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Tri-Shul Shaped Microstrip Patch antenna for X-Band Wireless Applications

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Abstract-
A rectangular microstrip patch antenna with slots in the Tri-shul shape has been developed. The design parameters and outcomes for a rectangular microstrip patch antenna in the Tri-shul shape are presented using CST software, and the simulation results are shown. The suggested antenna is built of a substrate called Roger with a dielectric constant of 3.48 sandwiched between a patch and a copper ground plane. Microstrip feed line is used to link the Tri-shul-shaped antenna to the coaxial connection, and the antenna's impedance is matched. Slotted antenna has been found to resonate at a frequency of 9.49 GHz. At 9.49 GHz, the proposed antenna has a return loss of 35.59dB. The VSWR for the proposed antenna is 1.03dB. Microstrip line feed technique is used to create the microstrip patch design. This patch is being researched because it has a low VSWR and high bandwidth. By adopting an appropriate feeding mechanism and adequate cutting slots in the rectangular patch, the gain increase has been accomplished.
The electromagnetic simulation of the proposed antenna has been carried out using CST software. The analysis of performance will be based on changing the geometry of the patch and the obtained results are gain, VSWR, antenna efficiency and radiation pattern.

Key Words - Microstrip Patch antenna, gain, S_{11} Parameters, antenna efficiency.

I INTRODUCTION

Microwave and wireless engineers' interest in research on compact microstrip antenna design has grown recently due to the requirement for small antennas for wireless communication [1-6]. Microstrip antennas are commonly employed in the microwave frequency range due to their simplicity and compatibility with printed-circuit technology. A microstrip antenna is merely a piece of metal of any shape that is placed on top of a grounded dielectric substrate. For a variety of factors, microstrip patch antennas are appealing in antenna applications. They are lightweight, inexpensive, and planar to produce.

Microstrip patch antenna:-
It consists of conducting patch on a ground plane separated by substrate material. Low dielectric constant substrates are generally preferred for maximum radiation. Conducting patch can take any shape
Microstrip patch antennas can define by its length, width, input impedance, and gain and radiation pattern.

Dipole Antenna: - it differs in geometric shape; its length should be less than 0.05ʎ.it is used for linear polarization .Feed mechanism is very important in these types of antennas.

Printed slot Antennas:-
It has a slot in ground plane of a grounded substrate. These slots are bi-directional radiators, radiates the power in both side of the slot.by placing a reflector on one side of slot, it can use as unidirectional radiator; it means linear polarization is possible.

Equivalent radiated power (ERP):-it is slandered theoretical measurement of radio frequency (RF) energy in watts and it is determined by adding system gain and subtract by system losses.

$$ERP = G_a(\text{Gain}) - L_c(\text{Cable Losses})$$

Feeding Techniques:-

- Microstrip line feeding
- Co-Axial Probe feeding
- Aperture couple feeding
- Proximity feeding

Microstrip line feeding-
This is an excitation technique in which microstrip line is directly connected to the patch made up of same substrate. In this process microstrip line is directly connected to the side of the microstrip patch. This procedure has merit due to direct feeding on same substrate to obtain the planner structure and the equivalent circuit is as shown in Figure .2, the conducting strip is directly connected to the edge of microstrip patch antenna.

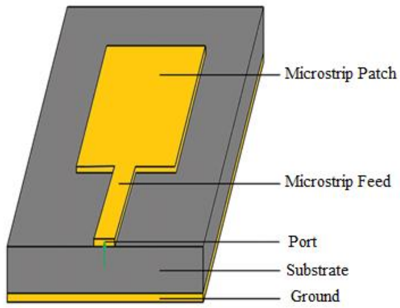

Figure.1:-Microstrip Feed line

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Co-Axial Probe Feeding:-

This is the most commonly used technique for power coupling to the patch antenna. In this the outer surface of the conductor is attached to the ground plane and inner surface of the conductor is connected to the radiating patch. Inner conductor used as a feed line which can transfer the power from the ground plane to patch.

This feed technique has a best advantage from the other feed technique to place the feed anywhere on the antenna for proper impedance matching. It provides easy technique to fabricate antenna. It has low power radiation also. This feeding technique has a demerit too it will give a narrow bandwidth.

