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Inverted S-Shaped Quad Band Patch Antenna for Wireless Applications

[1]P.Maheswara Venkatesh, [2]T.Jaya SAnkar, [3*]K.Vinoth Kumar
[1,2]Electronics and Communication Engineering,Anna University BIT campus,Thiruchirappalli India.
[3*]Electronics and Communication Engineering, J.J. College of Engineering &Technology,Thiruchirappalli,India.

ABSTRACT

Inverted S-shaped multiband patch antenna is designed for wireless applications. Two rectangular slots are cut from the patch to perturb the surface current patch of the antenna that change the conventional rectangular patch antenna into inverted S-shaped patch antenna. By changing the length and the width of the slots the operation bands of the multiband antenna can be adjusted. The proposed antenna is designed using low cost FR4 substrate having relative permittivity of 4.6 to achieve antenna parameters. The antenna is simulated using IE3D electromagnetic simulator. The antenna parameters measured are return loss, gain and VSWR. The proposed antenna is operated at 2.4 GHz, 3.5GHz, 4.4GHz and 4.8GHz covering operating bands of Bluetooth, WIMAX and C band applications respectively and thus making it compact multiband antenna for wireless applications.

Indexing terms/Keywords

Gain, IE3D, Inverted 'S' shaped Patch antenna, Quad band, Return loss, VSWR.**ltural Studies;**

INTRODUCTION

Modern wireless communication systems require low profile, light weight, low cost and high gain antennas to obtain high efficiency. They are used in radio broadcasting, television broadcasting, two-way radio, communications receivers, radar, cell phones, and satellite communications. A microstrip patch antenna is simple in structure which consists of dielectric substrate with the patch on one side and ground plane on other side. The patch is generally made up of conducting material such as copper and takes any shape. The radiating patch and feed lines are photo etched on the dielectric substrate. The dielectric constant of the substrate is typically in the range $2.2 \le \varepsilon_r \le 12$. The Microstrip antenna is a resonator type antenna and it is usually designed for single mode operation that radiates mainly linear polarization. For a circular polarization radiation, a patch must support orthogonal fields of equal magnitude but in-phase quadrature. This requirement can be accomplished by single patch with proper excitations.

Plannar fix radio wires emanates in light of the bordering fields between the fix and the ground plane. An effective radio wire is planned utilizing thick dielectric substrate having low permittivity. Be that as it may, this prompts to bigger radio wire measure. So that higher dielectric steady should be utilized to plan smaller microstrip fix reception apparatus. Microstrip fix radio wires has a few preferences, for example, low volume, light weight, low creation cost. Additionally it can be effortlessly incorporated with alternate circuits. Be that as it may, the disadvantage of the fix recieving wire is its tight data transfer capacity. To improve the transfer speed a few strategies are utilized, for example, creating spaces in the fix, changing state of the fix, utilizing diverse dielectric substrates, by applying fractal geometry and by utilizing abandoned ground structure. Multiband reception apparatuses have been intended to confront the rising requests for current correspondence framework.

As of late, numerous recieving wires have been intended to create either more extensive data transfer capacities or various recurrence operation in a solitary component. Numerous strategies are actualized to accomplish single-or multifrequency operations. Multiband or wideband microstrip reception apparatuses have planned by cutting spaces inside the fix, by applying fractal shape system to radio wire geometrics, utilizing dielectric resonator, utilizing multilayer stacked fix, with shorted parasitic component and single-layer microstrip recieving wire has been intended for accomplishing double band or multiband. S formed radio wire has been intended for various applications.

A microstrip S-shaped patch antenna was designed by inserting two slots into the rotated square patch, and it looked like the English letter "S" which was fed by a coaxial feeding. S-shaped Patch Antenna for 5-6GHz High Speed Network was proposed and dual offset electromagnetically coupled feed technique was used [6]. A study on analysis and design of rectangular microstrip antenna in X band at different frequencies has been proposed and the operating frequency is 9 GHz [2]. Broadband microstrip S-shaped patch antenna for wireless communication was proposed. The ground plane is consisting of foam of dielectric constant 1.07 with height 3.4mm and second substrate is consisting of FR4 material with height 1.6mm whose dielectric constant is 4.4 [10].

