DVB-T BROADCASTING ERROR RATE MEASUREMENT

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ABSTRACT

This paper deals with a measurement of bit error rates in the DVB - T transmission system. All basic transmission channel models (Gaussian, Rice and Rayleigh) are examined. Measured bit error rate before Viterbi error correction (channel error rate) and after Viterbi error correction, with varying C/N ratio, are graphically expressed and compared to the values mentioned in the DVB - T specification. A broadcast test system "SFU" developed by Rohde& Schwarz and a test receiver “MSK 33” by Kathrein were used for the measurement. Finally, obtained results are evaluated and discussed with the theory.

1. INTRODUCTION

Digital terrestrial television broadcasting DVB-T is subject of implementation in recent years in the Czech Republic. The topic of digital television is well examined, with enough tools for computer simulation. In spite of that, to provide good quality level of broadcasting in more complicated areas, especially ones with strong multipath propagation, is more experimental than theoretical issue.

This paper contains preliminary step of research aimed on development of Matlab application which allows simulation of a DVB – T transmission in various transmission channel to obtain bit-error rate (*BER*) depending on channel type and its parameters. The only possible solution so far is using expensive hardware simulators, for example Rohde & Schwarz “SFU” Fading simulator unit, which was used for the measurement described in following chapters. The measurement was done to obtain error rates for later comparison with error rates obtained by software simulations in Matlab. The aim is to evaluate the transmission channel and its fading influence on the transmitted DVB-T data in RF band.

2. CHANNEL MODELLING

In the ideal case, only one signal is received by the receiving antenna. This is case of Gaussian channel, where the signal is impaired just with additive white Gaussian noise (AWGN). Therefore the only parameter to simulate is a carrier to noise ratio C/N.

If there are multiple echoes, with varying power, delay and phase, added to signal in direct signal path, as described above, we talk about Rice channel.

Channel with just indirect signal paths, with no direct path is called Rayleigh channel, which is the worst for stationary reception, as the received signal is composed just from echoes.

The output signal *y(t)* of the general multipath channel model is described as a function of the input signal *x(t)* [1]:

$$y(t) = \frac{\rho_0 \cdot x(t) + \sum_{i=1}^{N_e} \rho_i e^{-j2\pi\theta_i} x(t-\tau_i)}{\sqrt{\sum_{i=0}^{N_e} \rho_i^2}} \tag{1}$$

where ρ_0 = attenuation in the direct signal path; N_e = number of echoes; ρ_i = attenuation in echo path *i*, θ_i = phase rotation in echo path *i*, τ_i = relative delay time in echo path *i*.

The ratio of the signal in the direct path, applied in the Rice channel, is denoted by the Ricean factor [1]:

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

For the measurement of the Rice channel a Ricean factor K = 10 dB has been used, as suggested in [1]. In this case:

$$\rho_0 = 10\sqrt{\sum_{i=0}^{N_e} \rho_i^2} \tag{3}$$

Ricean factor is $K = 0$ in case of Rayleigh channel simulation, as there is no direct path in this channel type.

Twenty paths were modeled for both Rice and Rayleigh channel. Parameters ρ_i, τ_i, θ_i were set individually for each path and their exact values can be found in [1].

3. EQUIPMENT USED

As we mentioned before, the Rohde & Schwarz “SFU” test system was used as a transmitter. Some of the key features are listed below [3]:

- Output frequency from 100 kHz to 3 GHz
- Generation of internal noise and interferer signals
- I/Q modulator with 180 MHz RF bandwidth
- Transmission channel simulations: Noise, Fading and Interference
- TS baseband generator and recorder with universal coder for realtime signal generation

Kathrein “MSK 33/TMR” was used as a test receiver. The key features of this instrument are [4]:

- Reception and demodulation of DVB-T signals in the frequency range of 174–230 MHz and 470–862 MHz
- Level measurement in the range from 30 to 130 dBμV
- Automatic adjustment of all required demodulation settings
- Measurement of BER before and after Viterbi decoder from 1E-02 to 1E-08

- Representation of the constellation diagrams of all modulation types

Presented laboratory measurement system can be seen in Figure 1, including second DVB-T transmitter and set-top box receiver. The measurement was done in the Laboratory of digital television system, DREL BUT.

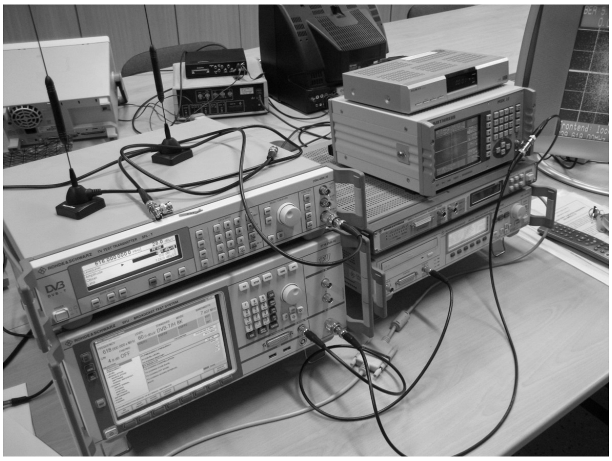

Figure 1: Laboratory workstation used for the measurement

4. RESULTS

Output level was set to 60 dBμV, transmission was performed on CCIR D/K channel C39 (618 MHz), 8 MHz bandwidth. DVB-T parameters were chosen according to DVB-T parameters used in the Czech Republic:

- modulation 64-QAM
- code rate 2/3
- guard interval of 1/8

Minimal *C*/*N* ratios mentioned in the DVB – T specification are compared to the measured ones in Table 1.

