Design of Tri - band L Shaped Parasitic Patch Antenna

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Abstract

This paper proposed the Tri band antenna using L shape parasitic. The rectangular patch antenna works as driven element. FR4 is used as dielectric material. First the simple RMSA is design for frequency 2.4 GHz and after the effect of parasitic is considered. This proposed antenna covers the L, S, C bands with enhanced impedance bandwidth in each band.

Keywords- Wideband, L shape parasitic, RSMA, L, S, C Bands.

1. Introduction

In the recent years, multi and wide band antennas received an intense boost with innovative research works. Due to the demand of cheap, compact, and reliable microstrip planar antennas in the society, researcher motivates to design of such specific antennas. In long range communication applications, where the high gain and wide bandwidth are major factors, parasitic patch antennas are suitable and widely used.

The conventional microstrip patch antenna resonates at single frequency and has narrow bandwidth with low gain. Researchers have used numerous techniques to improve the gain and enhance the bandwidth of patch antennas.. Most of the work has done to increase the gain and widen the bandwidth for a single band. Few researches have done on multi wide band antennas .

Many techniques was reported and investigated for multi and wide band patch antennas. Dual and triple-band antennas were designed and used multiple monopole or dipole antennas with different operating frequencies [1,2], that creates multiple operation bands but introducing multiple antennas requires extra matching circuits and combining circuits. Another method to improve the bandwidth is increasing the substrate thickness [3] but surface wave power increases and radiation power decreases which lead to poor radiation efficiency, a multilayer antenna structure is also used for improving the impedance bandwidth [4] but this technique is costly. A parasitic patch with shorting vias are used to enhance the bandwidth [5], it covers only one band with 10 dB impedance bandwidth of 13.8 %. Again by using parasitic patch [6] it covers only one band with 10 dB bandwidth of 5.2 %. Triple band is obtained by using two parasitic elements and EBG structure [7]. It gives narrow bandwidth in each band.

In the proposed paper a triband parasitic rectangular patch antenna has designed. The proposed antenna consist of one “L" shape parasitic patch and a driven rectangular patch. This proposed parasitic patch antenna gives three resonances in L, S, and C bands with improved 10-dB impedance bandwidth in each band.

2. Design of microstrip patch antenna with L shaped parasitic patches

2.1 Analysis of the antenna antenna-1

The proposed geometry of Antenna 1 is shown in figure 1. The dimensions of basic rectangular patch antenna are calculated by the standard formulae as given [8].

$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_R + 1}{2}}} \tag{1}$$

$$\varepsilon_{eff} = \frac{\varepsilon_R + 1}{2} + \frac{\varepsilon_R - 1}{2}\left[\frac{1}{\sqrt{1 + 12\left(\frac{h}{W}\right)}}\right] \tag{2}$$

$$L = \frac{c}{2 f_0 \sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}\right) \tag{3}$$

Where
c = velocity of light
ε_R = relative permittivity of dielecric material
ε_{eff} = effective permittivity
h= height of the dielecric substrate
W= width of the patch
L= length of the patch
f_0 = resonant frequency

The proposed antenna is designed on the FR4 material having dielectric constant εr = 4.4 and thickness of 1.6 mm. The dimensions of the basic rectangular patch are calculated by the given equations for frequency of 2.4 GHz. And the value of length L and width W is 29.42mm and 38.01 mm respectively. Co-axial feeding technique is used to excite the antenna

Table 1. Dimensions of the proposed antenna.

L1	L2	L3	L4	W1	W2	W3	W4
66 mm	29.42 mm	40 mm	8.8 mm	66 mm	38.01 mm	9.8 mm	38.5 mm

