INFORMATION TECHNOLOGY

UDC 621.396(03)

Leonid Sibruk[1]
Alexander Basansky[2]
Denis Bondarenko[3]

SIMULATION OF RADIATION FIELD OF DVB-T2 DIGITAL TELEVISION

National Aviation University
Kosmonavta Komarova avenue 1, 03680, Kyiv, Ukraine
E-mails: [1]sibruk@nau.edu.ua; [2]Krol128@mail.ru; [3]bloodden2005@mail.ru

Abstract. *DVB-T2 TV is at the implementation stage in Ukraine. Usually a national organization carries out measurements to quantify the occupied bandwidth using the level of X dB, which is lower than the predetermined 0 dB reference level. It is necessary to find the correspondence between the occupied bandwidth of transmission by* $\beta/2$*-method and X dB level. Simulation of the radiation field is considered as one of the means for the solution.*

Keywords: digital television; DVB-T2 standart; methods of measurements; occupied bandwidth; simulation; spectrum monitoring.

1. Introduction

The Ukrainian State Centre of Radio Frequencies ensures the usage of the radio frequency resource in the interests of all kinds of users, creates the conditions for implementing and developing advanced radio technologies. Radio frequency monitoring procedures were developed on the basis of national and international normative documents, for example [Recommendation ITU-R SM.443-4, Recommendation ITU-R SM.1138]. Unfortunately the normative documents provide little information on parameters measurement of the modern digital radio technologies, such as cellular radio communication, the system of broadband wireless access, digital radio-relay communication, satellite and mobile-satellite radio, terrestrial digital TV broadcasting.

Occupied bandwidth is one of the most important parameters which characterizes the effective usage of the radio frequency resource. Due to the implementation of digital TV broadcasting of DVB-T2 standard in Ukraine the occupied bandwidth determination is an essential problem. It is necessary to find the dependence of the measurement results on signal parameters and the channel type. One of the possible approaches is to use the existing software.

2. Analysis of research and publications

DVB-T2 standard for digital terrestrial television broadcasting offers benefits in capacity up to 50% and the better protection from multipath in comparison with DVB-T. The physical layer channel is divided into Physical Layer Pipes (PLPs).

One PLP carries one logical data stream. There is a possibility of transferring several data streams in individual PLPs. In a single radio frequency channel various PLPs can be characterized by different levels of coding, modulation and time interleaving depth.

The block diagram of DVB-T2 includes five sub-systems [Digital…2012]. The first sub-system forms MPEG-2 Transport Streams and/or Generic Streams from input signals. Transmitted data are packaged in Baseband frames (BB-frames) in input mode “A” with one PLP, or in an input mode “B” with several PLPs. BB-frame header includes information about its content.

Subsystem SS2 performs the bit interleaved coding and modulation (BICM). Forward error correction (FEC) includes low density parity check (LDPC – inner coding) and Bose-Chaudhuri-Hocquenghem multiple error correction binary block code (BCH – outer coding). LDPC ensures the gain in 3 dB in ratio C/N with respect to convolutional coding on the basis of Reed-Solomon code. The output of LDPC coding shall be bit interleaved and de-multiplexed into sub-streams (words) due to modulation format (QPSK, 16-QAM, 64-QAM, 256-QAM), then words are fed to constellation mapper. The Gray mapping of cells into modulation characters (OFDM cells) is accompanied by normalization for obtaining the correct complex cell value. OFDM cell is a signal corresponding to one carrier and can be modulated by one constellation point. The set of OFDM cells creates a FEC block. There is an opportunity to rotate the constellation at which cell values of each FEC block are rotated in a complex plane and additionally imaginary component are delayed by one cell within a block. Channel distortions are distributed along FEC codewords with Pseudo Random Cell Interleaver, from which FEC blocks for each PLP are grouped into interleaving frames. Interleaving frame is mapped onto one or more T2-frames. Also interleaving frames are divided into one or more TI-blocks according to selected interleaving time. T2-frames in the amount of up to 255 frames are united in a super frame, which can contain future extension frames. At the subsystem SS2 output there is T2-MI stream, which characterizes the transport level, includes data, transfer time for T2-frames and is fed into one or more modulators.

