

Design of a Miniaturized Square Slot Antenna Using Y-Strips for Enhancement of Circularly Polarization Bandwidth

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1. Introduction

Circularly-polarized (CP) planar antennas have been received much attention for mobile wireless communication applications since they are not only able to reduce the multipath effects but also provide flexibility for transceivers [1]. CP microstrip antennas are widely used but they are required to have broadband, small size, light weight, and low profile characteristics [2]. However, conventional CP microstrip antennas had some drawbacks such as narrow impedance and CP bandwidths [3][4]. Also it is difficult to implement a broadband CP microstrip antenna having small dimensions. To enhance the impedance bandwidth, CP antennas using slot structure instead of the microstrip structure were proposed [5]. Still in the open articles, the slot antennas which have wide CP bandwidth of more than 20% are quite few and their dimensions are larger than that of a microstrip antenna normally.

The purpose of this paper is to propose a slot CP antenna with enhanced impedance and CP bandwidths with a reduced size. Broadened impedance and CP bandwidths are implemented by adopting the inverted L-shaped feed line and the square slot with a pair of y-strips. By adjusting the dimensions of y-strips which have a great role in enhancing the CP bandwidth, the CP bandwidth of the antenna can be increased up to 29 %. the CP bandwidth of the proposed antenna can cover the entire industrial, scientific, and medical (ISM) band (2.4 ~ 2.485 GHz). Additionally, the dimension of the antenna is reduced by using the meander feed line.

2. Antenna design and performance

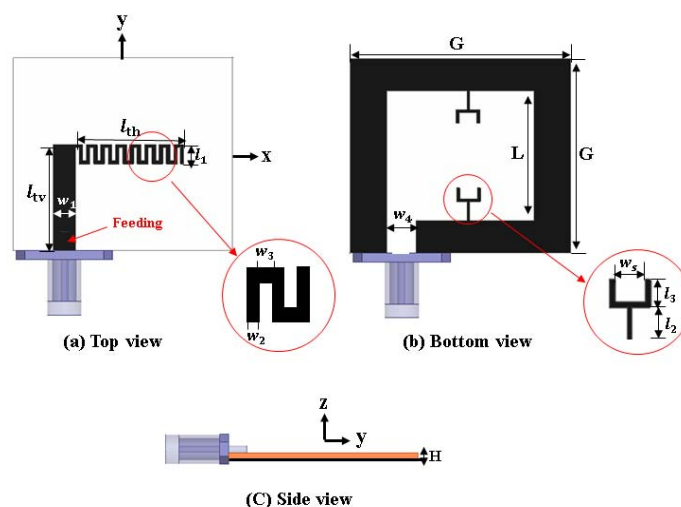


Figure 1: Configuration of the proposed antenna

Fig. 1 shows the configuration of the CP square slot antenna. The square slot with side length, L , is etched on the bottom plane of an FR-4 substrate ($G \times G \times H = 36 \text{ mm} \times 36 \text{ mm} \times 1.6 \text{ mm}$) having a relative dielectric permittivity (ϵ_r) of 4.4. The geometrical parameters of the inverted L-shaped microstrip feed are l_{tv} , l_{th} , l_1 , w_2 and w_3 . To reduce the size of the antenna, the inverted L-shaped feed is meandered. Also, L_{th} denotes total length of the meandered line. For the impedance matching at the center frequency of the ISM band (2.45 GHz), the constitutive parameters for asymmetric feed of the antenna are chosen as $l_{tv} = 19 \text{ mm}$, $l_{th} = 18 \text{ mm}$ and $L_{th} = 66 \text{ mm}$. A pair of y-strips is implanted along the y-axis in the slot to broaden the 3 dB axial ratio (AR). The improved CP bandwidth property for the required band vanishes when the grounded y-strips are removed. Hence, if switching elements are inserted on a y-strip, the antenna could show the polarization reconfigurable performances.

The performances of the proposed antenna were calculated using HFSS which is commercial EM simulator based on the FEM method and the measured results were obtained with an Agilent 8719ES network analyzer. When all the other parameters except for L_{th} are fixed, the simulated return loss and axial-ratio results for the case of $L_{th} = 18, 32, 50$, and 66 mm are presented in Fig. 2(a) and (b). It is clearly observed seen that, when L_{th} increases, 3dB AR bands move to the lower frequency but the return loss characteristics of the antenna are rarely affected.

