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Enhancement of Bandwidth using Inset-Fed Patch Antenna for High Frequency Applications

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***Abstract:** Today in communication field, many antennas have been evolved for various applications. The most popularly used antennas are micro-strip antennas. These antennas can be easily fabricated at reasonably low cost. Hence, these antennas are gaining lot of importance in recent times. Many techniques have been in use for micro strip antennas to improve the performance of the antenna parameters. The design of these antennas is slowly moving towards high frequencies, where there is lot of advantage with bandwidth. In this paper a normal and E shaped inset micro-strip antenna in Ku-Band is simulated and the results are presented. It is noted that CST-MS 2015 tool has been used to get the simulation results.*

***Index Terms:** Gain, Ground plane, Micro-strip, Return loss.*

I. INTRODUCTION

Patch antenna is the most prevalent type of micro-strip antenna. An antenna can be used as an element in the array. The patch antenna is designed with different shapes like elliptical, square, rectangular and circular. However, any model can be considered in design of micro-strip antenna. These antennas can be shaped to any curve to meet the fitment requirements of the vehicle or mobile units, etc. The most important application of patch antenna is telecommunications and cellular communications. Due to advent of IOT technologies, these antennas can be extended their applications to IOT and medical segments in the near future. Patch antennas are comparatively low cost to fabricate and design because of the uncomplicated geometry. A maximum directive gain of 6dBi is been provided by a single microstrip antenna. Higher gains are achieved by an array of patches when compared to a single patch. Because of a matured fabrication process the phase and matching adjustments are easily accomplished by the feed structures. With the ability of dynamic beam forming technique phased array antennas are easily designed with an array of patch antennas [2]. The capability of polarization diversity is an essential advantage of patch antennas. Polarizations like horizontal, vertical, right hand circular polarization (RHCP) and left hand circular polarization (LHCP) of patch antennas can be designed using multiple feed points or single feed Point with irregular patch structures [3].

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An important characteristic of patch antenna is that it can be used in various types of communication links which have a variety of requirements. Different techniques like increasing the thickness of substrate with low dielectric constant, slot cutting and different shapes of patch increases the bandwidth of an antenna. An increase in bandwidth upto 13.7% for an compact L shaped patch has been proposed by the author A.A.Deshmukh [1]. An array of patch antennas with higher bandwidth is demonstrated in [2]. Z. M.Chen [3] with his theory explained the increase in bandwidth of the antenna up to 23%. K.F. Lee [4-5] had obtained 42% increased bandwidth using micro strip Antenna with U Shaped slot. Author Garg [5] experimented on significant increase in bandwidth by increasing height of dielectric material. S.C.Gao [6] had achieved the increasing the bandwidth and gain by using band gap structure of uniplanar photonic device. M.Khodier [7] increased the bandwidth by stacking of patch antennas. Shafai [8] enhanced the gain and bandwidth by forming the ring by accumulating different conducting layers separated by laminating dielectric.

By surveying the literature it is therefore concluded that there is an increase in bandwidth of inset-fed patch antenna upto considerable value. Hence the simulation has been carried out for this antenna in this paper

II. DESIGN EQUATIONS

For designing the rectangular micro strip patch antenna , the following equations are considered.

The width (W) of the patch is given by

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\in_r + 1}}$$

The effective dielectric constant $(\in_{reff})$ of the patch is given by

$$\in_{reff} = \frac{\in_r + 1}{2} + \frac{\in_r - 1}{2}\left(1 + 12\frac{h}{w}\right)^{\frac{-1}{2}}$$

Effective length (L_{eff}) of the patch is given by

$$L_{eff} = \frac{c}{2f_r\sqrt{\in_{reff}}}$$

The Actual Length (L) of the patch is given by

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

The extension length (ΔL) of the patch is given by

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

III. DESIGN PARAMETERS

Design parameters of rectangular patch antenna at 2.45GHz and 14GHz are calculated based on the designed equations, which are presented in the section II.

TABLE-1: Design Parameters of Rectangular Patch with Two Feeding Techniques.

S.No.	Antenna Parameters	Patch with Inset-fed technique	Patch with E-Shaped Inset-fed technique
1	Resonant frequency	2.45 GHz	14 GHz
2	Length	41mm	6mm
3	Width	48mm	8mm
4	Dielectric constant	2.2	2.2
5	Substrate height	1.5mm	1.5mm

IV. INSET FED MICROSTRIP PATCH AT 2.45 GHZ

The micro strip antenna has been modified as a rectangle shape of patch with a truncated micro strip transmission line. The length of the above mentioned patch is nearly half of the wavelength. The inset-fed patch antenna is shown at Fig-1. A linearly polarized directional pattern along the width of the patch can have a peak gain from 6 to 8 dBi for a well designed patch antenna. The simulated patch antenna radiation pattern is shown at Fig-2.

