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Star Shape Slotted Microstrip Patch Antenna for Wireless Application

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ABSTRACT

In this paper three rectangular microstrip patch antennas is designed on the FR4 glass epoxy substrate having the thickness of 1.6 mm. The two antennas contain slots in the form of six corner star. The feeding techniques used in all designs are probe feed. The multiband behavior of printed antennas is analyzed using two slotted structure of rectangular patch antenna. The perposed patch antennas cover the multiband behavior from 1.6 GHz to 6 GHz. The designed antennas are simulated using IE3D electromagnetic simulator. The electrical parameter of the antenna such as return loss, radiation pattern and VSWR exc. are investigated .The simulated antennas is used for wireless application such as IEEE 802.11 (a,b,g and n).

Keywords: *IE3D; Star; Multiband; Slotted.*

1.0 Introduction

The rapid progress in wireless communications requires the development of low-profile, lightweight, flush-mounted and single-feed antennas. Also, it is highly desirable to integrate several radio frequency modules for different frequencies into single piece of equipment. Hence, multi-band antennas that can be used simultaneously in different standards have been in the focus points of many research projects [1]. A microstrip patch antenna has a conducting patch that made of metals such as copper or gold, printed on a grounded dielectric substrate [2]. A large number of microstrip patches to be used in wireless applications have been developed. Various shapes such as square, rectangle, ring, disc, triangle, elliptic, pentagonal, kite like, etc. have been introduced [3-6]. In comparison to patch elements, the antennas with slot configurations demonstrate enhanced characteristics, including wider bandwidth, less conductor loss and better isolation. The regular microstrip antennas configurations, such as rectangular and circular patches have been modified to rectangular ring and circular ring by cutting slots to enhance the BW. The larger BW is because of a reduction in the quality factor Q of the patch resonator, which is due to less energy stored beneath the patch and higher radiation [7]. Wireless local area network (WLAN) is rising its application in wireless communications. Antennas for portable WLAN device require broad band, high gain and compact design. As a result of these parameters multiband antenna techniques have attracted more attentions. Recently many new technologies have been proposed for multiband antenna design [8].In this paper slotted microstrip patch antennas are designed in the form of six corner star which can be obtained easily by overlapping two same dimensions triangles located at 900 to each other. Calculating all its geometric characteristics easily make this shape usage advantageous in microstrip patch antenna design. Although many star shape patch designs are available as in [8, 9], but the six corner star is different. In other star shape antenna studies, rather than a simple, single layer design with a single coaxial feed line, aperture-coupled feed, stacked geometry exc. different and more complex techniques are preferred. Performance simulations of antenna are performed on IE3D software, which is based on the method of moments [10].

2.0 Antenna Geometry

The basic design of microstrip patch antennas is given through the rectangular microstrip patch and runs through two slotted mictrostrip antennas to generate multiband characteristics. The initial dimension of the patch is taken at 2.4 GHz by taking the FR4/glass epoxy substrate and the height of substrate is 1.6 mm, loss tangent 0.02 and the relative

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dielectric constants of the substrate is 4.4. The basic formulae for length and width are given below [21.

$$W = \frac{c}{2f_0}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (1)$$

$$\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2}\left(1+\frac{12h}{w}\right)^{-\frac{1}{2}} \quad (2)$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{w}{h}+0.8)} \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

Where

c = Velocity of light in free space

f0=Operating resonant frequency

er = Relative dielectric constant

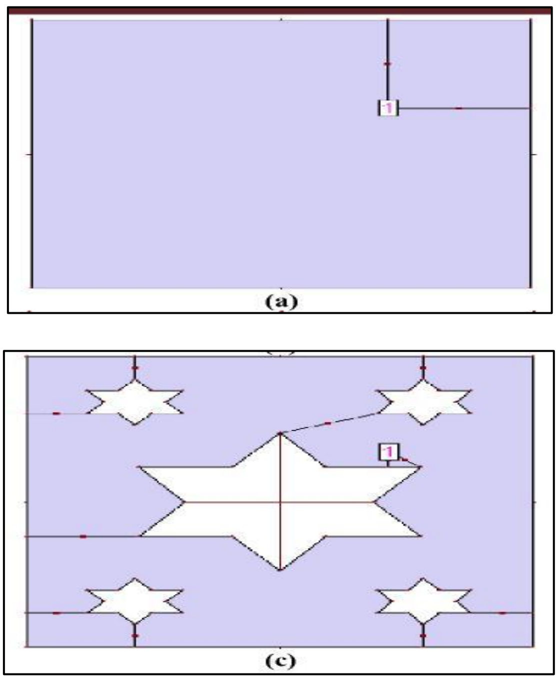
ereff =Effective dielectric constant of the substrate

h= Height of the substrate

W = Width of the substrate

Length and width of the rectangular patch is 28mm and 38 mm respectively. The single slotted geometry is found making a slot in the rectangular patch in form of star , this shape is designed by taking the two equilateral triangles of 10 mm approximately one third of the wavelength , centered at (0,0). In the five slotted geometry four additional star slots is made symmetrically by taking the triangles of

