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Design and analysis of single element multiple feed antenna

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Abstract

The single element square patch dual polarised antenna with two feed has been designed and simulated on FR4 substrate. The designed patch antennas are used for wireless applications. The characterization of MIMO antenna may be obtained from single element antenna with multiple feed ports. The single antenna with two feeds produces two unique resonance modes that occur at the same frequency. This is referred as isolated mode antenna technology (iMAT). The main objectives of single element antenna are isolation improvement and achievement of polarisation diversity for dual polarised antenna. It is used to minimize the fading in wireless communication. The dual polarised antenna covers WLAN applications. The isolation between two ports is better than 20 dB over the operating band. The simulations are performed on CST Microwave Studio Suite 2014.

***Index Terms*:**Single antenna, Isolation, Polarisation diversity, Microstrip Patch.

1 INTRODUCTION

Growing interest on designing compact microstrip antennas due to demand of small antenna in wireless communication systems. But disadvantage in simple microstrip patch antenna is its narrow band frequency response. The need is to broaden the frequency band and cover more frequency bands for to support many applications. For that many techniques are used like slot and slit loaded patches, parasitic patches, direct coupling patches, probe compensation, stacked patches, etc. In [1], a dual polarisation slot antenna with CPW feeding structure is designed for wide bandwidth and high isolation between ports in WLAN band. For broadband dual polarisation applications, an isosceles triangular slot antenna is proposed in [2]. The square ring slot antenna is proposed in [3] are ultra wide band with good isolation and impedance bandwidth. In [4], the two triangular slots along with two diagonal feed lines are introduced in square patch antenna for dual linearly polarised applications. A printed fan shaped slot antenna is designed in [5] using hybrid feeding techniques for polarisation diversity wide band applications. The defective digital ground structures are used to produce different resonance band on each port with good isolation [6]. A novel highly integrated antenna triplexer on a two layer PCB for multiband communication systems has good three port isolations that realized by multi-mode excitations [7]. The stacked patch antenna is proposed for dual polarisation and isolation between the two ports is improved significantly by modified corner fed. It is highly suitable for micro-base station applications [8]. The slanted polarization diversity is proposed in [9] to overcome the problem of space diversity using T-shaped aperture coupled feeds with stacked patches. A very compact ultra wide band (UWB) multiple input multiple output (MIMO) antenna has high isolation by etching a line slot. It has low mutual coupling [10]. The antenna is designed to enhance communication performance, isolation and high impedance matching [11, 12]. In [11], the port isolation is enhanced by DGS spiral shaped pattern under feed line for dual polarised antenna. A novel feed circular polarization diversity antenna has good diversity gain [12].

This paper presents the design of single element antenna with two feed. The patch antenna has been designed to attain polarisa-

tion diversity and enhancement in isolation. The antenna is simulated using CST Microwave Studio Suite. The rest of the portion is organized as follows. The design and dimensions of antenna is discussed in Section II. Section III briefly reviews the simulated and measured results of square patch antenna with two feed. In Section IV, some conclusions are followed.

2 ANTENNA DESIGN

Microstrip antenna consists of dielectric substrate, a radiating patch on one side and ground plane on other side. It uses the substrate as low cost FR4 epoxy with r=4.4 at a height of 1.6mm. The square patch is designed for particular resonant frequency. Fig. 1. shows the configuration of two feed dual polarised antenna which is fed by 50 microstrip feed line.

In Fig. 1, the length and width of the square ring are labeled L and W, the feed line are labeled M1, M2. The width and length of the ground plane are represented G1 and G2. The length and width of the substrate are labeled Ls and Ws The detailed dimensions of the antenna is mentioned in Table. 1. It has fed with T - shaped feed line. The feed line matches the characteristic impedance of 50. The feed lines are also stepped for better impedance matching. The square ring of 4 x 4 mm2 at bottom leftmost and top rightmost produces the operating band at port 1 and port 2. It is used to achieve polarisation diversity. The square ring at top leftmost corner improves the return loss of resonant frequencies at port 1 and port 2.