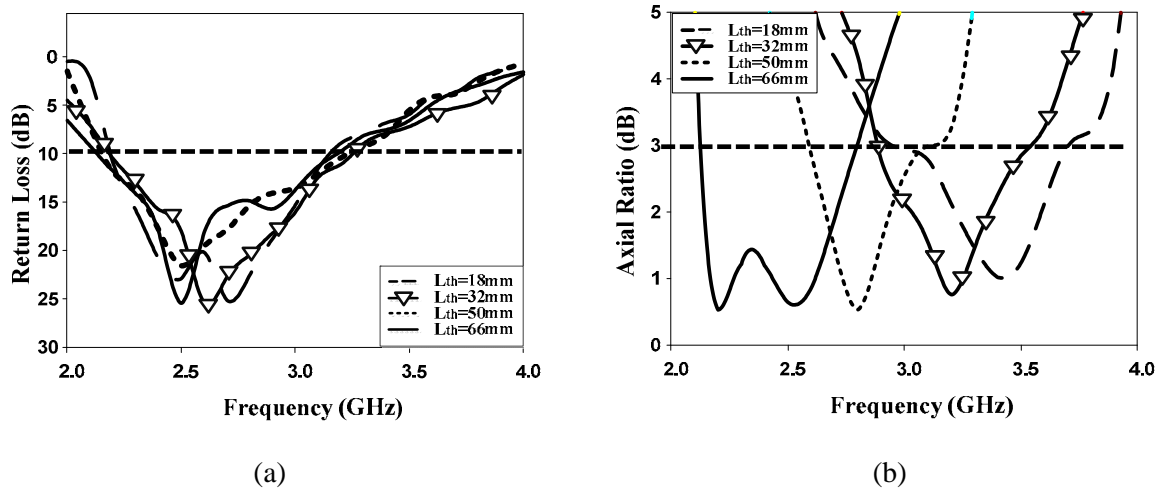


Figure 2: (a) Return losses and (b) axial ratios of the antenna with varying L_{th}

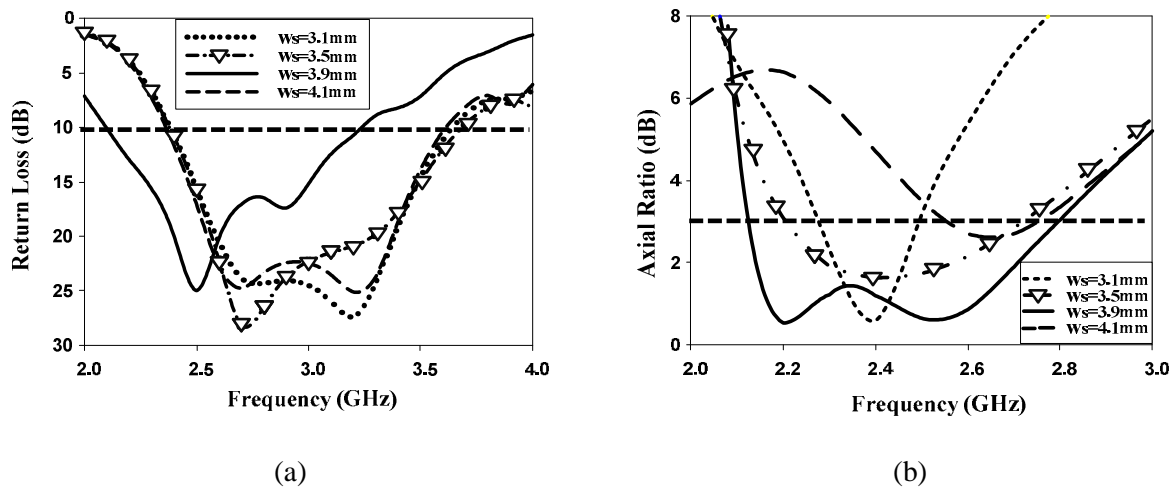


Figure 3: (a) Return losses and (b) axial ratios of the antenna with varying w_s

Fig. 3 shows the return loss (RL) and the axial ratio (AR) values of the antenna for varying the distance between two tips of y-strips, w_s . When w_s increases from 3.1 mm to 3.9 mm, the resonance frequency move to lower frequency band and 3dB axial ratio bandwidth (ARBW) becomes wider as shown in Fig. 3(a) and (b). However, these characteristics are disappeared when w_s becomes 4.1 mm. Parameters and 3dB ARBW of the proposed antenna for various L_{th} and w_s are summarized in Table 1.

