11TH INTERNATIONAL SCIENTIFIC CONFERENCE
ON DEFENSIVE TECHNOLOGIES
OTEH 2024
Serbia, Tara, 9-11 October 2024

MICROSTRIP DC-BLOCK ON TEXTILES USING ONLY SELF-ADHESIVE COPPER TAPE

DUŠAN NEŠIĆ
Centre of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade
nesicad@nanosys.ihtm.bg.ac.rs

DRAGAN TANASKOVIĆ
Centre of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade
dragant@nanosys.ihtm.bg.ac.rs

MILOŠ VORKAPIĆ
Centre of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade
worcky@nanosys.ihtm.bg.ac.rs

Abstract: *Self-adhesive copper tape with non-conductive glue is used for DC-block on textiles. As capacitance, overlapping of copper strips was used, and the dielectric is the non-conductive glue of the strips. Two overlapping lengths were realized and measured. Due to the specificity of the textile, especially when worn, the cases of flat structure and when it is in S-shape were measured. The structure is easy to put on and take off and does not damage the textile. By easily correcting the length of the overlap, the range of impervious lower frequencies can be changed.*

Keywords: *Microwave on textiles, DC-Block, Self-Adhesive Copper Tape*

1. INTRODUCTION

The application of microwave structures on textiles is becoming more and more common [1-4]. In this case, the technique must be adapted to both the textile substrate and the applicable metallization.

Textile as a substrate is soft, flexible, somewhat anisotropic and rough. There is no precisely determined dielectric constant and no precisely determined thickness [3,4].

Conductive thread (embroidery), direct application of a conductive layer (paste, ink, etc.) and conductive self-adhesive tapes are the basic techniques of metallization on textiles. Conductive self-adhesive tapes have several advantages [4-6]. The most important are [4]: easy to put on and take off without damaging the textile, metallization similar to printed circuit boards (well-defined conductive layer) and easy formation of multi-layered (overlaped) structures.

DC-blockers in microstrip are important structures in microwaves. They are predominantly constructed on the basis of lateral coupling [7-9], which occupies more surface area and requires a narrow lateral gap for capacity. The solution can be also vertical coupling [10], which includes a multi-layered structure but without a narrow lateral gap.

The vertical coupling is more suitable for metallization on textiles. It is easier and more precise processing with easier formation of a multi-layered structure with avoided lateral coupling. DC-block on textile substrate using vertical coupling is given in [11]. The capacity is formed by screen printing of silver on commercially-available polyurethane (PU) film 50 μm thick as the interface layer on textile (felt). An additional thermal treatment was done to fix the PU dielectric on the textile which complicates the process.

A simpler structure can be formed just using direct overlap of two Cu tapes with non-conductive glue (around 15 μm thick and around $\varepsilon_r = 1.3$) as a dielectric layer [12]. This makes direct use of the possibility of easy formation of overlapped layers using Cu tapes. Substrate is felt about h=0.9 mm, dielectric constant around $\varepsilon_r = 1.3$.

2. REALIZATION AND MEASUREMENT

An example of the structure is given in Fig. 1 [12] where the overlap area on the microstrip line represents the DC-block. The overlap area is between the black vertical lines in Fig.1. Overlapping was first realized on adequately cut 4 mm wide strips for 50 Ω microstrip. One strip is glued to the appropriate length over the other and then they are glued together to the textile. A special self-adhesive tape was used to transfer the formed structure [4]. Simulations for low frequencies depending on the capacitance between two microstrip structures are given in Fig. 2.

The structures were measured flat and S-shaped, Fig. 3. The S-shape was chosen as the most complicated shape in clothing textiles. Two overlaps are fabricated: 11 mm and 5 mm. Both are measured flat and S-shaped.

First, a structure with an overlap of 11 mm was made and measured, Fig.4. The measured attenuation value of 1 dB

Corresponding author: D. Nešić;
E-mail: nesicad@nanosys.ihtm.bg.ac.rs
DOI: 10.5937/OTEH24092N

at 0.1 GHz corresponds to a capacitance of about 30 pF in low frequency simulation. The results are good up to about 5 GHz for the flat structure, while for the S-shape it is about 4.5 GHz, and that is because of the S_{11}.

