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DUAL-BAND TWO PORT TEXTILE ANTENNA FOR MIMO AND SIMULTANEOUS WIRELESS INFORMATION AND POWER TRANSFER (SWIPT) APPLICATIONS

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ABSTRACT

This abstract provides an overview of textile antenna design, which involves the incorporation of textile materials with antenna technology to create flexible and wearable antennas. The design process, including material selection, shape, size, and performance evaluation, is discussed. Various textile 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 (felt).

KEYWORDS: Antennas, e-textiles, multi-in multi-out (MIMO), wearable antennas, linear polarization, Proxmity feeding.

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.

Owing to the mobility of a wearable antenna and the unpredictable body-centric communications environment, dual-polarization antennas are essential for both communications and energy harvesting. The proposed antenna utilizes dual ports for both off-body communication and energy harvesting from horizontal and vertical polarizations. In Internet of Things (IOT) networks, the power required by the sensors to communicate with the peripherals is provided by the energy harvesting. It transmits single or multiple wave forms carrying both information and power to wireless “edge” nodes. As the proposed antenna is aimed at wearable applications, the specific absorption rate (SAR) of the transmitter port will be simulated. Based on the proposed antenna’s performance, SWIPT antennas can be adopted

for MIMO applications, significantly reducing the complexity of future battery-free networks for both wearable and non-wearable applications.

2. LITERATURE REVIEW

After a survey, we have decided to do a project based on textile antenna. Textile Antenna which uses the Textile materials are used 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 two ports which helps in simultaneous power and information transfer. As of now the designed antenna is operated in at 1.6 Ghz and 2.8 GHz respectively. The substrate used is felt.

The feeding mechanism involved in this design is proximity feed for both the ports. There is port isolation between the orthogonally placed feeds.

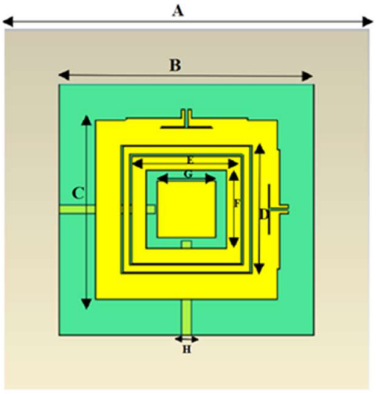
The textile antenna has been chosen due to its applications such as it can be operated while wearing the antenna. As the substrate used is textile, the is no need to worry about the breaking of antenna and it's durable and rigid.

3.1 SELECTION OF SUBSTRATES

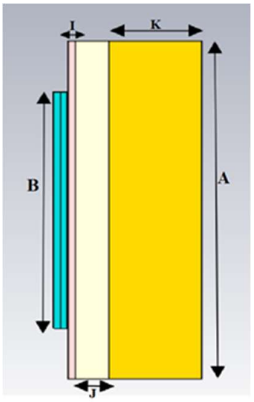
The conductivity compares favorably against inkjet printed antennas on Textiles and is easier to apply to various substrates. We have used felt here due to its insulating properties and its water repellent and Its is soft and flexible. It is a durable material that can withstand wear and tear, making it suitable for use in various applications. Felt 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 felt 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

