UTILIZATION OF MATLAB FOR EDUCATION OF THE DIGITAL IMAGE TRANSMISSION

Tomáš Kratochvíl, Jindřich Hrdina

Department of Radio Electronics, Brno University of Technology
Faculty of Electrical Engineering and Communication

Abstract: *The contribution deals with the simulation of the non-compressed digital image transmission by the model of the digital transmission channel in baseband. The transmitted digital image corresponds to the CCIR ITU-R 601 recommendation that is set up as standard in Digital Video Broadcasting baseband image processing. The channel is modelled as a digital filter with variable parameters and type of the channel. The developed Matlab application is aimed at education and research area of the digital television signal transmission in baseband. The quantification and evaluation of the distortions that may have influence on the transmitted digital signal in digital television technique according to standard DVB in the spatial, time and frequency domain are the aims too.*

Keywords: *digital image transmission, model of the digital channel, simulation, DVB*

1 Applied simulation model

The analysis and simulation model philosophy deals with all phenomena that are introduced in DVB baseband image processing.

The applied simulation model shows **Figure 1**. The input signal for the proposed model is any image (BMP, JPG, PCX, PNG format) with 8 bits depth. The standard image is discretized into raster 720 x 576 picture elements (pixels). Then RGB analog signals are counted and after analog-to-digital conversions the digital image components Y, C_B and C_R are obtained. The composition of serial/parallel digital data multiplex is individual for each sampling format. The digital signal elements sequence is standardized by CCIR ITU-R 601 recommendation and generates the serial/parallel data with data rates introduced in **Table I** [2]. Then the serial/parallel digital signal is transferred with the model of the digital transmission channel in baseband.

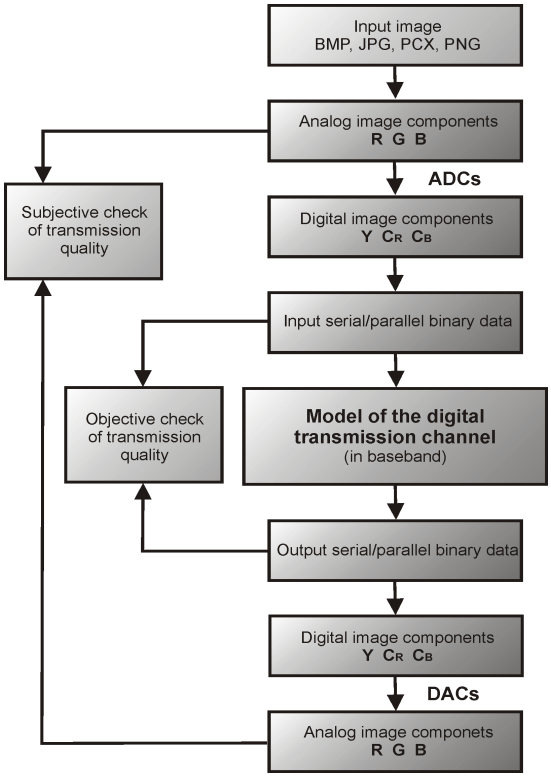

Figure 1 Simulation model block diagram.

The conversions at the receiver side are vice-versa to described transmitter side. Only the image data interpolation in dependence on used sampling format is added as the last process of analysis. After the transmission by the model of the digital transmission channel the objective check (comparison of binary signals) and subjective check (comparison of analog images in spatial area) of transmission quality can be figured out.

2 Transmitted digital image

The mentioned DVB non-compressed digital image corresponds to the CCIR ITU-R 601 recommendation and the transmission components are the luminance signal Y and chrominance signals C_B and C_R. Each signal component is sampled by the standardized sampling frequency and quantized by 8 bits per sample (256 levels) in broadcast quality or 10 bits per sample (1024 levels) in studio quality. The data rate of the digital video signal and its serial/parallel data multiplex depends on the sampling format. The **Table I** shows the possible sampling frequencies and according data rates for the sampling formats in baseband, serial multiplex and broadcast quality. The data rates are 0.768 times multiplied when only active part of image is in-process [2].

Table I Sampling frequencies and data rates of signal components (broadcast quality).

