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Compact CPW-fed Ultra-Wideband (UWB) Antenna Using Denim Textile Material

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Abstract

A compact and flexible CPW-fed UWB antenna is designed using denim material .The proposed structure consists of an eclipse patches and modification of ground plane to obtain an impedance bandwidth between 2.52 GHz and 13.35 GHz. The dimension of antenna is 35 mm x 45 mm with thickness of 0.78 mm. The antenna is simulated using CST Microwave Studio. The structure is then fabricated using copper tape as radiating element and denim textile as substrate. The dimension of antenna are studied and optimized to obtain UWB requirement. The simulated and measured result are compared and analyzed in this paper.

Keywords: CPW-fed UWB, Ultra-wideband, textile antenna, wearable antenna, denim textile

1. Introduction

Ultra-wideband is a potential wireless technology for development of wearable application system, which have capabilities of high data rate, high bandwidth, low cost, low consumption energy and simple configuration with system. Federal Communication Commission (FCC) stated that the frequency range of UWB is from 3.1 GHz until 10.6 GHz [1]. CPW fed antenna is one of planar antenna technology which can be designed for UWB application. A lot of researches are conducted on designing CPW antenna to produce high bandwidth and miniaturize the antenna size such as finding suitable radiator shape and adding slots or stubs on radiator and ground plane [2,3,4]. From previous research, eclipse radiator has the best performance in term of impedance bandwidth [5]. Textile antenna is introduced due to the flexibility compared to the conventional antennas. Denim textile is one of the best candidate for textile antenna which is durable, inelastic, low thickness, comfortable for user and low cost material [6,7].

2. Material and Antenna Design

The proposed antenna consists of two parts which are copper tape as radiating element and denim textile as substrate. A copper tape which has a thickness of 0.035 mm is attached on the denim textile material. Denim textile with thickness of 0.78 mm have permittivity of 1.8 and tangent loss of 0.07 at 2.4 GHz. The antenna feature ellipse radiator with different radius on vertical and horizontal part (ra= 14mm rb =15mm). The width of feed line (3.5 mm) are determined to archive 50 ohm impedance matching with SMA port. The overall size of antenna is 35 mm x 45 mm. The ground plane structure is modified by cutting technique to achieve UWB specification. The designed antenna is optimized using CST Microwave Studio and the common optimized dimensions are illustrated in Figure 1. Figure 2 shows the fabricated structure of CPW-fed UWB antenna.

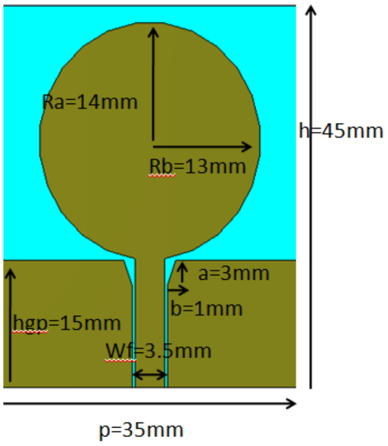


Figure 1: Dimension and prototype of designed antenna

Figure 2: Fabricated antenna using denim textile

Parameter of h_{gp}, r_a, r_b, a and b are studied to optimize the antenna performance. As depicted in Figure 3, the size reduction of ground plane will improve the performance of antenna. Figure 4 show the parameter of r_a is varied from 10 mm to 15 mm. Then, r_a of 13 mm is selected due to the best simulated result. Next, r_b = 14 mm is selected and the resonant frequency is shifted to left side when r_a is varied from 13 mm to 14 mm. The modification of ground plane is the most significant part on designing UWB antenna in this paper. The ground plane will be cut on the edges of ground plane with a triangular shape. Parameter of a and b are involved in determining the triangular shape. Figure 6 shows the best result of various size of a and b when a=1 and b=3. After optimization, the antenna is fabricated with cutting overall CPW-radiator -plane and attaching it onto denim substrate.

