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Wide Beam Circularly Polarized Microstrip Antenna with Parasitic Ring for CNSS Application

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ABSTRACT

The antenna is very essential element of communication as it is used for a transmitting and receiving electromagnetic waves. Today Communication devices such as mobile phones become very thin and smarter, support several applications and require higher bandwidth where the microstrip antennas are the better choice compare to conventional antennas. A compact single-feed circularly-polarized (CP) wide beam microstrip antenna is proposed for CNSS application. The antenna is designed with a double-layer structure, comprising a circular patch with two rectangular stubs along the diameter direction and a parasitic ring right above it. The resonance frequency and the CP characteristics are mainly controlled by the circular patch and the rectangular stubs, respectively. The vertical HPBW (half power beam width) could be widened by the parasitic ring.
Keywords :- Circular Polarization, Gain Control, Microstrip Antennas, Parasitic Antennas

I. INTRODUCTION

In the last decades, satellite positioning and navigation have become more and more important, both for military as well as civil use. GPS (Global Positioning System) in USA, Galileo in European Union and Glonass in Russia have been developed greatly. In China, CNSS (Compass Navigation Satellite System) or "BeiDou" in its Chinese name, began to provide navigation and positioning services in late 2001 [1]. The downlink band (S band) of the CNSS system is 2491.75 4.08 MHz. In order to receive the satellite signal quickly, the terminal antenna generally should be designed to have wider vertical HPBW and higher gain for low elevation angle. That has especially important meaning for CNSS which has fewer satellites compared with others at present. According to the official performance specifications of CNSS antennas, the gain for 5 elevation angle should be no less than 3 dB and its out-of-roundness for the horizontal radiation pattern must be less than 3 dB [2].

Quadrifilar helix antenna [3]–[5] has good circular polarization characteristics. Its heart-shaped radiation pattern, which leads to wide vertical HPBW and high gain for low elevation angle, could meet the demand of satellite communication. However, the profile of quadrifilar helix antenna is too high to be coplanar and integrated with communication systems. Microstrip antenna [6]–[8] has many advantages such as low profile, light weight, easy fabrication and conformability to mounting hosts. Meanwhile it could be easy to generate good circular polarization characteristics and because of this it has been highly appreciated. Generally, the vertical HPBW of microstrip antenna is about 70–110. On the premise of circular polarization characteristics, how to broaden the vertical HPBW and improve the gain for low elevation angle are very challenging.

There are some traditional ways to broaden the vertical HPBW of circularly- polarized microstrip antennas, such as using the materials with high permittivity, decreasing the ground size and so on. In [7]. A single feed circularly-polarized microstrip antenna is placed in a semi-closed dielectric wall, which could effectively broaden the vertical HPBW and meanwhile maintain good low-profile characteristics. But its lateral dimension is large. In [8], a wide-beam circularly-polarized microstrip dielectric antenna is designed through adjusting the substrate size and the vertical radiation beam width could be widened. Nevertheless, this structure has very strict requirements for the ground size, which may be rather hard to be applied in real environment. Besides, the half-power vertical beam-width of slot antenna could be widened with a cavity [9], but it will bring in mass waviness in the radiation pattern and the out-of-roundness for the horizontal radiation pattern may become bigger.

II. METHODS AND MATERIAL

A. Geometry of antenna

The proposed antenna comprises two circular substrates, each of which has a radius of R. The upper one is single-side. Metal structure and the parasitic radiation ring is on the top. The radiuses of the outer and inner ring are R1 and R2, respectively.

