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Design of Circular Microstrip Patch Antenna for ISM Band Wireless Applications

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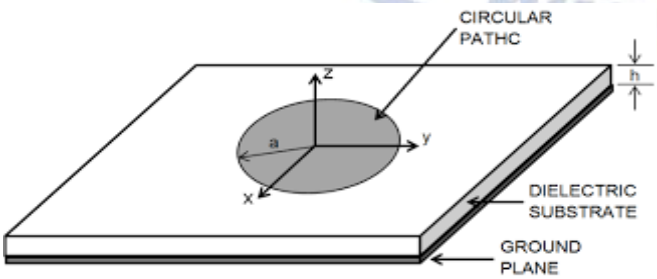
ABSTRACT

In this paper, a coaxial feed and an inset feed Circular Micro strip Patch Antennas operating at 2.4GHz band using ansys based HFSS simulator software are designed. It is useful for Wireless applications (2.4GHz-2.5GHz) in ISM band. The circular patch antenna is constructed by using Fr4 substrate with a dielectric constant of 4.4 and loss tangent of 0.02, and height of substrate is 1.6mm for coaxial feeding technique, 3.6mm for inset feeding technique. Several antenna characteristics such as return loss, VSWR, radiation pattern, gain, beam width are examined.

KEYWORDS: Circular patch; Return loss; VSWR; Resonant frequency.

1. INTRODUCTION

Low cost, light weight and easy to fabricate are the most important factors to be considered for future antennas.The urge for smaller antennas has expanded the attentiveness of researchers towards the scheming of micro strip patch antenna for wireless communication becausethey are of light weight, less volume, easy to integrate, compactand cost effective.



The micro strip patch antenna consists of a dielectric substrate which is sandwiched between the ground plane and patch as shown in the above figure. The patch, feed and ground plane are made of highly conducting materials. The patches may be in variety of shapes but one of the most popular and commonly used patch is circular shaped because of its ease of analysis and fabrication, attractive radiation characteristics, especially low cross polarization. The patch is designed in such a way that its pattern is normal to it [1].

The micro strip patch antenna can be used for many kinds of applications by using a contacting feed [2].The coaxial probe feeding technique main advantage is that the feed can be placed at any desired position in order to obtain the impedance matching and its ease of fabrication process. The advantage of inset feeding technique is that it is easy to implement, easy to know the behavior of the antenna by adjusting the inset gap and inset length. This feed also provides good impedance matching.

In this paper, circular micro strip patch antenna is designed using coaxial and inset feeding techniques are

presented. Two ring slots are inserted on circular radiating patch for coaxial feed and a triangular slot is inserted on the circular radiating patch for inset feed to improve the performance of the proposed antennas. At last the simulated results of the antennas are compared.

2. ANTENNA DESIGN

An important parameter for designing the micro strip patch antenna is the operating frequency (f_r).The resonant frequency of the antenna should be chosen appropriately. Here for the proposed structure of the antenna in Industrial, Scientific and Medical (ISM) band the operating frequency range for wireless applications is 2.4GHz – 2.5GHz and the chosen resonant frequency for our design is 2.4GHz.

The dielectric substrate used here is Fr4 with dielectric constant(ε_r) of 4.4 and loss tangent of 0.02 with height (h) as 1.6mm and 3.6mm for coaxial feeding and inset feeding techniques respectively.

Then the radius of the circular patch is evaluated by using the formula:

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}}$$

Where,

$$F = \frac{8.971\ X\ 10^9}{f_r\sqrt{\varepsilon_r}}$$

Where,

a = radius of the patch

h= height of the dielectric substrate

ε_r= relative permittivity of the substrate

f_r = resonant frequency of the antenna

Also,

Length of the antenna, L = 2(Patch diameter) =2(2a)

Width of the antenna, W = 2(Patch diameter) =2(2a)

A.Coaxial Feed:

For the design of coaxial feed circular micro strip patch antenna by using the above formulae the radius of the patch obtained is 17mm and the ground area is 53.2mm x 53.2mm. The inner and outer diameters of the coaxial feed are 0.5 and 1 respectively. The height of coaxial feed probe is 5mm and the impedance is taken as 50Ω. The feed point is optimized and is placed at the location of (4, 0, 0).

