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Corner Cut Wide Band Microstrip Patch Antenna for Biomedical Applications

D. D. Ahire
Assistant Professor
Matoshri College of Engineering and Research Centre, Nashik
Savitribai Phule Pune University, Pune

G. K. Kharate
Professor
Matoshri College of Engineering and Research Centre, Nashik
Savitribai Phule Pune University, Pune

ABSTRACT
In this research work a square corner cut rectangular wide band microstrip patch antenna is presented. A FR4 substrate is used to design a reference antenna of size 28×37 mm^2 with partial ground structure feed using microstrip line and results are observed for impedance bandwidth, radiation patterns and antenna gain with the help of CADFEKO, proposed wide band antenna which is design on the FR4 substrate with Partial ground structure and square notch at the lower corners on radiating patch. Results are observed from simulated design and presented current distribution for the same. Simulated impedance band width is 4.21GHz (2.99GHz-7.2GHz). Gain is up to 2.049dBi. Improvement in design antenna is studied, comparison carried out between these designs. Proposed antenna VSWR bandwidth enhance from 31.8GHz to 4.21GHz.

Keywords
Microstrip Line; Partial Ground; Square Notch; Wide Band; VSWR bandwidth

1. INTRODUCTION
Today's Wireless Technology needs a contender which fulfills need of compactness, simply fit with microwave circuits to make systems portable & multiband operations with wide bandwidth. In recent times most of the biomedical applications wants wide bandwidth Microstrip Patch Antenna. Enormous research is going on to achieve Wideband designs. FCC defines UWB band which is suitable for biomedical application from 3.1GHz to 10.6GHz.

Microstrip Patch Antenna is a major device which plays very important role in Ultra-Wideband (UWB) system, Ultra-Wideband Technology is in its initial stage, with a huge competency. This technology shows a notable mark of capability and have a major strength in the wireless communication in upcoming years. UWB can be used in biomedical applications. Microwave imaging is one of the biomedical application, which is used to detect Breast cancer in its primary stage. Many research groups proposed techniques to achieve wide band performance, embedding Metamaterial, introducing various shapes slots, shorting pin, defective ground structure, CPW feed. Metamaterial technology is used to miniaturize antenna and also enhance efficiency of antenna. Slotting technique is introducing to match desire impedance and enhance bandwidth of micro strip patch antenna. U slot, T slot shapes have been presented P shape slot incorporated to design a UWB device to be used for Microwave imaging technology Matching have been achieved by selecting wide slot on patch. To improved broader bandwidth by using RT Duroid substrate. [1]-[5].

Latest advance wireless communication needs compact and mobile devices with multiband operation capability antennas. All needs are completed by microstrip patch antennas which are suitable for microwave integrated circuits. These antennas have few limitations to fulfill these requirements that is of less bandwidth and gain. Research have been undertaking to achieve the bandwidth and gain. Now a days slotting technique widely used to attain multiresonant wideband performance. Other methods such as shorting pin, meandering, stacking or use of high thickness substrates have been implemented to overcome the limitations of microstrip antenna. Embedding metamaterial to achieve compact design and use of high thickness material to enhance bandwidth. [6]-[18].

Analysis have been carried out to find impedance of slot loaded microstrip patch antenna [19]-[22]

2. RECTANGULAR MICROSTRIP PATCH ANTENNA DESIGN
Antenna1 is a reference rectangular antenna, geometry structure shown in Fig.1 The antenna structure is designed on 1.6mm thick FR4 substrate having εr of 4.4 using approximate transmission line equations [21]-[22].

Calculated dimension of rectangular microstrip patch antenna is Lp=28mm, Wp= 37mm. Antenna is fed through microstrip line with 3mm × 30mm with full partial ground structure.

Antenna 1 geometry has partial ground structure (28mm × 70mm) and square notches are introduced at lower corner of radiating patch with dimension of (5mm × 5mm). This structure resonates at 3.18GHz, it has been observed that square notch is changes current length and tune to single resonating frequency. Multi resonating structure tunes to single frequency when square notch is etched out on radiating patch. VSWR bandwidth is observed to be 2.97GHz(1.59GHz-4.56GHz) with gain of 1.40dBi

Microstrip feed line is design to match impedance with microstrip patch. Analysis of feed line is carried out using L and C values and find out frequency of feed line.

