Journal of Materials and Electronic Devices 5 (2021) 18-20

JOURNAL OF MATERIALS AND ELECTRONIC DEVICES

FYTRONIX JMED http://dergi-fytronix.com/

The effect of conductive weft-knitted fabric structure on electromagnetic shielding at 1-12 GHz frequencies

Ediz Delihasanlar, Ahmet Hayrettin Yüzer

Karabuk University, Faculty of Engineering, Department of Electrical-Electronics Engineering, Karabuk, 78050 TURKEY

In this study, the effect of weft-knitted fabric structure on electromagnetic shielding was investigated at 1-12 GHz frequencies. The weft-knitted fabric was drawn in the Autocad program using 50 μm thick conductive yarn. The three different designs were applied using weft and warp yarn. These are designed in such a way that first the entire structure is conductive, then one loop conductive other loop is not conductive, and the last one, one weft yarn conductor other weft yarn is not a conductor. The designs were measured using the waveguide measurement system in the CST program and the results were compared between each other. The obtained simulation results that conductive weft-knitted fabrics can be used as very effective, lightweight, wearable, flexible microwave shielding materials for clothing, tents, curtain, and related applications at 1-12 GHz frequencies.

Keywords: Electromagnetic shielding; Wearable; Weft-knitted fabric.

Submission date: 02 May 2021

Acceptance Date: 11 September 2021

**Corresponding author. Tel: +90 (370) 418 7207 / 7207*
E-mail address: edizdelihasanlar@karabuk.edu.tr (Ediz Delihasanlar)

1. Introduction

In recent years, with the development of science and technology, electrical devices have started to include our lives more and more. These devices expose to electromagnetic waves. When these electromagnetic waves encounter a living thing, it causes molecules to vibrate and heat, while it interferes with and damages electronic systems[1–3]. Electromagnetic shielding is one of the basic methods of shielding electromagnetic radiation. It acts as a barrier to prevent the spread of electromagnetic waves from one point to the medium.

Since it is light, wearable, and easy to shape, textile structures are preferred in applications to electromagnetic shields and are used in many areas. Some of these are telecommunications, military application, medical monitoring, and treatment, electro-thermal devices[4–9].

In this study, the effect of weft knitted fabric structure on electromagnetic shielding was investigated at frequencies of 1-12 GHz frequencies. Since it covers all communication frequencies used in daily life, simulations were made in this frequency range. Designs were made in the AutoCAD program using weft and warp yarn in a weft-knitted fabric structure. The designs were measured in the CST program between 1-12 GHz frequencies. According to the results obtained, it is predicted that it can be applied to many areas.

2. Material and Methods

Weft-knitted fabric is one of the basic knitted fabrics used since ancient times. While designing, the thread thickness was chosen as 50 μm. Since metal structures are hard and difficult to shape, they are preferred as thin as possible. While knitting with a thickness of 50 μm without breaking, it can also maintain its flexibility. The structures shown in yellow in the weft-knitted fabric structure describe the copper and the dimensions of weft-knitted fabric are given in the Fig. 1.

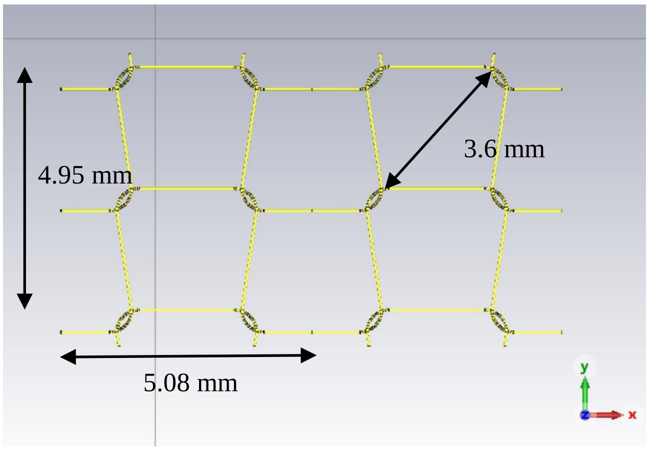

Figure 1. First (a), next (b), and last design of weft-knitted fabric.

