Effectiveness of a Dipole Feeder for the Cross Spiral Antenna Which is a Circularly and Linearly Polarized Planar Antenna

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***Abstract*—A novel feeding way for balanced antennas, loop antennas and spiral antennas, is presented. The author invented recently a circularly polarized simple loop/spiral antenna (CSA), which is configured only by twisting a loop like a cross shape. The CSA can radiate good circular polarization (CP), if it is fed by a good balanced feeder. The strict balance of currents is needed that CSA radiates good CP waves, so a feeder that can neutralize unbalanced currents of a poor balanced feeder is necessary. In this paper, a dipole element is employed to feed CSA. To show the effectiveness of the dipole feeder, the S_{11} characteristics and radiation patters obtained by feeding CSA with a coaxial cable are compared with those obtained by feeding CSA with a balanced feeder. These results show that the dipole feeder is useful to neutralize unbalanced currents.**

Keywords—cross spiral antennas; circularly polarized antennas; folded dipole antennas; dipole feeders

I. Introduction

Antennas are important key technologies for the mobile communication development. In particular, multi-polarization antennas—simultaneously handling circularly and linearly polarized waves—are attractive for improving indoor communication performance [1]. If there were polarization compatible antennas which are electrically switchable between circular polarization (CP) and linear polarization (LP), or between LP in a horizontal direction and LP in a vertical direction, multi-pass could be reduced in indoor communication.

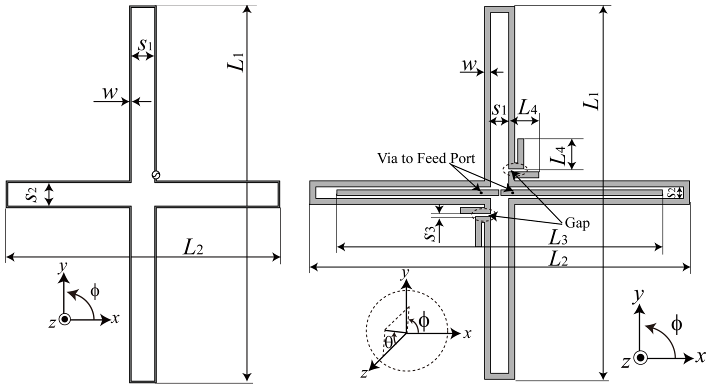
The author invented a spiral/loop antenna radiating circularly polarized waves recently [2], [3]. The antenna is a cross shaped loop formed by winding a wire—the antenna is named “CSA” and radiates circular polarization because of the shape [1]. The CSA radiates good CP waves, if it is fed by a good balanced port. My recent study shows that the S11 characteristics and CP radiation patterns drastically change if the current balance of the port is poor. However, to be fed by good balanced currents is often difficult when antennas are used in practice [4]. In this paper, a dipole element is employed as the feeder that can help CSA to radiate CP even though the balance of the currents is poor.

In the first place, the author tried to feed CSA by a dipole element for developing CSA into a multi-polarization antenna [3]. As far as the author knows, there is few conventional studies that loop antennas are fed by dipole elements, the author succeeds in feeding CSA—loop antennas—by a dipole. This antenna is named "a dipole-fed CSA (DF-CSA)" and achieves radiating linear polarization simultaneously with circular polarization. The measurement results with a coaxial cable also show that being fed by a dipole element makes CSA a more effective antenna. This means that CSA radiates good CP even though it is fed by a poor balance port.

In this paper, representative structures of CSA and DF-CSA are explained first in the second section. Then, in the third section, S_{11} characteristics and radiation patterns are compared between those obtained by simulations with a balanced feed and those obtained by simulations with an unbalanced feed to show the effectiveness of the dipole feeder.

II. Structures of CSA

Figure 1(a) shows a basic structure of CSA. This CSA is constituted by a cross shaped single loop, and is fed with a balanced port. Figure 1(b) shows a representative structure of Dipole-Fed CSA—DF-CSA [3]. A dipole element is put in the center of a basic CSA. The dipole element is fed through via holes. The spiral element is a parasitic one fed indirect by the dipole element. The spiral element has two gaps for making both of dipole and spiral elements work as they are. It means that the spiral elements and the dipole element interfere in each other when they exist closely. The two gaps on the spiral element can get rid of the EM interference.



