Circularly Polarized Small Microstrip Antenna for Wireless Sensor Network

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***Abstract*—A circularly polarized square MSA with one pair of crank-shaped slit at each edge is proposed for wireless sensor network. The simulated bandwidths of 3dB-axial ratio with 10dB-return loss is 2.398GHz-2.482GHz (3.5%). Moreover, the antenna has the radiation characteristic with wide beam width. The size of the antenna patch is approximately (0.16 wavelength)^2. The designed antenna is small in size.**

Keywords—microstrip antenna, circular polarization, Wireless sensor network, Zigbee, Crank shaped slits

I. INTRODUCTION

Recently, the wireless sensor network (WSN) has received much attention at the medical care, the agriculture, and the social infrastructure etc. In such fields, the WSN is used for monitoring. Wireless standard used for the WSN is Zigbee (IEEE 802. 15. 4). To easily perform setting the antennas and to keep the stable communication of WSN, it is desirable that antennas for WSN radiates both horizontal and vertical polarized waves and have unidirectional radiation pattern.

Author has proposed a dual-band circularly-polarized square microstirp antenna (MSA) [1] for GPS. The geometry of the patch conductor in [1] is a square with one pair of *L*-shaped slits at each edge to miniaturize the patch's size and achieve a circularly polarized wave in the dual band (1.227GHz and 1.575GHz). In this paper, the MSA proposed in [1] is redesigned as a small MSA for wireless sensor network by simulations. For the simulations in this paper, the simulation software packages FEKO [2] and Wipl-D [3], which are based on the moment method, are used.

II. ANTENNA DESIGN

Fig. 1 shows a circularly polarized square MSA. The geometry of the patch conductor is a square with one pair of crank slits at each edge. The dimension of the square patch conductor is $W_{Tx} \times W_{Ty}$. The width of the crank slits is also fixed at S_t=0.5mm. In order to radiate circularly polarized waves, the dimensions and the positions of the crank slits along the *x*-axis are different from those along the *y*-axis. In order to tune impedance matching at the broad frequency ranges, the antenna is excited by an *L*-probe feed which lies at the diagonal on the square patch conductor. The thickness and the relative dielectric constants of each dielectric layer are h_1=1.6mm and h_2=3.2mm and $\varepsilon_{r1}=\varepsilon_{r2}$= 3.8, respectively. The loss tangent of both the dielectric substrates is 0.022. Dimension of the dielectric substrate is fixed at G_t=66mm.

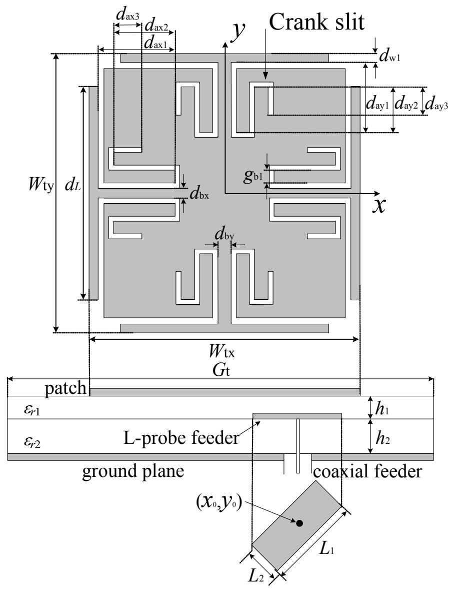


Fig. 1. Geometry of a proposed MSA.

III. RESULTS AND DISCUSSION

Relationships between the dimension of the crank slits and the axial ratio and between the dimension of the *L*-probe and the return loss were investigated in detail by simulation. According to the results, the antenna was designed in the Zigbee band. The size of the patch of the designed MSA is $W_{tx} \times W_{ty}$=19.035mm × 20.035mm=0.154$\lambda_{2.44}$ × 0.163 $\lambda_{2.44}$ (λ_f is wavelength of *f* GHz). The designed antenna is small in size.

Fig. 2 (a) and (b) show the simulated axial ratio and return loss, respectively. There are two minimum axial ratios in the Zigbee band. Circular polarized waves are radiated due to the *T*-shaped elements at the center of the square patch in the lower frequency with the minimum axial ratio and due to the crank slits in the higher one. The ratio of the two frequencies giving the minimum axial ratio is 1.02 (= 2.466GHz/2.414GHz). In the MSA for GPS [1], the ratio of the two frequencies is 1.575GHz/1.227GHz=1.28. By changing the configuration of the slit from *L*-shape to crank-shape, the ratio of the two frequencies decreases and the bandwidth of 3dB-axial ratio becomes broadband. The bandwidth of 3-dB axial ratio with 10-return loss satisfies the specification of Zigbee (2.401-2.481).