Analysis of a S-shaped patch antenna for X band and wireless/microwave applications has been designed. The antenna was designed for X band applications that covers two frequency bands and the dimension of the designed antenna is 30.08 × 45.9 × 1 mm3 [9]. Wideband Patch Antenna for X-band Applications has been designed. Rectangular patch was designed and compared with polygonal shaped antenna, the bandwidth was increased by increasing width and decreasing the permittivity of substrate [7]. A compact microstrip antenna for X band application was designed. A single feed circular patch antenna was designed by introducing L slits to reduce the resonant frequency [5].'G' shaped microstrip antenna has been designed. The G-shaped patch antenna with defected ground structure compared with simple microstrip antenna without defected ground structure. For the wideband operation the defected ground structure is used [11].

Design and simulation of rectangular and U shape microstrip patch antenna using IE3D software was proposed. The proposed structure of rectangular and U shape microstrip patch antenna have been designed for high frequency application and their performances were verified [1]. Microstrip patch antenna has been designed for ISM band applications. The proposed antenna is operating at 2.4 GHz and microstrip feed line method is used. E-Shaped Microstrip Patch Antenna for Ku Band was designed that covers three frequency bands [5]. Dual staircase shaped microstrip patch antenna was designed to improve the impedance matching and coaxial feed technique. The patch antenna was designed for S band applications and the dimension of the designed antenna is 30 × 20 × 1.6 mm3 [8].

ANTENNA DESIGN

The design of the microstrip patch antenna depends on three parameters such as resonant frequency, dielectric substrate and its dielectric constant and thickness of the substrate. The resonant frequency of the proposed antenna is 2.4 GHz. In order to reduce the antenna size FR4 low cost dielectric substrate having relative permittivity of 4.6 is used. The thickness of the substrate is 1.6 mm.

A.Calculation of the width of the patch antenna

The width of the Microstrip patch antenna is expressed as

$$W = \frac{c}{2fo} * \sqrt{\frac{2}{\varepsilon_r + 1}}$$

B.Calculation of the effective dielectric constant of the patch antenna

The effective dielectric constant is expressed as

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

C.Calculation of the length extension (ΔL)

The extension length is calculated by

$$\Delta L = 0.412h * \frac{[(\varepsilon_{reff} + 0.3) * (W/h + 0.264)]}{[(\varepsilon_{reff} - 0.258) * (W/h + 0.8)]}$$

D.Calculation of Effective length

The Effective length (Leff) is given by

$$Leff = \frac{c}{2fo\sqrt{\varepsilon_{reff}}}$$

E.Calculation of length of patch

The length of the patch is

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

PROPOSED ANTENNA DESIGN

The proposed antenna is shown in Figure.1. The length and width of the proposed antenna are L = 28 mm and W = 37 mm. Two rectangular slots are cut from the patch that change the conventional rectangular patch antenna into inverted ‘S’ shaped patch antenna. These slots are used to reduce the overall antenna size compared to conventional rectangular patch antenna. The different cuts in the patch are used to change the direction of the current path which may cause the patch antenna to resonate at different frequencies.

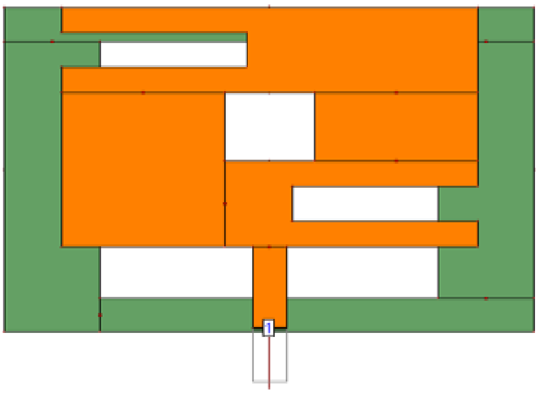


Fig 1: Proposed antenna design

By changing the length and the width of the slots the operation bands of the quad band antenna can be adjusted. The proposed antenna is designed using low cost FR4 substrate having relative permittivity of 4.6 to achieve antenna parameters**.** The loss tangent value of the substrate is 0.02. To increase the peak gain defected ground structure is applied. Some portions of the ground plane are etched to enhance the antenna performance.

Microstrip feed is given as shown in Figure.2. In this feeding technique conducting strip is directly connected to edge of the patch. The width of the strip is smaller than patch and the advantage is that feed can be etched on the same substrate.

