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CIRCULARLY POLARIZED MONOPOLE ANTENNA FOR BROADBAND APPLICATIONS

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ABSTRACT

Nowadays circular polarization is very important in the antenna design industry as it gives much more flexibility to the angle between transmitting & receiving antennas. Also it enhances weather penetration and mobility. It is widely used in commercial and military applications. In this project a broadband circularly polarized monopole antenna is designed and simulated using Ansys HFSS Software. This circular microstrip patch antenna with a asymmetrical slot at the centre resonates at 2.4GHz frequency. The slot is added to obtain the proper axial ratio. The antenna is designed on an FR4 substrate with dielectric constant $\epsilon_r = 4.4$. The height of the substrate is 1.6mm. Coaxial cable (or) probe feed is used for excitation. From simulation, the antenna characteristics such as return loss, radiation pattern and axial ratio are studied. The designed circular patch antenna shows return loss value of -15.16 dB at the designed frequency. The antenna gain is equal to 1.52 dB. The axial ratio is 0.57 dB (less than 3dB), which satisfies the required criteria for circular polarization.

Keywords: Circular polarization, Monopole Antenna, Axial ratio, Coaxial feed.

INTRODUCTION

Patch antenna could be a kind of oftenness antenna with an occasional profile, which might be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a bigger sheet of metal referred to as a ground plane. they're the initial kind of microstrip antenna represented by Howell in 1972 the 2 metal sheets along type a resonant piece of small strip line with a length of roughly common fraction wavelength of the radio waves

The idea of microstrip patch Antennas arose from utilizing computer circuit technology not just for the circuit parts and transmission lines however conjointly for the divergent components of an electronic system. It consists of a golden patch that is either written on a grounded substrate or suspended on top of a ground plane ANd fed against the bottom at an applicable location. The patch form will in essence be whimsical. In follow, the parallelogram, the circle, the equitriangle, and therefore the ringed ring area unit common shapes. Feeding is sometimes by a coaxial probe or a stripline. The latter will be directly connected to the patch, or proximity coupled to the patch, or coupled through AN aperture

In this paper a broadband circularly polarized monopole antenna is intended and simulated using Ansys HFSS code. This circular microstrip patch antenna with an asymmetrical slot at the center resonates at a pair of 4GHz frequency. Section two describes connected works. Section three & four explains projected antenna style and simulation results. Section four concludes overall work.

Lin et al 2020 have projected a low-profile high-directivity circularly-polarized patch antenna. Two orthogonal slots are cut in the center of a square patch. It is realized that the size of the slots will increase radial asymmetry slightly and effectively stop radiation from tilting tendency.

Wong et al 2020 have conferred a four dual-band shorted patch antennas (SPAs) with an occasional profile of one millimeter (0.008λ at 2.4 GHz) integrated into a square-ring structure of size 66 millimeter x 66 millimeter (about 0.53λ x 0.53λ at 2.4 GHz) for four x four multi-input-multi-output (MIMO) operation.

AnhTu metal et al 2020 have projected the look of a compact SIW cavity-backed circular-polarized antenna employing a slow-wave structure in PCB technology.

Zhang, X et al 2017 have projected pin-loaded circularly-polarized (CP) patch antennas with wide 3-dB axial quantitative relation beamwidth (ARBW). The ARBW of a CP patch antenna is principally obsessed on its electrical dimension at a frequency, whereas the patch size at resonance is absolutely controlled by the shunt inductive load.

Zhang et al projected a single-fed microstrip patch antenna (MPA) with loading of shorting pins for high-gain circularly polarized (CP) radiation.

Lei, W et al 2016 have proposed a ground radiation antenna with circularly polarized (CP) properties for medical specialty applications. A square ground with a little clearance is enforced within the projected antenna.

Ta, S et al have projected a projected low-profile single-feed circularly polarized (CP) patch antenna using a metasurface for broadband operation. The antenna is comprised of a truncated corner square patch sandwiched between a lattice of four x four periodic metal plates and therefore the ground plane.

Nasimuddin, Anjani et al 2015 have projected a wide-beam circularly polarized (CP) asymmetric microstrip antenna with four unequal circular-patches for world navigation satellite systems.

