Creating the information basis of spectral masks for automated radiomonitoring

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***Abstract*— The report presents the results of developing a method for constructing, experimentally checking and creating an information basis for spectral masks for transmitters of basic digital and analog radio technologies. The source data for the construction of spectral masks was a sample of radio electronic devices (RED) types from a database of frequency assignments that differ either by the range of operating frequencies, either by the radiation class, or by the type of modulating data code. A database of spectral masks and an algorithm for their construction was developed on the basis of tabular data. The software product allows the formation of a dynamic list of spectral masks, for visual and convenient work with the developed database (DB) of transmitting devices. His application made it possible to construct spectral masks for transmitting devices of basic digital and analog radio technologies. For integration into the spectrum analyzers, the possibility of mass translation of table values into the necessary formats is provided.**

Keywords — infocommunication facilities; radio electronic devices; spectral masks; automated radiomonitoring; database.

INTRODUCTION

The use of spectral radiation masks for monitoring allows detecting out-of-band spurious emissions, which may be the cause of interference [1]. Violation of the established radiation parameters can also cause legal liability [2]. Notification of violation of mask boundaries is provided in modern spectrum analyzers, for example in Anritzu and Rohde & Schwartz [3, 4].

The control over the effective use of the radio frequency resource of Ukraine by common users is ensured by the national automated radio frequency monitoring system (NARFMS). It consists of regional subsystems of radio frequency monitoring, equipped with various technical facilities of radio monitoring to measure the parameters of radio emission RED.

A promising and relevant way to automate the process of monitoring the parameters of radio emission of radio transmitters of various radio technologies for compliance with permits is the use of spectral "masks" of their radio emissions standardized on the basis of European, national standards and other regulatory documents [2, 5, 6].

The purpose of the report is to present the results of the development and the procedure for creating and experimentally verifying the information basis of the spectral masks of the RED transmitters of the main digital and analogue radio technologies operated in Ukraine for the subsequent automation of their radio monitoring process.

MAIN PART

The initial data for the construction of spectral masks was a sample of the types of radio electronic devices from the database of frequency assignments of the State Enterprise “Ukrainian State Center of Radio Frequencies”, differing either in the operating frequency range, or the emission class, or the type of the modulating code. In table 1a presents a fragment of the source data for several types of transmitters of radio-electronic broadband radio access technologies operating in the frequency range from 1.35 GHz to 6 GHz. Then, on the basis of the relevant standards and regulatory documents [2, 5. 6], spectral masks of radio emissions of the RED transmitters were formed in tabular form (Table 1b). A similar procedure was used in the development of spectral masks of all types of transmitters RED 26 used in Ukraine radio technologies. For an example in Table 2 shows the procedure for the formation of spectral masks of radio transmitters of radio relay technology operated in the frequency range from 3.4 GHz to 40.5 GHz.

For the analytical description and graphic representation of the spectral masks of the transmitters covering the main and out-of-band emissions, a piecewise linear approximation of the envelope of the real energy spectrum was chosen

$$M(\Delta f) = M_1(\Delta f_i) + M_2 \lg \frac{[\Delta f]}{\Delta f_i}, \tag{1}$$

where $M(\Delta f)$ - the value of the envelope with detuning relative to the center of the spectrum by Δf ; $M_1(\Delta f_i)$ - the value of the radiation power at the edge of the band (in dB) relative to some initial level (taken as 0 dB); *i* - is the number of the approximated area of the envelope; M_2 - the slope of the spectrum envelope within the band Δf_i ,

Table 1 - Results of the development of spectral masks for transmitters of radio broadband radio access technologies

a

Serial number	*ID*	*Quantity RED*	*Name / Type RED*	*Analogue/Digital*	*Initial data*		*Radiation class*	*Code position*	*Code*	*Modulation*	*Normative references*
					Minimum frequency (MHz)	*Maximum frequency (MHz)*					
1	2249	5	MicroMAX 1,5G "Airspan Communication limited"	D	1427	1492	1M75D7W	16	QAM	16-QAM	[2], [1] (O, 4)
2	2338	0	MicroMAX 1,5G "Airspan Communication limited"	D	1427	1492	5M00D7W	64	QAM	64-QAM	[2], [1] (O, 6)
3	1159	79	AS.MAX MicroMAX 1.5G	D	1430	1492	3M50D7W	64	QAM	64-QAM	[2], [1] (O, 6)
4	1045	524	AS WipLL 1,5GHz (BSR)	D	1427	1525	1M33 F7D	64	QAM	64-QAM	[2], [1] (O, 6)
5	1070	10	BS-1785-RU-A	D	1785	1805	5M00D7W	64	QAM	64-QAM	[1] (O, 6)
6	2228	27	McWill Micro BTS	D	1785	1805	5M00D7W	64	QAM	64-QAM	[1] (O, 6)
7	2326	8	Base Station System XWB 6500	D	1785	1805	5M00D7W	64	QAM	64-QAM	[1] (O, 6)

