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CPW-Fed Parasitically Loaded Circular Disc Monopole Antenna for WLAN Applications

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Abstract—A coplanar waveguide (CPW)-fed parasitically loaded circular disc monopole antenna is presented and its performance analyzed in this paper. The proposed antenna comprises of straight strips, a parasitic circular patch and a slotted CPW ground plane for wireless local area networks (WLAN) applications. By using a parasitic circular patch and inserting straight strips in CPW ground plane, it is found that overall impedance bandwidth enhanced. The predicated impedance bandwidth of 2.32 GHz or ~ 48.33 % is from 3.64 GHz to 5.96 GHz, for VSWR < 2, which covering 5.2/5.8 GHz WLAN and 5.5 GHz HIPERLAN/2 standards. The peak antenna gain of the proposed antenna is 4.45 dBi at the resonant frequency 5.29 GHz and monopole like radiation patterns have been obtained in the operating bandwidth.

Index Terms— Circular Patch, Coplanar waveguide, HIPERLAN/2, monopole antenna, straight strips, WLAN,

1 Introduction

In last decades, CPW-fed monopole antennas have found widespread applications in wireless communication systems due to low profile, ease of fabrication, low cost, broad bandwidth, lower dispersion, lower radiation loss, can be easily integration with the other circuit components and a simplified configuration with a single metallic layer [1]. These wireless communication systems are WLAN band (5.15-5.35 GHz and 5.725- 5.825 GHz) and HIPERLAN/2 band (5.45-5.725 GHz). Several probe-fed, CPW-fed and microstrip-fed antenna design schemes has been reported in the literature [2]-[4]. However, the microstrip-fed antenna usually has a larger size of ground plane and the probe-fed antenna requires a via-hole connection to feed the radiating element, and these therefore increase the antenna size and complexity. Therefore, CPW-fed antenna is of major importance because of its simplified configuration with a single metallic layer and provides broad bandwidth and gain against simple microstrip patch antennas. A center-fed circular microstrip patch antenna with a coupled annular ring was presented [2] to attain lower bandwidth and monopole like radiation pattern. The dual-frequency properties of a dual annular-ring slot antenna fed by coplanar waveguide and microstrip feed line were presented in [3] to attain higher bandwidth for CPW-fed. A broadband CPW-fed parasitic-loaded and slotted monopole antenna presented [4] to excites dual-resonance and achieve a broad bandwidth with suitable radiation performance.

In this paper, a CPW-fed parasitically loaded circular disc monopole antenna is proposed. The antenna is constructed by open-end annular ring slot with straight strips (along the centre of x-axis) etching into rectangular patch that is excited by a CPW feed line. The performance of straight strips lengh and width is analyzed and suitable bandwidth is achieved. Simulation is carried out with CST Microwave Studio [5] predict the performance of this antenna.

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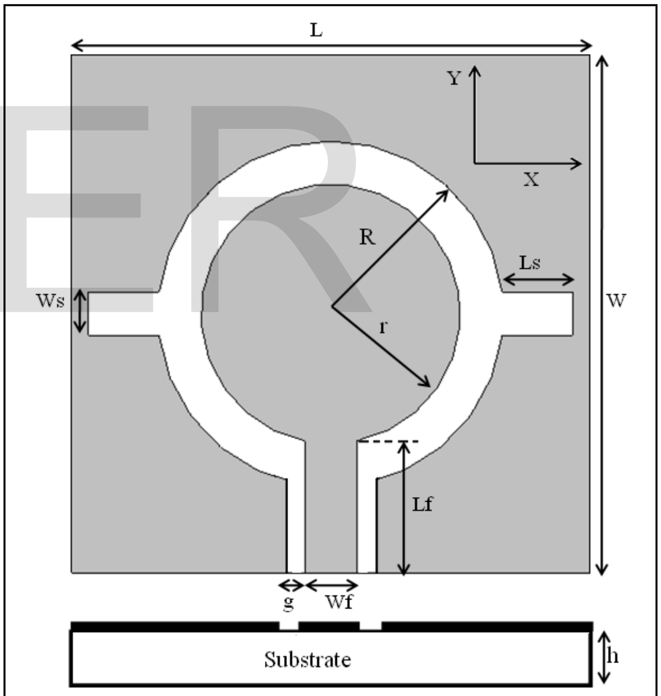

Fig. 1. Geometry of CPW-fed parasitically loaded circular disc monopole antenna.

