E - Shaped Micro-strip Notched Patch Antenna for Wireless Applications

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ABSTRACT
A new design of Microstrip patch antenna has been proposed for wireless communication applications. An E- shaped Microstrip Notched Antenna structure has been designed and simulated using Ansoft HFSS simulator. Low-profile, compact, easily mountable, light weight are the advantages of this antenna. The proposed antenna has compact dimensions of 30.31 mm × 25.37 mm ×1.2 mm. The proposed structure is simulated on FR4 epoxy substrate, it resonates at frequencies 3.0270 GHz, 7.2432 GHz and 9.1892 with a return loss of -16.015 dB, -21.2168 dB and -37.3031 dB respectively. VSWR of the proposed antenna lies within the acceptable values of 0.237 to 1.5283 for all resonating frequencies. The maximum achieved gain is 7.28 dB. Proposed antenna can work in S, C and X frequency bands which covers useful applications like radio location, mobile/fixed-satellite service and wireless computer networks.

Keywords E-Shaped, HFSS, Notched

1. INTRODUCTION
In Modern wireless communication systems, Antennas are required to be simple in structure, compact in size and stable in radiation patterns while retaining an extremely broad operating frequency range [1]. However, the design of a multiband/wideband antenna is not an easy task, especially for a portable device since a compromise between the size, cost, and bandwidth has to be achieved simultaneously. Antennas has to be kept at low cost, low profile and ease of fabrication [2]. Proposed antenna has been designed by keeping in mind such constraints and requirements. E-shaped microstrip notched patch antenna is a kind of antenna that offers a low profile [3], for instance thin and easily manufacturability, which provides great advantages concluded traditional antennas [4]. However, patch antennas have a main disadvantage i.e. narrow bandwidth [5]. Researchers have made many efforts to overcome this problem and many configurations have been presented to extend the frequency bands and bandwidth [6]. Notched Patch antennas are antennas used in wireless communication and other microwave applications. By cutting the notch from a patch, gain and bandwidth of microstrip antenna can be enhanced [7]. An E-shaped patch antenna has been proposed in this paper. In this designed microstrip antenna the E-shaped patch is placed on the top of the dielectric sheet and the dielectric sheet is placed on a ground plane [8]. The upper side view of fabricated E-Shaped microstrip notched patch antenna shown in Figure 1, fed by a microstrip transmission line. The patch antenna, microstrip transmission line and ground plane are made of high conductivity metallic (typically copper) thin layers. E-Shaped Notches used here plays an important role in balancing resistive part and reactive part. These multiple tuning capabilities are used for various wireless applications. The shape of these notches may vary [9]. An E-shaped patch antenna is easily formed by cutting three notches in a rectangular shape as shown in Figure 1. The patch is of length L, width W and sitting on top of a substrate of thickness 1.2mm shown in Figure 2.

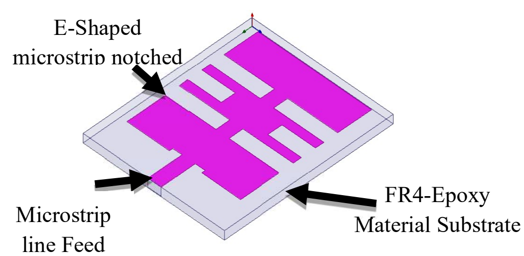


Figure 1. Proposed E-shaped microstrip notched patch antenna

2. ANTENNA STRUCTURE
The antenna consists of a full ground plane, dielectric substrate and E-shaped rectangular patch. The size of the ground plane is 30.31 mm × 25.37mm and the thickness of the dielectric layer is 1.2 mm. The dielectric constant of the dielectric layer is 4.4. The size of the patch is 23.5mm × 20.37mm which is calculated by help of effective dielectric constant. The dimensions of length and width is the actual dimensions. In the E-shaped patch microstrip line is feed in the middle of rectangular with the 50 ohms microstrip feed line [10] as shown in figure 2. The microstrip patch dimensions are calculated with following equation.

Step 1: Width of proposed antenna is calculated by using the equation [3]

$$W = \frac{c}{2f_0\sqrt{\left(\frac{\varepsilon_r + 1}{2}\right)}} \qquad 1.1$$

Step 2: Calculation of the Effective Dielectric Constant. This is based on the height, dielectric constant of the dielectric and the calculated width of the patch antenna [3].

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{-1}{2}} \qquad 1.2$$

Step 3: Calculation of the Effective length [3].

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \qquad 1.3$$

Step 4: Calculation of the length extension ΔL [3].