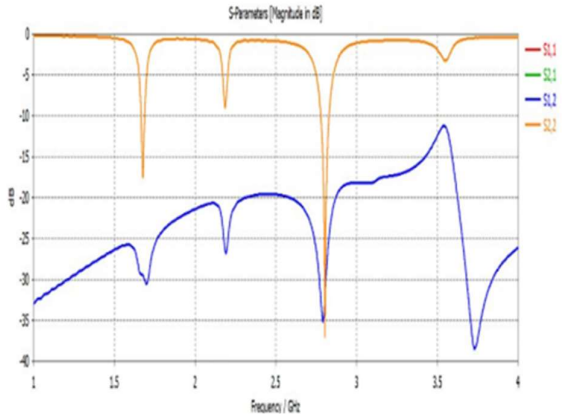


Antenna Side View

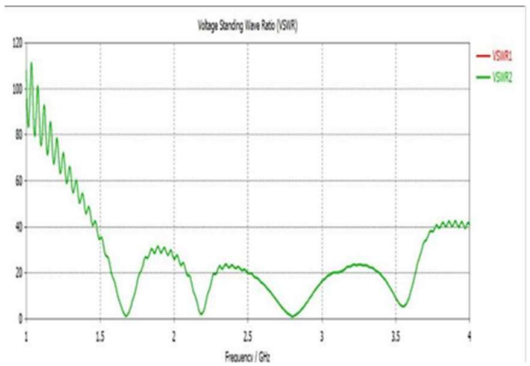
Dimensionalnotation	Values	Dimensional notation	Values
A	100.0 mm	G	16.0 mm
B	70.0 mm	H	2.5 mm
C	50.0 mm	I (Skin)	2.0 mm
D	35.0 mm	J (Fat)	8.0 mm
E	30.0 mm	K (Muscle)	23.0 mm
F	22.0 mm		

The chosen antenna is Textile antenna with two ports which helps in simultaneous power and information transfer. The feeding mechanism involved in this design is Proxmity feeding. This textile antenna has been chosen due to its applications such as it can be operated while wearing the antenna.

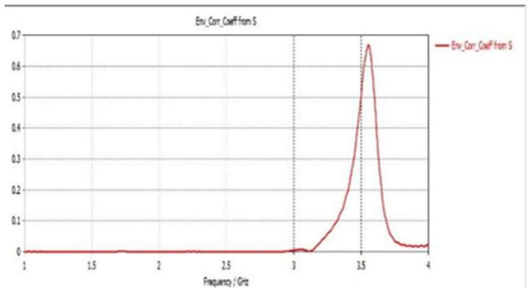
3.3 S – PARAMETERS:



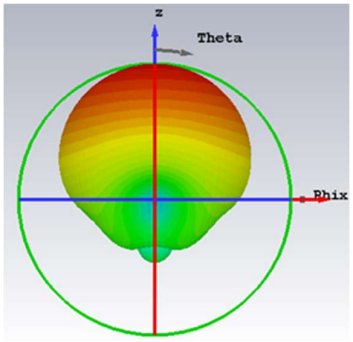
3.4 VOLTAGE STANDING WAVE RATIO (VSWR):



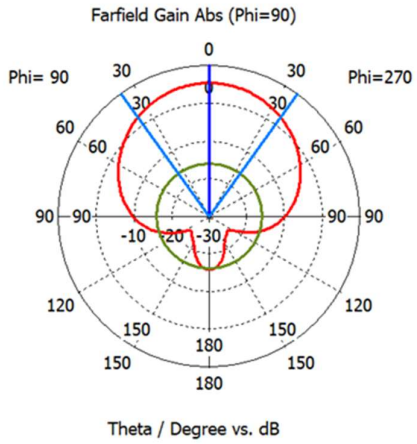
3.5 ENVELOPE CORRELATION COFFICIENT (ECC):



