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# Embroidery Leaf Shape Dipole Antenna Performances and Characterisation

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**ABSTRACT**

In this paper, leaf shape textile antenna in ISM band has been chosen to study. The operating frequency of the dipole antenna is 2.45GHz. The effect of conductive threads with three different types of sewing has been analysed. The first type of sewing leaf shape dipole antenna is to stitch around itself and embroidered into a fleece fabric with circular follow by vertical and horizontal stitch respectively. From measured return loss, the antenna with circular stitch shows better performances with optimum resonances compared with the two types of stitching. The measured results confirm that the circular stitch is more suitable for leaf shape dipole antenna design. Thus it can be concluded that different stitch gives different results for leaf shape dipole antenna.



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## 1. INTRODUCTION

Wearable antenna technology has attracted a lot of attention recently, the demand for lighter and personal electronic devices which are compact, robust, portable, cost-effective and easy to use pushed industries to consistently producing these smart devices. To meet these requirements, fabric-based antenna is one of the promising options. Wearable antenna with copper foil attached to fabric substrate has studied been in [1]. Apart of it, wearable antenna also has been discovered by using printed conductive layer on fabric material as in [2]. Integrating electronic devices into daily worn is smart options in hand free applications. Another research shows different fabricating wearable antenna by embroidered conductive yarn into woven textile [3].

By using computerized machine, the conductive yarn is directly stitch into textile. Therefore, different sewing types can be chosen, such as Zigzag stitch is used for a RFID tag in [4] and a Fill stitch is used for meander line antenna [5] and an asymmetric meandered flare antenna in [6]. From these studies, the findings show different sewing types have different effects on embroidery accuracy and RF performances [7].

In this paper, a 2.45GHz leaf shape antenna dipole is studied. Initially, leaf shape dipole antenna stitched with conductive threads around the leaf shape itself. The performances of measured return loss shows better results compared to leaf shape without conductive threads. Then, three different stitch types are analyzed including circular stitch, vertical stitch and also horizontal stitch. The measured results illustrate the different stitch types effect the dipole antenna performances.

## 2. RESEARCH METHOD

The diamond shape of textile antenna in [8] has been studied initially. The length and width for diamond shape is similar. In this study, the original diamond shape of the antenna is chamfered with a radius of 8mm. Figure 1 shows the geometry of the leaf shaped textile antenna. This antenna dipole is fed with 50Ω discrete port and simulated with CST software.

The overall size of suggested antenna is 60mm x 40 mm as show in Figure 1. The intended wearable antenna consists of copper textile as a radiating element and the non-conductive fleece fabric as a substrate. The antenna is designed on the material of fleece substrate which has εr = 1.25 and tanδ = 0.05. The surface wave loss reduces and the bandwidth of antenna improves as the substrate has low loss tangent and permittivity [9]. Parameter of the proposed antenna shows in Table 1.

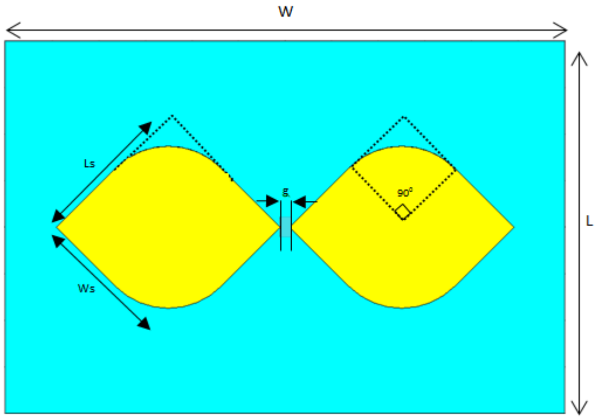



Figure 1. Leaf shaped textile antenna simulation design

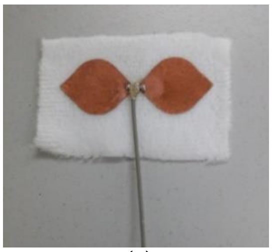
Table 1. Parameter of leaf shaped textile antenna

| Parameter | Dimension (mm) |
|---|---|
| Length of substrate (L) | 40 |
| Width of substrate (W) | 60 |
| Length of leaf shape (Ls) | 17 |
| Width of leaf shape (Ws) | 17 |
| Gap (g) | 2 |
| Thickness of substrate (h) | 1 |
| Thickness of copper textile (t) | 0.035 |

## 3. RESULTS AND ANALYSIS

### 3.1. The Effect of Conductive Threads on Leaf Shape Dipole Antenna

The leaf shape dipole antenna with copper textile as conducting element is operating at 2.45GHz which is applicable for ISM band. Figure 2 (a) and (b) show the leaf shape dipole antenna without conductive threads and with conductive threads respectively. At first, leaf shape dipole antenna was placed to the fleece fabric by using glue stick and pressed by SINGER steamed press iron for 20 seconds. For the next, the copper textile also placed by using glue stick and stitch with conductive threads around itself.


