is transformed into the time domain by using IFFT (Inverse Fast Fourier Transformation) function [1]. This function is implemented in MATLAB (as `ifft`) and it can be used very easily. Once we have OFDM symbols assembled, a guard interval (GI) can be inserted.

The purpose of the guard interval insertion is to introduce immunity to propagation delays, related reflections and echoes, to which terrestrial signals are very sensitive. According to the DVB-SH-A specification the options are 1/4, 1/8, 1/16 and 1/32 of the symbol period. The end part of each symbol is copied to the beginning of the present symbol [1], [20].

2.7 Carrier Modulation

Real $Re(t)$ as well as imaginary $Im(t)$ part of the OFDM signal is upsampled and filtered with RRC (Root Raised Cosine) filter with roll-off factor equal to 0.35 [6].

The simulation (and also an example of implementation) of the DVB-T modulator with OFDM is described in detail in [21]. Also a guide for the extension of the DVB-T modulator part for the analyzing of I/Q imperfections (Amplitude Imbalance, Phase Error, Carrier suppression) is presented in [22]. The same modulator was used in this paper and slightly modified to the DVB-SH-A operation.

2.8 Channel Simulation

At this point, DVB-SH-A signal is prepared and it can be transmitted by using transmission channel model.

There exist several types of channel models (AWGN, Rice, Rayleigh) in MATLAB Communication Toolbox, which can be used for the evaluation, how the signal behaves in the terrestrial transmission environment. More details about the implementation (and again with examples of source codes) of the fading transmission channel models (with Doppler shift) can be found in [23]. The channel profiles and their typical impulse responses, which were used for this simulation too, are shown in Fig. 4 to Fig. 7.

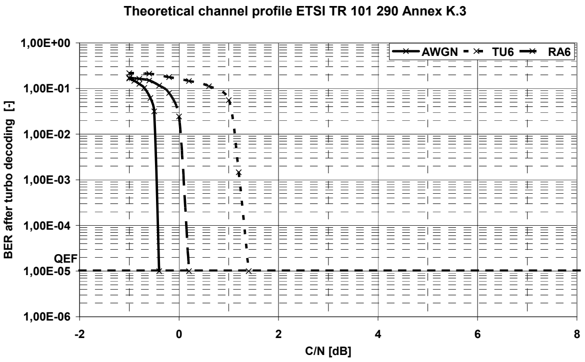


Fig. 8. Mobile reception scenario (QPSK, mode 2k, CR 1/4 and GI 1/16) and DVB-SH-A performance (*BER* after turbo decoding with 8 iterations as a function of *C/N* ratio) in typical mobile TV channel profiles.

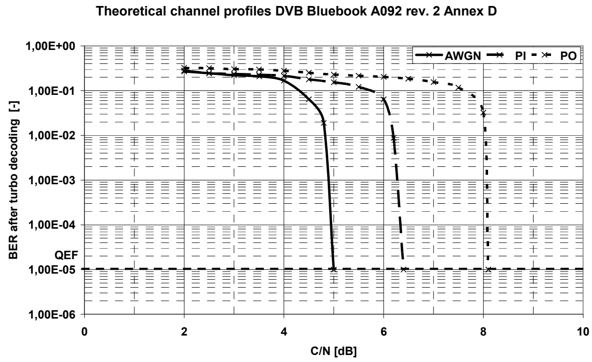


Fig. 10. Portable reception scenario (16QAM, mode 4k, CR 1/4 and GI 1/8) and DVB-SH-A performance (*BER* after turbo decoding with 8 iterations as a function of *C/N* ratio) in typical portable TV channel profiles.

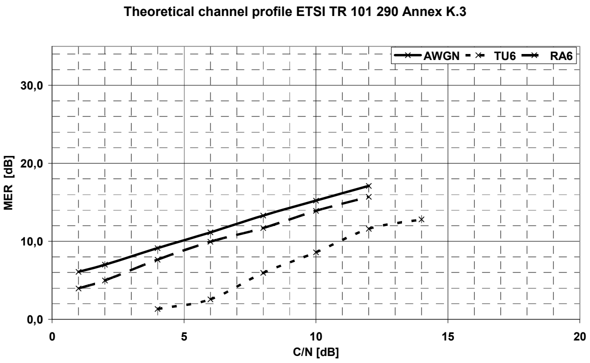


Fig. 9. Modulation error ratio *MER* in the DVB-SH-A mobile scenario as a function of *C/N* ratio in the Gaussian channel and in typical mobile TV channel profiles (QPSK, mode 2k, CR 1/4 and GI 1/16).