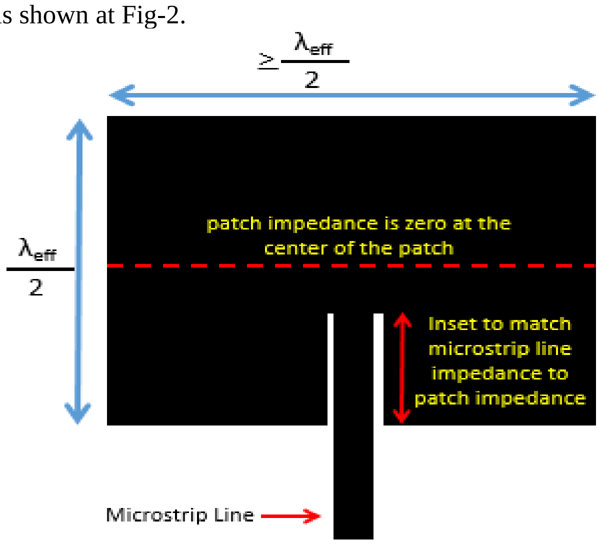

Fig.1: Inset Fed Patch Antenna

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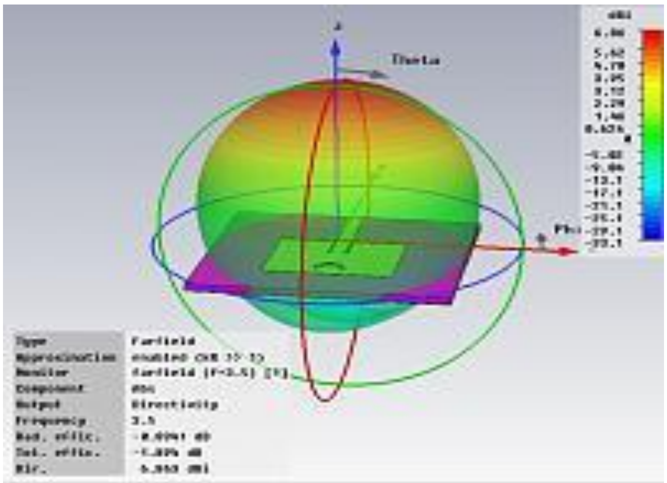

Fig.2: Patch Antenna Radiation Pattern

According to feeding point of the patch antenna, the input impedance changes and at any one point the impedance of patch and feeding impedance will match each other. Input impedance is high, if the feeding point is nearer to the edge of the patch. The impedance is low at the centre of the patch where feeding point is located. The impedance of an inset fed patch antenna at 2.45GHz is shown at Fig-3.

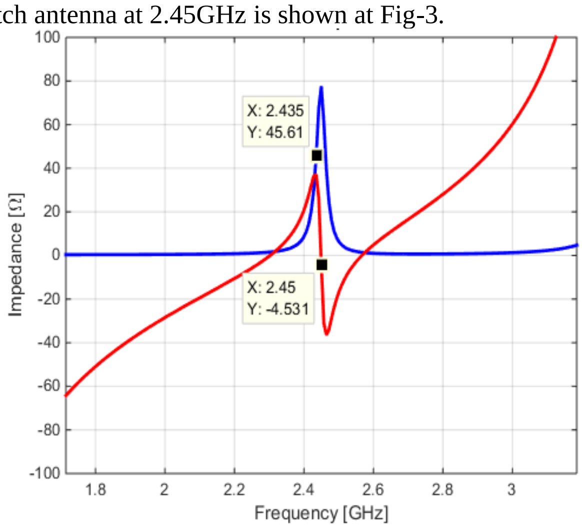

Fig.3: Impedance of Inset Fed Patch Antenna

The patch antenna has been designed at a resonant frequency of 2.45GHz with a 50Ω bandwidth and which is shown in below figure. This type of antenna has high quality factor (Q) in turn this will have lower bandwidth. The return loss of inset fed patch antenna is shown at Fig-4.

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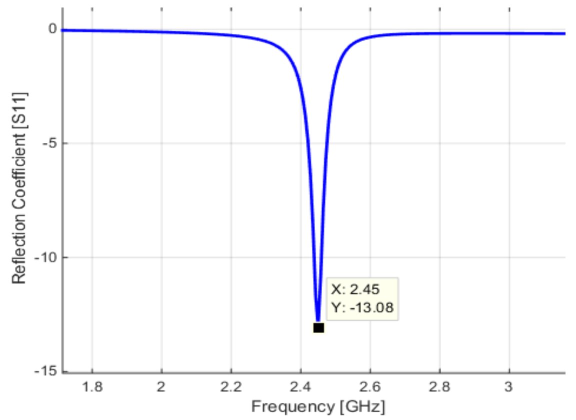

Fig.4: Return Loss of Inset Fed Patch Antenna

V. V. INSET FED PATCH ANTENNA DESIGN AT 14GHZ

With the above explanation, an inset fed patch antenna can be easily designed at any suitable frequency. In this design, a patch antenna at 14 GHz is designed. The three parameters such as resonant Frequency (f_r) is14 GHz, dielectric constant ($\in_r$) is 2.2 and dielectric substrate height (h) is1.5mm. The simulated patch is shown at Fig-5. The length and width of the substrate is considered as 100 mm x 100 mm. After that, the designed patch was created on the substrate material using calculated mathematical dimensions [7]. After this, a micro strip feed line (50 Ω) is also drawn on the same substrate. A radiation box is also created maintaining a minimum height of $\lambda/4$. The simple patch at 14GHz is simulated in CST studio and is shown at Fig-5. The simulated return loss is shown at Fig-6.