b

Frequency deviation	*Radiation mask*											
	Level (dB)	*Frequency band (MHz)*	*Level (dB)*	*Frequency band (MHz)*	*Level (dB)*	*Frequency band (MHz)*	*Level (dB)*	*Frequency band (MHz)*	*Level (dB)*	*Frequency band (MHz)*	*Level (dB)*	*Frequency band =5×CS (MHz)*
±12 kGz	0	1,75	-8	1,75	-27	2,5	-32	3,7	-50	7	-50	8,75
±12 kGz	0	5	-8	5	-32	7,2	-38	10,6	-50	20	-50	25
±12 kGz	0	3,5	-8	3,5	-32	5	-38	7,4	-50	14	-50	17,5
±12 kGz	0	1,33	-8	1,33	-32	1,9	-38	2,8	-50	5,4	-50	6,7
±36 kGz	0	5	-8	5	-32	7,1	-38	10,5	-50	20	-50	25
±36 kGz	0	5	-8	5	-32	7,1	-38	10,5	-50	20	-50	25
±36 kGz	0	5	-8	5	-32	7,1	-38	10,5	-50	20	-50	25

c

Normative references
[1] - ETSI EN 302 326-2
[2] - 802.16d
[3] - 802.11-2012
[4] - EN 300 328
[5] - Norms 19-13
[6] - 802.15.4
[7] - 802.16e

Table 2 – The results of the development of spectral masks for equipment radio relay communication

a

Serial number.	*ID*	*Quantity RED*	*Name / Type RED*	*Analogue/Digital*	*Initial data*		*Radiation class*	*Code position*	*Code*	*Modulation*	*Normative references*	*Frequency deviation*
					Minimum frequency (MHz)	*Maximum frequency (MHz)*					*EN 302.217-2-2014*	
1	2385	201	9500 MPR 11	D	10700	11700	28M0D7W--	4	PSK	QPSK	B2, 2, >32	±176kGz
2	2386	8	9500 MPR 11	D	10700	11700	28M0G7W--	4	PSK	QPSK	B2, 2, >32	±176kGz
3	2623	1	9500 MPR 15	D	14400	15350	28M0D7W--	4	PSK	QPSK	D2, 2, >32	±231kGz
4	2571	1	9500 MPR 18	D	17700	19700	13M8D7W--	4	PSK	QPSK	D2, 2, >16	±296kGz
5	2574	39	9500 MPR 18	D	17700	19700	27M5D7W--	4	PSK	QPSK	D2, 2, >32	±296kGz
6	2463	69	9500 MPR 18	D	17700	19700	27M5G7W--	4	PSK	QPSK	D2, 2, >32	±296kGz
7	2664	7	9500 MPR 18	D	17700	19700	55M0D7W--	4	PSK	QPSK	D2, 2, >64	±296kGz
8	2572	34	9500 MPR 38	D	37100	39400	14M0D7W--	4	PSK	QPSK	E2, 2, >16	±591kGz
9	2573	7	9500 MPR 38	D	37100	39400	28M0D7W--	4	PSK	QPSK	E2, 2, >32	±591kGz
10	2361	31	9500 MPR 38	D	37100	39400	56M0D7W	4	PSK	QPSK	E2, 2, >64	±591kGz
11	2426	0	9500 MPR 8	D	7900	8400	28M0D7W--	4	PSK	QPSK	B2, 2, >32	±126kGz
12	2425	3	9500 MPR 8	D	7900	8400	28M0G7W--	4	PSK	QPSK	B2, 2, >32	±126kGz

