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DEFECTIVE GROUND CORNER ROUNDED ULTRA-WIDEBAND MICROSTRIP PATCH ANTENNA FOR BIO-MEDICAL APPLICATIONS

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Abstract

In this research work, design of Ultra-Wide-band microstrip line feed partial ground structure corner rounded rectangular microstrip patch antenna is presented. Design is implemented on FR4 substrate, and results implies that, just by making lower corners of rectangular patch and upper corners of partial ground rounded form sharp edges, good impedance bandwidth is achieved for the proposed antenna. Presented design full fill the essential bandwidth, needed for Ultra-Wideband applications defines by FCC from 3.1GHz to 10.6GHz. Proposed design resonates from (3.21GHz to 12.72GHz) with impedance bandwidth is of 9.51GHz has a moderate gain of 2.88dBi. Parametric analysis is presented to show effect of corner round and ground gap on performance of antenna.

Keywords:

Corner Rounded, Current Distribution, Ground Gap, UWB, Wideband

1. INTRODUCTION

This era's growth of communication technology is very fast and every needs very high data rate. Medical field needs wide band devices to detect disease at early stages to survive lives. FCC defines a band from 3.1GHz to 10.6GHz as an Ultra-wideband (UWB) band. UWB has a tremendous potential of high data rate for short distance communication. In woman's case second largest cause for death is breast cancer. Now a days different techniques have been used like mammography, X-Ray and so on. To detect breast cancer in early days and save life microwave imaging is proposed. Most important candidate in microwave imaging is antenna who operates in wide band range. To fulfill this need proposed a design of Ultra-wide band antenna [17] [18].

Technology needs a suitable candidate which fulfills needs as compact size low cost easily integrated with the microwave devices of recent developed wireless communication system. Microstrip patch antenna has limitations of narrow bandwidth, low gain and stable response in the wide band region. Design of UWB antenna with stable response is big challenge for the researchers. A microstrip square-ring slot antenna and truncated ground plane and two-tapered radiating patch separated by a slot (Air Gap) of different slopes for UWB (Ultra-Wideband) antenna applications is proposed and improved by compaction [1] [2]. Issa and Essaaidi designed A new ultra-wideband (UWB) patch antenna, based on two number of split ring resonator with the ground on the same substrate face [3]. Slotting technique is presented to design single resonating antenna to multi resonating for ISM band [4]. A single-fed miniaturized circularly polarized microstrip patch antenna is designed for industrial-scientific-medical (2.4-2.48GHz) biomedical applications [5]. Broader bandwidth is achieved by using RT Duroid substrate consist of composite patch antenna [6-8]. A novel hexagon shape bow-tie antenna for implantable bio-medical application and spear shaped antenna is designed with CPW feed for wireless communication [9] [11].

Analysis of two parallel slots embedded in circular disk patch antenna has been proposed for WLAN application [10]. A small planar elliptical dipole antenna and a CPW-fed circular ensures wideband impedance matching and stable omnidirectional pattern over an UWB frequency range from 3GHz to 10.6GHz [13] [14] [15]. An aperture coupled microstrip antenna with a rectangular patch which is located on top of two slots on the ground plane. The patch and slots are separated by an air gap and a material with low dielectric constant [12][16].

This paper is organized as follows. Section 2 provides design of microstrip patch antenna. Section 3 depicts the detailing of simulated results. Section 4 describe mathematical equations and section 5 gives parametric analysis and conclusion respectively.

2. ROUNDED CORNER MICROSTRIP PATCH ANTENNA DESIGN

Antenna1 is a reference antenna with rounded corner to radiating patch with 3mm×3mm radii, geometry structure shown in Fig.1. The antenna structure is designed on 1.6mm thick FR4 substrate having ε_r of 4.4 using approximate transmission line equations. Calculated dimension of rectangular microstrip patch antenna is L_p = 12.7mm, W_p = 15.2mm. Antenna is fed through microstrip line with 3mm×16.01mm with partial ground structure. Antenna 1 geometry has partial ground structure (15.21mm×30mm). Microstrip feed line overcomes limitation of probe feed design to achieve desire bandwidth for UWB application. Analysis of feed line is carried out using L and C values and find out frequency of feed line. Reference antenna is resonating at frequency range from 3.28GHz to 12.44GHz with VSWR < 2 and moderate gain of 3.02dBi.