Format	4 : 4 : 4		4 : 2 : 2		4 : 2 : 0		SIF	
	f_s [MHz]	*H*[Mbit/s]	f_s [MHz]	*H* [Mbit/s]	f_s [MHz]	*H* [Mbit/s]	f_s [MHz]	*H* [Mbit/s]
Signal Y	13.5	108	13.5	108	13.5	108	6.75	27
Signal C_B	13.5	108	6.75	54	6.75	27	3.375	6.75
Signal C_R	13.5	108	6.75	54	6.75	27	3.375	6.75
Serial data	**40.5**	**324**	**27**	**216**	**27**	**162**	**13.5**	**40.5**

The **4:4:4** sampling format is used for master record, the **4:2:2** and **4:2:0** sampling formats are used for standard television broadcasting (quality accords to PAL CCIR 625/50) and format **SIF** (Source Input Format) is used for low-quality transmissions (video conferences).

3 The digital transmission channel model

The channel is modelled as non-recursive digital filter FIR [4]. The simulation of the channel appears from the similarity with the characteristics and the process of design and realization of the digital filters. The mentioned filter is a single-purpose digital device or equipment that works with the input digital signal in according to saved programme. It has finite impulse response, numerical stable algorithm of design and relatively easy hardware implementation on Digital Signal Processor (DSP) platform. Another advantage of this filter is the linear phase characteristic in mentioned frequency band that is important especially for digital components signal transmission in digital television technique. The simulation of the digital filter characteristics is generally very efficient way to design.

The conventional model [1] for digital transmission channel simulation for baseband digital television transmission is the FIR filter with low-pass character and variable parameters and methods of design. The developed model [3] can change the character of the filter (LP, HP, BP, BS, multiband), possibility of design method selection and it has variable parameters (filter order, cut-off frequencies, attenuations and allowed ripples of transmission module in passband and stopband, eventually interactive design by using the tolerant field of the digital transmission channel model).

4 Transmission quality evaluation

The objective check evaluates the Bit Error Rate (BER), propagation delay of the channel model and the frequency spectrum of input and output digital signal can be compared. The general parameters of the digital channel model (module and phase transmission characteristic, filter order, cut-off and sampling frequencies, impulse response) are displayed after the simulation experiment.

The subjective check of transmission quality evaluates comparison of the input and output RGB images. This evaluation is not standardized, the result can be classified into the five level quality scale (from excellent to unsufficient image) with decimal graduation.

5 Developed GUI application in Matlab

The developed Matlab application for research and education uses functions of the Signal Processing and Image Processing Toolboxes of Matlab Release 11 (5.3) and allows [3]:

- Selection of the image from file (BMP, JPG, PCX, PNG event. etc.).
- Selection of the sampling format (see **Table I**), transmission quality (broadcast/studio) and multiplex type (serial/parallel).
- Design of the baseband transmission channel model parameters (interactive graphics design) and saving the model parameters into file for future utilization (see **Figure 2**).
- The visualization of design results (e.g. transmission characteristics) (see **Figure 3**).
- Simulation of the transmission through the channel model (including the process of the transmission).
- Restoration of the image from transmitted component signals.
- Evaluation of the transmission influence on transmitted image (subjective and objective check of transmission quality) (see **Figure 4**).
- Interactive help for simulation process and Matlab application.

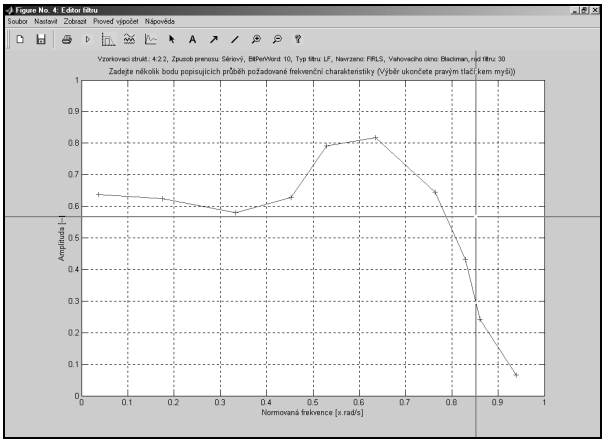

Figure 2 The channel model parameters - - interactive design (example).