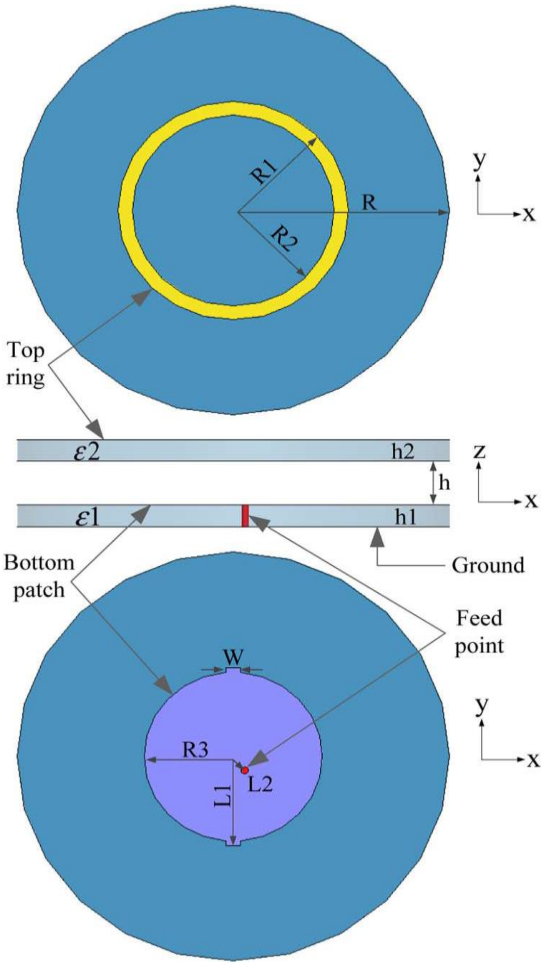

Figure 1. Geometry of the wide-beam circularly-polarized microstrip antenna

The lower one is a two-sided metal structure, of which the bottom is the ground and the upper is the main radiation patch of the antenna. The main radiation patch comprises a circle with radius R3 and two rectangular stubs along the diameter direction. Each stub has a width of W and is at a distance of L1 from the substrate center. The width of the gap between these two substrates is h, which is generally selected less than in order to maintain the low-profile characteristics of microstrip antennas. The main radiation patch of the proposed antenna is fed with 50 SMA. The feed point is located on 45 degree diagonal of the diameter along the two rectangular stubs. The distance between the feed point and the center of the main radiation patch is L2. The surface current excited by the feed point could be resolved into two parts, one along and the other perpendicular to the rectangular stubs. With the two rectangular stubs inserted, the former path is lengthened while the latter is scarcely affected. Therefore, there is length difference between the two directions. In other words, the surface current could be split into two near-degenerate modes with equal amplitude and 90 phase shift for CP characteristics. By adjusting the stub length and the distance between the feed point and the patch center, good circularly polarized characteristics could be achieved. The parasitic ring unit is fed by air coupling..

B. Literature Survey

Assembled dual-band broadband quadrifilar helix antennas with compact power divider networks have been proposed for CNSS application. Its heart-shaped radiation pattern, which leads to wide vertical HPBW and high gain for low elevation angle, could meet the demand of satellite communication. However, the profile of quadrifilar helix antenna is too high to be coplanar and integrated with communication system. [1]

Dual-band circularly-polarized square microstrip antenna is developed. In this proposed antenna the described the advantages of microstrip antenna such as low profile, light weight, easy fabrication and conformability to mounting hosts. Meanwhile it could be easy to generate good circular polarization characteristics and because of this it has been highly appreciated. [2]

A Rectangular Dielectric fortification for wide-beam width patches arrays for cnss application. a single feed circularly-polarized microstrip antenna is placed in a semi-closed dielectric wall, which could effectively broaden the vertical HPBW and meanwhile maintain good low-profile characteristics. But its lateral dimension is large [3]

A novel wide beam circular polarization antenna-microstrip-dielectric antenna, for cnss application is proposed a wide-beam circularly-polarized microstrip-dielectric antenna is designed through adjusting the substrate size and the vertical radiation beam-width could be widened. Nevertheless ,this structure has very strict requirements for the ground size, which may be rather hard to be applied in real environment.[4]

Dual-band circularly polarized pentagonal slot antenna *IEEE Antennas Wireless Propag has been* presented for cnss application. In this proposed antenna the described the advantages of microstrip antenna such as low profile, light weight, easy fabrication and conformability to mounting hosts. Meanwhile it could be easy to generate good circular polarization characteristics and because of this it has been highly appreciated [5]

"Low-profile cavity-backed crossed-slot antenna with a single-probe feed designed for 2.34 GHz satellite radio applications. In this paper, the half-power vertical beam width of slot antenna could be widened with a cavity [11], but it will bring in mass waviness in the radiation pattern and the out-of-roundness for the horizontal radiation pattern may become bigger. [6]

C. Advantage and Disadvantage

Microstrip patch antenna has several advantages over conventional microwave antenna with one similarity of frequency range from 100 MHz to 100 GHz same in both type. The various advantages and disadvantages are.

- **Advantages**
  1. Low weight
  2. Low profile
  3. Require no cavity Backing
  4. Linear & circular polarization
  5. Capable of dual and triple frequency operation
  6. Feed lines & matching network can be fabricated simultaneously

- **Disadvantages**
  1. Low efficiency
  2. Low gain
  3. Large ohmic losses in feed structure.
  4. Low power handling capacity
  5. Excitation of surface wave
  6. Polarization purity is difficult to achieve.
  7. Complex feed structure required high performance arrays

D. Antenna Design

The proposed antenna comprises two circular substrates, each of which has a radius of R. The upper one is single-side metal structure and the parasitic radiation ring is on the top. The radiuses of the outer and inner ring are R1 and R2, respectively. The lower one is a two-sided metal structure, of which the bottom is the ground and the upper is the main radiation patch of the antenna. The main radiation patch comprises a circle with radius R3 and two rectangular stubs along the diameter direction. Each stub has a width of W and is at a distance of L1 from the substrate center. The width of the gap between these two substrates is h, which is generally selected less than in order to maintain the low-profile characteristics of microstrip antennas.