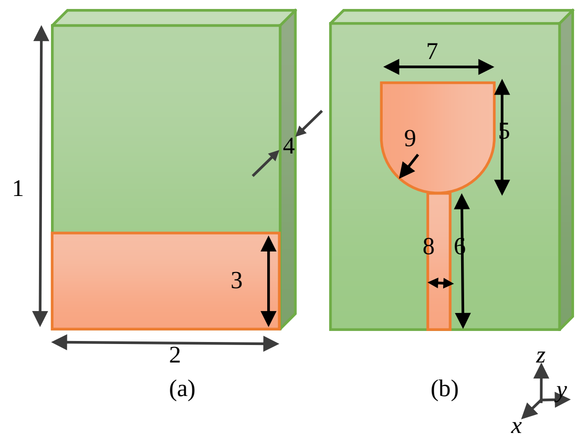

Fig.1. (a) Ground Structure (b) Corner Round Patch

The Dimensions of Geometry includes the following,

- Width of Substrate,
- Length of Substrate,
- Width of Ground,
- Height of Substrate,
- Width of Patch,
- Width of Feed Line,
- Length of Patch,
- Length of Feed and
- Radii of corner round.

Antenna 2 geometry is modifying by making upper corners of partial ground smooth rounded from sharp edges with radii of (3mm×3mm) resonates from 3.26GHz to 12.56GHz VSWR bandwidth is observed is of 9.30GHz with gain of 2.46dBi. Shows improvement in impedance bandwidth as well gain.

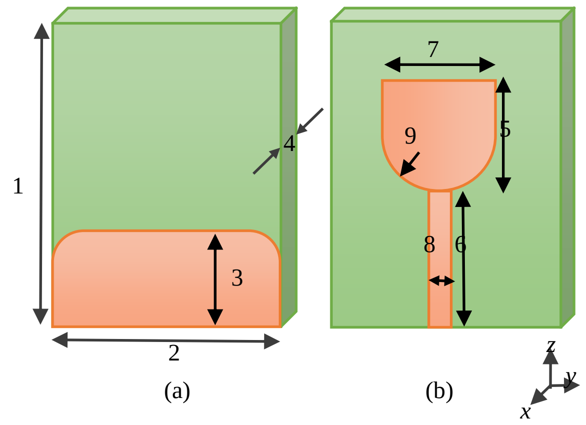

Fig.2. (a) Round Corner ground structure (b) Increase round radii patch

Antenna 2 geometry is further modified and observed effects on performance parameters as bandwidth and gain. Rounded lower corners have been modified and curve is made more rounded from 3mm×3mm to 6mm×5mm ellipse shape with ground corner keep as 3mm×3mm radii. Results shows good enhancement in VSWR bandwidth from 9.30GHz to 9.61GHz with improved gain of 2.88dBi. Proposed designed is with simple structure, geometry resonates from 3.19GHz to 12.8GHz covers UWB band. Radiation pattern of proposed antenna shows E plane and H Plane field.

3. SIMULATED RESULTS

The Fig.3 to Fig.10 shows simulation results of proposed geometries. Reflection coefficient of antenna1 is shown in Fig.3. Modified geometry reflection coefficient is shown in Fig.4 along with VSWR bandwidth in Fig.5 which shows good matching below 2. The Fig.6 to Fig.10 shows radiation pattern.