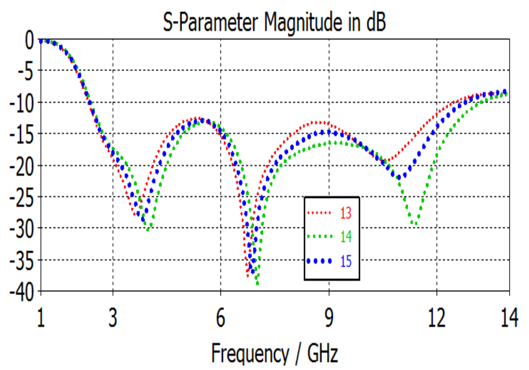


Figure 3: S_{11} for various size of h_{gp} (height ground plane)

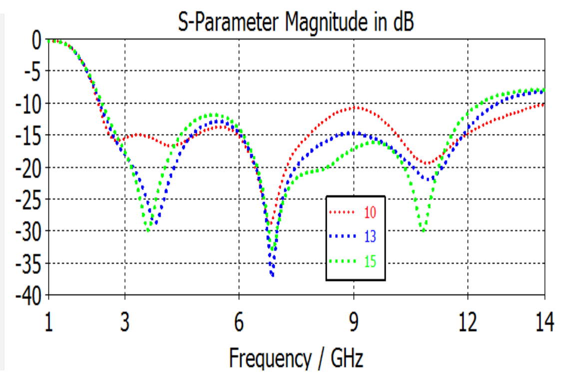


Figure 4: S_{11} for various size of r_a (horizontal)

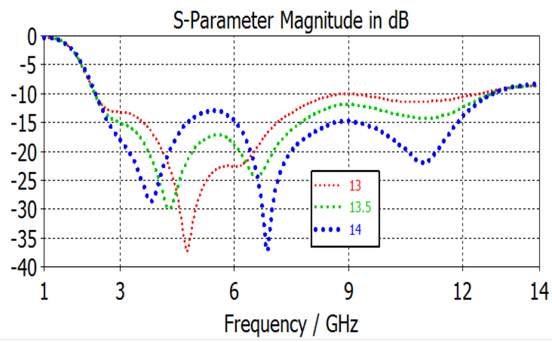


Figure 5: S_{11} for various size of r_b (vertical)

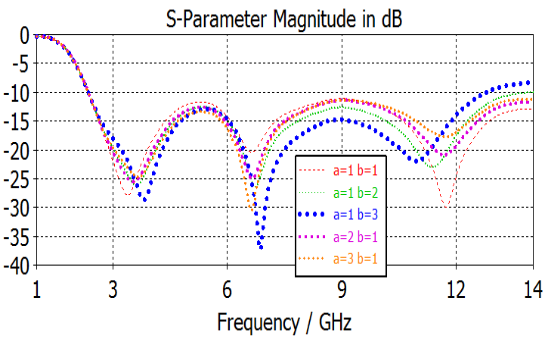


Figure 6: S_{11} for various size of *a* and *b*

3. Result and Discussion

Figure 7 shows the simulated and measured return loss for CPW-fed antenna. The simulated return loss is slightly higher than measured result. However, the bandwidth of simulated result is slightly lower than measured result. From the result, the percentage of fractional bandwidth of simulated result is 137% (2.4 GHz - 12.8 GHz) and measured result is 136% (2.52 GHz -13.35 GHz). The graph shows a good agreement between simulated and measured result.

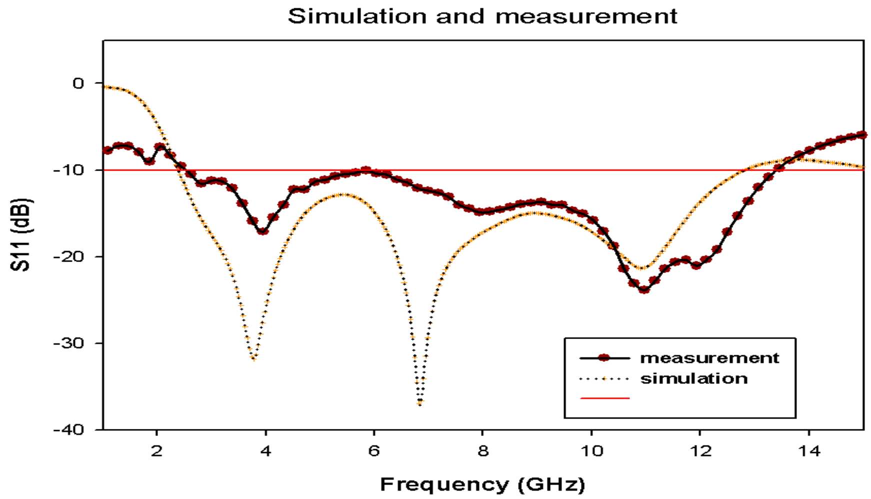
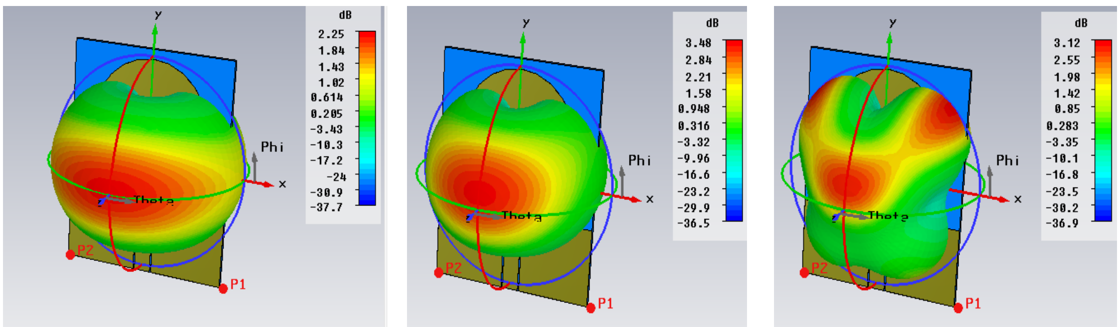