2 Antenna Desgin and Parameteric Analysis

The geometry of CPW-fed parasitically loaded circular monopole antenna is as shown in Fig. 1. The proposed antenna has a rectangular patch with dimensions of $L \times W$ printed on one side of a glass epoxy FR-4 dielectric substrate with thickness of 1.6 mm, relative permittivity of 4.4, and loss tangent $tan\delta$ = 0.025. An open-end annular ring slot with straight strips is etched into the rectangular patch and found an antenna structure as a CPW-fed parasitically loaded circular monopole an-

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tenna. The inner and outer radiuses of the open-end annular ring slots are *'r'* and *'R'* respectively is situated at the center of the rectangular patch. A CPW feed line with dimensions of $L_f \times W_f$ is printed on same side of a glass epoxy FR-4 substrate to achieve 50 *ohm* characteristic impedance. The gap *'g'* is provided between the CPW feed line and slotted CPW ground plane. A sub-miniaturized type A (SMA) connector is connected to the port of the CPW feed line. The final optimized dimensions of antenna are listed in Table 1.

TABLE 1
OPTIMIZED PARAMETERS OF THE PROPOSED ANTENNA

Parameters	Description	Value (mm)
L	Rectangular patch length	30
W	Rectangular patch width	30
Wf	CPW feed line width	3
Lf	CPW feed line length	7.65
g	Feed point gap	0.3
R	Outer ring radius	10
r	Inner ring radius	7.5
Ls	Straight strip length	4
Ws	Straight strip width	12

To analyze the structure a parametric study was carried out which demonstrates the influence of various parameters on the performance of the proposed CPW-fed parasitically loaded circular disc monopole antenna.

A. Effect of Variation of Straight Strip Width *'Ws'*

Fig. 2 shows the variation of reflection coefficient (S11) curve as function of frequency. The effect of *'Ws'* is studied and keeping other parameters constant. The value taken for *'Ws'* in the study were 4 mm, 8 mm and 12 mm. It can be seen that with increasing the width of straight strip from 4 mm to 12 mm, the resonance frequency of the antenna almost remain constant and the impedance bandwidth increases. The maximum impedance bandwidth is obtained when *'Ws'* = 12 mm. It can be concluded that impedance bandwidth depends on *'Ws'* and maximum at *'Ws'*=12 mm.

B. Effect of Variation of Straight Strip Length *'Ls'*

Fig. 3 shows the variation of S11 curve as function of frequency with different values of straight strip length *'Ls'*, keeping other parameters constant. By increasing the length of straight strip from 2 mm to 4 mm, the resonance frequency of antenna decreases with improved impedance matching and the impedance bandwidth increases. The maximum impedance bandwidth is obtained when the value of straight strip length *'Ls'* = 4 mm. This shows the impedance bandwidth can be controlled by *'Ls'* and optimum results are obatined at *'Ls'*= 4 mm.

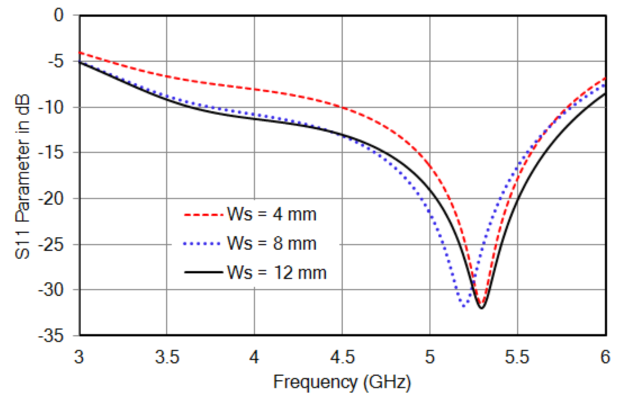

Fig. 2. Simulated variation of reflection coefficient of CPW-fed parasitically loaded circular disc monopole antenna with varying the straight strip width *'Ws'*.