Fig 1: Antenna Layout (a) Base shape (b) Single Slotted Shape (c) Five Slotted Shape



dimension of one third of the center star coordinates (8,12.5), (8,-12.5), (-8,12.5) and (-8,-12.5).The symmetrical slots is made around the center slot so that cross polarization is reduced. In this study all the designs is probe fed and the excitation is done at the same points in patch antennas.

3.0 Results and Discussions

Fig. 2 shows the variation of return loss with the frequency for the base shape, single slotted patch antenna and five slotted patch antenna. The no. of resonating bands is three in base shape patch ,four in the single slotted patch antenna and five in the slotted patch antenna in which SI 1 is less than or equal to -10 dB.

Fig 2: Return Loss of Patch Antennas (a) Base Shape (b) Single Slotted Shape (c) Five Slotted Shape

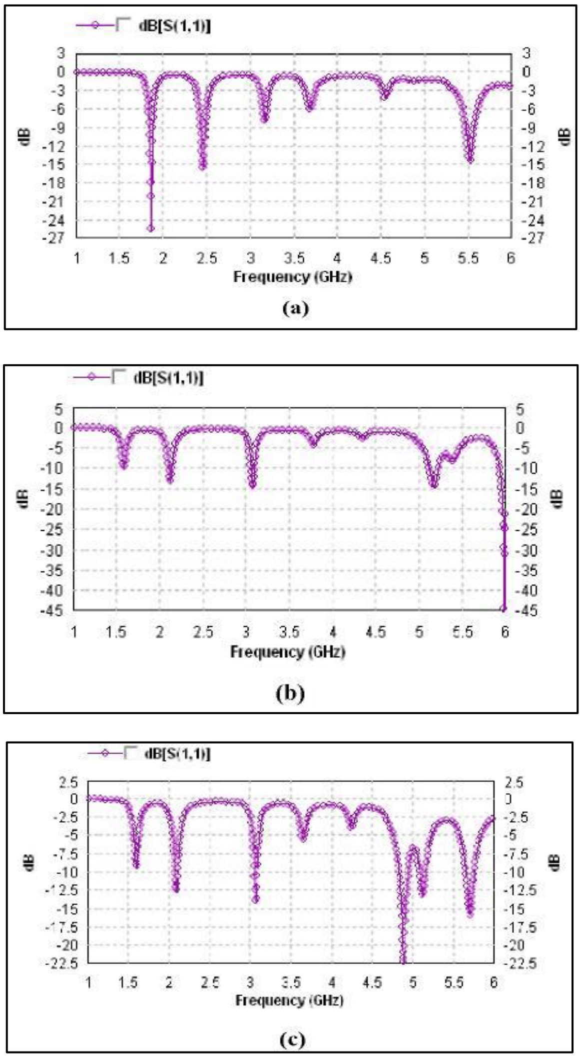


Table 1.0: Comparison of Return Loss for Base Shape, Single Slotted Shape and Five Slotted Rectangular Microstrip Patch Antenna

Base Shape Patch Antenna		Single Slotted Patch Antenna		Five Slotted Patch Antenna	
Frequenc y(GHz)	Retur Loss dB)	Freque cy(G z)	Retu rn oss (dB)	Freque cy(G z)	Retu rn oss (dB)
1.86	23.19	.12	13.5	.09	12.4
2.46	-15.6	3.07	-14.7	3.07	-14.2
5.52	-14.4	5.17	-14.5	4.88	-22
		5.93	-11.3	5.1	-13.2
				5.67	-15.7

The table has the values of return loss (< -10 dB) for different frequency points, from the table values it is quite clear that the antenna suits for various commercially available frequency range applications such as for GSM (1.86 GHz), ISM band (5 GHz), Wi-Fi IEEE 802.11(2.4-2.5GHz for 802.11 b, g and n) and (5.7-5.9 for 802.11 a & n). This shows that the proposed antenna has wide application range for commercial application.

The other important parameter such as directivity, efficiency and three dimension radiation parameter are also simulated of all designed printed antennas. Figure 3 shows the Directivity comparisons curve for designed patch antennas and it is seen that average directivity is 8 dBi and the maximum directivity reaches approximately lldBi.Figure 4 shows the efficiency comparison curve for the entire three designed patch antennas.

It is seen that efficiency is not so high because the substrate FR4 glass-epoxy taken has high value of loss tangent of 0.02, so the dielectric loss is high in the substrate and this material is less costly and easily available everywhere. In these comparison curves Violet color shows the single slotted patch, Green for five slotted and the black for base shape patch antenna results.

