DESIGN OF CPW-FED CIRCULAR PLANAR ANTENNA FOR BROADBAND APPLICATION

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Abstract. The design of a circularly polarized, broadband planar monopole antenna is proposed in this work. The aim of the planar monopole antenna is to deliver maximum bandwidth with respect to radiation performance. In this work, the planar monopole antenna used is rectangular patch. The antenna gain is improved by correctly slicing a horizontal slit and placing a vertical stub on the ground plane. FR4 epoxy material with a dielectric constant (εr) of 4.5 is suggested for use in the design of the CPW-Fed Circularly Polarized planar monopole antenna. The suggested planar monopole antenna exhibits the best performance at 5 GHz, with a return loss of -33.504 dB and an antenna gain of 8.231 dB at the resonance frequency.

Keywords: Monopole antenna, axial ratio, circular polarisation.

1 Introduction

The development of wireless telecommunications technology over the past few decades has been significantly aided by antennas. An antenna is a piece of equipment used to transmit and receive radio waves-based information messages. In other words, an antenna serves as a conduit for the transformation of electromagnetic wave energy into electrical energy, or the opposite, between the free space transmission line. The effectiveness of the antenna will determine the signal quality that is received. It should be made as small, flexible, useful, and of the highest possible quality. The antenna's electromagnetic field radiates in a direction that is determined by its polarization. A variety of polarization types are used in this situation, including circular polarization. The radiation patterns' circular polarization makes the transmitting and receiving antennas less sensitive to their respective orientations (CP). Several wireless systems, such as WLAN, RFID, and broadband, have emerged as a result. For which planar CP antennas to be quite useful for their system. Broadband antennas are used to send and receive radio signals with a wide frequency range, for instance in radio astronomy, television, and radar. A wideband antenna is a useful tool for communicating across a large frequency range. Due to the large frequency range provided by broadband antennas, a single antenna can be utilized to transmit and receive data at several frequencies. Hence, one or more of these antennas can be replaced. It is frequently necessary to know which sort of broadband antenna is ideal for installation site and environment before choosing one for Internet use. Selecting a broadband antenna that can be easily measured and placed close to the modem. Broadband occasionally has weak signals, so it's not always dependable. The distance between the antenna and the modem will undoubtedly have an effect on the broadband gain. To achieve the best gain, it is advisable to keep the antenna as close to the modem as feasible.

2 Literature Survey

An innovative circularly polarised antenna with triple-mode properties is presented [1]. It is intended to provide an 80% wide impedance bandwidth and an 80% wide axial ratio bandwidth. At the lowest working frequency, it has a small profile (0.18 wavelength in free space), a wide axial ratio bandwidth (80%), and a high impedance bandwidth (104%). It is suitable for contemporary broadband CP applications due to its inherent advantages in reducing multipath fading, polarisation imbalance, and the Faraday rotation effect. With its high impedance bandwidth of 104%, wide axial ratio bandwidth of 80%, and low profile of 0.18, the suggested antenna is promising for a variety of CP applications, including GNSS, RFID etc.

A newly developed broadband omni-directional circularly polarised antenna for utilisation in mobile communications that performs close to 2 GHz is examined [2]. The antenna has a return loss of 10 dB, a frequency range of 36.1% (1.75 GHz-2.52 GHz), an average AR of 3 dB, and 30.8% (1.7 GHz-2.32 GHz). A unique 3D broadband omni-directional circularly polarised antenna structure for mobile communications is proposed, consisting of four broadband circularly polarised rectangular loop components with a bandwidth of 50%. It provide a conducting cylinder and a broadband balun, respectively, to provide good circularly polarised performance and impedance matching.

For global navigation satellite systems, a compact dual-band circularly polarised slotted patch antenna is suggested [3]. It consists of a primary patch radiator, a parasitic patch radiator, and a coaxial feeding probe. The circular patch radiators have four circular-ring holes drilled within them for antenna miniaturisation and circularly polarised radiation. At the L1/L2 bands, the prototype reaches the desired measured performance, with an ideal gain of 4.0 dBic at 1.227 GHz and 5.6 dBic at 1.555 GHz. Over the 3-dB AR bandwidth, the 3-dB AR beamwidth for both bands is more than 145°.

In order to increase 3-dB axial ratio bandwidth, this research suggests a circularly polarised monopole antenna with an elliptical form and a slanted slot [4]. For applications involving radio-frequency identification readers, it operates in the ultrahigh frequency band. Standing wave ratio 2 measured bandwidth is 535 MHz, whereas 3-dB axial ratio measured bandwidth is 45 MHz. The radiating element is 137 mm by 122 mm in dimension. To make circularly polarised antennas, two feeds with similar amplitude and 90 degree phase difference, or a single stimulation, are recommended. However, the typical circularly polarised bandwidth of these single-feed antennas is only about 1%.

