SIMULATION OF DVB-S2 TRANSMISSION IN MATLAB

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Abstract

This contribution is focused on simulation of the DVB-S2 (Digital Video Broadcasting – Satellite 2nd generation) digital television transmission. For this simulation an application in MATLAB has been developed. It can be use for simulation of whole processing in DVB-S2 transmitter including stream adaptation, FEC (Forward Error Correction) coding with interleaving, modulation, channel distortion and of course inverse operations in the receiver. We have designed very illustrative and robust GUI (Graphical User Interface), because we have taken into account utilization as a teaching aid for students in laboratory measurements. The paper also contains a comparison of measurement and simulation results of channel BER (Bit Error Ratio) and post FEC BER that depend on SNR (Signal-to-Noise ratio). These characteristics are investigated in case of various transmission parameters defined in the DVB-S2 standard. These could be modulation scheme or LDPC (Low Density Parity Check) code rate etc. We also compare simulated results of SNR with the ETSI standard when so called “cliff-off” effect is present.

1 DVB-S2 system introduction

The DVB-S2 (Digital Video Broadcasting – Satellite 2nd generation) system has been developed as the improvement of first generation DVB-S (Digital Video Broadcasting – Satellite) system, to increase the custom data rate in the same channel bandwidth. System was standardized by ETSI in March 2005 [1] [2]. It has been also required to set up the system, which should work with same ground segment figure of merit *G*/*T* (gain-to-noise temperature), not to need change the costumer’s ground segment, especially antennas with LNBs (Low Noise Blocks). The main improvements against first generation are new channel coding and modulations schemes. Instead of Reed-Solomon and convolution code exploits the second generation BCH (Bose Chaudhuri Hocquenghem) and LDPC (Low Density Parity Check) codes as FEC (Forward Error Correction). These allows deployment of mentioned higher modulation schemes in the same conditions (same channel, existing earth segment, same ground segment, same *G*/*T* etc.) like in previous generation.

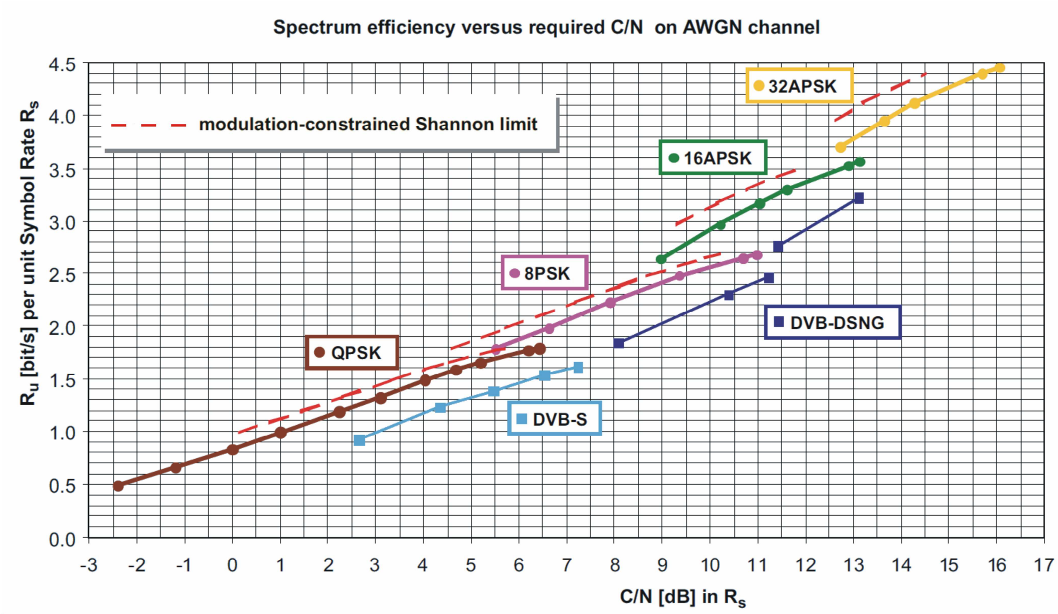


Figure 1: The spectrum efficiency improvement of second generation of satellite broadcasting [1].

