Dual-Band Circularly-Polarized Small Microstrip Antenna

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Abstract

A dual band circularly polarized square microstrip antenna with one pair of L-shaped slits has been proposed. Design procedure of the axial ratio is obtained. The relationships between the geometrical parameters and the bandwidth are discussed.

Keywords: Microstrip antenna Circularly polarized wave Dual band operation GPS

1. Introduction

In Radio frequency identification (RFID) at center frequencies, 900MHz and 2.45GHz, circularly polarized wave is used in Japan. In Global positioning system (GPS), in additional to L1band (center frequency 1.575GHz), the services at L2 and L5 bands (center frequencies are 1.227GHz and 1.176GHz) are planning in the near future. For these purposes, multi band circularly polarized small antennas are required. Authors have proposed a dual band circularly polarized square microstrip antenna (MSA) [1]. The geometry of the patch conductor is square with one pair of L-shaped slits at each edge. In [1], the design procedure of frequencies giving the minimum axial ratio at dual frequency bands was obtained and the operational principle of the antenna was clarified by the studies of the geometrical parameter.

In this paper, the design procedure of the axial ratio at L1band and L2band and the relationships between the geometry of the antenna and the bandwidth are discussed by the simulation.

2. Antenna Design

Figure 1 shows a dual band circularly polarized square MSA. The geometry of the patch conductor is a square with one pair of L-shaped slits at each edge. The dimension of the square patch conductor is $W_T \times W_T$. The width of the T-shaped elements and the width of the L-shaped slits are fixed, d_w =1.0mm and S_t =0.5mm. In order to radiate circularly polarized waves at the two frequency bands, the dimension and the location of the L-shaped slits along the *x*-axis are different from those along the *y*-axis. Moreover, the antenna is excited at x_0, y_0 around the diagonal on the patch conductor by a coaxial feed through the dielectric substrate. The relative dielectric constant and the thickness of the dielectric substrate are ε_r =4.7 and *h*=3.2mm, respectively.