A revolutionary wideband circularly polarised (CP) microstrip antenna with improved pattern is suggested [5]. Four metal isosceles triangular patches and four vertical conducting walls make up the structure. Large impedance bandwidth and 3-dB AR bandwidth are provided using a small wideband phase shifting network and electromagnetically linked method. The antenna's size may be decreased while retaining a large 3-dB beamwidth using feed techniques and networks. In contrast to the 82% and 79.4% of a state-of-the-art broadband 900 hybrid feed network, a dual-fed antenna with a Wilkinson power divider produces impedance bandwidths of 35% and 49% with 3-dB AR. There are numerous ways to reduce the size of an antenna with a large 3-dB beamwidth.

A dual-frequency even-mode resonance square loop antenna with circular polarisation is simulated [6]. A fork-shaped dipole launcher feeds diagonally into the square loop antenna. In the vicinity of the second odd-order resonant even-mode's current distribution nulls, four tuning stubs are symmetrically added. This results in the excitation of the second odd-order even-mode and the realisation of the dual-band circular polarisation characteristic. A closed-form formula is derived after statistically studying the antenna's dual-band behaviour. Future dual-band CP loop antenna designs are anticipated to benefit from the preliminary findings of this work.

For Ka-band satellite applications, a microstrip array antenna with circular polarisation has been proposed [7]. The parasitic circular-ring radiator and L-shaped patch that make up the antenna element are supplied by a microstrip line that travels through a via. A wide 3-dB axial ratio bandwidth of 6.0 GHz, 2:1-VSWR bandwidth of 7.0 GHz, and 10 dBic gain bandwidth of 6 GHz are all attained with the recommended 22 array antenna. The 88 antenna array shows more than 24 dBic of boresight gain spanning 27.25 GHz and 31.25 GHz.

3 Antenna Design

The specifications are laid forth in the design of a broadband FR-4 epoxy-substrate, CPW-fed planar monopole antenna as shown in Fig.1 Using a trial-and-error approach, the circular polarised planar concept is employed to achieve the desired results. Flame Retardant is also known as fibre glass epoxy and FR. FR-4's exceptional mechanical strength and nearly nonexistent water absorption make it the most popular choice for use as an electrical insulator.

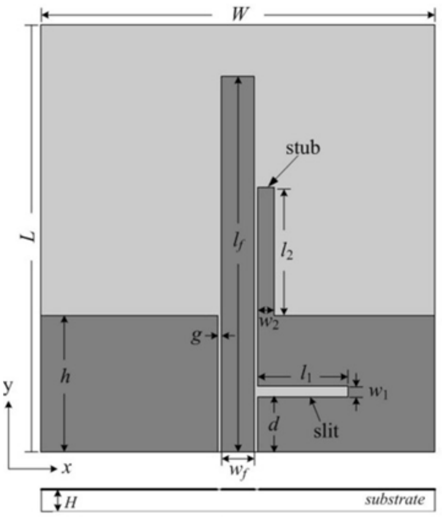

Fig. 1. Geometry of the proposed antenna

The dimensions of the proposed antenna are obtained using these equations.

Effective dielectric constant, $\in eff$ can be obtained,

$$\epsilon eff= \varepsilon r+12\ (1+0.3*H)$$

Length of monopole, lf can be calculated by the equation,

$$lf= 0.42*Cfr*\sqrt{\in eff}$$

Width of planes, w is obtained by the equation,

$$w= 1.38*Cfr*\ \sqrt{\in eff}$$

Height of planes, h is calculated by the equation,

$$h = 0.36*Cfr*\ \sqrt{\in eff}$$

Resonant frequency (GHz),

$$fr=3+2\in eff\ [21lf+ 65w+ 18h -3]$$

The substrate utilised in the design of the CPW planar monopole antenna has the following characteristics and dimensions: the dielectric material is FR-4 epoxy; the dielectric thickness (h) is 1 mm; and the relative permeability is 1. The substrate measures L = 25 mm, W = 24 mm, and H = 1 mm. The monopole is 22 mm and 2 mm in length and breadth, respectively. The plane measures 8 and 10.8 millimetres in height and breadth, respectively. There is a 0.2mm gap between the planes and the monopole. The slit has the following measurements: length (l1) = 5.5 mm, width (w1) = 0.6 mm, and depth (d) = 3.25 mm. The stub has a width of 1 mm and a length of 7.5 mm.

