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ACS-Fed Wide Band Antenna with L-Shaped Ground Plane for 5.5 GHz WLAN Application

Kalikuzhackal A. Ansal* **and Thangavelu Shanmuganatham**

Abstract—A compact asymmetric coplanar strip fed wide-band monopole antenna with modified L-shaped ground plane for WLAN applications is presented. The proposed antenna operates at 5.5 GHz covering IEEE802.11WLAN/RFID/HYPERLAN2 bands. The antenna has an overall dimension of only $21 \times 7.35\,\text{mm}^2$ when printed on a substrate of dielectric constant 4.4. The planar design with simple feeding technique and miniaturized size makes it easy for integration of the antenna into circuit boards. Details of the antenna design with simulated and experimental results are presented and discussed.

1. INTRODUCTION

The increasing demand for wireless internet for high data rate communication has fostered tremendous attention towards the design of miniaturized WLAN antennas. Different types of designs serving to various user requirements have been reported in literature [1–18, 20, 21]. These designs, however, have complex structures which make them difficult to integrate with WLAN systems. Planar antennas have the advantage of easy integration with the active circuits. Many types of planar multi band antennas have been reported in literature [2–5]. In this article, we present an Asymmetric Coplanar Strip (ACS) fed monopole antenna with ground modifications. The resulting antenna operates at 5.1–5.9 GHz and covers 5.2 GHz WLAN IEEE802.11a (5150–5350, 5725–5825 MHz) HIPERLAN2 (5470–5725 MHz) and 5.8 GHz RFID frequencies. A dual wideband G-shaped slotted antenna for WLAN and WiMAX application was proposed in [3]. A Tri-band U-shaped monopole antenna was proposed for WiMAX and WLAN in [4]. The various slotted multi-band antennas for WLAN reported in [5–11]. However, these designs occupy a little bit more space, and it is difficult for integration. In this article, we propose a wideband ACS-fed antenna with modified ground for WLAN operations with a compact size composed of a ground plane and a vertical strip, which gives wideband at 5.1–5.9 GHz.

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 [12–14]. This feeding mechanism is analogous to the coplanar wave guide feed except that the ACS feed has a single lateral ground strip compared to the twin lateral ground strips in the CPW feed. The overall size of the antenna is reduced about one half of similar coplanar wave fed antennas. Another ACS L-strip fed antenna for WLAN application has been proposed in [15]. But proposed L-fed antenna is larger in size than our proposal.

2. ANTENNA DESIGN AND CONFIGURATION

The geometry of the proposed wideband ACS-fed monopole antenna is shown in Figure 1. The antenna is designed on a 1.6-mm-thick FR-4 epoxy substrate with relative permittivity of 4.4, and the overall dimension is only $21 \times 7.35\,\text{mm}^2$. The ACS feed line has a signal strip width of 3 mm and gap distance of

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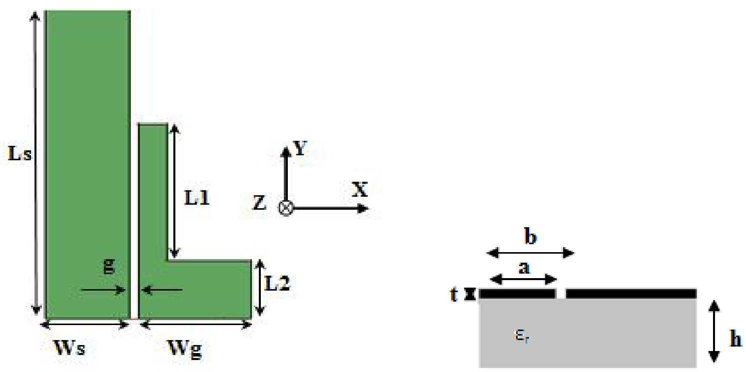
* Corresponding author: Kalikuzhackal Abbas Ansal (ansal.555@gmail.com).
The authors are with the Department of Electronics Engineering, School of Engineering and Technology Pondicherry University, Puducherry 605 014, India.



(a) (b)

Figure 1. (a) Geometry of proposed ACS-fed monopole antenna. (b) Side view.

