Symmetric Pattern Patch Antenna For Yielding Circular Polarization

Prajakta Doiphode, Chandan Bangera, Tazeen Shaikh

Abstract: A rectangular patch with a symmetric pattern for obtaining circular polarization with an axial ratio of 2.2 dBi and the same antenna can be operated at multiple frequencies 1.26 GHz, 1.73 GHz, 2.16 GHz and 2.59 GHz suitable for GPS, WLAN and WiFi applications is designed using IE3D software from Zeland. The microstrip patch is constructed using a single layer glass epoxy substrate, having dielectric constant ε_r = 4.3 and loss tangent tan δ =0.001.The patch is provided with a dual feed having 180° phase difference.

Index Terms: Circular polarization, Dual feed, MSA, Multiple operating frequency, RMSA, Symmetric pattern, WLAN, Wi-Fi.

1 Introduction

Recent developments in communication systems such as the global positioning systems (GPS), Wireless local network (WLAN), and wireless communications often require antennas with compact size, low cost and capable of operating more than one band of frequencies. Microstrip patch antenna have been well known for its advantages such as light weight, low fabrication cost, mechanically robust when mounted on rigid surfaces and capability of dual and triple operating frequencies.[1] A wireless LAN is a flexible data communication network used as an extension to, or an alternative for, a wired LAN. Increasingly more and more wireless LANs are being setup in home and or home office situations as the technology is becoming more affordable.[2] The ever increasing demand of indoor wireless LAN capable of high-speed transfer rate is prompting the development of efficient antennas. Global positioning technology has been widely used as a navigation system for the determination of location and position of devices. With the rapid growth of the wireless communication, the uses of GPS functionalities are becoming more pronounced.[3] In order to meet the requirements such as precision and reliability, a high performance GPS antenna must be capable to operate at two or more frequencies at the same time. Various approaches have been taken to suit the need of wireless communication applications including modification of substrate parameters and the patch shape.

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Conventional antenna designs yields circular polarization by either inserting perturbation elements at the boundary of a circular patch or by cutting diagonal slots along the patch.[4] Circular polarization has been observed typically in circular, square and triangular microstrip patches. The paper focuses on a rectangular patch having a total area 1073 mm^2 modified by a symmetric pattern having reduced total radiating area 847 mm^2 design yielding circular polarization has been proposed. The patch is provided with a dual feed having 180° phase difference.[5] Experimental geometry of the antenna and the simulated results yielding circular polarization are presented and discussed.

2 Mathematical Analysis

To design a rectangular microstrip patch antenna following parameters such as dielectric constant (ε_r), resonant frequency (f_0), and height of the substrate (h) should be considered for calculating the length and the width of the patch.[6] Width of patch (W)

$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}} \tag{1}$$

Effective dielectric constant (ε_{reff}) of antenna is

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

Effective dielectric length (L_{eff}) of antenna is

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}} \tag{3}$$

Extended length (ΔL) of antenna is

$$\Delta L = 0.421h\frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \tag{4}$$

The length (L) is

$$L = L_{eff} - 2\Delta L \quad (5)$$

3 Antenna Design

The proposed symmetric pattern antenna design having dimensions width (W) = 37 mm, length (L) = 29 mm, thickness (h) = 1.5 mm and dielectric constant =4.3 is shown in fig. 1 .The patch is cut into a symmetric pattern having dimensions d1 = 9.5mm, d2 = 2mm, d3 = 6mm, d4 = 6.5mm. The patch is provided with a dual feed having 180° phase difference.

