Advanced Russian Conferences

ACTUAL PROBLEMS OF RADIOPHYSICS

Proceedings of the VII International Conference “APR–2017”

September, 18–22, 2017, Tomsk, Russia

RED SQUARE scientific

Published in 2018 by Red Square Scientific
20-22 Wenlock Road, London, N1 7GU, UK
www.redsquaresci.com

A CIP record for this book is available from the British Library.
ISBN 978-0-9928299-8-8

First edition
1 2 3 4 5 6 7 8 9 10

Printed in Russia

Table of Contents

ACTUAL PROBLEMS OF RADIOPHYSICS
Proceedings of the VII International Conference "APR-2017"

DECREASE OF MICROSTRIP LINE CHARACTERISTICS SENSITIVITY AT THE EXPENSE OF A SHIELDING

I.Ye. Sagiyeva, T.R. Gazizov
Tomsk State University of Radio Electronics and Control Systems, Tomsk, Russia

Abstract. Microstrip line covered with a grounded conductor and shielded microstrip line are simulated. Per-unit-length delay and impedance are calculated. For the covered line the possibility of minimizing the sensitivity of the per-unit-length delay to the change of the strip width and the height of the grounded conductor is shown. For the shielded one the possibility of zero sensitivity of the per-unit-length delay and the impedance to the change of strip width and shield height is revealed. Effect of the shielded line side walls on the revealed behavior of the characteristics is shown.

Keywords: printed circuit board, microstrip line, per-unit-length delay, impedance, shielding, zero sensitivity.

Correspondence to:
I. Ye. Sagiyeva
Post Address: Lenina Ave., 40, Tomsk, Russia, 634050
E-mail: indira_sagieva@mail.ru

Citation:
Sagiyeva, I. Ye., and Gazizov, T. R. (2018). Decrease of microstrip line characteristics sensitivity at the expense of shielding. In. *Proceedings of the VII International Conference "APR–2017"* (pp. 67–70). London: Red Square Scientific.

Published: 20 March, 2018

Microstrip lines (MSL) are widely used as high-speed signal transmission lines [1]. An important task is to obtain stable characteristics of the lines. In this regard, the minimization of the lines characteristics sensitivity to a change in their parameters is actual. Meanwhile, the possibilities of such minimization are limited by the simplicity of the classic MSL construction. Therefore, various modifications of MSL, such as suspended and inverted microstrip lines, allowing obtaining zero sensitivity of per-unit-length delay (τ) and impedance (Z) to change in the thickness of dielectric layers are considered [2]. In the multilayer printed circuit boards (PCBs) the varieties of MSLs, for example, MSL with polygons on different layers allowing obtaining a stable value of the τ, are used [3]. Similar possibilities are revealed in MSL with side grounded conductors buried into the substrate [4] and located over the substrate [5], and also in MSL with a shielding [6, 7]. Such a possibility arises from the redistribution of the electric field in the layers of air and the substrate. In practice, microstrip circuits are housed in enclosures protecting against external electromagnetic and climatic influences. Wherein the idealized consideration about the remoteness of the side walls and the shield cover in a number of cases turns out to be inaccurate. Therefore, it is important to investigate their effects on the values of the τ and the Z, and also the possibility of using these effects to obtain stable values of τ and Z.

The aim of this work is to consider in a single paper the shielding of MSL not from the point of view of its designated purpose, but as a means to decrease the sensitivity of MSL characteristics.

Investigation of microstrip structure characteristics, especially in the first stage, is advisable to perform through modeling, as it is less costly and may be more accurate than measurements. Two types of MSL are considered (Figure 1). Strict full-wave analysis of fields in the investigated lines is rather complicated. The parameters of the filling medium in the lines are heterogeneous over the cross-section so that only a part of the field is concentrated in the dielectric substrate, and the rest is in the air. Therefore, not pure TEM-mode but quasi-TEM-mode propagates in the lines. Nevertheless, for such lines, one can apply the quasi-static analysis based on the calculation of the per-unit-length capacitance.