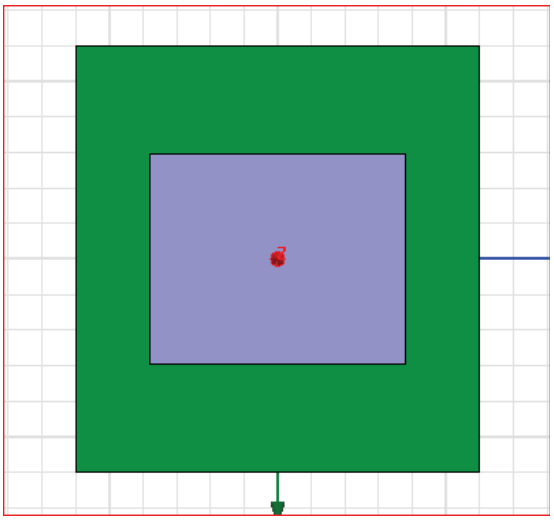

Figure1. Antenna 1 Simple rectangular patch antenna with coaxial feeding

2.2 Analysis of the antenna Antenna-2

The gap between the fed and the parasitic patches depends primarily on ε_r and h of the substrate. A good starting point for the value of the gap is around 0.8h for the radiating edge gap coupled RSMA and around 0.3h for the non radiating edge gap coupled RSMA.[9]. After parametric analysis on various parameters such as gap of the parasitic from the radiating and non radiating edge of the driven element, size of the L shape parasitic element, the dimension of 40X9.8 mm^2 at the side of non radiating edge and 8.8X38.5 mm^2 at the side of radiating edge of rectangular driven patch gives the best result. The size of the ground is 66X66 mm^2. The Antenna -2 is shown in figure 2. Table 1. Shows the dimensions.

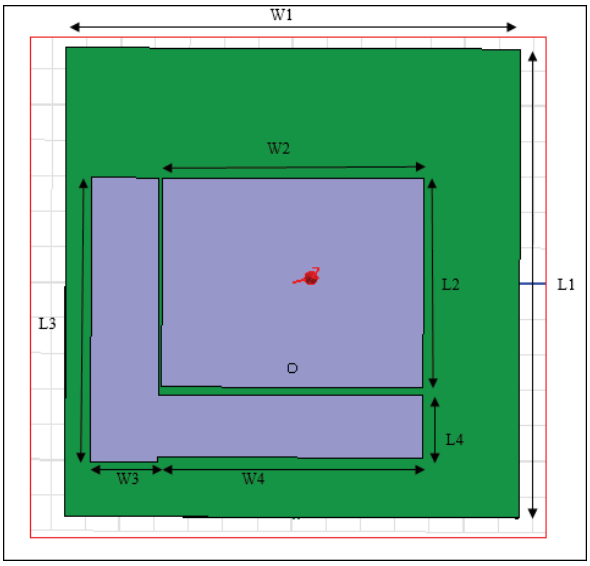

Figure2. Antenna 2 Simple rectangular patch antenna with L shape parasitic element

3. Results and Discussion

The simulation is done on HFSS 11.1 version. Antenna 1 single patch antenna has the return loss S_{11} as shown in the figure3.

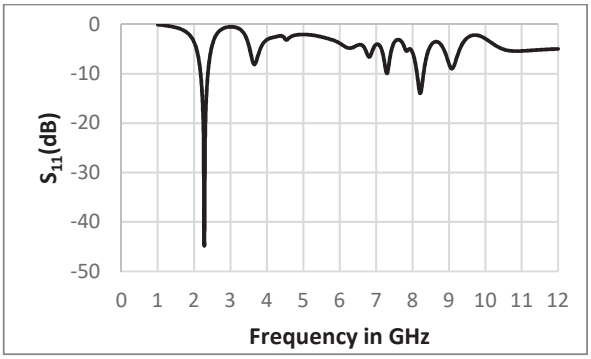

Figure3. Return Loss (S_{11}) vs Frequency Plot of Antenna1

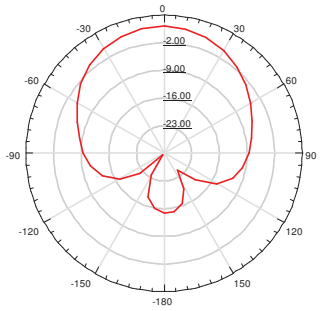

Figure4. 2D Radiation Pattern at Resonant Frequency

Figure 4 shows the 2D radiation pattern at 2.4 GHz. It shows that the radiation of the simple rectangular patch is the directional with 2.13 dBi gain.