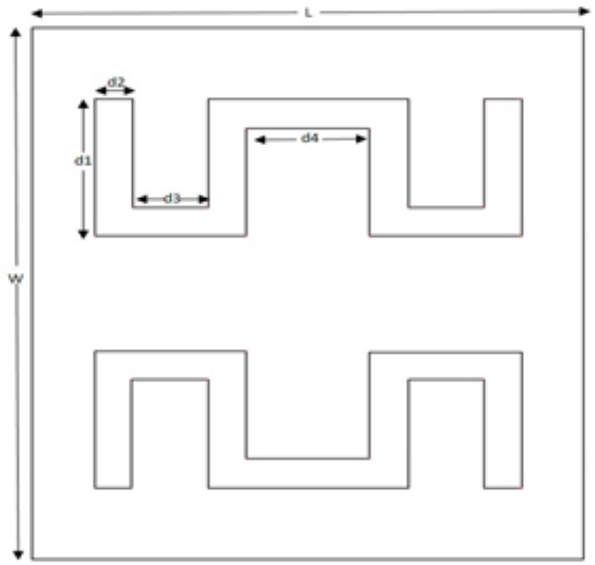


Fig.1. Geometry of the proposed antenna

TABLE 1
OPTIMIZED ANTENNA PARAMETERS

Antenna Parameter	Value
Dielectric constant	4.3
Thickness(h)	1.5 mm
Length(L)	29 mm
Width(W)	37 mm
Cut width d1	9.5 mm
Cut length d2	2 mm
Cut length d3	6 mm
Cut length d4	6.5 mm

The proposed antenna simulated using IE3D simulator is operated at multiple frequencies 1.26 GHz, 1.73 GHz, 2.16 GHz and 2.59 GHz.

4 Result And Discussion

The antenna simulated using IE3D simulator is best operated at 2.59 GHz. The simulated antenna parameters results are shown below.

4.1 Smith chart

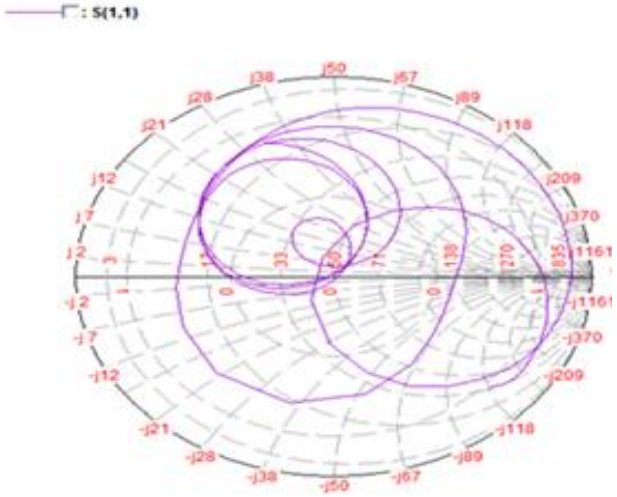


Fig.2. Smith Chart

4.2 Return Loss Measurement

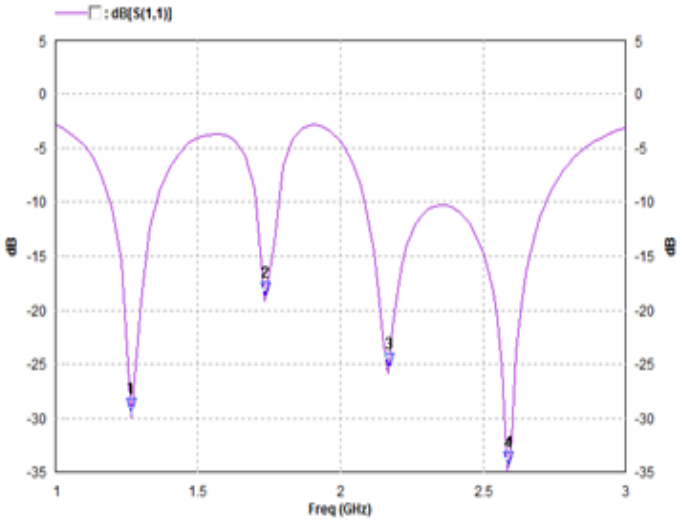


Fig.3. Return Loss Measurement

Return loss = -30 dB at 1.26 GHz
Return loss = -18.36 dB at 1.73 GHz
Return loss = -25.25 dB at 2.16 GHz
Return loss = -34.28 dB at 2.59 GHz

The designed antenna has the best return loss with -34.28 dB at 2.59 GHz.

