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Multibanding of Patch Antenna Using spur lines

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Abstract - *A microstrip antenna resonating in L-band at 1.81 GHz has been designed. The S11 parameter of the coax fed antenna is more than -20.3684 dB at desired frequency. The same antenna is then converted into multiband antenna by using two spur lines. Now the antenna resonates in L-band at 1.65 GHz and 1.8375 GH with return losses of -19.377 and -23.8268dB respectively.. The gain of both the antennas is 4.2 and 5 dB respectively. The simulated results in Ansoft HFSS confirm that the antenna can be used in L band. The VSWR of the antennas are 1.9 and 1.5 respectively.*

Key Words: L-band, S-parameter, Return loss, gain, polar plot.

1. INTRODUCTION

In most of the handheld devices in wireless communication, there is a need to cover more than a single frequency band in order to support more wireless applications. For example, a mobile phone antenna may be required to provide wireless access services for both WLAN(2.45GHz) and PCS(2.2 GHz) If the antenna is to cover the band of WiMAX (3.3 - 3.7 GHz), a triple band antenna is desirable. However, the microstrip antenna has narrow bandwidth and works at single frequency. So these antennas need to be modified so that multiband antenna with sufficient bandwidth is achieved.

Recently, multiband patch antennas are designed and analyzed to coverage of various wireless communication services such as GSM, DCS, CDMA and PCS [2, 3 4]. For a single antenna to cover these bands multibanding ought to be done. The solutions for the problem is to use the techniques like Probe Compensation (L-shaped probe, capacitive “top hat” on probe), Parasitic Patches, Direct-Coupled Patches, Slot and Slit loaded patches (U-slot, V-shaped slots and E patch, U-Shaped Slit), Stacked Patches, Patch with parasitic strip and the use of Electromagnetic Band Gap (EBG) structures [4-10] Most of these methods require complex feeding techniques and complex structures like more layers and parasitic structures.

In order to avoid the foreseen drawbacks, a simple antenna with spur lines on both resonating sides of the patch is proposed. Firstly, a simple coax fed rectangular patch antenna is designed and simulated in Ansoft HFSS. Then two spur lines are stripped off the patch. The simulated results of the antenna are compared in this paper. Moreover, the making of the spur lines is very easy to do as the fabrication steps do not need some special tool for printing the same.

2. PROPOSED ANTENNA

In proposed antenna, a rectangular patch is designed on the FR4 substrate. This patch is then stripped off with single and double spur lines on it. But the dimensions of the coax fed antenna are calculated from its design equations.

Design Equations:- The dimensions of the rectangular patch antenna are calculated by the following design equations[2].

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\epsilon r+1}} \qquad \text{--- (1)}$$

For the given frequency of operations and dielectric constant, the width of the patch antenna can be calculated by equation 1. Also the effective dielectric constant is calculated by the equation 2[2].

$$\epsilon reff = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}\left[1+12\frac{h}{W}\right]^{-.5} \text{--- (2)}$$

Due to the fringing effect, there is an increase in the effective length of the patch. This is calculated by the equation 3.

$$\Delta L = 0.412h\frac{(\epsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon reff-0.258)\left(\frac{W}{h}+0.8\right)} \qquad \text{--- (3)}$$

Now the net length of the patch is calculated by the formula

$$Leff = L + 2\Delta L \qquad \text{--- (4)}$$

The table 1 shows the various dimensions that calculated & taken for the design of the single band antenna.

Table 1: Calculated Dimensions of Patch Antenna

Parameter	Single band antenna(in mm)	Patch with spur line
Length of patch (L)	38	38
Width of patch(W)	28	28
Resonate frequency(F_r)	1.89 GHz	28
Length & Width of slots	NA	11.5 & 1 mm
Length & Width of spur line in mm	--	21.5 & 2 mm

Antenna Design:- The designed patch shapes are shown in the figure 1. Firstly, a coaxial fed rectangular patch is antenna is designed on 1.6 mm high FR4 substrate. Then two slots are cut on one side of the patch, followed by the single and double spur lines.

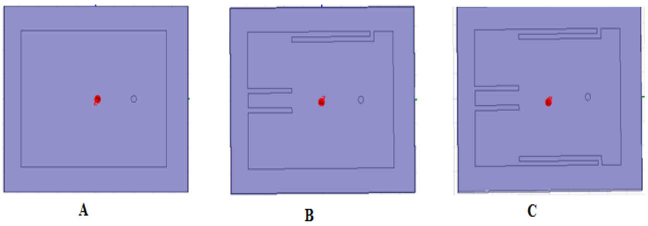

Figure 1:- A) Rectangular patch antenna B) Patch with single spur line C) Patch with double spur lines.

