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WEARABLE ULTRA-WIDE BAND ANTENNA FOR MICROWAVE MEDICAL IMAGING APPLICATIONS

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ABSTRACT

This abstract provides an overview of wearable antenna design, which involves the incorporation of wearable materials with antenna technology to create flexible and wearable antennas. The design process, including material selection, shape, size, and performance evaluation, is discussed. Various wearable antenna designs and potential applications are presented, along with the challenges and future directions for research.

we can monitor the parameters of antenna such as efficiency, bandwidth, radiation pattern, and gain for substrate (Denim).

KEYWORDS: Textile antenna, Ultra-Wideband antenna, Wearable technology, medical imaging.

1. INTRODUCTION

An antenna is an electronic device which converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver.

In transmission, a radio transmitter supplies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of power of electromagnetic wave in order to produce tiny voltage.

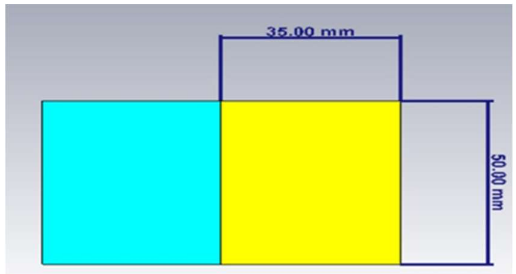
Microwave imaging has been widely employed in medical field to visualize the interior of human bodies and to detect diseases. These diseases may be tumors, bone fractures, brain strokes. Unlike conventional methods such as magnetic resonance imaging (MRI), computed tomography (CT), which suffers the disadvantage of ionized radiation and high cost. Microwave imaging involves transmitting RF signals into the tissues and receiving backscattered signals to reconstruct images of inner- body.

Furthermore, wearable technologies which allow to be worn directly on bodies as these technologies offer many advantages as continuous health monitoring with low energy consumption.

The major advantages of wearable antennas are low cost, low maintenance. Textiles are utilized as substrates. Low relative permittivity(εr) and thin thickness(h) all results in increased antenna performance.

2. LITERATURE REVIEW

After a survey, we have decided to do a project based on wearable ultra-wide band antenna. wearable antenna which uses the Textile materials as a substrate material or conductive material that is part of clothes. Textile materials generally have very low dielectric constant which reduces the surface wave losses and improve the impedance bandwidth of the antenna.



3.METHODOLOGY

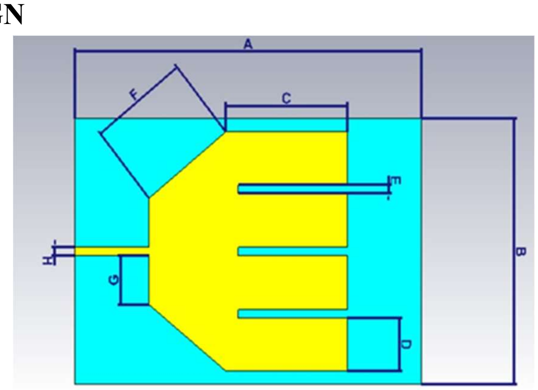
The chosen antenna is textile antenna with 3 parallel slots and 2 triangles are cut in corner edges of substrate to reduce the size of antenna and to get an ultra-wideband frequency.

In the following subsections outlines the antenna design workflow. The design and its optimization before production is part of the scope. The subsections below specify the materials, stages involved in this research project. The design's approach also included the appropriate design.