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad 1.4$$

Step 5: Calculation of actual length of the patch [3].

$$L = L_{eff} - 2\Delta L \qquad 1.5$$

Where, f_0 is the Resonance Frequency
W is the Width of the Patch
L is the Length of the Patch
h is the thickness
ε_r is the relative Permittivity of the dielectric substrate
c is the Speed of light: 3 x 10^8

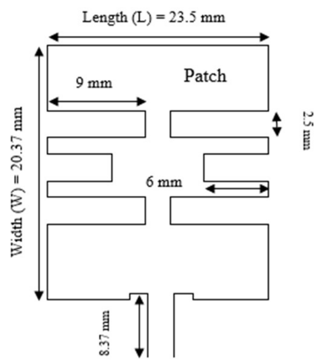


Figure 2 Dimensions of proposed antenna

2.1 Variation in Notch Width of E-shaped Patch

The effect of change in small variation make great effect on the performance antenna. It has been observed that a 0.1 mm variation can make huge difference in antenna result. The specific antenna structure affects the various performance parameters such as gain, radiation pattern and return loss of the antenna. Variations in the dielectric constant also affect the performance parameters of the designed microstrip antenna [11]. The comparison of different variation in width is show in Figure 3 this variation is from 2 to 3 mm in different design structure of E-Shaped Patch.

Table 1 Variation in Notch Width and S11 Parameter

Variation in Notch Width (mm)	2 mm	2.2 mm	2.3 mm	2.4 mm	2.5 mm	2.6 mm	3 mm
Frequency bands	3	3	3	3	3	2	2
Resonate Frequency (F_r) in GHz	3.02 7.24 8.86	3.02 7.24 8.94	3.02 7.24 9.10	3.02 7.24 9.10	3.02 7.24 9.18	7.16 9.02	7.16 9.43
Return loss S11 (-dB)	14.81 28.51 11.25	13.20 23.83 15.94	11.87 21.11 17.39	16.02 22.22 21.80	16.80 21.21 37.30	22.56 13.11	20.68 19.86

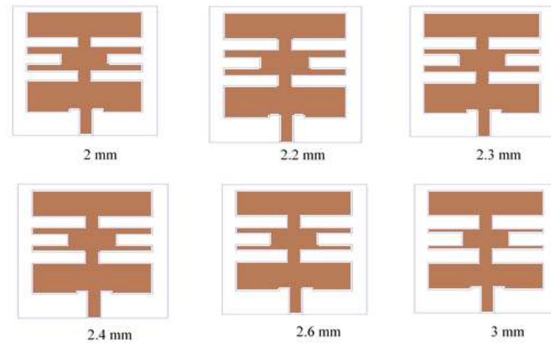


Figure 3 Different variation in E-shaped patch

The variation of notch width on return loss shown in the table 1, in which the different variation in notch width is present and effect of parameter like return loss is seen .in given table the frequency band shows that at 2.5 GHz the return loss is maximum so this value is taken as notch in designed patch.

2.2 Ground

The change of ground length and width is cause of reduce parameters which are less results show in proposed antenna. Variations in the dielectric constant also affect the performance parameters of the designed microstrip antenna [12]. The thickness of the ground plane or of the microstrip is not critically important. Typically, the height h is much smaller than the wavelength of operation.

3. Simulated Results

In this section we will discuss the results obtained from the simulation of the proposed E-shaped microstrip antenna. Simulation of the designed antenna has been done using HFSS software. In this simulation analysis we try to optimize different performance parameters of the antenna such as return loss, VSWR and radiation pattern.

3.1 Comparison of Return Loss with variation in Notch Width

Figure 4 shows the variation in the return loss with different widths of the notch on the patch. With decreasing notch width up to 2mm from 2.5mm the bandwidth decreases and return loss and other parameter are also decrease with this variation. It can also be observed that the second resonant frequency reduces with the increasing the notch width to 3 mm. Thus, the notch width 2.5mm is used as the optimized value for simulated antenna.

