Design and Performance Analysis of Inset-Feed slotted Rectangular Micro-strip Patch Antenna for Wireless Mobile Communication

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Abstract- Narrow bandwidth and more return loss is a major constraint of micro strip antennas. To overcome these limitations an Inset-feed slotted rectangular micro strip patch antenna has been designed on a substrate size of 45×58.67 mm2 with 2.8 mm thickness. This antenna is designed for the match impedance with 50 ohm of characteristic impedance. FR4 Epoxy substrate material is used with 0.02 as dielectric loss tangent and 4.4 as permittivity. The result of simulation of slotted rectangular micro strip patch antenna at 2.4 GHz resonance frequency shows that return loss is improved up to 10db in slotted patch antenna as compared to conventional patch antenna at the frequency 2.5147 GHz. The multiple resonance frequency obtained like 1.24, 2.44, 2.5146 and 2.71 GHz in slotted patch antenna. At resonance frequency 1.24 GHz, the return loss is examined up to -23.66db. Also the improvement in radiation pattern is obtained up to 4.5%.

Keywords- Inset-fed, Micro strip Antenna, Return Loss.

I. INTRODUCTION

Today, micro strip antennas are attracting so much attention in number of wirelesscommunication systems such as Wi-Fi, satellite, radar, biomedical telemetry systems and wireless local area network (WLAN). The flexibility of these applications have become possible only due to their several advantage of it like compact in size, planar configuration, lowprofile,ease in fabrication, light in weight and it can also integrate with their microwave components. But the major draw-back of the micro-strip antennas is their very narrow bandwidth. Therefore, in the past two to three decades extensive research has been carried to increase the bandwidth of patch antennasby keeping in mind that the size of the patch antenna should be assmall as possible [1].

Today, the number of bandwidth enhancement and return loss improvement techniques present like use of cutting the resonant slot inside the patch[2, 3], use of Frequency Selective Surface [4,5], use of multiple resonators, use of low dielectric substrate, employing stacked configuration [6] and use of thicker substrate [7].But the bandwidthand the size of radiating micro strip patch antenna are generally reciprocally to each other. Its means the improvement in one of the characteristics will produce degradation in characteristic of the other. In the past, several researchers examined number of techniques to improve these restrictions especially enhancing thebandwidth. Therefore, various types of antenna designtechniques such as slot loaded stacked patch [10], cutting of slot and U-slot loading patchwas proposed in [8, 9] with a bandwidth improvement up to 30%.This paper presents the design and performance analysis of an inset-feed slotted rectangular micro strippatch antenna. The antenna is designed and simulated at resonant frequency of 2.4 GHz for wireless applications.

The remainder of this paper is organized as follows: Section II briefly presents the proposed slotted rectangular micro-strip patch antenna design. Section III concludes the antenna design parameters. Insection IV the antenna simulations and results are examined. Finally, the paper ends with the conclusion.

II. ANTENNA DESIGN

TheMicro-strip Patch Antenna is a single element resonant antenna which has mainly four partslike patch, ground plane, feeding part and the substrate. These antennas are small in size, lightweight, low profile, simple and cheap to manufactureby using modern printed circuit technology. It will take a very little volume of the structure. However, patch antennas also have disadvantages like low efficiency and narrow bandwidth etc. Due to the small separation between the radiation patch and the ground planeit has low RF power so it is not suitable to use for high-power applications [1].

For designing the micro-strip patch, we choose the design strategy in which the minimum -10dB returnloss achieve at the resonant frequencies over bandwidth. There arethree essential parameters for the design of patch antenna i.e. the dielectric constant (ε_r) of the substrate, the frequency of operation and the height (h) of the dielectric substrateabove the ground plane. So during the designing process, the above parameter are choose at starting stage, since the radiation efficiency and return loss etc. are effected on its dimension.Due to this we can achieved a good impedance match for inset-feed rectangular shaped patch antenna [3].

