International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 9, September- 2014

Performance Analysis of Different Shapes Patch Antennas At 2.45 Ghz

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***Abstract*— The area of microstrip antennas is one of the most dynamic fields of antenna theory and has seen some inventive work in recent years. The increasing need for mobile communication and the emergence of newer technologies require an efficient design of antenna of smaller size for wider frequency range applications such as Wi-Max. In this work, different geometry shapes, the E-shape and U-slot are developed from a rectangular patch of the width (W) = 39 mm and length (L) = 29 mm at a frequency of 2.45 GHz. The proposed antennas are simulated using CST microwave 2011 software and the results are compared with the conventional rectangular patch antenna. Patch antennas resonating at 2.45 GHz are simulated, manufactured and tested. The properties of the antenna such as bandwidth, S parameter, VSWR have been investigated. The substrate material used for the proposed antennas is FR-4 lossy, with the dielectric constant of 4.1.**

***Index Terms*—*microstrip patch antenna, CST, return loss, VSWR*.**

I. INTRODUCTION

In wireless communication, there are several types of micro strip antennas, the most common of which is the patch antennas. Microstrip antenna consists of very small conducting patch built on a ground plane separated by dielectric substrate. The microstrip patch antenna offers the advantages of low profile, ease of fabrication, and compatibility with integrated circuit technology. They can be designed to operate over a large range of frequencies (1- 40 GHz) and easily combine to form linear or planar arrays. It can generate linear, dual, and circular polarizations. The microstrip antenna has different feeding techniques like probe fed, aperture coupled, proximity and insert feed. As conventional antennas are often bulky and costly part of an electronic system, the microstrip antenna considered as an engineering breakthrough for compact communication devices and systems especially for remote uses where compactness is much desirable feature. However, conventional microstrip patch antenna suffers from very narrow bandwidth. This poses design challenge for the microstrip antenna designer to meet the broadband requirements. The proposed antennas are designed for 2.45 GHz frequency with rectangle patch, E-shape patch and U-slot patch and compared with the measured result. The proposed antennas are made by using microstrip feed and simulated on CST microwave 2011. A typical patch antenna is shown in fig 1.

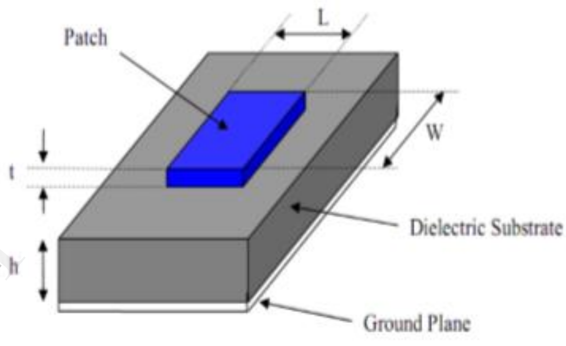

Fig 1: A typical patch antenna

Microstrip antenna is a simplest form of antenna configuration. It consists of a radiating patch on one side of dielectric substrate ($\epsilon_r \leq 10$) and it has a ground plane on other side. A microstrip patch antenna consists of a many conducting patch of any planar or nonplanar geometry. The rectangular and circular patches are the basic and mostly common used for microstrip antennas because of ease of fabrication system. The microstrip antenna have various advantages such as small size, low-cost of fabrication process, low profile of antenna, light in weight, ease of installation process and integration with many feed types. The applications of these type of antennas in various fields such as in the medical applications, satellite and of course even in the military systems just like in the rockets, aircrafts missiles .However, the microstrip antenna has a low gain and a narrow bandwidth. To overcome its limitation of narrow impedance bandwidth and low gain, many techniques have been proposed. In microstrip patch antenna there are some well-known methods to increase the bandwidth of patch antennas, such as, cutting a resonant slot in the patch, reduced ground plane, the use of thick substrate, the use of a low dielectric substrate, the use of a low dielectric substrate, the use of various impedance matching feeding techniques, the use of slot antenna geometry and multi-resonator stack configurations. However, the bandwidth and the size of an antenna are generally reciprocal conflicting properties that are improvement of one of the characteristics normally results in degradation of the other one. Various shapes of cutting slots and slits have been designed on patch antennas to reduce their size. For efficient radiation, the size of microstrip antenna should be λ/2. If the size reduces less than λ/2, the radiation efficiency of antenna decreases along with other antenna parameters.

II. DESIGN ANTENNA GEOMETRY

A proposed Microstrip patch antenna starting with a rectangular patch, substrate and ground plane. These rectangular parameters are simulated to optimize the performance and ending with slotted patch and E-shape patch. The proposed antenna use Microstrip feed line of impedance 50 ohm.

