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Composite Right/Left-Handed Coplanar Strip Leaky Wave Antenna for MIMO Applications

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***Abstract* - In our previous report, the authors realized a slender omnidirectional leaky wave antenna with a single branch using CRLH line. This paper presents measurement results of a dual branch antenna orthogonally arranged the CRLH line. The diameter of the antenna including a cover is 0.14 wavelength at 3.5 GHz, and the antenna has high isolation characteristic.**

***Index Terms* — Composite Right/Left Handed Line, Leaky Wave Antenna, Omnidirectional Antenna, MIMO.**

1. Introduction

Omnidirectional downtilted beam antennas are typically required as base station antennas that are applied to the microcells of mobile communication systems. A leaky-wave antenna using a composite right/left-handed (CRLH) line is a promising candidate for realizing a downtilted beam antenna that is inexpensive and has a slender shape. However, conventional leaky-wave antennas using a CRLH line are typically formed on a ground plane, owing to which their radiation patterns are unidirectional [1]-[3].

We proposed a novel omnidirectional, slender, downtilted beam antenna in our previous report [4]. The antenna adopts a leaky-wave antenna composed of a CRLH line. The antenna radiates linearly polarized waves, however the polarization is rotated according to the azimuth angle. Omnidirectional radiation pattern is achieved attributing to the polarization composite property [5]. However, in our previous study, the antenna consisted of a only single branch. For MIMO applications, many mobile base stations are used dual branch antenna. This paper presents the measurement results obtained using a prototype antenna with two branches arranged orthogonally, and shows the effectiveness of the proposed antenna. The antenna is designed in the 3.5 GHz band of a cellar system.

2. Antenna Configuration

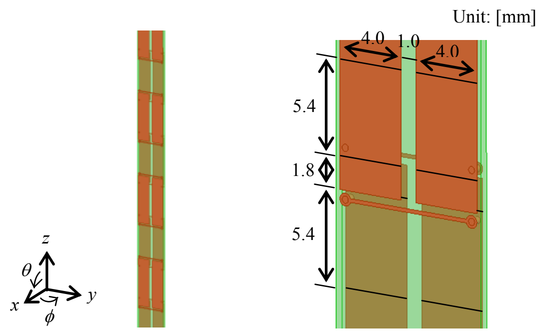
(1) Configuration of Single Branch Antenna

Fig. 1 shows the configuration of our previous antenna and the structure of a unit cell. The antenna is constructed with a coplanar strip type CRLH line on a dielectric substrate. The relative permittivity and thickness of the substrate are 3.38 and 0.508 mm, respectively. The characteristic impedance of the coplanar strip line is 145 Ω. The unit cell is constructed using the coplanar strip line, in which a pair of parallel plate capacitors and two horizontal thin wires are included to generate a series capacitance and a shunt inductance, respectively. A vertically polarized wave is radiated toward the $\pm y$ direction from the two strip lines and parallel plate capacitors, and a horizontally polarized wave is radiated toward the $\pm x$ direction from the thin wires and the gap between the strip lines. If the magnitude of the composite electric field of the two components at each angle in the horizontal plane is equal, an omnidirectional area will be created. The number of cells is 30, and the terminal cell is the open end.

The length and width of the designed unit cell are 12.6 and 9 mm, respectively. At 3.5 GHz, the phase shift in the unit cell is 39.8°. The band is in the left-handed fast wave band and a downtilted pattern is obtained. The direction of the beam in the vertical plane, θ_m, is expected to be 128.7° (tilt angle is 38.7°) with reference to [4].

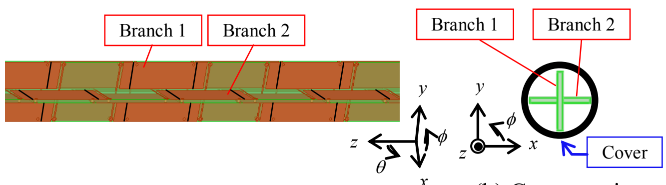
(2) Configuration of Dual Branch Antenna

Fig. 2(a) shows the configuration of a dual branch antenna. For the realization of two branches, two CRLH lines are arranged orthogonally and two lines shifts half period of unit cell. For the measurement, the antenna is fed from the bottom of proposed antenna by using a balun. Fig. 2(b) shows the cross section of antenna, which mounts a cover. The internal and



(a) Antenna configuration (b) Unit cell structure

Fig. 1 Configuration of single branch antenna and unit cell structure.



(a) Antenna configuration (b) Cross section

Fig. 2 Dual branch antenna configuration.

external diameters of the cover are 10 and 12 mm, respectively. The material of the cover is fiberglass reinforced plastic. Because the two branches are arranged orthogonally, the diameter of the antenna is the same as that of the single branch antenna.

3. Measurement Results

(1) Scattering Parameters

Fig. 3 shows the measured frequency characteristics of the scattering parameters. S_{11} and S_{22} are below −10 dB, and S_{21} is below −30 dB with the design frequency of 3.5 GHz. The antenna exhibits high isolation characteristics.