The modulator subsystem SS3 uses T2-MI stream to create cell arrays for each PLP and L1 signaling data corresponding to OFDM symbols. Frequency interleaver distributes cell content throughout carriers. In the ODFM generation module the cells are used as frequency factors of inverse fast Fourier transform, the pilots carrying reference information for interference protection are inserted, peak to average power ration is diminished, the guard interval (GI) is inserted, digital-to-analog transform is carried out.

The demodulator subsystem SS4 receives RF signal and in case of consumer receiver outputs the stream of one PLP. The subsystem SS5 receives data stream and extracts video, audio signals.

36 organizations from European countries were participants of B21C projects [2009] devoted to research of DVB-T2 system including modeling usage.

Fig. 1 presents blocks of the physical layer, which were used for the simulation.

BICM block includes the LDPC Encoder, the Bit Interleaver, and the Mapper to constellation. The Cell Interleaver rearranges modulation symbols in each FEC frame and the Time Interleaver - only through an integer number of FEC-frames.

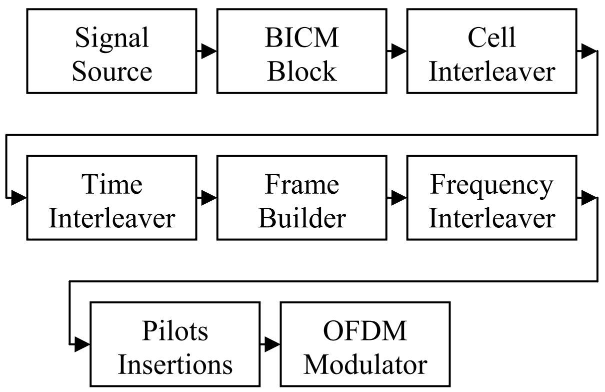


Fig. 1. Physical level model of signal forming in DVB-T2

In the last blocks pilot signals and GI are inserted and the signal transformation to the time domain is done.

The DVB-T2 Common Simulation Platform (CSP) was collaboratively developed in MATLAB by AICIA, BBC, Pace, Panasonic and SIDSA [Haffender….]. The CSP corresponds to standard ETSI EN 302 755 [DVB….] and is released in SourceForge.net under the open-source lisence. CSP includes models of a transmitter, channel, receiver, modules which help to choose model components in the selected configuration, modules for determining the DVB-T2 dependent parameters. Input and output signals are represented by vector or matrix and in case of multiple PLPs the additional output matrixes with ordering information are created. In CSP transmitter the signals are formed within the limits of one T2-frame. CSP blocks do not remember other T2-frames.

3. Problem definition

It is necessary to research the possibility of CPS usage for determining the X dB level on DVB-T2 spectrum which corresponds to the occupied bandwidth by $\beta/2$-method.

4. Analysis of simulation results

Using CPS with DVB-T2 parameters: bandwidth BW= 8 MHz; *f*=729.833 MHz; 64-QAM; FFT size 8 K; code velocity 5/6 and definite channel, the signal spectrum on channel output is found by Welch method. During simulation the ratio of signal to AWGN was 20 dB.

In Fig. 2 the signal spectrums on the output of AWGN (Gaussian noise), Ricean and Rayleigh channels are shown.

Model of Ricean fading channel characterizes fixed rooftop antenna reception and includes 21 rays. The output signal is defined by Table 1 [Digital…2012]:

$$y(t) = \frac{\rho_0 x(t) + \sum_{i=1}^{n} \rho_i e^{-j\theta_i} x(t-\tau_i)}{\sqrt{\sum_{i=0}^{n} \rho_i^2}},$$

where ρ_0 and ρ_i – correspondingly attenuation of direct and *i*th path;

$x(t)$ – input signal;

$n = 20$;

θ_i and τ_i – correspondingly phase shift and time delay of *i*th path relatively to direct.

