

# Design of a Compact Circularly Polarized Folded Square Patch Antenna for GPS Applications

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**Abstract:** A compact circularly polarized (CP) folded square patch antenna is developed for global positioning system (GPS) receivers. The antenna is designed on the flame resistant (FR4) substrate of relative permittivity 4.4 and thickness 1.6 mm. By connecting four different length of meander strips to the four edges of the patch of a single coaxial feed square patch antenna are folded to achieve a circularly polarized antenna. The CP antenna has an advantage of greater flexibility in orientation angle between the transmitter and receiver. The proposed folded patch antenna receives the GPS operating frequency of 1575 MHz. Due to its compact size, simple structure and less expensive, the proposed antenna can be used for GPS applications. The antenna parameters is simulated by HFSS.

**Keywords:** Folded square patch antenna, Circularly polarized antenna, Coaxial probe feeding, FR4 substrate, global positioning system.

## 1. Introduction

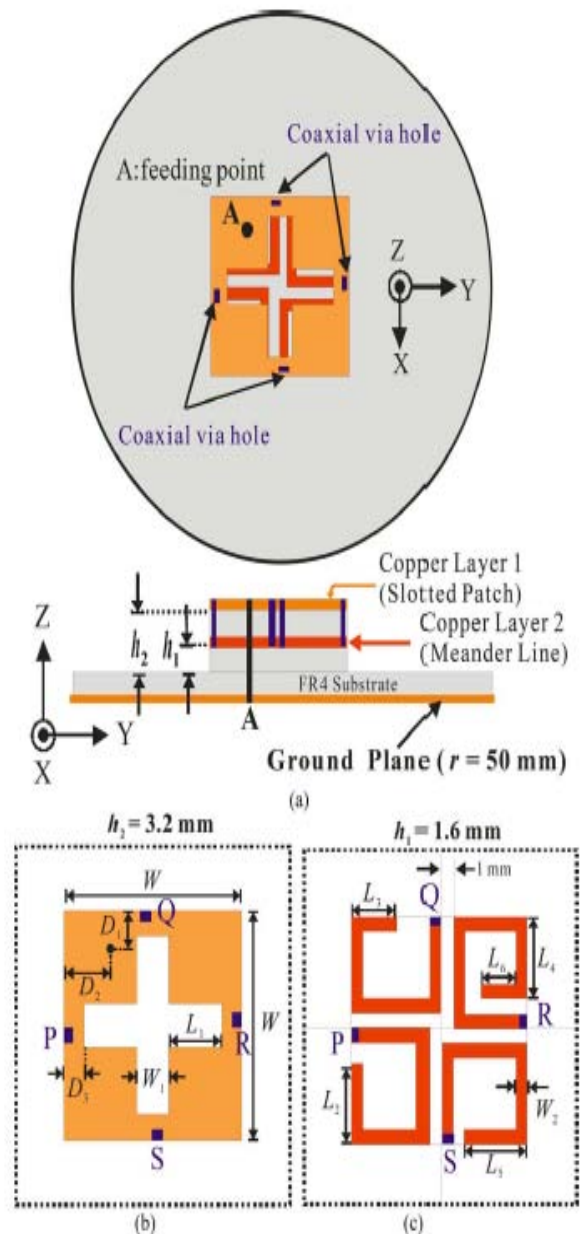
An antenna is an electronic device that converts radio frequency (RF) electric current to electromagnetic waves that are radiated into free space. Thus antennas play a very important role in wireless communications. Circularly polarized folded patch antennas are widely used in global positioning systems (GPS), radio frequency identification systems (RFID) and vehicle communication devices.

GPS is a space-based navigation system that provides location and time information in all weather conditions. It plays a very important role in tracking and location mapping in most of the ships, automobiles and in aircrafts by using triangulation method. GPS receivers composed of an antenna, receiver processors and a highly stable clock. GPS antenna requires right hand circular polarization, which enables a flexible orientation angle between the transmitter and receiver. Generally single feed and dual feed are used in patch antennas. As compared to the dual feed patch antennas, single feed provides a larger circularly polarized bandwidth but it should require a larger ground plane for the feeding network.