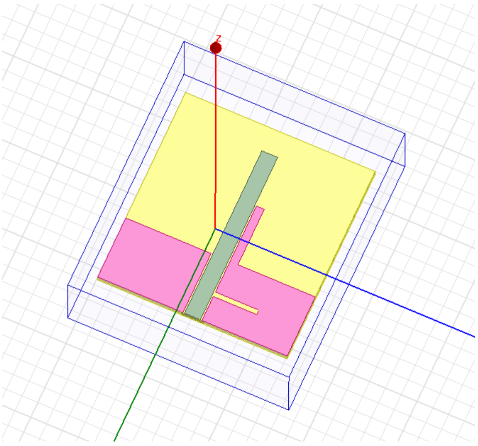

Fig. 2. Simulated design of CPW planar monopole antenna

4 Simulation and Results

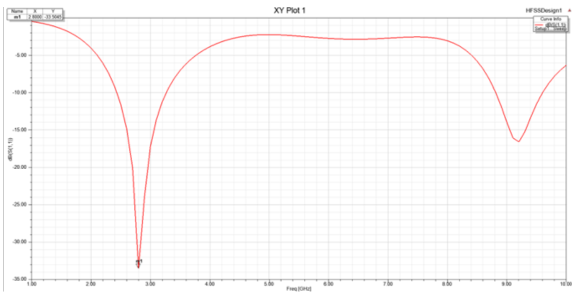

Fig. 3. Reflection Loss

An antenna's S-parameters explain how it responds to electromagnetic waves at various frequencies and propagation directions. In order to maximise antenna performance and guarantee the optimal system integration, S-parameters are frequently utilised in antenna design and testing. Terminal S parameter of proposed CPW fed circularly polarized antenna is -33.504 dB.

Fig. 4. 3D Polar Plot(Gain)

implies that the suggested CPW fed circularly polarised antenna achieves a gain of 8.231 dB, which is very good for transmitting signals in all directions.

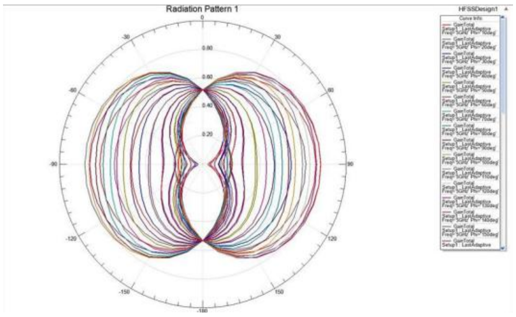

Fig. 5. Radiation Pattern

Radiation patterns are used to describe how an antenna's power varies depending on which way it is pointed away from the antenna. This statistic provides a visual representation of the relative field strength that the antenna broadcasts or receives. Also visually represented as the antenna pattern is the radiation from an antenna as a function of spatial coordinates. Radiation Pattern of the proposed CPW fed circularly polarised antenna is represented here.

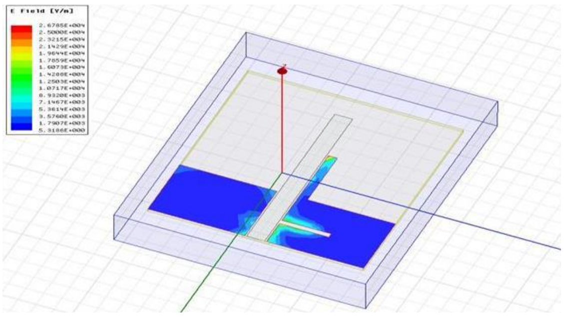

Fig. 6. E- field of an antenna

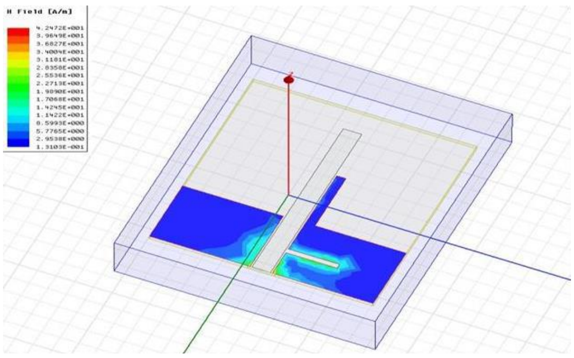

Fig. 7. H- field of an antenna

This figure represents the E-field and H-field of the proposed CPW fed circularly polarised antenna. The frequency of the transmission, as well as the size and form of the antenna, affect the strength and direction of the electric and magnetic fields, respectively.

Fig. 8. Fabricated structure of proposed antenna

The proposed antenna designed using HFSS software is in dx file format. It should be converted to Gerber file for further PCB design. For Gerber file conversion, Dip Trace Launcher Software is used. Once the Gerber file is generated for the corresponding simulated antenna design, it is uploaded in Copper CAM Software and extracted as G-code and it is given Auto Leveller Software for surface level checking and stored as AL G-code. Mach3Mill software and in PCBMATE 300W machine is used for the hatching of AL G-code. After Completion of Hatching, Hatched part gets separated by cutting.

5 Conclusion

This work proposes a planar monopole antenna for use in broadband applications that is fed by a CPW feeding arrangement. To attain good radiation properties, the suggested antenna comprises of a rectangle patch. HFSS simulation package is used to simulate the proposed antenna.

The ground-plane is used to boost the antenna's gain by correctly slicing a horizontal slit and adding a vertical stub. At the resonance frequency of 5 GHz, a circularly polarised planar monopole antenna fed by CPW has an antenna gain of 8.231 dB and a return loss of 33.504 dB.

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