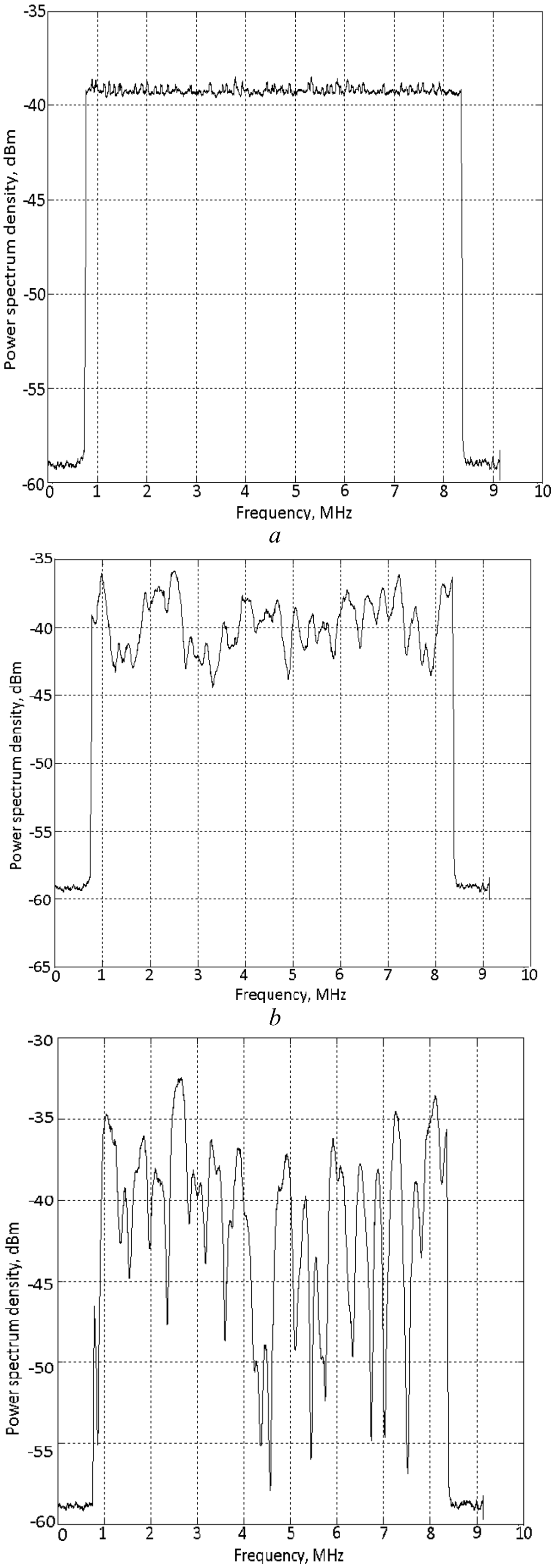


Fig. 2. Signal spectrum in AWGN (*a*), Ricean (*b*), Rayleigh (*c*) channels

Model of Rayleigh fading channel describes portable indoor or outdoor reception. Output signal is defined without taking into account Doppler effect:

$$y(t) = \frac{\sum_{i=1}^{n} \rho_i e^{-j\theta_i} x(t-\tau_i)}{\sqrt{\sum_{i=0}^{n} \rho_i^2}},$$

where ρ_i, θ_i and τ_i are given in Table 1.