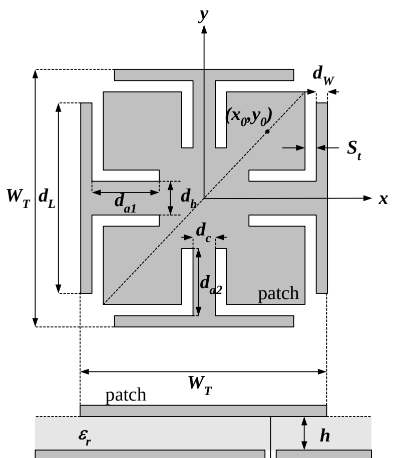


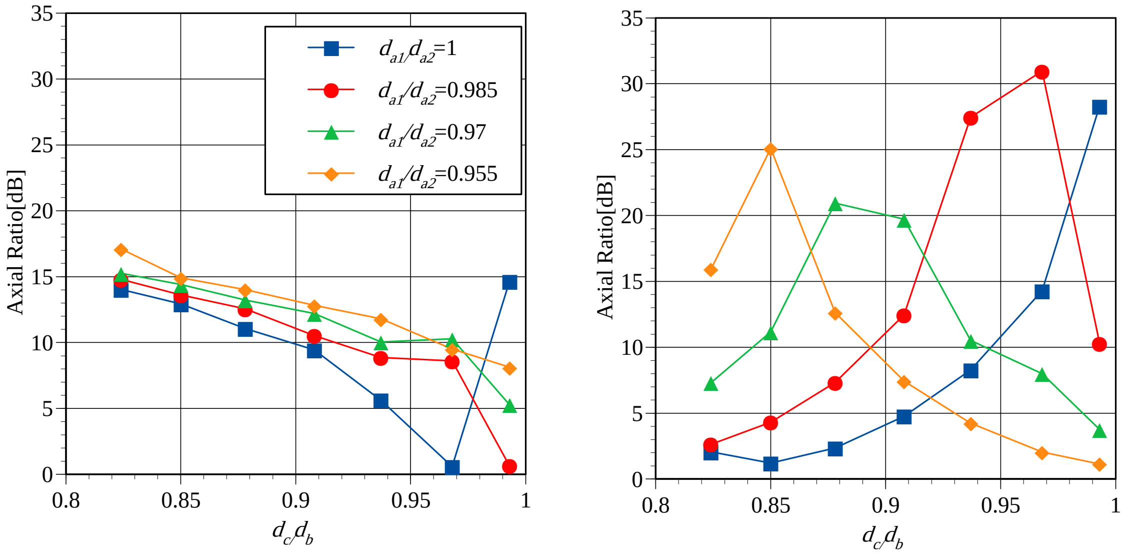
Figure 1: Geometry of a proposed MSA

3. Results and discussion

In the calculations, the simulator software package WIPL-D based on the method of moments [2] is used. Two frequency bands used in this paper is L1band (center frequency is 1.575GHz) and L2band (center frequency is 1.227GHz) in GPS.

3.1 Parametric study on axial ratio

Figures 2 (a) and (b) show the axial ratios for change of the ratios of the T-shaped conductor elements' width d_b and d_c at some ratios of the L-shaped slits' length d_{a1} and d_{a2}. The axial ratios at the dual band can be adjusted using d_c/d_b. Moreover, the ratio d_c/d_b giving the minimum axial ratio can be controlled by adjusting d_{a1}/d_{a2}.



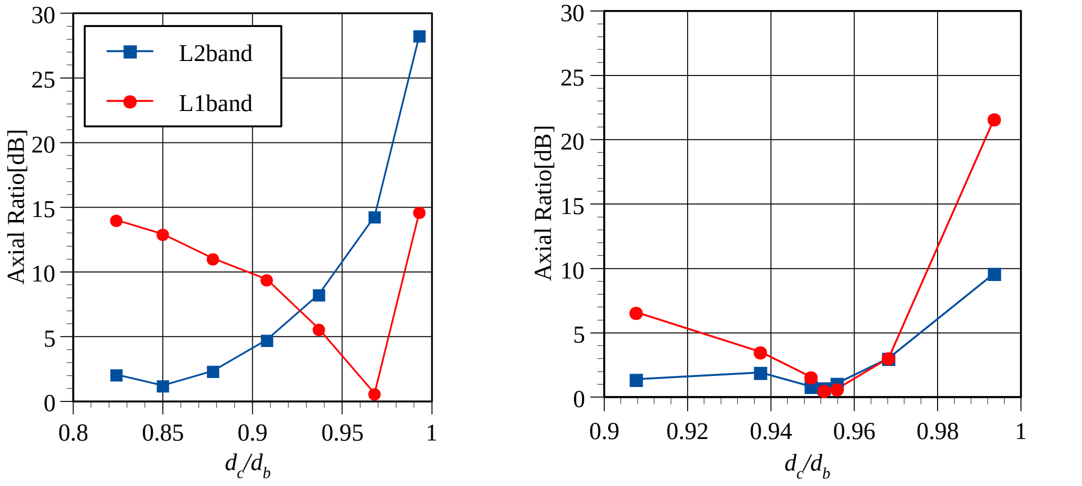
(a) L1band (b) L2band

Figure 2: Characteristics of axial ratio for changes of the ratios of the T-shaped conductor elements' width d_b, d_c at some d_{a1}, d_{a2}
(x_0=1.84mm, y_0=1.84mm, d_L=33.7mm, W_t=37.86mm)

