Design of Embroidery Antenna for Wearable Applications

P. Ramya[a], J. Abinaya[b], S.R. HariniPreethi[c], P. Sritha[d], G.M. Abinaya[e] and S.G. Bharathiprabha[f]
[a] Assistant professor, Department of ECE, Bannari Amman Institute of Technology, Erode, Tamilnadu.
[b]UG Scholar, Department of ECE, Bannari Amman Institute of Technology, Erode, Tamilnadu.
[c]UG Scholar, Department of ECE, Bannari Amman Institute of Technology, Erode, Tamilnadu.
[d]Assistant professor, Department of EEE, Bannari Amman Institute of Technology, Erode, Tamilnadu.
[e]UG Scholar, Department of ECE, Bannari Amman Institute of Technology, Erode, Tamilnadu.
[f]UG Scholar, Department of ECE, Bannari Amman Institute of Technology, Erode, Tamilnadu.

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Abstract: The rapid growth of wearable devices has augmented the requirement for body centric wireless communication. In addition to this, to reduce the size of the device and its power consumption, it is also significant to develop a flexible antenna's that may be incorporated for wearable applications. This paper presents the primary development of the wearable embroidery textile antenna for the wireless body area networks. The operating centre frequency (fc) of this wearable embroidery textile antenna is 2.40 GHz. Textile materials are used as the substrates as it has low relative permittivity and dielectric constant. A strip lines made up of conductive materials is used as radiating element. The nylon material used as a substrate material with a relative permittivity of 1.7 .The size of the antenna is very thin .The properties were analyzed for the proposed antenna.

Keywords: Body Centric, Wireless Body Area Network, Wearable Antenna, Embroidery, Micro Strip Patch Antenna

1. Introduction

Wearable embroidery textile antennas will play a vital role in the upcoming electronic world. The wearable embroidery textile antennas have huge applications in medical applications. It can be used for short-distance communication with high-speed data and low power consumption for continuous real-time monitoring of psychological patients data (Heo et al., 2018); (Karimiyan-Mohammadabadi et al., 2017). The well being and trustworthiness is the necessity thing in wearable textile antennas. Estimation of the conductivity of a conductive thread, the dielectric property of a nylon substrate, and enhancement of the fabrication techniques are the most important things to increase the wearable textile antenna performance (Salvado et al., 2012). In order to increase the antenna bandwidth substrate materials which has high dielectric constant (εr) is used. Embroidery design has immense power in wearable textile applications because they are low weight, easy to carry, profitable, and accessible to incorporate with substrate materials (Tsolis et al., 2014); (Kaufmann et al., 2013); (Ginestet et al., 2016). Wearable embroidery textile antennas have to potential to act in different environments and in twisting situations. In field of wearable

Innovation one testing improvement is wearable textile antennas. Essential necessity for wearable textile antennas is adaptable development materials which incorporates texture with planar design. Properties of the material receiving wire like transfer speed; efficiency, input impedance and so forth rely on sort of substrate materials utilized. These properties are generallydictated by the substrate dielectric constant (Locher et al., 2006). Texture material dielectric consistent exact worthis to be determined from full recurrence of fix reception apparatus. In this paper, rectangular micro strip fix receiving wire with various materials like cotton, polyester, nylon, and nylons with various dielectric properties is plan numerically and recreated utilizing ADS software. Its impacts on reception apparatus boundaries are explored for planning of material receiving wire with great productivity. This paper tends to the plan, recreation, producing, and exploratory trial of wearable textile antenna. The proposed dipoles are planned to work at the 2.40 GHz modern logical and clinical radio band for remote body region network applications. The effect and reasonability of these embroidery strategies over the dipole execution in cotton and felt material substrates are accounted for. Test outcomes affirm remarkable reception apparatus boundary brings about terms of return loss, radiation design, gain, and efficiency.

2. Literature Survey

U Slotted Wide Band Wearable Patch Antenna for WBAN Applications by Sharma & Tipathy, (2020)

The suggested technique involves the design of U Slotted Wide Band Wearable Patch Antenna for WBAN Applications by using PTFE material as a substrate with a dielectric constant of 2.1. The frequency range of the proposed method is 5.4 GHz. The shape and return loss obtained by using this technique is U – shape and -30 dB respectively."Wearable Antenna for Wireless Applications" by Dimri et al., (2018). The suggested technique involves the design of rectangle shaped wearable antenna for wireless Applications by using ROGERS R04232 material as a substrate with a dielectric constant of 3.41. The frequency range of the proposed method is 5.3 GHz.