In the TALGAT [8] software the geometric model of the line cross-section are built and the matrixes (2*2 for Figure 1, *a* and 1*1 for Figure 1, *b*) of per-unit-length coefficients of electrostatic induction, taking into account

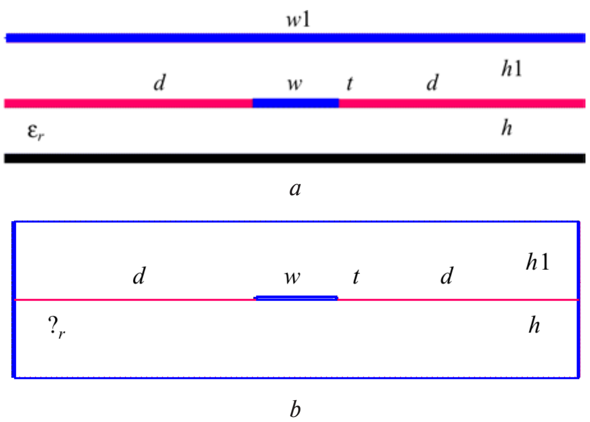


Fig. 1. – Cross-sections of covered (*a*) and shielded (*b*) MSLs.

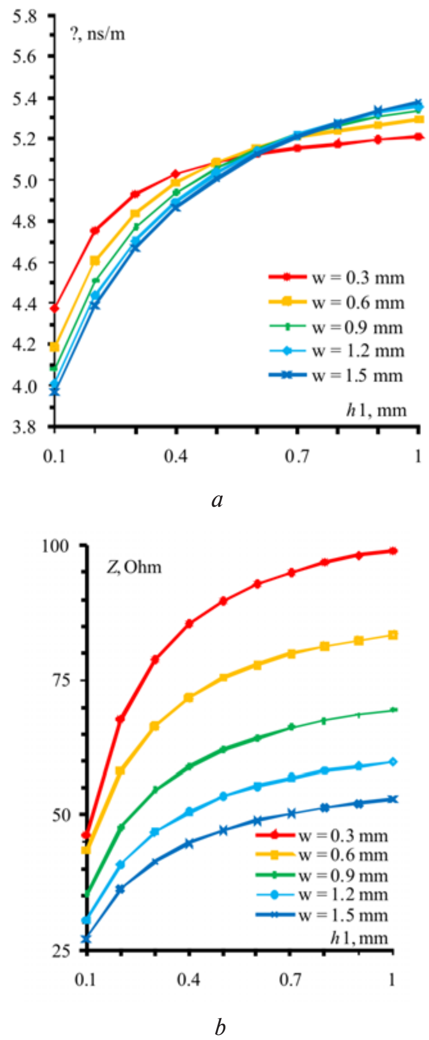


Fig. 2. – Dependences of t (*a*) and *Z* (*b*) on *h*1 for the covered MSL.

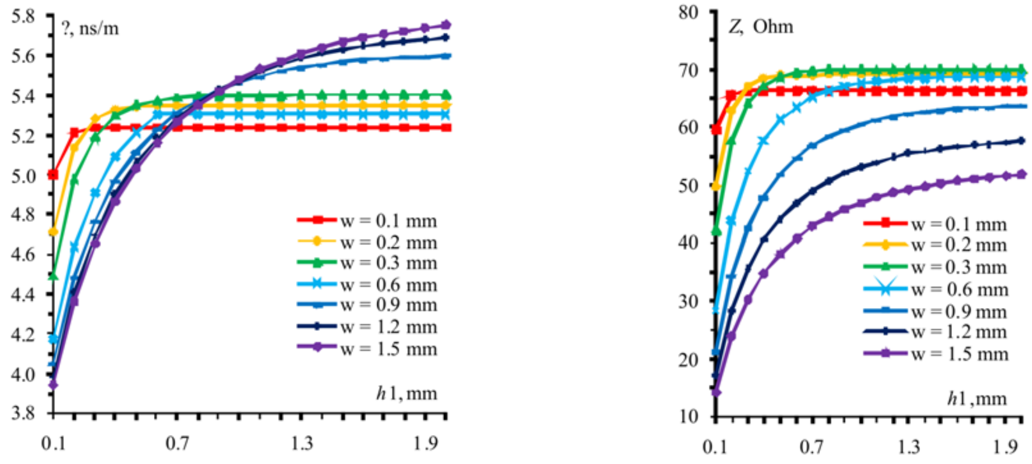
the dielectric and without it, are calculated. The values of a number of parameters were chosen typical and did not change: the thickness of the signal and ground conductors t = 18 μm, the thickness of the substrate ε = 1 mm, the relative dielectric constant of the substrate $e_r = 4.5$. From the matrices, the values (denoted below C and C_0) of the diagonal element corresponding to the signal conductor were taken, and the values of τ and Z were calculated (v_0 is the speed of light in vacuum):