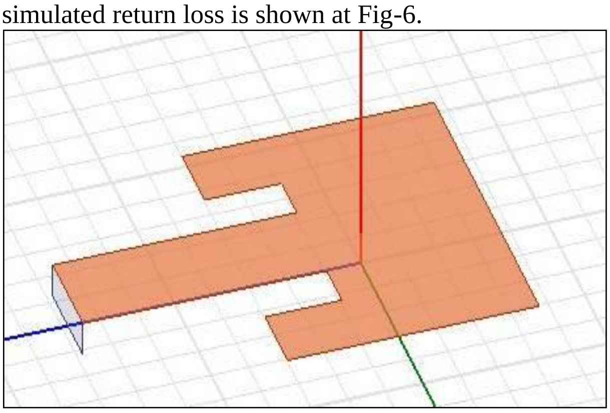

Fig.5: Simple Inset Fed Patch Antenna

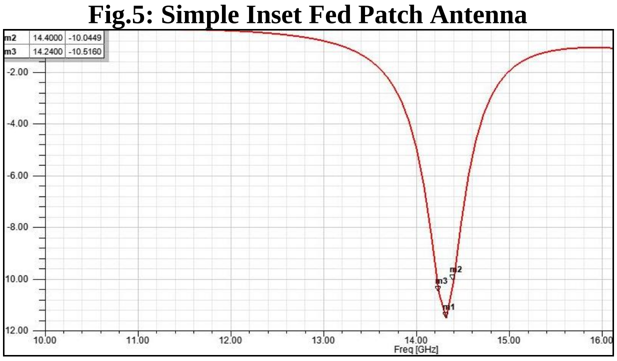

Fig.6: Return Loss

Similarly, E-shaped inset fed patch antenna is simulated and shown at Fig-7 and the Return loss is shown at Fig-8.

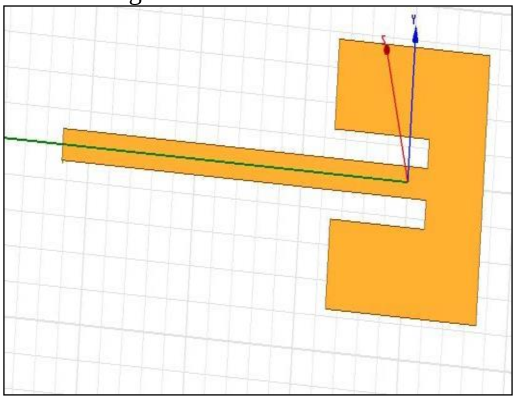

Fig.7: E-shaped Patch Antenna:

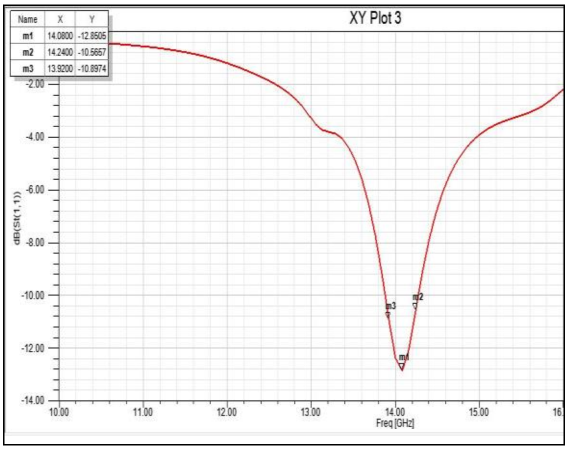

Fig.8: Return Loss

VI. SUMMARY OF THE RESULTS

The summary of the results of two simulations of Inset fed patch antennas designed at 14GHz are given in Table-2.

TABLE-2: Return Loss and Bandwidth

S. No.	Feeding Techniques	Return loss in dB	Bandwidth in MHz
1	Inset fed Patch	-11.35 dB	200 MHz
2	E-shaped Patch	-12.83 dB	300 MHz

From the table-2 it is observed that double of the bandwidth has been obtained for a patch with E-shaped Inset-Fed technique when compared to the patch with normal Inset-Fed technique.

VII. CONCLUSION

In this paper, an inset fed patch antenna at 14 GHz resonant frequency is simulated and analyzed for its bandwidth enhancement and return loss performance. It is concluded that the bandwidth of E-shaped inset patch is double that of simple inset fed patch. This provides scope to design additional shapes of the antenna with inset fed to increase the bandwidth of the patch antennas.

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