(a)

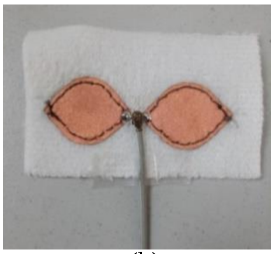

(b)

Figure 2. Leaf shape dipole antenna (a) without conductive thread (b) with conductive threads

The results of reflection coefficient of these two antennas are shown in Figure 3 above. It can be observed that, the reflection coefficient of measurement copper textile is slightly shifted to the right with respect to the simulated reflection coefficient. Meanwhile the measurement copper textile with round stitch shows a good agreement in terms of reflection coefficient. The bandwidth for these three results is tabulated in Table 2. It can be concluded that, the existence of conductive threads gives a good performances for leaf shape dipole textile antenna. As the thread is conductives, it helps the antenna to perform well.

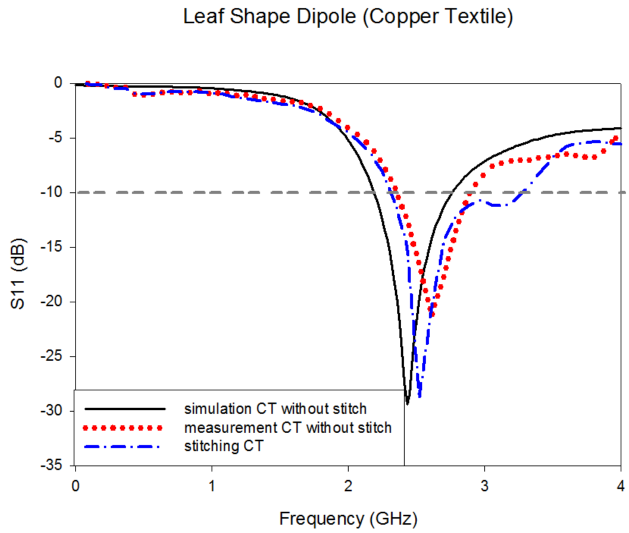
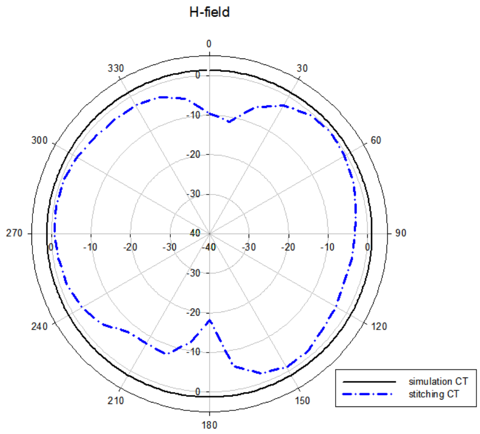



Figure 3. Reflection coefficient for simulation copper textile, measurement copper textile and stitching copper textile

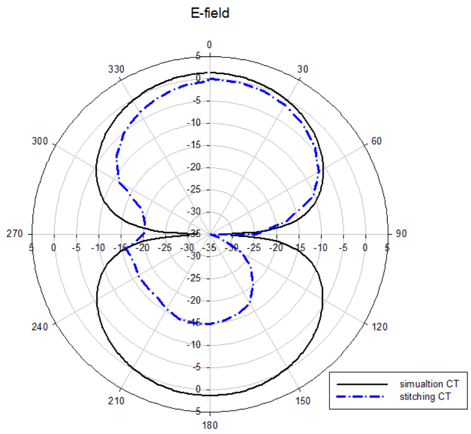
Table 2. Bandwidth for simulation, measurement and stitching antenna

| Antenna | Bandwidth (MHz) |
|---|---|
| Simulation | 580 |
| Measurement | 500 |
| Stitching | 950 |

Figure 4 (a) and (b) above shows the radiation pattern H-Field and E-Field for both simulation and measurement results. Simulation for copper textile as radiating element generates gain of 1.26dB. Meanwhile the measurement copper textile with stitch around leaf shape generates roughly about 1.50dB gain.




