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DESIGN AND OPTIMIZATION OF H-SHAPED MULTI-BAND MICROSTRIP PATCH ANTENNA

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ABSTRACT
The design and optimization of rectangular patch antenna and comparison between H-shaped patch antenna and rectangular patch antenna have been investigated keeping in view of vital parameters such as S- parameters, VSWR, axial ratio, bandwidth & operating frequency. A novel approach is followed in the optimization process using FEM (Finite Element Method). This FEM technique gave more easy calculation in the design of Microstrip patch antenna and analysis of effect of various design parameters like dimensions (L & W) and substrate of antenna has been done. The proposed antenna is designed at 2.4 GHz of frequency and the simulation results a gain of 1.1016 with directivity of 2.2577 and bandwidth 307 MHz. The proposed 'H' shaped Microstrip antenna is fed by 50 Ω Microstrip feed line. The improvement in the results has been incorporated in the design.

INTRODUCTION
The rapid development of wireless communication systems has increased the demand for compact microstrip antennas with high gain and wideband operating frequencies. Microstrip antenna in its simplest form consists of a radiating patch (of different shapes) on one side of a dielectric substrate and a ground plane on the other side. Microstrip antennas are used in communication systems due to simplicity in structure, conformability, low manufacturing cost, and very versatile in terms of resonant frequency, polarization, pattern and impedance at the particular patch shape and model.

Microstrip patch antenna has advantages such as low profile, conformal, light weight, simple realization process and low manufacturing cost. However, the general microstrip patch antennas have some disadvantages such as narrow bandwidth etc. Enhancement of the performance to cover the demanding bandwidth is necessary. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, and the use of multiple resonators.

Antenna feeding technique can generally divide into two categories which are contacting and non-contacting. The four most popular feed techniques used in patch antenna are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting). In this paper an antenna with microstrip line feed is presented. Microstrip line feed is a feeding method where a conducting strip is connected to the patch directly from the edge. The microstrip line is etched on the same substrate surface which gives advantage of having planar structure. The method is easy to fabricate because it only need a single layer substrate and no hole.

We have used FR-4 substrate because it is a very common and by far the most used substrate in consumer electronics market as it has a good quality-to-price ratio. It is mostly used where cost is more efficient than performance. A highly recommended distributor is Rogers, who is a little more expensive but performs much better in RF applications. In the cellphone industry, companies uses higher quality FR-4 substrate because it is more cost efficient. To further reduce the costing associated with the antenna we cut the patch into a H-shaped antenna and then further we have changed the position of H .
In this paper a H-shaped multi-band antenna patch antenna is presented. The antenna is simulated using Ansoft HFSS. The results show that the impedance, bandwidth, VSWR and return loss has achieved a good match.

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ANTENNA DESIGN

The mathematical formula is used to calculate the dimensions of ground plane and patch in the form of length and width. Width formula of Rectangular MSP is taken by [3].

$$W = \frac{c}{2f_c\sqrt{\frac{\varepsilon_r+1}{2}}}\ , \qquad (1)$$

Where $c = 3\times10^8$ m/s, $f = 2.4$ GHz, $\varepsilon = 4.4$.

Because the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing. The amount of fringing is a function of the dimensions of the patch and the height of the substrate. An effective dielectric constant ε_{reff} is introduced to account for fringing and the wave propagation in the line. The equation of εreff is given by:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r+1}{2}\left(1+12\frac{h}{W}\right)^{-\frac{1}{2}}\ , \qquad (2)$$

Where $\varepsilon_r = 4.4$, h=1.6 mm.

Because of the fringing effects, electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length is extended on each end by a distance ΔL, which is given by :

$$L = 0.412\times h\times\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.255)\left(\frac{W}{h}+0.8\right)}\ , \qquad (3)$$

Since the length of the patch has been extended by ΔL on each side, the effective length of the patch is now

$$L = L_{eff} - 2\times\Delta L\ , \qquad (4)$$

The width and length ground plane can be calculated by the following equations:

$$W_g = 6\times h + W\ , \qquad (5)$$

$$L_g = 6\times h + L\ . \qquad (6)$$

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RESULT AND DISCUSSION

To further reduce the costing associated with the antenna we cut the patch into a H-shaped antenna and then further we have changed the position of H . On varying the position of H we recorded different values of VSWR and return loss. We created H-shaped antenna with two different configuration. We designed a patch of width 38.04mm and length of 29.4mm. Figure 3.2 and figure 3.3 shows two different configuration.
Using the formula given above, we can find the Patch dimensions.