The proposed antenna has dimensions given below:

Operating frequency	2.45 GHz
Dielectric Constant	4.1 FR-4
Patch Material	PEC
Length of Patch L	29 mm
Width of patch W	39 mm
Substrate thickness, h	1. 5m
Patch thickness, t	0.1 mm
Inset-fed gap, Gpf	1 mm

Table 1: Physical dimensions of proposed patch antennas

For designing the proposed rectangular microstrip patch antenna the equations are used to calculate the dimensions of antenna. The designed antenna is resonating at 2.45 GHz and simulated results using CST software.

1. Leff = effective length

$$Leff = \frac{c}{2\,fo\sqrt{\varepsilon reff}}$$

2. W = width of patch

$$W = \frac{c}{2\,fo\sqrt{\frac{\varepsilon r+1}{2}}}$$

3. εreff = effective permittivity

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}}$$

4. ΔL= Change in length

$$\Delta L = 0.421h\frac{(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)}$$

5. Length of patch

$$L = Leff - 2\Delta L$$

6. Length of ground

$$Lg = 6h + L$$

7. Width of ground

$$Wg = 6h + W$$

The terms used in these equations are described below:
c = speed of light
fo= resonant frequency
h = substrate thickness
εr = relative permittivity

III. GEOMETRY OF PROPOSED PATCH ANTENNA

III.a. Design of rectangular patch antenna

Inset-fed length, Fi	10 mm
Feed line length, Lf	24.5 mm
Feed width, Wf	2.9 mm

Table 2: Physical dimensions of rectangular patch antenna

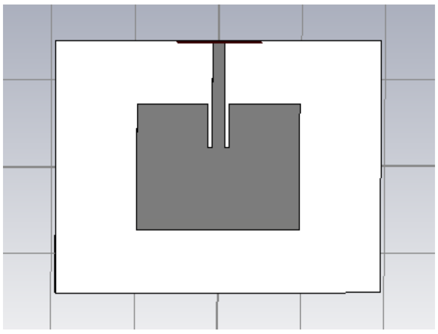

Fig 2: Rectangular patch on CST

III.b. Design of U-slot patch antenna

Inset-fed length, Fi	10.5 mm
Feed line length, Lf	25 mm
Feed width, Wf	2.9 mm
Slot Length, Ls	7 mm
Slot Width, Ws	11 mm

Table 3: Physical dimensions of E-Shape patch antenna

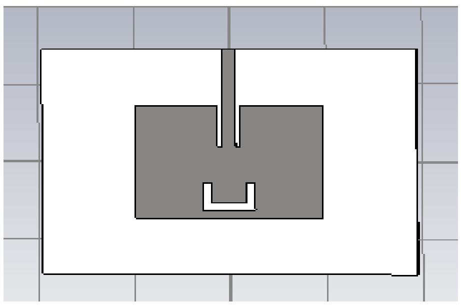

Fig 3: U-slot patch on CST

III.c. Design of E-shape patch antenna

Inset-fed length, Fi	11.5 mm
Feed line length, Lf	25 mm
Feed width, Wf	2.9 mm
Arm width, Ls	12.6 mm
Mid E-Arm Width, Wt	18 mm
Mid E-Arm Length, Lt	8.1 mm
Arm length, Ws	12 mm

Table 4: Physical dimensions of E-Shape patch antenna

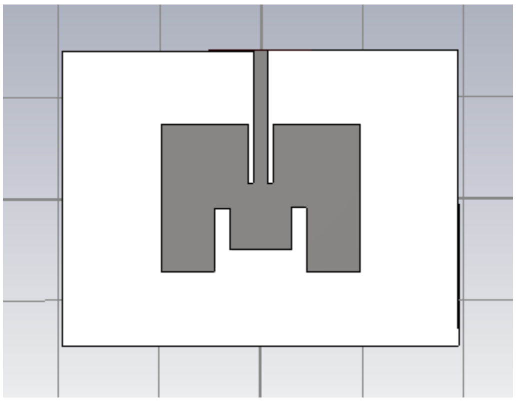

Fig 4: E-shape patch on CST

III. SIMULATION & RESULTS

Microstrip patch antennas are designed for wideband applications using CST as shown in figures. First rectangular patch has been designed and from this keeping the length and width of the patch constant, U-slot and E-shape has been cut. As a result, the frequency of patch shifted. Therefore U-slot and E-shape patches have been optimized for the desired frequency. We have seen that, on changing the Inset-fed length Fi, the frequency of operation changes. Hence, by modifying Fi and feed line length Lf, we optimize the frequency at 2.45 GHz. As a result, all the three patch antennas are working at same frequency with same dimensions, but the return loss, VSWR and gain of the antennas changes.