Many industries require a high performance, compact size and low cost antenna. To meet the miniaturization requirements, folded patch GPS antenna is designed with FR4 substrate. This antenna operates in right-hand circular polarization (RHCP) wave in two orthogonal linear resonant modes. Folded patch antennas with different ground planes are designed and simulated to verify the effectiveness of the antenna. No complex feeding network is required. The final design is compact and inexpensive. Details of the proposed GPS antenna design and its performance are discussed.

## 2. Antenna Design

The proposed GPS antenna is printed on two layers of the FR4 substrate. The slotted square patch on layer 1 is connected to layer 2 via four holes namely P, Q, R, S at the edges of the square patch.



**Table 1:** Dimension of the proposed GPS antenna

Parameters	Values (mm)	Parameters	Values (mm)
W	15	L <sub>1</sub>	4.2
W <sub>1</sub>	2.8	L <sub>2</sub>	5
W <sub>2</sub>	1	L <sub>3</sub>	4
D <sub>1</sub>	2	L <sub>4</sub>	5.5
D <sub>2</sub>	3	L <sub>5</sub>	5.2
D <sub>3</sub>	1.5	L <sub>6</sub>	3
h <sub>1</sub>	1.6	h <sub>2</sub>	3.2

The strips front end are connected to the holes using short wires. Here circular ground plane of radius(r)=50 mm is used. A larger ground plane will increase the gain of the antenna.

**A. Radiation Mechanism**

The radiating patches are folded to provide excitation in different resonant modes. The current flows from layer 2 to layer 1. The circular polarization can be achieved only when the magnitude of the two field components are similar and their time difference is an odd multiple of 90 degrees. The circular polarization can be achieved when,

$$|E_{\theta}| = |E_{\phi}|,$$

$$\angle E_{\phi} - \angle E_{\theta} = \begin{cases} +90^{\circ}, & \text{for LHCP} \\ -90^{\circ}, & \text{for RHCP.} \end{cases}$$

**B. Effects of Ground Plane and Antenna Positions**

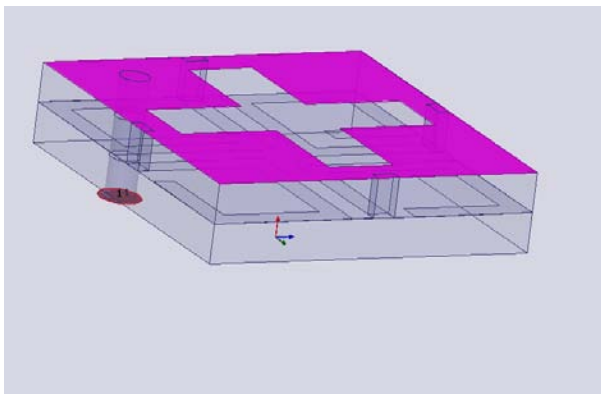
To optimize the location of the folded patch GPS antenna, the antenna is tested on a finite ground plane. The circular polarization performance gets changed due to different size of the ground plane. Changes in radius(r) affects the axial ratio (AR).

The antenna receives the satellite signals and passes to the GPS receiver so it can Fig 1. Geometry of the proposed GPS antenna be located outdoors with 360° view of the sky.