Table 1. Parameters of Ricean (without direct path) and Rayleigh channels

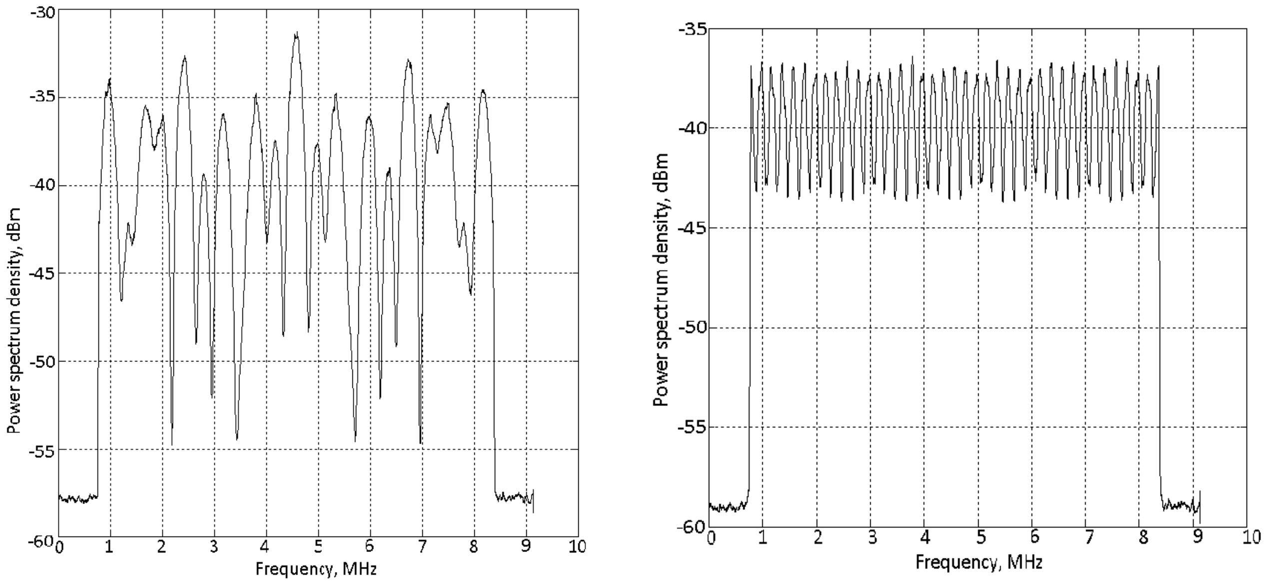
Path number	Amplitude	Delay, μs	Phase, rad
1	0.057662	1.003019	4.855121
2	0.176809	5.422091	3.419109
3	0.407163	0.518650	5.864470
4	0.303585	2.751772	2.215894
5	0.258782	0.602895	3.758058
6	0.061831	1.016585	5.430202
7	0.150340	0.143556	3.952093
8	0.051534	0.153832	1.093586
9	0.185074	3.324866	5.775198
10	0.400967	1.935570	0.154459
11	0.295723	0.429948	5.928383
12	0.350825	3.228872	3.053023
13	0.262909	0.848831	0.628578
14	0.225894	0.073883	2.128544
15	0.170996	0.203952	1.099463
16	0.149723	0.194207	3.462951
17	0.240140	0.924450	3.664773
18	0.116587	1.381320	2.833799
19	0.221155	0.640512	3.334290
20	0.259730	1.368671	0.393889

In another Rayleigh channel models [Marshall 2005] the wave propagation with longer and shorter paths are considered (Table 2).

Fig. 3. depicts signal spectrums using given channel models.

Table 2. Rayleigh channel parameters

Path num.	The channel with lower delays		The channel with greater delays	
	Attenuation, dB	Delay, μs	Attenuation, dB	Delay, μs
1	2.8	0	0	0
2	0	0.05	9	5
3	3.8	0.4	22	14
4	0.1	1.45	25	35
5	2.6	2.3	27	54
6	1.3	2.8	28	75



a *b*

Fig. 3. Signal spectrum in Rayleigh channels:
a – with lower delays;
b – with greater delays

Simulation results can be compared with normative spectrum [Digital…2012] in Fig. 4 and signal spectrums on the basis of monitoring at a short distance from the transmitter in Kyiv, example for f=714 Mhz is on Fig. 5.

Channel parameters used for mathematical modeling, except for the channel with the greater time delays lead to unacceptable distortions of the spectrum.

