УДК: 621.396.6

L.V. Sibruk, Doctor of Science (NAU, Ukraine)
D.P. Bondarenko, postgraduate (NAU, Ukraine)
D.L. Sibruk, postgraduate (NAU, Ukraine)

THE DEVELOPMENT OF PROGRAM MODEL FOR ELECTROMAGNETIC COMPATIBILITY ESTIMATION

The paper addresses the problem of electromagnetic compatibility of television transmitters (standard dvb-t2) with existing radio relay and troposphere stations. The simulation program is based on Rec. and comparison of results by models ITU-R P.452 and ITU-R P.1546. Examples of computations and experimental investigations are given.

On November 26th 2008 the State program of digital broadcasting in Ukraine was approved. The aims of program are to implement the decisions adopted by Ukraine at the Regional Radiocommunication Conference of ITU-R in Geneva in 2006, which envisages the transition from analog to digital broadcasting by 2015.

The country must build an infrastructure for digital broadcasting with guaranteed coverage throughout the territory in the band 470-862 MHz (fourth and fifth television band).

An obligatory step in obtaining permission for broadcasting is positive decision about electromagnetic compatibility of digital broadcasting with other radio electronic equipment (REE), including radio relay and troposphere stations (RRS and TRRS).

Standards DVB-T2 are based on the algorithm coding audio and video MPEG-4 [1-3]. Implementation of standards DVB-T2 stipulates construction single-frequency synchronous network SFN. In single-frequency network synchronization of operation should be provided with satellite transmitters or terrestrial channels. Radiated symbols have to be identical.

In the DVB standard modulation COFDM (OFDM with previous coding) is used. TV signal of 8, 7, 6 MHz bandwidth is formed using orthogonal carrier, the frequencies of which are defined as:

$$f_n(t) = \cos\left[2\pi\left(f_0 + n/\tau\right)t\right],$$

where: f_0 - the lower frequency of range; n - the number of sub-currier 1 до N ; τ - time interval of transmission of one symbol.

During modulation packet data stream is divided by N parts, which modulate carriers with less speed. Carrier frequency offset

$$\Delta f_n = \frac{1}{\tau}.$$

To preserve orthogonality and prevent intersymbol interference that may arise as a result of multipath propagation, each symbol interval obtain protective value of $0{,}25\tau$.

In the 8 MHz bandwidth, used in Europe, the maximum carrier number $8\times1024 = 8192$ or $8K$. Each carrier is modulated by 4-position quadrature phase shift keying (QPSK) or 16-, 64-, or 256-position quadrature amplitude modulation (QAM). Accordingly, one modulation symbol on carrier transfers from two to eight bits.

Also according to the number of quadrature modulation levels the data stream is divided into: 2 sub-streams for QPSK, 4 sub-streams for 16- position QAM. So during demultiplexing the first bit appears in the first sub-stream etc. Sense of internal interleaving is permutation by definite individual rule in each sub-stream of bits by block with length 126 bits. In parallel outputs of the internal interleaving block the modulation symbol is formed with two, four or six digits. One carrier transfers one symbol. Therefore, using $8K$ mode simultaneously is radiated 48 groups of 126 symbols, that corresponds to 6048 carriers with useful information, or 12×126=1512 carriers using $2K$ mode. QAM-symbols are divided into different sub-channel of OFDM interleaving, which allows to restore the information at a loss OFDM-symbol. Complex signal of OFDM-symbol [3] is written

$$S_n = \sum_{k=0}^{N-1} C_k(nT)e^{i2\pi knT/n}, \qquad (1)$$

where: T - discrete time interval; n - reference number.

Expression (1) identical to the Fourier inversion at sampling interval equals to the ratio of duration of one transmission symbol to the carrier number.

Radiated DVB signal looks like noise-type with Gauss distribution. Spectrum of signal consists of a large number of partial spectral modulated carriers. Due to this spectrum is practically continuous.

Radio frequency mask of DVB-T2 radiation signal is presented at Fig. 1 [4].