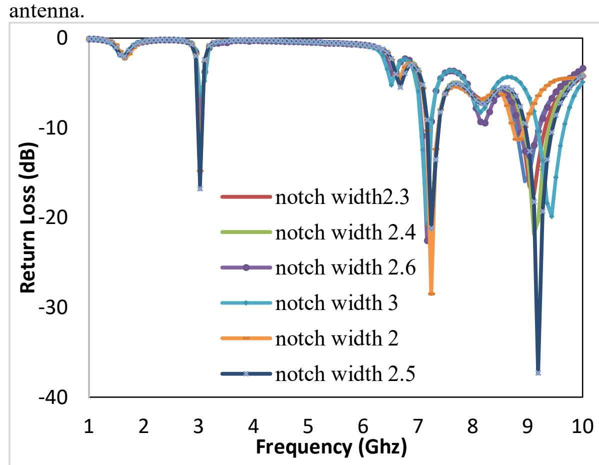


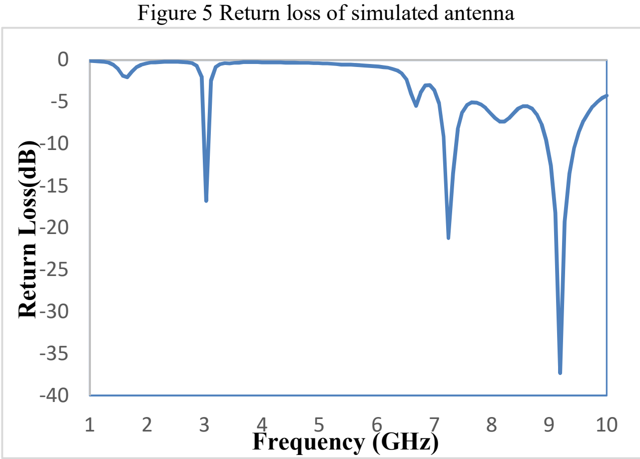
Figure 4 Comparison of various notch width variations

Notch width variation from 2 mm to 3 mm with 0.1mm change each time. All results are good but at 2.5 mm the results are better than others like return loss, VSWR, Gain etc. The bandwidth of given E-shaped microstrip patch antenna is maximum 247.4 MHz

3.2 Return Loss

The Return loss parameters describes the reflected power in antenna this is very important parameter and the simulated antenna. Figure 5 shows the simulated results of the return loss of the proposed patch antenna which are in good agreement. The three resonant frequencies obtained are 3027.0 MHz, 7243.2 MHz and 9189.2 MHz are shown in the Figure 4. Maximum return loss is -37.3031 dB and least is -16. 8015 dB.

Figure 5 Return loss of simulated antenna



3.3 VSWR

The VSWR is always a real and positive number for antennas. The smaller the VSWR better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal. The simulated antenna lying in between 0.23 to 1.52 value of VSWR.

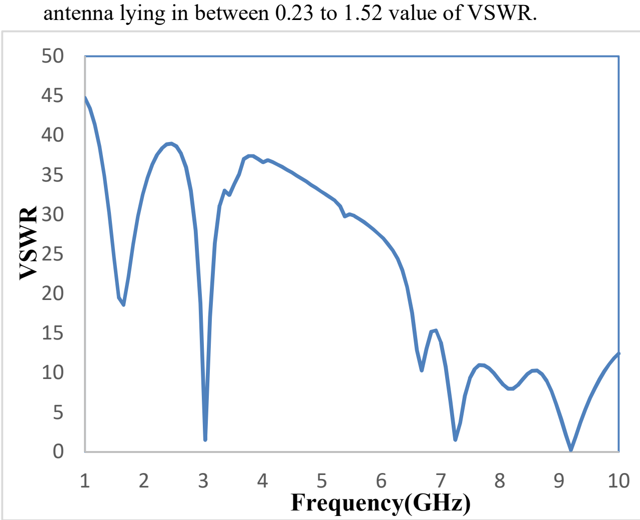


Figure 6 VSWR of simulated antenna

3.4 Radiation Pattern

Figure 7 shows the simulated radiation patterns of the azimuth and the elevation planes. The radiation patterns are measured at resonant frequencies of 3.0270 GHz ,7.2432 GHz and 9.1892 GHz as shown in Figure 7 (a-c)

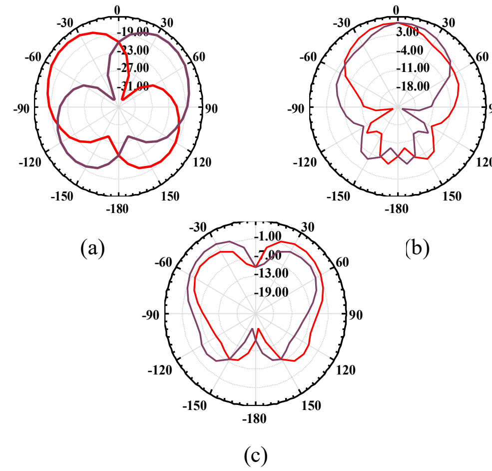


Figure 7 Radiation pattern at different frequencies

4. CONCLUSION

It can be easily observed that the designed E-shaped microstrip antenna has good gain i.e. 7.28 dB and has maximum return loss value of -37 dB and resonates at 3027.0 MHz, 7243.2 MHz and 9189.2 MHz. It has also been observed that feed point has a crucial effect on the performance of the designed antenna. The experimental results demonstrate return loss, covering from 3 GHz to 10 GHz frequency. Technique obtaining multiband, size reduction, stable radiation pattern and high gain are applied with significant improvement in the design by employing the proposed multi-notched patch E -shaped design.

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