Xu, H et al 2013 have projected a reduced-size single-feed circularly-polarized (CP) patch antennas and investigated the strategy of mixing meta-surfaces and meta-resonators owning robust space-filling capability.

Agarwal et al have 2013 projected a compact, asymmetric/symmetric-slotted/slit-microstrip patch antennas on reactive ohmic resistance surface (RIS) and studied for circularly polarized (CP) radiation. The antennas include a slotted-slit-microstrip patch on a RIS substrate.

Le, D et al 2020 have conferred a compact circularly polarized (CP) antenna for wearable passive ultrahigh frequency RFID tags. The antenna could be a square-shaped microstrip patch antenna wherever we've applied corner truncation and slotting techniques within the prime layer conductor for achieving the CP property and a shorting pin and loop structure for ohmic resistance matching.

AnhTuHO et al have 2016 projected the look of a compact SIW cavity-backed circular-polarized antenna employing a slow-wave structure in PCB technology. supported a multilayer substrate, this topology includes internal metallized blind via holes connected to very cheap conductive plane causing the physical separation of electrical and magnetic fields within the SIW cavity.

DESIGN METHODOLOGY

A circular microstrip patch antenna designing is easy to design than the other patch configuration. here we required one design parameter i.e. radius of the patch. followed by the cavity model formulation, a design procedure is formed which helps the practical designs of circular microstrip antennas for dominant TM₁₀ mode. The procedure assumes that information includes, dielectric constant of the substrate (ϵ_r), the operating frequency (f_r) and the height of the substrate (h). To find the actual radius 'a' of the patch we have

$$a = \frac{F}{\sqrt{\left\{1 + \frac{2h}{\pi\epsilon_r} \left[\ln \left(\frac{\pi F}{2h} + 1.7726 \right) \right] \right\}}} \dots \dots \dots (1)$$

Where,

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\epsilon_r}} \dots \dots \dots (2)$$

The operating frequency could be taken in hertz and the height could be taken in mm. In our proposed work, a circular microstrip antenna resonates at 2.4 GHz is designed. Circular patch is mounted over FR-4 epoxy substrate ($\epsilon_r = 4.4$) with dimension 50mm x 50mm and thickness h=1.6mm. The designed circular microstrip antenna is fed by coaxial feed with the central asymmetrical Slot. The coaxial cable inner radius is 0.2mm and the coaxial outer radius is 0.3mm and the radius of the circle is 16.2mm.

ANTENNA DESIGN

The antenna is designed based on equation (1) to resonate at 2.4GHz. The design specifications are listed in Table 4.1.

Table:1 Antenna Specifications

Part of the Antenna	Dimensions(in mm)
Substrate length	50
Substrate width	50
Substrate height	1.6
Circle radius	16.2
Feed pin radius	0.2
Feed pin height	1.6
Coaxial pin radius	0.3
Coaxial pin height	1

To generate the circularly polarized wave a central asymmetrical slot is introduced as in fig.1. The specifications of the slot are given in Table 2.

Table: 2 Slot Specifications

PARTS OF SLOT	DIMENSIONS(in mm)
Slot length	11.3
Slot width	8
Slot upper edge	2
Slot lower edge	2
Slot left corner	1
Slot right corner	1

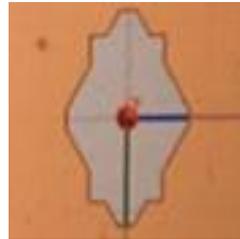


Fig 2 Central asymmetrical slot

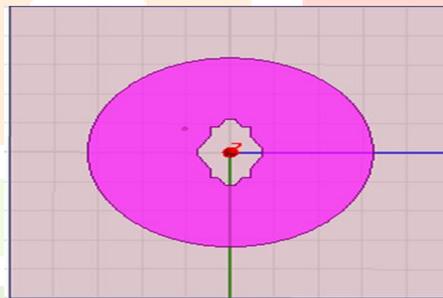


Fig 3 Top view of the antenna

The top view of the designed circular microstrip antenna is shown in figure 3.

SIMULATION

The circular microstrip patch antenna is simulated and a various antenna characteristics are obtained. The circular patch antenna shows a resonance peak at 2.40GHz and gives return loss value equal to -15.1604dB. it refers that almost a perfect feed configuration is achieved, hence patch and feed line are in perfect impedance matching state.

