

Asymmetric Coplanar F-strip Fed Antenna for Dual Band Wireless Applications

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Article Info

Article history:

Received Oct 12, 2014

Revised Nov 25, 2014

Accepted Dec 20, 2014

Keyword:

Asymmetric Coplanar Strips

Coplanar Waveguide (CPW)

Defected ground structure

Dual Band antennas

Radiation Pattern

ABSTRACT

A compact planar antenna for dual band applications is presented in this paper. The proposed antenna has Dumbbell shaped defect on the ground plane and it is fed by asymmetric coplanar strip (ACS). The antenna is printed on FR4 epoxy substrate and it has a compact size of $21 \times 19 \times 1.6$ mm³. The antenna exhibits a dual band of resonances at 3.4GHz and 5.5 GHz which is used for WiMAX/WLAN/HYPERLAN-2/RFID. The planar design, simple feeding techniques and compactness make it easy for the integration of the antenna into circuit boards. Details of the antenna design and simulated results are presented and discussed. Simulation tool, based on the method of moments (Mentor Graphics IE3D version 15.10) has been used to analyze and optimize the antenna. Various features such as compactness, simple configuration and low fabrication cost make the antenna is suitable for dual band wireless applications.

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1. INTRODUCTION

The rapid growth of wireless internet for high data rate communication has fostered tremendous attention towards the design of compact WLAN antennas. Different types of designs catering to various user requirements have been reported in literature [1-11]. These designs, however, have complex structures which make them difficult to integrate with WLAN systems. Planar antennas have the advantage of easy integration with active circuits. Many types of planar antennas have been reported in the literature. A planar monopole antenna with shorted inverted-L wire proposed [2]. A dual band planar antenna for laptop PC applications is presented [3]. ACS fed antenna with U-shaped open stub for WLAN/WiMAX application proposed in [4]. A CPW fed antenna with asymmetrical ground plane for bandwidth enhancement proposed [5]. ACS antenna for dual band application proposed [6-9]. However these geometries are planar in nature, but larger in dimension than our current proposal. Mentor Graphics IE3D electromagnetic solver is used for the simulation and analysis of the structure. The resulting antenna operates on dual band frequencies of 3.4/ 5.5 GHz and which meets the requirements of WiMAX / WLAN/HIPERLAN-2/RFID applications.

In literatures [10, 11] proposed a fractal antenna for RFID applications, these designs also need rigorous iteration to achieve the desired band of resonance. Hence In this article, a planar ACS fed configuration obtained by removing the ground plane at the left of CPW fed antenna which produce a dual band resonance. Some CPW fed designs occupy a little bit more area, so it's difficult for integration. So here, we propose a planar monopole antenna with defected ground structure (DGS) for wireless application with a compact size composed of a ground plane and a vertical F shaped exciting stub, which give two operating bands at 3.4 and 5.5GHz. Details of the proposed antenna design and results are presented. Here dumbbell shaped cascaded

defect on a lateral ground plane which helps to produce resonance at two different frequency bands. DGS [12] is an etched periodic or non-periodic cascaded configuration which located in the ground plane of planar transmission lines, defect in ground of a planar transmission line (e.g., microstrip, coplanar and conductor backed coplanar waveguide) which disturbs the shield current distribution in the ground plane causes resonance. This disturbance will change the characteristics of a transmission line such as line capacitance and inductance. In effect, any defect etched in the ground plane of the palanar transmission line can give rise to increasing effective capacitance and inductance.

The feeding mechanism of an antenna is a critical factor as far as the compactness is concerned. Normally the feed structure consumes much of the overall antenna dimension. In this antenna design a compact and effective feeding technique is employed. The asymmetric coplanar strip [13-16] feed used here has all the advantages of a uniplanar feed along with compactness. This feeding mechanism is analogous to the CPW feed except that the ACS feed has a single lateral ground strip compared to the twin lateral ground strips in the CPW feed. The characteristic impedance of ACS fed transmission line is calculated by the equation 2.

2. GEOMETRY AND DESIGN METHEDODOLOGY

The geometry of the antenna is shown in Figure 1. The antenna is printed on an FR4 dielectric substrate with dielectric constant $\epsilon_r = 4.4$ and loss tangent $\tan\delta = 0.02$. The antenna has a compact size of $21 \times 19 \times 1.6 \text{ mm}^3$. The antenna is fed by Asymmetric coplanar F-strip with the thickness $h = 1.6 \text{ mm}$. The gap 'g' between the center conductor and ground planes of proposed ACS fed antenna is 0.35 mm . The ACS feed has 50Ω characteristic impedance and it is terminated by sub miniature version A (SMA) connector. Since the exciting patch and feed structure are constructed on the same plane, only one metallic layer is present which is in co plane. Hence, the antenna can be easily fabricated with low cost. The antenna has a novel tuning stub of F shape and dumbbell shaped defect on the lateral ground plane. The antenna is simulated and optimized with IE3D electromagnetic solver.