Figure 5 shows the three dimension radiation pattern of designed patch antennas. Figure 5(a) show the radiation pattern of the base shape patch antenna at the frequency 2.4 GHz, figure 5(b) show the radiation pattern of single slotted patch antenna at the frequency 5.15 GHz and figure 5(c) is the radiation pattern at a frequency 4.8 GHz. In all the three design the pattern are nearly Omni directional and shows the positive gain or we can say the antenna can be used as a transmitting as well as receiving antenna.

Fig 3: Antenna Directivity Comparison Curve for Base Shape, Single Slotted Patch and Five Slotted Patch

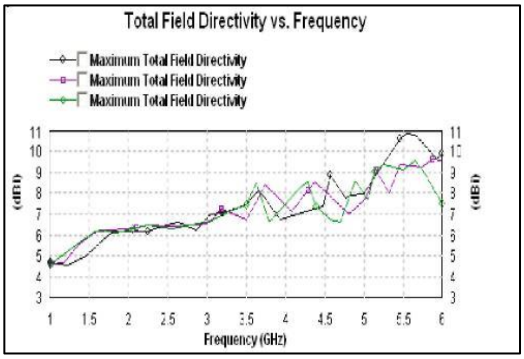


Fig 4: Antenna Efficiency Comparison Curve for Base Shape, Single Slotted Patch and Five Slotted Patch

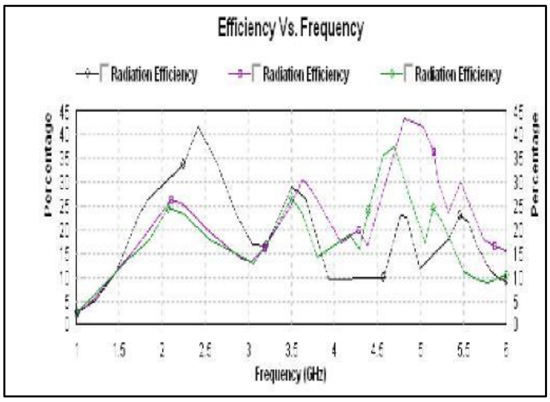
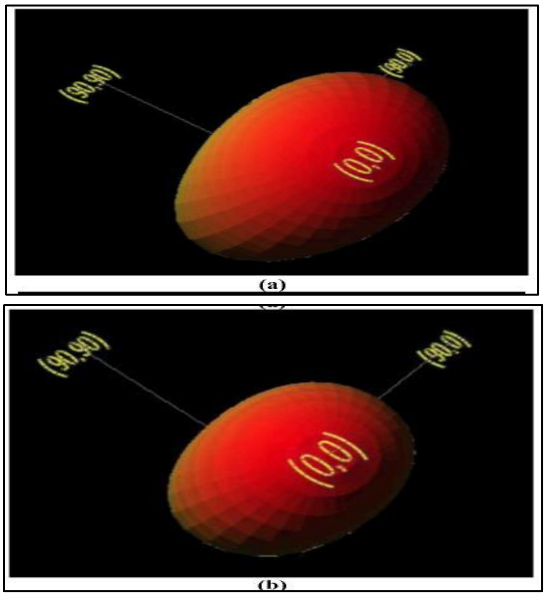
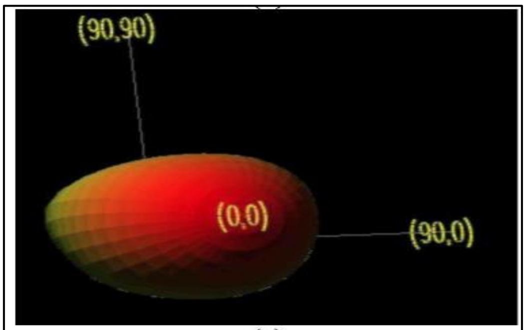


Fig 5: Antennas Radiation Patterns (a) Base shape (2.4 GHz) (b) Single Slotted Shape (5.15 GHz) (c) Five Slotted Shape (4.8 GHz)





(c)

4.0 Conclusions

In this paper a star shape multiband microstrip patch antennas is simulated. The proposed antennas have slotted geometry. The performances of the said antenna are studied for different number of slots. It is found that the as the number of slots are increased, the operational frequency band also increases. For base shape microstrip rectangular patch antenna three resonant frequency bands occur, for single slotted patch antenna five resonant bands occurs and for five slotted patch antenna six resonant frequency bands occurs. These antenna can be used at various application such as GSM and WLAN-IEEE-802.11 (a, b, g and n). Therefore the proposed antennas have satisfactory performance for use as a multiband communication antenna.

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