2017

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Publication Details

Rahim, H. A., Malek, F., Soh, P. Jack., Romli, A., Abd Rani, K., Che Isa, C. & Fuad, F. Afzal Ahmad. 2017, 'Measurement of dielectric properties of textile substrate', American Journal of Engineering and Applied Sciences, vol. 12, no. 17, pp. 4311-4312.

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Journal of Engineering and Applied Sciences 12 (17): 4311-4312, 2017
ISSN: 1816-949X

Measurement of Dielectric Properties of Textile Substrate

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Abstract: This study presents the measurement of dielectric properties of textile substrate in which is used in fabricating the textile antenna. The measurement setup of felt's dielectric properties is shown in this study. The results were compared to the previous work where the dielectric properties of felt was found to be consistent with the one reported in the literature. This research provides dielectric properties value of felt textile which will be used widely for all-textile based antennas.

Key words: Dielectric properties, textile antenna, textile substrate, fabricating, dielectric, Malaysia

INTRODUCTION

Textile-based antennas have gained in popularity recently because they provide flexibility, conformality and ergonomicity to the users. Several textile-based antennas have been proposed both for narrowband and wideband Wireless Body Area Network (WBAN) (Mantash *et al*., 2011; Rais *et al*., 2013; Soh *et al*., 2012; Shakhirul *et al*., 2014). One of the most important materials to fabricate the textile-based antennas is the substrate textile which is a non-conductive textile material.

There are many types of non-conductive textiles available in the market such as cotton, denim, felt, fleece fabric, hypalon cotted dacron fabric, woven fiberglass, flannel and jeans fabric. Shakhirul *et al*. (2014) showed the detail specification of substrate materials in terms of permittivity, thickness, characteristics and performances. Thus, the aim of this work is to measure and determine the dielectric properties of felt textile in which is used to design and fabricate all-textile based antennas.

MATERIALS AND METHODS

Experimental: An Agilent 85070B high temperature dielectric probe kit was used to determine the dielectric properties of felt used as a substrate in both wearable

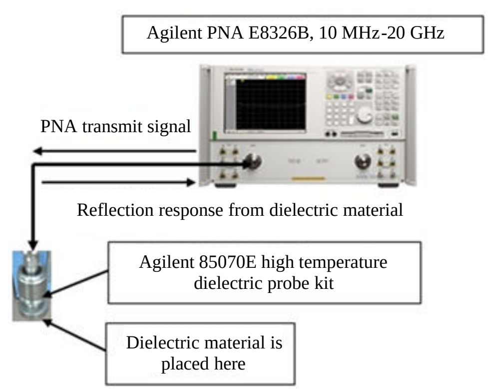

Fig. 1: Dielectric properties measurement setup with Agilent 85070B high temperature dielectric probe kit

textile antenna topologies. The dielectric probe technique is performed by contacting the sample with the probe. In this measurement, setup the Agilent 85070B high temperature dielectric probe an agilent Performance Network Analyzer (PNA) (Model Agilent PNA E8362B) and Agilent 85070 Software were used. Figure 1 shows experimental procedure for using the high temperature probe the probe makes contact with the flat surface of a

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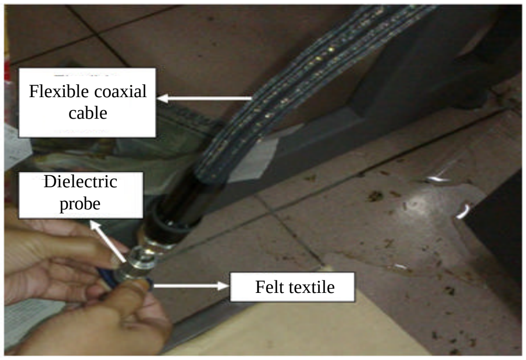

Fig. 2: Measuring the dielectric properties of felt

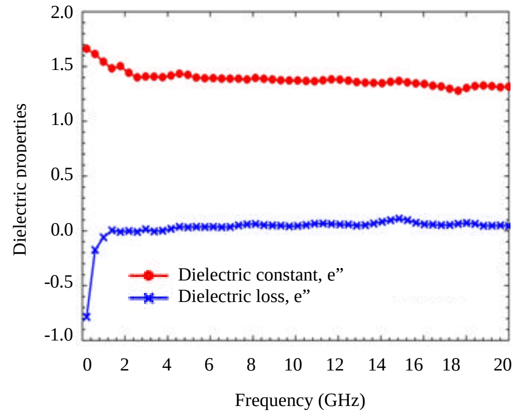

Fig. 3: Dielectric properties of felt textile

solid which in this case was felt. The felt was folded to form three layers of flat surfaces before the dielectric probe was pressed on the layered felt, ensuring the minimum air gap between the layers of felt.

The Agilent 85070 Software, featuring frequency ranges from 200-20 GHz, computes the measured reflected response which consists of the dielectric constant and the dielectric loss of the flat felt. The reflected signal, S11 is measured and then associated with εr. The calibration is conducted prior to using of the high temperature Dielectric Probe kit, involving three components and the software. The components used in the calibration are air a metallic shorting block and water. The water was measured using commercially available natural mineral water (Locher *et al.*, 2006) at a temperature of 25°C. The dielectric constant and loss tangent of the mineral water after the calibration measurement was consistent with. Cylindrically-shaped dielectric material blocks were used in measuring the dielectric properties. Figure 2 shows the measurement of dielectric properties of felt textile material using Agilent flexible coaxial cable.

RESULTS AND DISCUSSION

Five repetitive readings of the dielectric properties were obtained and averaged. Figure 3 shows the dielectric properties, i.e., dielectric constant and dielectric loss) of felt textile. It was observed that a slight decrease in dielectric constant of felt across the frequency range from 200-20 GHz while the dielectric loss of felt remained constant across the frequency range from 2-20 GHz. Furthermore, in order to design the textile-based antenna resonated at 2.45 GHz the felt's dielectric properties are determined at that particular frequency. The Software computes the values of felt's dielectric Ghz. Thus, it was concluded that the dielectric properties of the felt substrate measured at 2.58 GHz essentially was the same as the dielectric properties measured at 2.45 GHz (±0.01).

CONCLUSION

In this research, the measurement of dielectric properties of textile substrate was determined for frequency range from 200-20 GHz. This felt textile is used to design and fabricate the all-textile based antennas. A detailed measurement setup of felt's dielectric properties was described in this study. The results were found to be consistent with the one measured at 2.45 GHz in the open literature.

ACKNOWLEDGEMENT

The researchers appreciate the financial support provided by grants from UniMAP and KPT the Ministry of Higher Education (MOHE) (9001-00016).

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