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Design of Multiband Microstrip Radiating Structure for C band Application

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Abstract—In this paper Multiband microstrip patch antenna is designed and analyzed. Our Main objective to design this antenna is to achieve multiband applications which are required in today's scenario. Here, Patch of dimension $48\times48mm^2$ is analyzed. This design has eight bands but out of which we have four working bands centered around 4586 MHz, 5300 MHz, 6480 MHz and 7350 MHz which can be used for multiband application purposes. Design results of VSWR, Return loss S_{11}, Total Gain and Total Directivity is shown in this paper. Design results are obtained by a HFSS 11 (High Frequency Structure Simulator) which is used for simulating microwave passive components.

Index Terms—Microstrip, Multiband, C band.

I. INTRODUCTION

Nowadays, Multiband antenna is popular because same antenna can be used for many applications [12][15][16]. Microstrip patch antennas are widely used because of their many merits, such as the low volume, light weight, low cost etc. [1-8] However, Patch antennas have a main disadvantage: narrow bandwidth while others are low gain, low power handling capacity etc. [1-8]

In recent scenario, Microstrip patch antennas are widely used in wireless devices and other compact sizes with multiband antenna operation. The irregular shape of the developed planar antenna achieves multi-band (Broadband) performance [9]. In traditional planar antennas, the distances between the edges are fixed and therefore, the antennas dominant mode resonates only at a single frequency [9]. In contrast, the irregular shape of the current antenna facilitates, its broadband character by allowing the structure to have more than one degenerate mode that resonate at more than one frequency, based on the irregularity introduced [9]. In general, multi-sided patches are excellent candidates for broadband operation, since many closely spaced resonant modes can be excited using the different edges of the patches [9]. This property makes them uniquely suited for multi-band operation in wireless applications.

II. DESIGN AND MODELING

This section, we will introduce the design of our antenna. First the conventional patch length and width is designed. After designing the patch, we have taken out five slots from the patch to improve the radiation path. Basic length and width is designed with the use of following equations [5].

$$w = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}} \qquad (1)$$

Width of the patch can be designed using the equation (1), here f_0 is the resonance frequency, ε_r is relative permittivity of the dielectric substrate and c is speed of light.

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

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1+\frac{12t}{w}}}\right) \qquad (3)$$

$$\Delta L = 0.412t \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{w}{t} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{w}{t} + 0.8\right)} \qquad (4)$$

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

Length of the patch can be designed by using the equations (2-5) [5]. Here't' is the thickness of substrate. Using these equations we have designed length and width of conventional patch here.
Here we designed square patch so length and width are same and it is 48 mm, so a square patch is 48×48 mm^2

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over here which is shown in Figure 1. We have taken out five slots from the patch to increase the Radiation path and to improve the results as shown in figure. The slots taken out have dimension of 10×10mm^2. The top view and side view of the design is shown in Figure 1(a) and 1(b) respectively.

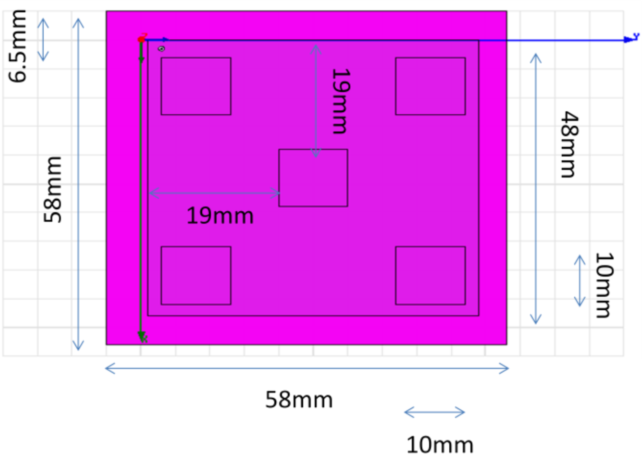

Fig. 1 (a) Actual HFSS Model (top view)

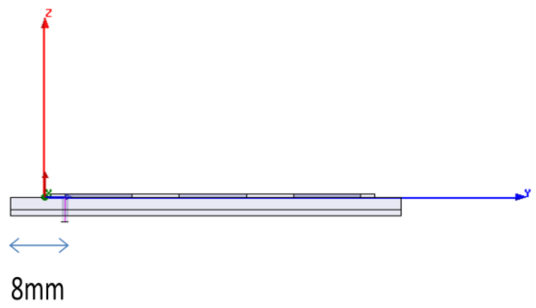

Fig.1 (b) Actual HFSS Model (side view)

Table: 1 Material used for patch antenna

	Material
Patch	Copper
Substrate	FR4 epoxy with ε=4.4

Table 1 shows details about the material. Patch is of copper material. Substrate is of FR4 epoxy material with ε=4.4. The base material is also of copper.

III. SIMULATION RESULTS AND DISCUSSIONS

For simulation we used HFSS 11 (High Frequency Structure Simulator) of Ansoft, which is very good simulator for simulating microwave passive components specially RF antenna.