Table 1: Parameters and 3dB ARBW of the proposed antenna for varying L_{th} and w_s

L_{th} (mm) ($w_s = 3.9$ mm)	w_2 (mm)	w_3 (mm)	f_c (GHz) 3dB ARBW (GHz)	w_s (mm) ($L_{th} = 66$ mm)	3dB ARBW (%) Range (GHz)	f_c (GHz)
18	18	0	2.45 (2.13~3.12)	3.1	8 (2.3~2.7)	2.4
32	2	0.5	2.8 (2.62~3.12)	3.5	20 (2.2~2.8)	2.4
50	1	0.5	3.21 (2.87~3.5)	3.9	27 (2.15~2.8)	2.45
60	0.5	0.5	3.45 (3.12~3.7)	4.1	4 (2.5~2.6)	2.65

3. Results and Discussion

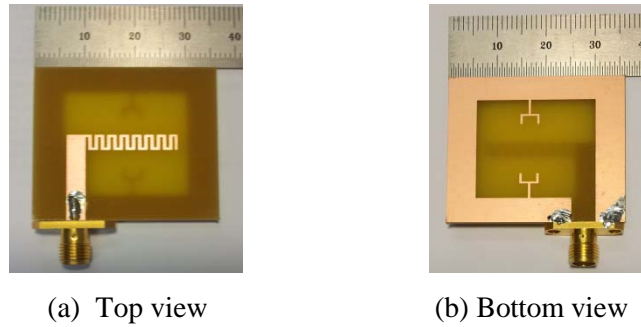


Figure 4: Configuration of the fabricated CP antenna

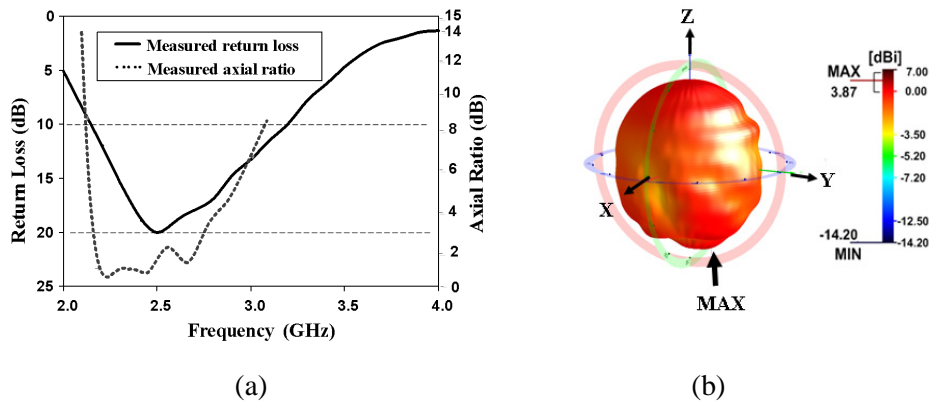


Figure 5: Measured performances of the proposed antenna

The proposed antenna was fabricated with optimized parameters: $L = 24$ mm, $G = 36$ mm, $l_1 = 3.6$ mm, $l_2 = 3.5$ mm, $l_3 = 2.5$ mm, $l_{iv} = 19$ mm, $l_{th} = 18$ mm, $w_1 = 3.6$ mm, $w_4 = 4.8$ mm, $w_s = 3.9$ mm, $L_{th} = 66$ mm. Photographs of the fabricated CP antenna are shown in Fig. 4. Fig. 5(a) shows measured return loss and axial ratio for the proposed antenna. From Fig. 5(a), it is found that the impedance bandwidth is as large as 1120 MHz (2170-3290 MHz) or about 46 % and the 3dB ARBW reaches 710 MHz (2110-2820 MHz) or about 29 % with respect to the center frequency of 2450 MHz. Note that in terms of the ground-plane and slot sizes, the proposed antenna here is more compact than those presented in other reference [4-7]. Nevertheless, the achieved 3dB ARBW is larger than all those appearing in [4-7]. Fig. 5(b) shows that the measured peak gain of the proposed antenna was found to have a maximum value of 3.87 dBi at the 2.45 GHz

4. Conclusion

The proposed antenna has wide impedance bandwidth and 3dB ARBW with small dimension. The experimental results show that the measured 10dB return loss bandwidth is 46 % (2170-3290 MHz) and the 3dB axial-ratio bandwidth is 29 % (2110-2820 MHz). The overall size of the antenna is only 36 mm \times 36 mm \times 1.6 mm. The proposed antenna provide numerous advantages such as small size, low weight, low production cost, and improved circular polarization properties.

Acknowledgments

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