(a) A Basic structure of CSA (b) A Representative Structure of DF-CSA

Fig. 1. Representative structures of CSA.

TABLE I. DIMENSIONS OF CSA (a) BASIC CSA, (b) DF-CSA.

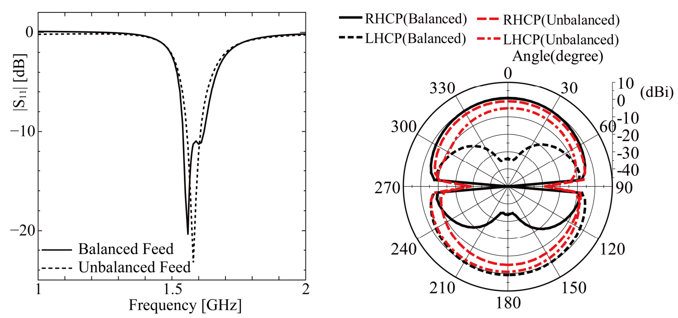
(a) Basic CSA				
L_1	L_2	s_1	s_2	w
48.0	34.8	3.0	3.0	0.2

(b) DF-CSA							
L_1	L_2	L_3	L_4	s_1	s_2	s_3	w
59.8	60.8	52.2	5.0	3.0	2.0	0.3	1.0

Units are in mm

III. DISCUSSION OF CSA CHARACTERISTICS

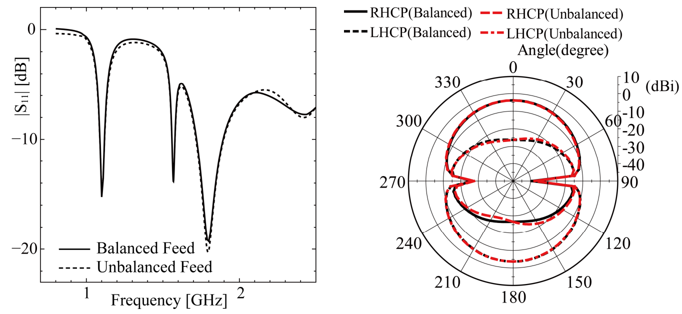
Figure 2 shows the comparison of S_{11} characteristics of the basic CSA between the simulation data calculated with a balanced feed and those calculated with an unbalanced feed. The basic CSA is formed by using the measurements shown in Table 1(a) and the PCB whose εr is 3.9, tanδ is 0.008 and thickness is 1.6 mm. Figure 2(a) shows that the S_{11} characteristics change if it is fed by an unbalanced port. Figure 2(b) shows that CP radiation pattern obtained with an unbalanced feed is very different from that obtained with a balanced feed. This means that the CSA fed by an unbalanced feed does not radiate good circular CP waves, whose axial ratios are 3dB or less, anymore.



(a) S_{11} characteristics of CSA (b) CP radiation patterns in ϕ=90° cut at 1.57GHz

Fig. 2. The comparisons of CSA characteristics between that obtained by a balanced feed and that obtained by a unbalanced feed.

Figure 3 shows the comparison of S_{11} characteristics of the DF-CSA between the simulation data calculated with a balanced feed and those calculated with a unbalanced feed. The DF-CSA is formed by using the measurements shown in Table 1(b) and the PCB whose εr is 4.4, tanδ is 0.016 and thickness is 1.6 mm. Figure 3(a) shows that the S_{11} characteristics little change even if it is fed by an unbalanced port. Figure 3(b) shows that CP radiation pattern obtained with an unbalanced feed are in good agreement with that obtained with a balanced feed. This means that the CSA fed by an unbalanced feed also radiate good circular CP waves.



(a) S_{11} characteristics of CSA (b) CP radiation patterns in ϕ=0° cut at 1.57GHz

Fig. 3. The comparisons of CSA characteristics between that obtained by a balanced feed and that obtained by a unbalanced feed.

IV. CONCLUSIONS

The effectiveness of the dipole feeder for CSA is presented. The dipole feeder made it possible that CSA radiates good linear polarization simultaneously with circularly polarization. Moreover it works as a kind of balun helping to reduce unbalanced currents as well. Therefore, the DF-CSA has the possibility to become a compact planar multi-polarized antenna which can be fed by a coaxial cable directly. It means that DF-CSA is applied to many mobile communication devices easily.

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