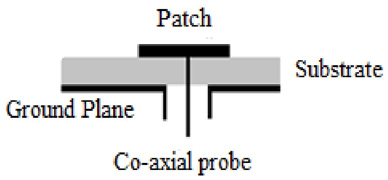

Figure.2:- Co-axial Probe feeding

Aperture Couple Feeding:-

This technique is also known as non-contacting feed technique. Here ground plane divides the radiating patch and microstrip feed line. The main advantage of this technique is to provide wider band width and reduce the radiation from the radiating patch as shown in figure 4. It has an aperture on the ground plane which couples the patch and feed line. Through this aperture feed line is coupled electromagnetically from the lower substrate to the patch. The aperture size and shape decide the amount of coupling power. It also depends on the location of the aperture separation between the feed line and patch from the ground plane. It can minimize the radiation from the patch. Radiation can be also minimized by using high dielectric material of lower substrate and low dielectric material for upper substrate.

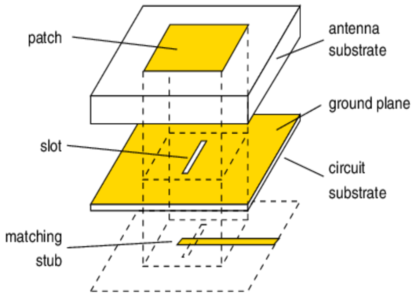

Figure.3:-Aperture Couple Feeding

Proximity Feeding:-

It is also known as none contacting and non-coplanar feed technique. This configuration has two layers of the different substrate first is upper layer substrate which has the patch and second one is lower layer substrate which has a microstrip feed line.

There is an electromagnetic coupling between these two layers. Due to this capacitive coupling between the patch and the feed line this technique will differs from others technique of feeding of patch antenna.

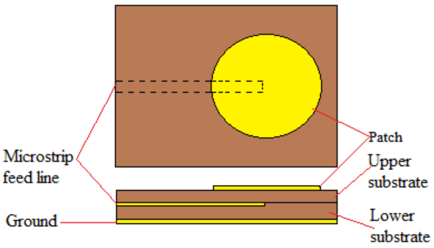

Figure.4:-Proximity Feeding

This antenna could be used in a wide range of applications such as in the communications industry for cell phones or satellite communication. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with ε_r = 3.48) has VSWR 1.03. The simulation has been carried out by CST software. Due to the small size, low cost and low weight this antenna is a good entrant for the application of S-Band wireless communication.

In this paper the microstrip patch antenna is designed for frequency range 8-12 GHz. The results obtained provide a workable antenna design for incorporation in wireless applications.

II. DESIGN ANALYSIS

Patch Antenna Materials:

The different basic parts of a patch antenna are:

- The patch
- Dielectric Substrate
- Ground Plane
- Feed Line

The patch is made up of thin metallic film with different shapes and sizes where the ground plane has mostly same material.

Used dielectric material is known as substrate .the selection of substrate depends on cost of material, dielectric constant, loss tangent, the surface properties and the fabrication process. There are many types of materials for the substrate selection .the range of dielectric content for the materials are 1.16 to 22.

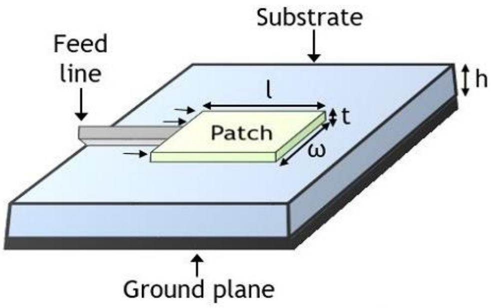

Figure.5:- Side view of Microstrip Rectangular Patch Antenna

The proposed antenna structure is designed by cutting a Tri-shaped slot of fixed dimensions. Cutting of this slot in antenna increases the current path which increases current intensity as a result efficiency is increased and desired parameters are obtained. The Essential parameters for this Rectangular microstrip patch antenna are W= 40 mm, L= 40 mm, Length of ground plane= 40 mm, Width of ground plane= 40 mm and height of the ground plan is 0.5 mm. The rectangular microstrip patch antenna designed on one side of epoxy structure with ε_r =3.48, height from the ground plane h=0.8 mm and loss tangent=0. 0009. Design is being calculated. Taking frequency 9.49 GHz. Steps for calculating the dimension of patch [10]