(a)




(b)

Figure 4. Radiation pattern for leaf shape dipole antenna (a) H-Field (b) E-Field

### 3.2. Effect of Three Different Stitch Types

In order to further confirm the existence of conductive threads gives a good performance for leaf shape dipole antenna, three different types of stitching are fabricated on leaf shape dipole antenna. The stitches involve circular stitch, vertical stitch and horizontal stitch. Figure 5(a), (b) and (c) shows the fabricated leaf shape dipole antenna for each stitch.

(a) (b) (c)

Figure 5. Fabricated leaf shape dipole antenna (a) circular stitch (b) vertical stitch (c) horizontal stitch

The S-parameter is measured for these three stitch types as shown in Figure 6. It is noted that return loss for three types of stitches gives a good agreement to the simulation results. But, circular stitch gives the best results to the simulation as the resonance frequency not shifted to the right compared to vertical and horizontal stitch. Eventhough the return loss of horizontal stitch gives better performances compared to the circular and vertical stitch, the resonance frequency for horizontal stich is not so good as it slightly shifted to the right. Based on these, it can be concluded that circular stitch demonstrated better performances for leaf shape dipole antenna compared to vertical and horizontal stitch.

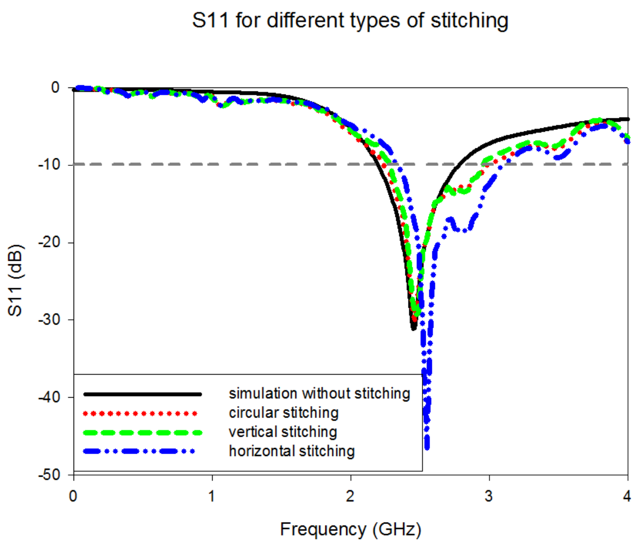


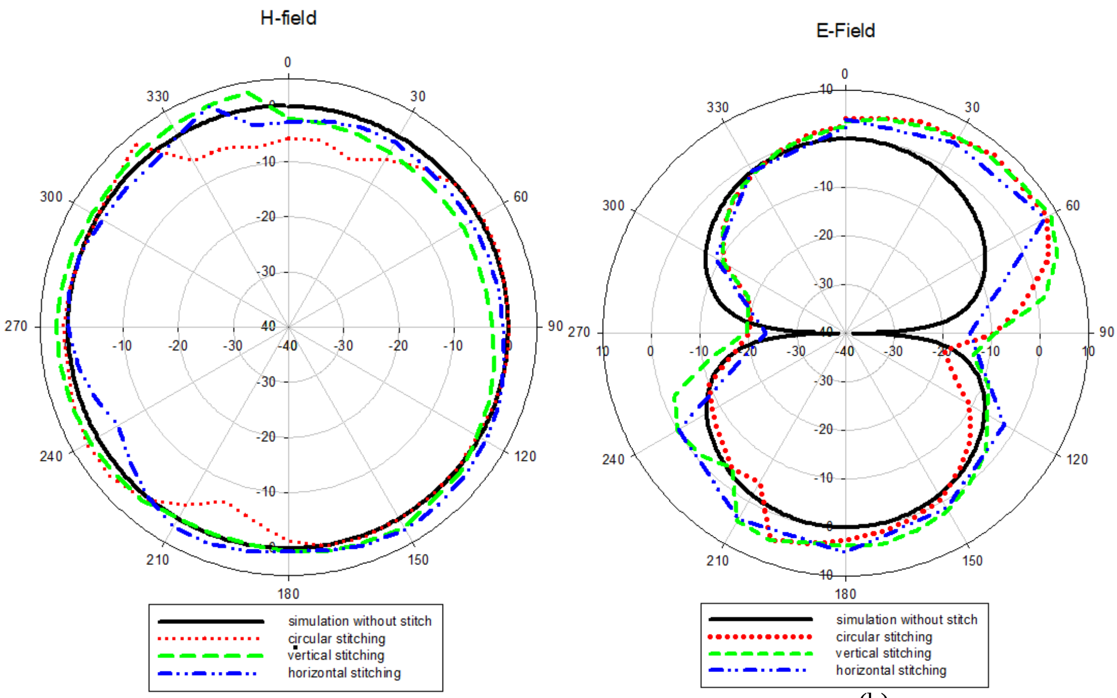

Figure 6. Reflection coefficient leaf shape dipole antenna (a) circular stitch (b) vertical stitch (c) horizontal stitch