3.6 RADIATION PATTERN:

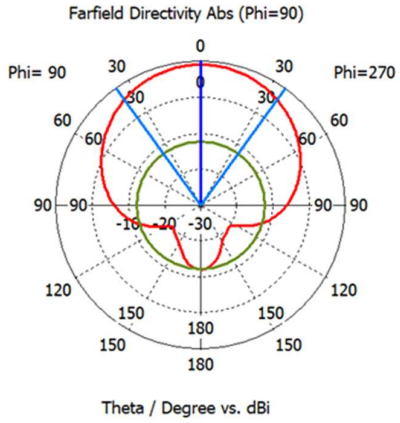


3.7 GAIN:



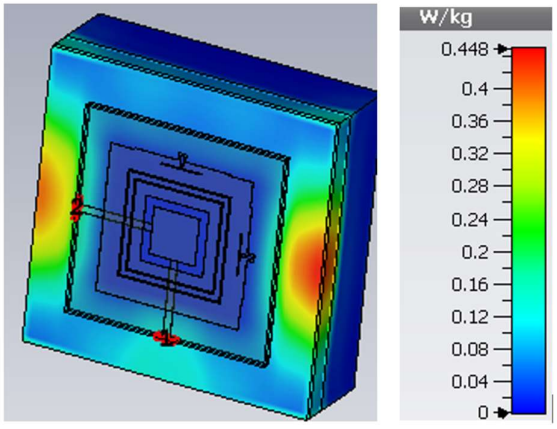
Frequency = 2.803 GHz
Main lobe magnitude = 5.35 dB
Main lobe direction = 0.0 deg.
Angular width (3 dB) = 71.4 deg.
Side lobe level = -21.3 dB

3.8 DIRECTIVITY:

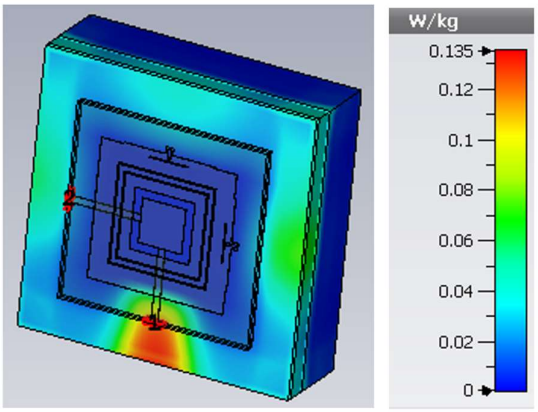


Frequency = 2.803 GHz
Main lobe magnitude = 9.09 dBi
Main lobe direction = 0.0 deg.
Angular width (3 dB) = 71.4 deg.
Side lobe level = -21.3 dB

3.9 SPECIFIC ABSORBTION RATE (SAR):



SAR= 0.448 w/kg at Frequency= 1.675 GHz



SAR =0.135 w/kg at Frequency= 2.803 GHz

CONCLUSION:

In this paper, a dual-band two-port textile antenna has been proposed for SWIPT applications in MIMO The first antenna designed for simultaneously harvesting power and communicating over two orthogonal polarization. Owing to the hybrid feeding approach using proximity coupling for the 50 dB as base impedance. The antenna maintains at least 10 dB port isolation for all ports in both small and large-signal measurements, and up to 37 dB isolation between the communications ports. The antenna achieves 30 MHz bandwidth around 1.6 GHz and it achieves 60 MHz bandwidth around 2.8 GHz and maintains an S11 < −10 dB while conforming to different body parts as well as when used in proximity with other wearable.

The antenna maintains a simulated gain around 5 dBi, inclusive of mutual coupling and a directivity around 9 dBi. For off-body communications, the proposed antenna compares favorably with reported dual-band wearable antennas.

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5. CONFLICTS OF INTEREST:

The authors have no conflicts of interest to declare.

6. REFERENCES:

1. T. D. P. Perera, D. N. K. Jayakody, S. K. Sharma, S. Chatzinotas,and J. Li, “Simultaneous wireless information and power transfer (SWIPT): Recent advances and future challenges,” IEEE Commun. Surveys Tuts., vol. 20, no. 1, pp. 264–302, 1st Quart., 2018.

2. Z. Hu, C. Yuan, and F. Gao, “Maximizing harvested energy for full-duplex swipt system with power splitting,” IEEE Access, vol. 5,pp. 24975–24987, 2017.

3. M. Wagih, A. S. Weddell, and S. Beeby, “Omnidirectional dual-polarized low-profile textile rectenna with over 5% efficiency for Sub-µW/cm2 wearable power harvesting,” IEEE Trans. Antennas Propag., vol. 69, no. 5, pp. 2522–2536, May 2021.

