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Bandwidth Enhancement of Compact Rectangular Microstrip Patch Antenna

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Bandwidth Enhancement of Compact Rectangular Microstrip Patch Antenna

Vivek Singh Rathor [α] & J. P. Saini [σ]

Abstract- A compact single feed rectangular microstrip patch antenna using dielectric substrate 4.2, loss tangent .0012 and having substrate height of 1.6 is used. The compact antenna of dimension (14mm X 18.6mm X 1.6mm) is used and analyzed on MoM based simulating software IE3D. A probe of different radius has been taken to improve the Bandwidth of the proposed structure. Simulation results show that antenna can realize wide band characteristics and single band of 4.148 GHz (impedance bandwidth of 76.53%) has been achieved.

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I. Introduction

Microstrip patch antennas are popular for their well-known attractive features of low profile, light weight, and compatibility with monolithic microwave integrated circuits (MMICs). Because of their attractive feature they are in great demand in wireless communication applications. The main disadvantage of this microstrip antenna narrow bandwidth, which is due to the resonant nature of the patch structure.[4] Conventional microstrip antennas in general have a conducting patch printed on a grounded microwave substrate, and have the attractive features of low profile, light weight, easy fabrication, and conformability to mounting hosts.[1] However, conventional microstrip patch antenna suffers from very narrow bandwidth, typically about 5% bandwidth with respect to the center frequency. This poses a design challenge for the microstrip antenna designer to meet the broadband techniques [3]. To overcome this problem of narrow bandwidth, many proposals and techniques have been analyzed and investigated such as probe fed stacked antenna, microstrip patch antennas on electrically thick substrate, slotted patch antenna and stacked shorted patches, the use of various impedance matching and feeding techniques, the use of multiple resonators. [14] The development of antenna for wireless communication also requires an antenna with more than one operating frequency. This is due to many reasons, mainly because there are various wireless communication systems and many telecommunication operators using various frequencies. Therefore one antenna that has multiband characteristic is more desirable than having one antenna for each frequency band. [7] Our aim is to increase the operating bandwidth the simulation has been carried out by IE3D.

So we want an antenna which offers a low profile, wide bandwidth, compact antenna element. Among these standards, the following frequency bands can be mentioned: (1) PCS-1900 requires a band of 1.85–1.99 GHz; (2) IEEE 802.11b/g requires a band of 2.4–2.484 GHz; (3) IEEE 802.11a requires a band of 5.15–5.35 GHz and an additional band of 5.725–5.825 GHz; (4) HiperLAN2 requires a band of 5.47–5.725 GHz besides the band of 5.15–5.35 GHz. [2, 6, 7, 12]

To overcome the above problem, a microstrip antenna structure with a typical Kite symbol shaped patch is proposed which exhibits good enhanced impedance bandwidth of up to 76.53% depending upon the radius of probe.

II. Antenna Design

The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth, The resonant frequency of microstrip antenna and the size of the radiation patch can be similar to the following formulas while the high dielectric constant of the substrate results in smaller size of antenna [1].The Length of ground plane of Antenna is 24 mm and Width is 28.2 mm, L & W of the patch is 14 mm & 18.6 mm the radius of the coaxial probe feed is taken as 0.5 mm. The material used for substrate is glass epoxy with dielectric constant of 4.2, loss tangent .0012 and substrate height of 1.6 mm. The proposed structure is shown in fig 1.

The patch width, effective dielectric constant, the length extension and also patch length are given by

$$W = \frac{c}{2f\sqrt{\varepsilon_r}} \qquad (1)$$

where **c** is the velocity of light, ε_r is the dielectric constant of substrate, f is the antenna working frequency, W is the patch non resonant width, and the effective dielectric constant is ε_{eff} given as,

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 10\frac{H}{W}\right]^{-\frac{1}{2}} \qquad (2)$$

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The extension length Δ is calculates as,

$$\frac{\Delta L}{H} = 0.412\frac{\left(\varepsilon_{eff} + 0.300\right)\left(\frac{W}{H} + 0.262\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{W}{H} + 0.813\right)} \quad (3)$$