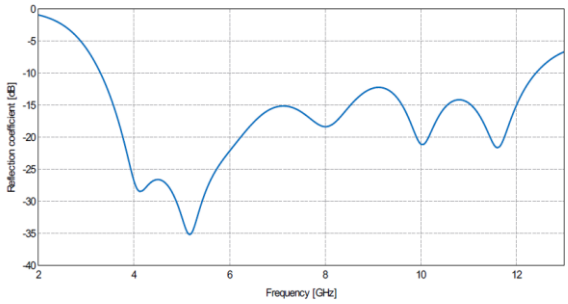

Fig.3. Simulated Reflection coefficient of Antenna1

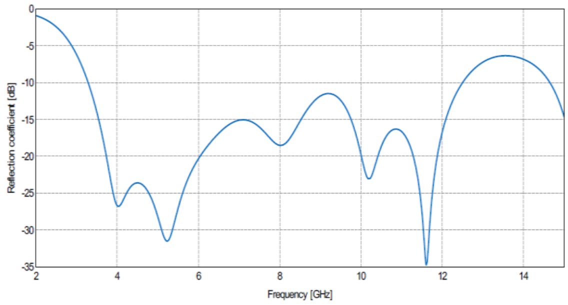

Fig.4. Simulated Reflection coefficient of Antenna2

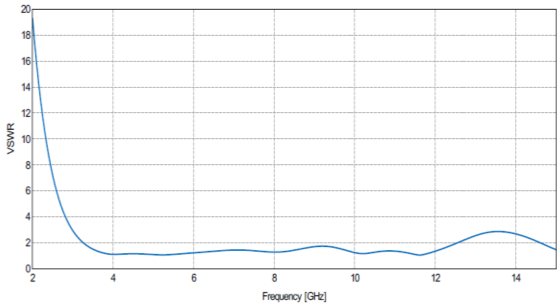

Fig.5. Simulated VSWR Band width of Antenna2

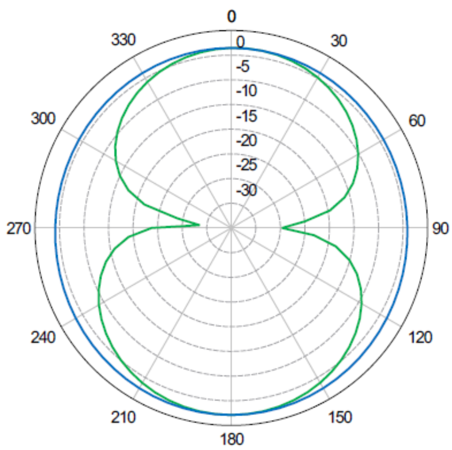

Fig.6. Simulated result of Radiation Pattern of Antenna2

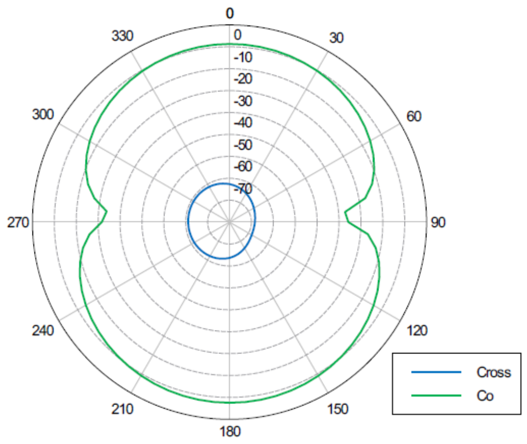

Fig.7. Simulated result of Radiation Pattern of Antenna2

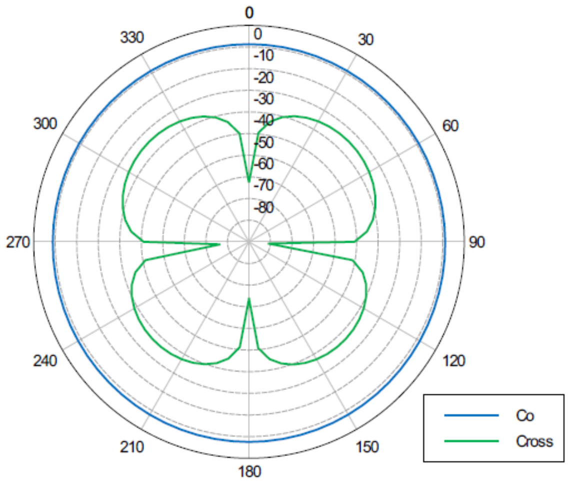

Fig.8. Simulated Reflection Coefficient of Reference Antenna2

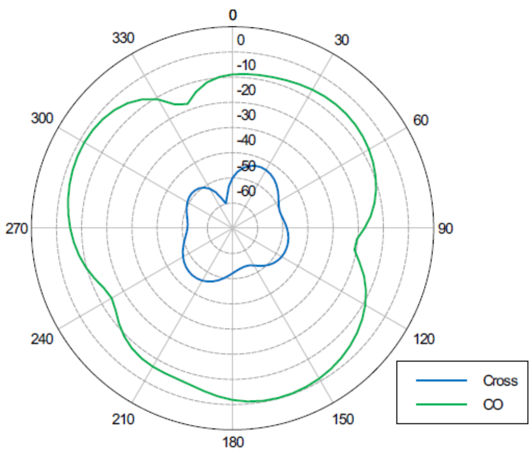

Fig.9. Simulated VSWR Band width of Antenna2

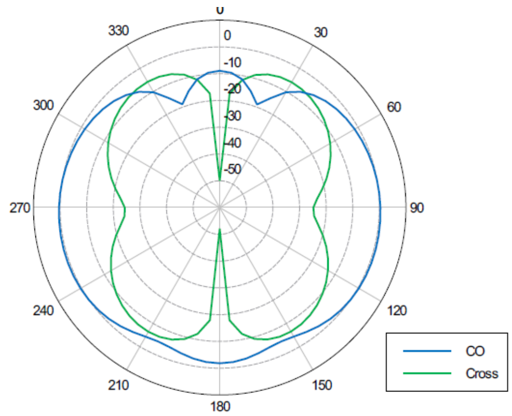

Fig.10. Simulated result of Radiation Pattern of Antenna2

4. DESIGN EQUATION

$$C_1 = \frac{LW\varepsilon_0\varepsilon_e}{2H}\cos^2\left(\left[\frac{\pi X_0}{L}\right]\right) \tag{1}$$

$$R_1 = \frac{Q}{C_1\omega_r^2} \tag{2}$$

$$L_1 = \frac{1}{C_1\omega_r^2} \tag{3}$$

$$Q = \frac{c\sqrt{\varepsilon_e}}{4fH} \tag{4}$$

where, L - Length of rectangular patch, W - Width of rectangular patch, X_0 - y coordinate of feed point, H - Thickness of the substrate material and ε_e - effective permittivity of the medium.

The Microstrip Line,

$$L_L = 100.H(4\sqrt{W_S/H} - 4.21)\,\text{nH} \tag{5}$$

$$C_L = W_S\left\{(9.5\varepsilon_r + 1.25)W_S/H + 5.2\varepsilon_r + 7.0\right\}pF \tag{6}$$

Resonance frequency of transmission line is given by,

$$f = \frac{c}{2L_e\sqrt{\varepsilon_{re}}} \tag{7}$$

These equations use to design microstrip patch, feed line equations are also used to design feed line.

5. RESULTS AND DISCUSSION

5.1 PARAMETRIC STUDY

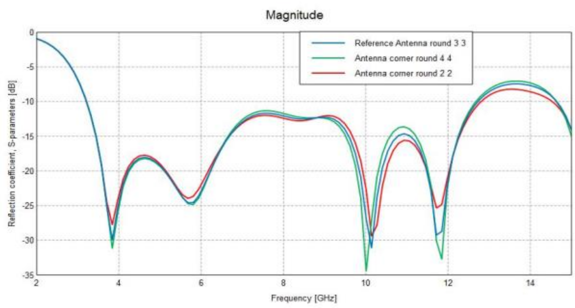