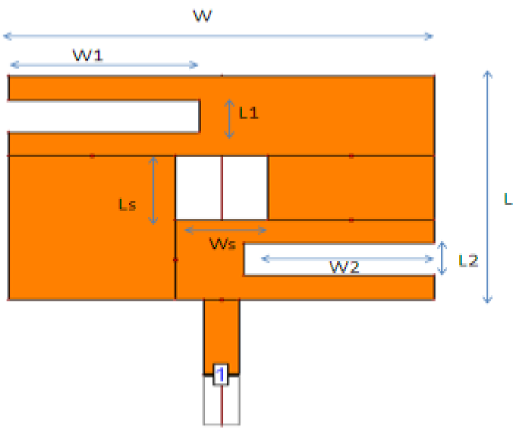


Fig 2: Patch design

To increase the peak gain defected ground structure is applied. Some portions of the ground plane are etched to enhance the antenna performance. The ground plane of the antenna is shown in Figure.3. A square slot is generated in the ground plane of the proposed antenna which is used to increase the bandwidth and gain.

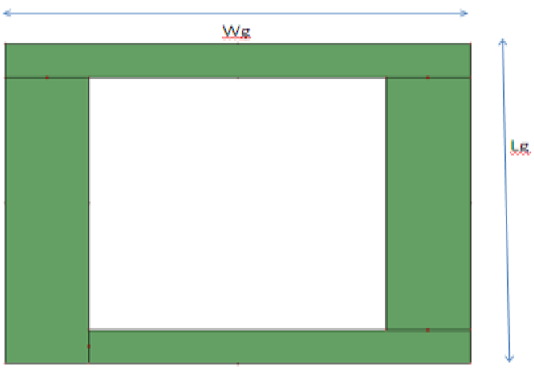


Fig 3: Ground plane

Table 1. Optimised antenna parameter values

L	28 mm
W	37 mm
Lg	38 mm
Wg	47 mm
W1	16.5 mm
L1	4 mm
W2	16.5 mm
L2	4 mm
Ls	8 mm
Ws	8 mm

SIMULATION RESULTS

A. Return loss and VSWR

When the load is mismatched the full power is not delivered to the load and some power is returned back to the input and that loss is called as 'return loss'. The bandwidth is calculated from the return loss plot. The bandwidth of the antenna is said to be those range of frequencies over which the return loss is greater than -10 db. Fig.4 shows the proposed antenna resonates at four different frequencies which is used for four different applications and so it is a multi frequency patch antenna.

VSWR describes how well the antenna is impedence matched to the transmission line. It is the function of reflection coefficient or return loss. If the VSWR is between the value of 1-2 the antenna is well matched to transmission line and more power is delivered to the antenna. Figure.5 shows VSWR plot of proposed antenna.

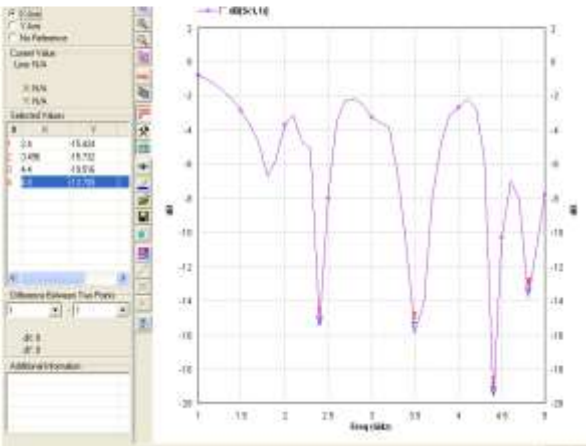


Fig 4: Return loss

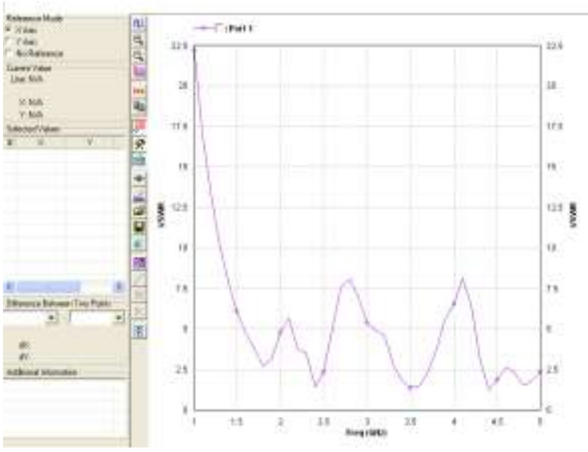
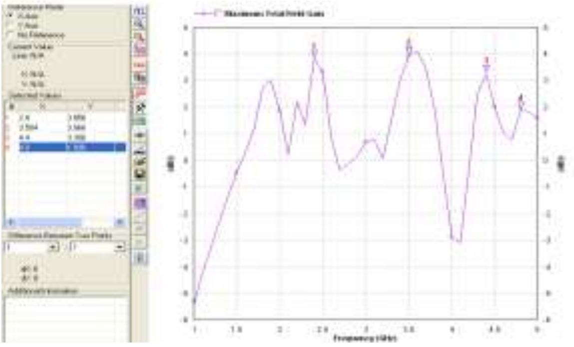