The antenna 2 having single L shape parasitic element along with the patch. The return loss is given as

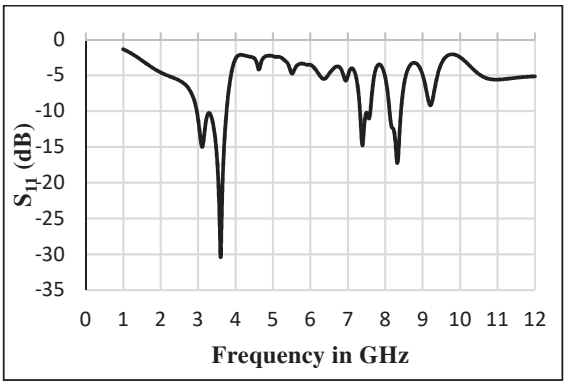

Figure5. Return Loss (S_{11}) vs Frequency Plot of Antenna2

According to the graph it is clear that due to parasitic element the antenna resonates at two more frequencies

which are at 7.39GHz and 8.32 GHz. And the radiation pattern at other frequency is given as

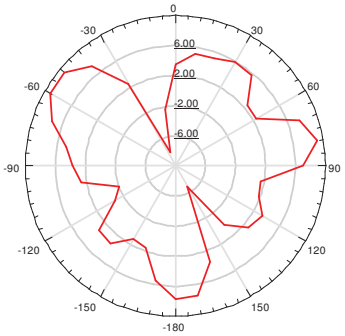

Figure 6. 2D Radiation Pattern at 3.60 GHz.

Fig 6 shows the 2D radiation pattern (at $\varphi=0^0$) at frequency 3.60 GHz. It shows that the gain at the bore sight is about 3dBi.

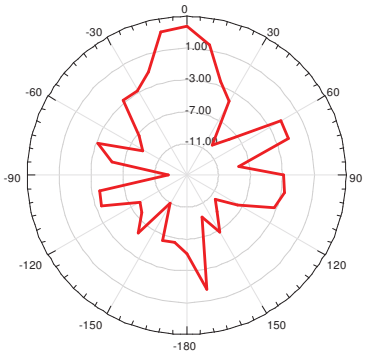

Fig 7. 2D Radiation pattern at 7.39 GHz.

Figure 7 shows 2D radiation pattern at frequency 7.39 GHz. It is directional with gain of 4.33dBi. Figure 8 shows 2D radiation pattern at 8.38 GHz. It has directional gain of 1.81dBi.

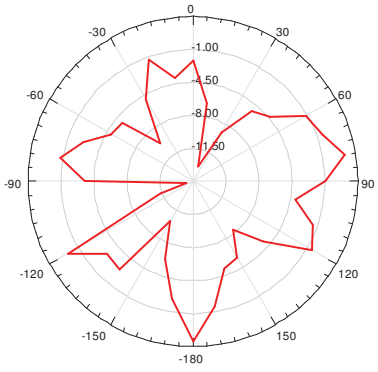

Fig 8. 2D Radiation pattern at 8.31 GHz.

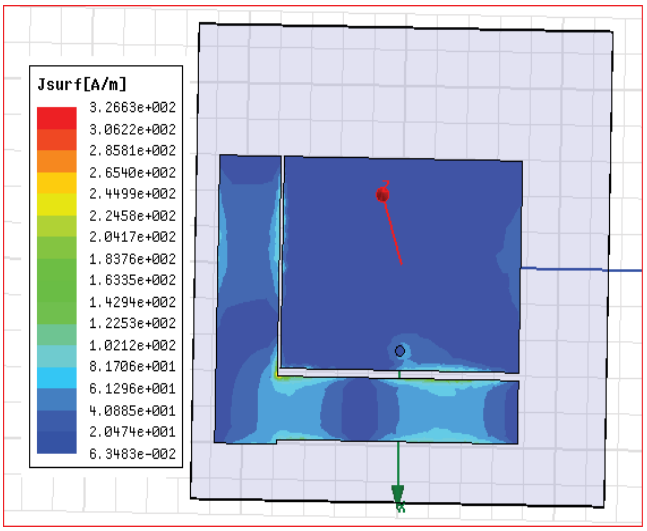

Figure 9. Current distribution at frequency 3.60 GHz

Figure 9 shows the current distribution at the frequency of 3.60 GHz. This shows that the current is induced in the parasitic element through the driven element. The radiating edge is highly coupled to the radiating edge to the patch and less coupled to the non radiating edge to the patch.

4.Conclusion

The proposed antenna is having one L parasitic patch along with rectangular driven patch. With the effect of parasitic patch,antenna gives multi wide band resonances. The simulated results of L shaped parasitic antennas show that the impedance bandwidths with $|S11| < -10$ dB range from 2.96 to 3.75GHz (23.54%) , 7.32 to 7.61 GHz (3.88%) and 8.12 to 8.43 GHz (3.74%) respectively.

V. References

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