S-parameters are used to find the transmitted, reflected power and absorption parameters of the electromagnetic wave that comes to the environment at high frequency. Reflection coefficient (R) and transmission coefficient (T) are defined based on S-parameters as given in equation 1.

$$R = |S_{11}|^2 \ , \ T = |S_{21}|^2 \tag{1}$$

The absorption coefficient (A) can be obtained from the simple relationship in equation 2.

$$A + R + T = 1 \tag{2}$$

Electromagnetic shielding efficiency (SE) is calculated as the ratio of incident wave Pi power to transmitted Pt wave power as given in [10,11].

$$\mathrm{SE} = 10 \log\left(\frac{P_i}{P_t}\right) \tag{3}$$

Three different designs were applied to match the sub-wavelength of the measurement frequency range using weft and warp yarn. The first structure is designed such that the entire structure is conductive. The second design has one loop conductor and the other non-conductive loop and the third one is that one weft yarn conductor and the other weft yarn non-conductive. The designs are shown in Fig. 2.

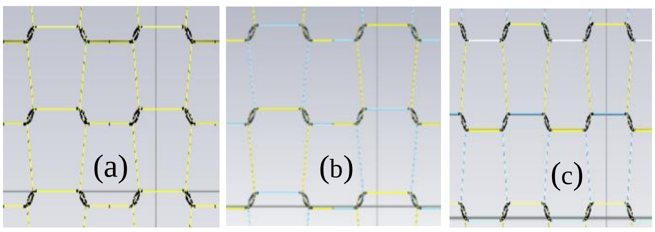

Figure 2. First (a), next (b), and last design of weft-knitted fabric.

The waveguide measurement setup was prepared for measuring and taking S-parameters, in the CST program. Waveguide ports are identified in front of and behind the designs and each design is measured individually. The simulation measurement setup is given in Fig. 3.

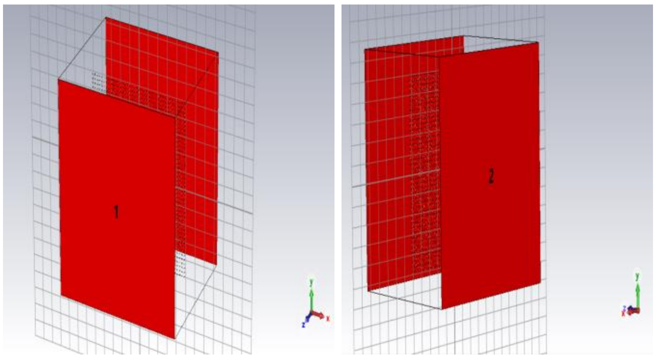

Figure 3. Simulation setup front view (a) and back view (b)

4. Results and discussion

The broadband measurements in the 1-12 GHz frequency range completed in the CST simulation program. SE is calculated by using S parameters separately for each design and is shown in Fig. 4.

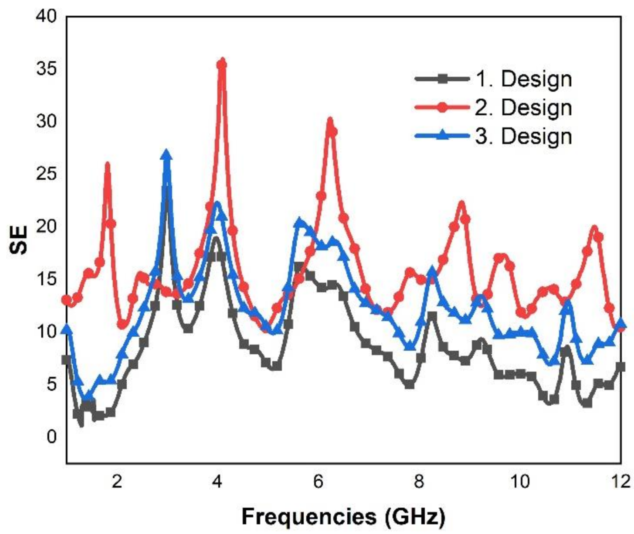

Figure 4. Simulation result of SE

When the simulation results are examined, it is seen that the highest SE value is obtained from the full copper weft-knitted fabric structure (1. Design). It appears to have a value of 35.95 SE at a frequency of 4.1 GHz. In general, it is seen that while having higher SE values in the frequency band, there are also peak values at different frequencies. In the other two designs, the results were found to be close to each other, and the maximum SE was found to be 27.05 SE at a frequency of 2.99 GHz. It is the point where it has a better SE value than the first design result.