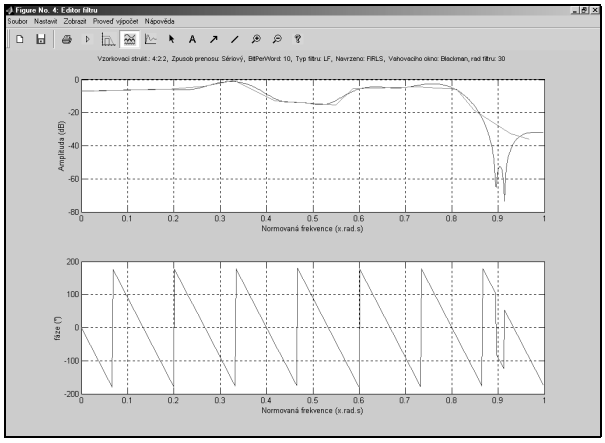

Figure 3 The channel model parameters - - design visualization (example).

6 Future work

The future work is possibility of the pertubative signals influence on the transmitted digital signal. The pertubative signals are developed in all parts of transmission system. The substitution by one source of pertubation signal is simplification of this idea. This source is usually added to useful signal - additive pertubation and may be modelled for e.g. as the white noise with normal distribution. The next example of pertubative signal is the reflected signal and its influence on the transmitted digital signal (used rather in RF band).

The further wide area is simulation of channel encoding by Forward Error Corrections (FECs) in according to DVB standard. The channel encoder is divided into two blocks. The FEC1 is outer protection by block Reed-Solomon Code and the FEC2 is inner protection by Convolution code with possible Interleaving. The next DVB signal processing (image compression, digital modulation, RF band channel) could be definetely further work too.

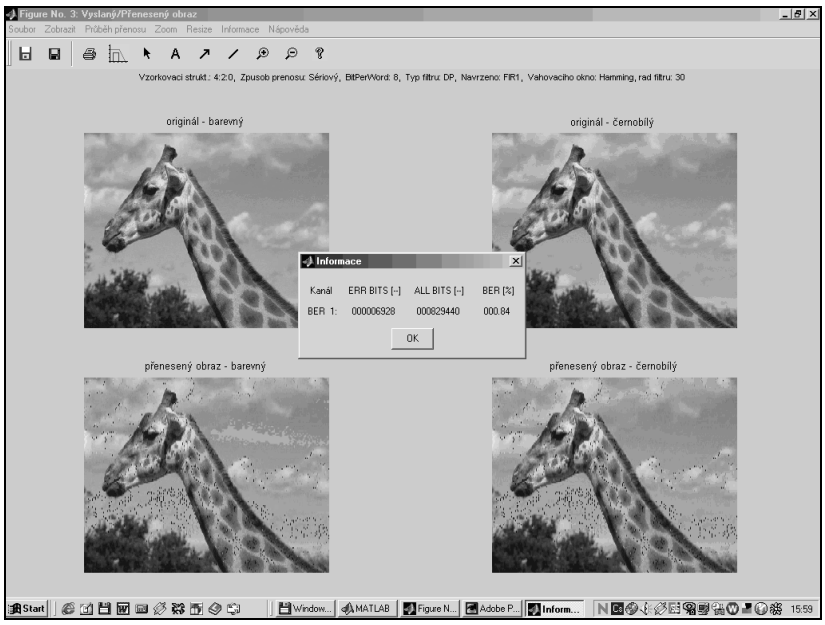

Figure 4 The subjective check of transmission quality screen including objective check with the *BER* screen (example).

Acknowledgement

This contribution is supported by the research programme of Brno University of Technology, Research of electronic communication systems and technologies CEZ MSM 262200011.

References

[1] Kratochvíl T. *Simulation of the Digital Real Transmission Channel Characteristics*, Research report of development project FRVS no. 156/2001, Brno, 2001.

[2] Riemers U. *Digital Video Broadcasting,* Springer – Verlag Berlin Heildeberger New York, 2001.

[3] Hrdina J. *Modelování přenosu číslicového obrazového signálu v televizní technice.* Ročníkový projekt 2, FEKT VUT v Brně, 2002.

[4] Kratochvíl T. and Říčný V. *Characteristics of an Ideal Low-Pass Discrete Digital Filter Used for Transmission of the Video Signal in TV Technique*. Proceedings of the 9th Electrotechnical and Computer Science Conference ERK 2000, p. 25-28, Portorose, Slovenia, 2000.

Contact

Tomáš Kratochvíl (Ph.D. student), Jindřich Hrdina (Ms.S. student)
Department of Radio Electronics
Faculty of Electrical Engineering and Communication
Brno University of Technology
Purkyňova 118
612 00 Brno
Tel: +420 541 149 162, Fax: +420 541 149 244
Email: kratot@feec.vutbr.cz, xhrdin01@stud.feec.vutbr.cz