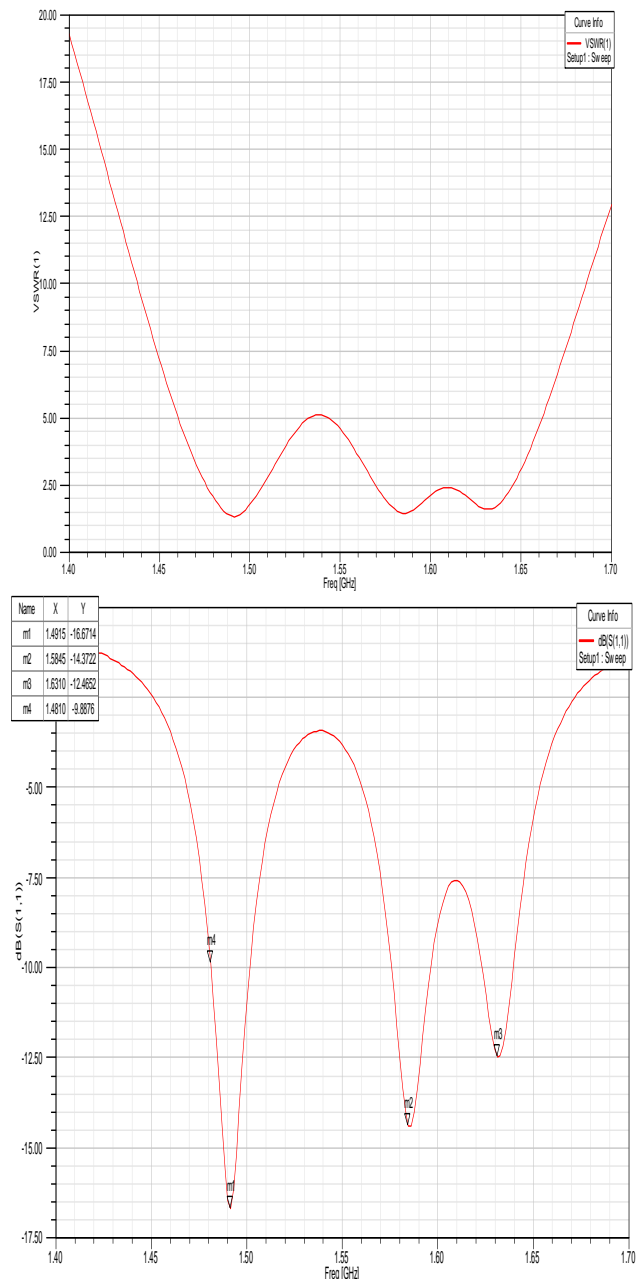
- (a) top view and y-z plane view
- (b) slotted patch & (c) meander-strip

**3. Simulation Results**

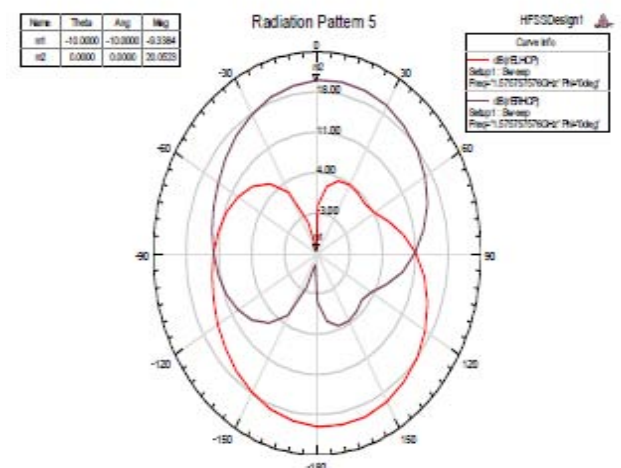
The compact folded square patch antenna is designed and antenna parameters such as, VSWR, return loss (RL), radiation pattern is simulated using HFSS.



**Figure 2:** 3-D perspective view of folded square patch GPS antenna



**Figure 3:** Frequency Vs Return Loss



**Figure 4:** Frequency Vs VSWR Fig 5. Radiation pattern at 1575 MHz

#### 4. Conclusions

The compact circularly polarized folded square patch antenna for GPS applications is designed by the software package HFSS. A good impedance bandwidth and circular polarization is achieved. Several attractive features of this antenna is small size, low cost and stable radiation pattern.

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