From the reflection coefficient results above, the bandwidth for each types of stitching are calculated and shown in Table 3. The simulation leaf shape dipole antenna has 570 MHz bandwidth, followed by circular stitching which has 740MHz bandwidth, meanwhile vertical stitch notes 750MHz and horizontal stitch recorded 760MHz bandwidth. It can be concluded that these three types stitches improves the bandwidth of simulation but each stitch gives not much different in bandwidth performances when compared to themselves. It shows that the conductivity of threads helps the antenna to perform better in real application.

Table 3. Bandwidth for leaf shape dipole antenna (a) circular stitch (b) vertical stitch (c) horizontal stitch

| Antenna | Bandwidth (MHz) |
|---|---|
| Simulation | 570 |
| Circular stitching | 740 |
| Vertical stitching | 750 |
| Horizontal stitching | 760 |

Figure 7 (a) and (b) above shows the radiation pattern H-Field and E-Field for both simulation and measurement results which involves three types of stitching. From the radiation pattern results above, all three types of stitch shows a good pattern for both H-Field and E-Field. Simulation for copper textile as radiating element generates gain of 1.26dB. Meanwhile the measurement copper textile with three different stitches types generates gain roughly about 2dB.




(a) (b)

Figure 7. Radiation pattern for three types of stitching on leaf shape dipole antenna (a) H-Field (b) E-Field

## 4. CONCLUSION

A leaf shape dipole antenna operates at 2.45GHz has been designed, simulated and measured. The antenna was made from fleece fabric which works on ISM band. In this study, the antenna initially measured with and without existence of conductive threads. Then, the antenna was stitch with three different types of stitches. These three different stitches have been studied on leaf shape dipole antenna. For leaf shape antenna, the circular stitch is always along the direction of leaf shape, so it has demonstrated better performances compared to vertical and horizontal stitch. Based on this, it can be concluded that the best RF performances can be obtained when the stitch direction is along the shape of antenna itself.

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## REFERENCES


[1] P. S. Hall and Y. Hao, "Antennas and propagation for Body-Centric communications," *1st European Conference on Antenna and Propagation, (EuCAP)*, 2006.

[2] H. Kim, *et al.*, "A wearable fabric computer by Planar-Fashionable circuit board technique," *Sixth International Workshop on Wearable and Implantable Body Sensor Network, BSN 2009*, Berkeley, CA, pp. 282, 2009.

[3] G. Kim, *et al.*, "Design of a UHF RFID Fiber Tag Antenna with Electric-Thread Using Sewing Machine," *IEEE Microwave Conference*, pp. 1-4, 2008.

[4] Moradi, *et al.*, "Characterization of Embroidered Dipole-type RFID Tag Antennas," *IEEE Internatioanal Conference on RFID-Technologies and Applications (RFID-TA)*, pp. 248-253, 2012.

[5] Z. Wang, *et al.*, "Multilayer printing of embroidered RF circuits on Polymer Composites," *IEEE Internatioanal Symposiums on Antenna and Propagations (APSURSI)*, pp. 278-281, 2011.

[6] Z. Wang, *et al.*, "Flexible Textile aAntennas for Body-worn Communication," *IEEE International Wokshop on Antenna Technology (iWAT)*, pp. 205-208, 2012.

[7] Y. P. Huang, "Effect on Seing Types on Flexible Embroidery Antennas in UHF Band," *IEEE European Microwave Conference (EuMC*), pp. 88-91, 2013.

[8] L. Akhoondzadesh-Asl, *et al.*, "Wideband dipoles on Electromagnetic bandgap ground planes," *IEEE Transaction on Antenna and Propagation*, vol/issue: 55(9), 2007.

[9] H. M. R Nurul, *et al.*, "Evaluation of a wearable hybrid textile antenna," *Loughborough Antennas and propagation Conference (LAPC)*, 2012.


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