4.3 VSWR Measurement

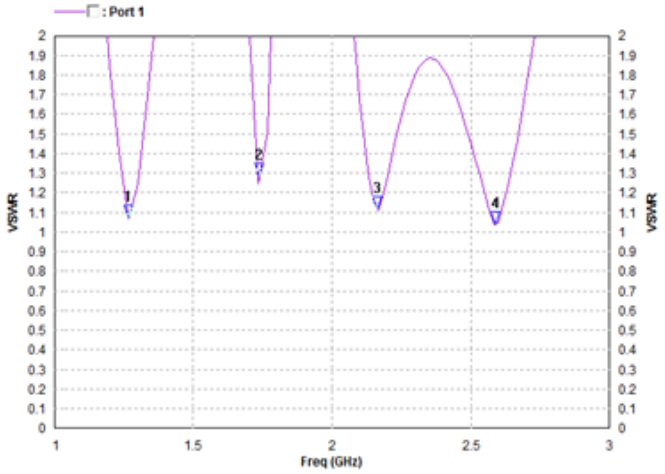
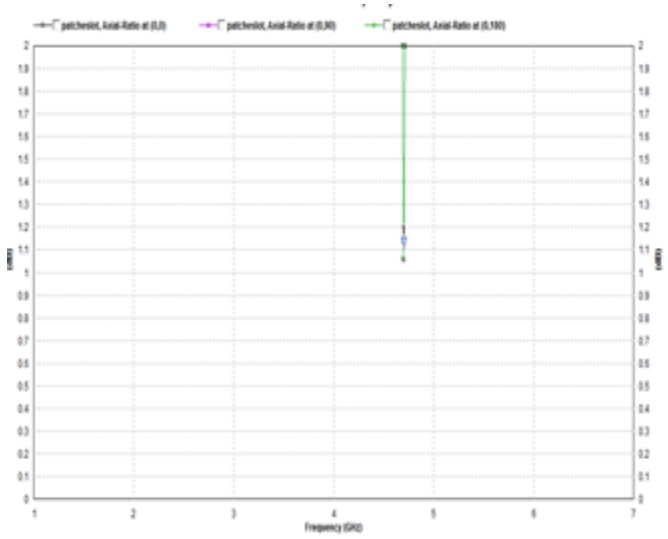


Fig.4. VSWR Measurement

VSWR = 1.06 at 1.26 GHz.
VSWR = 1.24 at 1.73 GHz
VSWR = 1.11 at 2.16 GHz
VSWR = 1.05 at 2.59 GHz

The antenna has the best VSWR 1.05 at 2.59 GHz.

4.4 Axial Ratio



Fig,5. Axial Ratio

Axial ratio = 2.2 dBi at 3.7 GHz

4.5 Radiation Pattern

The 2D elevation and azimuth angle pattern for the antenna are shown below in fig. 6 and fig. 7