4. G. Monti, L. Corchia, and L. Tarricone, “UHF wearable rectennaon textile materials,” IEEE Trans. Antennas. Propag., vol. 61, no. 7,pp. 3869–3873, Jul. 2013.

5. S.-E. Adami et al., "A flexible 2.45-GHz power harvesting wristband with net system output from −24.3 dBm of RF power," IEEE Trans.Microw. Theory Techn., vol. 66 no. 1, pp. 380–395, Jan. 2018.
6. D. Vital, S. Bhardwaj, and J. L. Volakis, "Textile based large area RF-power harvesting system for wearable applications," IEEE Trans.Antennas Propag., vol. 68, no. 3, pp. 2323–2331, Mar. 2020.
7. J. A. Estrada et al., "An RF-harvesting tightly-coupled rectenna array tee-shirt with greater than octave bandwidth," IEEE Trans. Microw. Theory Techn., vol. 68 no. 9, pp. 3908–3919, Sep. 2020.
8. M. Wagih, N. Hillier, S. Yong, A. S. Weddell, and S. Beeby, "RF-powered wearable energy harvesting and storage module based on E-textile coplanar waveguide rectenna and supercapacitor," IEEE Open J. Antennas Propag., vol. 2, pp. 302–314, 2021.
9. M. Wagih, G. S. Hilton, A. S. Weddell, and S. Beeby, "Broadband millimetre- wave textile-based flexible rectenna for wearable energy harvesting," IEEE Trans. Microw Theory Techn., vol. 68 no. 11,pp. 4960–4972, Nov. 2020.
10. M. Wagih, O. Cetinkaya, B. Zaghari, A. S. Weddell, and S. Beeby, "Real-world performance of sub-1 GHz and 2.4 GHz textile anten-nas for RF-powered body area networks," IEEE Access, vol. 8,pp. 133746–133756, 2020.
11. C.-X. Mao, D. Vital, D. H. Werner, Y. Wu, and S. Bhardwaj, "Dual-polarized embroidered textile armband antenna array with omni-directional radiation for on-/off-body wearable applications," IEEE Trans. Antennas Propag., vol. 68 no. 4, pp. 2575–2584, Apr. 2020.
12. M. K. Magill, G. A. Conway, and W. G. Scanlon, "Circularly polarized dual-mode wearable implant repeater antenna with enhanced into-body gain," IEEE Trans. Antennas Propag., vol. 68 no. 5, pp. 3515–3524,May 2020.
13. C. X. Mao, Y. Zhou, Y. Wu, H. Soewardiman, D. H. Werner, and J. S. Jur, "Low-profile strip-loaded textile antenna with enhanced bandwidth and isolation for full-duplex wearable applications," IEEE Trans. Antennas Propag., vol. 68 no. 9, pp. 6527–6537, Sep. 2020.
14. H. Li, S. Sun, B. Wang, and F. Wu, "Design of compact single-.layer textile MIMO antenna for wearable applications," IEEE Trans.Antennas Propag., vol. 66, no. 6, pp. 3136–3141, Jun. 2018.
15. S. Yan, P. J. Soh, and G. A. E. Vandenbosch, "Dual-band textile MIMO antenna based on substrate-integrated waveguide (SIW) technology, "IEEE Trans. Antennas Propag., vol. 63, no. 11, pp. 4640–4647,Nov. 2015.
16. D. Wen, Y. Hao, M. O. Munoz, H. Wang, and H. Zhou, "A compact and low-profile MIMO antenna using a miniature circular high-impedance surface for wearable applications," IEEE Trans. Antennas Propag. ,vol. 66, no. 1, pp. 96–104, Jan. 2018.
17. A. Iqbal, A. Smida, A. J. Alazemi, M. I. Waly, N. K. Mallat,and S.Kim,"Wideband circularly polarized MIMO antenna for high data wearable biotelemetric devices," IEEE Access, vol. 8,pp. 17935–17944, 2020.