An antenna performance parameters like the radiation efficiency, operating frequency, return loss, directivity and other related parameters influenced on its designed dimension. So, to achieve an efficient radiation and less return loss, the practical width of the rectangular shaped patch [3] can be written as:

$$W = \frac{c}{2f_r\sqrt{\frac{2}{\varepsilon_r+1}}} \quad (1)$$

Here f_r is resonance frequency, c is speed of light and ε_r is the dielectric constant.The length of antenna can be calculated by the following equation number 2:-

$$L = \frac{\lambda}{2} - 2\Delta L \qquad (2)$$

Where $\lambda = \frac{c}{f_r}$ and ΔL is given below:-

$$\Delta L = 0.412 \times h \times \frac{(\varepsilon_{eff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{eff} - 0.258)(\frac{W}{h} + 0.8)} \quad (3)$$

Here ε_{eff} is

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}} \quad (4)$$

The conductance (G_1) of a single slot and mutual conductance (G_{12}) can be calculated byusing the following equation 5 and 6:-

$$G_1 = \frac{\int_0^{\pi}\left(\left(\frac{\sin\left(\frac{k_0 W}{2}\cos\theta\right)}{\cos\theta}\right)^2 \times \sin^3\theta\right)d\theta}{120\pi^2} \quad (5)$$

$$G_{12} = \frac{\int_0^{\pi}\left(\left(\frac{\sin\left(\frac{k_0 W}{2}\cos\theta\right)}{\cos\theta}\right)^2\right)}{120\pi^2} \times J_0(K_0 L_P \sin\theta)\sin^3\theta \, d\theta \quad (6)$$

Here, J_0 is the Bessel function of the first kind oforder zero. Also, the mutual conductance (G_{12}) is small as compared to the self-conductance (G_1) when it calculated by the above equation 5 and 6. With the help of G_1 and G_{12} the resonant input impedance can be calculated using the equation (7):-

$$R_{in} = \frac{1}{2(G_1 + G_{12})} \quad (7)$$

III. ANTENNA CONFIGURATION:

In the following figure 1 shows a single patch antenna that has been designed to cover operating frequency of 2.4 GHz using FR4 (ε_r=2.4) and height (h=0.79mm).

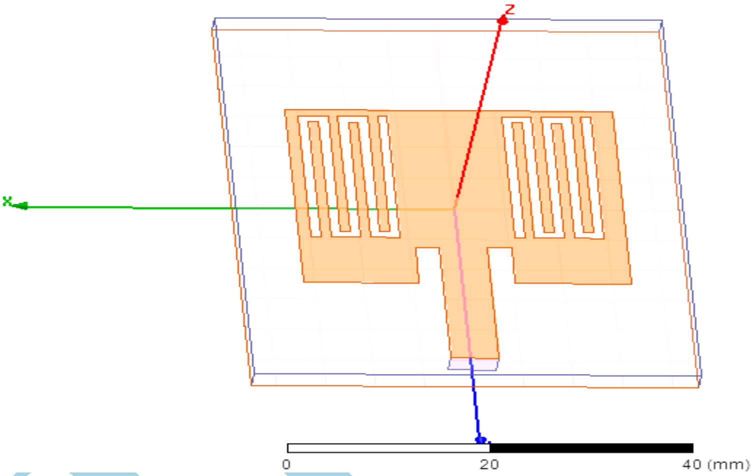


Fig. 1:- Designed Rectangular Patch Antenna

The antenna design parameters are tabulated in the Table1:-

Table1:- Antenna Design Parameter

Antenna Parameter	Value
Width of Patch (W)	33 mm
Length of Patch (L)	28.5mm
Resonance Frequency	2.4 GHz
Height of Substrate	2.8mm
Dielectric constant of Substrate(Material-FR4 Epoxy)	4.4
Notch Width	2.426mm
Inset Feed distance	5.901mm
Slot Width	1mm
Slot Length	20mm

IV. SIMULATION AND RESULT:

The Return loss, impedance, 3D polar plot, Directivity and peak gain is obtained by using HFSS 13.0. The results are shown below:-