The design of the antenna is as shown in the figure given below:

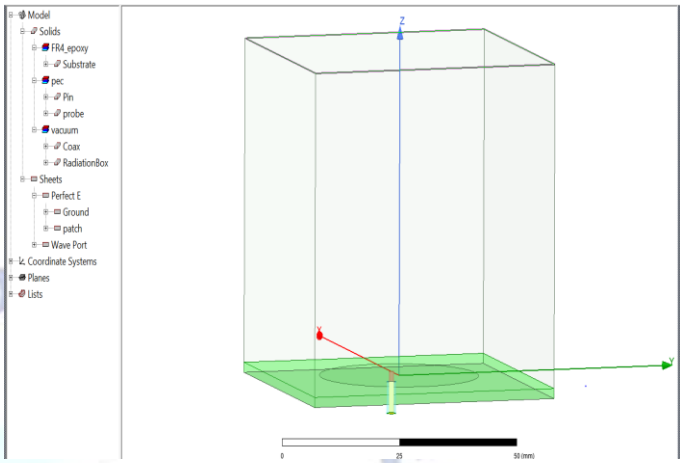


Fig.1: coaxial feed antenna without any slots.

Performance of the antenna depends upon number of factors such as feeding point, radius of circular slot and circular patch, shape and size of ground plane. In order to improve the performance of the antenna, two ring slots of diameters 4.5mm and 3.5mm are incorporated into the circular patch respectively. The antenna is designed as:

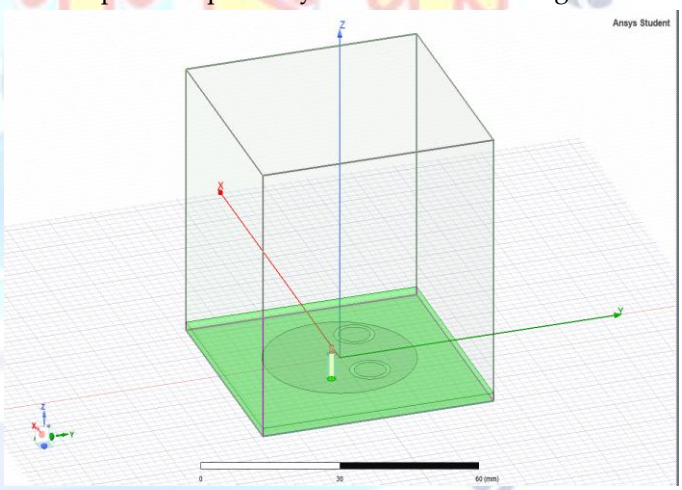


Fig.2: Coaxial feed antenna with two ring slots.

First ring slot location = (-7.5, 4.5, 0)

Second ring slot location = (9.5, 6.5, 0)

For designing the above antenna, by increasing and decreasing the radii of ring slots resonant frequencies are not adequate. Therefore it is required to maintain the minimum sizes as 4.5mm and 3.5mm for the ring slot.

Only by choosing the optimized feed location and adequate diameters of the slots, the performance of the antenna will be improved. Hence we have to choose carefully.

B. Inset Feed:

For the design of inset feed circular microstrip patch antenna by using the above formulae, the radius of the patch obtainedis 17.5mm and the ground area is 69.9mm x 69.9mm. In order to design the feed, the inset cut length (F*i*) should be calculated and the width of inset feed is 2mm. It is calculated as,

$$Fi = 0.20682(L)$$

Where, L = length of the ground plane (or) antenna length.

Here the length of inset cut obtained is 14.45mm and the antenna is designed as shown in the figure below:

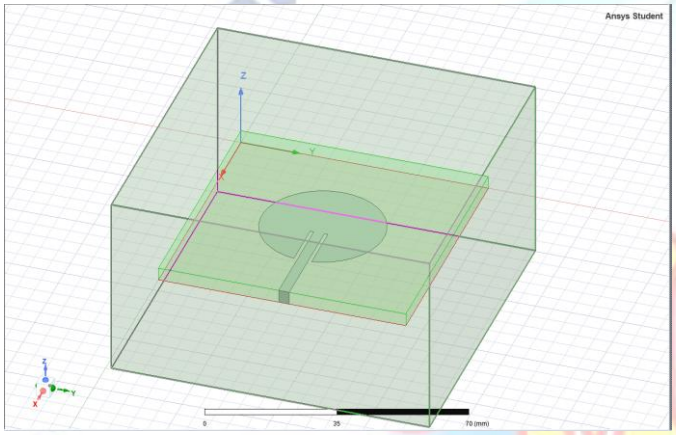


Fig.3: Inset feed antenna without any slots.