Results have been shown below in the table :

	Rectangular patch	U-slot	E-shape
Return loss (dB)	-32.36	-28.93	-19.04
VSWR	1.04	1.07	1.25

It can be seen after simulation that the return loss degraded if we cut shapes from a rectangular patch without changing its dimensions.

Return loss and VSWR compared are also shown in the figure below:

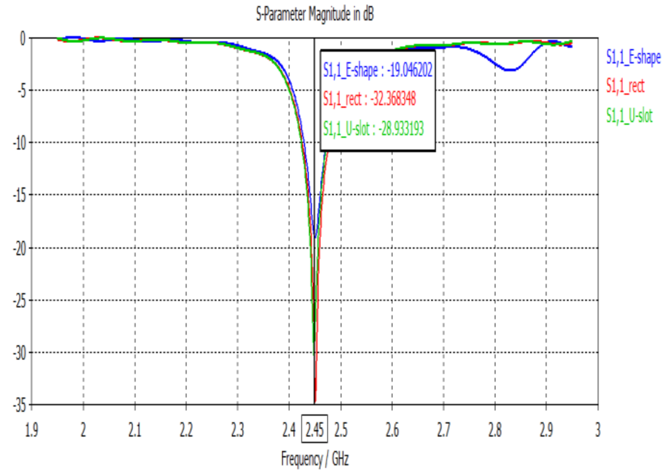

Fig 5: S11 parameter simulated on CST

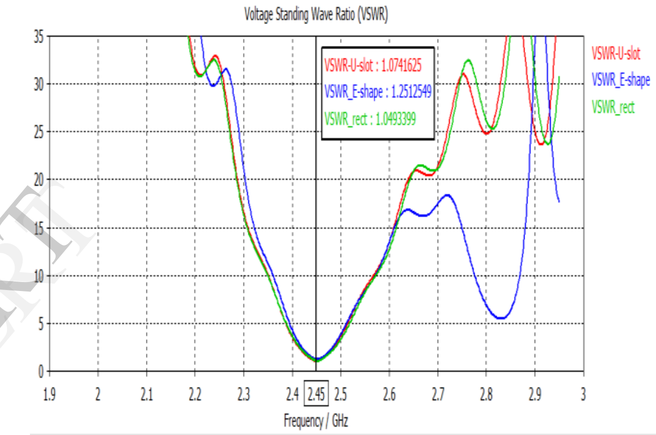

Fig 6: VSWR simulated on CST

All the simulated antennas are fabricated and tested on VNA (Vector Network Analyzer) in laboratory. Experimental results are shown below.

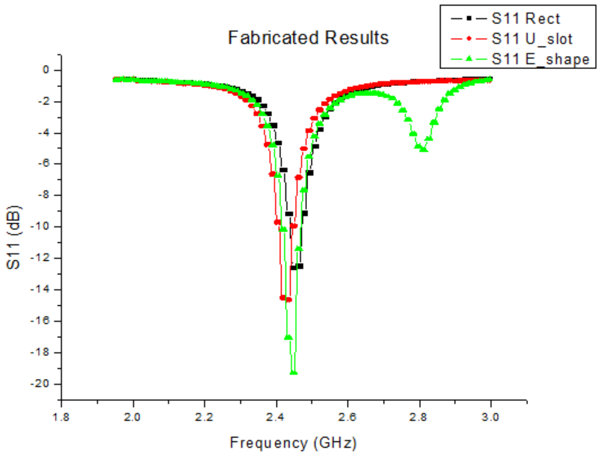

Fig 7: S11 parameter tested on VNA

It has been found that the fabricated antennas work well in the given range at the desired frequency.

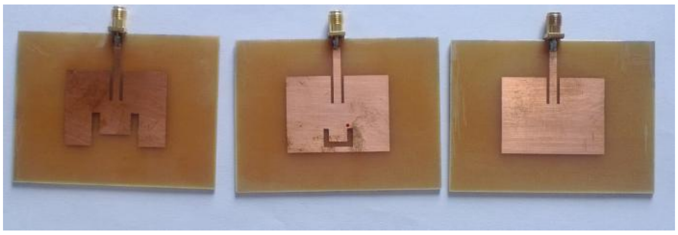

Fig 8: Fabricated antennas

IV. CONCLUSION

In this work, the aim was to design different shapes of antenna from a rectangular patch keeping the patch length and width constant, operating at the single frequency. We have selected three different patch antennas and are simulated and fabricated. The simulated results are compared with the conventional microstrip patch antenna. Experimental result shows that the given antennas work well at 2.45 GHz with the bandwidth of 50 MHz. The fabricated antennas can be used for Wimax applications.

V. REFRENCES

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