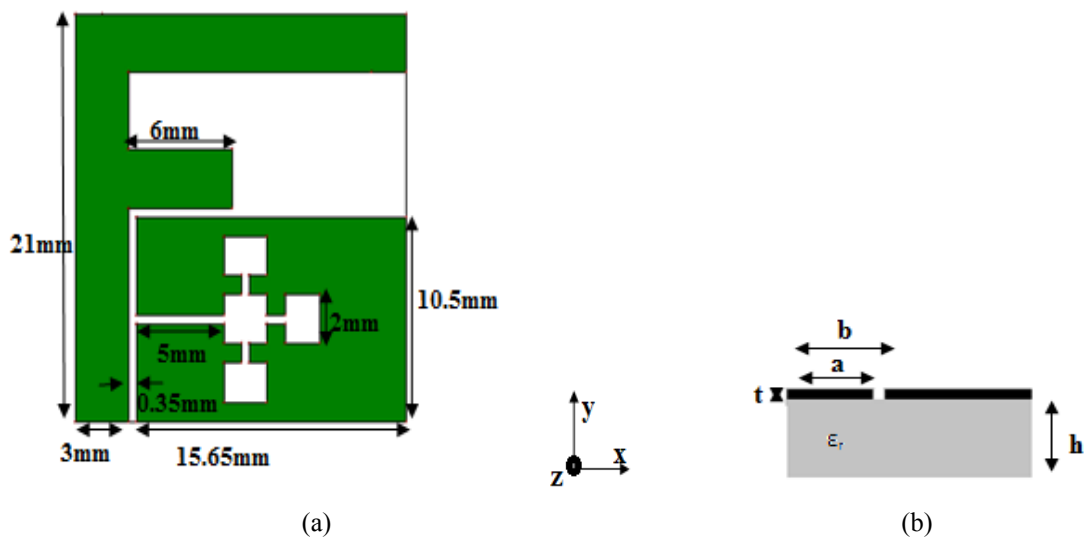


Figure 1. (a) Geometry of proposed ACS fed monopole Antenna (b) Cross section antenna

For the desired resonant frequency guided wavelength λ_g is given by

$$\lambda_g = c / \sqrt{\epsilon_{eff}} f \quad (1)$$

The design equations [13, 14] for the perfect matching of impedance are given below

$$Z_o = \frac{60 \pi}{\sqrt{\epsilon_{eff}}} \frac{K(k)}{K(k')} \quad (2)$$

Where, from Figure.1 (b)

$k = a/b$ and $\frac{K(k)}{K(k^1)}$ is the elliptical integral of first kind which is given by
 $k^1 = \sqrt{1-k^2}$

$$\frac{K(k)}{K(k^1)} = \begin{cases} \frac{\pi}{\ln \frac{2(1+\sqrt{k^1})}{(1-\sqrt{k^1})}} & 0 \leq k \leq \frac{1}{\sqrt{2}} \\ \frac{1}{\pi \ln \frac{2(1+\sqrt{k})}{(1-\sqrt{k})}} & \frac{1}{\sqrt{2}} \leq k \leq 1 \end{cases} \quad (3)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \quad (4)$$

3. RESULTS AND DISCUSSIONS

The radiation characteristics of compact dual band ACS fed antenna shown in Figure 2. The antenna shows the resonance at 3.4GHz with return loss of about -25dB bandwidth of 300 MHz and, another resonance at 5.5GHz and with return loss about -30dB and impedance bandwidth of 1300MHz for WiMAX/WLAN applications. The Figure 3(a) shows the various iterations of DGS on ground plane of ACS fed antenna. The comparison of return loss characteristics of proposed antenna with different iterations of dumbbell shaped DGS are shown in Figure 3(b). From it is clear that proposed antenna gives optimum performance comparing with other defected iteration from which it is evolved.