The overlap part was then trimmed to 5 mm and the new structure was also measured, Fig.5. The measured attenuation value of 3 dB at 0.1 GHz corresponds to a capacitance of about 15 pF in low frequency simulation. The results are good up to near 5.5 GHz for the both flat and the S-shape structure.

Figure 1. DC-block construction using Cu adhesive tape on felt substrate [12]. The overlap area on the microstrip line is between the black vertical lines.

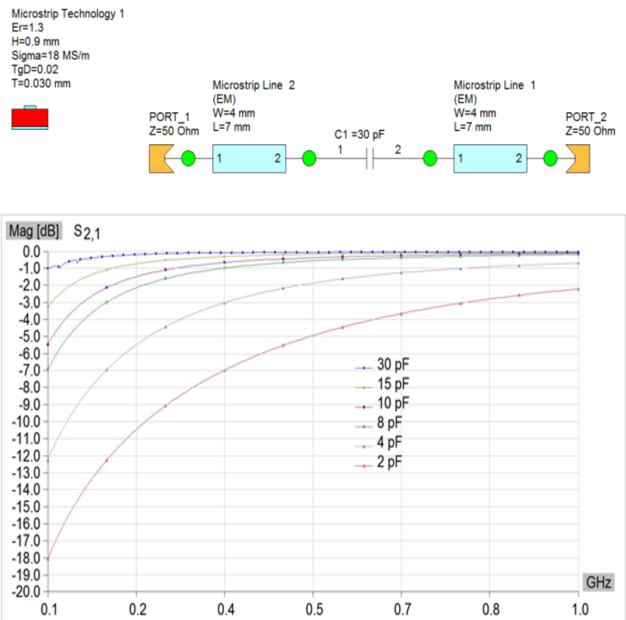

Figure 2. Simulations for low frequencies depending on capacity: simple model and results. Lower S_{21} corresponds to lower capacity [12]

Figure 3. S-shape structure

3. CONCLUSION

The paper presents microstrip DC-block on textile with use only self-adhesive copper tape. Implementation is simple; easy to put on and easy to take off, which supports the sustainability of textiles. The dielectric is just a non-conductive glue between the overlap of two copper strips.

The folds are realized as 11 mm and 5 mm, with the second realized as trimming of the first. The S-shape measurement in addition to the flat state measurement perturbed the S-parameters very little. Logically, an 11 mm overlap has a lower DC-block than a 5 mm overlap. The latter has a slightly higher acceptable higher frequency. Good for lower microwave frequencies in communications, up to 6 GHz.

This type of DC-block structure is easy to apply and occupies a small area due to vertical coupling. This especially applies to textile structures, especially clothing. As it is easy to put on, it is also easy to take off without damaging the textile. It is suitable for suppressing low frequencies and DC in military application without complicated technological process such as printing and embroidery.

Disadvantage can be the imperfection of textiles as a substrate for microwaves. Also, it depends on the fineness of the workmanship.

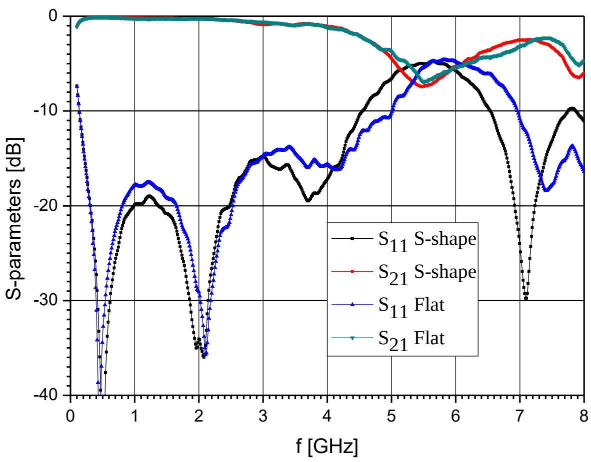

Figure 4. Overlap 11 mm: The measured S-parameters, flat and S-shape, 0.1 GHz to 8 GHz