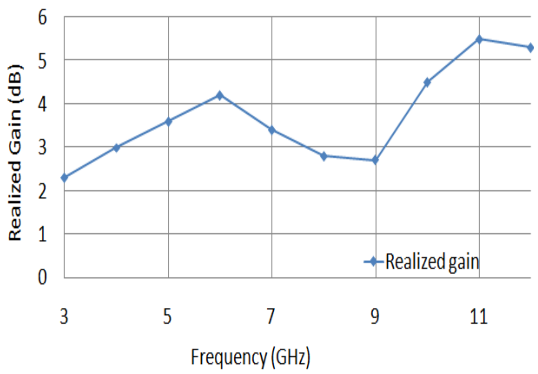
Figure 7 : Simulation and Measurement CPW fed antenna

The simulated radiation pattern of CPW-fed antenna is presented in Figure 8. At H-plane, omnidirectional patterns are produced at 3 GHz and 5 GHz, more directional pattern are produced at 7 GHz. These kind of radiation patterns are observed due to the highest current mode which is excited when increasing the frequency. Figure 9 show the simulated realized gain from 3 GHz to 12 GHz with the minimum and maximum value is 2.3 dB and 5.5 dB respectively. Figure 10 demonstrates the effect of bending for the fabricated antenna. Figure 10 demonstrates the effect of bending for the fabricated antenna. Two different sizes of foam (27 cm and 34 cm) and actual size of arm (30 cm) are bent on the antenna to investigate the return loss of antenna. Based on Figure 10, the arm affect the resonant frequencies to the lower frequency range. Bending between 27 cm to 34 cm do not affect the performance of antenna compared to the no bending condition.



a) b) c)

Figure 8: Simulated 3D radiation pattern at a) 3 GHz b) 5 GHz and c) 7 GHz



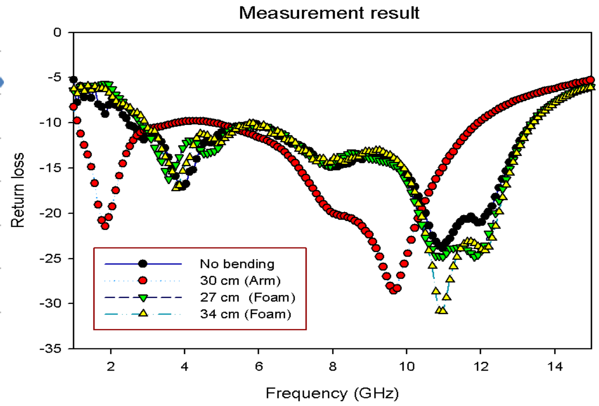


Figure 9.Simulated Realized Gain of Antenna

Figure 10: Return loss of different bent size circumference for antenna

4. Conclusion

In this paper, a flexible, low cost and compact CPW-fed textile antenna using denim textile is designed, simulated, fabricate and analyzed. The parameters of antenna such as h_{gp}, r_a ,r_b ,a and b are committed to optimize the performance of the antenna. Fabrication process is the most challenging part for designing textile antenna because all the processes require manual tool which may cause an inconsistent result

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