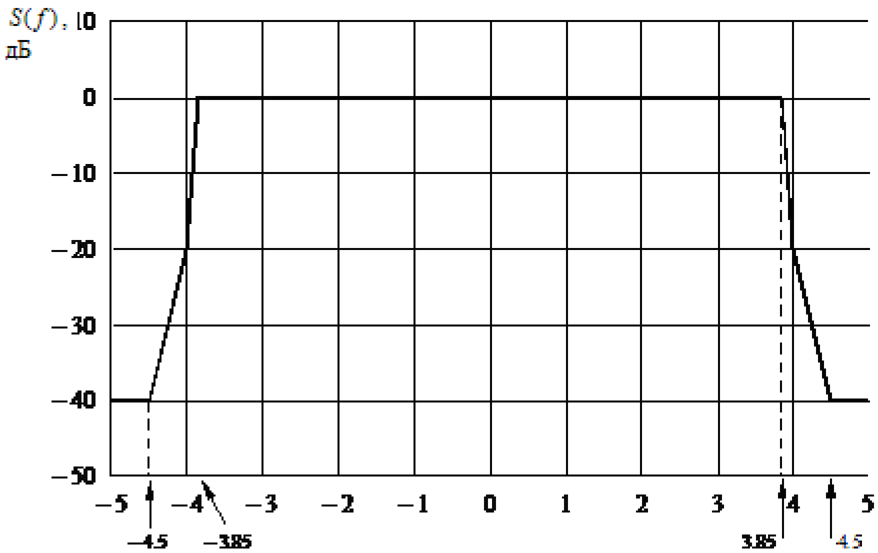

Fig. 1 Radio frequency mask of digital television with bandwidth of 8 MHz

Typical antenna system can be built on the basis of firm ELTI sectored antennas TVA 31/50 or TVA 24/50, which have a similar structure and different number of radiators (respectively 4 and 2). TVA 24/50 can radiate waves with horizontal or vertical polarization (depending on the spatial position) in a working range of 470-862 MHz, directivity factor 6.8 ... 9 dB (with respect to the dipole), bandwidth in E and H planes $2\theta_{0,5}^{E} = 56^o$, $2\theta_{0,5}^{H} = 49^o$.

Many types and combinations of interference path may exist between stations on the surface of the Earth, and between these stations and stations in space, and prediction methods are required for each situation. This paper addresses one of the more important sets of interference problems, i.e. those situations where there is a potential for interference between microwave radio stations located on the surface of the Earth. The method [5] includes a complementary set of propagation models which ensure that the predictions embrace all the significant interference propagation mechanisms that can arise. Methods for analyzing the radio-meteorological and topographical features of the path are provided so that predictions can be prepared for any practical interference path falling within the scope of the procedure up to a distance limit of 10 000 km.

Microwave interference may arise through a range of propagation mechanisms whose individual dominance depends on climate, radio frequency, time percentage of interest, distance and path topography. At any one time a single mechanism or more than one may be present. The principal interference propagation mechanisms are as follows:

– *Line-of-sight* (Fig. 2): The most straightforward interference propagation situation is when a line-of-sight transmission path exists under normal (i.e. well-mixed) atmospheric conditions. However, an additional complexity can come into play when subpath diffraction causes a slight increase in signal level above that normally expected. Also, on all but the shortest paths (i.e. paths longer than about 5 km) signal levels can often be significantly enhanced for short periods of time by multipath and focusing effects resulting from atmospheric stratification (see Fig. 2).
– *Diffraction* (Fig. 2): Beyond line-of-sight (LoS) and under normal conditions, diffraction effects generally dominate wherever significant signal levels are to be found. For services where anomalous short-term problems are not important, the accuracy to which diffraction can be modelled generally determines the density of systems that can be achieved. The diffraction prediction capability must have sufficient utility to cover smooth-earth, discrete obstacle and irregular (unstructured) terrain situations.
– *Tropospheric scatter* (Fig. 2): This mechanism defines the "background" interference level for longer paths (e.g. more than 100-150 km) where the diffraction field becomes very weak. However, except for a few special cases involving sensitive earth stations or very high power interferers (e.g. radar systems), interference via troposcatter will be at too low a level to be significant.