The shape and return loss obtained by using this technique is rectangle shape and -16.0295 dB respectively."Compact printed antenna with h-shaped stub for dual-band operation" by Hu et al., (2010). The suggested technique involves the design of the compact printed antenna with h-shaped stub for dual-band operation.

The frequency range of the proposed method is from 2.36 –4.53 GHz. The shape and return loss obtained by using this technique is H – shape and -10 dBrespectively. "Compact Dual Band Printed 2.5-Shaped Monopole Antenna for WLAN Applications" by Papantonis & Episkopou, (2011). The suggested technique involves the design of the Compact Dual Band Printed 2.5- Shaped Monopole Antenna for WLAN Applications. The frequency range of the proposed method is from 2.4 GHz. The shape obtained by using this technique is 2.5."Wearable Textile Half-Mode Substrate-Integrated Cavity Antenna Using Embroidered Vias" by Kaufmann & Fumeaux, (2013)**.** The suggested technique involves the design of half-mode substrate integrated cavity which has a centre frequency around 5GHz. The gain obtained by using this technique is 7.2 dB.

3. Antenna Design and Dimensions

The Embroidery antenna layout is designed using advanced design system software. Embroidery antenna is also an eco-friendly way to reduce the metallic waste from traditional antennas. The Embroidery antennas are more stretchable than the metallic antennas. Figure 3.1 depicts the layout of our wearable embroidery textile antenna. Here the embroidery is done using a Conductive Copper thread in the substrate (Textile Material). Figure 3.2. depicts the antenna dimensions.

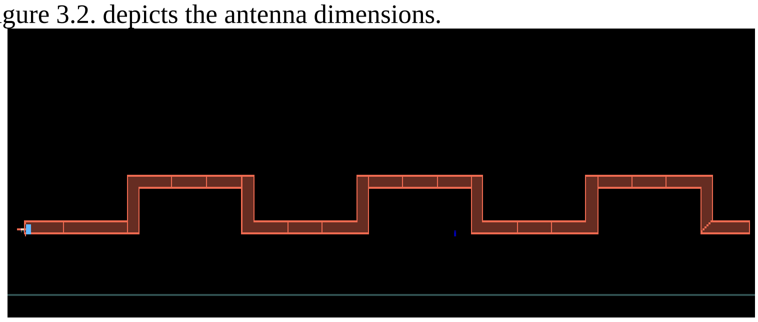

Figure 3.1. Antenna Design

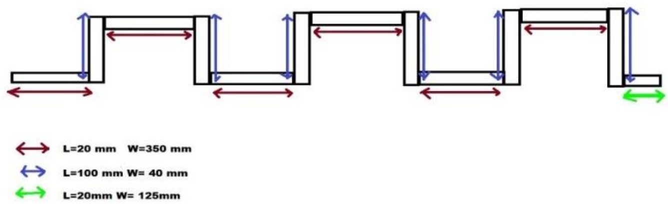

Figure 3.2. Antenna Dimension

4. Results and Discussion

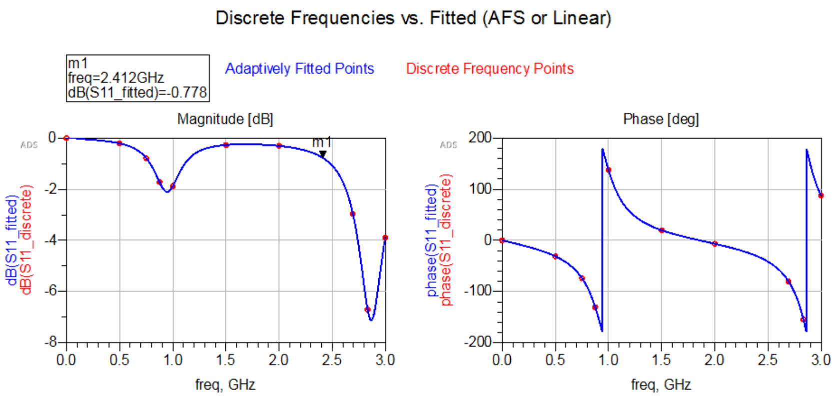

Figure 4.1. Reflection Coefficient for Jeans

Figure 4.1 shows the simulated reflection coefficient graph for jeans substrate. Here we obtained 2.8 GHz as a centre frequency which is greater than the operational centre frequency. The S11 value for the jeans substrate is -7 which is not suitable for good antenna performance.