0.35 mm between the signal strip and the coplanar ground plane, corresponding to the 50 Ω characteristic impedance. This feeding mechanism is analogous to the CPW-fed except that the ACS-fed has a single lateral ground strip compared to the twin lateral ground strips in the CPW-feed. Furthermore, the ACS-fed antenna exhibits similar radiation patterns to CPW-fed antenna. Therefore, the antenna constructed using the ACS-fed exhibits all the advantages of the CPW-fed antenna together with more compactness. The width and length of L-shaped ground plane is optimized to obtain the desired resonant frequency with wider bandwidth. The dimensions of the proposed antenna are optimized and shown in Table 1.

Table 1. Parameters of the proposed antenna.

Parameter	L_s	W_s	W_g	L_1	L_2	g
Value (mm)	21	3	4	7	3	0.35

For the desired resonant frequency guided wavelength λ_g is given by

$$\lambda_g = c/\sqrt{\varepsilon_{eff}}\,f \tag{1}$$

The design equations [19] for the perfect matching of impedance are given below

$$Z_o = \frac{60\pi}{\sqrt{\varepsilon_{eff}}}\frac{K(k)}{K(k^1)} \tag{2}$$

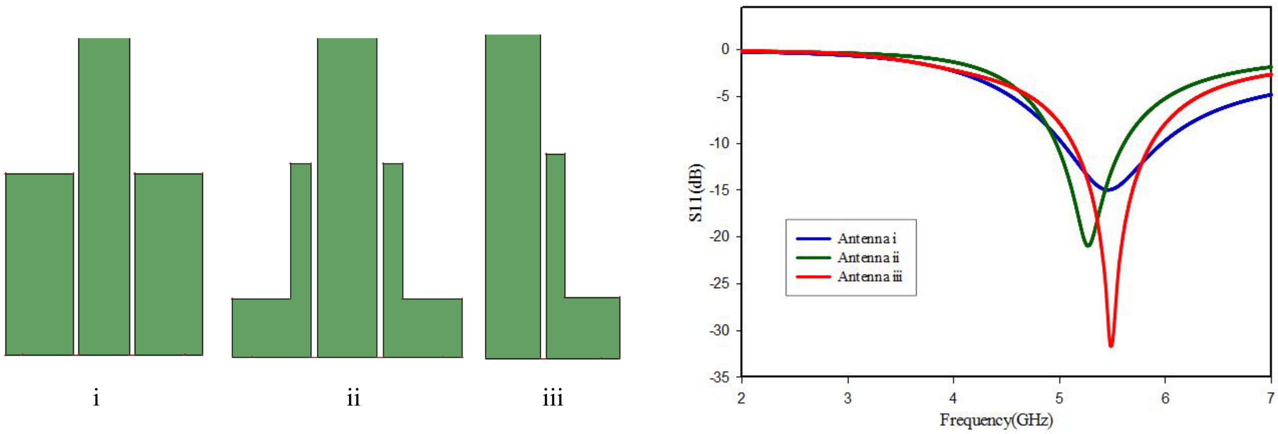
where, from Figure 1(b)

$$k = {}^{a}\!/_{b}$$
$$k^1 = \sqrt{1-k^2}$$

and $\frac{K(k)}{K(k^1)}$ is the elliptical integral of first kind and given by

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

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \tag{4}$$



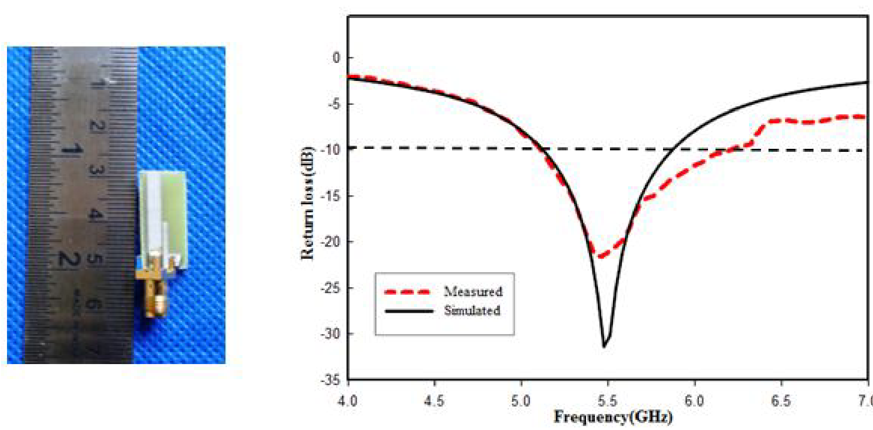
(a) (b)