Return Loss:-

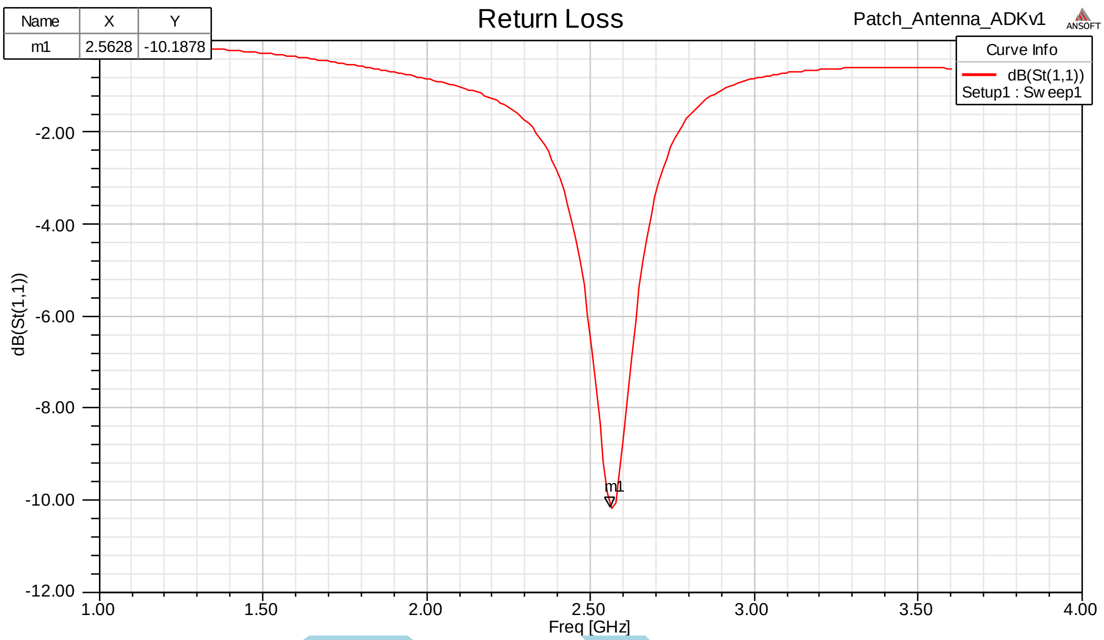


Fig. 2:- Return Loss of Conventional Patch

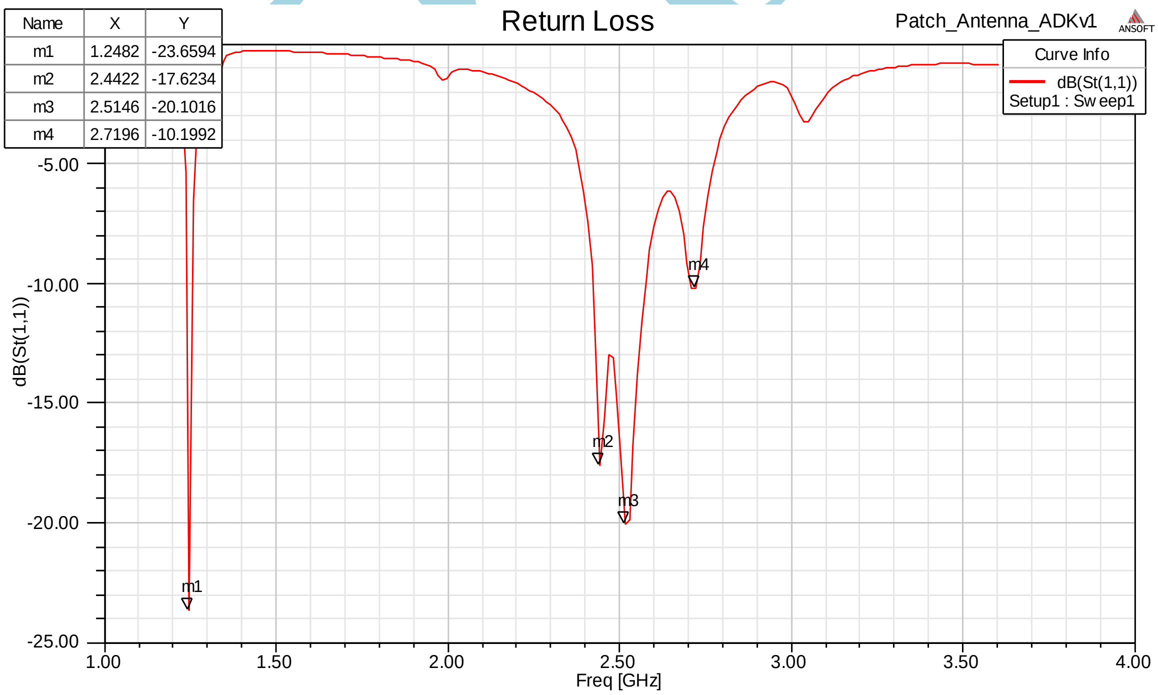
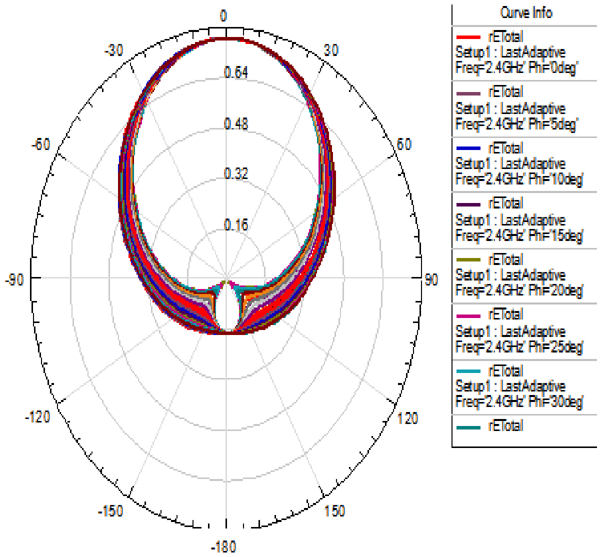