By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta L \quad (4)$$

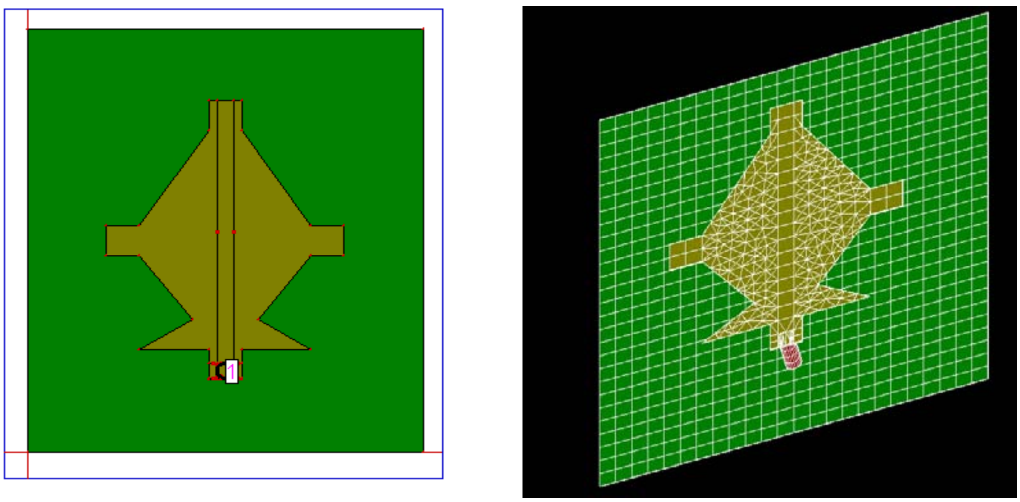
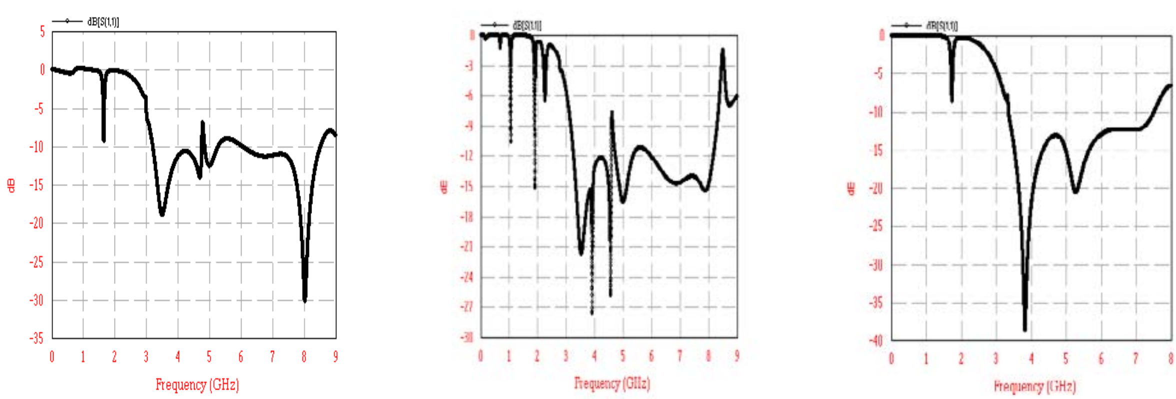


Figure 1 : Top view of the microstrip patch antenna

III. Simulated Results

In this section various parametric analysis of the proposed antenna are done and presented. Parameter of the antenna has been investigated to improve bandwidth, gain and return loss performance of the antenna. The return loss plot of structure with probe of different radius is shown is shown in fig 2 (a, b, c)



(a) (b) (c)

Figure 2 : Return loss plot of the microstrip patch antenna with probe of different radius (a).5mm (b) 0.4mm (c) 0.16mm

In proposed antenna the return loss is -18dB at 3.5 GHz and -30 dB at 8GHz. While the frequencies range of band below -10 dB and VSWR < 2 is 3.208 GHz - 4.763 GHz, 4.853 GHz - 5.293 GHz and 6.029 GHz-8.533 GHz shown in fig 2(a). We can see that there is no resonant frequency at 3.9GHz and 4.5 GHz in fig 2 (a) while in fig 2 (b) return loss at 3.9 GHz Frequency is around 28 dB and at 4.5GHz it is 26 dB, at 3.5 GHz we get the return loss of around 22 dB. The frequency range we are getting below 10 dB and VSWR < 2 is 1.899GHz – 1.912GHz, 3.189GHz – 4.601GHz and 4.655GHz – 8.29 GHz. In fig 2(c) the return loss at around 3.9 GHz is around 39 dB and band below 10 dB (VSWR < 2) is ranging from 3.362 GHz – 7.53GHZ.