Third innovation is two or more independent transport streams or another data stream input opportunity in one channel. However, various modulations or channel code rate are not planned for each of these streams unlike in case of DVB-T2 (Digital Video Broadcasting – Terrestrial 2nd generation). ETSI standard plans also possibility of backward compatibility with first generation system [2] by the hierarchical mapper, but this system is not realized definitely.

As an epiphenomenon of new channel coding schemes the improvement of spectral efficiency occurs. Figure 1 shows dependency of spectral efficiency (defined as useful bit rate R_U per symbol rate R_S) on C/N (Carrier-to-Noise ratio) for both system generations.

2 Simulation of second generation satellite system

The simulation system (Figure 2) has been developed as a part of the master thesis [4]. It serves primary for laboratory courses, where students can verify by simulation their measured values. The illustrative GUI allows adjusting whole transmission chain simulation parameters. System enables all modulation schemes (QPSK, 8-PSK, 16-APSK and 32-APSK) and LDPC code rates, which are defined in standard. Defined parameters are summarized in the right panel. User can set up here also value of C/N or step this parameter. Elementary AWGN channel (Additive White Gaussian Noise) is implemented for channel simulation because ETSI simulations are also done with this [3].

The simulation results are values of total BER after FEC, channel BER and also the set of constellation diagrams at bottom of the Figure 2, which are quite illustrative for students. The first one on the left shows mapped payload data before scrambling. You can see that some of the constellation points do not occur in whole 64800 bits of FEC frame. Data after scrambling and PL (Physical Layer) header insertion are shown in second one constellation diagram. The couple diagrams on the right presents data and header after transmission by satellite link.

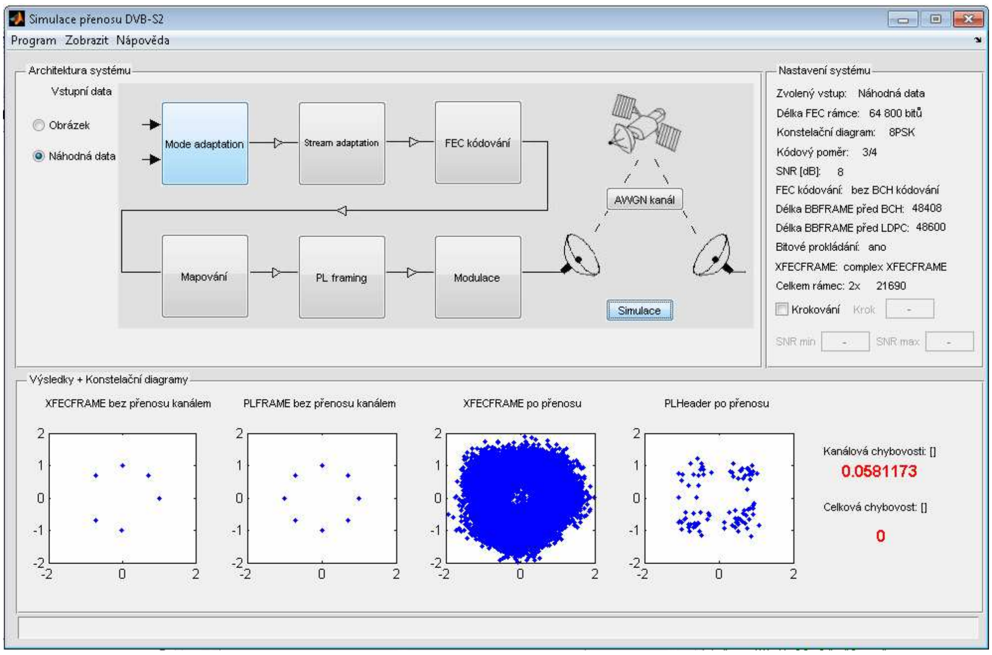


Figure 2: Matlab GUI of DVB-S2 broadcasting application used for simulation [4].

