An annular ring microstrip patch antenna with metallic vertical ring for circularly polarization

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Abstract

This paper presents a new small circularly-polarized (CP) antenna element composed by a microstrip ring patch (MRP) and a vertical ring patch (VPA). With the combination of these two types of patch antennas, the proposed antenna finds a significant enhancement in the axial ratio bandwidth as well as the impedance bandwidth with employing a single coaxial excitation only. The antenna yields an impedance bandwidth of 4.5 %, an axial ratio bandwidth of 1.1% and the maximum gain of 4dBi with a stable broadside radiation pattern across the operating bandwidth.

Introduction

Small circularly-polarized (CP) microstrip antennas are widely used in many wireless communications systems, particularly in mobile satellite applications such as the global positioning system (GPS), due to their inherited advantages like low-profile, ease of fabrication and compact in size. Many literatures have reported how to realize small CP patch antennas by loading a high dielectric substrate into the CP patches [1]; cutting slots [2-4]; or adding tails [5-6] and etc. However, those methods have drawbacks in a consequence of narrow impedance bandwidth as well as the poor axial ratio bandwidth. Another proper solution to have wider AR bandwidth for the CP patch antennas is to use the dual feed / sequential excitation to achieve orthogonal modes in the patch [7]. This method is effective to enhance the AR bandwidth but an additional feeding network has to be involved. Therefore, this technique may not be good for applying in the small antenna design. Other solutions for having wider AR bandwidth for the CP patch antennas are increasing the thickness of the substrate [8], employing stacked patches [9], using M/ T/ L-probe fed [10-12], or aperture-coupled [9]. All of these [8-12] techniques are proficient in AR bandwidth enhancement; notwithstanding, they have disadvantages in neither causing the complexity in the antenna structure nor boosting the materials cost.

In this paper, a novel CP patch antenna is introduced by using a metallic vertical ring top-loaded with an annual ring microstrip antenna. With the presence of the additional vertical ring, the proposed small antenna yields a double AR bandwidth when comparing with the conventional ring patch with same dielectric substrate.

Antenna description

The configuration of the microstrip ring patch with a metallic vertical ring for circularly polarization is shown in Fig. 1. This antenna consists of two parts. The first part is the microstrip ring patch antenna which is printed on a thick PCB (t=2.54mm) with ε_r=10. The dimension of this ring patch has an inner radius r_1=11mm and an outer radius r_2=14mm. Then four T-shaped slotted-stubs are cut and located at the point A,B,C and D sequentially. These stubs have an unbalanced ratio by selecting proper values of the orthogonal slotted-stubs length as a=4.5mm, b=3mm and l=4.6mm for generating two orthogonal modes in the ring patch antenna, such that a circular polarization can be excited. The metallic vertical ring has a radius r_1=11mm and a height h=8mm, which is attached to inner circumference of the microstrip patch. After having this additional vertical ring, the axial ratio bandwidth as well as the impedance bandwidth of the antenna can be improved. The antenna is excited by a Y-shaped microstrip transmission line with a coaxial probe feed. The Y-shaped microstrip is to transform the high impedance from the antenna to 50-ohm. A SMA-connector is located underneath the ground plane. The size of the ground plane is 70mm x 70mm.

Result

The measured results obtained using Aglient's E8363B network analyzer and a fully automated anechoic chamber are presented. Figure 2 shows the SWR, axial ratio and antenna gain. The antenna has an impedance bandwidth of 4.5% (for SWR<2) with the center frequency at 1.575GHz ranged from 1.547GHz to 1.618GHz, and has an axial ratio bandwidth of 1.1% (for AR<3dB) from frequencies of 1.565GHz to 1.582GHz. The radiation pattern is depicted in Fig. 3, the antenna has a symmetrical broadside radiation pattern at both principle planes (for phi=0^0 and 90^0). The antenna has the maximum gain of 4dBi.

Conclusion

A small microstrip ring patch antenna with top-loaded the metallic vertical ring is presented in this paper. Through the additional vertical ring, the antenna finds enhancements in both impedance and axial ratio bandwidths. With the presence of a pair of diagonal slotted-stubs, the antenna is capable of generating a circularly polarized wave. The antenna has an impedance bandwidth of 4.5% (SWR<2) and an axial ratio bandwidth of 1.1% (AR<3dB). Moreover, the antenna yields the maximum gain of 4dBi with a symmetric radiation pattern and a wide AR beamwidth.