The experience of the measurement during radio monitoring shows that such distortions of the spectrum form are not observed. It is known that the spectrum rolls farther extend for smaller number of carriers.

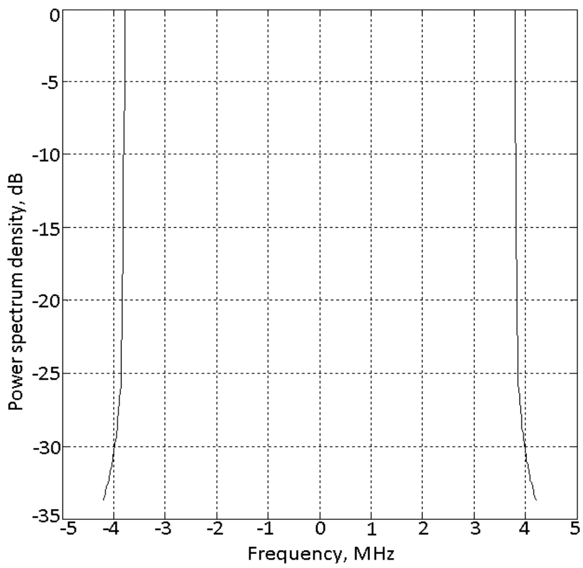


Fig. 4. The normative signal spectrum

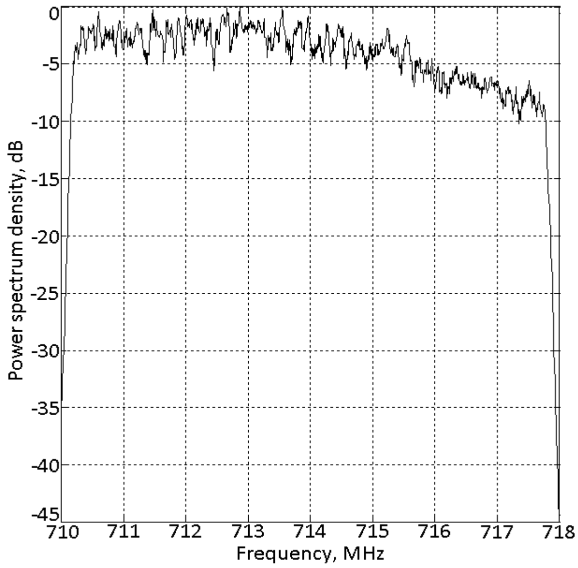


Fig. 5. Measured signal spectrum

In normative spectrums to the level -30 dB corresponds to slope width about 20 kHz for 32K and about 160 kHz for 2K. Similar results can be obtained with the help of simulation. But experimental spectrums have slopes approximately 1.5 times wider, which may be caused by an imperfect power amplifier and antenna system.

5. Conclusions

The correspondence between the occupied bandwidth of transmission by $\beta/2$-method and X dB level can be found on the basis of experimental data or it is necessary to modify CSP with the account for the real width of spectrum slopes.

References

B21C Project D07. Part A. Report on Simulating Chains and Outcomes. 2009. Available from Internet: <http://www.google. com.ua/url?sa>

Digital Video Broadcasting (DVB). Implementation Guideline for a Second Generation Digital Terrestrial Television Broadcasting System (DVB-T2). DVB Document A133, February 2012. Available from Internet: <http://www.dvb.org/technology/standards/ a133_DVB-T2_Imp_Guide.pdf>

ETSI EN 302 755. Digital Video Broadcasting (DVB). Framing structure, channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2). V1.3.1. Available from Internet: <http://www.etsi.org>

Haffender, O. *BBC Research White Paper WHP196. DVB-T2.* The Common Simulation Platform. Available from Internet: <http://downloads.bbc.co.uk/rd/pubs/whp/ whp-pdf-files/WHP196.pdf>

Marshall, P. 2005. *Digital Television Project.* Provision of Technical Assistance. Issue 1.1, March. Available from Internet: <http://www.digitalelevi sion.gov.uk/pdf_documents/publications/art_v1-2.pdf>

Recommendation ITU-R SM.443-4. Bandwidth measurement at monitoring stations.