18. M. Wagih, G. S. Hilton, A. S. Weddell, and S. Beeby, "Dual-band dual-mode textile antenna/rectenna for simultaneous wireless information and power transfer (SWIPT)," IEEE Trans. Antennas Propag., early access, Apr. 6, 2021, doi: 10.1109/TAP.2021.3070230.
19. J. Bito, R. Bahr, J. G. Hester, S. A. Nauroze, A. Georgiadis, and M. M. Tentzeris, "A novel solar and electromagnetic energy harvesting system with a 3-D printed package for energy efficient Internet-of-Things wireless sensors," IEEE Trans. Microw. Theory Techn., vol. 65 no. 5, pp. 1831–1842, May 2017.
20. A. E. Abdulhadi and R. Abhari, "Multiport UHF RFID-tag antenna forenhanced energy harvesting of self-powered wireless sensors," IEEE Trans. Ind. Informat., vol. 12, no. 2, pp. 801–808, Apr. 2016.
21. P. Lu, X.-S. Yang, and B.-Z. Wang, "A two-channel frequency reconfigurable rectenna for microwave power transmission and data communication," IEEE Trans. Antennas Propag., vol. 65 no. 12,pp. 6976–6985, Dec. 2017.
22. P. Lu, C. Song, and K. M. Huang, "A two-port multi-polarization rectenna with orthogonal hybrid coupler for simultaneous wireless information and power transfer (SWIPT)," IEEE Trans. Antennas Propag., vol. 68 no. 10, pp. 6893–6905, Oct. 2020.
23. K. Dautov, M. Hashmi, G. Nauryzbayev, N. Nasimuddin, and M. A. Chaudhary, "Compact multi-frequency system design for swipt applications," Int. J. RF Microw. Comput.-Aided Eng., vol. 31, no. 6,2021, Art. no. e22632.
24. M. Wagih, G. S. Hilton, A. S. Weddell, and S. Beeby, "2.4 GHz wearable textile antenna/rectenna for simultaneous information and power transfer," in Proc. 15th Eur. Conf. Antennas Propag., 2021,pp. 1–5.
25. K. Turbic, L. M. Correia, and M. Beko, "A channel model for polarized off-body communications with dynamic users," IEEE Trans. Antennas Propag., vol. 67 no. 11, pp. 7001–7013, Nov. 2019.
26. M. Wagih, A. S. Weddell, and S. Beeby, "Rectennas for RF energy harvesting and wireless power transfer: A review of antenna design [antenna applications corner]," IEEE Antennas Propag. Mag., vol. 62 no. 5, pp. 95–107, Oct. 2020.
27. K. R. Jha, Z. A. P. Jibran, C. Singh, and S. K. Sharma, "4-port MIMO antenna using common radiator on a flexible substrate for sub-1GHz, sub-6GHz 5G NR and Wi-Fi 6 applications," IEEE Open J. Antennas Propag., vol. 2, pp. 689–701, 2021.
28. C. Song, Y. Huang, P. Carter, J. Zhou, S. D. Joseph, and G. Li,"Novel compact and broadband frequency-selectable rectennas for a wide input-power and load impedance range," IEEE Trans. Antennas Propag., vol. 66, no. 7, pp. 3306–3316, Jul. 2018.
29. H. Sun and W. Geyi,"A new rectenna with all-polarization-receiving capability for wireless power transmission," IEEE Antennas Wireless Propag. Lett., vol. 15,pp. 814–817, 2015.
30. N. Ginzberg, D. Regev, G. Tsodik, S. Shilo, D. Ezri, and E. Cohen,"A full-duplex quadrature balanced RF front end with digital pre-PA self-interference cancellation," IEEE Trans. Microw. Theory Techn.,vol. 67, no. 12, pp. 5257–5267, Dec. 2019.
31. C. Song et al., "Matching network elimination in broadband rectennas for high-efficiency wireless power transfer and energy harvesting,"IEEE Trans. Ind. Electron., vol. 64, no. 5, pp. 3950–3961, May 2017.

