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Transmission of DVB-T2 Standard Signal in a Turn of Protective Meander Microstrip Line

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Abstract— **First results of the analysis of the useful signals transmission along meander microstrip line turn are presented and the possibility of meander line using for the protection against ultrashort pulses in systems based on OFDM modulation is shown. The results of an experimental study of the DVB-T2 signal transmission for frequency range 96–850 MHz are presented. Comparison of the main DVB-T2 signal parameters at the outputs of the modulator board and meander line is executed. The results of the executed analysis show that the maximum attenuation of the useful signal at the output of the meander line does not exceed 3 dB.**

Keywords— ultrashort pulse; meander line, protecion, OFDM, DVB-T2

I. Introduction

Radioelectronic equipment (REE) protection against electromagnetic interference (EMI) of different physical origin (natural or intentional) is one of the urgent problems of electromagnetic compatibility (EMC) and, as a result, safety of a society at large [1]. The most dangerous are powerful ultrashort pulses of nanosecond range, electrostatic discharge, secondary lighting discharge, nuclear explosion pulse [2]. Such effects are capable almost momentary disabling REE units. Various traditional protective devices (TVS assemblies, varistors, gas dischargers) often incapable to provide proper protection due to their deficiencies [3]. Therefore, it is important to study new protection devices based on strip structures with a strong electromagnetic coupling between conductors: modal filters [4] and meander lines [5, 6]. The physical principle of the protection is based on the decomposition of the ultrashort pulse into a sequence of pulses of smaller amplitude due to modal distortion. From the advantages of such devices, in comparison with traditional devices, we can allocate: radiation resistance, almost infinite resource, absence of lumped components and parasitic parameters.

But only a series of first results for one and two turns of a meander microstrip line and a line with a broad-side coupling was obtained, and the decomposition of ultrashort pulse in a turn of meander microstrip line was experimentally proved on the example of a number of prototypes of such lines [5]. Additionally the frequency dependences of $|S_{21}|$ was obtained and studied and the pass band of each prototype (up to 1.1 GHz) was determined, which allows to evaluate the behavior of useful signals in protective lines. Meanwhile, the study of the useful signals transmission through such devices was not carried out explicitly, although this step is obvious for further studies. Therefore, it is advisable to perform such study.

Relative to wide spread occurrence of digital communication system based on Ortogonal Frequency Division Multiplexing (OFDM) modulation, such as Wi-Fi, WiMAX, LTE, DRM, UMTS and the using of this type of modulation in DVB digital television broadcasting standards, the estimation of OFDM signals behavior in such protective meander lines is actual. Since the calculated pass band value of the meander microstrip line prototype is 1.1 GHz, it is advisable to conduct this study on the example of DVB-T2 standard signal [7, 8], since the frequency channels of terrestrial and cable television are in the range 48.5–862 MHz.

The aim of this paper is to execute the analysis of the transmission of useful signals, conforming to the DVB-T2 standard, along the turn of the protective meander line.

II. Background

As we noted earlier, to date, an experimental study of the decomposition of the ultrashort pulse in the turn of the meandering microstrip line was performed using the example of a printed circuit board with a number of prototypes of the meander line (Fig. 1). The cross section parameters and the length of the line choice were described in detail in [5]. Also, the frequency dependences of $|S_{21}|$ for each prototype were obtained. As an example, the calculated and measured dependences of $|S_{21}|$ for a prototype with separation between conductors s=150 μm are shown in Fig. 2.