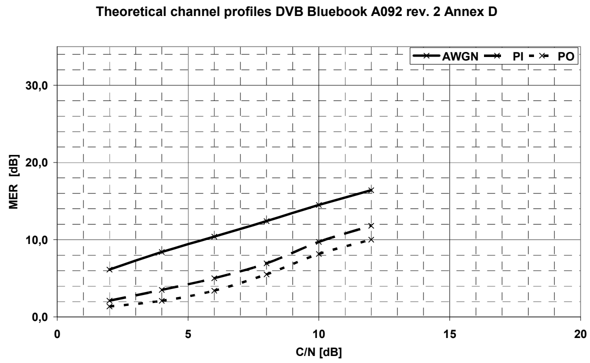


Fig. 11. Modulation error ratio *MER* in the DVB-SH-A portable scenario as a function of *C/N* ratio in the Gaussian channel and in typical portable TV channel profiles (16QAM, mode 4k, CR 1/4 and GI 1/8).

3. Simulation of the DVB-SH-A Transmission in Fading Channels

A brief description of the block diagram of the DVB-SH-A was presented in the previous chapter. This chapter contains a brief description of the transmission channel models, which were used for the simulation and analysis of the mobile TV transmission. In all tested scenarios, the Gaussian (AWGN channel) as a reference was used.

The RA6 (Rural Area) channel profile reproduces the terrestrial propagation in a typical rural area. It has been defined by COST207 [24] and consists of 6 paths having relatively short delay and small power (see Fig. 4). The first part of this channel model has zero delay and attenuation; therefore it is a direct path. The speed of the receiver is equal to 100 km/h.

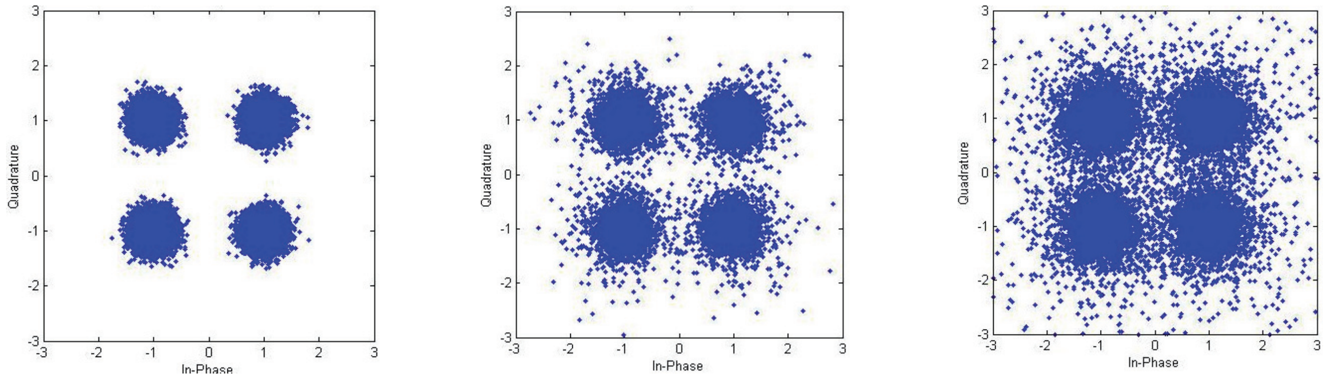
The TU6 (Typical Urban) profile reproduces the terrestrial propagation in an urban area [24]. Again, it consists of 6 paths having wide dispersion in delay and relatively strong power (see Fig. 5). Parameters values fluctuate dynamically following a Rayleigh law. The speed of the receiver is equal to 50 km/h.

The PI (Pedestrian Indoor) and PO (Pedestrian Outdoor) channel models have been developed by the Wing-TV project [25] for describing the slowly moving (at speed approx. 3 km/h) handheld reception indoors and outdoors. Both channels consist of 12 independent paths and the first path is the direct (see Fig. 6 and 7).