$$\tau = (C/C_0)^{0,5}/v_0, \quad Z = 1/(v_0(CC_0)^{0,5}).$$

We performed the modeling in a wide range of parameters for the line from Figure 1, *a* and revealed the region of parameters with an interesting behavior of the characteristics. The dependencies of τ on *h*1 for different values of *w* are shown in Figure 2, *a*. A characteristic feature of the dependencies is their intercrossing. At the beginning of the range of *h*1, the increasing of *w* decreases τ, and at the end – increases. In the middle of the range (at *h*1 = 0.5–0.8 mm) there will be a minimal (up to zero) sensitivity of τ to the variation of *w*. Decreasing the sensitivity of t to the variation of *h*1 with decreasing the *w* is also interesting. In Figure 2, *b* the similar dependencies for *Z* are shown. They increase monotonically and do not intercross. Thus, selecting the line parameters it becomes possible to obtain the required value of *Z* with the minimum sensitivity τ to the variation of *w* and *h*1.

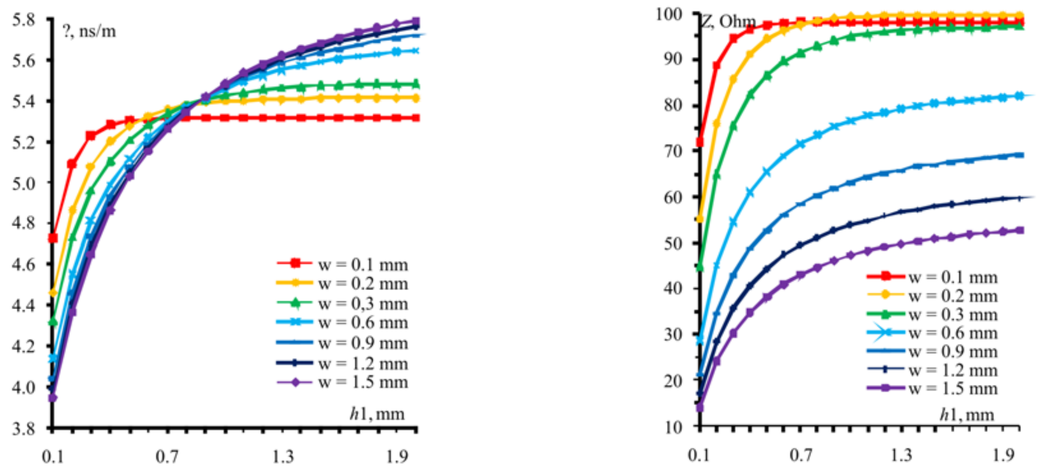
A similar modeling is performed for the shielded MSL (Figure 1, *b*) with $d = w$, $3w$, to estimate the effect of the side walls of the shield. The dependencies of τ for the shielded MSL on the height of the shield cover over the substrate *h*1 for different values of *w* for $d = w$ are shown in Figure 3, *a*. Analysis of the dependences shows that over variations of *h*1 in the entire range, when the strip is widest (*w* = 0.6, 0.9, 1.2, 1.5 mm), the value of τ increases monotonically, and when the width of the strip is small (*w* = 0.1, 0.2, 0.3 mm), the zero sensitivity of τ to the variation of *h*1 is observed, almost in the entire range. Dependencies over *w* = 0.6, 0.9, 1.2, 1.5 mm intercross at one point (*h*1 = 0.9 mm), i.e. at this point there will be a zero sensitivity of t to the change of *w*. As *w* decreases to 0.1 mm, the intercrossing point of the dependencies shifts to *h*1 = 0.2 mm. In Figure 3, *b* the corresponding dependences for *Z* are shown. Remarkably, they behave similarly to the dependencies for τ, also showing the possibility of obtaining zero sensitivity to changes in *h*1 and *w*. Note that for a covered line the zero sensitivity of *Z* to change in neither *h*1 nor *w* were observed.

