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Circularly Polarized Microstrip Square Patch Antenna for Global Positioning System

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Abstract

This paper presents the design of circularly polarized square patch antenna using a coaxial feed. By using a coaxial feed instead of normal feed shown that the area of perturbation must increase inorder to maintain circular polarization. Consequently the effect of manufacturing errors on the axial ratio is reduced. The antenna is matched using a simple matching network consisting of a short length of micro strip line. A matched antenna was designed to operate at 1.575 GHz and the axial ratio of >3db and the return loss of >-40db was obtained experimentally The predicted, simulated and practical results are shown to be in good agreement.

Index terms: Circularly polarized microstrip patch antenna

I. INTRODUCTION:

A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and Radiation patterns. A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations .A microstrip patch is one of the most widely used radiators for circular polarization. A patch including square, circular, pentagonal, equilateral triangular, ring, and elliptical shapes which are capable of circular polarization operation. However all patches are widely utilized in practice. A square patch antenna can be made to radiate circular polarization for GPS.

The circularly polarized GPS square patch antenna for frequency band of

1.575 GHz. Microstrip patch antenna is used to get a better form factor in GPS receiver.The dielectric substrate FR4 which has the relative permittivity using 4.3, with constant 2.2 (h=0.1588 cm).The axial ratio is less than -3db.High bandwidth and reduced size with varying resistivity.Simulation carried out with CST Microwave Studio