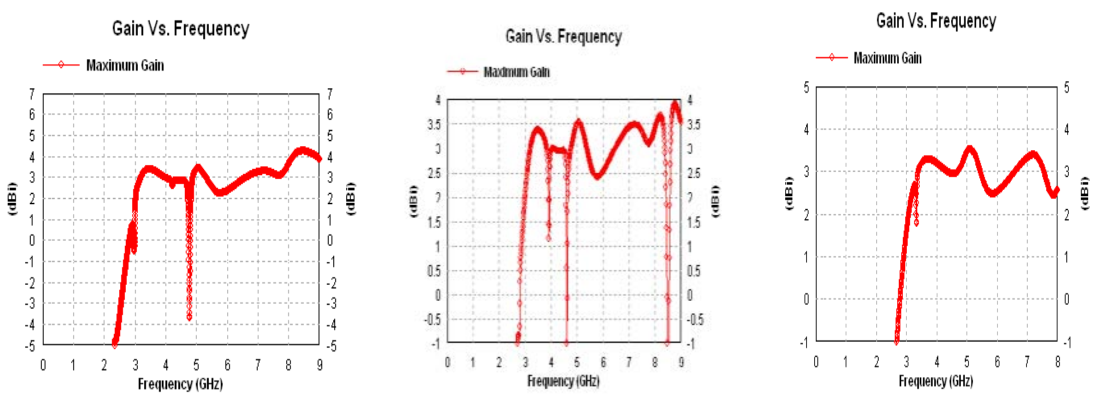
a) Effect of Parameter (radius r of probe) on Band of Proposed Design

If the radius of the probe is decreased from 0.5 mm to 0.4 mm dramatically changes will appear in the result. We can see the details given in table 1, we are getting three bands of frequency in first structure when radius is 0.5 mm but when we decrease the radius we get two band in which we get the bandwidth of 36.25% in first band and 56.16% in the second band the max. Gain remains the same in band 1 as in the previous case but in band two the max. Gain is reduced by only 0.5 dBi. Max. Efficiency remains almost same and max. Directivity is around 6.5 dBi. Now if we further decrease the radius of probe from 0.4 mm to 0.16 mm (sl.no.3, fig.1) we achieve impedance bandwidth of 76.53 % which is almost double the frequency in the first stage when radius of the probe is 0.5 mm with max. Gain of 3.5 dBi, efficiency 90 % and max. Directivity of 5.5 dBi.

Table 1 : Parameters on probes of different radius

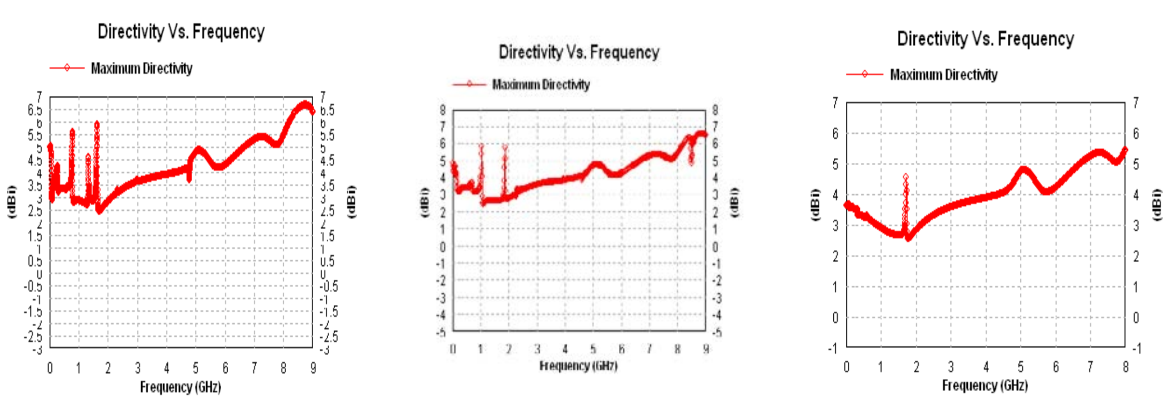
Serial No.	Radius of probe	Band of Freq. (in GHz)	%Bandwidth	Max. Gain	% Efficiency	Max. Directivity
1	0.5 mm	3.208 - 4.763 4.853 - 5.293 6.029 - 8.533	39.02 % 8.67 % 3.39 %	3.5 dBi 3.5 dBi 4.5 dBi	90% 65 % 65 %	6.75 dBi
2	0.4 mm	3.189 – 4.601 4.655 – 8.29	36.25 % 56.16 %	3.5 dBi 4.0 dBi	90 % 75 %	6.5 dBi
3	0.16 mm	3.362 – 7.53	76.53 %	3.5 dBi	90 %	5.5 dBi