Figure 2. (a) Evolution of the proposed antenna. (b) Corresponding return loss characteristics.

Figures 2(a) and 2(b) show the design evolution and its return loss characteristics of the proposed antenna. Initially, we started from the conventional coplanar waveguide fed planar configuration and finally arrived at the proposed ACS fed geometry with L-shaped ground plane. From Figure 2(b) it is clear that the proposed ACS-fed design performed well compared with the CPW-fed geometries from which it is evolved.

3. RESULTS AND DISCUSSION

A prototype of the proposed wideband antenna is fabricated and measured, and its photograph is shown in Figure 3(a). The return loss of the wideband antenna is measured by Agilent E8363B vector network analyzer (VNA). The simulated and measured return losses against frequency of this antenna are given in Figure 3(b). It can be seen that the simulated and measured results show reasonable conformity, and the resonant frequency at about 5.48 GHz is achieved. The measured impedance bandwidth for $S_{11} < -10$ dB is about 1100 MHz (5.1–6.2 GHz), but simulated bandwidth is about 800 MHz (5.1–5.9 GHz).



(a) (b)

Figure 3. (a) Fabricated prototype of wide band ACS-fed antenna. (b) Simulated and measured return loss versus frequency.

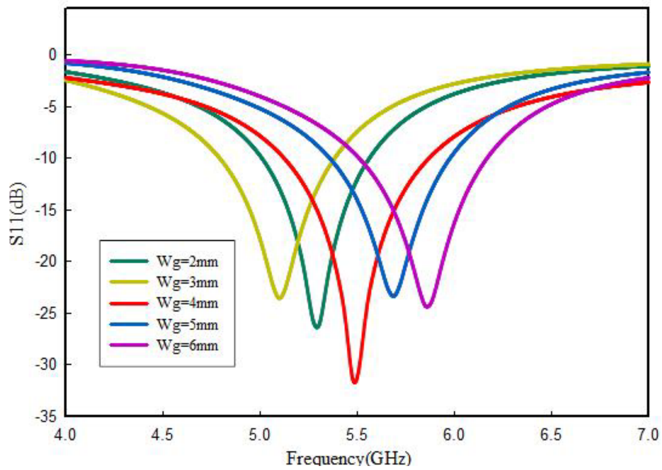


Figure 4. Comparison of return loss for varying width of the ground plane (W_g).

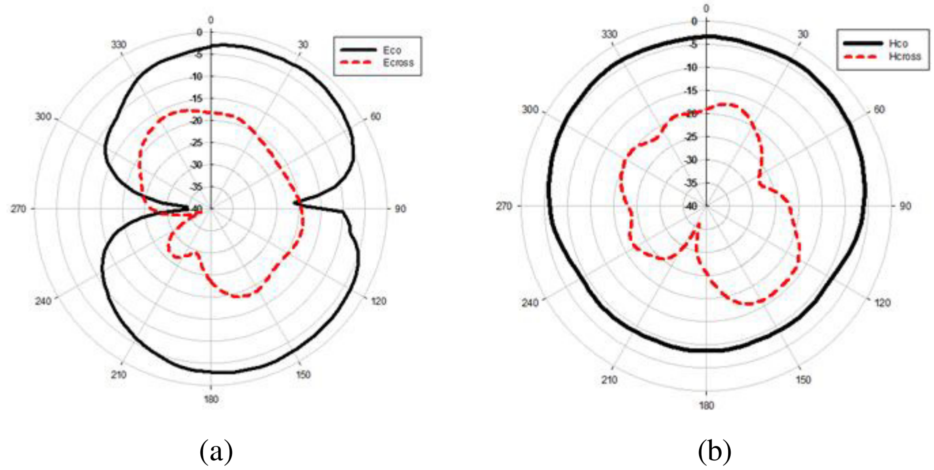


Figure 5. Measured radiation pattern xz plane and yz plane; (a) E-plane at 5.5 GHz; (b) H-plane at 5.5 GHz.

