Design of E-Shaped Triple Band Microstrip Patch Antenna

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ABSTRACT
The paper presents the design of patch antenna that can operate on a triple band 2.4GHz, 4.6GHz, 5.5GHz. The shape of the patch resembles an English alphabet `E`. Two parallel slots are incorporated to get the shape of 'E' and the dimensions were optimized using CST Microwave Studio EM Simulator. Different parameters like return loss, VSWR, Radiation pattern in 3D are presented.

Key words: Microstrip patch antenna, Return loss, triple band, EM Simulator.

I. INTRODUCTION
A tremendous development in wireless communication systems leads to the demand for compact microstrip antennas with high gain and wide band operation. A microstrip antenna generally consists of a dielectric substrate sandwiched between a radiating patch on the top and a ground plane on the other side. Microstrip antennas have advantages such as low profile, conformal, light weight and low manufacturing cost [1]. However, one of the main disadvantages is its narrow bandwidth. Many methods were developed to increase the bandwidth of antennas such as increase of substrate thickness, use of low dielectric substrate [2-3]. The techniques include frequency selective surfaces [4-5], employing stacking [6], slot antennas like U-slot [7], double U-slot [8], L-slot[9], and feeding techniques like L-probe feed [10], and circular co-axial probe feed[11]. In many applications, operation in two or more discrete bands is desired. The trend in development of wireless communication systems has been in the pursuit of a single system that can be accommodating the needs of all users. In such cases, patch antenna capable of operating in multiband is desirable. The paper presents an E-shaped patch antenna with probe feeding.

II. ANTENNA DESIGN
Figure.1 shows the structure of the E-shaped patch antenna on Air or Foam substrate. Initially the patch is designed to operate at 2.24GHz frequency. The length and width of the patch antenna are calculated using the design procedure mentioned below as explained in [12].

ε_r=1, fr= 2.4GHz and h=3.2mm

2.1 Design Procedure

1. For an efficient radiator, a practical width the leads to good radiation effiencies

$$W = \frac{1}{2f_r\sqrt{\mu_o\varepsilon_o}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Where v_o is the free-space velocity of light.

2. Determine the effective dielectric constant of microstrip antenna using

$$\frac{W}{h} > 1 \varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\,h/W\right]^{-1/2}$$

3. Once W is found, determine the extension of the length ΔL using

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.8\right)}$$

4. The actual length of the patch can now be determined by solving for L

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_o\varepsilon_o}} - 2\Delta L$$

$$L_{eff} = L+2\Delta L$$

Length and width of ground plane are

$$L_g = L+6h$$

$$W_g = W+6h$$

Initially the patch antenna is modeled with the dimensions obtained using the above procedure and two slots are inserted to get the shape of 'E' with some arbitrary dimensions. The width of the middle arm controls the dimension of slots. The dimension of the slots inserted is optimized with parameter sweep to get the triple band. The optimized dimensions of different parameters of the patch are tabulated in Table-1.

Parameter	Lp	Wp	Ls	Wc	Lf	Lg	Wg	S	Dt	Dc
Value(mm)	62.5	58	35	14	5	81.7	75	3.6	4.17	0.85

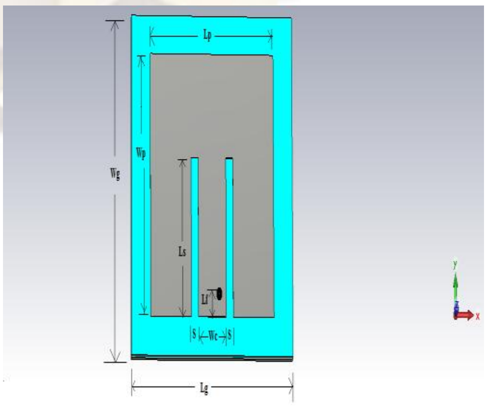

Fig.1 Proposed 'E'-shaped microstrip patch antenna

III. RESULTS

Simulation is carried out using CST Microwave Studio 12. Version. The criterion for the determination of frequency band is value of return loss less than -10dB. Figure.2 shows return loss plot and the resonant frequencies are fr1=2.24GHz, $f_{r2=}$ 4.65GHz and $f_{r3=.}$5.59GHz.