32. J. W. Massey and A. E. Yilmaz, "AustinMan and austinwoman: High-fidelity, anatomical voxel models developed from the VHP color images," in Proc. 38th Annu. Int. Conf. Eng. Med. Biol. Soc. (EMBC), 2016, pp. 3346–3349.
33. H. Sun, Y.-X. Guo, M. He, and Z. Zhong, "Design of a high-efficiency 2.45-GHz rectenna for low-input-power energy harvesting,"IEEE Antennas Wireless Propag. Lett., vol. 11, pp. 929–932, 2012.
34. M. Wagih, A. S. Weddell, and S. Beeby, "High-efficiency sub-1 GHz flexible compact rectenna based on parametric antenna-rectifier co-design," in Proc. IEEE/MTT-S Int. Microw. Symp. (IMS), 2020,pp. 1066–1069.
35. W. G. Whittow et al., "Inkjet-printed microstrip patch antennas real-ized on textile for wearable applications," IEEE Antennas Wireless Propag. Lett., vol. 13, pp. 71–74, 2014.
36. N. Chahat, M. Zhadobov, S. A. Muhammad, L. L. Coq, and R. Sauleau, "60-GHz textile antenna array for body-centric communications," IEEE Trans. Antennas Propag., vol. 61, no. 4,pp. 1816–1824, Apr. 2013.
37. M. Ur-Rehman, N. A. Malik, X. Yang, Q. H. Abbasi, Z. Zhang, and N. Zhao, "A low profile antenna for millimeter-wave body-centric applications," IEEE Trans. Antennas Propag., vol. 65 no. 12,pp. 6329–6337, Dec. 2017.
38. M. Wagih, Y. Wei, A. Komolafe, R. Torah, and S. Beeby, "Reliable UHF long-range textile-integrated RFID tag based on a compact flexible antenna filament," Sensors, vol. 20, no. 12, p. 3435, 2020.
39. L. Vallozzi, H. Rogier, and C. Hertleer, "Dual polarized textile patch antenna for integration into protective garments," IEEE Antennas Wireless Propag. Lett., vol. 7, pp. 440–443, 2008.
40. M. W. Abdullah, X. Fafoutis, M. Klemm, and G. S. Hilton, "Radiation pattern analysis of single and multi-antenna wearable systems," in Proc. IEEE 84th Veh. Technol. Conf. (VTC-Fall), 2016, pp. 1–5.
41. D. L. Paul, H. Giddens, M. G. Paterson, G. S. Hilton, and J. P. McGeehan, "Impact of body and clothing on a wearable textile dual band antenna at digital television and wireless communications bands," IEEE Trans. Antennas Propag., vol. 61 no. 4, pp. 2188–2194,Apr. 2013.
42. K. D. Palmer and M. W. van Rooyen, "Simple broadband measure-ments of balanced loads using a network analyzer," IEEE Trans. Instrum. Meas., vol. 55, no. 1, pp. 266–272, Feb. 2006.
43. T. Q. V. Hoang, E. Séguenot, F. Ferrero, J.-L. Dubard, P. Brachat, and J.-L. Desvilles, "3D voltage pattern measurement of a 2.45 GHz rectenna," IEEE Trans. Antennas Propag., vol. 61, no. 6,pp. 3354–3356, Jun. 2013.
44. A. Eid, J. Hester, and M. M. Tentzeris, "A scalable high-gain and large-beamwidth mm-Wave harvesting approach for 5G-powered IoT,"in Proc. IEEE MTT-S Int. Microw. Symp. (IMS), 2019, pp. 1309–1312.
45. H. Sun, H. He, and J. Huang, "Polarization-insensitive rectenna arrays with different power combining strategies," IEEE Antennas Wireless Propag. Lett., vol. 19, no. 3, pp. 492–496, Mar. 2020.