Total gain versus frequency plot is shown in fig3.Max. Directivity versus frequency plot and efficiency versus frequency plot are shown in fig 4 and 5. 3D Radiation pattern plot, 2D Elevation Pattern Gain display plot and 2D azimuth pattern Gain display plot is shown in fig.6, 7 and 8 respectively.



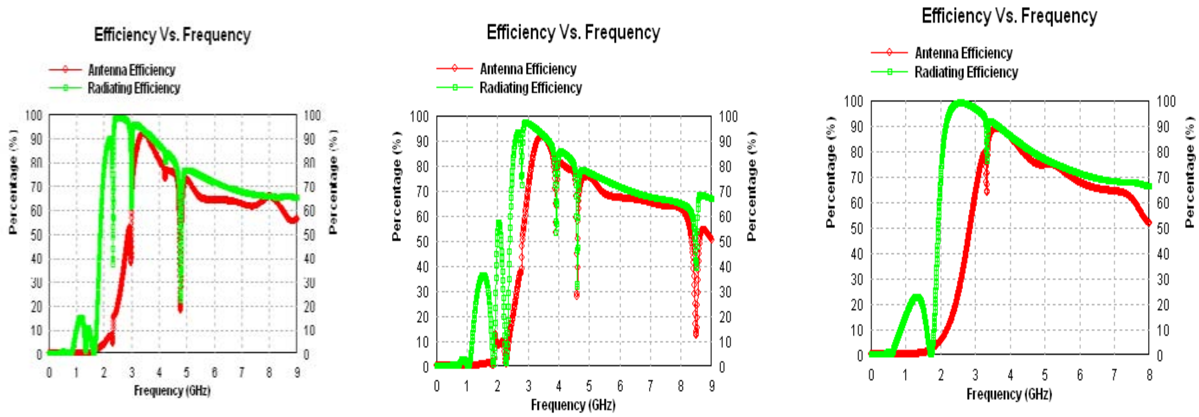
(a) (b) (c)

Figure 3 : Maximum gain plot of microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



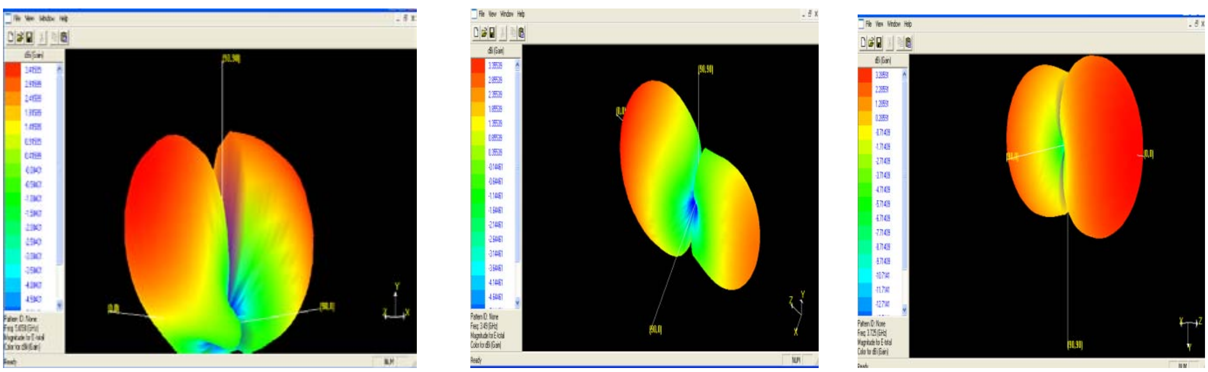
(a) (b) (c)

Figure 4 : Directivity versus frequency plot of microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