b

Radiation mask									
Level (dB)	*Fr. band (MHz)*	*Level (dB)*	*Fr. band (MHz)*	*Level (dB)*	*Fr. band (MHz)*	*Level (dB)*	*Fr. band (MHz)*	*Level (dB)*	*Fr. band = 5×CS (MHz)*
+2	25,6	-23	32,8	-23	50	-45	90	-45	140
+2	25,6	-23	32,8	-23	50	-45	90	-45	145
+2	25,6	-23	32,8	-23	50	-45	90	-45	140
+1	13,6	-23	16,8	-23	27,2	-45	48	-45	65
+2	25,6	-23	32,8	-23	50	-45	90	-45	135
+2	25,6	-23	32,8	-23	50	-45	90	-45	135
+2	51,2	-23	65.6	-23	100	-45	180	-45	275
+1	13,6	-23	16,8	-23	27,2	-45	48	-45	70
+2	25,6	-23	32,8	-23	50	-45	90	-45	140
+2	51,2	-23	65.6	-23	100	-45	180	-45	280
+2	25,6	-23	32,8	-23	50	-45	90	-45	140
+2	25,6	-23	32,8	-23	50	-45	90	-45	145

characterizing the rate of decrease of the power of the spectral components and defined as

$$M_2 = \frac{M(\Delta f_{i+1}) - M(\Delta f_i)}{\lg(\Delta f_{i+1}) - \lg(\Delta f_i)} . \qquad (2)$$

The advantage of this method is the availability of source data, as it is taken as a basis in the ETSI standards and a small amount of computation.

Based on the tabulated data formed in accordance with the standards, a database of spectral masks was created, and in accordance with the mathematical model (1) the software for their construction was developed. In fig. 1 shows the interface of the developed software for the construction of spectral masks on the database in the form of a multilevel list. A tabular and graphical representation of the spectral mask for the signal of the transmitting station of a broadband radio access is given.