In order to improve the performance of the antenna, a triangular slot is incorporated into the circular patch. It is designed as:

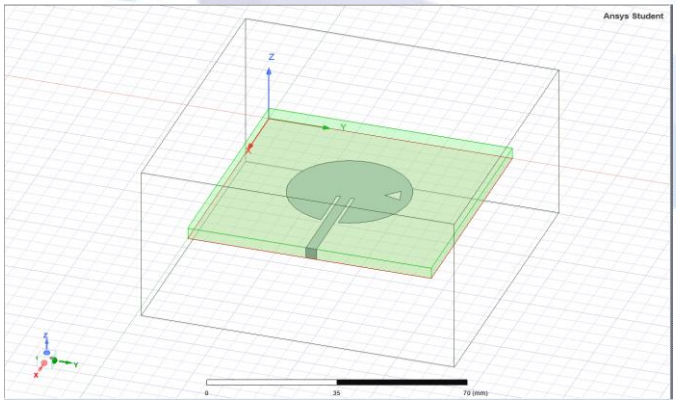


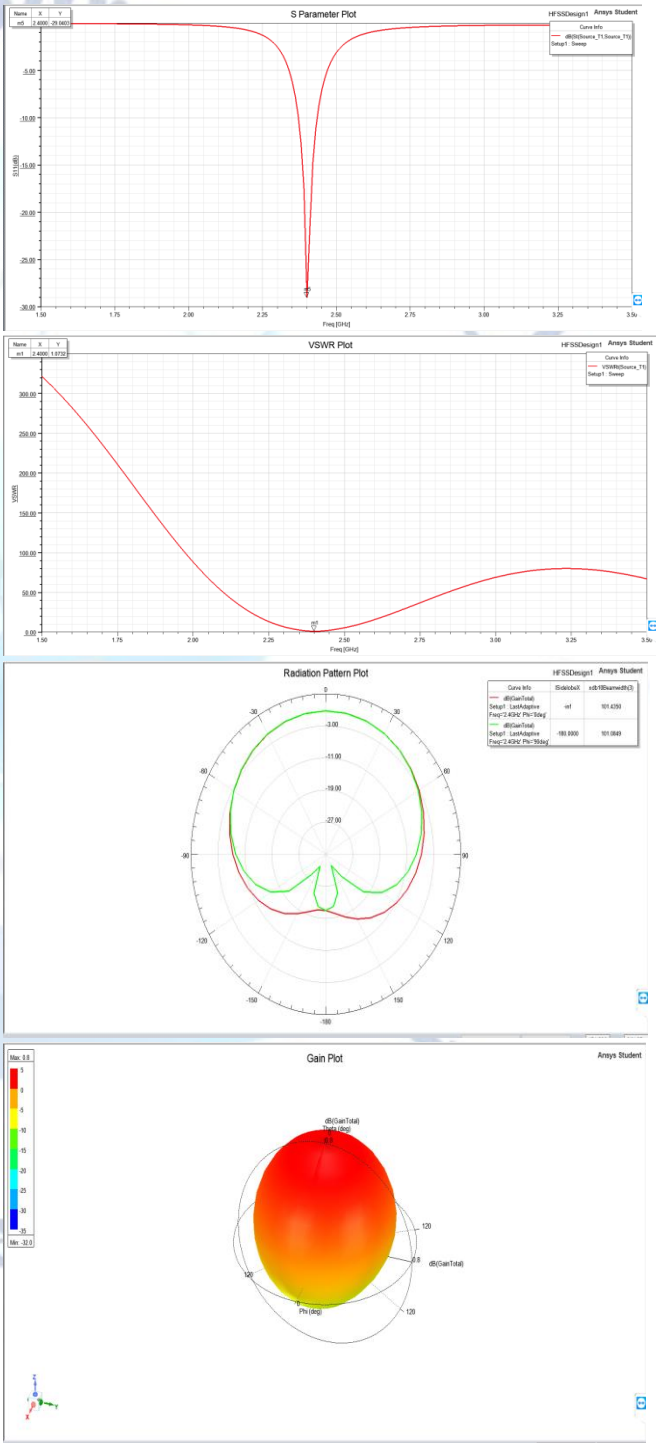
Fig.4: Inset feed antenna with a triangular slot.