Consider the influence of the side walls on the calculated characteristics. Quantitative estimates can



a *b*

Fig. 3. – Dependences of (a) and Z (b) on $h1$ for $d = w$.



a *b*

Fig. 4. – Dependences of τ (a) and Z (b) on $h1$ for $d = 3w$.

be done from a comparison of the relevant dependencies from Figure 3 and Figure 4. Meanwhile, a comparison with the dependencies for covered MSL (without side walls) of the same parameters, allows assume that exactly presence of side walls, at the expense of the increase in the edge capacitances, gives the possibility to obtain the zero sensitivity of t and Z over a wide range of values of $h1$.

Thus, in the work, the characteristics of the MSL with a grounded cover, as well as the shielded MSL, are investigated. In conclusion, we note that these results are obtained for specific values of the line parameters. However, it is easy to obtain similar dependencies for other values of the parameters. The results of the work can be used to design transmission lines with stable characteristics.

Acknowledgments

This research was supported by The Ministry of Education and Science of the Russian Federation (RFMEFI57417X0172).

References

1. Johnson, H. W., and Graham, M. (2003). *High speed signal propagation: advance black magic*. New York Prentice Hall, 792.

2. Gazizov, T. R. (1996). Characteristics of suspended and inverted microstrip lines. *Izvestiya vuzov. Fizika*, *39*, 2, 126–128.
3. Gazizov, T. R., Salov, V. K, and Kuksenko, S. P. (2017). Stable delay of microstrip line with side grounded conductors. *Wireless Communications and Mobile Computing, 2017*, 1965739, 5. DOI: 10.1155/2017/1965739.
4. Sagiyeva, I. Ye. (2017). Modelirovaniye kharakteristik mikropoloskovoy linii s bokovymi zazemlennymi provodnikami, uglublennymi v podlozhku = Modeling of the characteristics of a microstrip line with side grounded conductors recessed into the substrate. In. *Sbornik tezisov nauchno-tekhnicheskoy konferentsii molodykh spetsialistov AO “ISS” = Proceedings of the Scientific and Technical Conference of Young Specialists of JSC “ISS”*, 89–91. [In Russian].
5. Sagiyeva, I. Ye. (2016). Modelirovaniye kharakteristik mikropoloskovoy linii s bokovymi zazemlennymi provodnikami sverkhu = Simulation of characteristics of a microstrip line with side grounded conductors from above. In. *Materialy trinadtsatoy mezhdunarodnoy nauchno-prakticheskoy konferentsii “Elektronnyye sredstva i sistemy upravleniya” = Materials of the Thirteenth International Scientific and Practical Conference “Electronic means and control systems”*. Tomsk, Russia: V-Spektr, (*in print*). [In Russian].
6. Sagiyeva, I. Ye. (2017). Modelirovaniye kharakteristik mikropoloskovoy linii, pokrytoy zazemlennym provodnikom = Modeling of the characteristics of the microstrip line covered with a grounded conductor. In. *Materialy Mezhd. nauchno-tekhn. konf. studentov, aspirantov i molodykh uchenykh, posvyashchennoy 55-letiyu TUSURa* = Materials of the Scientific and Technical Conference of students, graduate students and young scientists dedicated to the 55th Anniversary of TUSUR. Tomsk, Russia: V-Spektr, 77–79. [In Russian].
7. Sagiyeva, I. (2017). Investigation of shieldied microstrip line characteristics. *Izvestiya vuzov. Fizika*, *60*, 12/2, 103–107.
8. Kuksenko, S. P. [et al.] (2015). New developments for improved simulation of interconnects based on method of moments. Advances in Intelligent Systems Research. *Proc. of the 2015 Int. Conf. on Modelling, Simulation and Applied Mathematics (MSAM 2015)*. Phuket, Thailand, 293–301.