Figure3:- Return Loss of Slotted Patch

As we compared the result in figure 2 and 3 we examined that return loss is improved up to 10db in slotted patch antenna as compared to conventional patch antenna at the frequency 2.5147 GHz. The multiple resonance frequency obtained like 1.24, 2.44, 2.5146 and 2.71 GHz in slotted patch antenna. Also the return loss up to -23.66db obtained at resonance frequency 1.24 GHz.

Radiation Pattern:-



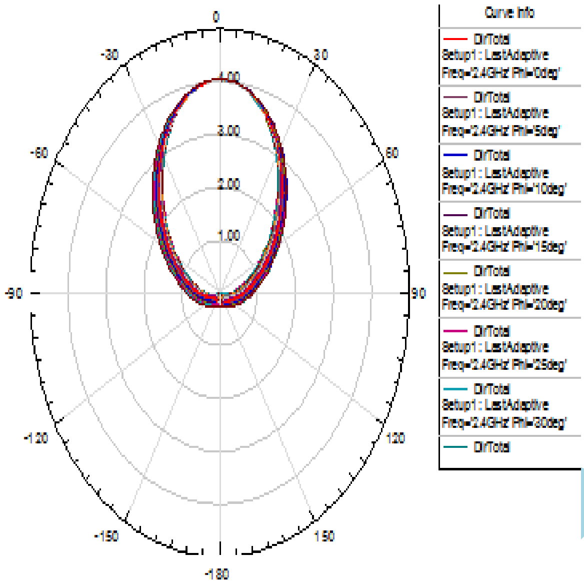


Fig.4:- Radiation pattern of conventional Patch Fig.5:- Radiation pattern of Slotted Patch.

Radiation pattern shown in figure 4 and 5 shows the improvement in directivity up to 4.5%.

V. CONCLUSION

In this article, the slotted rectangularpatch antenna is successfully designed and fabricated for broad-band operation with large improvement in return loss up to 10db. From the above analysis, it is found that that return loss is improved up to 10db in slotted patch antenna as compared to conventional patch antenna at the frequency 2.5147 GHz. The multiple resonance frequency obtained like 1.24, 2.44, 2.5146 and 2.71 GHz in slotted patch antenna. At resonance frequency 1.24 GHz, the return loss is examined up to -23.66db. Also the improvement in radiation pattern is obtained up to 4.5%. So it concluded that the proposed structure gives superlative performance as compared to conventional patch antenna in terms of return loss as well as radiation efficiency.

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