Position of the triangular patch is given as, Start = (37, 50, 3.6) and Center = (35, 48, 3.6).

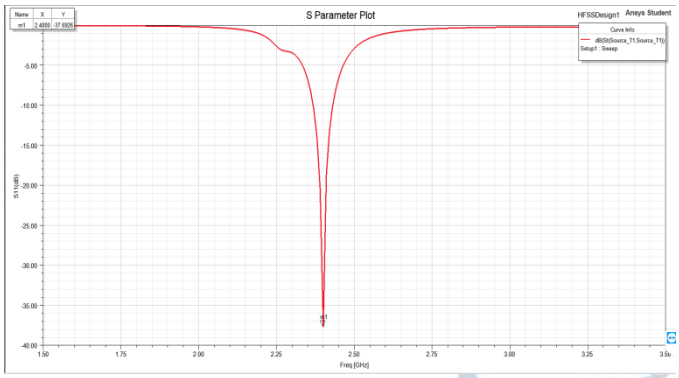
3. **SIMULATION RESULTS**

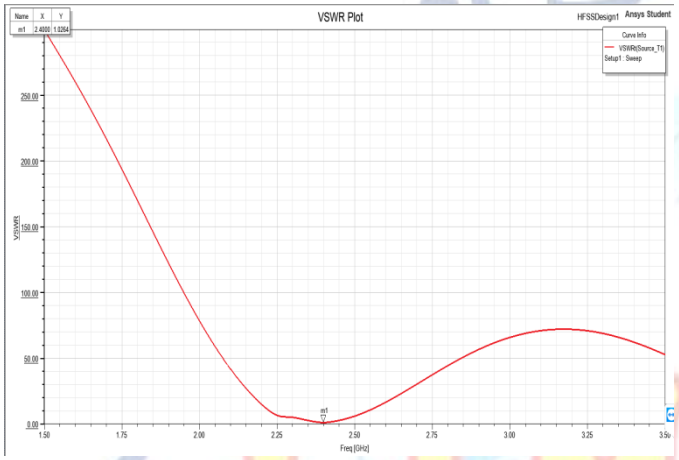
After designing the above proposed antennas, they are simulated by using the HFSS (High Frequency Simulator Tool)software. For every design of the antenna its return loss, VSWR, gain and radiation patterns are plotted using HFSS. The simulation results are:

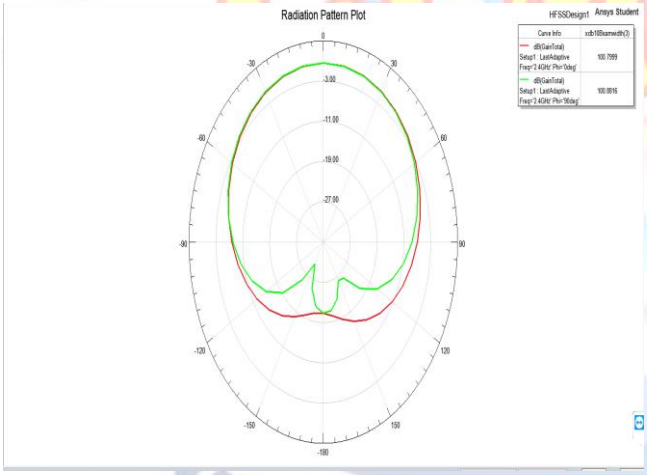
Coaxial feed antennawithout slot:

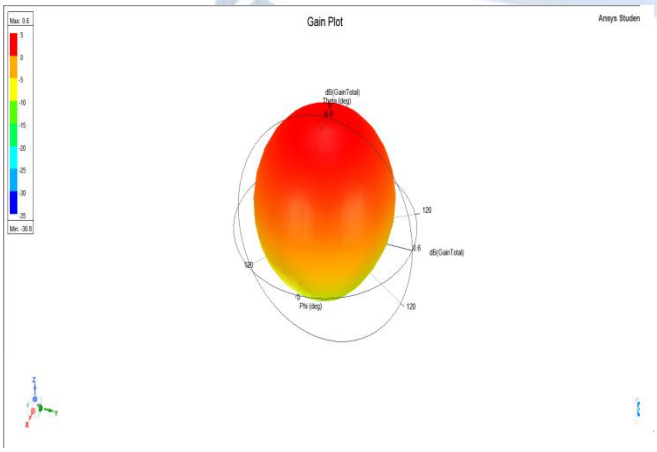


Coaxial feed antenna with two ring slots:

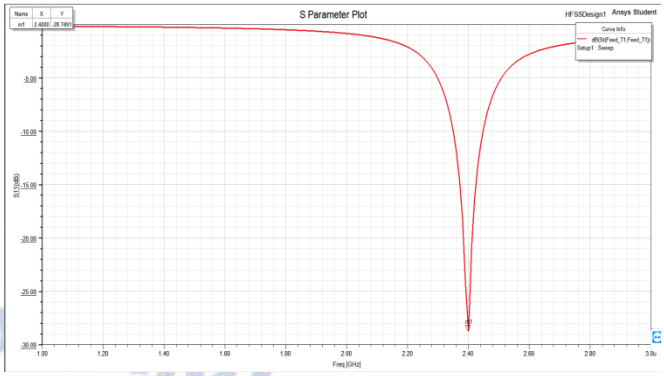


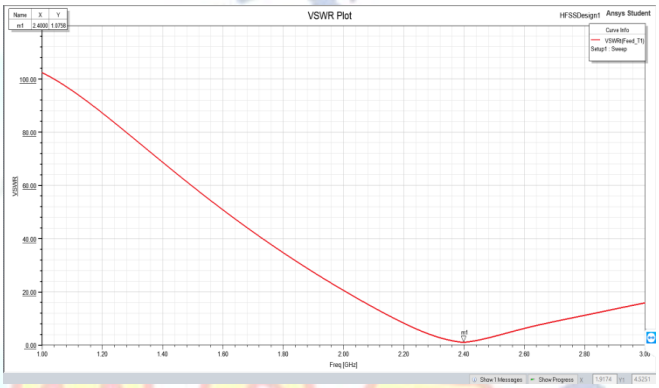


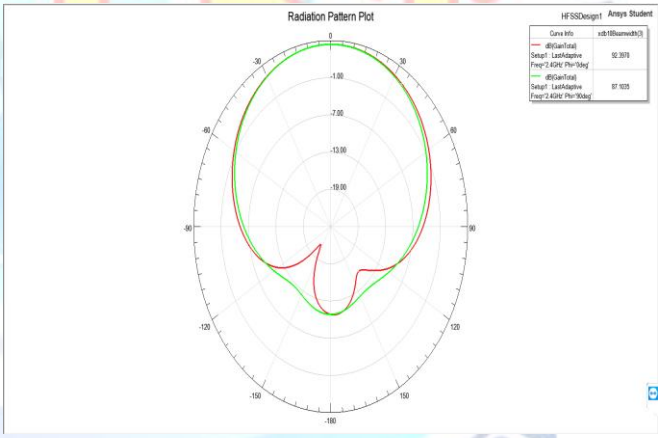


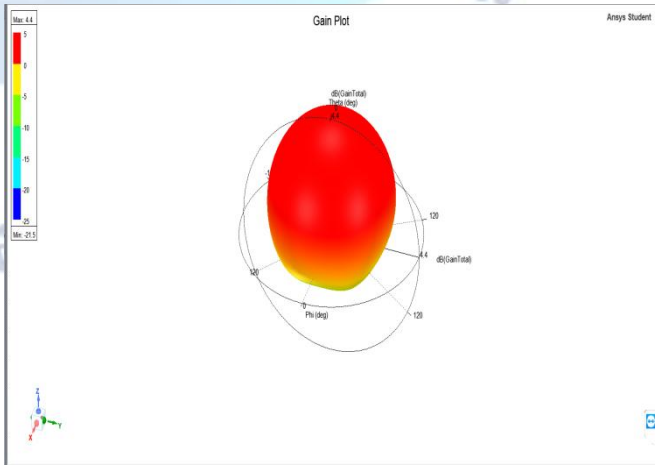


Inset feed antenna without slots:

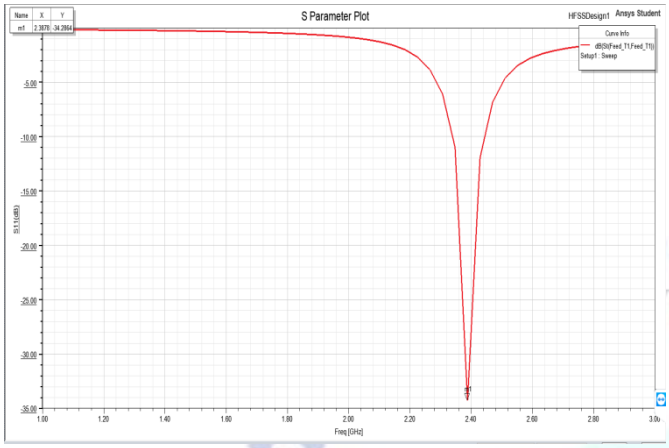


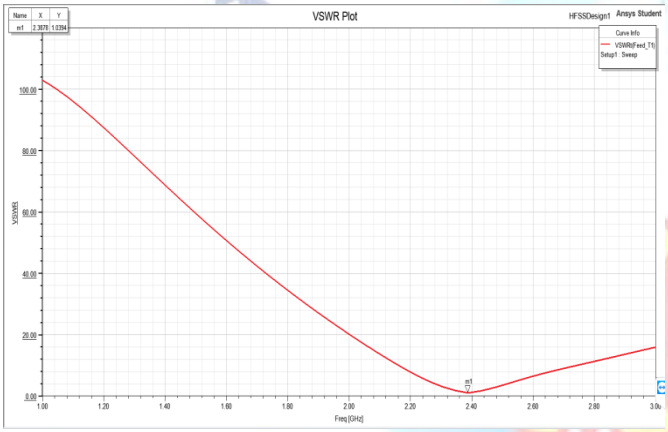


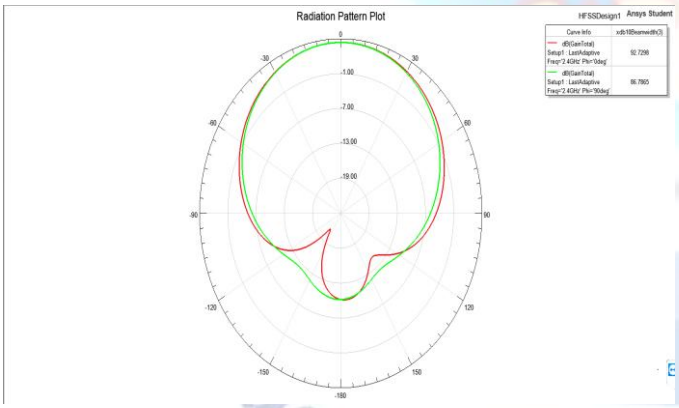


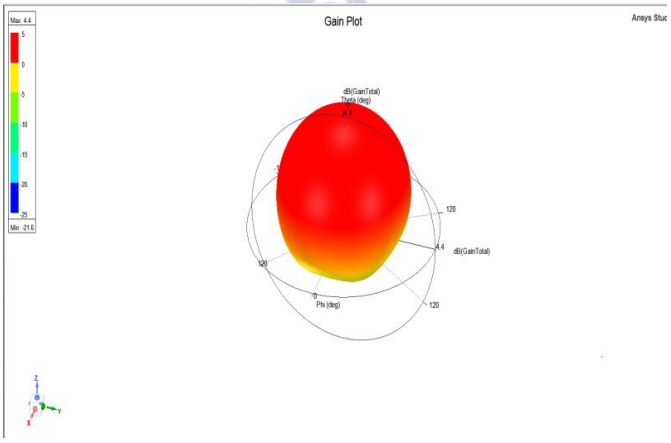


Inset feed antenna with a triangular slot:









4. RESULTS COMPARISION

TYPE OF FEED	TYPE OF SLOT	*fr* (GHz)	S11 (dB)	VS WR	GA IN (dB)	BEAM WIDTH (degree)
Co-axial	No Slot	2.40	-29.1	1.07	0.77	101.43
Co-axial	Ring	2.40	-37.7	1.03	0.61	100.81
Inset	No Slot	2.40	-28.7	1.08	4.39	92.38
Inset	Triangular	2.39	-34.3	1.04	4.37	92.73

5. CONCLUSION

From the above table of comparison, it is concluded that:

- Different feeding techniques like inset and co-axial are used.
- Co-axial feed circular patch micro strip antenna without slots, with two ring slots and Inset feed circular patch antenna without slots, with a triangular slot are simulated.
- By comparing the results of these designs, it is concluded that Coaxial feed circular micro strip patch antenna is having greater return loss around -37.7dB and VSWR around 1.03.
- Hence this antenna is found to be reliable with greater performance when it is operated at resonant frequency of 2.4GHZ for ISM band wireless applications.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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