

Highly Efficient Dual Band Circular Patch Textile Antenna for WLAN Applications

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Abstract - In this work, a slotted circular patch textile antenna is proposed which is modeled on a defected ground plane. A jeans fabric having the relative permittivity value of 1.6 is used as the substrate material. The proposed antenna is designed with a circular shape patch etched with a circular split ring resonator (SRR) in the middle. The ring has the width of 0.5mm. The effective area of the circular patch is 150mm². A rectangular slot is also created in the ground plane. The circular SRR in the patch and the rectangular defect in the ground plane introduce two pass bands with a notch band in the antenna radiation characteristics. The antenna results in dual band characteristic with resonant frequencies of 7.5GHz and 2.8GHz. The notch band lies from 4.9GHz to 5.5GHz. The antenna is simulated using hfss software. The proposed antenna shows an enhancement in the fractional bandwidth. The resulted fractional bandwidth is 61.64% with the center frequency of 7.95GHz and 76% with 3.5GHz. The antenna also results in good impedance matching having return loss of -46.71dB at 7.5GHz and -23.89dB at 2.8GHz. The proposed antenna is highly efficient with the radiation efficiency of 99.65% efficiency at 7.5GHz. The antenna finds its application in the WLAN and eliminates the interference by providing a notch band.

Keywords- Textile antenna, Split ring resonator (SRR), hfss (high frequency structure simulator).

1. INTRODUCTION

A low profile large bandwidth antenna is a primary requirement for any communication system. The dimension of the antenna, now a days, plays an important role to select it for particular application [1-2]. The electronically active textile materials are new one in the field of antennas. These materials have very low relative permittivity and this property makes them eligible to be used as a substrate in the antenna geometry [3]. One more essential feature of any textile material is its flexibility. This feature makes the antenna fabricated using textile material easy to be mounted on human clothing.

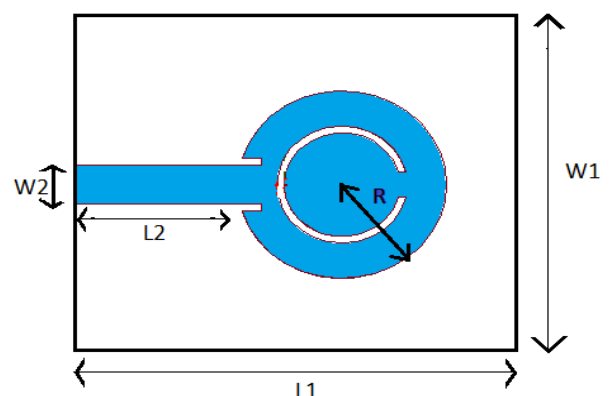
The antenna designed to be used as wearable textile antenna must have wide bandwidth. The ultra wide band (UWB) as defined by FCC covers the wide frequency range from 3.1GHz to 10.6GHz [4]. So, the textile antennas are usually designed to operate in the entire range of this UWB spectrum, providing one or more stop bands. The antennas modeled to operate in this UWB frequency band find

applications in multiple fields as in satellite communication, radar communication, military outfit designs and bio-medical equipment [5].

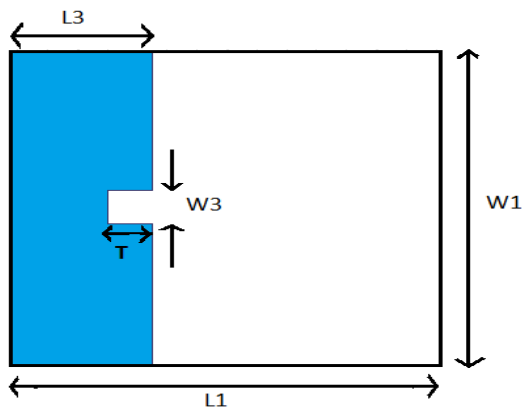
The paper proposed a wearable textile antenna having dual band characteristics with a notch band from 4.9GHz to 5.5GHz for avoiding interference. The antenna is designed on a jeans fabric used as the substrate material and a circular patch. The presented antenna is simulated using hfss software and the antenna parameters are calculated. The antenna shows an improvement in the fractional bandwidth and is properly matched in terms of impedance. The results obtained by simulation are discussed in the paper.