To the purpose of this contribution some real system measurements has been realized, which proves relevance of simulation results. In the Figure 3, there are well known water-fall curves of channel BER dependency on SNR. The discrete values are measured ones. Unfortunately, APSK modulations are not common in DVB satellite broadcasting. The QPSK characteristic is of course almost same as in case of DVB-S system. DVB-S with Reed Solomon and Convolutional Coding with code rate of 3/4 needs MER (Modulation Error Ratio) equal or higher to 8.7 dB for QEF transmission (channel BER $1.2{\cdot}10^{-2}$). On the other hand, DVB-S2 with BCH and LDPC of the same rate suffices with MER of 5 dB and higher (channel BER $5.5{\cdot}10^{-2}$).

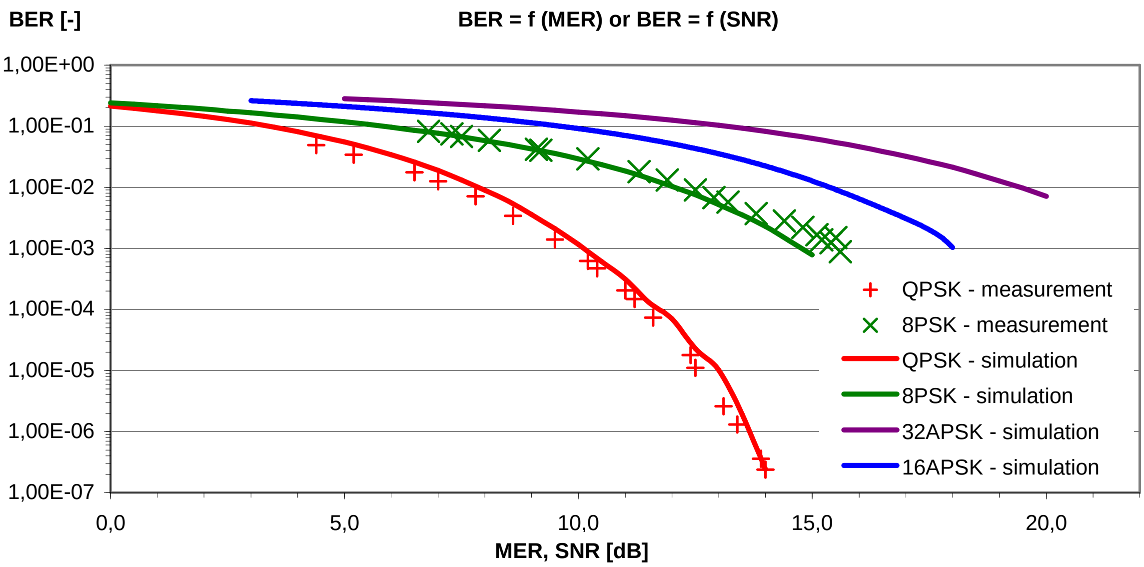
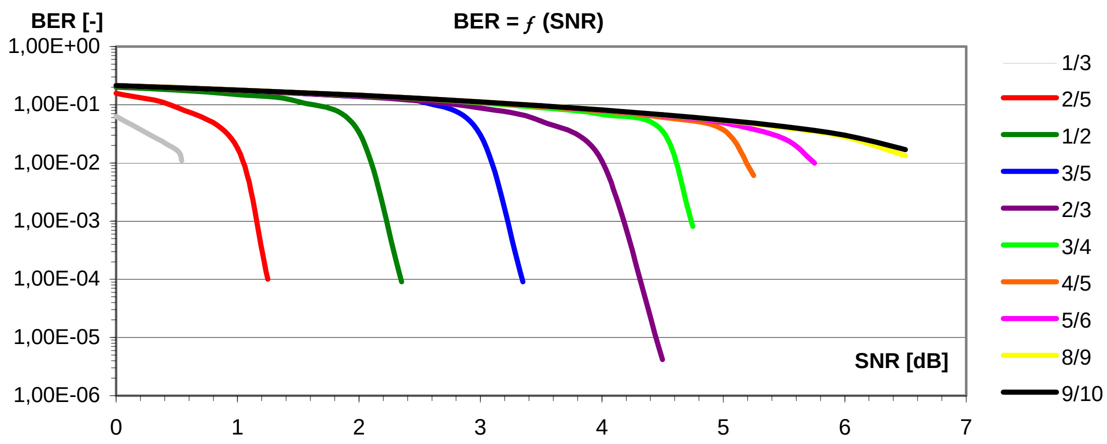