Effects of the Parasitic Ring

The simulated results of LHCP pattern for XZ-plane before and after loading the parasitic ring. It is observed that, before and after loading the parasitic ring, the LHCP gains for 90 elevation angle are respectively 3.52 dB and 6.58 dB and the vertical HPBW are respectively 90 and 131 , as shown in Fig. 4(a). The average gains for 5 elevation angle are respectively 2.56 dB and 1.45 Db. Therefore the radiation pattern similar to tire shape generated by the parasitic ring, could decrease the gain for 90 elevation angle and improve the gain for low elevation angle.

III. RESULT AND DISCUSSION

A. Simulated Results

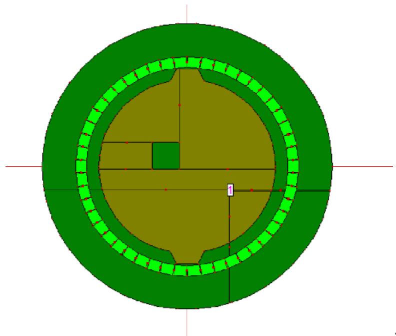

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Figure 2. Geometry

The measured bandwidth of 10 dB return loss is 30 MHz (2468–2498 MHz) and approximately 1.2% with respect to 2492 MHz, which could meet the S band impedance bandwidth requirement of CNSS application.

It can be seen that the radiation pattern has wide beam in XZ plane and good omni directional characteristics in XY-plane. The measured vertical HPBW is approximately 140 and the measured out-of-roundness for the horizontal radiation pattern is only 1.1 dB, less than the system requirement (3 dB).

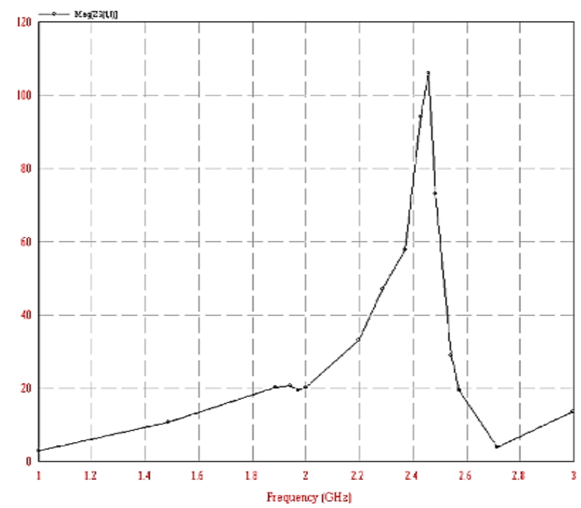


Figure 3. HPBW

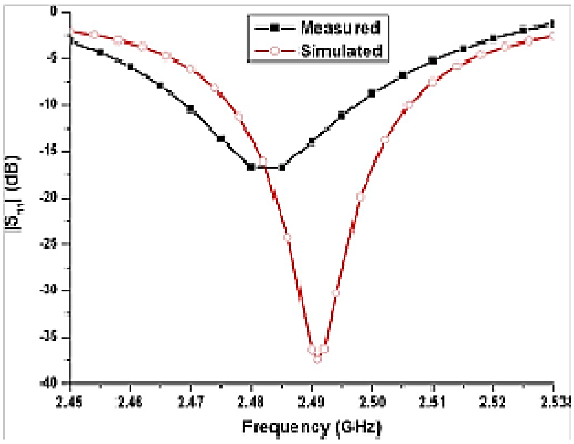
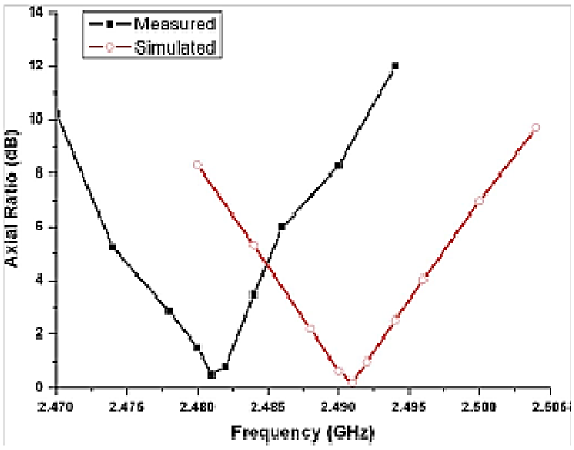