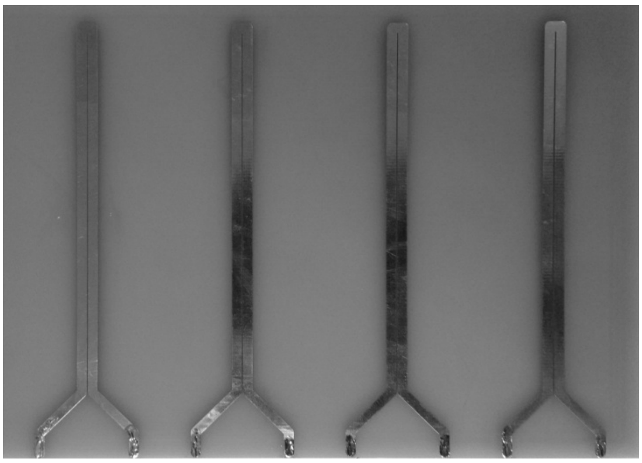

Fig. 1. Printed circuit board with prototypes of meander lines

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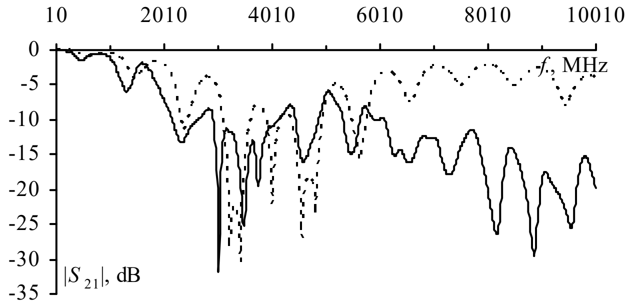

Fig. 2. Calculated (—) and measured (- -) frequency dependences of $|S_{21}|$ for meander line turn with s=150 µm

III. EXPERIMENTAL RESEARCH

The printed circuit board shown in Fig. 1 is used for experiment. The analysis of the transmission of useful signals, corresponding to DVB-T2 standard for the prototype with s=150 µm is performed.

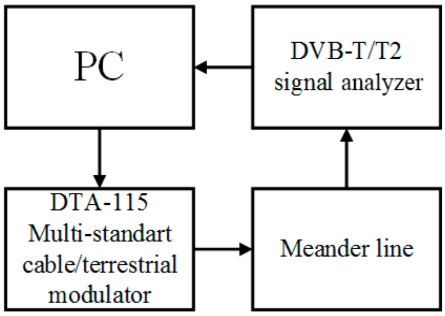

Fig. 3. Schematic figure of experimental setup

DVB-T2 signal was formed with the established parameters using a DekTec DTA-115 GOLD multistandard modulator board connected to a PC via a PCI interface. The output impedance of the modulator board is 50 Ω. The MPEG-TS, with a capacity of 22,394,118 bps, was used as a traffic stream. First, to fix the frequency spectrum of the signal and its basic parameters such as signal level, modulation error ratio (MER) and bit error ratio (BER), the modulator board was directly connected to the signal analyzer Planar IT15-T2 by coaxial cable, which is connected to PC via USB interface. The input impedance of the signal analyzer is 75 Ω. The meander line prototype was connected to the measuring tract between the output of the modulator board and the input of the signal analyzer using a coaxial cable with BNC connectors at its ends. Cable impedance is 75 Ω. In the cable break, its ends are connected to the prototype terminals by soldering. The parameters of the signal transmitted by the modulator board were controlled using the DekTec StreamXpress software, and the signal reception and fixation of the parameters were controlled using the Planar ItToolsT2 software. Visual control of the image was carried out using a television receiver with on-board DVB-T/T2 tuner.

Table I presents the parameters of the DVB-T2 signal used in the experiment; similar parameters are used in the broadcast transmitters of the first and second multiplex in Tomsk. The signal level at the modulator board output was set to minus 30 dBm and did not change during all measurements.

TABLE I. TRANSMITTER OPTIONS

Parameter	Value
Stream type	TS
TX mode	SISO
FFT mode	32k
Guard interval	1/16
PLP modulation	64QAM
PLP Code Rate	2/3
Pilot pattern	PP4
Bitrate	27 641 574 bps

Experimental studies were performed at the carrier frequency (f_H) in the range from 96 to 850 MHz. During the experiment, the signal parameters were first measured directly from the modulator board output, and then between the output of the modulator board and the input of the signal analyzer, the meander microstrip line prototype was connected.

Fig. 4 shows frequency spectrum of the signal in the range of 45–900 MHz at the output of the modulator board, and Fig. 5 – at the output of the meander line turn, for the extreme frequencies of the measured range, f_H=96 and 850 MHz. It can be seen from Fig. 5, that at all frequencies the original DVB-T2 signal almost does not change, except of a slight level decreasing with frequency increasing. Fig. 5 also shows that the DVB-T2 signal is transmitted through meander microstrip line without significant distortions. There is nose in the entire frequency range, but not more than 16 dB. The likely reason for the presence of noise is induced signal over the radio channel, as the meander line is not shielded. Over a DVB-T2 signal transmitted through a meander microstrip line, its level decreases slightly relative to the signal at the output of the modulator board. Thus, the maximum attenuation of the signal amplitude was about 2.9 dB. Potential cause of the attenuation can be inhomogeneities represented by BNC-type connectors, soldering of coaxial cables to the meander microstrip line terminals and poor line matching due to differences in the impedance of the measuring tract, meander microstrip line and connecting devices.