Graphical expression of the *BER* dependence on the *C*/*N* ratio can be seen in Figure 2. before Viterbi error correction performed (channel error rate). Dependence from Figure 2 after Viterbi decoding performed is shown in Figure 3. The QEF (quasi error-free) operation (in Figure 3 dashed line) is defined as a *BER* after Viterbi decoding less or equal to 2E-4. Then the *BER* after Reed-Solomon decoding is less or equal to 1E-11 (one error per hour of the broadcasting). The DVB-T service must be guaranteed under QEF operation if the picture “blocking” is not visible [5].

channel	**theoretical**	**measured**
	C/N [dB]	**C/N [dB]**
Gaussian	16,5	16,5
Rice	17,1	17,0
Rayleigh	19,3	20,0

Table 1: Comparison of theoretical and measured minimal C/N ratios

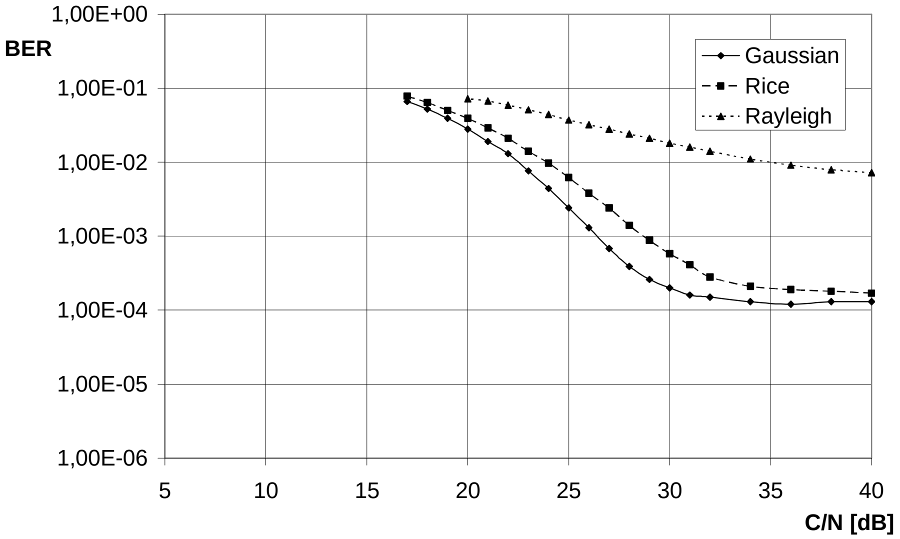

Figure 2: BER as function of on C/N ratio in Gaussian, Rice and Rayleigh channel using non-hierarchical modulation, before Viterbi error correction (channel BER).

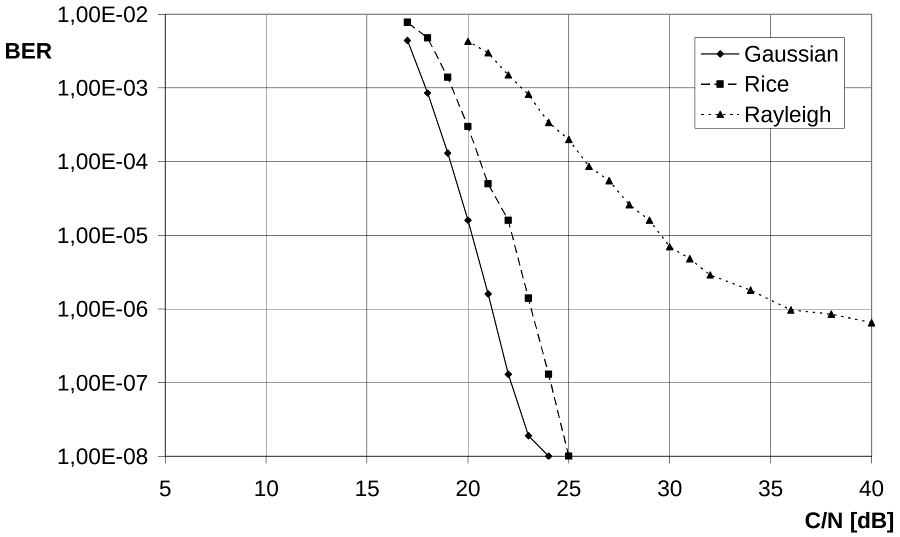

Figure 3: BER as function of C/N ratio in Gaussian, Rice and Rayleigh channel using non-hierarchical modulation, after Viterbi error correction.

5. CONCLUSIONS

All measured results were expected. We can see how much worse performance has the Rayleigh channel when compared to the Rice or even Gaussian channel in Figure 2 and Figure 3. This is caused by absence of direct signal path.

When we compare approximated values of minimal *C*/*N* ratio mentioned in the DVB-T specification [1] to the measured ones (Table 1), we can see that these are within a tolerance of equipment used. To conclude, we can say that measured values are accurate enough to serve as reference point for evaluating a success of computer simulations.

ACKNOWLEDGMENTS

This paper was supported by the Research programme of Brno University of Technology no. MSM0021630513, “*Electronic Communication Systems and New Generation Technology (ELKOM)*” and the grant projects of the Czech Science Foundation no. 102/08/H027 “*Advanced methods, structures and components of the electronic wireless communication*” and no. 102/08/P295 “*Analysis and Simulation of the Transmission Distortions of the Digital Television DVB-T/H*“.

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