Figure 4. S11 for the proposed antenna



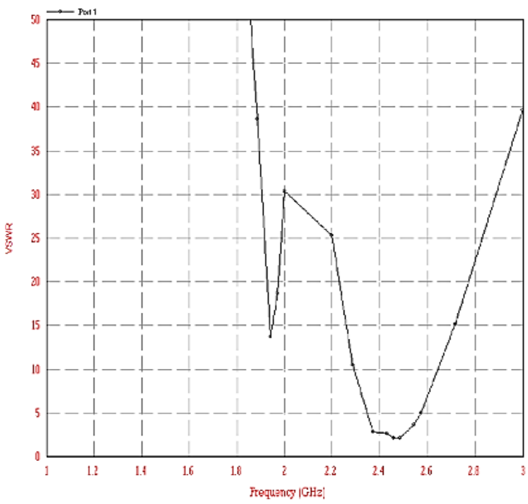


Figure 5. VSWR

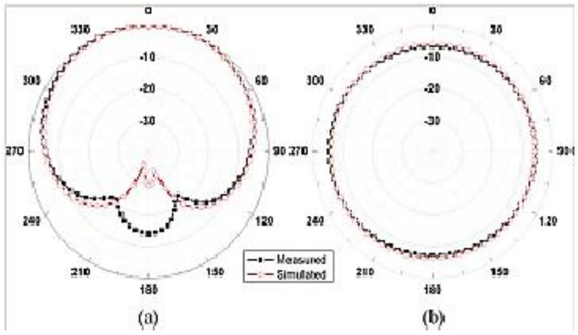


Figure 6. Radiation Patters

IV. CONCLUSION

In this communication, a practical method has been discussed for controlling the vertical HPBW of circularly polarized microstrip antennas. This method is based on a parasitic ring right above the microstrip antenna. A prototype antenna based on the proposed method was designed, at 2.492 GHz for CNSS application, fabricated and tested. The measurements showed it could effectively widen the vertical HPBW and improve the gain for low elevation angle. The structural parameters of the parasitic ring are key factors for determining the vertical HPBW. Besides, it could maintain good omnidirectional characteristics for the horizontal radiation pattern. This structure is simple and easy to manufacture.

V. REFERENCES

[1] Inside GNSS, Compass/Beidou|Inside GNSS Online.Available: http://www.insidegnss.com/compass 2013

[2] J. Z. Liu, Y. H. Huang, and M. Lei, “Dual-Band Wide-Beam Circularly- Polarized Antenna With Good Gain of Low Elevation Angle,” Chinese patent, CN2865037Y.

[3] C.Kilgus, “Shaped-conical radiation pattern performance of the backfire quadrifilar helix,” IEEE Trans. Antennas Propag., vol. 23, no. 3, pp. 392–397, 1975.

[4] O. P. Leisten, “Miniaturised dielectrically loaded quadrifilar antenna for global positioning system (GPS),” Electron. Lett., vol. 37, no. 22, pp. 1321–1322, 2001.

[5] Q. X. Chu, W. Lin, W. X. Lin, and Z. K. Pan, “Assembled dual-band broadband quadrifilar helix antennas with compact power divider networks for CNSS application,” IEEE Trans. Antennas Propag., vol. 61, no. 2, pp. 516–523, 2013.

[6] K. P. Yang and K. L. Wong, “Dual-band circularly-polarized square microstrip antenna,” IEEE Trans. Antennas Propag., vol. 49, no. 3, pp. 377–382, 2001

[7] S. Foo and B. Vassilakis, “Dielectric fortification for wide-beamwidth patch arrays,” presented at the Antennas and Propagation Society Int. Symp., IL, USA, 2008.
[8] H. D. He, “A novel wide beam circular polarization antenna-microstrip- dielectric antenna,” presented at the Int. Conf. on Microwave and Millimeter Wave Technology, Beijing, China, 2002.
[9] D. Sievenpiper, H. P. Hsu, and R. M. Riley, “Low-profile cavity-backed crossed-slot antenna with a single-probe feed designed for 2.34 GHz satellite radio applications,” IEEE Trans. Antennas Propag., vol. 52, no. 3, pp. 873–879, 2004.
[10] H. D. He, “A novel wide beam circular polarization antenna-microstrip- dielectric antenna,” presented at the Int. Conf. on Microwave and Millimeter Wave Technology, Beijing, China, 2002.
[11] C.A. Balanis, Antenna Theory Analysis and Design, third edition, Wiley, New Jersey, 2005.
[12] Girish Kumar, K.P.Ray, ‘Broadband Microstrip Antennas”, Artech House 685 Canton StreetNorwood, MA 02062 , London,2003