Table II is summarized the main parameters of the television DBV-T2 signal for all frequencies of the range of experimental measurements from the modulator board output and from the output of the meander microstrip line, respectively, and for clarity, Fig. 6 shows a summary dependences of the signal level versus frequency.

It can be seen from Table II that the MER signal value during all measurements without and with protective line remained unchanged, and its minimum value exceeds 35 dB. The BER value after the LDPC signal decoder (PostLBER) for all measurements without and with protective line is also remained unchanged, and its value did not exceed 1.0e-8. The maximum BER value before the decoder (PreLBER) was 2.0e-5 for a DVB-T2 signal at a carrier frequency of 298 MHz, measured at the output of the meander microstrip line. Fig. 6 shows decreasing tendency for the signal amplitude with the increasing of the carrier frequency. The maximum attenuation of the signal compared with the case without prototype is 2.9 dB.

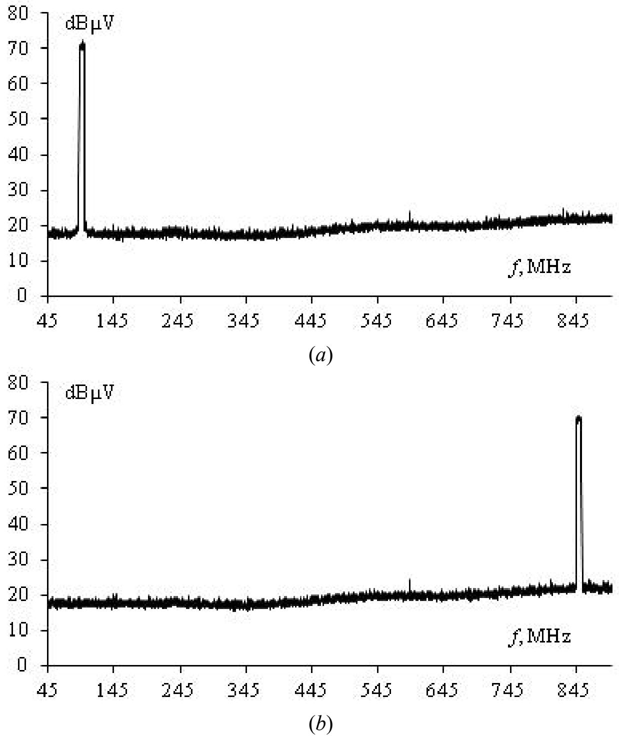

Fig. 4.Signal spectrum at the output of the modulator board at a frequency 96 (*a*) and 850 (*b*) MHz

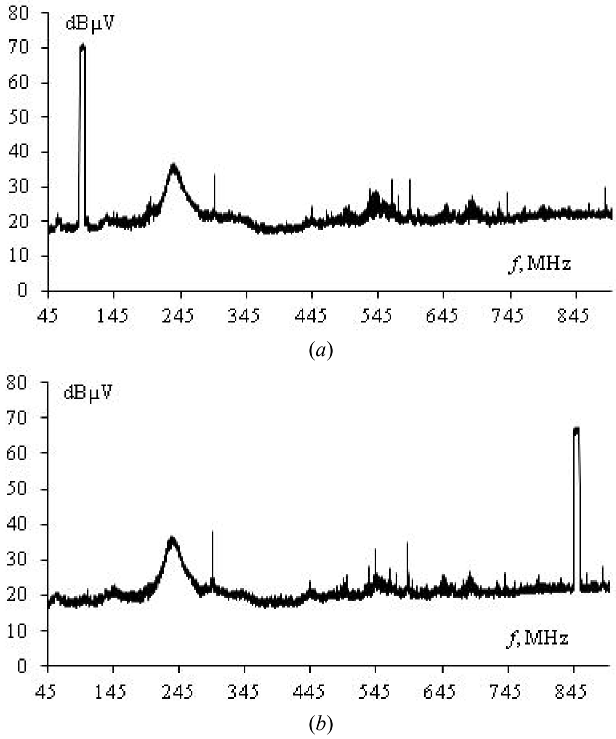

Fig. 5.Signal spectrum at the output of the meander microstrip line turn at a frequency 96 (*a*) and 850 (*b*) MHz