Dimensions of Geometry

1 Width of Substrate,	2 Length of Substrate
3 Width of Ground,	4 Height of Substrate
5 Width of Patch,	6 Width of Feed Line
7 Length of Patch,	8 Length of Feed

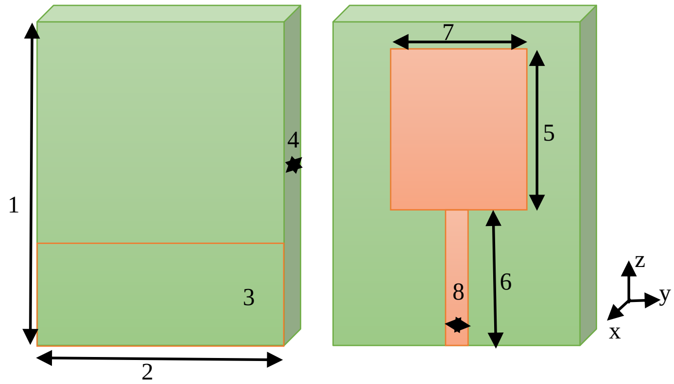

Fig 1: (a) Partial Ground Structure (b) Radiating Patch

Antenna 2 geometry is modifying by introducing square notch to upper corners of ground with dimension of (5mm × 5mm) resonates at 2.59GHz further improvement in VSWR bandwidth is observed is of 3.29GHz (1.63GHz-4.92GHz) with gain of 2.35dBi

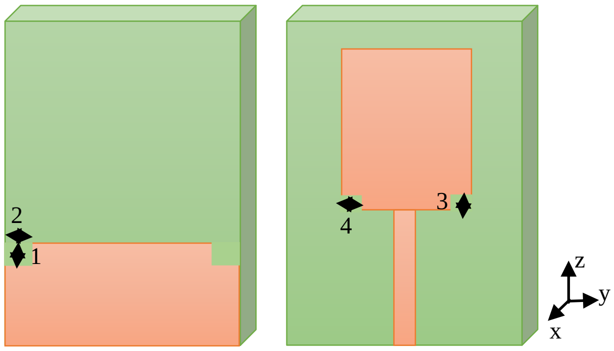

Fig.2(a) Notch cut ground structure(b)Notch cut radiating patch

1 Width of ground slot, 2 Length of ground slot
3 Width of patch slot, 4 Length of patch slot

Antenna 3 geometry is modifying by introducing square notch to upper corners of ground with dimension of (5mm × 5mm) resonates at 6.25GHz further improvement in VSWR bandwidth is observed is of 4.21GHz (2.99GHz-7.2GHz) with gain of 2.049dBi

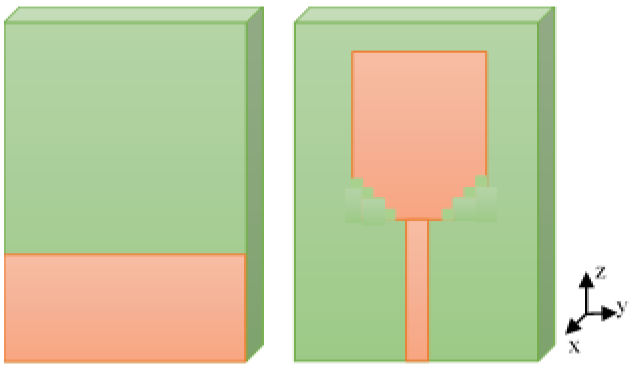

Fig.3(a) Partial Ground Structure (b)Notch cut Radiating Patch

With this structure VSWR bandwidth is improved up to 4.21GHz from multiband resonating antenna to single tuned wide band design. To enhance the performance of antenna square notch on radiating patch well use of partial ground structure. lower corners of patch etched out in square shape shows enhancement of VSWR bandwidth.

Radiation pattern of proposed antenna shows E plane and H Plane field. E filed pattern shows effect of notches etched out on patch as compared to antenna 1 and antenna 2