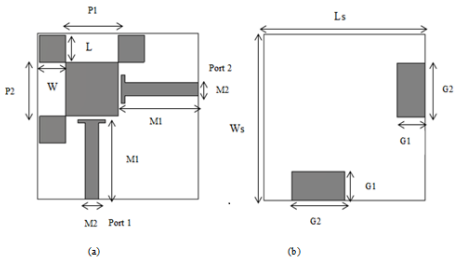


Fig. 1. Two feed square patch antenna (a) Top view (b) Bottom view

TABLE I. Optimized Dimensions (in mm)

Parameter	Dimensions
Ls,Ws	24.5
G1	4.25
G2	8
P1,P2	8
L,W	4
M1	11.75
M2	2

3 RESULTS AND DISCUSSION

A. Return losses and Isolation

Fig. 2. shows the return loss improvement of horizontal polarisation port i.e., Port 1. The square ring at bottom leftmost is used to resonate the required frequency at port 1. Fig. 3. shows the return loss improvement of vertical polarisation port i.e., Port 2. The square ring at bottom leftmost is used to resonate the required frequency at port 2. Fig. 4. shows the return loss of port 1 and port 2. The square ring at top leftmost corner improves the return loss of the resonant frequency at port 1 and port 2. The Port 1 and Port 2 resonate at same frequency of 5.27 5.94 GHz. It achieves bandwidth of 670 MHz. It covers applications of WLAN (5 GHz 6 GHz). The return loss of the resonant frequency is less than 15 dB.

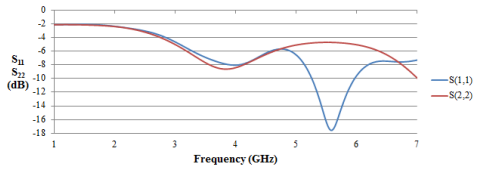


Fig. 2. Improvement in return loss at Port 1

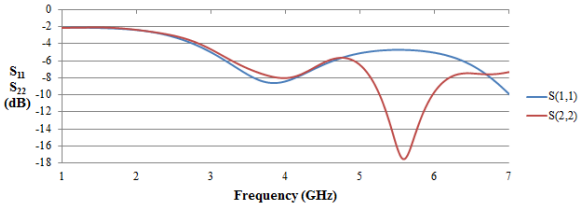


Fig. 3. Improvement in return loss at Port 2

Fig. 5. shows the isolation between port 1 and port 2. The isolation loss of the resonant frequency between two ports is better than 15 dB. It has good isolation. The overall size of the antenna is 24.5 mm x 24.5 mm. It can be used in the WLAN (5.2/5.8 GHz) and C band (4-8 GHz).

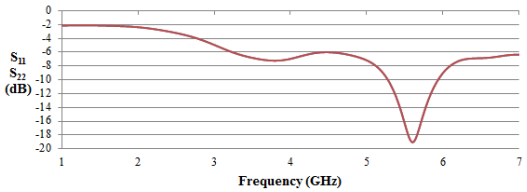


Fig. 4. Return loss of Port 1 and Port 2

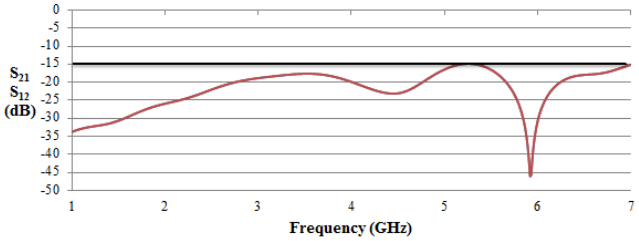
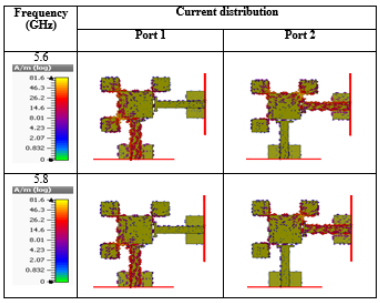


Fig. 5. Isolation loss

B. Surface Current and Radiation Pattern

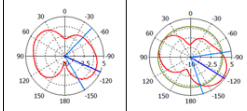
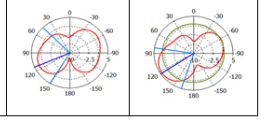
Table II represents the surface current of square patch dual polarised antenna for resonant frequency. In first case i.e., at port 1 the concentration of surface current is strongly distributed on port 1 and least distibuted on port 2 due to horizontal polarisation. In second case i.e., at port 2 the concentration of surface current is strongly distributed on port 2 and least distibuted on port 1 due to vertical polarisation.