To explain the role of the spurlines in multibanding of the antenna, the surface current density of the antennas are drawn. Since the current get multi path to move with the printing of the spur lines, multiple resonating bands are formed. Figure 2 shows the comparison of the electric field o the patch of the antenna.

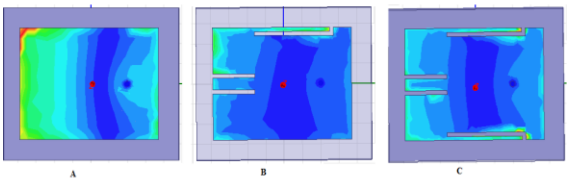

Figure 2:- Electric fields of A) Rectangular patch antenna B) Patch with single spur line C) Patch with double spur lines.

3. SIMULATED RESULTS

In simulated results, the antennas are designed in HFSS which on the basis of method of moments solve the mesh equations of the antenna. Various parameters like return loss, voltage standing wave ratio and polar plots of antenna are compared. Figure 3 shows the comparison of S11 parameter of antenna with green lines showing antenna without spur line, blue with single line and red with two spur lines.

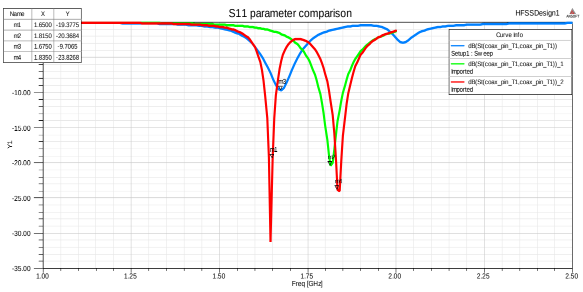

Figure 3:- Comparison of S11 parameters of the antenna.

Another parameter which shows the impedance matching of the antenna is the polar plot. Figure 4 shows the comparison of the polar plots of the three simulated antenna.

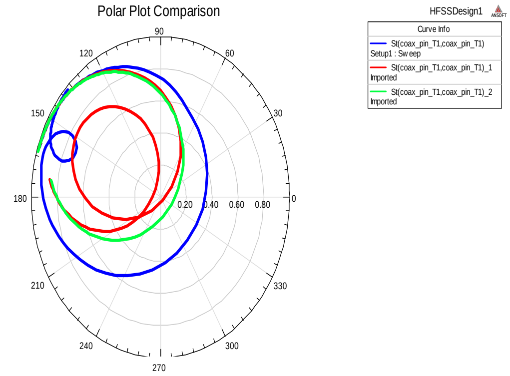

Figure 4:- Comparison of the polar plots of designed antenna.

Furthermore to study the radiating behavior of the antennas, the radiation patterns are compared. Microstrip patch antennas radiates in a single half due to the presence of perfect electric field ground structure below the substrate. The same is proven by the figure 5.

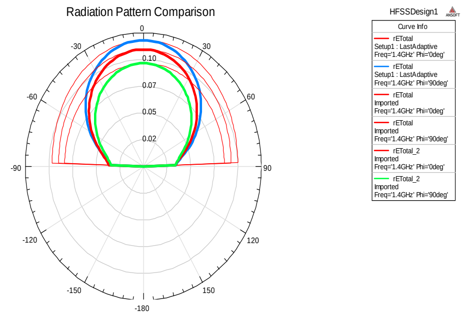

Figure 5: Radiation pattern of the designed antennas.

To conclude the paper, all the parameters of the designed antennas are compared in form of the Table II.

Table II: Comparison of the Antenna parameters.

Antenna Parameter	Without spur lines	With One spur line	Two Spur lines
S11 parameter	-20.3684 @ 1.81GHz	-9.7065 @1.67 GHz	-19.377 @ 1.65 GHz and -23.8268 @ 1.8350 GHz
VSWR	1.9	3.26	1.5 & 1.3
Gain (in dB)	4.2	5.2	4.9

As can be seen from the graph and the table, VSWR of the antennas are within the prescribed limits. Also the gain is sufficed to meet the L-band applications, however techniques are available to improve the gain of the antenna.

4. CONCLUSION

In this paper, multibanding of the antenna is proposed by modifying the shapes of the patch. The shape can be modified by slots and the spur line. The return loss of the antenna is found to be below 10 dB at the L-band frequency. Also the VSWR is below 2 and the gain is around 5 dB. Thus the antenna can be used in L band.

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