Microstrip array antenna for orthogonal linear polarization discrimination

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Abstract

In this paper, a microstrip antenna array with a linear polarization discrimination function is proposed. The antenna consists of 12-element antenna array and a polarization discriminating circuit. The configuration of the proposed antenna is very compact. The fundamental characteristics of the antenna array are investigated experimentally.

Keywords: Microstrip antennas linear polarization discrimination

1. Introduction

In this paper, a microstrip array antenna for orthogonal linear polarization discrimination with compact configuration is proposed. The proposed antenna consists of a dual linear polarized 12-element microstrip antenna array and a linear polarization discriminating circuit. For excellent the orthogonal linear polarization discrimination, the proposed antenna needs the following characteristics,

(1) The antenna can receive dual orthogonal linear polarization.
(2) The antenna has an excellent cross polarization.
(3) The antenna elements and the discrimination circuit are arranged on a same substrate.

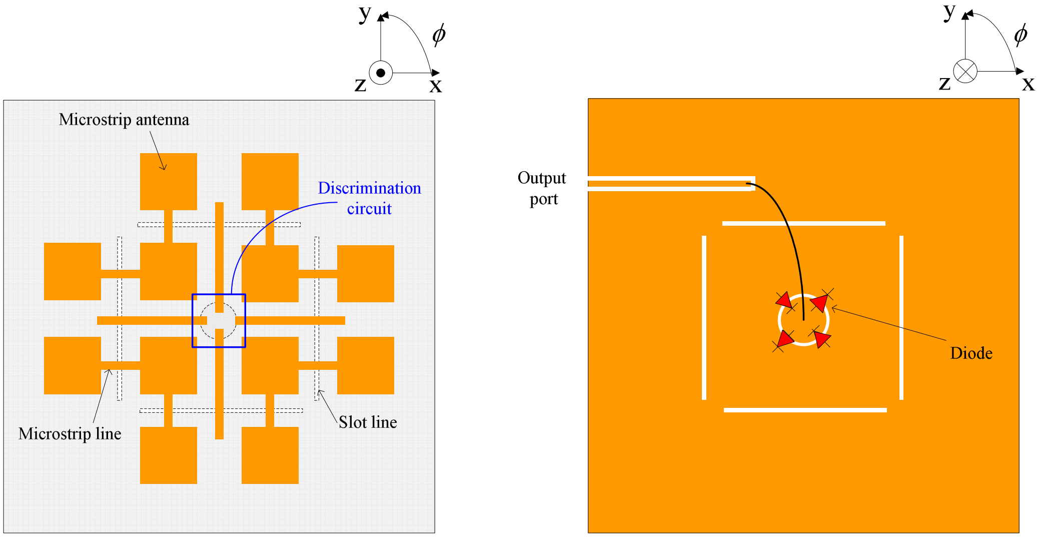
We have reported the liner polarization switchable microstrip array antenna which has excellent cross polarization and compact structure by using both-side circuit technology [1, 2]. In this paper, this array technique is effectively used for the dual linear polarization discrimination function with a compact structure and an excellent cross polarization. A RF multiplier which consists of 4 diodes on a slot ring is used as the decimating circuit.

In this paper, the fundamental characteristics of the proposed array antenna for polarization discrimination are investigated experimentally.

2. Multiplying array antenna for polarization discrimination

Figure 1 shows the proposed 12-element microstrip array antenna for polarization discrimination. This array antenna consists of 12 array patch elements and feed lines on the top of the substrate and discrimination circuit on the bottom. The parameter of the array antenna structure is shown in Table 1. The both-sided circuit technology is effectively applied for a simple array configuration. Moreover, 4 diodes are loaded in order to configure onto the slot-ring as a RF multiplier.

Fig. 2 shows the basic behaviour of antenna array. In this figure, when ±45° polarization tilted waves are received, schematic currents on the patches and the microstrip lines are shown. The array #1 is excited when ±45° polarization tilted waves are received as shown in Fig.2 (a). When polarization tilt angles are +45° and -45°, the currents on array #2 are demonstrated in Fig. 2 (b) and (c), respectively. The ±45° polarization tilted waves are splitted into orthogonal vector components directed in X and Y axis. In the array #1, regardless of the polarization angle, the excitations are the same. In the case of array #2, according to the received polarization angle of ±45°, the excitation phase is changed as shown in Fig. 2 (b) and (c). The received signals by the array #1 and #2 are multiply at the discriminating circuit and the multiplier output voltage according to the polarization angle is obtained. Consequently, the received polarization angle is discriminated by the polarity of the output voltage of the multiplier.