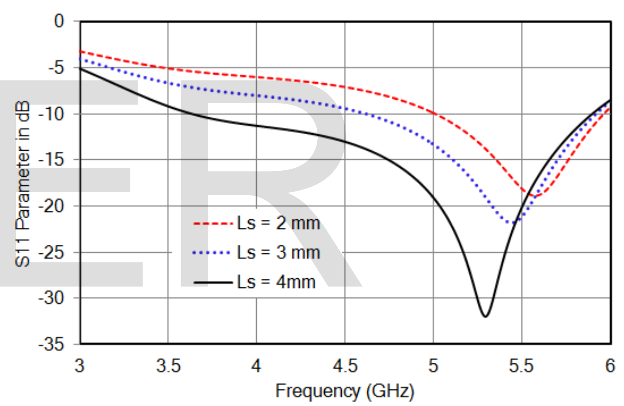

Fig. 3. Simulated variation of reflection coefficient of CPW-fed parasitically loaded circular disc monopole antenna with varying the straight strip length *'Ls'*.

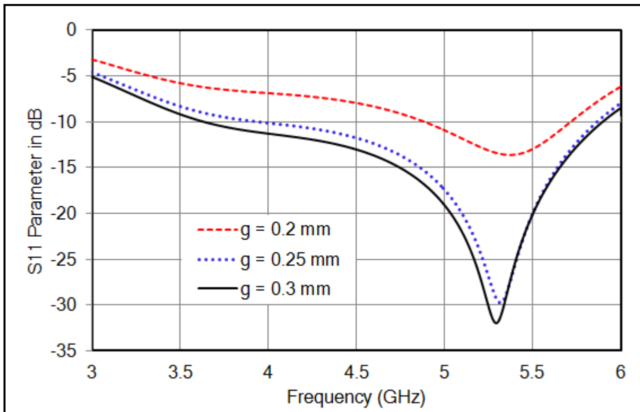

Fig. 4. Simulated variation of reflection coefficient of CPW-fed parasitically loaded circular disc monopole antenna with varying the feed point gap *'g'*.

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C. Effect of Variation of Feed Point Gap 'g'

The variation of S11 curve as function of frequency is shown in Fig. 4. At three values of feed point gap *'g'*, other parameters are kept constant. Fig. 4 shows that by increasing the feed point gap from 0.2 mm to 0.3 mm, the resonance frequency of antenna almost remain constant while impedance matching and the impedance bandwidth improves. The maximum impedance bandwidth is obtained at the value of feed point gap *'g'* = 0.3 mm.

3 Results and Discussion

In this section, simulation results of CPW-fed parasitically loaded circular monopole antenna are presented. Fig 5 shows the S11 curve as function of frequency. It can be seen that the antenna is resonating at frequency 5.29 GHz. The proposed antenna provides impedance bandwidth of 2.32 GHz or ~ 48.33 % with respect to central frequency 4.8 GHz, which is from 3.64 GHz to 5.96 GHz. Hence, VSWR is less than 2 for the proposed antenna in the entire impedance bandwidth range. The value of VSWR at resonant frequency 5.29 GHz is 1.05, which is well below the desired value two.

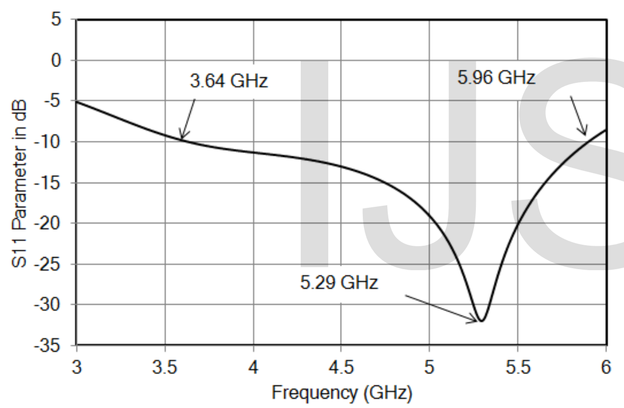

Fig. 5. Simulated variation of reflection coefficeint with frequency for CPW-fed parasitically loaded circular disc monopole antenna.