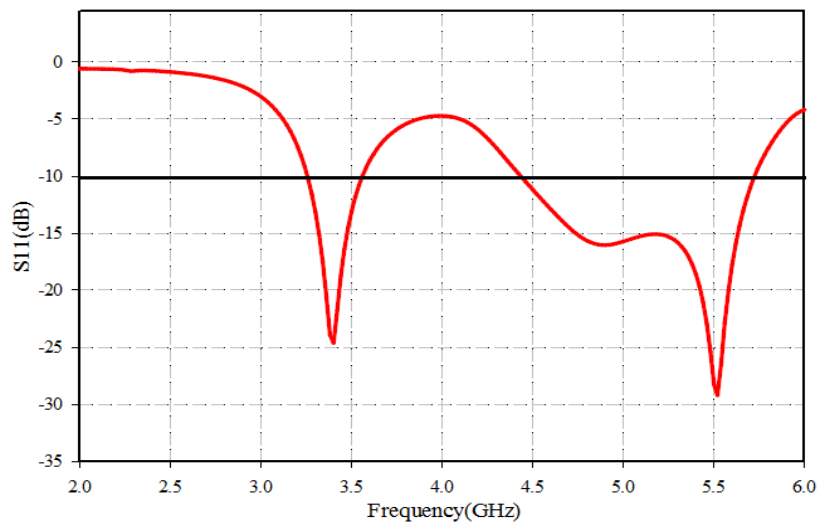


Figure 2. Return loss characteristics of proposed antenna

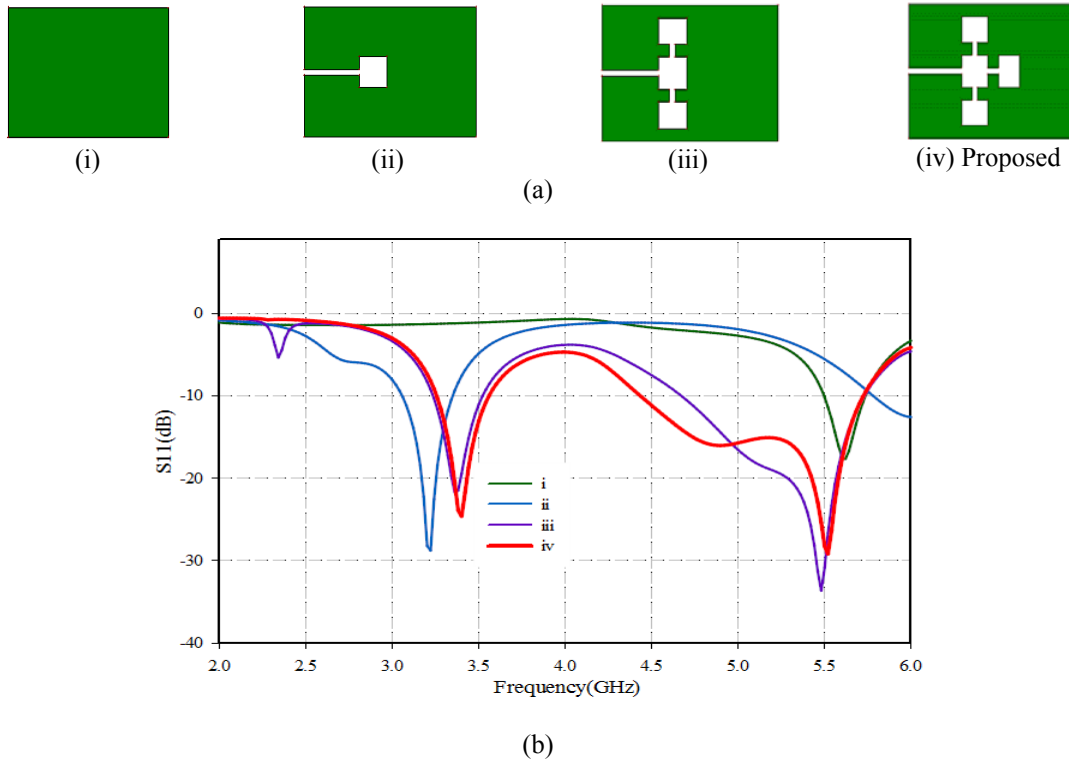


Figure 3. Various iterations of DGS; (a) Design evolution of ground plane with DGS, (b) Comparison of return loss characteristics for proposed antenna with different iterations of defects in the ground plane

Figure 4 shows the current distribution of proposed antenna with F shaped exciting stub and dumbbell shaped defected resonators. In figure 4(a) it is clear that current will perturb across F shaped exciting stub on which causes the resonance around 3.4GHz. In 4(b) shows the disturbance in the current which is perturbed across the dumbbell defect in the lateral ground plane which contribute second resonance at 5.5GHz. The resonances are useful for the present wireless communication standard such as WiMAX/IEEE 802.11a WLAN/HIPERLAN-2/RFID standards