Fig.11. Parametric Analysis of ground corner

Table.1. Ground Corner Effect

Ground Corner (mm)	BW (GHz)	Resonant Frequency (GHz)	Reflection Coefficient (dB)
4	9.59	3.84	-27.77
		10.14	-29.39
3	9.51	3.84	-29.97
		10.14	-31.09
2	9.46	3.84	-31.17
		10.01	-34.44

Parametric study observes effect of ground corner on antenna performance. It is observing that corner of upper edge of partial ground is more curvature cause to enhancement in bandwidth is observed and as it has lesser reduces bandwidth. Impedance matching is achieved by creating defect in partial ground structure. It is observed for 2mm, 3mm and 4mm radius. More power is delivered from feed to patch as ground curvature modified, it is observed from surface current.

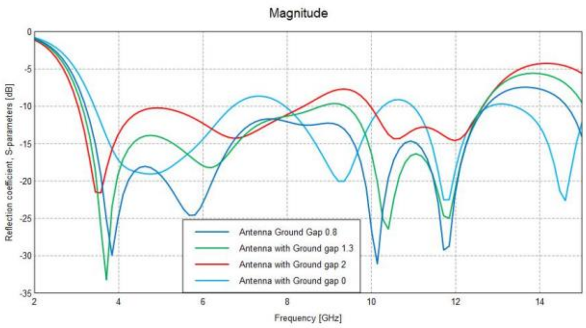

Fig.12. Parametric Analysis of Ground gap

Table.2. Ground Gap Effect

Ground Gap (mm)	BW (GHz)	Resonant Frequency (GHz)	Reflection coefficient (dB)
0.8	9.51	3.84	-29.97
		10.14	-31.09
1.3	5.67	3.71	-33.3
	3.23	10.4	-26.5
2	5.35	3.53	-21.6
	2.66	11.98	-14.59
0	3.28	4.66	-19
	2.31	9.3	-20.03
	1.81	11.79	-22.5

Another parametric study does to observe effect of gap between partial ground and patch. Partial ground mainly used to match impedance. Ground width changes which reduces gap between patch and partial ground. Optimized dimensions which keeps gap between ground and patch as 0.8mm gives good result of proposed design. As gap increases bandwidth of proposed antenna is decrease. Also observes to lower gap that cause for multi resonance and hence wideband antenna is turned to multiband antenna. To achieve broad band response gap between patch and ground kept as less as possible as it functions like dipole antenna.