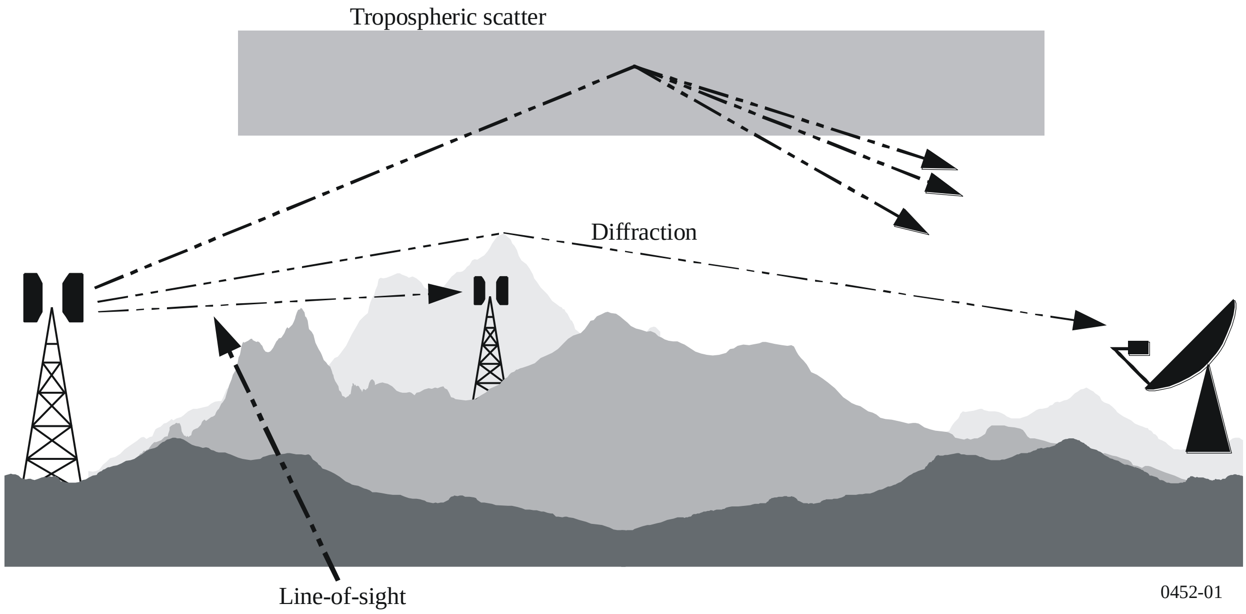

Fig. 2 Long-term interference propagation mechanisms

Computer program is used for thin-route RRS and TRRS [6-10]. Detail description of EMC evaluation procedures is considered in paper [11]. Parameters and placement location of RRS transmitters are placed in database MS-SQL. Computation results for definite examples are presented in Table 1, terrain for consider examples – on Fig. 3 and Fig. 4.

The raw data for computations:

- distance – 20 km;
- two pairs coordinates of RRS (coordinates of TV transmitters are chosen from database), RRS parameters and characteristics;
- frequency 475 MHz.

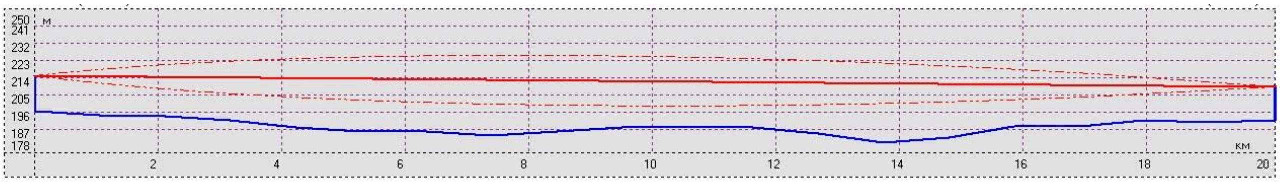

Fig. 3 Propagation path with simple terrain

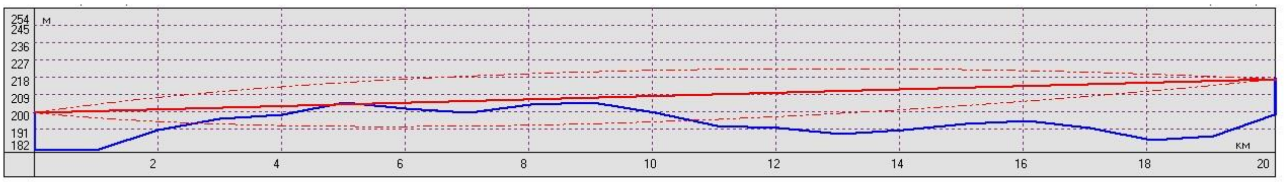

Fig. 4 Propagation path with interference

Table 1

Computation experimental investigations results

Model	Signal level for Radioline on Fig. 3	Signal level for Radioline on Fig. 4
ITU-1546	-109.6 dBW	-109.6 dBW
ITU-452	-84.5 dBW	-101.8 dBW
Experimental investigations	-87 dBW	-102 dBW

Results in Table 1 indicate that designed computer program can be used for frequency planning during digital TV implementation.

References

1. *Довідник* з радіомоніторингу / Під аг. Ред.. П.В. Слободянюка. – Ніжин: ТОВ «Видавництво Аспект-Поліграф», 2008. -588 с.
2. *ETSI TR101 190:* 2004 Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects.
3. *Вишневский В.М., Ляхов А.И., Портной С.Л., Шахнович И.В.* Широкополосные беспроводные сети передачи информации. – М.: Техносфера, 2005. – 592 с.
4. *Recommendation* ITU-R BT.1206. Spectrum shaping limits for Digital Television Broadcasting.
5. *Recommendation* ITU-R P.452-14. Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth.
6. *www*.interpolitex.rasu.ru/index.php.
7. *www*.radioscanner.ru/photo/antennas/relay.php
8. *vkmtuci*.edu.mhost.ru/texcba/rrlspravka.htm
9. *www*.omskindustry.ru/firm.asp?skl=7579
10. *www*.techtorg.ru/firm.asp?skl=7579
11. *Іванов В.О., Решетнік М.В., Бондаренко Д.П.* Алгоритм розрахунку норм частотно-територіального рознесення радіоелектронних засобів. – К.: Вісник ДУІКТ. – 2007. – Том5(3). – С.262 – 270.