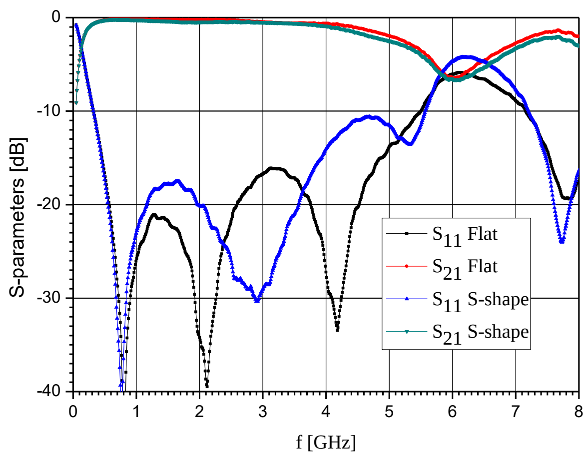

Figure 5. Overlap 5 mm: The measured S-parameters, flat and S-shape, 0.1 GHz to 8 GHz

Acknowledgement

The authors thank to V. Milosević (Institute of Physics, Belgrade), M. Potrebić and M. Tasić (School of Electrical Engineering, University of Belgrade) for help in measuring.

This work was financially supported by the Minister of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-47/2023-01/200026).

References

[1] WAGIH,M: *Microwave-Enabled Wearables: Underpinning Technologies, Integration Platforms, and Next-Generation Roadmap*, IEEE Journal of Microwaves, Vol. 3, Iss. 1, pp 193 – 226, 2023

[2] TSOLIS,A., BAKOGIANNI,S., ANGELAKI,C., ALEXANDRIDIS,A.A.: *Review of Clothing Components in the Development of Wearable Textile Antennas: Design and Experimental Procedure*, Sensors 2023, 23, 3289.

[3] CUPAL,M., RAIDA,Z.: *Frequency Limits of Textile-Integrated Components*, 2020, 23rd International Microwave and Radar Conference (MIKON)

[4] NEŠIĆ,D.: *Application of conductive tapes and foils in textile electronics*, 2023 10th International Conference on Electrical, Electronic and Computing Engineering (IcETRAN), East Sarajevo, Bosnia and Herzegovina, 2023, pp. 1-11

[5] ALIMENTI,F., MEZZANOTTE,.P, DIONIGI,M., VIRILI,M., ROSELLI,M.: *Microwave Circuits in Paper Substrates Exploiting Conductive Adhesive Tapes*, IEEE Microwave and Wireless Components Letters, Vol. 22, Iss. 12, 2012

[6] NEŠIĆ.D., TANASKOVIĆ,D., VORKAPIĆ,M.: *Application of Self-Adhesive Conductive Material on Textiles*, TEKSTILNA INDUSTRIJA, Vol. 70, No 4, 2022.

[7] KAUR,A., MALHOTRA,J.: *An Efficient Design of a DC-Block Band Pass Filter for the L Band*, Transactions on Electrical and Electronic Materials, vol. 18, no. 2, pp. 62–65, Apr. 2017.

[8] WU,F., LIU,X., LIU,Y.A., YANG,Y.: *Analysis and Design of Dual-Band Micro strip DC-Block*, J. of Electromagn. Waves and Appl., Vol. 25, 1763–1772, 2011

[9] JUN,S., CHANG,K.: *Compact Square DC-Block Bandpass Filter with Slots*, Progress in Electromagnetics Research Letters, Vol. 38, 17–23, 2013

[10] TAO,Z., ZHU,J., ZUO,T., PAN,L., YU,Y.: *Broadband Microstrip-to-Microstrip Vertical Transition Design*, IEEE Microwave and Wireless Components Letters, Vol. 26, No. 9, pp. 660-662, 2016

[11] WAGIH,W., KOMOLAFE,A., HILLIER,N.: Screen-*Printable Flexible Textile-Based Ultra-Broadband Millimeter-Wave DC-Blocking Transmission Lines Based on Microstrip-Embedded Printed Capacitors*, IEEE Journal of Microwaves, Vol. 2, no. 1, 2022

[12] NEŠIĆ,D., TANASKOVIĆ,D., VORKAPIĆ,M.: *Microstrip DC-Block on Textiles Using Self-Adhesive Copper Tape*, 2023 16th International Conference on Advanced Technologies, Systems and Services in Telecommunications (TELSIKS-2023), 34-36.