5.2 CURRENT DISTRIBUTION

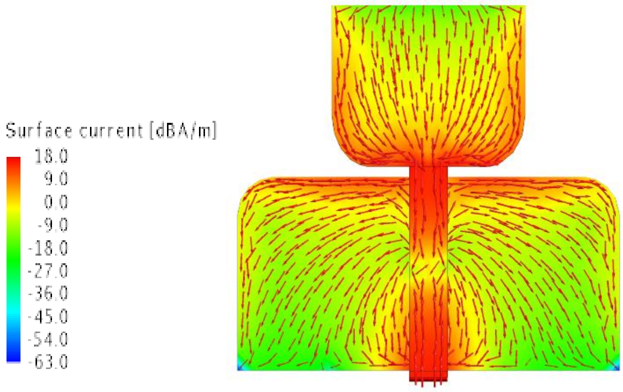

Fig.13. Current Distribution of Proposed wide band Antenna 2 for frequency 3.83GHz

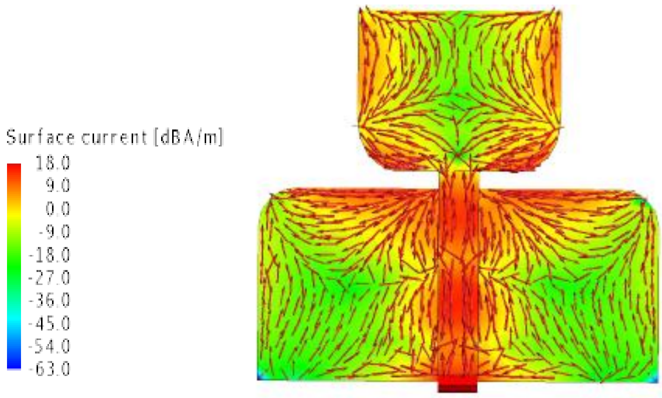

Fig.14. Current Distribution of Proposed wide band Antenna 2 for 10.14GHz

The simulated far field radiation pattern of Antenna 2, shown in Fig.6, Fig.7, Fig.8 and Fig.9 in E plane and H plane resonating at 3.83GHz, and 10.14GHz. E Plane Co and Cross radiation pattern and H plane CO and Cross radiation pattern shows good radiation of CO field components as compare to cross filed components. Radiation performance of design antenna 2 is studied by surface current distribution at Centre frequency of 3.83GHz and 10.14GHz. Current distribution of first resonating frequency is linear in nature shows excitation of fundamental mode TE_{00}. Current distribution for higher resonating frequency shows excitation of higher mode TE_{11}. Designed antenna shows good matching between microstrip feed line and patch to deliver maximum power to patch.

Table.3. Simulated Results

Antenna	Impedance Bandwidth (GHz)	VSWR Bandwidth (GHz)	Gain dBi
Reference Antenna	9.10	9.21	3.02
Proposed Antenna	9.51	9.62	2.87

Proposed design structure resonates to frequency range from 3.18GHz to 12.8GHz with VSWR < 2 with good impedance matching. Gain of proposed design is good at lower resonance that is of 2.87dBi. More smooth corners of radiating patch resonate with wide bandwidth.

6. CONCLUSION

Corner rounded microstrip line feed wideband patch antenna with corner rounded partial ground structure is presented. The simulated results show that the proposed design gives VSWR band width of 9.51GHz with gain of 2.87dBi. Which covers Ultra-Wide Band. It is observed that by making smoother corner from sharp edge to lower corners of radiating patch enhancement in bandwidth is observed from 9.10GHz to 9.51GHz as compared to reference antenna. This proposed structure is suitable for biomedical applications. This antenna can be further modify using slotting and loading of parasitic technique to get stable radiation pattern throughout the resonance. This will be the focus of further research

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