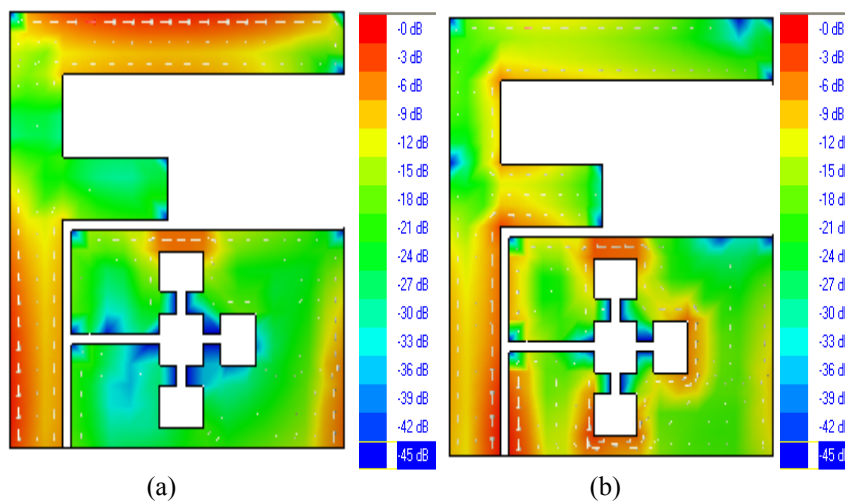


Figure 4. Current distribution of proposed antenna (a) 3.4GHz (b) 5.5GHz

Table 1. Comparison of size and peak gain of proposed antenna with existing literature

Existing literatures	Peak Gain (dBi)	Total size(mm ³)	Band
Bo Li et al [4]	1.4	35x19x1.6	dual
Chow.et.al [5]	1.3	35 x15x1.6	dual
Deepuet.al [7]	2	28x30x1.6	dual
Yue Song et.al [8]	1.5	15x31x1.6	dual
Ashkarali et. Al [9]	1.81	37.5x24.5	dual
Proposed Antenna	3.8	21x19x1.6	dual

The table 1 shows the comparison of gain and overall area of proposed antenna with existing literatures. The proposed design yield simulated peak gain is about 3.8dBi with dumbbell shaped defect on the lateral ground plane which is superior than other geometries in the existing literatures. Here it is clear that proposed antenna occupies only 21x19x1.6mm³ which is very less than that of other possible variants in the literature. The defect using dumbbell also enhances the miniaturisation of proposed design.

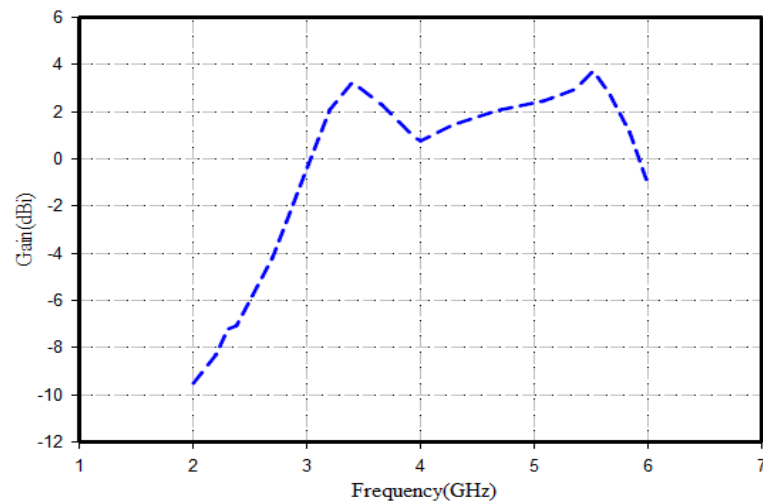


Figure.5 Gain Vs Frequency of proposed antenna

Figure 6 shows the simulated radiation patterns with Elevation and azimuthal plane at resonant frequencies by using Mentor Graphics IE3D software. The simulated radiation patterns of antenna in the E-plane (XZ-plane) and H-plane (YZ-plane) for two different frequencies 3.4 GHz and 5.52GHz. The patterns and other curves are obtained at the time of simulation. We observed good radiation patterns by taking 20 cells per wavelength. Finally the antenna gain is calculated and displayed in Figure 5 the antenna gain is observed more than 3.4dBi at 3.4 GHz owing to good return loss of about -25dB, and gain of about 3.8 dBi 5.5GHz which is sufficient for present and future wireless communication standards.