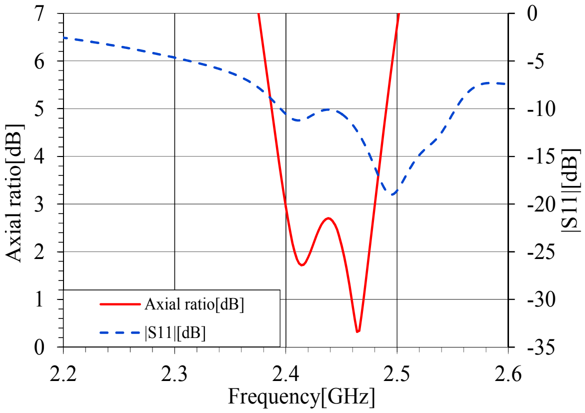
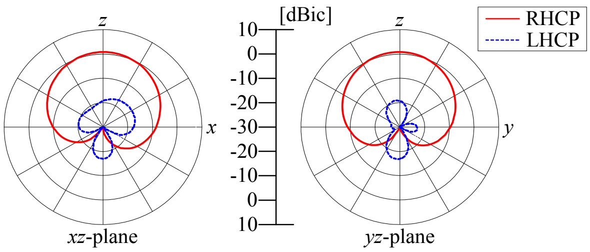
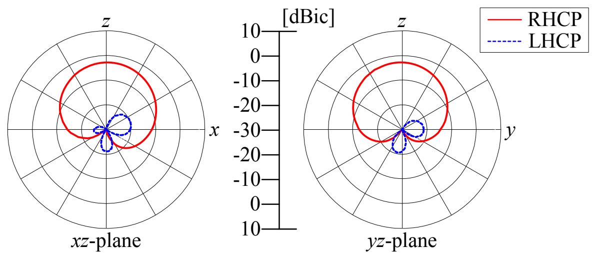


Fig. 2. Simulated axial ratio and return loss.



(a) 2.414GHz



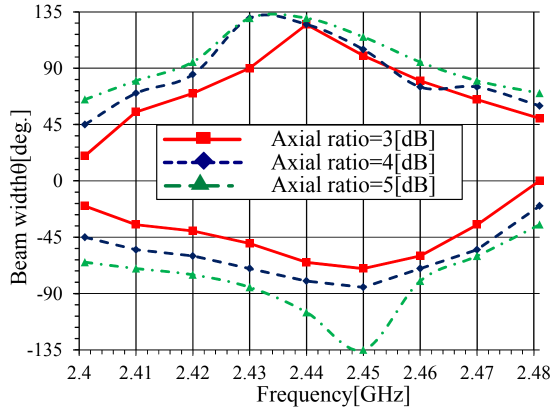
(b) 2.466GHz

Fig. 3. Simulated radiation patterns.

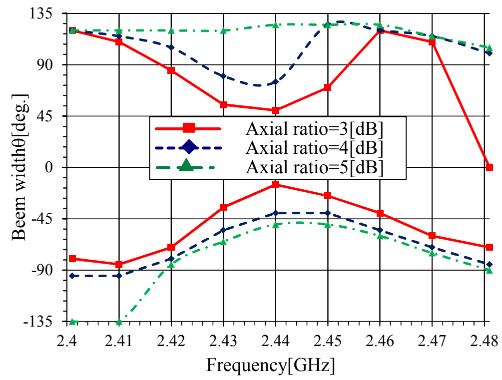
Fig. 3 (a) and (b) show the simulated radiation patterns at two frequencies giving the minimum axial ratio. The MSA radiates the right-hand circular polarization wave (RHCP) at the high elevation angles at the two frequencies.

At the lower frequency giving the minimum axial ratio, the electric currents at the T-shapes elements at the square patch contributes to the radiation. While, at the higher frequency, the electric current around the crank slits contributes to the radiation. The electric currents at the both sides of the crank slits flow to the directions opposites each other along the crank slits (the electric current distributions are omitted in this paper). Therefore, the gain at the higher frequency giving the minimum axial ratio (-3.2dB) is much less than that at the lower frequency giving the minimum axial ratio (1.4dB).

It is required to radiate both horizontal and vertical polarized waves at the wide angles for wireless sensor network. Figs. 4(a) and (b) show elevation angle for change of axial ratio. Beam widths with 5dB-axial ratio are 105 degrees in the *xz*-plane and 130 degrees in the *yz*-plane. The proposed MSA radiates circularly polarized wave in the wide angles.



(a) *xz*-plane ($\phi = 0^\circ$)



(b) *yz*-plane $\phi = 90^\circ$

Fig. 4. Elevation angle for change of axial ratios

IV. Conclusion

A circularly polarized MSA with crank slits has been proposed for wireless sensor network. The relationships between axial ratio and the geometrical parameters of the crank slits were investigated. The bandwidth of 3dB-axial ratio with 10dB-return loss of the proposed antenna satisfies the specification of the Zigbee band. Moreover, the proposed antenna radiate circularly polarized wave at the wide angles.

References

[1] T. Fujimoto, Y. Yoshitake, and D. Yagyu, "Design and simulation based studies of a dual-band circularly-polarized microstrip antenna," Progress In Electromagnetics Research Letters, vol. 52, pp. 129-134, April 2015.

[2] http:// www.feko.info/

[3] http://www.wipl-d.com/