II. PROPOSED ANTENNA MODEL

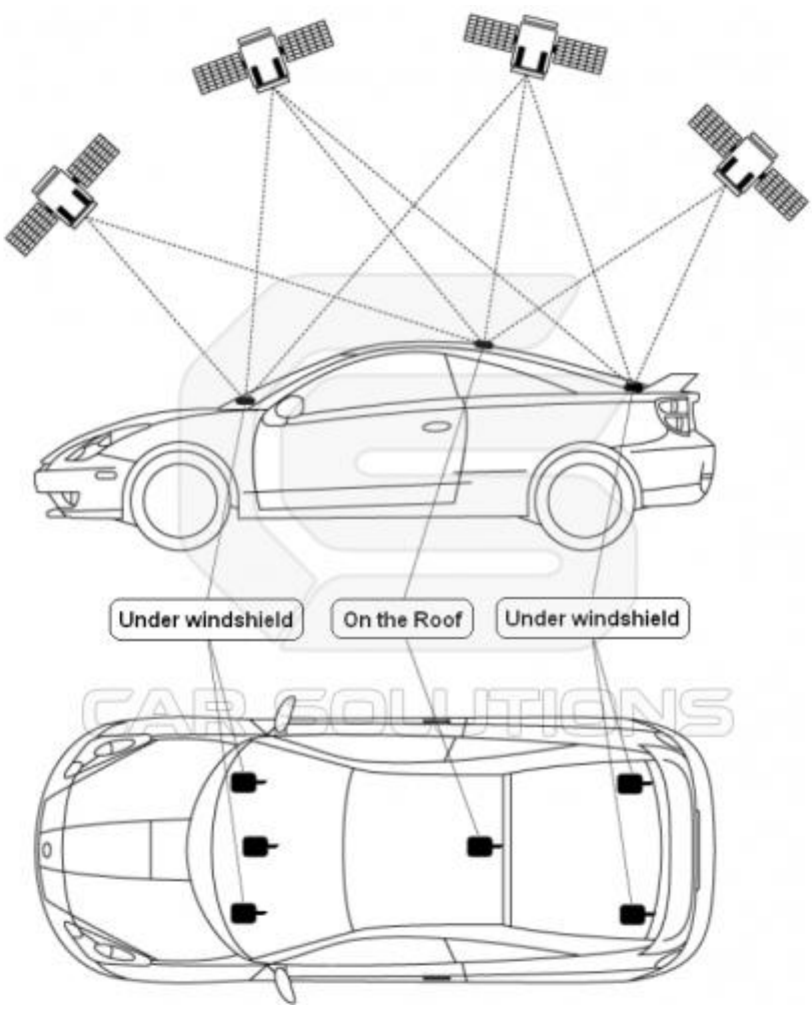

Figure 1 :Geometry of the Proposed Antenna

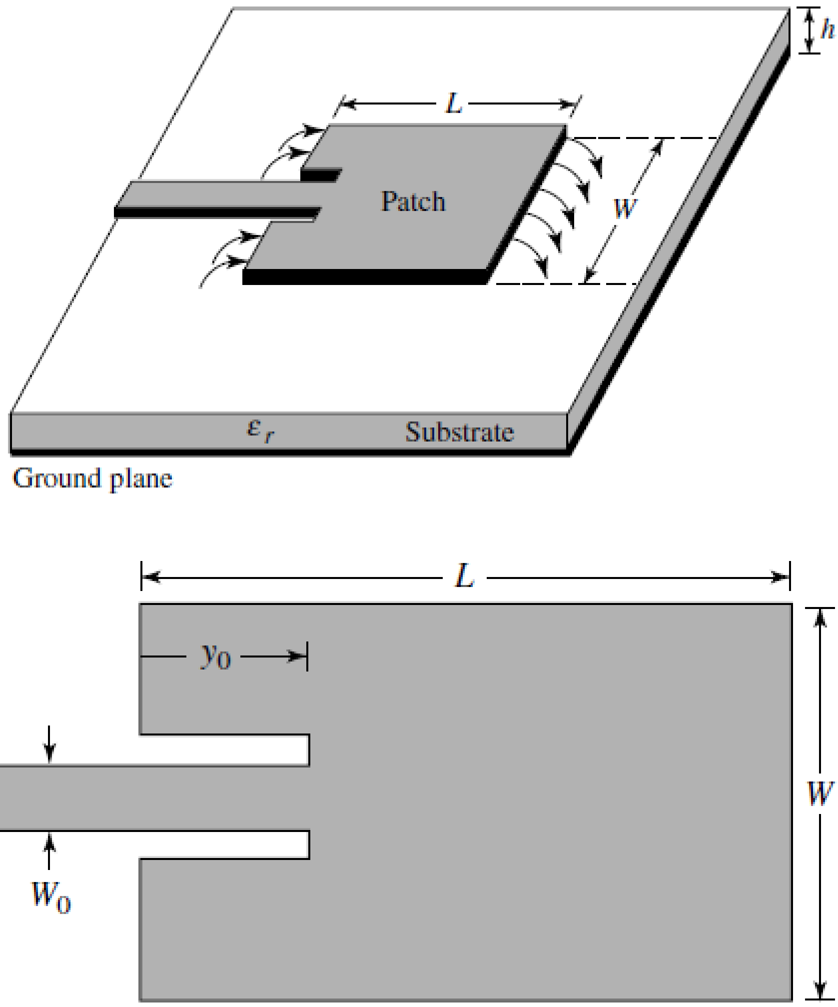

Figure 2 : Microstrip square patch antenna with coaxial feed

III. ANTENNA DESCRIPTION

Microstrip antennas received considerable attention starting in the 1970s, although the idea of a microstrip antenna can be traced to 1953 and a patent in 1955 .Microstrip antennas, as shown in Figure 2, consist of a very thin (t _ λ_0, where λ_0 is the free-space wavelength) metallic strip (patch) placed a small fraction of a wavelength (h _ λ_0, usually $0.003\lambda_0 \leq h \leq 0.05\lambda_0$) above a ground plane. The microstrip

Patch is designed so its pattern maximum is normal to the patch .This is accomplished by properly choosing the mode of excitation beneath the patch. End-fire radiation can also be accomplished by judicious mode selection.

There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range of $2.2 \leq er \leq 12$. The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. Thin substrates with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling.

IV. DESIGN EQUATIONS

Calculation of the Width (*W*): The width of the Micro strip patch antenna is given by

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Where
$c = 3\times10^8$ m/s (free space velocity)
f_o = resonant frequency
ε_r = Dielectric constant of the substrate.

Calculation of Effective dielectric constant (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Calculation of effective length (L_{eff}):

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

Calculation of length extension (ΔL):

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

Calculation of actual length (L):

$$L = L_{eff} - 2\Delta L$$

V. IMPEDANCE

The input impedance of the antenna can be matched by using either a coaxial feed o.

The approximate input edge impedance of a microstrip element is given as Rin=60 λo/W, where W is the width of the slot. The input impedance in the embodiment is matched to 50Ώ impedance by using a coaxial feed. The 50 Ώ point for the feed is obtained by varying the distance between the feed location and the edge of the element. Each candidate feed position for 50Ώ impedance is calculated for material properties and roughly located for the element. These values are used as starting points, but exact dimensions are adjusted empirically. Fabrication accuracy, materials consistency and mutual coupling result in small variations over a group of units. This antenna uses a coaxial approach for circular polarization.

VI. CST MICROWAVE STUDIO

CST MICROWAVE STUDIO (CST MWS) is a specialist tool for the 3D EM simulation of high frequency components.CST MWS enables the fast and accurate analysis of high frequency (HF) devices such as antennas, filters, couplers etc.It is user friendly.