Figure 2 shows the Return Loss (S_{11}) plot of the design and Table 2 shows values of Return Loss (S_{11}) in dB for different bands with their frequency. The minimum return loss which we are getting for this design is -27 dB for the band centered around 2.063 GHz

Table: 2 Return Loss (S11) values

Band	Frequency in GHz	Minimum Return Loss (S11) in dB
First	1.45	-14
Second	2.06	-27
Third	2.86	-16
Fourth	3.30	-14.9
Fifth	4.58	-22.7
Sixth	5.30	-24.6
Seventh	6.45	-23.5
Eighth	7.35	-22.2

Fig.2 Return Loss (S_{11}) parameter of the Antenna

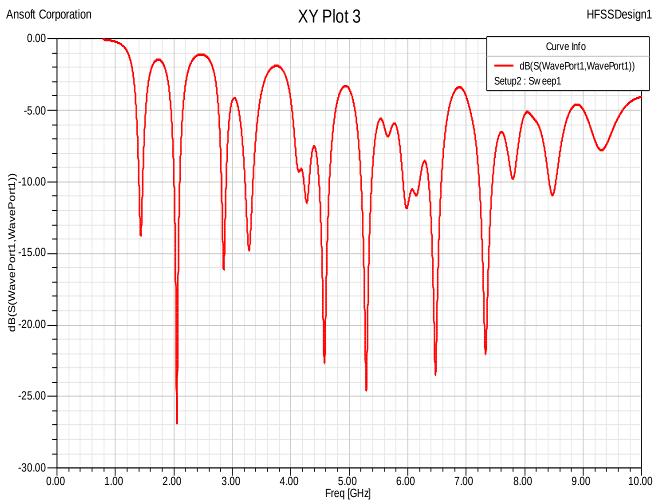

Figure 3 shows the VSWR plot of the design and Table 3 shows values of VSWR for different band with frequencies. For the four bands VSWR is less than 2 and lowest VSWR for the design is 1.03 for the sixth band centered around 5.30 GHz.

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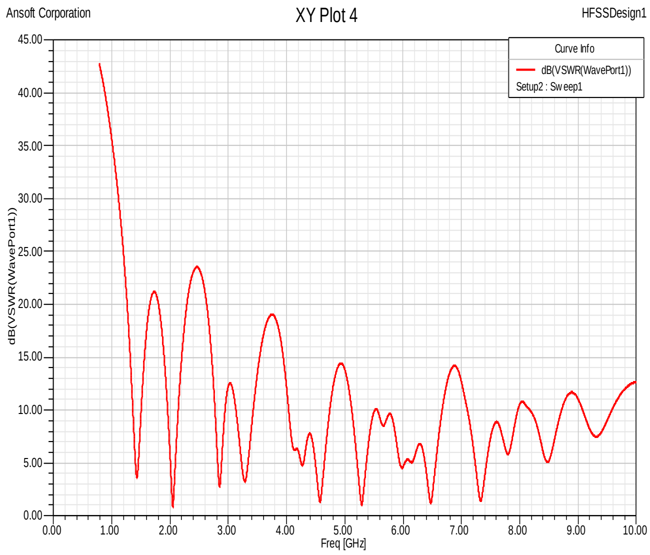

Fig.3 VSWR of the Antenna

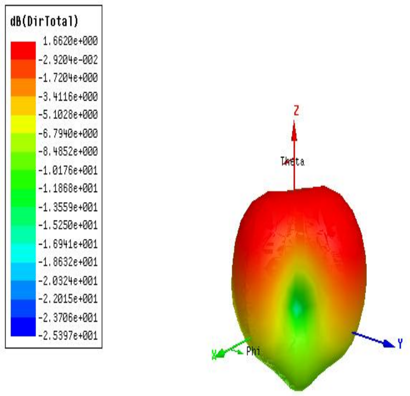

Fig.5 Total Directivity plot in 3D view

Figure 4 shows the Total Gain plot of the design in 3D view. Here, we are getting Total Gain of -1.2031 dB. Figure 5 shows the Total Directivity plot of the design in 3D view. Here, we are getting Total Directivity of 1.6620 dB.

Table: 3 VSWR Values

Band	Frequency In GHz	VSWR
First	1.45	3.5
Second	2.06	0.9
Third	2.86	2.5
Fourth	3.30	3.0
Fifth	4.58	1.27
Sixth	5.30	1.03
Seventh	6.45	1.2
Eighth	7.35	1.53

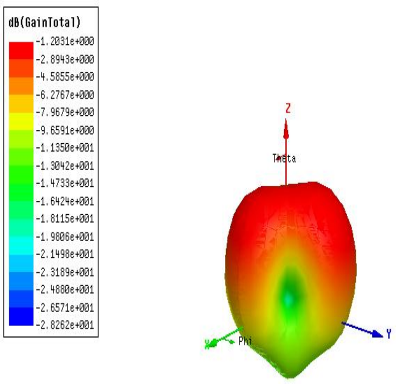

Fig.4 Total Gain plot in 3D view

IV. CONCLUSION

Here Microstrip patch is designed for multiband applications using five rectangular square slots in the Patch. The modeling and iterative simulations are carried out at center frequency of 5 GHz. The result indicates the four working bands, 4.5GHz, 5.3GHz, 6.4GHz and 7.35GHz so the antenna can used for C Band Applications. VSWR is very good for 5.3GHz frequency which is 1.03 near to 1. Further design can be modified to have multiband for other applications in L Band, S Band, X Band and other bands. The results are in very good agreement with the industry and standard published antenna-requirements with respect to ease of fabrication, compactness and volume miniaturization.

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