- **Calculation of the Width (W):**

The width of the Microstrip patch antenna is given as:

$$W = \frac{C}{2fo\sqrt{\frac{\epsilon r+1}{2}}}$$

- **Calculation of the Effective length (L_{eff}):**

The effective length is:

$$Leff = \frac{c}{2fo\sqrt{\mathcal{E}\text{reff.}}}$$

- **Calculation of the length extension ($\triangle L$):**

The length extension is:

$$\triangle L = 0.412h\frac{(\mathcal{E}\text{reff}+0.3)(\frac{W}{h}+0.264)}{(\mathcal{E}\text{reff}-0.258)(\frac{W}{h}+0.8)}$$

- **Calculation of actual length of patch (L):**

The actual length is obtained by:

$$L = Leff - 2.\triangle L$$

- **Calculation of the ground plane dimensions (L_g and W_g):**

Only infinite ground planes can use the transmission line concept. However, a limited ground plane is necessary due to practical reasons. It has been demonstrated by [9] that if the size of the ground plane is bigger than the patch dimensions by around six times the Substrate thickness all around the periphery, equivalent results for finite and infinite ground planes may be produced. The slotted antenna's dimensions are shown in Figure [1].

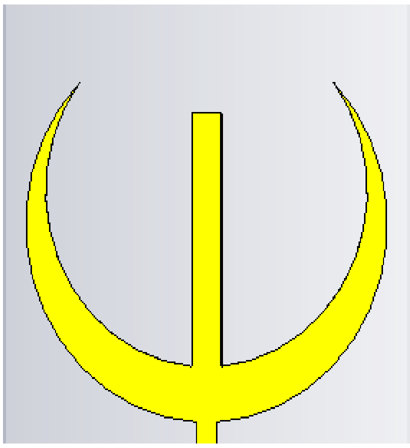

Figure.6:- Slotted Tri-shul shaped structure of Proposed Antenna

III. RESULTS

The simulation of micro-strip patch antenna is done by using CST software. The VSWR graph for a slotted Tri Shul-shaped patch antenna is shown in figure (6). The VSWR indicates the mismatch between the antenna and the transmission line. For perfect matching the VSWR value should be close to unity as shown in Figure (7). The VSWR for this slotted antenna is 1.03. The simulated radiation pattern in 3D is shown in figure (8), the return loss graph is shown in figure (9) and it is -35.95 dB, the far field gain at angle theta =90 degree is shown in figure (10), the far field gain at angle phi =90 degree is shown in figure (11) and proposed antenna excitation graph is shown in figure (13)