Fig 5: VSWR

B. Gain and Directivity

Figure.6 and Figure 7 shows the gain and directivity plot of proposed antenna. The simulation results show that the proposed antenna has improvement in the gain as well as in the directivity.



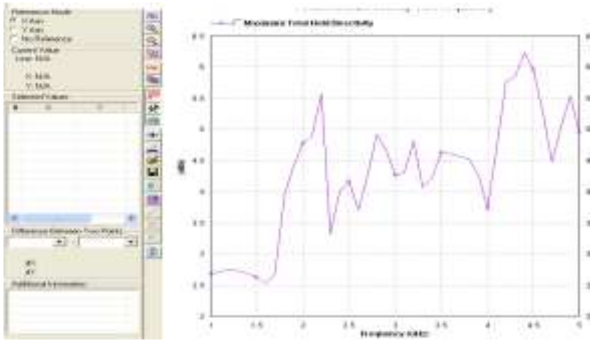


Fig 6: Gain **Fig 7: Directivity**

C. Radiation pattern

On pattern refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source. The radiation pattern for the proposed patch antenna is shown in Figure.8 and Figure.9.

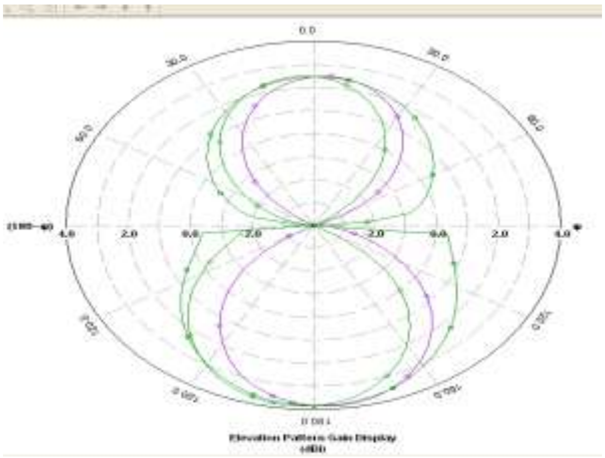


Fig 8: Elevation radiation pattern

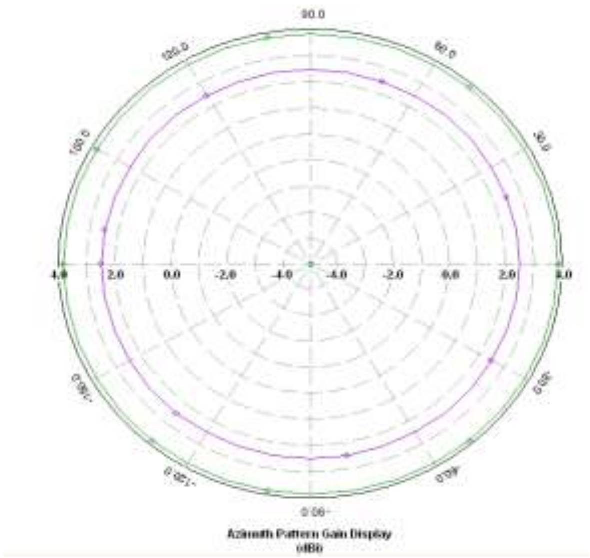


Fig 9: Azimuth radiation pattern

CONCLUSION

In this paper, an inverted S-shaped, quad band, compact patch antenna is designed to obtain desired frequency ranges for Bluetooth/WiMax/WLan applications. Three slots in the patch are used to decrease the area of the antenna and wide slot in the ground is used to increase the gain of the proposed antenna. Simulation results show that the proposed antenna is resonated at the four different frequencies with higher bandwidth and gain. The efficiency of the proposed antenna is nearly 97.2% at the resonant frequency. With these features this antenna is used in wireless communication systems operating at Bluetooth/WiMax/C band applications.

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