(a) (b) (c)

Figure 5 : Efficiency versus frequency plot of the microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



(a) (b) (c)

Figure 6 : 3D Radiation pattern plot of the microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm

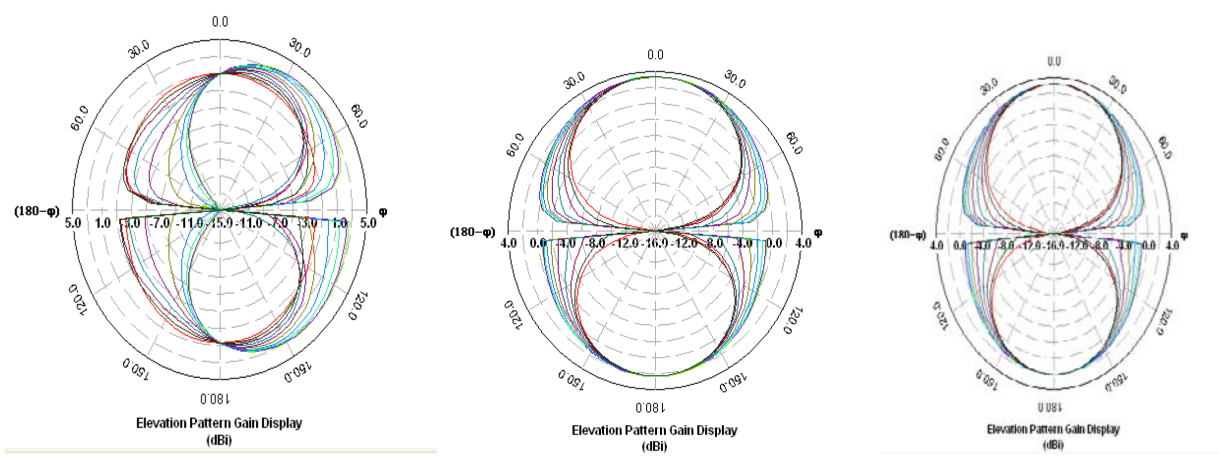
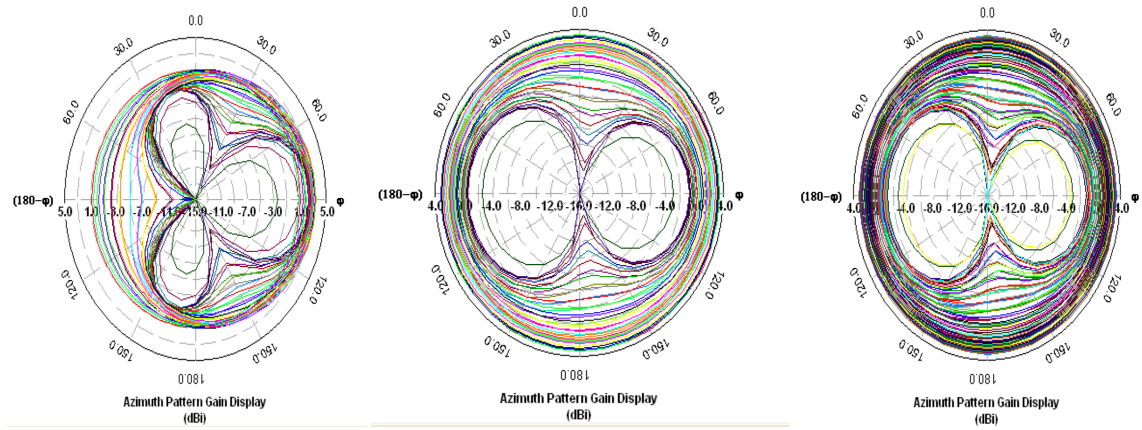


Figure 7 : 2D Elevation Pattern Gain Display (dBi) for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



(a) (b) (c)

Figure 7 : 2D Azimuth Pattern Gain Display (dBi) for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm

IV. Conclusion

In this paper a compact size microstrip antenna has been designed having good impedance matching as well as high antenna efficiency of about of about 90% is achieved by changing the radius of the probe. The impedance band width has been enhanced from 39 % to 76.53 %. The proposed antenna have larger impedance bandwidth of 76.53% covering the frequency range from 3.362 GHz -7.53 GHz which is suitable for WLAN (upper band application).

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