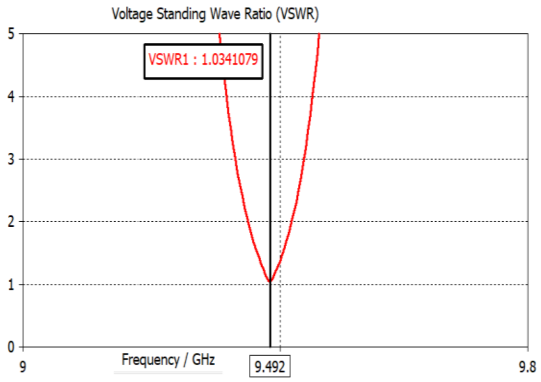

Figure.7:- VSWR of the Proposed Antenna = 1.03 at 9.49 GHz

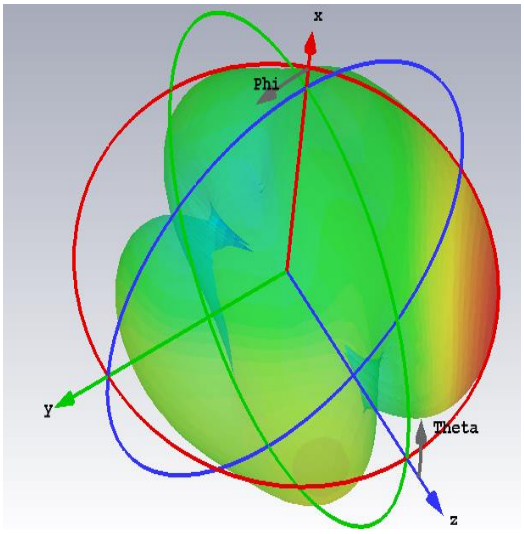

Figure.8: Radiation pattern in 3D of the Proposed Antenna

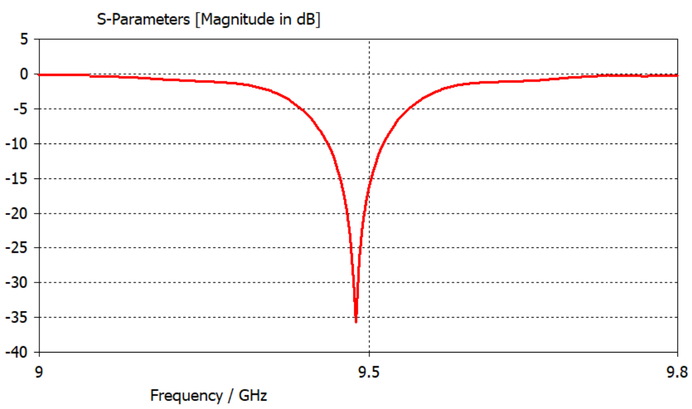

Figure.9:-Return Loss of the Proposed Antenna = -35.95dB at 9.49 GHz

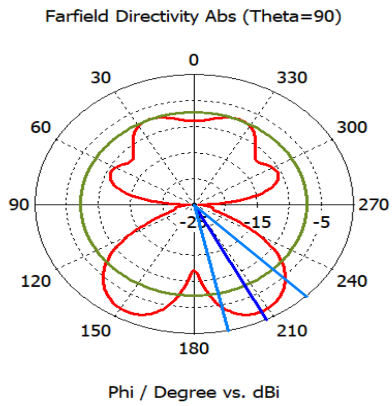

Figure.10:-Total far field gain of proposed antenna when theta=90 degree at 9.49 GHz

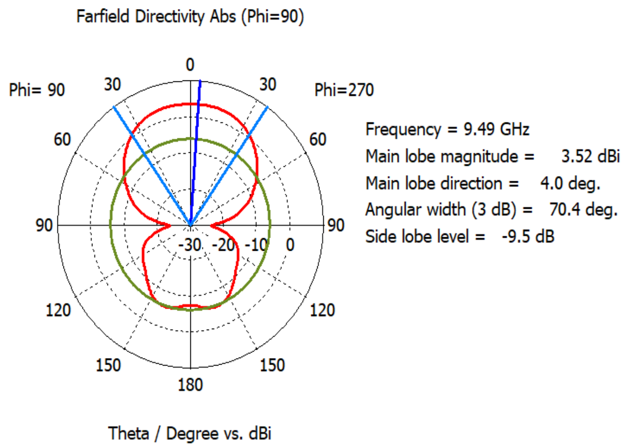

Figure.11:- Total far field gain of proposed antenna when Phi= 90 degree at 9.49 GHz

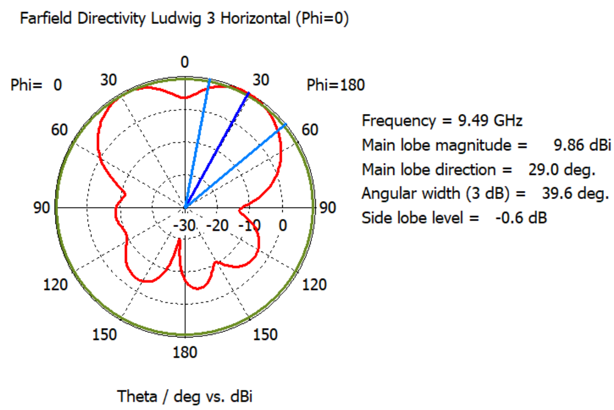

Figure.12. Total far field gain of proposed antenna when Phi= 0 degree at 9.49 GHz

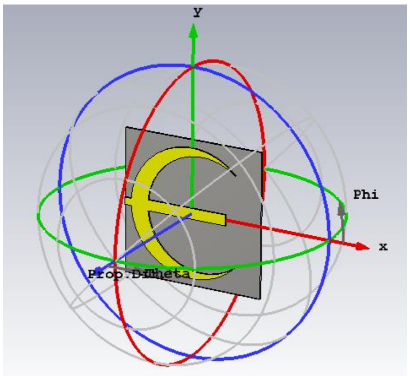

Figure.13. Proposed antenna-excitation graph at 9.49 GHz

IV. CONCLUSION

An effective microstrip patch antenna with slots can be constructed to deliver the necessary results, according to experimental research. The suggested antenna is compact and has adequate X-band coverage for wireless technologies.

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