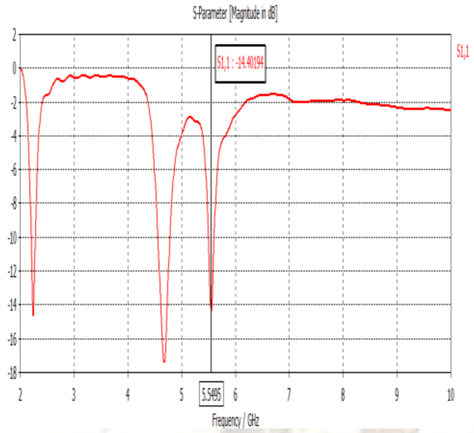

Fig.2 Return loss (s_{11}) of designed antenna.

Fig.3 shows the VSWR plot of the designed antenna. The Directivity at 2.24GHz is 9dBi, at 4.65GHz is 8.7dBi and at 5.59GHz is 9.7dBi are shown in figs.(4-6). Fig.7 shows the surface current at 2.24GHz.

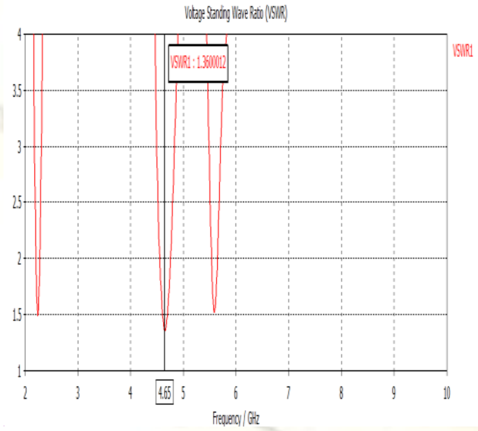

Fig.3 VSWR plot of designed antenna

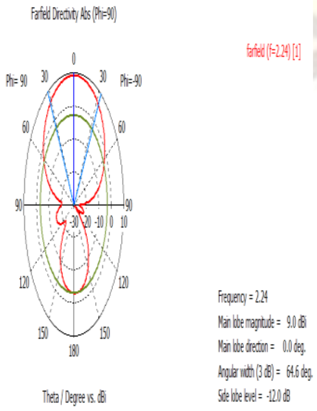

Fig.4 3D-Radiation pattern at f_{r1}= 2.24GHz

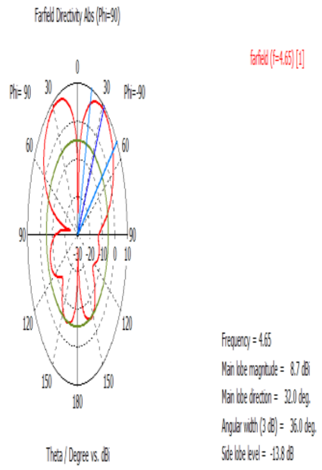

Fig.5 3D-Radiation pattern at f_{r2}=4.65GHz

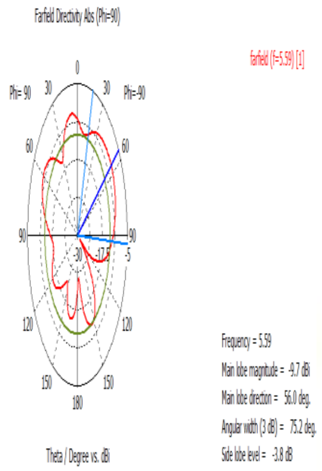

Fig.6 3D-Radiation pattern at f_{r3}=5.59GHz

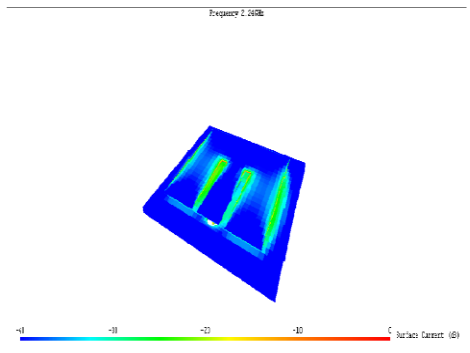

Fig.7

Surface current at 2.24GHz

IV. CONCLUSION

'E' shaped patch antenna is designed to operate at triple band. By controlling the width of the middle arm, triple band is obtained and is useful to operate for various wireless applications.

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