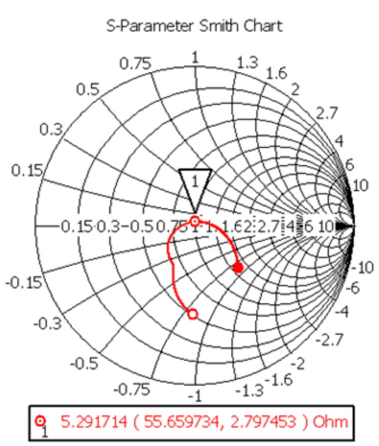

Fig. 6. Simulated variation of input impedance with frequency for CPW-fed parasitically loaded circular disc monopole antenna.

Fig. 6 shows the simulated input impedance curve as the function of frequency. It can be seen that at resonant frequency 5.29 GHz, input impedance of the antenna is (55.65 + j 2.79) ohm which is very close to 50 ohm impedance of feed line. The simulated VSWR and input impedance variations indicate good impedance matching between the feed line and antenna structure.

Fig. 7 shows the simulation results of the surface current distribution at resonant frequency 5.29 GHz of the proposed antenna. It can be seen that at the red region, the current has increasingly greater value. Conversely, moving toward the green region, the current has increasingly smaller value. It is observed at the resonance frequency 5.29 GHz, the monopole works as an antenna and generating strong surface current mainly on the edge of the open-end annular ring slot. In addition, a significant current distribution is also observed along the two straight strips edges and outer of the parasitic circular patch. The CPW-fed line and the ground plane coupling effect may usually affect the impedance matching condition. It means the effect of the feed line gap *'g'* provides impedance matching for the proposed antenna. In addition, it is found that the overall bandwidth is increases if the feed line gap is increased from 0.2 mm to 0.3 mm as shown in Fig. 4. It can also be seen that the surface currents have been appeared on the inner side of CPW-fed line and the outer side edges of the ground plane. The currents on the two vertical side edges have the same phase with that along the CPW-fed line to thus enhance the co-polarization radiation in the far-field zone, whereas bottom of the two vertical side edges and CPW-fed line are out of phase with each other. Therefore, it does not affect the cross-polarization pattern in the far-field zone.

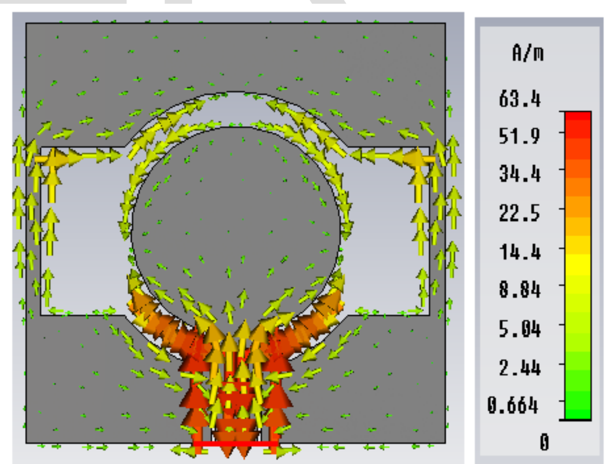

Fig. 7. Simulated surface current distribution for CPW-fed parasitically loaded circular disc monopole antenna at resonant frequency 5.29 GHz.

Fig. 8 shows the simulated gain curve as the function of frequency. The gain variation of antenna in impedance bandwidth range is from 3.72 to 4.34 dBi. The gain variation within impedance bandwidth of this proposed antenna design is less than 1 dBi. It is also observed that the peak antenna gain of the

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proposed antenna is 4.45 dBi at the resonant frequency 5.29 GHz.