CST MWS quickly gives you an insight into the EM behaviour frequency designs.CST promotes Complete Technology for 3D EM .Users of the software are given great flexibility in tackling a wide application range through the variety of available solver technologies.

VII. FEED POINT LOCATION

Feed points are located using the 1-D current distribution of the element at the resonant frequency. The feed input impedance of the antenna varies proportionally with patch current and location. Resonant frequency and pattern of the microstrip element are essentially independent of feed position. The rectangular patch's dimensions are mechanically tuned to resonate at the L1 frequency.

VIII. DESIGN PROCEDURE

- Decision of GPS application with frequency 1.575GHz.
- Selection of type of antenna(microstrip square patch antenna)
- Calculation for the parameter and its specifications.
- Computer aided designing with CST MWS software.
- Simulation under the Transient solver in CST software.
- Optimization and attaining the goal of the project
- To make the design circularly polarized perturbation technique is used.

IX. RESULT OF LINEAR DESIGN USING CST MWS

Designed antenna with the obtained parameter calculation

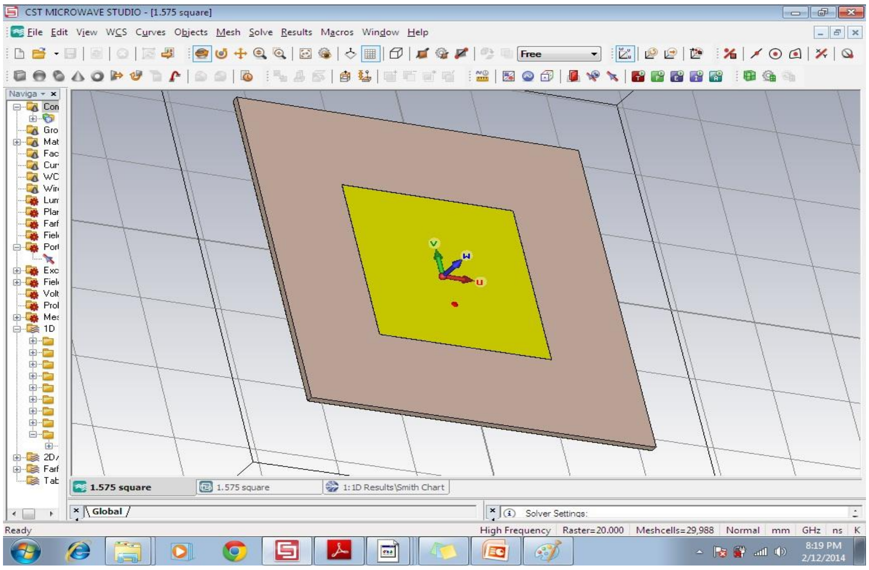

Figure 3 :Linear Antenna Design

Smith chart

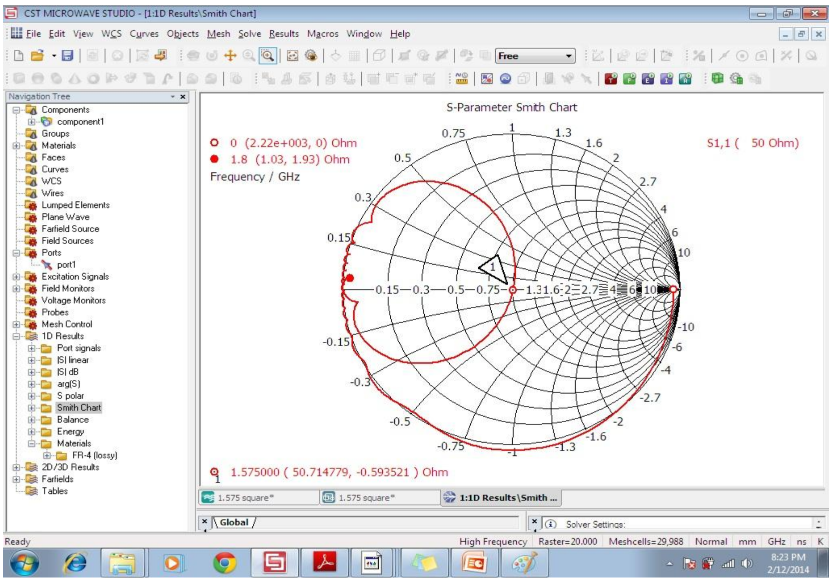

Figure 4: Smith Chart

Radiation pattern

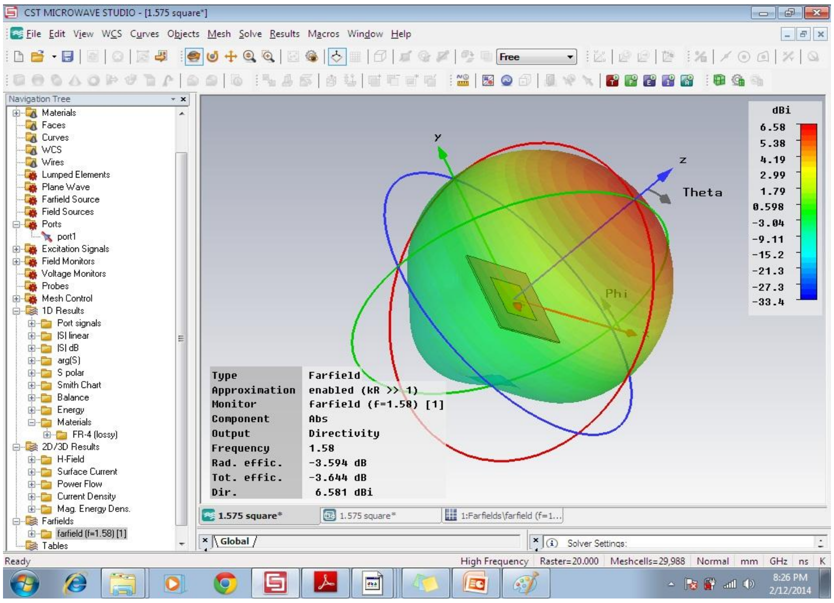

Figure 5: Radiation Pattern

S Parameter graph

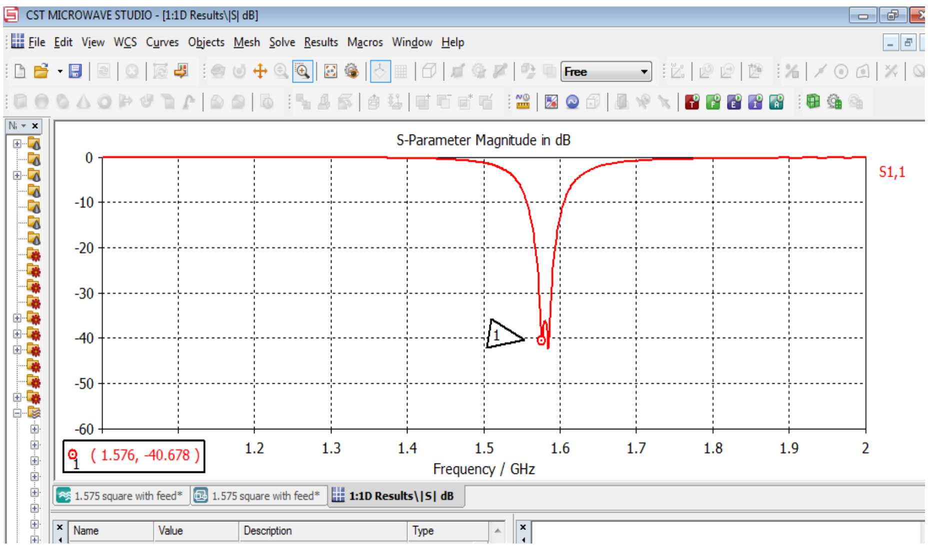

Figure 6: S parameter Graph