TABLE II. Surface Current of two feed square patch antenna



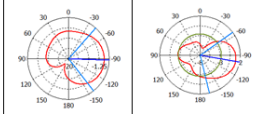
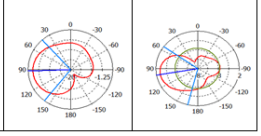
The simulated radiation pattern of E - plane and H - plane are represented in Table III and Table IV for resonant frequency at port 1 and port 2. The radiation pattern of the two-port antenna at 5.6 and 5.8 GHz in both E - Plane and H Plane is omnidirectional when port 1 and port 2 is excited.

TABLE III. E Plane Radiation Pattern

Radiation Pattern (E - Plane)	Frequency (GHz) 5.6	5.8
Port 1		
Port 2		

The radiation pattern of the two-port antenna for all resonance frequencies in both E - Plane and H - Plane is directional when port 1 and port 2 is excited. It has less side lobe level.

TABLE IV. H Plane Radiation Pattern

Radiation Pattern (H - Plane)	Frequency (GHz) 5.6	5.8
Port 1		
Port 2		

C.Diversity Gain and VSWR

The simulated peak gain of the square patch dual polarised antenna over the operating band for port 1 and port 2 is shown in Fig. 6. For the frequency range between 5.27 5.94 GHz, diversity gain of 10 dB was obtained approximately.

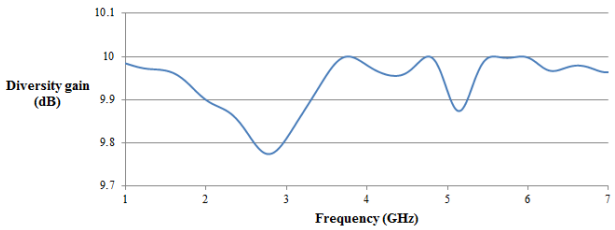


Fig. 6. Peak gain

The simulated VSWR plot is shown in Fig. 7. The plot shows that in the desired respective frequency band for port 1 and port 2 VSWR is less than 2.

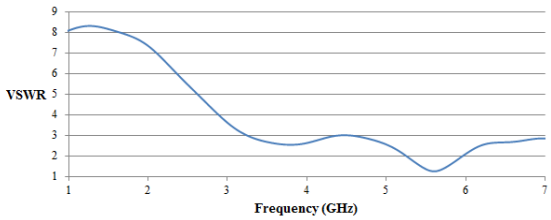


Fig. 7. VSWR

D. Envelope Correlation Coefficient

The envelope correlation coefficient is a measure of decorrelation between two ports. It is dependent on either S-Parameter or radiation pattern. It can be calculated using this formula [3]:

$$ECC = \frac{|S_{11} * S_{12} + S_{21} * S_{22}|^2}{(1 - (|S_{11}|^2 + |S_{21}|^2))(1 - (|S_{22}|^2 + |S_{12}|^2))}$$

Fig. 8. shows the correlation coefficients plot. The square patch antenna gives the value of correlation coefficient below 0.005 between the ports.

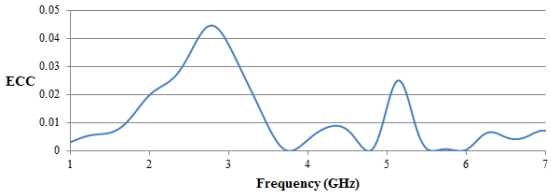


Fig. 8. Envelope correlation coefficients

4 CONCLUSION

The primary of this work is to design and investigate a microstrip patch antenna for wireless application with two feed technique. A compact single element square patch antenna with two feed is designed for WLAN application. By introducing square ring at bottom leftmost and top rightmost corner, the polarisation diversity is achieved. The isolation is better than 15 dB over the operating band. The advantages of compact structure, stable gain and good isolation, the antenna can be used in WLAN and C-band applications.

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