5. Conclusion

In this study, the effect of conductive weft-knitted fabric structure on electromagnetic shielding at 1-12 GHz frequencies has been presented. The three different designs were made from weft-knitted fabric and the effect of designs on SE value was investigated. In the CST simulation, measurements were made in the frequency range of 1-12 GHz by a waveguide measurement setup. SE values were calculated with the S-parameters obtained from the simulation measurements. When the results were examined, the maximum SE value was obtained as 35.95 SE at a frequency of 4.1 GHz. When the weft-knitted fabric designs were made, the maximum SE value was obtained at a frequency of 27.05 SE and 2.99 GHz. The rate of copper in the fabric was halved and frequency was shifted. It showed that a high SE value at the desired frequency can be obtained by using the fabric structure. In this way, it is predicted that conductive weft knitted fabrics can be used as very effective, light, wearable, flexible microwave protective materials for clothing, telecommunication, military application, medical monitoring and treatment, electro-thermal devices, tents, curtains, and related applications at frequencies of 1-12 GHz.

References

[1] C. I. su and J. T. Chern, “Effect of Stainless Steel-Containing Fabrics on Electromagnetic Shielding Effectiveness,” Text. Res. J., vol. 74, no. 1, pp. 51–54, 2004, doi: 10.1177/004051750407400109.
[2] Y. Wang, S. Gordon, T. Baum, and Z. Xu, “Multifunctional stretchable conductive woven fabric containing metal wire with durable structural stability and electromagnetic shielding in the X-band,” Polymers (Basel)., vol. 12, no. 2, 2020, doi: 10.3390/polym12020399.
[3] İ. Özkan, P. Duru Baykal, and M. Karaaslan, “Investigation of electromagnetic shielding properties of metal composite tufted carpets,” J. Text. Inst., vol. 111, no. 4, pp. 476–483, 2020, doi: 10.1080/00405000.2019.1643213.
[4] M. S. Abdelrahman et al., “Studies of polylactic acid and metal oxide nanoparticles-based composites for multifunctional textile prints,” Coatings, vol. 10, no. 1, p. 58, 2020.
[5] M. S. Abdelrahman and T. A. Khattab, “Development of One-Step Water-Repellent and Flame-Retardant Finishes for Cotton,” ChemistrySelect, vol. 4, no. 13, pp. 3811–3816, 2019.
[6] T. Chen, Q. Fang, Q. Zhong, Y. Chen, and J. Wang, “Synthesis and thermosensitive behavior of polyacrylamide copolymers and their applications in smart textiles,” Polymers (Basel)., vol. 7, no. 5, pp. 909–920, 2015.
[7] M. Stoppa and A. Chiolerio, “Wearable electronics and smart textiles: a critical review,” sensors, vol. 14, no. 7, pp. 11957–11992, 2014.
[8] R. Abdulla, E. Delihasanlar, F. G. Kizilcay Abdulla, and A. H. Yuzer, “Electromagnetic Shielding Characterization Of Conductive Knitted Fabrics,” Prog. Electromagn. Res. M, vol. 56, no. January, pp. 33–41, 2017, doi: 10.2528/PIERM17011305.
[9] R. Abdulla, E. Delihasanlar, F. G. K. Abdulla, and A. H. Yüzer, “Investigating the Electromagnetic Shielding Effectiveness Simulations of Metal Composite Fabrics,” pp. 1724–1728.
[10] K. T. Mathew, U. G. Kalappura, and R. Augustine, “Polyaniline based materials for efficient EMI shielding,” Kochi Univ. Sci. Technol., 2008.
[11] E. Delihasanlar and A. H. Yuzer, “Investigation of the Absorption Characteristics of Opuntia in Radio Frequencies,” in Aug. 2017 Thailand International Conferences, 2017, pp. 22–24, doi: 10.17758/URUAE.AE0817117.