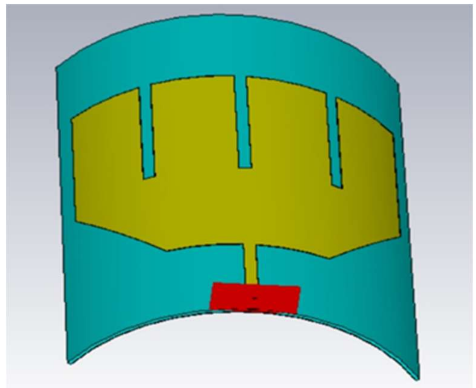
3.1 SELECTION OF SUBSTRATES

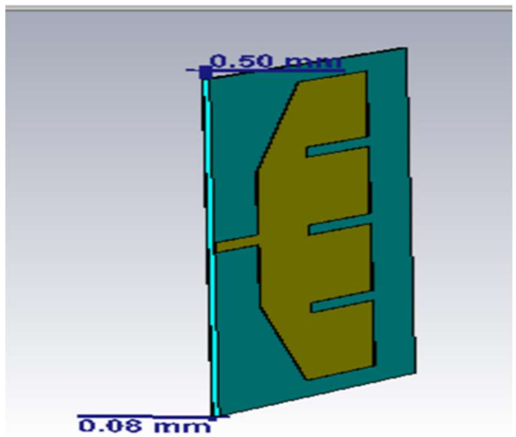
As it is a wearable device the material chosen must offer high flexibility, wide bandwidth, and mechanical resistance. We have used Denim here due to its insulation properties and Its is soft and stretchy. It is a durable material that can withstand wear and tear, making it suitable for use in various applications. Denim has good sound-absorbing properties, making it suitable for use in acoustic applications, such as in recording studios and concert halls.
Overall, the characteristics of Denim substrate make it a versatile material that can be used in various applications, including fashion, construction, and industrial settings.

3.2 ANTENNA DESIGN



Antenna Front view





Antenna Side View

Dimensional notation	Values	Dimensional notation	Values
A	70.00 mm	G	9.25 mm
B	50.00 mm	H	1.5 mm
C	24.50 mm		
D	10.00 mm		
E	1.50 mm		
F	19.91 mm		

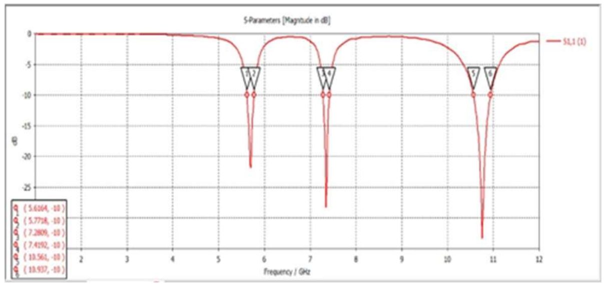
In the design few parallel slots and two triangles are cut at the bottom corners and top edge of the patch to achieve an optimized ultrawideband bandwidth and to reduce size of antenna. This textile antenna has been chosen due to its applications such as it can be operated while wearing the antenna.

3.2 ANTENNA DESIGN AFTER BENDING ANALYSIS:

RADIUS: 25

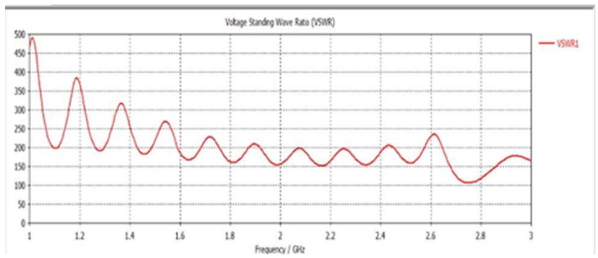
3.3 S11 – PARAMETERS:

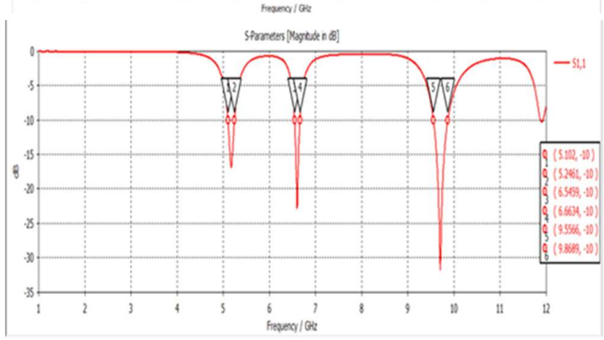
S11 before bending



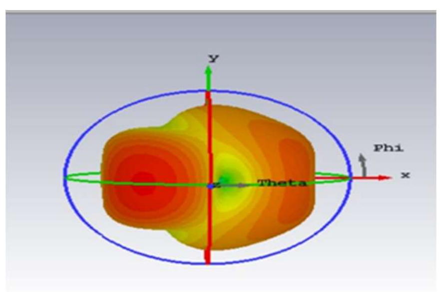
S11 after bending for radius : 25

3.4 VOLTAGE STANDING WAVE RATIO (VSWR):

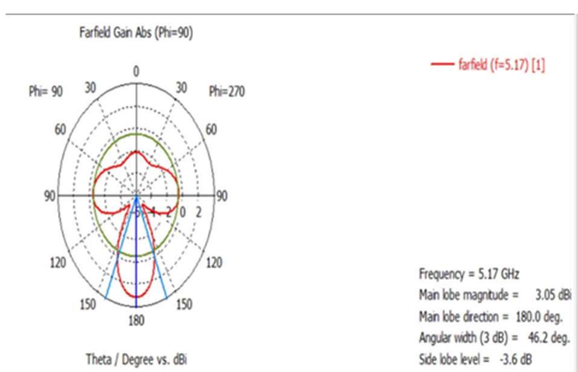




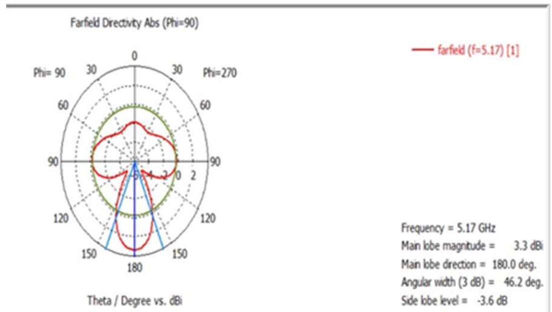
3.6 RADIATION PATTERN:



3.7 GAIN:



3.8 DIRECTIVITY:



CONCLUSION:

This project presents the design of wearable ultra-wide band antenna for microwave medical imaging applications. The proposed antenna is based on monopole structure, where few parallel slots and two triangles are cut at the bottom corners and top edge of the radiation patch; to achieve an optimized ultrawide bandwidth and to reduce size of the antenna. Microwave imaging offers an alternative option to monitor in vivo abnormalities in affordable, fast and non-ionizing manner. This technique involves transmitting radio-frequency (RF) signals into body tissues and receiving the backscattered signals from different locations to reconstruct inner body images. The antenna is used to monitor the recovery process of a bone fracture that is emulated by a body-mimicking phantom with size varying blood strip. The time domain reflection coefficient of the antenna varies significantly with size of the fracture introduced, which demonstrates the applicability of the antenna for such use scenarios in microwave medical imaging.

4. ACKNOWLEDGEMENT:

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5. CONFLICTS OF INTEREST:

The authors have no conflicts of interest to declare.

6. REFERENCES:

- Xiaoyou Lin, Yifan Chen ,Zheng Gong, Boon-Chong Seet, Ling Huang, and Yilong Lu, " Wearable Ultra wide band antenna for microwave medical imaging applications," IEEE Trans. On antenna and propagations. DOI-April19,2019
- R. Chandra, H. Zhou, I. Balasingham, and R. M. Narayanan, "On the opportunities and challenges in microwave medical sensing and imaging," IEEE Trans. Biomed. Eng., vol. 62, no. 7, pp. 1667–1682, 2015.
- B. J. Mohammed, A. M. Abbosh, S. Mustafa, and D. Ireland, "Microwave system for head imaging," IEEE Trans. Instru. Meas., vol. 63, no. 1, pp. 117–123, 2014.
- P. M. Meaney, et al., "Microwave imaging for neoadjuvant chemotherapy monitoring: initial clinical experience," Breast Cancer Res., vol. 15, no. 2, R35, 2013.
- E. C. Fear, X. Li, S. C. Hagness, and M. A. Stuchly, "Confocal microwave imaging for breast cancer detection: localization of tumors in three dimensions," IEEE Trans. Biomed. Eng., vol. 49, no. 8, pp. 812–822, 2002.