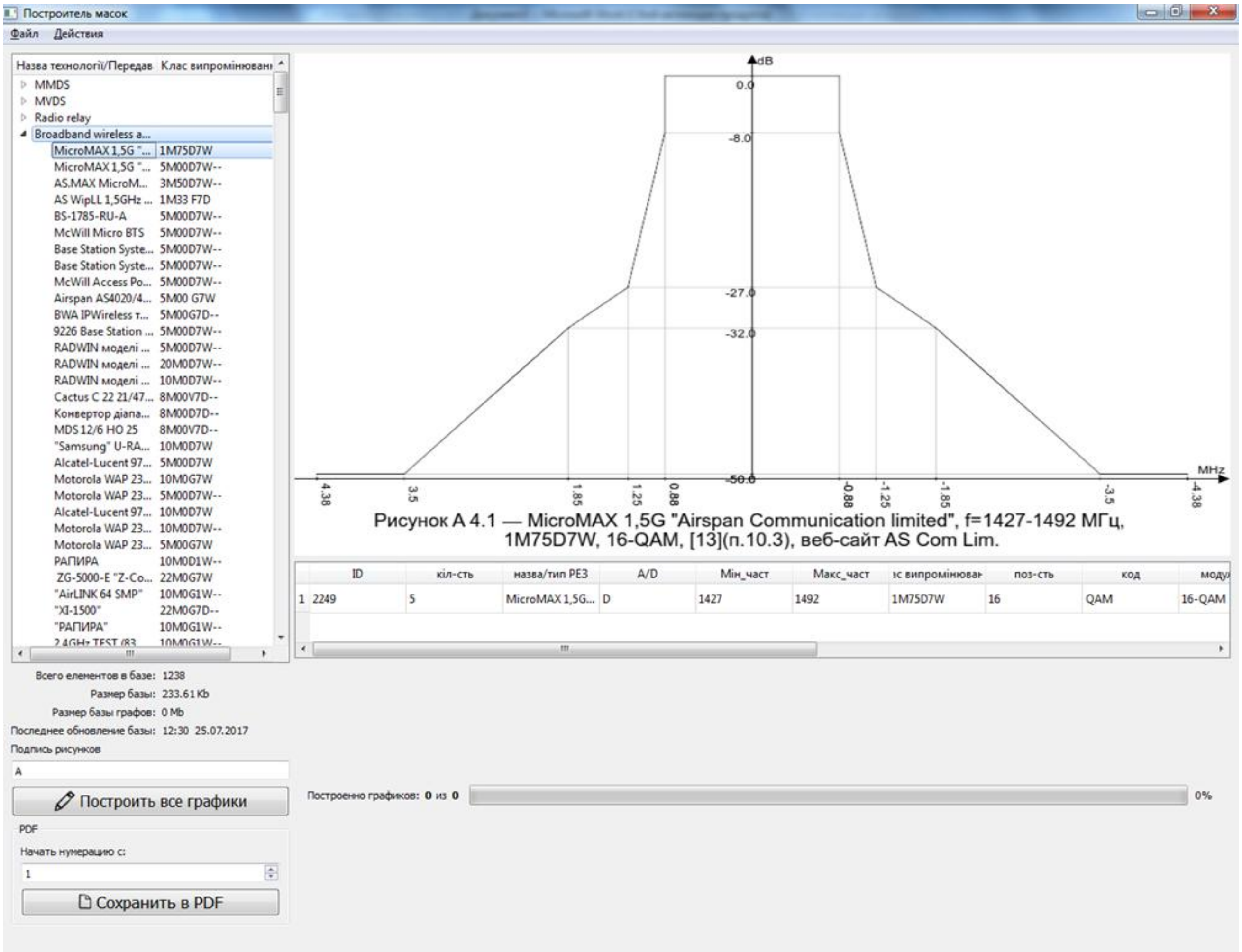

Fig.1 - Interface software for building spectral masks in graphic and tabular form

Software allows to create a dynamic list of spectral masks for visual and convenient work with the developed DB. Its use allows building and storing spectral masks of transmitting devices of all types of digital and analogue radio technologies operated in Ukraine of the following classes of digital and analogue radio technologies:

- RED broadband radio access in the frequency range from 1.35 to 6 GHz;

- RED of multi-service radio access (MMDS) in the frequency range from 2.3 to 10.65 GHz;

- RED multimedia radio access (MVDS) in the frequency range from 40.5 to 42.5 GHz;

- RED of digital radio relay communication in the frequency range from 3.4 GHz to 40.5 GHz;

- RED of digital cellular signal CDMA-450 and CDMA 800;

- RED digital wireless telephony (DECT);

- RED digital cellular GSM-900 and GSM-1800;

- RED digital cellular communications IMT-2000 (UMTS);

- RED digital terrestrial television broadcasting standards DVB-T and DVB-T2;

- RED analog audio broadcasting;

- RED analog television broadcasting;

- RED of multichannel terrestrial broadcasting;

- RED short-wave radio;

- RED radio communication data;

- RED radio communication of coastal and ship stations;

- RED radio telemetry security and fire systems;

- RED of radar search and tracking;

- RED radio telemetry and radio remote control;

- RED radio beacons;

- RED digital and analogue trunked radio communications;

- RED digital and analogue VHF radio.

In developing the spectral masks, international and national standards of the respective radio technologies were used (as shown in table 1c).

The greatest number of types of spectral masks of the RED transmitters is used in radio technologies of broadband radio access (408), radio relay radio communication (610) and analogue VHF communications (1520).

For experimental verification of the compliance of the developed spectral masks with the real radio emission spectra of the RED transmitters, the developed software was paired with the Rohde & Schwarz FSH-8 spectrum analyzer software. Fig. 2 shows a screen snapshot of a spectrum analyzer with a developed spectral mask (linear approximated envelope) reproduced from a database and a real Wi-Fi base station (BS) transmitter radiation signal of the 2.4 to 2.4835 GHz frequency band.

Fig. 2 - Screen View of the Rohde & Schwarz FSH-8 Spectrum Analyzer

The BS baseline radiation perfectly fits into the developed spectral mask. However, in the neighboring channel, BS radiation is above the allowable level and may cause interference. Consequently, the use of spectral masks allows in the automated mode to control the radiation of the radio-electronic device and detect violations in the use of the radio frequency resource.

Conclusion

As a result of the carried out information and analytical work, an important scientific and practical task of creating an information basis for about 4,300 types of spectral masks of RED transmitters of 26 classes of radio technologies used in Ukraine was solved. The created information basis is intended for integration of common users into the existing NARFMS software and introduction into the process of radio monitoring by the State Enterprise “Ukrainian State Center of Radio Frequencies”.

Using standardized spectral masks allows to automate the process of radio frequency monitoring and use automated tools for these purposes, which will lead to a significant reduction in costs and improve the quality of control.

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