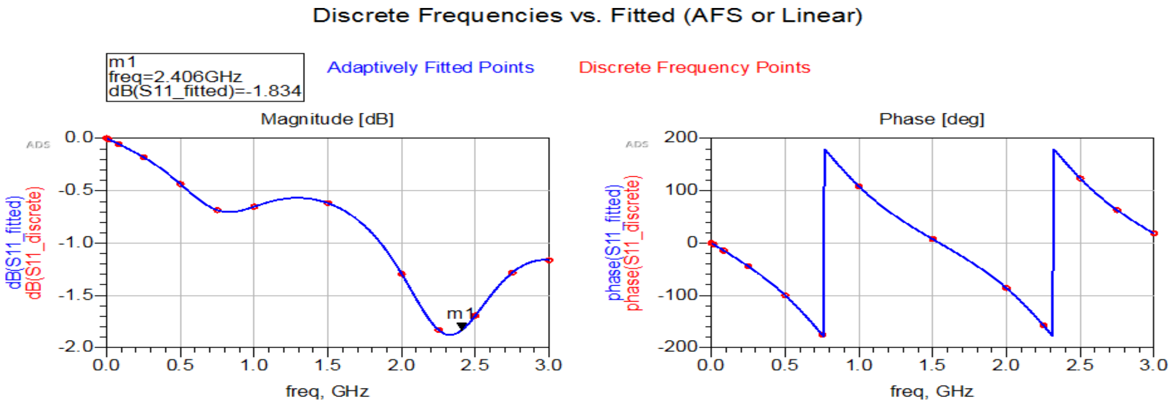

Figure 4.2. Reflection Coefficient for Cotton

Figure 4.2 shows the simulated reflection coefficient graph for cotton substrate. Here we obtained 2.406 GHz as a centre frequency which is equal to the operational centre frequency. Butthe S11 value for the jeans substrate is -1.834 which is not suitable for good antenna performance.

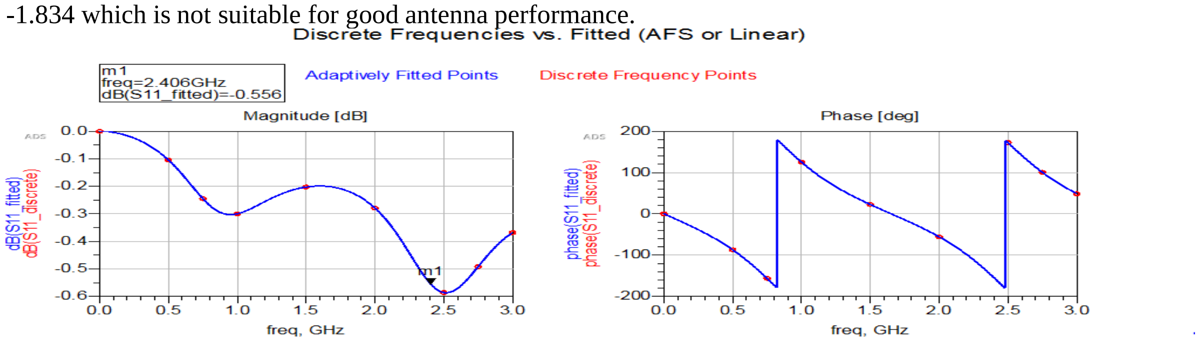

Figure 4.3. Reflection Coefficient for Polyester

Figure 4.3 shows the simulated reflection coefficient graph for cotton substrate. Here we obtained 2.5 GHz as a centre frequency which is equal to the operational centre frequency. But the S11 value for the jeans substrate is -0.6 which is not suitable for good antenna performance.