(2) Radiation Patterns

Figs. 4 and 5 show the radiation patterns of the horizontal and vertical planes respectively at 3.5 GHz. The maximum level is normalized 0 dB in these figures. At branch 1, the vertically polarized wave is radiated toward the ±y direction, and the horizontally polarized wave is radiated toward the ±x direction in the horizontal plane. Both field components are approximately at the same level, and the composite electric field forms an omnidirectional pattern. Conversely, the vertically and horizontally polarized waves are radiated toward the ±x and ±y directions respectively at branch 2. Therefore, the radiation patterns of branch 1 and 2 are orthogonal in every direction. The deviations in the horizontal plane pattern are 1.6 and 2.4 dB. In the vertical plane, the tilt angle is 39°, which is close to the expected tilt direction of 38.7°. The measured gain of this antenna is 7.8 dBi.

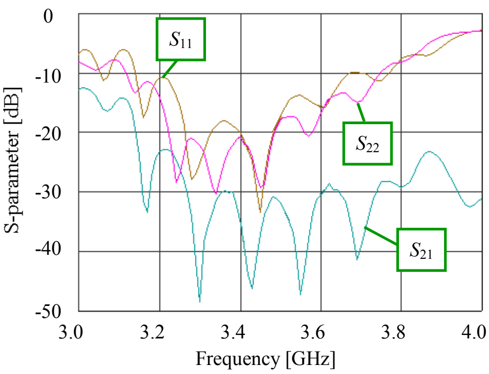
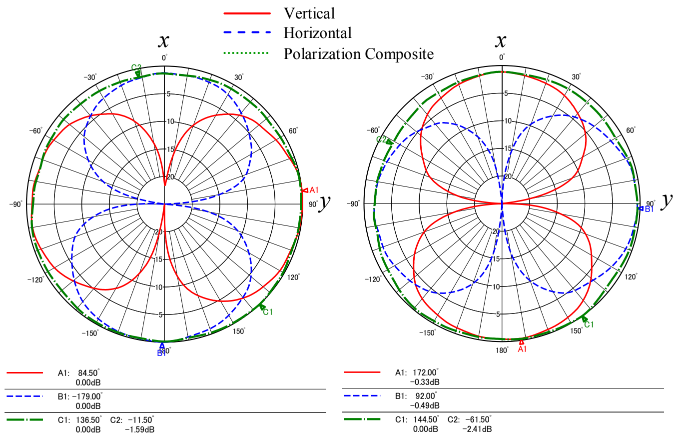
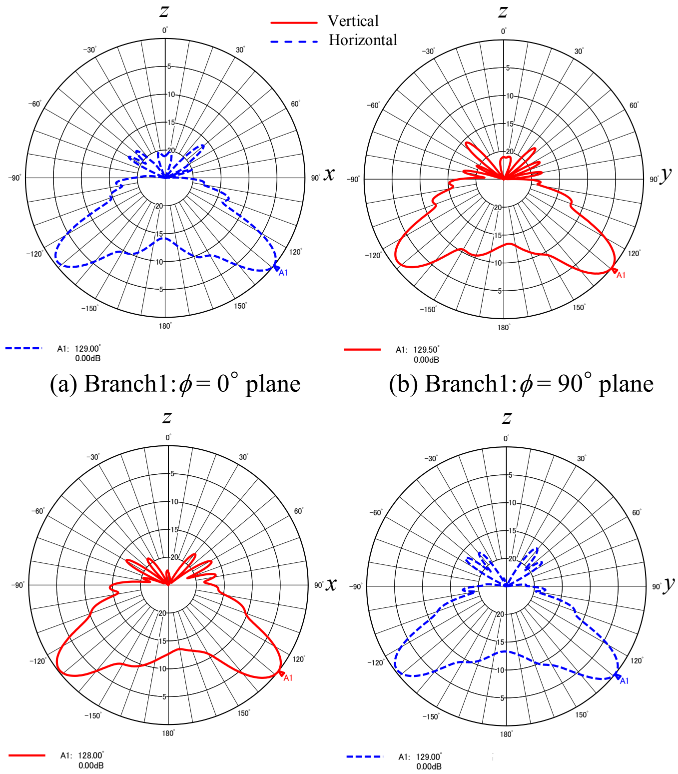


Fig. 3 Scattering parameters of proposed antenna.



(a) Branch1 (b) Branch2

Fig. 4 Horizontal radiation pattern (θ = 130° plane).



(a) Branch1: ϕ = 0° plane (b) Branch1: ϕ = 90° plane

(c) Branch2: ϕ = 0° plane (d) Branch2: ϕ = 90° plane

Fig. 5 Vertical radiation pattern.

4. Conclusion

In this study, we proposed a dual branch omnidirectional antenna using a coplanar-strip-type CRLH line. We designed a prototype antenna in the 3.5 GHz band, and measured its scattering parameters and radiation patterns. The results of this study show that an omnidirectional pattern in the horizontal plane was realized using a polarization composite method. Moreover, the radiation patterns of branch 1 and 2 are orthogonal in every direction. The tilt angle of the antenna is approximately 40° in the vertical plane, and deep tilt angle is realized. The diameter of the antenna including its cover is 12 mm, and 0.14 wavelength at 3.5 GHz. Moreover, the antenna has high isolation. The antenna is useful for utilizing of small cell antennas.

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