For the simulation of the DVB-SH-A mobile TV transmission the following settings were used:

- 1/4 (robust protection) code rate of turbo codes,
- QPSK (mobile) and 16QAM (portable) modulation,
- 2k (mobile) and 4k (portable) OFDM mode,
- Gaussian (AWGN), RA6 and TU6 (mobile), PI and PO (portable) transmission channel models,
- GI of 1/8 (large network) or 1/16 (mid network),
- SISO-MAP (Soft Input Soft Output - Maximum A Posteriori) turbo decoding (8 iterations [5]).

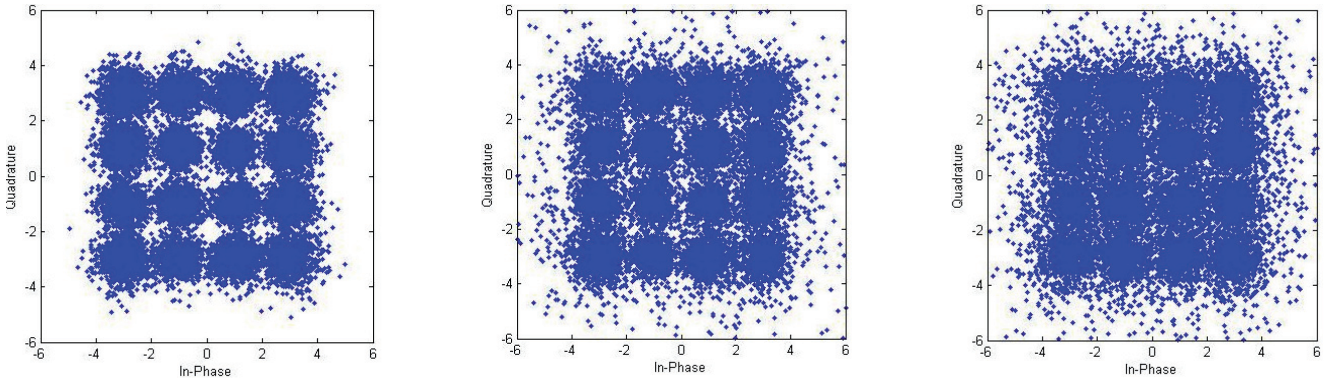
The number of iterations (the number of repeated decoding processes) is equal to eight (8) as it is recommended in [5].



a) AWGN channel and mobile reception scenario, MER = 15.1 dB;

b) RA6 channel and mobile reception scenario, MER = 13.9 dB;

c) TU6 channel and mobile reception scenario, MER = 8.4 dB;



d) AWGN channel and portable reception scenario, MER = 14.5 dB;

e) PI channel and portable reception scenario, MER = 9.7 dB;

f) PO channel and portable reception scenario, MER = 8.2 dB;

Fig. 12. Simulation: I/Q constellation of: a) to c) mobile scenario with QPSK modulation, d) to f) portable scenario with 16QAM modulation, and within typical DVB-SH-A fading channels (all the constellations incl. channel correction and removed pilots, *C/N* = 10 dB).

In the DVB-SH simulation, the FEC uses advanced turbo coding. Therefore, it cannot be used for the evaluation of *BER* in the QEF (Quasi Error-Free) [1] operation, known from DVB-T/H and related works [26]. The limit of the error-free reception is considered for *C/N*, where the *BER* is equal to 1.10^{-5} after turbo decoding. This *BER* operation has not been standardized yet, but most of the recent papers deal with this value.

4. Simulation Results and Their Evaluation

Simulation results of the mobile TV transmission in the DVB-SH-A standard for a varying C/N ratio in the Gaussian channel (AWGN), mobile environment (RA6, TU6) and portable (PI, PO) environment represented by the fading channels and their models are in Fig. 8 to 11, where *BER* after turbo decoding vs. *C/N* ratio in Gaussian and four fading channel models is illustrated. The results for modulations that are using QPSK and 16QAM in various types of transmission scenarios are different.