2. GEOMETRICAL MODEL

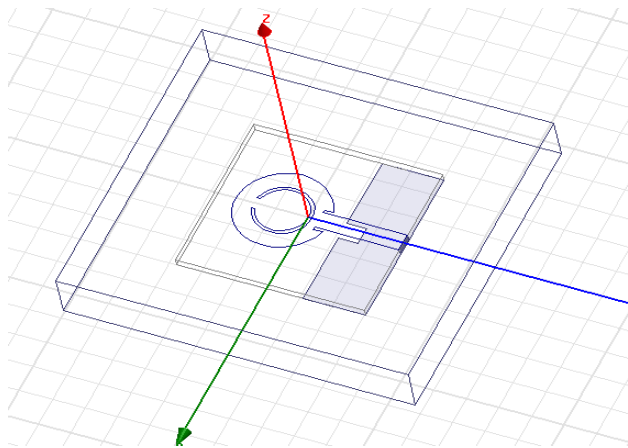
The wearable textile antenna is modeled using a jeans fabric as the substrate material. The jeans fabric has relative permittivity of 1.6. Figure 1 depicts geometrical aspects of the textile antenna. The thickness of the substrate material is chosen as 1.66mm. The dimensions of the patch and the ground are given in the table 1 below the figure. A circular SRR is etched on the circular patch having the width of 0.5mm.



(a)



(b)



(c)

Figure 1. Geometrical view of the simulated antenna (a) top, (b) bottom view, (c) hfss model

TABLE I

Dimensions of the simulated antenna

Parameter	Unit (mm)	Parameter	Unit (mm)
L1	28	L3	9.5
W1	29	W3	3
L2	11.5	T	3
W2	3	R	7.21

The feed line is connected with the circular using inset feed. The inset feed is used to reduce the effect of spurious radiation near the feed patch joint. The feed line is positioned to match the impedance with patch.

3. SIMULATED ANTENNA PARAMETERS

3.1 Return loss- Figure 2 below shows the simulated graph of the return loss the proposed wearable textile antenna. The proposed textile antenna shows dual band characterization with the notch band from 4.9GHz to 5.5GHz. The return loss is -46.71dB with the resonant frequency of 7.5GHz and -23.89dB with 2.8GHz. The proposed textile antenna shows very good impedance matching.



Figure 2. Return loss vs frequency at 7.5GHz

3.2 Fractional Bandwidth- The calculated fractional bandwidth is 61.64% with the center frequency of 7.95GHz and 76% with the center frequency of 3.5GHz. The typical antenna bandwidth is 4.9GHz and 300MHz with the center frequencies of 7.95GHz and 3.5GHz respectively.

3.3 Gain and Directivity- Figure 3 draws the plot of antenna gain vs frequency with reference to the direction of maximum radiation (at $\phi=0$ and $\theta=90$). The peak gain is received at the resonant frequency of 7.5GHz as 2.84dB and the directivity at the same frequency is 2.86dB.

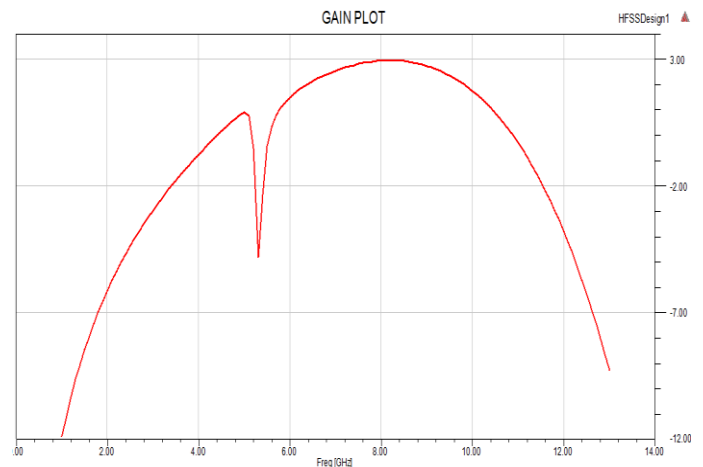
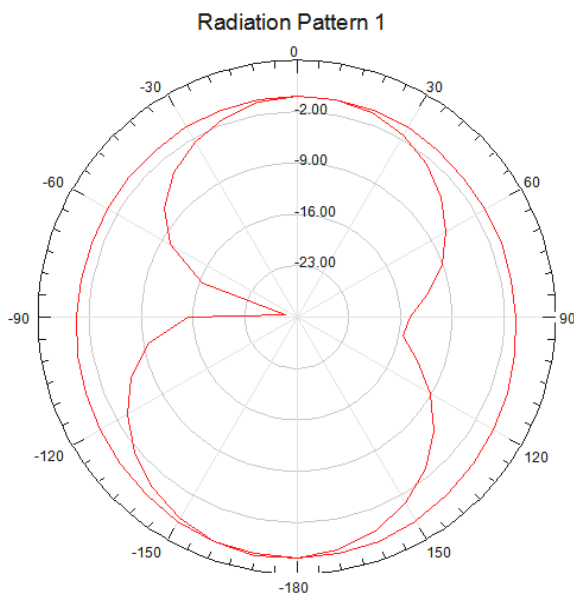


