WATERPROOF MODAL FILTER BASED ON FOUR-CONDUCTOR MICROSTRIP LINE

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Contemporary radio-electronic equipment has a wide range of functional capabilities but, at the same time, is susceptible to electromagnetic interference. Conducted interference is considered to be the most harmful one, as it can penetrate into devices directly through conductors [1]. Modern generators of ultrashort pulses have very high capabilities [2]. Such ultrashort pulses are able to penetrate and disturb the electronics due to the high power output and short duration. Therefore, it is necessary to improve the protection of electronics against ultrashort pulses.

A technique of modal filtration [3] has been proposed to protect radio-electronic devices against ultrashort pulses. This technique is based on the modal decomposition of a pulse signal which occurs due to the difference between modal delays in multiconductor transmission lines. There already exists a method of ultrashort pulse protection based on the use of modal signal distortions in multiconductor modal filters (MFs) based on microstrip lines (MSL) [4]. Meanwhile, the stability of a MF to external influences has remained without attention. Thus, it is advisable to consider and simulate a multiconductor MF with a coating layer to increase the resistance of the MF to external influences. The aim of this paper is to perform such research.

As the object of investigation, we took a four-conductor MF. As a coating layer, we used the lacquer ЭП-9114. The cross-section of the four-conductor MF is shown in Fig. 1, *a*; the schematic diagram is shown in Fig. 1, *b*; the waveforms of the exciting pulses are shown in Fig. 1, *c*.

For clarity, the optimization of the MF by heuristic search was carried out by the criterion of minimization of the maximum amplitude at the output of the line. The values of the width of the conductors w and spacing between them s_i were optimized in the range of 1–1000 μm; the thickness of the conductors t and the thickness of the dielectric h were optimized in the ranges of 10–175 μm and 100–2000 μm, respectively. The thickness of the coating layer h_O was assumed to be equal to 2 μm, the relative permittivity of the substrate was $\varepsilon_r = 5$ (glass-textolite) and its cover layer was $\varepsilon_{rO} = 4$; the line length is $l = 60$ cm, and $R = 50\ \Omega$. As a result of MF optimization, the values of the following parameters were obtained: $w = 1000$ μm, $s1 = 8$, $s2 = 23$ and $s3 = 390$ μm, $t = 35$ μm, $h = 501$ μm.

Signal parameters and waveforms were calculated in TALGAT software [5]. We assumed that a T-wave is propagating along the considered lines, and we took into consideration the losses in conductors (cooper) and dielectrics (loss-angle tangent of the substrate is tgδ = 0.017 and the covering layer is $tg\delta_O$ = 0.03). A digitized signal of the oscilloscope C9-11 was used as an exciting pulse; it was measured at 50 Ω load, with an amplitude of 0.644 V. The durations of rise was 56 ps, fall was 48 ps and the flat top was 4 ps so that the overall duration was 108 ps (durations were measured at levels of 0.1–0.9).

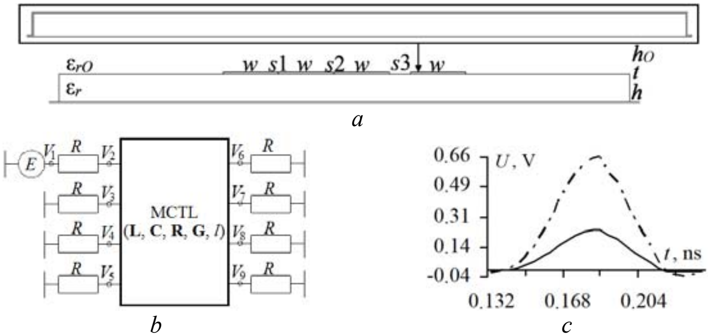

Fig. 1. The cross-section (with enlarged fragment of the covering layer) (*a*); schematic diagram (*b*) and the EMF (–·–·–) with the voltage (––) at the input (*c*) of the four-conductor MF with waterproof coating

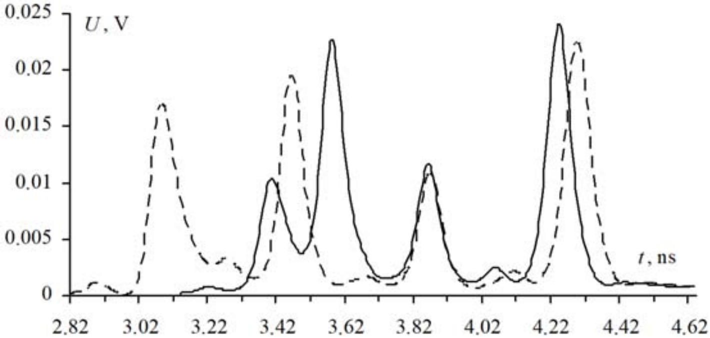

Fig. 2. The signal waveform at the output of a four-conductor MF with a waterproof coating (––) and without a waterproof coating (– – –)

It is seen from Fig. 2 that the maximum amplitude of the signal at the output of the line was 0.023 V, which is 28 times less than the EMF of the source. The minimization of the amplitude is achieved by relative equalization of the second and fourth pulses. Meanwhile, the covering layer entails a decrease in the difference in the pulse delays, which leads to partial pulse overlapping, and, as a result, to an increase in the maximum amplitude. Thus, we modeled and optimized a four-conductor MF with a cover layer, with an attenuation factor of 28 times when exposed to a pulse duration of up to about 180 ps. It should be noted that the MF has a coating which protects it from different factors, including corrosion, interaction with chemicals and temperature effects from –60 to +125 °C, and is moisture-proof, which allows it to be used in appropriate applications.

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REFERENCES

1. Gizatullin Z.M. Investigation of the immunity of computer equipment to the power-line electromagnetic interference / Z.M. Gizatullin, R.M. Gizatullin // Journal of Communications Technology and Electronics. – 2016. – No. 5. – P. 546–550.

2. Study and classification of potential IEMI sources / N. Mora, F. Vega, G. Lugrin, F. Rachidi, M. Rubinstein // System and assessment notes. – No. 41. – July 8, 2014.

3. Gazizov A.T. UWB pulse decomposition in simple printed structures / A.T. Gazizov, A.M. Zabolotsky, T.R. Gazizov // IEEE Transactions on Electromagnetic Compatibility. – 2016. – Vol. 58, No. 4. – P. 1136–1142.

4. Belousov A.O. Multicriteria optimization of four-conductor modal filter by genetic algorithms / A.O. Belousov, T.T. Gazizov, T.R. Gazizov // 2017 International Multi-Conference on Engineering, Computer and Information Sciences (SIBIRCON). Russia, Novosibirsk. – Sep. 18–22, 2017. – P. 445–448.

5. Kuksenk S.P. New developments for improved simulation of interconnects based on method of moments / S.P. Kuksenko, T.R. Gazizov, A.M. Zabolotsky et al. // Advances in Intelligent Systems Research // Proc. of the 2015 Int. Conf. on Modeling, Simulation and Applied Mathematics (MSAM2015). – Aug. 23–24, 2015, Phuket, Thailand. – P. 293–301.

THE POWER SUPPLY OF A REMOTELY OPERATED UNMANNED UNDERWATER VEHICLE WITH HIGH VOLTAGE DIRECT CURRENT TRANSMISSION VIA A STRENGTH-POWER COMMUNICATION CABLE

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The growing demand for energy sources stimulates the use of unmanned underwater vehicles (UUVs). UUVs are also used for rescue op-