Figure 3: Characteristics of the BER (Bit Error Rate) in dependence on MER (Modulation Error Rate) in case of the measurements or SNR (Signal-to-Noise Ratio) in case of the simulation in Matlab [5].

The comparison of code gain for different code rates in case of QPSK modulation is located in Figure 4a). Unfortunately problems appear with our software, if you want to simulate transmission with low BER, due to very low error probability. So, it is necessary to do a lot of iterations and wait for almost one error bit, which is time consuming. That is the reason, why curves do not attack lower BER toward to QEF border (see paragraph 3).

a)



b)

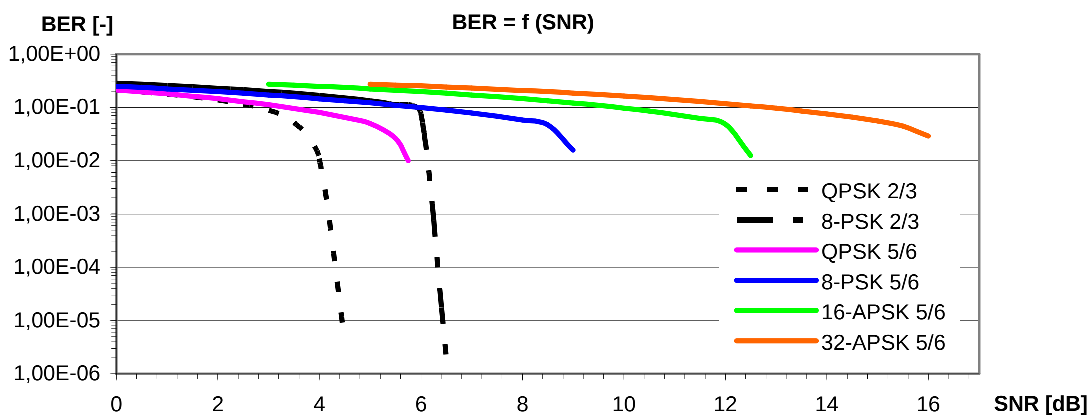


Figure 4: The dependency of post FEC BER on channel SNR: a) for various code rates and QPSK modulation, b) for the constant code rates and the various modulations.

Figure 4b) shows how behave various modulations with constants code rates. To explain, why ever to deal with this, simple example: Let's have two system setups: QPSK protected by FEC code rate 9/10 and 8-PSK with 2/3 code rate. These two modifications would have very similar characteristic of post FEC BER depend on SNR, so from the channel point of view, they are interchangeable between themselves. But the second variation provides about 10% higher bit rate. The reason, why both are standardized, is probably the problem with oscillator phase noise, which can more degrade higher modulation scheme.

3 QEF border definition

The crucial condition to design good quality satellite link is knowledge of needed minimum C/N of received signal before demodulation. In digital systems, where FEC is inseparable part of them, we are talking about "fall of the cliff" or "cliff-off" efect. From the other side, in digital television broadcasting there is defined border of system BER called QEF (Quasi Error Free). When output signal reaches this BER, we support, it is error free transmission (1 error per hour).

Next four graphs (Figure 5) summarize the effort to find the minimum SNR value for BER almost on the edge of the cliff. For most common modulations QPSK and 8-PSK, we can conclude pretty good matching of measured and simulated values with ETSI recommendation. The differences in cases of APSK modulations may be caused by not fully functional BCH encoder/decoder.