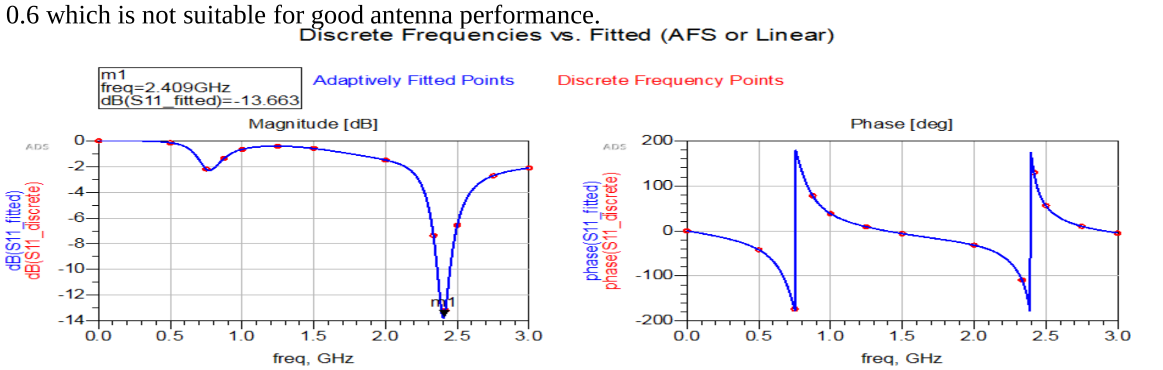

Fig 4.4. Reflection Coefficient for Nylon

Figure 4.4 shows the simulated reflection coefficient graph for cotton substrate. Here we obtained 2.409 GHz as a centre frequency which is equal to the operational centre frequency. The good antenna should achieve S11 value lower than -10 dB. Figure 4.5 shows the S11 value for various substrate among them the return loss for jeans substrate is -13.663dB which is highly suitable for good antenna performance.

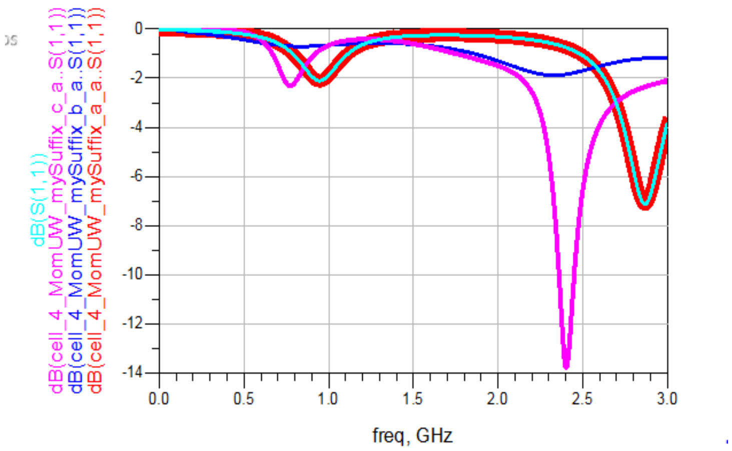

Figure 4.5. Comparison Results of the Substrates

Table 4.1. Comparative Results of Different Substrates

FABRIC MATERIAL	Ɛr	LOSS TANGENT δ	S11	CENTRE FREQUENCY fc
Nylon	4.0 – 5.0	1.2E-2	-13.663	2.409
Jeans	1.60	0.085	-7	2.8
Cotton	1.60	0.0400	-1.834	2.406
Polyester	1.90	0.0045	-0.6	2.5

The table 4.1 describes the relative permittivity, loss tangent, return loss, and centrefrequency for different textile materials like nylon, jeans, cotton, and polyester. By analyzing the reflection coefficient graphs and comparative results of different substrates we conclude that nylon is best substrate textile materials compared to jeans, cotton, and polyester. The following figures show the antenna parameters, and radiation pattern respectively.

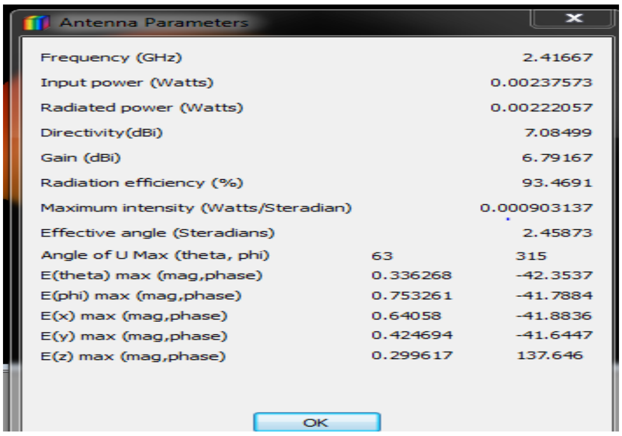

Figure 4.6. Antenna Parameters

Frequency	E_max	Theta_max	Phi_max	Directivity_max	Gain_max	RadiatedPower	InputPower	Efficiency	CutType	CutAngle
2.417E9	0.825	63.000	315.000	7.085	6.792	0.002	0.002	0.935	Phi	0.000