Recommendation ITU-R SM.1138. Determination of necessary bandwidths including examples for their calculation and associated examples for the designation of emissions.

Received 12 September 2013.

Л.В. Сібрук[1], О.А. Басанський[2], Д.П. Бондаренко[3]. Моделювання поля випромінювання цифрового телебачення стандарту DVB-T2

Національний авіаційний університет, просп. Космонавта Комарова, 1, Київ, Україна, 03680

E-mails: [1]sibruk@nau.edu.ua; [2]Krol128@mail.ru; [3]bloodden2005@mail.ru

Розглянуто принцип дії цифрового телебачення стандарту DVB-T2, яке впроваджується в Україні. Проаналізовано моніторинг радіовипромінювань. Показано, що відповідність між займаною шириною смуги частот за $\beta/2$-методом та рівнем X dB можна знайти за експериментальними данними або внесенням зміни до CSP для отримання реальної ширини схилів спектра випромінювання. Як один із засобів для досягнення вказаної мети проведено математичне моделювання поля випромінювання розглядається. Під час моделювання як базис використано платформу CSP. Отримано спектри на виході каналу поширення з Гаусівським шумом, Райсівського та Релеєвського каналів. Описано, що параметри каналів, які використовувалися для моделювання, призводять до неприпустимих спотворень спектрів. Зазначено, що під час вимірювань таких спотворень не спостерігається.

Ключові слова: займана ширина смуги частот; математичне моделювання; методи вимірювань; радіомоніторинг; стандарт DVB-T2; цифрове телебачення,

Л.В. Сибрук[1], А.А. Басанский[2], Д.П. Бондаренко[3]. Моделирование поля излучения цифрового телевидения стандарта DVB-T2

Национальный авиационный университет, просп. Космонавта Комарова, 1, Киев, Украина, 03680

E-mails: [1]sibruk@nau.edu.ua; [2]Krol128@mail.ru; [3]bloodden2005@mail.ru

Рассмотрен принцип действия цифрового телевидения стандарта DVB-T2, внедряемого на Украине. Проанализирован мониторинг радиоизлучений. Показано, что соответствие между занимаемой шириной полосы частот по $\beta/2$-методу и уровнем X dB можна найти по экспериментальным данным или внесением изменения в CSP для получения реальной ширины скатов спектра излучения. Как одно из средств достижения данной цели проведено математическое моделирование поля излучения. Во время моделирования в качестве базиса использована платформа CSP. Получены спектры на выходе канала с Гауссовским шумом, Райсовского Релеевского каналов. Описано, что параметры каналов, которые использовались для моделирования, приводят к недопустимым искажениям спектров. Отмечено, что во время измерений таких искажений не наблюдается.

Ключевые слова: занимаемая ширина полосы частот; математическое моделирование; методы измерений; радиомониторинг; стандарт DVB-T2; цифровое телевидение.

Sibruk Leonid. Doctor of Engineering. Professor. Head of Radio Electronic Devices and Systems Department, National Aviation University, Kyiv, Ukraine. Education: Kyiv Institute Ingeneers of Civil Aviation, Kyiv, Ukraine (1974). Research area: propagation, antennas, radiomonitoring. Publications: 160. E-mail: sibruk@nau.edu.ua

Basansky Alexander. Postgraduate Student. National Aviation University, Kyiv, Ukraine. Education: National Aviation University, Kyiv, Ukraine (2011). Research area: radiomonitoring. Publications: 2. E-mail: Krol128@mail.ru

Bondarenko Denis. Assistant. Radio Electronic Devices and Systems Department, National Aviation University, Kyiv, Ukraine. Education: National Aviation University, Kyiv, Ukraine (2003). Research area: propagation, simulation, radiomonitoring. Publications: 12. E-mail: bloodden2005@mail.ru