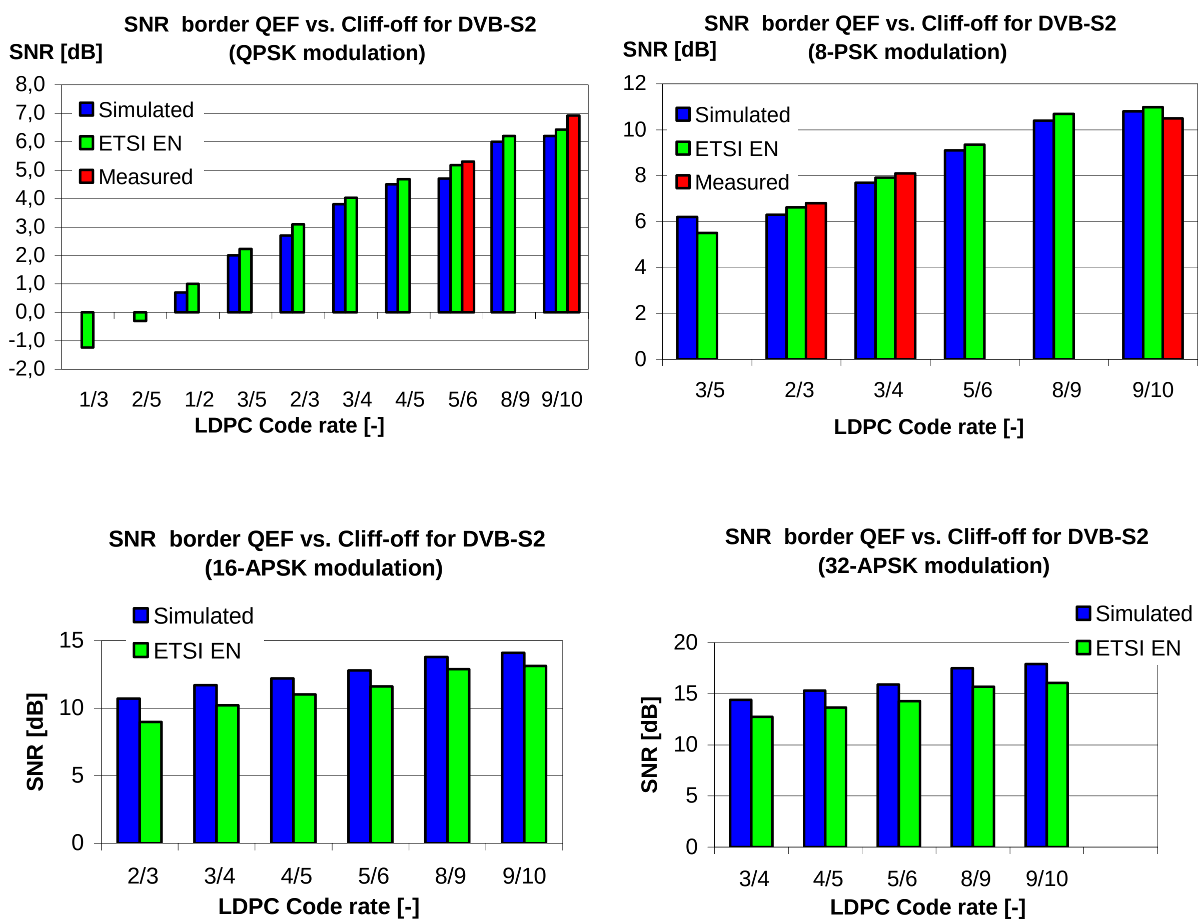


Figure 5: Minimum channel SNR values for QEF detection in case of the various code rates and modulations called QEF versus Cliff-off border.

4 Summary and conclusion

This article introduced new simulation system for DVB-S2, which should serves as student laboratory work. We also proved relevancy of obtained results by comparison with measured and normalized ETSI values.

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