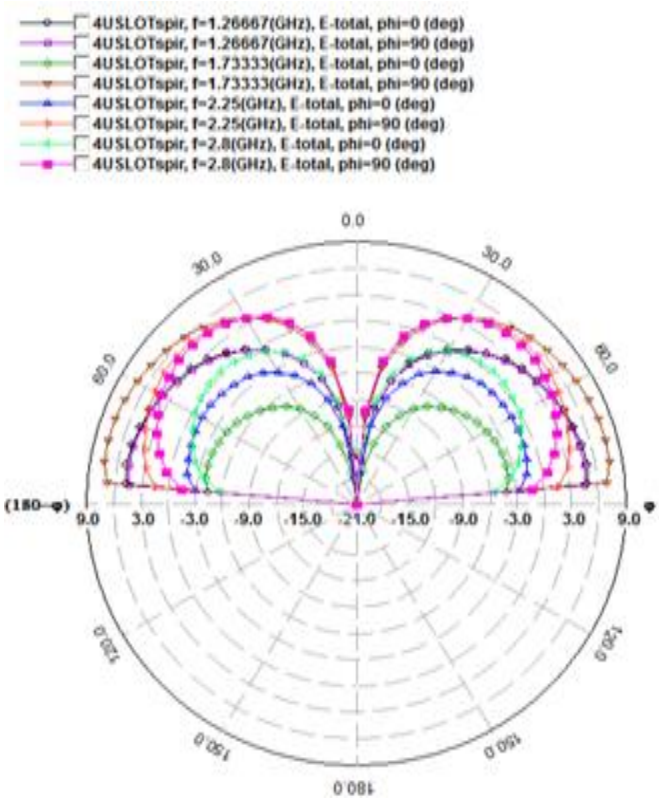


Fig.6. Elevation Pattern Directivity Display

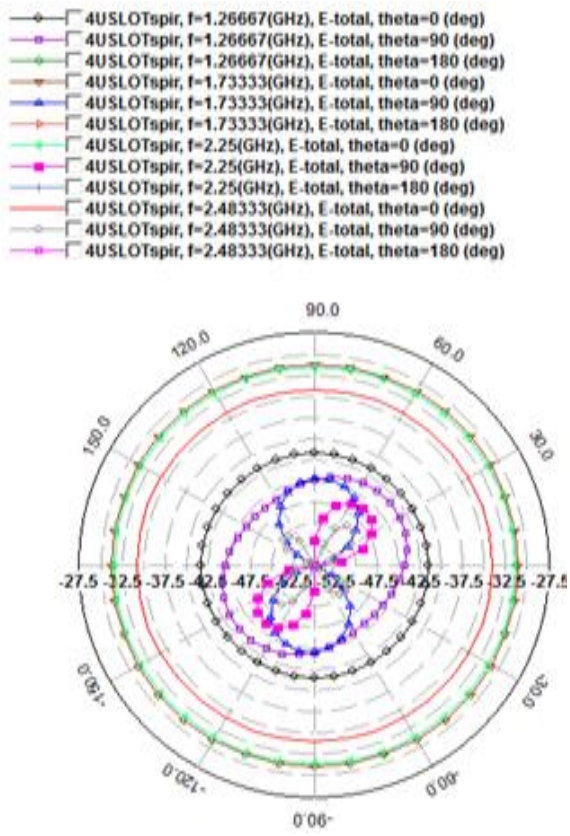


Fig.7. Azimuth Pattern Directivity Display

4.6 Antenna Efficiency

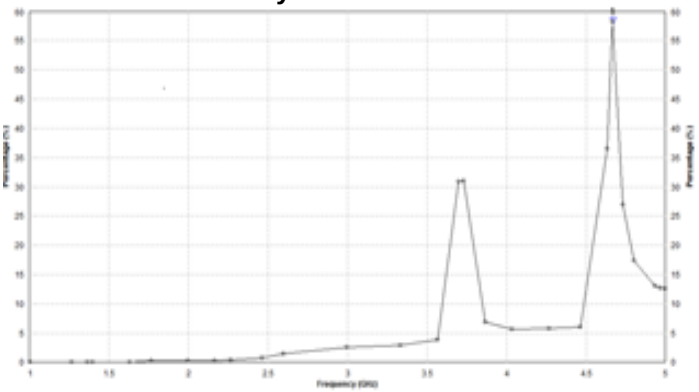


Fig.8. Antenna Efficiency

Antenna Efficiency = 56.64 % at 4.66 GHz

4.7 Radiation Efficiency

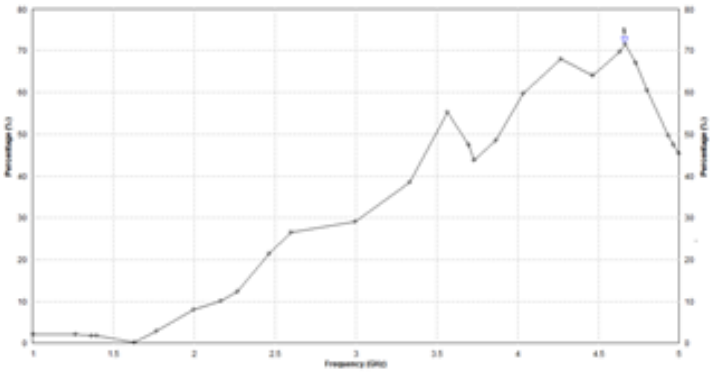


Fig.9. Radiation Efficiency

Radiation Efficiency = 71.3 % at 4.66 GHz

5 Conclusion

The design of symmetric pattern rectangular microstrip patch antennas can be widely used in GPS, WLAN and WiMAX applications. A dual feed with 180° phase difference is incorporated so as to obtain circular polarization. The symmetric pattern microstrip patch antenna is designed and the results are justified by simulating using IE3D simulator. The optimized antenna parameter results show that the antenna yields circular polarization having an axial ratio of 2.2 dBi, VSWR 1.06, 1.24, 1.1 and 1.05 at 1.26 GHz, 1.73 GHz, 2.16 GHz and 2.59 GHz. Return loss of about -35.28 dB at 2.59 GHz is observed. The symmetric pattern antenna has a bandwidth of 628 MHz at 2.59 Ghz. Antenna efficiency is 56.64% at 4.66 GHz while the radiation efficiency is 71.3% at 4.66 GHz.

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