RETURNLOSS

The figure 5.2 shows the response of the circular patch antenna. The antenna resonates at 2.4GHz frequency and the return loss of the circular patch antenna is -15. 16049dB. The bandwidth of the antenna is 400MHz. The percentage bandwidth of the antenna is 16%.

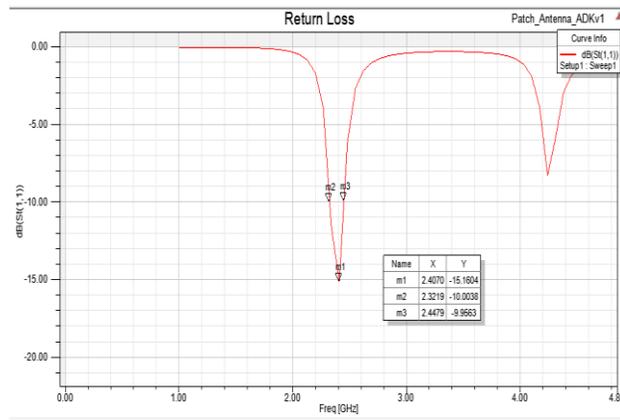


Fig 5.2 Return loss plot

RADIATION PATTERN

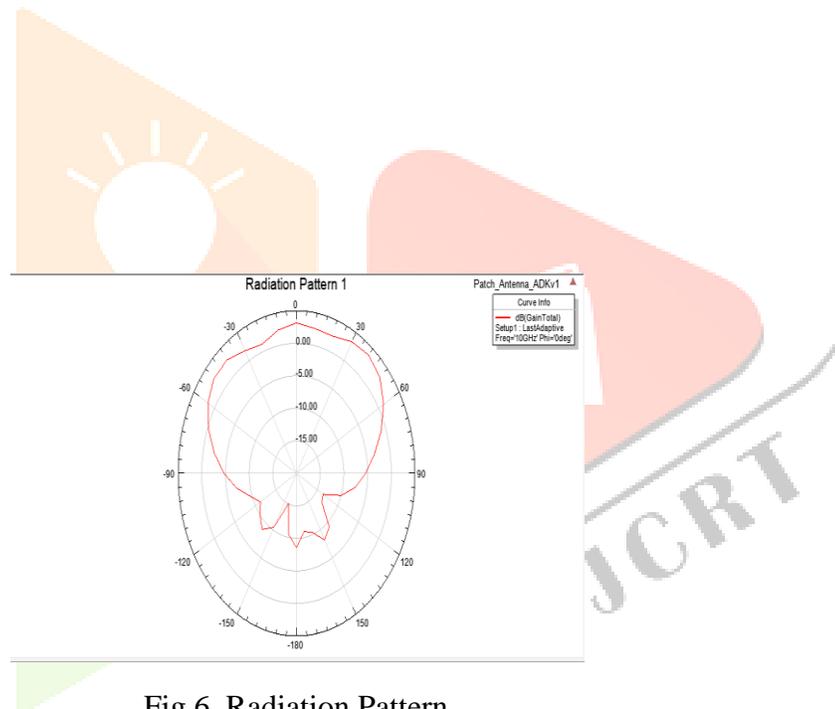


Fig 6 Radiation Pattern

The figure 6 shows the Radiation pattern of the circular patch antenna. it radiates at broadside direction. the magnitude of the radiation pattern is 3.13

VSWR

The VSWR is an indication of the amount of mismatch between an antenna and the feedline. If VSWR is less than 2 the antenna said to be at “good match” hence better radiation from antenna.

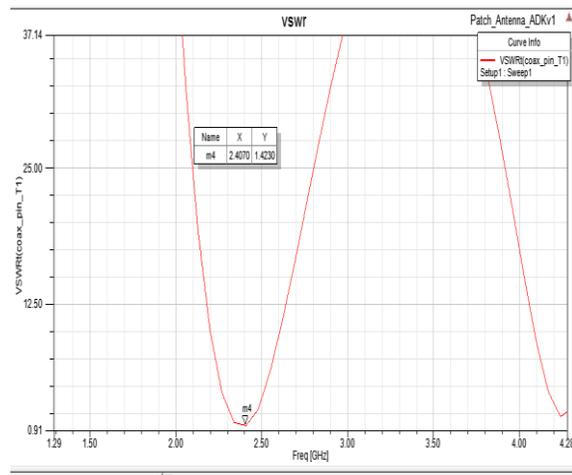


Fig 7 VSWR Plot

The figure 7 shows the VSWR plot of the circular patch antenna. The VSWR of the circular patch antenna is 1.42 which means the port and patch are perfectly matched and the radiation from the antenna will be good.