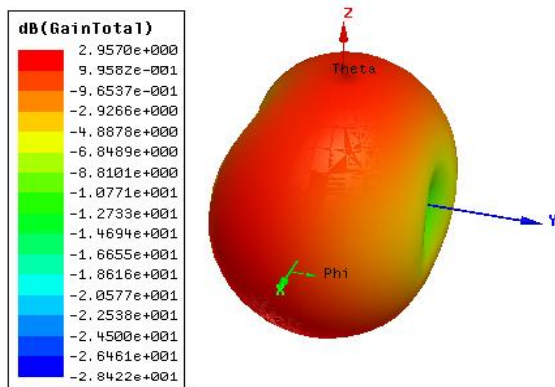
Figure 3. Gain vs frequency plot at 7.5GHz

3.4 Antenna Efficiency- Antenna efficiency is the ability of particular that shows how effectively the antenna is converting the radio frequency power to radiation. The calculated value of antenna efficiency for the proposed textile antenna is 99.65% at the resonant frequency of 7.5GHz.

3.5 Radiation Pattern- Figure 4 depicts the radiation pattern of the proposed textile antenna. The radiation pattern resulted from proposed textile antenna is suited for the applications of WLAN communication.



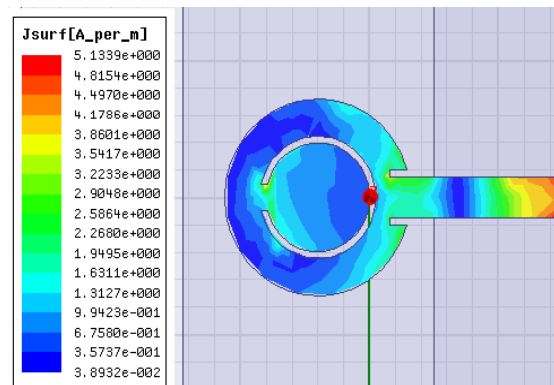
(a)



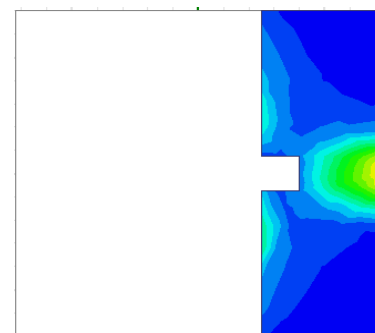
(b)

Figure 4 (a) Radiation Pattern, (b) Polar Radiation plot of the proposed antenna at 7.5GHz.

3.6 Current distributions- The current density plot for the circular patch having SRR and defected ground plane is shown in the figure 5(a) and 5(b) respectively.



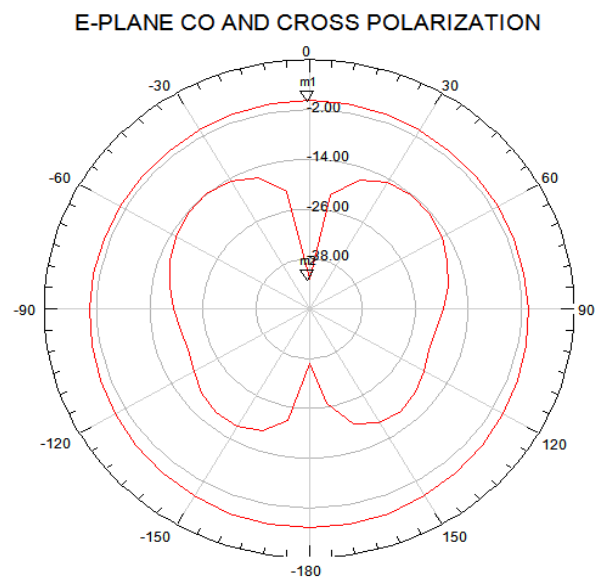
(a)



(b)

Figure 5. Current distribution (a) patch ,(b) ground plane etched with metamaterial unit cell

3.7 Co-Polarization and Cross-Polarization- The radiation patterns for the E-plane and H-plane are shown in the figure 6(a) and 6(b) respectively. The radiation pattern gives the measure of co-polarization and cross-polarization for the proposed textile antenna.