Table 1:Parameters of rectangular patch antenna

Dielectric	h (mm)	W (mm)	ε_{reff}	L (mm)	L_g (mm)	W_g (mm)
FR-4 Epoxy	0.8	38.0363	4.2191	29.6711	34.4711	42.863
FR-4 Epoxy	1.6	38.0363	4.0858	29.4291	39.0291	47.6363

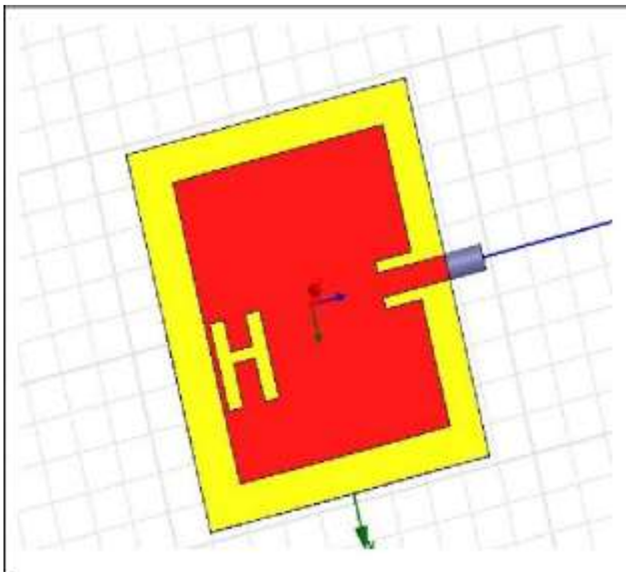

Fig 3.2:H-shaped antenna where H is at left bottom corner and is bigger in size.

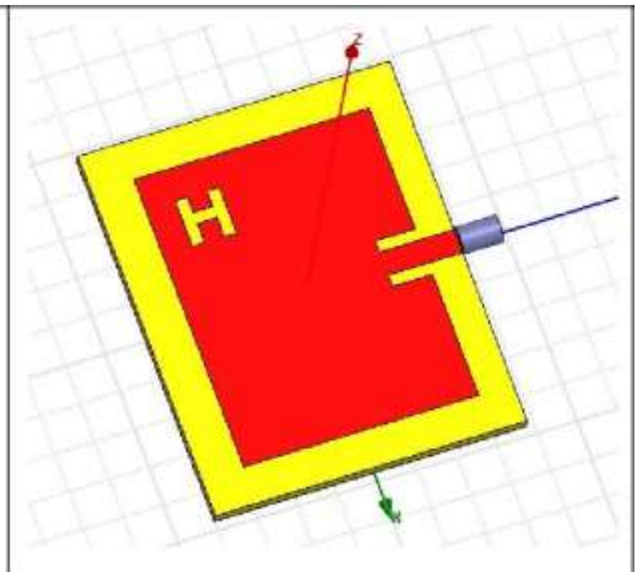

Fig 3.3:H-shaped antenna where H is at right top corner and is smaller in size

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Table 2: Different parameters of Microstrip antenna

Type of Antenna	Return loss (dB)	Bandwidth (MHz)	VSWR (dB)
Patch Antenna (h=0.8)	-22.63	184	1.16
Patch Antenna (h=1.6)	-23.20	317	1.20
H-shaped antenna where H is at left bottom corner.	-22.90	298	1.24
H-shaped antenna where H is at right top corner.	-24.51	307	1.03

CONCLUSION

As we observe, the Table-2 which displays all the parameters and the results for the design. On using substrate of height = 0.8mm we got optimum VSWR and return loss but it is difficult to fabricate this antenna so we designed another antenna with substrate height = 1.6mm. We have used FR-4 substrate because it is a very common and by far the most used substrate in consumer electronics market as it has a good quality-to-price ratio. It is mostly used where cost is more efficient than performance. A highly recommended distributor is Rogers, who is a little more expensive but performs much better in RF applications. In the cellphone industry, companies uses higher quality FR-4 substrate because it is more cost efficient. To further reduce the costing associated with the antenna we cut the patch into a H-shaped antenna and then further we have changed the position of H. On varying the position of H we recorded different values of VSWR and return loss. Having gone through the results it happened to be a bit difficult to decide the optimized design of the antenna, as there are different aspects that are involved in the design of the antenna. We can say that there are many aspects that affect the performance of the antenna. Dimensions, selection of the substrate, feed technique and also the operating frequency can take their position in effecting the performance.

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