Axial ratio

The Axial ratio is ratio of the major axis to the minor axis if the ratio is 1 then it becomes purely circularly polarized .

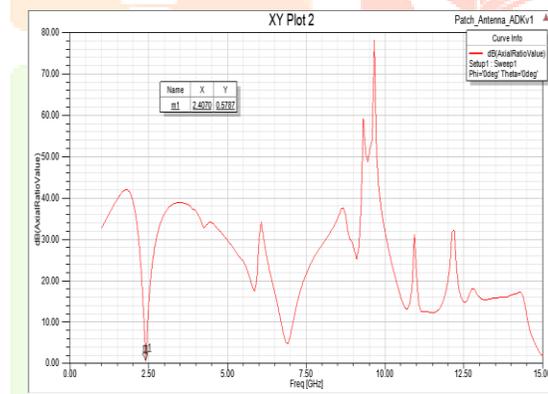


Fig 8 Axial ratio

The Figure 8 shows the axial ratio of the circular patch antenna. the axial ratio of the antenna is 0.57dB(below 3db) which represents the antenna is circularly polarized

Gain

The gain of the circular patch antenna it indicates power transmitted by an antenna in a specific direction

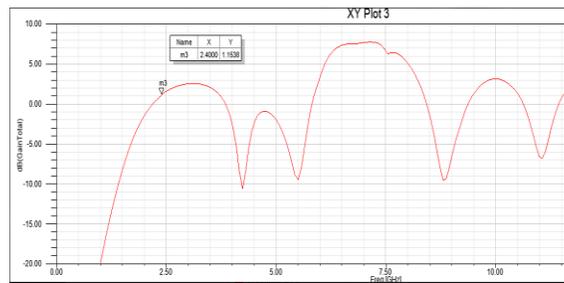


Fig 9 Gain

The Figure 9 shows the gain of the circular patch antenna. The gain of circular patch antenna is 1.52dB at 2.4GHz frequency.

MEASURED RESULTS



Fig.10 fabricated antenna prototype

The simulated antenna was fabricated and tested using the vector network analyser.



Fig.10 Return loss

This shows the good achievements between the simulated and measured results.fig.10 represents the measured return loss

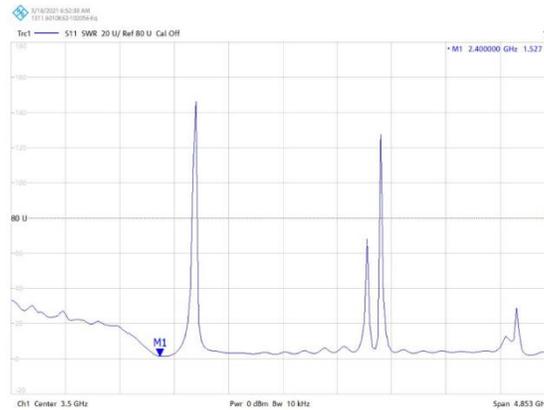


Fig.11 VSWR

The measure vswr value shows 1.52 which means the port is perfectly coupled. when it lies below 2.it represents a good matching

CONCLUSION

A Circular Micro strip patch antenna with a slot is designed using HFSS (high frequency structure simulator) software and its performance parameters are observed. From the simulation results, we can say that the circular Micro strip antenna gives better radiation at the designed frequency. The operating frequency of the circular micro strip antenna is 2.4GHz. The simulated value of return loss is -15.1604dB at 2.4 GHz. The simulated value of axial ratio is 0.57dB, which is an indication for the circular polarization. The VSWR of the antenna is 1.42, so the antenna is perfectly matched. The bandwidth of the antenna is 400MHz. The percentage bandwidth of the antenna is 16%, so that antenna can be used in broadband applications.

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