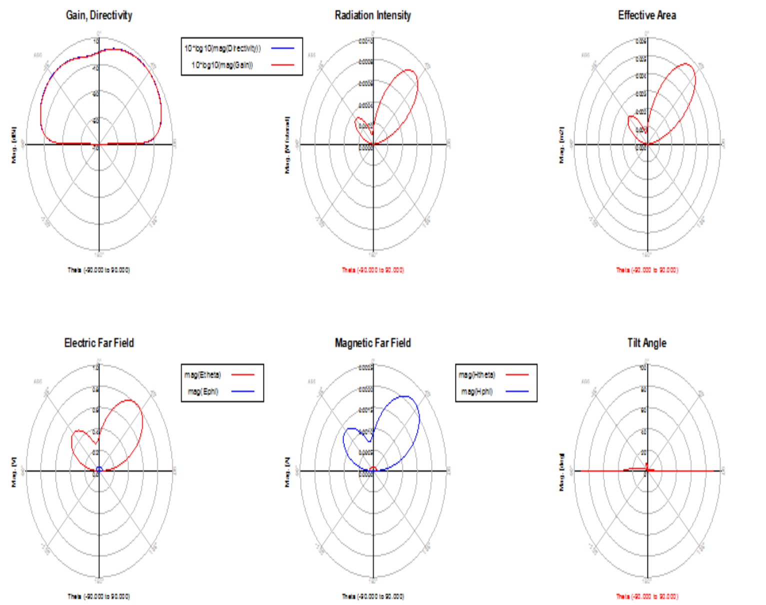

Figure 4.7. 2D View of Antenna Paramaters

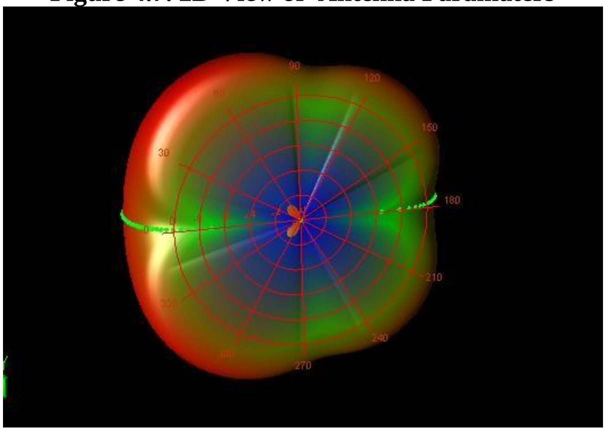

Figure 4.8. 3D Radiation Pattern

Figure 4.6 gives the various antenna parameters such as Frequency, Input power, Radiated power, Gain etc., obtained from simulating the designed antenna. figure 4.7 and figure 4.8 shows the 2D view of the antenna parameter and 3D radiation pattern of designed antenna respectively. The Radiation pattern refers to the directional dependence of the strength of the radio waves from the antenna to the other sources.

5. Conclusion

Wearable antenna for wireless body area network applications is designed and analyzed in this paper. The proposed antenna is compact compared to the existing antennas. The designed antenna has given good result in all the properties. It is clear from the above analysis that the wearable embroidery textile antenna can be made using our real time textile materials with low weight, easy to carry, profitable, and accessible to incorporate with substrate materials. As the value of relative permittivity changes the bandwidth of the respective substrates is also varied. The drawback of the wearable embroidery textile antenna is evaluated significantly. İn this paper the wearable embroidery textile antenna have been designed and simulated to analyze its radiation and impedance characteristics. Therefore it might be terminated that these wearable embroidery textile antenna change substrates on PCB for different applications one day. These wearable antennas must be droppable as the fabrics can take diverse shapes because of human body movements.

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