REFERENCES

1. B.R. Rao, M.A. Smolinski, C.C. Quach and E.N. Rosario, "Triple band GPS trap-loaded inverted L antenna array," *Microwave Opt. Tech. Lett*., vol.38. no.1, pp.35-37 Jul, 2003.
2. H. Iwasaki "A circularly polarized small-size microstrip antenna with a cross slot," *IEEE Trans. Antennas Propagat*., vol. AP-44, no 10, pp. 1399-1401 Oct, 1996.
3. K. L. Wong and Y. F. Lin, "Circularly polarized microstrip antenna with a tuning stub," *Electron. Lett*. vol.34, pp. 831–832 Apr, 1998.
4. K.P. Yang and K. L. Wong, "Dual-Band Circularly-Polarized Square microstrip" *IEEE Trans. Antennas and Propagation*, vol. 49, no. 3, pp.377-382. Mar, 2001
5. W. S. Chen, C. K. Wu, and K. L. Wong, "Compact circularly polarized microstrip antenna with bent slots," *Electron. Lett*., vol.34, pp.1278–1279 Jun, 1998.
6. M. L. Wong, H. Wong and K. M. Luk, "Small circularly polarized patch antenna", *Electron. Lett.*, vol. 41, pp.887-888, Aug. 2005.
7. Huang, J.John., "A technique for an array to generate circular polarization with linear polarized elements", *IEEE Trans. Antennas Propagat., Vol.* Ap-34,pp.1113-1124, Sept.1986.
8. Herscovici, N., and Sipus, Z., "Circularly Polarized Single-Fed Wide-Band Microstrip Patch", *IEEE Trans. Antennas Propagat.,* Vol. 51, No 6, Jun. 2003.
9. D. M. Pozar and S. M. Duffy, "A dual-band circularly polarized aperture-coupled stacked microstrip antenna for global positing satellite", *IEEE Trans. Antennas Propagat., Vol.* Ap-45,pp.1618-1625, Nov.1997.
10. H. W. Lai and K. M. Luk, "Meandering probe fed patch antenna with high gain characteristics for circularly polarized application", *Mircowave and Optical Technology Letters,* vol-49, no.5, pp.1095-1098, May 2007.
11. H. Wong, P. Y. Lau, K. M. Mak, and K. M. Luk, "Small circularly polarized folded patch antenna," *Electron. Lett.,* vol. 41, pp.1363-1365, Dec. 2005.
12. Lo, W.K., Chan, C.H. and Luk, K.M, "Circularly polarized patch antenna array using proximity-coupled L-strip line feed", *Electron Lett.,* Vol. 36, Issue 14, 6 Jul. 2000 Page(s):1174-1175.

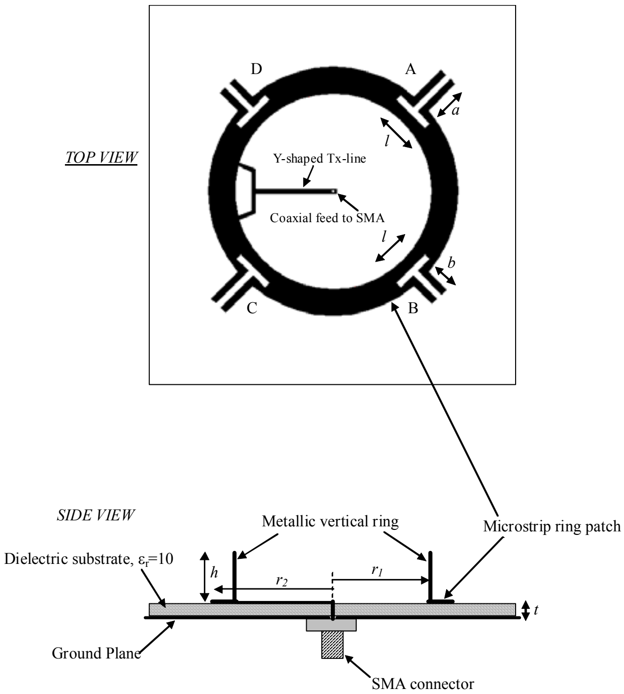

Figure 1 Antenna Geometry.

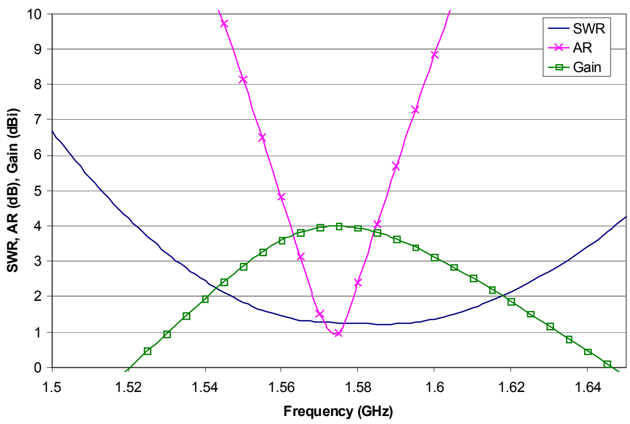

Figure 2 SWR, Axial Ratio and Gain against frequency.

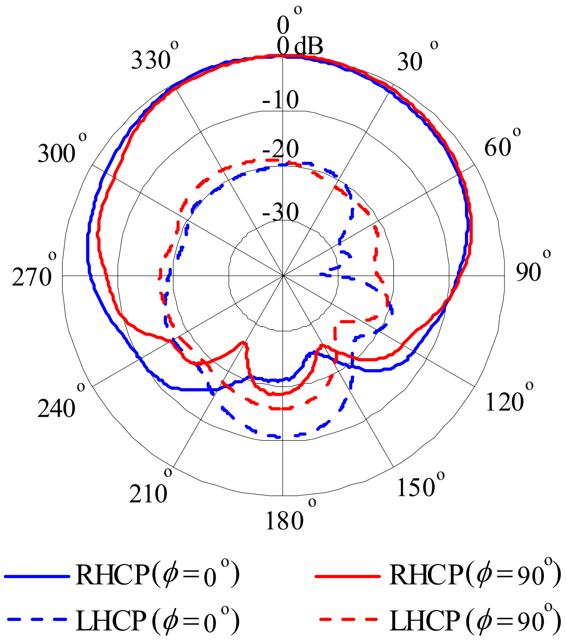

Figure 3 Measured Radiation Pattern at 1.575GHz.