UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT AND CHARACTERIZATION OF ELECTRO-TEXTILE ANTENNA FOR WEARABLE APPLICATION

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MSc

January 2021

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Nowadays, wearable antennas for body area networks, especially textile-based antennas, have gathered much attention due to being resilient, lightweight, and easily embedded into garments. Wearable antennas are highly in demand to support the Internet of Things (IoT) application, which includes tracking and navigation, mobile computing, public safety, and wireless communication. However, conventional textile-based wearable antennas such as copper tape, copper foil, or copper powder will lead to many related antenna performances. For example, the fabricated antennas can be easily detached from the fabric after being washed or worn many times, causing degradation in antenna performance. Thus, developing a new Self-Manufactured Electro-textile (SME-t) with a more structurally practical conductive fabric was proposed and analyzed in this research work. A rectangular patch wearable antenna fabricated using a SME-t material designed at 1.575 GHz based on the allocated spectrum for Global Positioning System (GPS) application is presented in this research. The SME-t was made up of 0.14mm copper threads as the conductive element and polyester threads as the non-conductive element with the weight ratio of 83:17 respectively using the plain weaving technique. To ensure the textile model's accuracy in the electromagnetic solver, the new textile's characteristics shall be taken into consideration. The dielectric constant, loss tangent, and fabric thickness were measured for the non-conductive element to determine the dielectric properties and electro-textile material's electrical properties. Meanwhile, for the radiating elements, the electrical conductivity was measured and analyzed, accordance to the American Society for Testing and Materials (ASTM) standards. Four design antennas were developed and analyzed to analyze and validate the capability and performance of the SME-t as a radiating element for the wearable antenna. As a reference and for performance comparison, two antennas were developed using established materials such as adhesive copper tape as a radiating element for Design-1 antenna (CPC antenna) and commercial off-the-shelf conductive fabric named SHIELDIT^{TM} as radiating element for Design-2 antenna (SPC antenna). Meanwhile, the Design-3 antenna (EPC antenna) is formed by fabricating the SME-t at the front(patch) and copper tape as the ground, while for the Design-4 antenna (EPE antenna), both sides are using the SME-t. The measured return loss values at the desired resonant frequency for the CPC antenna is -20.75dB with 1.5dB gain, while the measured return loss for the SPS antenna is -15.34dB, with 1.23dB gain. The fabricated EPE antenna gives good return loss performance, which is -17.83 dB at 1.575 GHz resonant frequency with 68MHz bandwidth. However, the frequency is slightly shifted by about 1% to the left due to fabrication and measurement uncertainties. Meanwhile, acceptable antenna gain and efficiency of 0.61 dB, and 25.95% are obtained through measurement. The deformation condition for the electro-textile antenna was conducted by focusing on a wearable implementation. For that reason, the bending effect of the EPE antenna was performed and analyzed for two specific bending angles associated to a 125° arc of radius, which resembles the human upper arm, and 171° for the human wrist. Moreover, the effect of bending on the electro-textile antenna in the H-plane and E-plane have also been simulated, measured and analyzed. Based on the results, both planes give relatively good agreement with return loss values of -16.52 dB and -11.03dB at 1.575GHz for H-plane and E-plane, respectively.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful

All praise to Allah and His blessing for the completion of this thesis. I thank Allah for all the opportunities, trials and strength that have been showered on me to embark on my Master and for completing this long and challenging journey successfully. My humblest gratitude to the Holy Prophet Muhammad (Pbuh) whose way of life has been continuous guidance for me.

First and foremost, I would like to express my deep gratitude to my supervisor, Ir. Dr. Nurul Huda Abd Rahman, for her patient guidance, enthusiastic encouragement and useful critiques of this research work. I would also like to thank Assoc. Prof . Dr. Rozi Ahmad, for his valuable and constructive suggestions during this research work's planning and development. His willingness to give his time so generously has been very much appreciated.

My appreciation goes to the Antenna Research Centre members who provided the facilities and assistance during sampling. Special thanks to my colleagues and friends for helping me with this project.

Finally, my deepest gratitude goes to all my family members. It would not be possible to complete this thesis without support from them. This thesis is dedicated to my very dear father, Hj Amin Nordin Bin Ahmad and my beloved mother, Hjh Zaleha Binti Abdullah, for the vision and determination to educate me. This piece of victory is dedicated to both of you. Alhamdulilah.

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