TABLE II. SIGNAL PARAMETERS AT THE OUTPUTS OF MODULATOR BOARD AND MEANDER LINE

№	f_H. MHz	Modulator bard output				Meander line output				Δ*U*, dB/μV
		U. dB/μV	*MER. dB*	*PreLBER*	*PostLBER*	*U. dB/μV*	*MER. dB*	*PreLBER*	*PostLBER*	
1	96	70.8	>35	7.4e-6	<1.0e-8	69.6	>35	8.5e-6	<1.0e-8	1.2
2	202	70.9	>35	6.0e-6	<1.0e-8	68.9	>35	7.6e-6	<1.0e-8	2
3	298	70.3	>35	9.6e-6	<1.0e-8	67.4	>35	2.0e-5	<1.0e-8	2.9
4	402	68.9	>35	7.5e-6	<1.0e-8	68.2	>35	6.7e-6	<1.0e-8	0.7
5	498	69.7	>35	7.5e-6	<1.0e-8	67.6	>35	1.4e-5	<1.0e-8	2.1
6	602	68.9	>35	9.8e-6	<1.0e-8	67.6	>35	8.6e-6	<1.0e-8	1.3
7	698	69.8	>35	9.1e-6	<1.0e-8	68.3	>35	9.0e-6	<1.0e-8	1.5
8	802	69.4	>35	7.6e-6	<1.0e-8	68.0	>35	7.8e-6	<1.0e-8	1.4
9	850	68.3	>35	9.0e-6	<1.0e-8	65.6	>35	8.9e-6	<1.0e-8	2.7

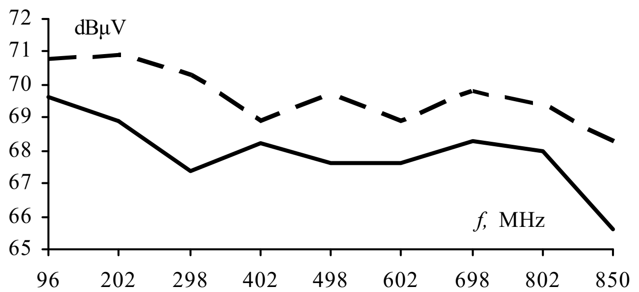

Fig. 6. DVB-T2 signal level dependencies at the outputs of menader microstrip line (—) and modulator board (– –)

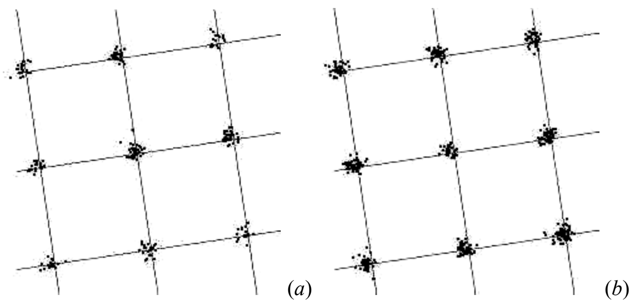

Fig. 7. Fragments of the QAM 64 constellation signal from the modulator board and meander microstrip line outputs for fH=498 MHz

Additionally to assess the image quality Fig. 7 shows fragments of the QAM 64 signal constellation at the center frequency 498 MHz at the modulator board and meander microstrip line outputs, respectively. From these fragments we can make a conclusion that the distortions of the amplitude and phase of the signal do not differ significantly. These results suggest that meander microstrip line can be used in such digital communication systems based on OFDM modulation.

IV. CONCLUSION

First results of the analysis of a useful signal transmission along meander microstrip line turn are briefly presented in the paper. The results of an experimental study of the DVB-T2 signal transmission for frequency range 96–850 MHz are presented. Comparison of the main DVB-T2 signal parameters at the outputs of the modulator board and meander line is executed. The results of the analysis show that the maximum attenuation of the useful signal at the output of the meander line does not exceed 3 dB. The obtained results shows that the meander lines, protecting against ultrashort pulse can be used in digital communication systems based on OFDM modulation. Using of the meander lines does not lead to significant distortions of OFDM signals in the calculated frequency band. It is also revealed that the meander delay line has the antenna properties, since it receives terrestrial signals and noises that are superposed on the useful signal and at some frequencies can lead to its distortion. The solution of this problem can be shielding of the line.

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