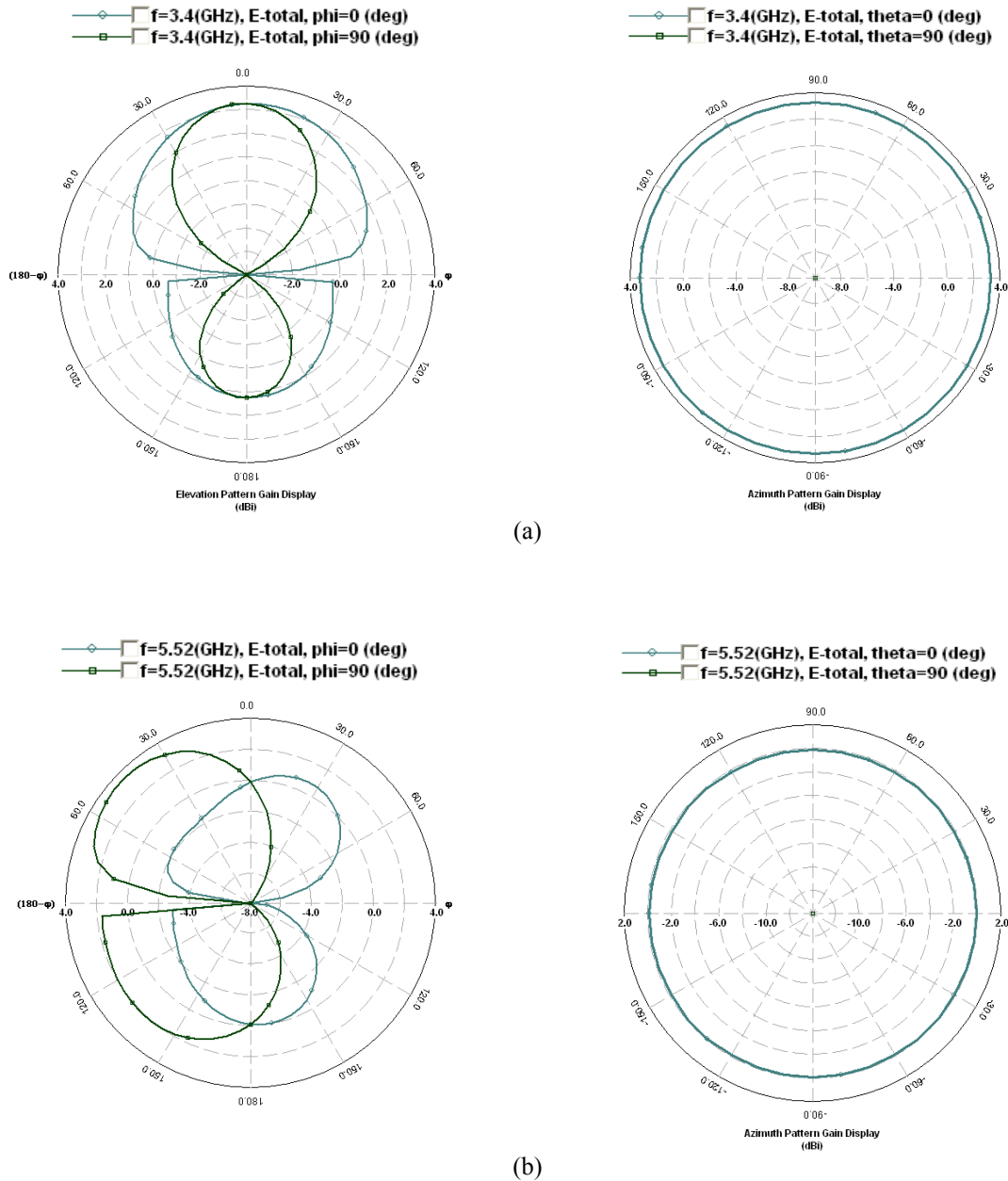


Figure 6. 2D Radiation patterns of proposed antenna (a) 3.4GHz (b) 5.52GHz

4. CONCLUSION

A novel ACS fed dual band antenna for wireless applications is presented with a compact size of $21 \times 19 \times 1.6 \text{mm}^3$. The proposed antenna was analyzed by mentor graphics software IE3D. Due to F Shaped exciting strip and defected ground structure the proposed antenna exhibit average return loss of (-25dB), good VSWR (around 1), better impedance matching at 50 Ohm with ACS structure. Therefore, the proposed antenna is the suitable structure for WiMAX/WLAN and various wireless applications.

ACKNOWLEDGEMENTS

Authors are gratefully acknowledge University Grant Commission, New Delhi for the technical and financial support

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