The parametric analysis of the proposed antenna by varying the lateral ground width W_g is shown in Figure 4. When reducing the ground width the resonance shifted towards 5 GHz and by increasing the lateral ground width it will shift towards 6 GHz. So W_g is a parameter to tune the proposed antenna in various nearby frequencies.

Table 2 shows the comparison of gain and area of the proposed structure with existing literatures presented in [12–18]. It is found that the proposed structure gains a significant size reduction about approximately 50% and yields moderate gain of 3 dBi for the wide band of operation. So the proposed antenna is a promising candidate for future generation handheld portable devices.

The measured radiation patterns for both E and H planes are shown in Figure 5. The proposed antenna exhibits omnidirectional radiation pattern at H plane and bidirectional radiation pattern at E-plane. The polarization of the antenna is also experimentally determined, and it is found that the antenna is polarised along X axis for wideband operation. The radiation patterns are slightly asymmetric because of asymmetry in the proposed antenna configuration. The measured and simulated gains against frequency is shown in Figure 6. It can be seen that the proposed antenna gives peak gain of 3.3 dBi, and it is stable in entire operating band, so it is a useful candidate for portable wireless gadgets.

Table 2. Comparison of antenna size and gain with existing literatures.

Published literatures/proposed	Peak Gain (dBi)	Purpose of Antenna	Area (mm^3)	Size Comparison Total area (mm^3)
Proposed	3.3	WLAN	$21 \times 7.35 \times 1.6$	246.96
Ref. [12]	1.21	WLAN	$37.5 \times 24 \times 1.6$	1440
Ref. [13]	2.1	WLAN	$30 \times 28 \times 1.6$	1344
Ref. [14]	1.9	WLAN	$21 \times 19 \times 1.6$	638.4
Ref. [15]	2.5	WLAN	$26.5 \times 12 \times 1.6$	508.8
Ref. [16]	1.25	WLAN	$17 \times 12 \times 1.6$	326.4
Ref. [17]	3.5	WLAN	$35 \times 15 \times 1.6$	840
Ref. [18]	3.3	WLAN	$28 \times 12.5 \times 1.6$	560

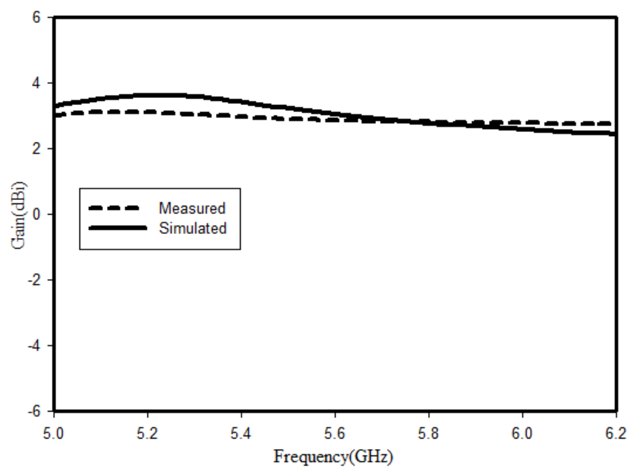


Figure 6. Measured peak gain of proposed antenna.

4. CONCLUSION

A compact ACS-fed monopole antenna with L-shaped ground plane for WLAN application is proposed, fabricated, and measured. The antenna has a simple structure and compact size of $21 \times 7.35\,mm^2$. The proposed antenna is evolved from basic CPW-fed monopole. Measured results demonstrate that the antenna can achieve desired band with wide bandwidth, good omnidirectional radiation characteristics, and reasonable gain. Consequently, the proposed antenna, which has an advantage of compact size, is designed, and it is suitable for WLAN applications.

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