X: RESULT OF CIRCULAR DESIGN USING CST MWS

Designed antenna

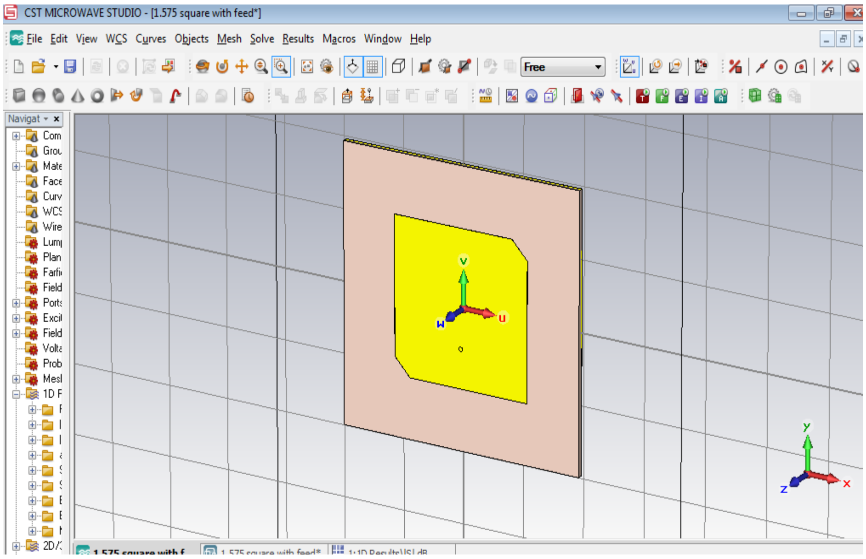

Figure 7 : Circular Polarized Antenna Design

❑Smith chart

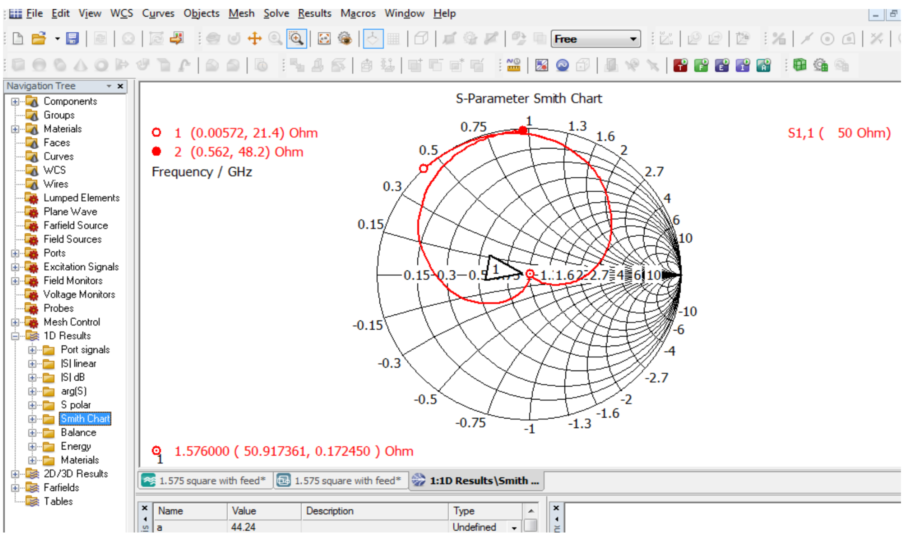

Figure 8: Smith Chart

❑OUTPUT

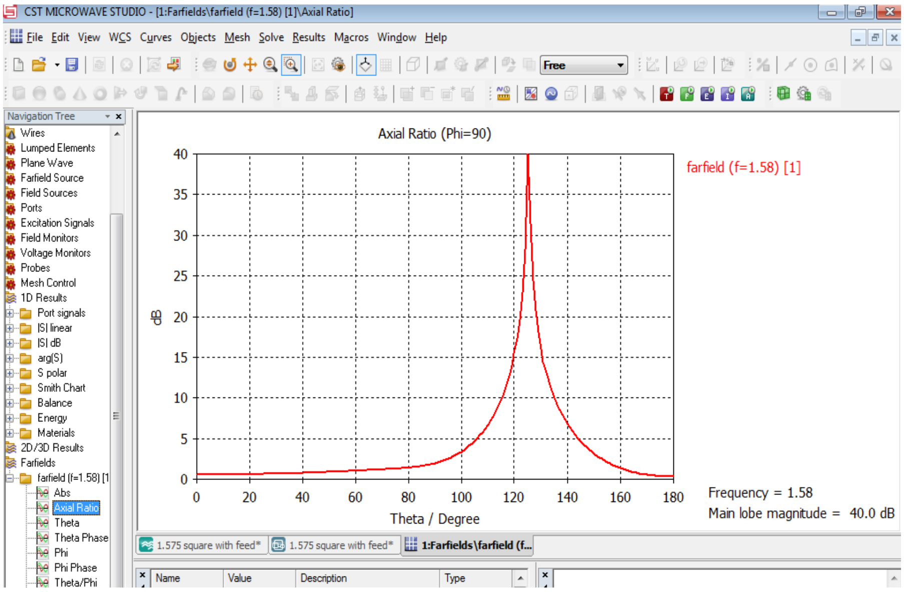

Figure 9: Output of circularly polarized microstrip square patch antenna

XI. CONCLUSION

Thus a circularly polarized square patch antenna for 1.575GHz is designed by the procedure and fabricated using FR4 substrate and obtained a gain -40db and axial ratio 1.58.

PARAMETER	PREVIOUS RESULT	OBTAINED RESULT
Frequency	1.575GHz	1.575GHz
Gain	-23dbi	-40dbi
Directivity	4.712dbi	6.581dbi
Axial ratio	2.56	1.58

XII. REFERENCES

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