Figure 3 (a) shows the axial ratios for change of the ratios of the T-shaped conductor elements' width d_b and d_c at $d_{a1}=d_{a2}$=13.3mm (d_{a1}/d_{a2}=1.0). As shown in Figure 3(a), the axial ratios have minimum value around d_c/d_b =0.88 and d_c/d_b =0.97 at L1band and L2band, respectively. This means that the antenna cannot radiate the circularly polarised wave at the dual bands in the case of d_{a1}/d_{a2}=1.0. Figure 3(b) shows the axial ratio at d_{a1}=13.42, d_{a2}=13.18mm (d_{a1}/d_{a2}=1.018). As shown in Figure 3(b), the axial ratios have minimum value at the same value (d_c/d_b=0.956) in L1band and L2band. Therefore, the antenna can radiate circularly polarized wave at dual band by adjusting d_b/d_c and d_{a1}/d_{a2}. In this case, the minimum axial ratios are 0.513dB and 0.723dB and the bandwidth of the axial ratio≦3dB are 2.6MHz and 1.5MHz at L1band and L2band, respectively.

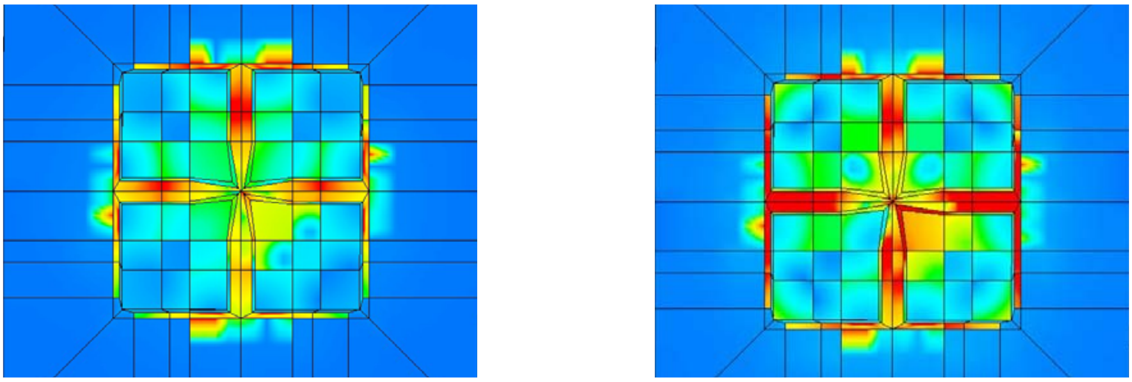
3.2 Parametric study on band width

Figures 4 (a) and (b) show the intensity of the time averaged electric current at L1band and L2band, respectively. The electric currents flow in the T-shaped elements strongly at the both of L1band and L2band, that is, the T-shaped elements operate as the radiation elements at the dual bands.



(a) d_{a1}=d_{a2}=13.3mm (d_{a1}/ d_{a2}=1.0) (b) d_{a1}=13.42mm, d_{a2}=13.18mm (d_{a1}/ d_{a2}=1.018)

Figure 3: Characteristics of axial ratio for changes of the ratios of the T-shaped conductor elements' width d_b/d_c at (a) d_{a1}/ d_{a2}=1.0 and (b) d_{a1}/ d_{a2}=1.018 (x_0=1.84mm, y_0=1.84mm, d_L=33.7mm, W_t=37.86mm)



(a) L1band (b)L2band

Figure 4: Time averaged electric current distributions (x_0=2.5mm, y_0=2.5mm, d_{a1}=12.15, d_{a2}=12.85mm, d_b=3.49mm, d_c=3.75mm, d_L=36mm, W_t=40mm)

Figure 5 shows the bandwidth (axial ratio $\leq$ 3dB) for change of $d_b + d_c$ (the sum of d_b and d_c) at L1band and L2band. In order to obtain the relationships between the $d_b + d_c$ and the bandwidth at the dual band, it is required that the frequencies giving the minimum axial ratio are tuned using a small number of geometrical parameters. Therefore, the only L-shaped slits' length d_{a1}, d_{a2} and T-shaped conductor elements' length d_L are used to tune the frequencies. In the figure 5, the axial ratios at all the sum of d_b and d_c are adjusted less than 1dB by change of d_c/d_b and d_{a1}/d_{a2}. As the sum of d_b and d_c is bigger, the sum of the bandwidth at the two frequency bands is wider.