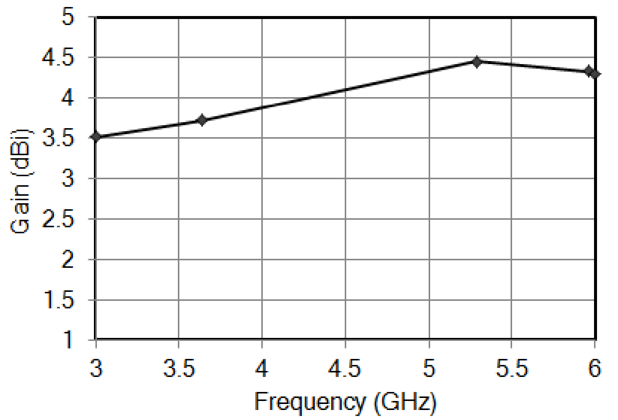

Fig. 8. Simulated variation of gain with frequency for CPW-fed parasitically loaded circular monopole antenna.

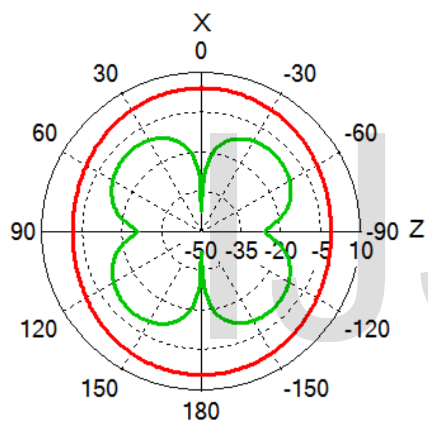

Fig. 9 (a). Simulated radiation patterns of the proposed antenna at resonant frequency 5.29 GHz in xz-plane.

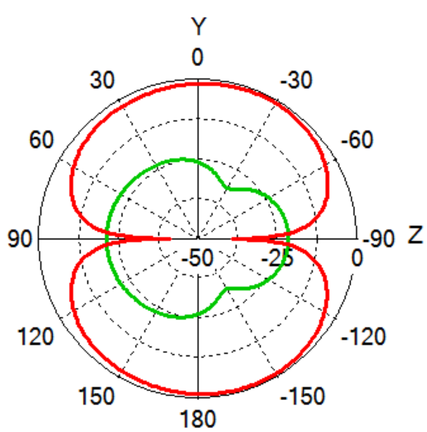

Fig. 9 (b). Simulated radiation patterns of the proposed antenna at resonant frequency 5.29 GHz in yz-plane.

The simulated radiation patterns in two principal planes (xz – plane and yz – plane) at resonant frequency 5.29 GHz are presented in Fig. 9 (a) and (b), respectively. For xz – plane, nearly omnidirectional pattern at co-polarization plane is observed at the resonant frequency 5.29 GHz shown in Fig. 9 (a). For yz – plane, dipole-like radiation pattern at co-polarization plane is observed at the resonant frequency 5.29 GHz as shown in Fig. 9 (b). In yz-plane, the radiation pattern is symmetric with respect to the y-axis. This is due to the current distribution is effectively symmetric with respect to y-axis in the proposed structure.

4 Conclusion

A CPW-fed parasitically loaded circular disc monopole antenna is presented. The proposed is analyzed in terms of reflection coefficient, Smith chart, surface current distribution, gain, and radiation patterns. With the use of parasitic element and slotted ground the proposed antenna provides impedance bandwidth of ~ 48.33 % is from 3.64 GHz to 5.96 GHz. The peak antenna gain is 4.45 dBi at the resonant frequency 5.36 GHz. For yz-plane, the dipole like radiation pattern at co-polarization plane observed at the resonant frequency is due to the current distribution symmetric with respect to y-axis. The proposed antenna is suitable for WLAN and HIPERLAN/2 applications.

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