3. SIMULATED RESULTS

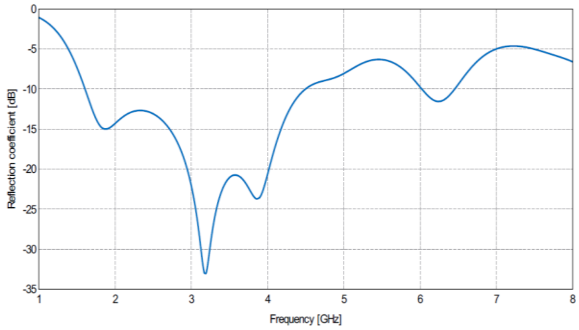

Fig 4: Simulated Reflection coefficient of Antenna1

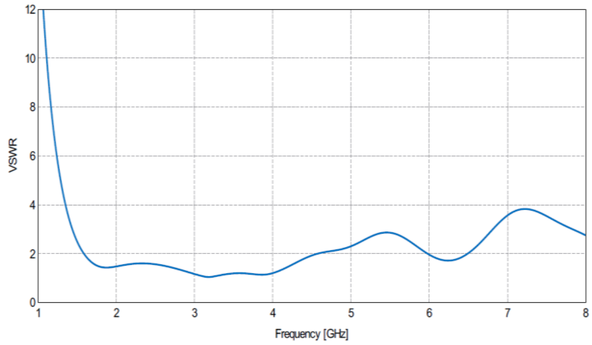

Fig 5: Simulated VSWR Band width of Antenna1

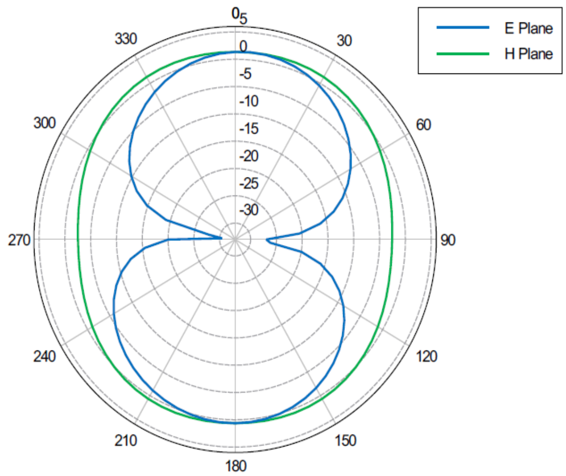

Fig 6. Simulated result of Radiation Pattern of Antenna 1

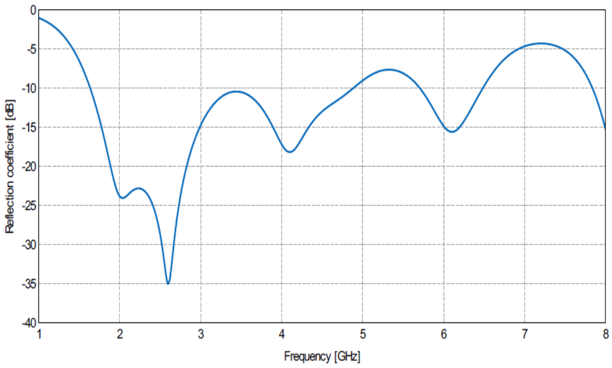

Fig 3: Simulated Reflection Coefficient of Reference Antenna2

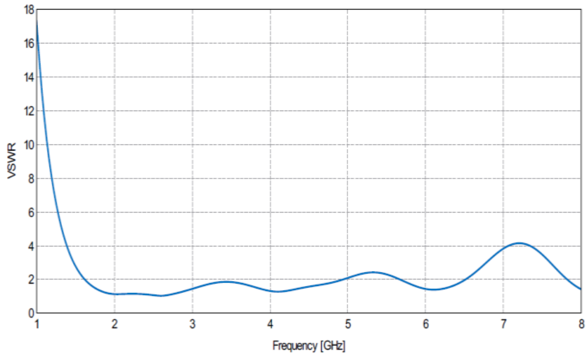

Fig 7: Simulated VSWR Band width of Antenna2

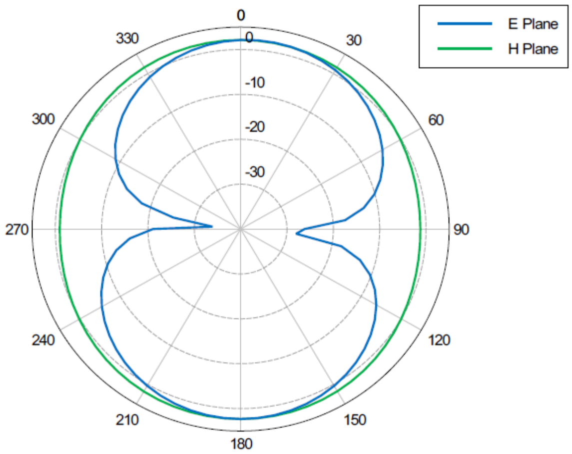

Fig 8. Simulated result of Radiation Pattern of Antenna 2

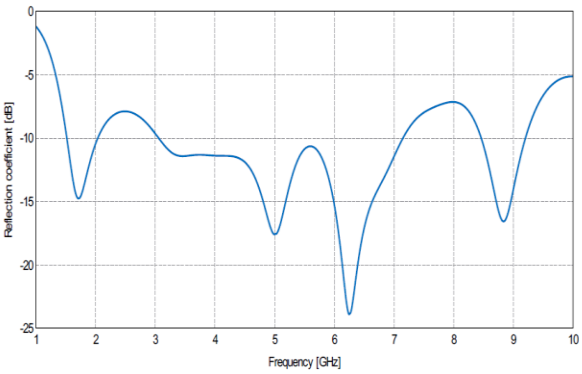

Fig 9: Simulated Reflection coefficient of Antenna3

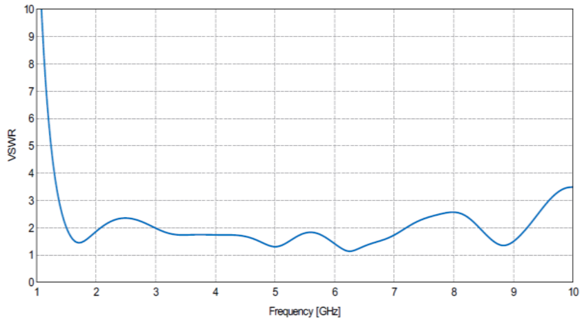

Fig 10: Simulated VSWR band width of Antenna3

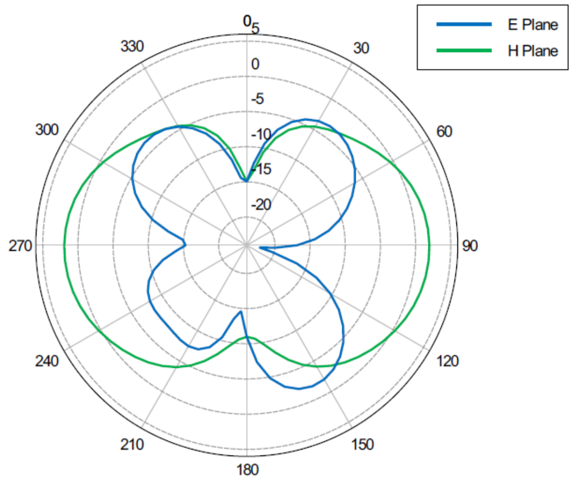

Fig 11. Simulated result of Radiation Pattern of Antenna 3

4. DESIGN EQUATION

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

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

$$L_1 = \frac{1}{C_1\omega_r^2} - iii$$

$$Q = \frac{c\sqrt{\varepsilon_e}}{4\,fH} - iv$$

where:

L =Length of rectangular patch
W =Width of rectangular patch
X_0 =y coordinate of feed point
H =Thickness of the substrate material
ε_e = effective permittivity of the medium

Microstrip Line

$$L_L = 100.H(4\sqrt{W_s/H} - 4.21)\,\text{nH} - v$$

$$C_L = W_s\{(9.5\varepsilon_r + 1.25)W_s/H + 5.2\,\varepsilon_r + 7.0\}\ pF - vi$$

Resonance frequency of transmission line is given by

$$f = c/2L_e\sqrt{\varepsilon_{re}} - vii$$

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

4.1 Parametric Study

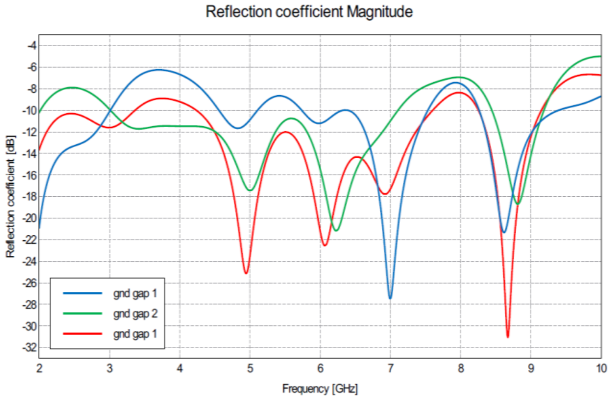

Fig 12. Reflection Coefficient graph for different ground and patch gap

Table 1 Ground Gap Effect

Ground GaP (mm)	B.W (GHz)	Resonant Frequency (GHz)	Reflection coefficient(dB)
1	3.34	4.94	-25.13
	0.896	8.67	-31.09
2	4.21	6.25	-21.18
	0.730	8.81	-18.69
0	1.13	6.998	-27.33
	1.12	8.63	-21.3

Parametric study observes gap between partial ground and patch of antenna 3, effect on bandwidth of design. Partial ground mainly used to match impedance. Ground width changes which reduces gap between patch and partial ground. Optimized dimensions give good result of proposed design.