Figures 6(a) and (b) show the axial ratio at $d_b + d_c$=7.24mm. It is observed that the minimum axial ratios are less than 1.0dB at the L1band and L2band. The bandwidths of the axial ratio $\leq$ 3dB are 2.0MHz and 3.0MHz at the L1band and the L2band, respectively.

The width of the square patch W_T is equal to 0.21 $\lambda_{1.575}$=0.16 $\lambda_{1.227}$ (λ_f:the wavelength at f GHz). The proposed antenna is very small in size.

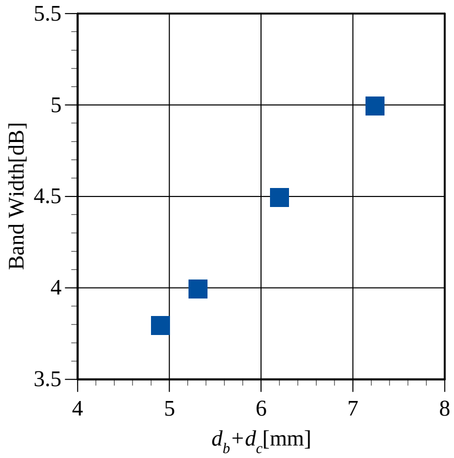
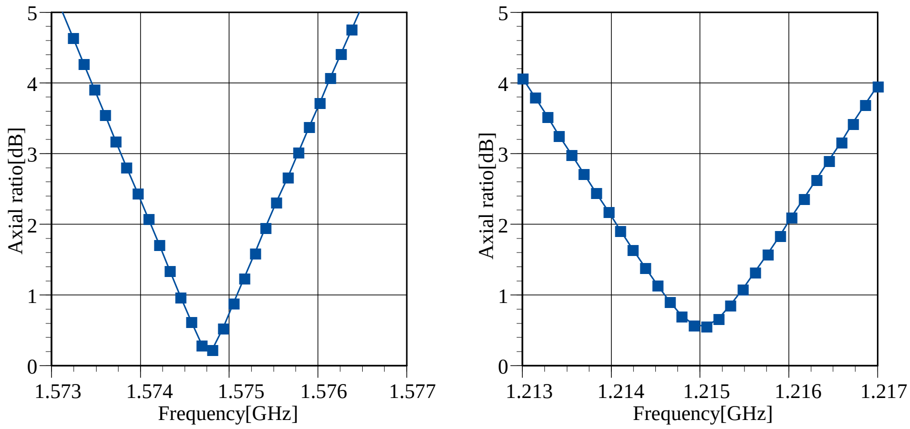


Figure 5: Relationship between $d_b + d_c$ and the bandwidth
(x_0=2.5mm, y_0=2.5mm, W_t=40mm)



(a) L1band (b) L2band

Figure 6: Axial ratio
(x_0=2.5mm, y_0=2.5mm, d_{a1}=12.15, d_{a2}=12.85mm, d_b=3.49mm, d_c=3.75mm, d_L=36mm, W_t=40mm)

4. Conclusion

A dual band circularly polarized square MSA with one pair of L-shaped slits has been proposed. A design procedure of the axial ratio was clarified. Axial ratio can be adjusted by the width of the T-shaped conductor elements and the length of the L-shaped slits. As the T-shaped conductors operate as the radiation elements, the bandwidth increases as the width of the T-shaped conductor elements is bigger.

References

[1] T. Fujimoto et al. , “Dual–band circularly–polarized microstrip antenna for GPS application, ” Proc. IEEE International Symposium on Antennas and Propagation, [CD-ROM], June 2008.
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