(a)

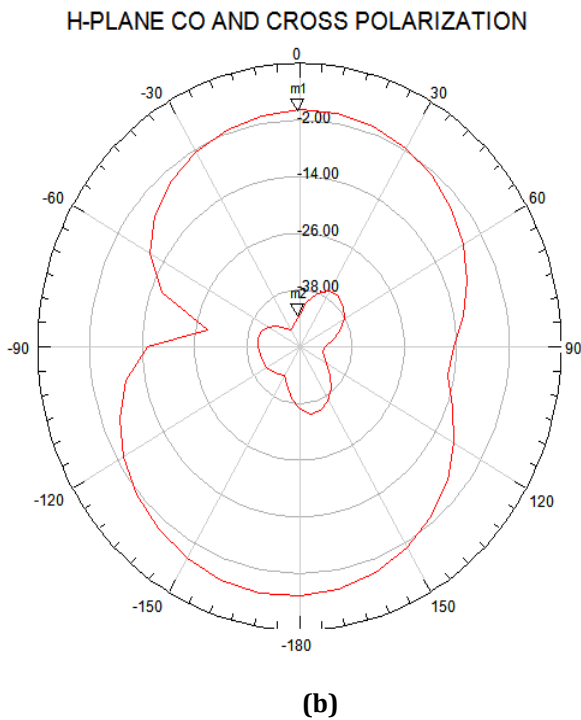


Figure 6. (a) E-Plane’s Co-polarization and Cross-polarization, (b) H-Plane’s Co-polarization and Cross-polarization

TABLE II

Measures of Co-Polarization and Cross-Polarization

Plane	Peak Co-pol.(dB)	Peak Cross-pol.(dB)
E-Plane	0.17	-42.9
H-plane	0.18	-43

3.8 Voltage Standing Wave Ratio (VSWR)- Antenna’s impedance matching ability is decided by its VSWR. Figure 7 below shows the VSWR plot for the proposed textile antenna. The value of VSWR at the resonant frequencies of 7.5GHz and 2.8GHz are 0.28dB and 1.11dB respectively.

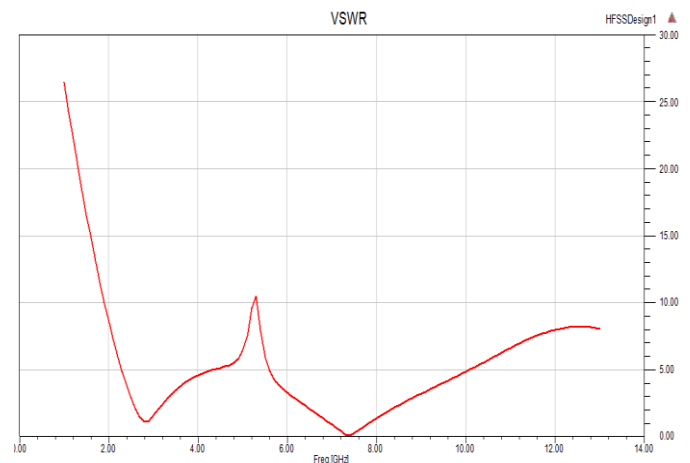


Figure 7. VSWR vs frequency plot at 7.5GHz

3.9 Miniaturization- The table 3 below shows a comparison of effective patch area of rectangular microstrip patch antenna designed at same resonant frequency and proposed textile antenna with slotted circular patch. The comparison results in a 68.61% miniaturization in the radiant patch size.

TABLE III
Comparison of effective patch area

S.No.	Antenna	Resonant Frequency (GHz)	Effective patch area (mm ²)
1	Conventional antenna with rectangular patch	7.5	252.92
2	Proposed textile antenna	7.5	150

Resulted miniaturization in effective patch size = 68.61%

4. CONCLUSION

A textile antenna is proposed and simulated in the paper. All the results simulated are attached with the paper. The textile antenna shows very good radiation characteristics in terms of its return loss, gain, directivity, fractional bandwidth and efficiency. The antenna is highly efficiency having 99.65% radiation efficiency. The reason of this high efficiency is the textile substrate that has quite low value of relative permittivity. Also, the proposed antenna shows dual band characteristics with a notch band to avoid interference. Table 4 below shows a comparison between previous works and the proposed antenna. The antenna is miniaturized in terms of both its effective patch area and substrate area.

S.No.	References	Effective Substrate Area (mm ²)	Resulted Notch band (GHz)
1	[6]	1050	5.5
2	[7]	896	5 - 5.6
3	[8]	840	5.1 - 5.8
4	[9]	1120	5 - 5.9
5	[10]	1305	5
6	Proposed textile antenna	812	4.9 - 5.5

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