- N. Nikolova, Introduction to Microwave Imaging. Cambridge: Cam- bridge University Press, 2017.
- M. Stoppa, and A. Chiolerio, "Wearable electronics and smart textiles: a critical review," Sensors, vol. 14, no. 7, pp. 11957–11992, 2014.
- G. Gao, B. Hu, S. Wang and C. Yang, "Wearable circular ring slot antenna with EBG structure for wireless body area network," IEEE Antennas Wireless Propag. Lett., vol. 17, no. 3, pp. 434–437, 2018.
- T. Liang and Y. J. Yuan, "Wearable medical monitoring systems based on wireless networks: a review," IEEE Sensors J., vol. 16, no. 23, pp. 8186–8199, 2016.
- D. Metcalf, S. T. J. Milliard, M. Gomez and M. Schwartz, "Wearables and the internet of Things for health: wearable, interconnected devices promise more efficient and comprehensive health care," IEEE Pulse, vol. 7, no. 5, pp. 35–39, 2016.
- E. J. Bond, Xu Li, S. C. Hagness and B. D. Van Veen, "Microwave imaging via space-time beamforming for early detection of breast cancer," IEEE Trans. Antennas Propag., vol. 51, no. 8, pp. 1690–1705, 2003.
- S. Mukherjee, L. Udpa, S. Udpa, E. J. Rothwell and Y. Deng, "A time reversal-based microwave imaging system for detection of breast tumors,"IEEE Trans. Microw. Theory Techn., vol. 67, no. 5, pp. 2062–2075, 2019.
- B. J. Mohammed, A. M. Abbosh, S. Mustafa and D. Ireland, "Microwave system for head imaging," IEEE Trans. Instru. Meas., vol. 63, no. 1, pp. 117–123, 2014.
- B. Biswas, R. Ghatak and D. R. Poddar, "A fern fractal leaf inspired wideband antipodal vivaldi antenna for microwave imaging system," IEEE Trans. Antennas Propag., vol. 65, no. 11, pp. 6126–6129, 2017.
- M. N. A. Karim, M. F. Jamlos, S. P. Jack and S. Z. Ibrahim, "Wideband slotted antenna for microwave imaging system in ground penetrating radar applications," 2016 IEEE Int. Symp. Systems Eng., Edinburgh, UK, 2016, pp. 1–5.
- A. T. Mobashsher, K. S. Bialkowski and A. M. Abbosh, "Design of compact cross-fed three-dimensional slot-loaded antenna and its application in wideband head imaging system," IEEE Antennas Wireless Propag. Lett., vol. 15, pp. 1856–1860, 2016.
- S. M. Aguilar, M. A. Al-Joumayly, M. J. Burfeindt, N. Behdad and S. C. Hagness, "Multiband miniaturized patch antennas for a com- pact, shielded microwave breast imaging array," IEEE Trans. Antennas Propag., vol. 62, no. 3, pp. 1221–1231, 2014.
- N. Ojaroudi, M. Ojaroudi and N. Ghadimi, "UWB omnidirectional square monopole antenna for use in circular cylindrical microwave imaging systems," IEEE Antennas Wireless Propag. Lett., vol. 11, pp. 1350–1353, 2012.
- S. Ahdi Rezaeieh, A. Abbosh and Y. Wang, "Wideband unidirectional antenna of folded structure in microwave system for early detection of congestive heart failure," IEEE Trans. Antennas Propag., vol. 62, no. 10, pp. 5375–5381, 2014.
- A. S. M. Alqadami, K. S. Bialkowski, A. T. Mobashsher and A. M. Abbosh, "Wearable electromagnetic head imaging system using flexible wideband antenna array based on polymer technology for brain stroke diagnosis," IEEE Trans. Biomed. Circuits Syst., vol. 13, no. 1, pp. 124–134, 2019.

- E. Porter, H. Bahrami, A. Santorelli, B. Gosselin, L. A. Rusch and M. Popovic´, “A wearable microwave antenna array for time-domain breast tumor screening,” IEEE Trans. Med. Imag., vol. 35, no. 6, pp. 1501–1509, 2016.
- H. Bahramiabarghouei, E. Porter, A. Santorelli, B. Gosselin, M. Popovic´, L. A. Rusch, “Flexible 16 antenna array for microwave breast cancer detection”, IEEE Trans. Biomed. Eng., vol. 62, no. 10, pp. 2516–2525, 2015.
- P. J. Soh et al., “A smart wearable textile array system for biomedical telemetry applications,” IEEE Trans. Microw. Theory Techn., vol. 61, no. 5, pp. 2253-2261, 2013.
- A. Kiourti and J. L. Volakis, “Wearable antennas using electronic textiles for RF communications and medical monitoring,” 2016 10th Euro. Conf. Ant. Propag. (EuCAP), Davos, Switzerland, 2016, pp. 1–2.
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