The simulation parameters and configuration for the mobile reception scenario have been chosen with respect to mobile channel model parameters. For the minimization of the negative effect of Doppler shift, modulation QPSK and 2K OFDM mode were used. Guard Interval was set on 1/16, because the maximum relative delay (in model TU6) of the signal echo is equal to 5 µs. Both channel profiles (RA6 and TU6) are significantly different. In RA6 model, one direct signal path is available and its maximum and relative delay is 10 times shorter than in TU6 model (see again Fig. 4 and 5). These are main reasons, why the signal reception conditions are better in RA6 channel model.

With regards of the portable channel model parameters, a little different system configuration has been used. PI and PO channels are characterized by a relatively small Doppler shift (walking speed of the receiver). Therefore, in this case, modulation 16QAM and 4K OFDM mode were used. Guard Interval was set on 1/8, because the maximum relative delay (in model PI) of the dominant signal echo is equal to 9.2 µs. In contrast to previous channel models, PI and PO models are very similar. Both channel models have one direct path, which is shifted in frequency by half of the maximum value of the Doppler shift. On the other side, of course, the path losses and delays of output paths are different. In the PI model all delayed paths are more attenuated than in PO model. Therefore, the signal reception conditions are better in PI channel model.

The difference in *BER* results for the various turbo code rates and channel types is also easy to compare in Tab. 1. Typical results and the example or illustration constellation diagrams for the various transmission scenarios and channel types are also easy to see in Fig. 12 a) to f).

Scenario	Modulation	Channel	C/N [dB]
Mobile 2k mode	QPSK	AWGN	-0.4
		RA6	0.2
		TU6	1.4
Portable 4k mode	16QAM	AWGN	5.0
		PI	6.4
		PO	8.1

Tab.1. Comparison of the simulation results of minimal *C/N* for *BER* equal to$1\cdot10^{-5}$ in standard DVB-SH-A.

5. Conclusions

In this paper, the one of the latest DVB-SH standard for mobile TV broadcasting was analyzed and simulated. The paper was especially focused on the model DVB-SH-A, which is using configuration with OFDM transmission mode, like as it is in DVB-T/H standards. Detailed description of the DVB-SH-A system configuration (transmitter side) with comprehensive examples of MATLAB scripts was presented too. The performance of the DVB-SH-A mode was analyzed in Gaussian (AWGN referenced), portable (PI, PO) and mobile (RA6, TU6) fading channels and their models.

The novelty of this paper is in exploration of the mobile TV service availability and signal distortions in mobile and portable fading channels in the DVB-SH-A system. How it was mentioned, many papers deal only with the signal processing in Gaussian channel (AWGN). Moreover, these works are mainly focused on the turbo encoding and decoding and not on the complete signal processing in the DVB-SH-A system. Therefore, the goal of this paper was to present the complete DVB-SH-A system simulation tool and to explore the most probable settings for the future mobile and portable TV service. The obtained values, which are needed to achieve a QEF, were compared whit the results, available in [5].

As it can be seen from the graphs (see again Fig. 8 to Fig. 11), there are principle differences between the results. Especially, there are significant differences between the results in the case, when the RA6 and TU6 channel models were used. Thank to the number of iterations (8 iterations), which is generally used in the DVB-SH-A decoding process, the results are much better for DVB-SH-A than in the DVB-T/H [23]. As it was mentioned above, the TU6 model has no direct signal path. Therefore, for achieving a good signal quality and mobile TV service availability, quite higher C/N ratio is needed (see again Tab. 1). How it can be seen, the higher number of turbo decoding can mean higher demand on the *C/N* for a good signal quality.

The DVB-SH standard represents very good possibilities for the next generation of mobile TV broadcasting. Thank for the advanced FEC scheme (turbo coding), a good signal quality can be achieved at very low *C/N* ratio. Moreover, the system configuration of the DVB-SH standard allows usage of alternative transmission mode, as a classical OFDM. The second possibility for mobile TV and its signals distribution is to use TDM (Time Division Multiplexing) for the satellite broadcasting (DVB-SH-B) with combination of OFDM. By using both these technologies, it can be possible to achieve coverage of large regions or even a whole country, as it is presented in [3].

The second part of this paper will be focused on the DVB-SH-B mode that uses single carrier TDM on the satellite link and OFDM for the terrestrial link. And again, after the description of this mode (with corresponding examples of MATLAB scripts), the performance of DVB-SH-B standard in transmission channels will be analyzed and simulated.

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