4.2 Current Distribution

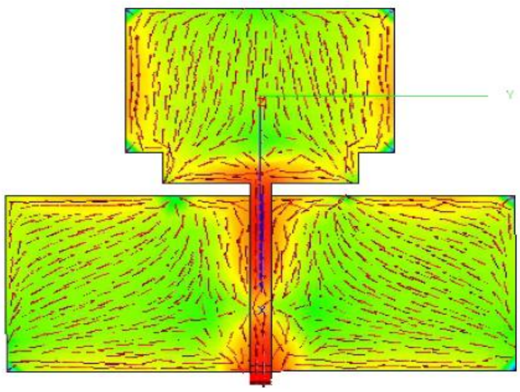

Fig.13 Current Distribution of Proposed wide band Antenna 1

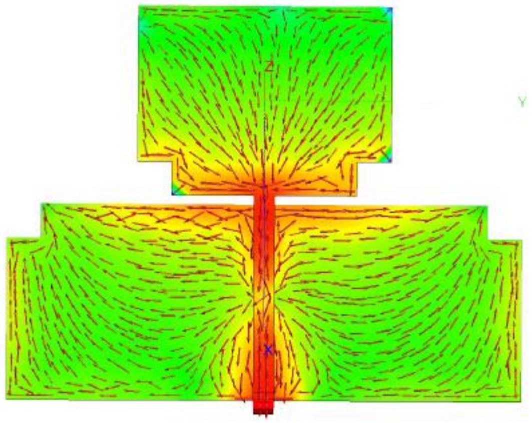

Fig.14 Current Distribution of Proposed wide band Antenna 2

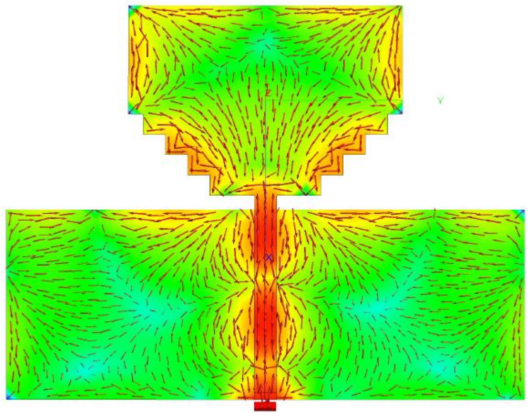

Fig.15 Current Distribution of Proposed wide band Antenna 3

The simulated far field radiation pattern of Antenna 1, Antenna 2 and Antenna 3 shown in Fig.6, Fig.8 and Fig.11 in E plane and H plane resonating at 3.18GHz, 2.59GHz and 6.25GHz Radiation performance of design antenna1, antenna2 and antenna3 is studied by surface current distribution at Centre frequency of 3.18GHz, 2.59GHz and 6.25GHz. Current in first two designs is linear and proposed antenna with square cut notch changes current direction helps to be a wide band design. Designed antenna shows good matching between microstrip feed line and patch to deliver maximum power to patch.

5. RESULTS AND DISCUSSION

Table 2: Comparison of simulated designs

Antenna	Resonance Frequency (GHZ)	VSWR B.W(GHz)	Gain (dBi)
1	3.18	2.97	1.40
2	2.59	3.29	2.35
3	6.25	4.21	2.049

Proposed design structure resonates to frequency range from 2.99GHz to 7.2GHz with VSWR <2 with good impedance matching.

5.1 Conclusion

Corner cut microstrip line feed wideband patch antenna with partial ground structure is presented. The simulated results show that the proposed design gives VSWR band width of

4.21GHz(2.99GHz-7.2GHz) with gain of 2.0049dBi. Which comes in Ultra-Wide Band(3.1GHz-10.6GHz). It is observed that by cutting square notch to lower corners of radiating patch improvement in bandwidth by 1.03GHz as compared to reference antenna. This proposed structure is suitable for biomedical applications. This antenna can be further use to design UWB system by using slotting and shorting pin technique to detect malignant tumors in breast at infancy. This will be the focus of further research

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