Dual-band Circular Polarization Antenna with Mu-zero Resonance and First-order Negative Mode

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Abstract **– In this paper, a compact dual-band circular polarization antenna is presented for GPS application. To make the antenna smaller, the mu-zero resonance mode of mu-negative transmission line and first-order negative mode of composite right-left handed transmission line are employed. The mu-zero resonance and first-order negative modes operates at L2(1.23 GHz) and L1(1.56 GHz) band, respectively. For excitation of two antennas, the cross aperture coupled feed is applied to the dual-band antenna. The size of the proposed antenna is 30mm by 30mm by 6.7mm, it has the peak gain of -0.23 dBic and 4.77 dBic in L1 and L2 band, respectively.**

Index Terms **— Global positioning system (GPS), Dual-band, Composite right-left handed transmission line (CRLH TL), Mu-negative transmission line (MNG TL), Circular polarization (CP).**

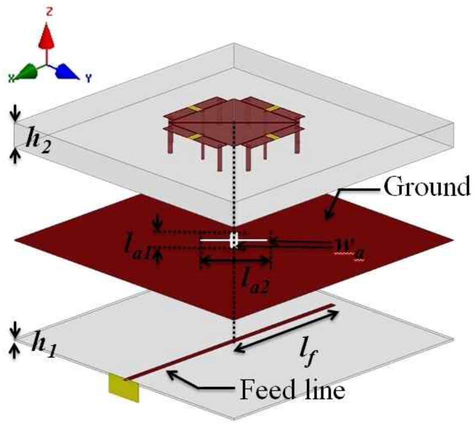
1. Introduction

The Global positioning system (GPS) has become essential for various applications that provide both location and time information of moving objects such as mobile device, car, ship, and aircraft. To improve the performance that tracks position of a target, controlled reception pattern antenna (CRPA) has been investigated to increase the signal-to-noise ratio of a system by controlling the beam pattern [1]-[2]. Individual GPS antennas of CRPA are often required to have multi-frequency operation and circular polarization (CP). In addition, the size of antenna is small enough to be within a few centimeters of diameter and a few millimeters of height in case of extremely small CRPA array [3].

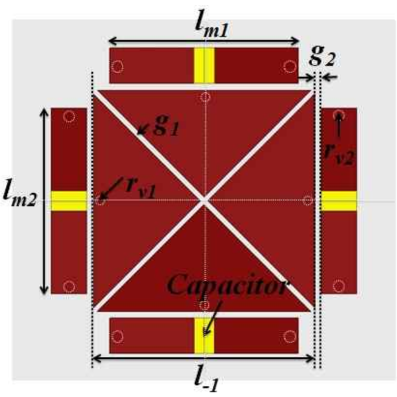
In this paper, a dual-band CP antenna based on composite right-left handed transmission line (CRLH TL) [4] and mu-negative transmission line (MNG TL) [5] is presented to satisfy the requirements of CRPA array. The antenna is just 30mm by 30mm by 6.7mm in size and it operates in L1(1.56 GHz) and L2(1.23 GHz) band, respectively.

2. Properties of the antenna

Fig. 1(a) shows the structure of the proposed small sized dual-band CP antenna with a cross aperture coupled feed [6]. The antenna is composed of two substrates separated by a ground with a cross aperture. One substrate contains the radiating elements while the other substrate does the microstrip feed line. The radiating element is designed by combining two CP antennas based on MNG and CRLH TL, respectively. The MNG TL consists of the series inductance



(a)



(b)

Fig. 1. Structure of antenna (a) whole (b) top view

and capacitance, and the shunt capacitance [5]. Then, the CRLH TL can be realized by adding the shunt inductance to the structure of the MNG TL. The series inductance and shunt capacitance are the same to those of a conventional TL and the series capacitance and the shunt inductance are realized by the gap and via, respectively. The proposed dual band CP antenna uses the mu-zero resonance mode of MNG TL and the first-order negative mode of CRLH TL, respectively. It is noted that the mu-zero resonance occurs at L1 band and the first-order negative resonance does at L2 band, respectively. Each antenna consists of two pairs of radiators and each pair of antennas is orthogonally aligned each other as shown in Fig. 1(b). It makes a pair of vertical polarization with 90˚ phase difference. The phase difference

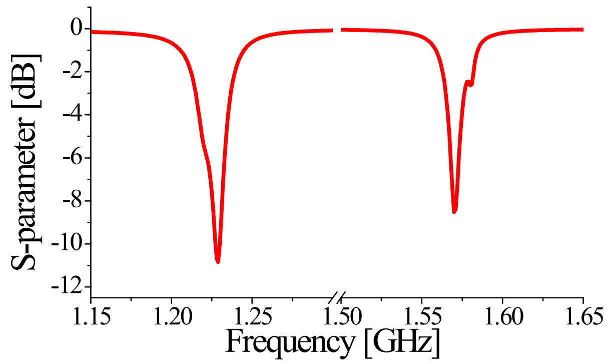


Fig. 2. S-parameter

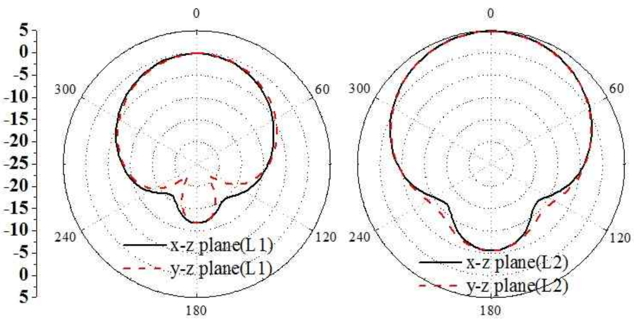


Fig. 3. Radiation pattern

of the first-order negative mode antenna is made by the asymmetric crossed aperture, and the difference of length between l_{m1} and l_{m2} makes the 90 ˚ phase difference at the mu-zero resonance. Each antenna is individually designed and combined. In order to reduce the coupling between two antennas, the first-order negative mode antenna is tilted as 45˚ from a mu-zero resonance antenna. Two antennas are fed by an asymmetric cross aperture, simultaneously.

Finally, the dual band CP antenna is designed on RT/Duroid5880 substrate (tanδ = 0.0009 and ε_r = 2.2) and the simulated S-parameter is shown in the Fig. 2. The final parameters are as follows: h_1 = 6.4mm, h_2 = 0.5mm, l_{a1}= 11.5mm, l_{a2} = 8mm, w_a = 2mm, l_f= 34mm, l_{m1} =18.2mm, l_{m2} =18.5mm, l_{-1} = 22.5mm, r_{v1}= 0.4mm, r_{v2}= 0.6mm, g_1 = 0.2mm, g_2= 0.25mm. The capacitors of 1 pF that has effective series resister of 0.13 ohm are employed.

Fig. 3 shows the simulated radiation patterns in L1 and L2 band, respectively. The antenna has the directional radiation patterns in each band. The peak RHCP gain of the antenna in L1 and L2 band is simulated as -0.23 dBic and 4.77 dBic, respectively. Detailed design and performance of the antenna will be discussed in the presentation.

3. Conclusion

In this paper, a small sized dual-band RHCP antenna is designed for GPS application. Dual-band and miniaturization are realized by combining the mu-zero resonance and the first-order negative mode CP antenna based on MNG TL and CRLH TL, respectively. The size of the antenna is just 30mm by 30mm and the peak gains of that are simulated as -0.23 dBic and 4.77 dBic in L1 and L2 band, respectively. The presented antenna is thought to be suitable for CRPA array for GPS application.

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