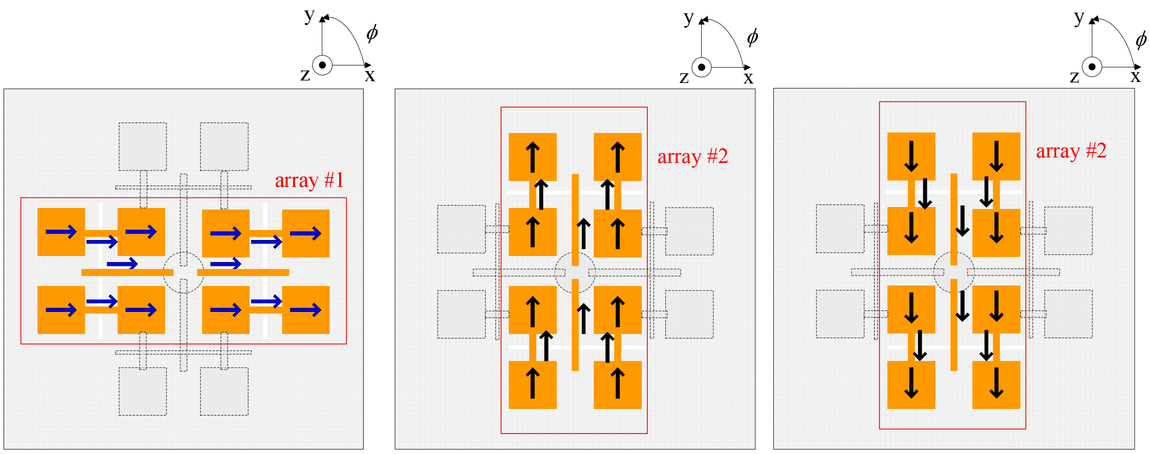


(a) Top view (b) Bottom view

Fig. 1 12-element array antenna for orthogonal polarization discrimination

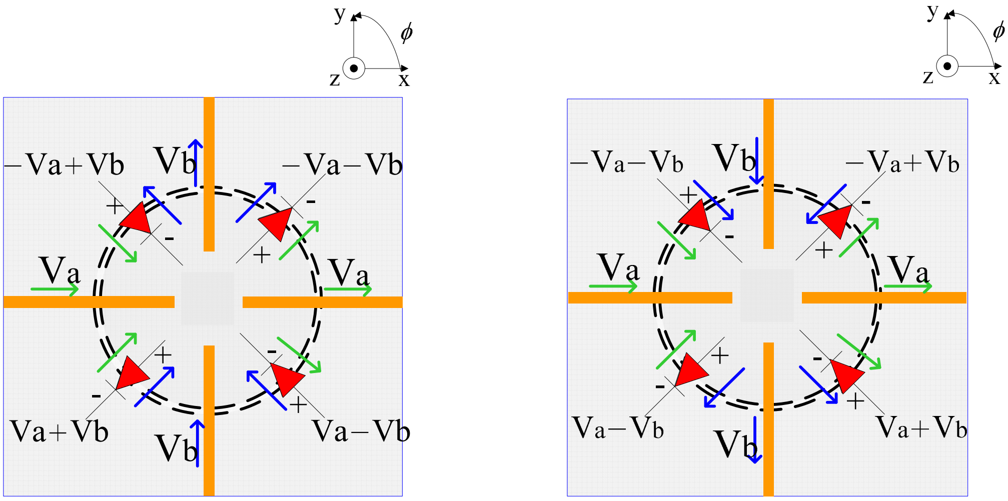
Table 1:Structure of array antenna

Design frequency	10 [GHz]
Patch size	9.375 [mm]
Distance between elements	24.0 [mm]
Thickness of substrate	0.8 [mm]
Relative permittivity	2.15



(a)The x axis component of the ±45° polarized wave (b) The y axis component of the +45° polarized wave (c) The y axis component of the −45° polarized wave

Fig. 2 antenna array behaviour with schematic current distributions



(a) +45° Polarization (b) −45° Polarization

Fig. 3 Principle of polarization discriminating circuit

Fig. 3 shows the voltage potential in the RF multiplier as the discriminating circuit, when ±45° polarization tilted wave are received.

The received RF voltage *Va* and *Vb* of the array #1 and #2 are the following equations,

$$Va = V_1 \sin(\omega t + \theta_1) \tag{3}$$

$$Vb = V_2 \sin(\omega t + \theta_2) \tag{4}$$

The current *Io* from the output port of the multiplier is as follows

$$Io \propto -V_1 V_2 \cos(\theta_1 - \theta_2) \tag{5}$$

Because the phase differences between V_a and V_b is $\theta 1$-$\theta 2$ = 0 when received polarization tilt angle is +45°, the output voltage of the multiplier is negative value. While the phase differences between V_a and V_b is $\theta 1$-$\theta 2$ = 180 when polarization angle is -45°, it becomes positive value. It possible to discriminate orthogonal linear polarization from the polarity of the output of the multiplier.

Fig. 4 shows frequency characteristic of the output voltage of discrimination circuit with 100kΩ load resistor when ±45° polarization tilted waves are received. The maximum peak to peak voltage of -28.9 to 28.9 mV is obtained at frequency of 10.31GHz.

The directivity of the antenna is shown in Fig.5. The absolute maximum voltages are 28.9 mV at θ=0, and the good performance is obtained.

The ability of the polarization discrimination of the proposed array antenna is experimentaly confirmed.

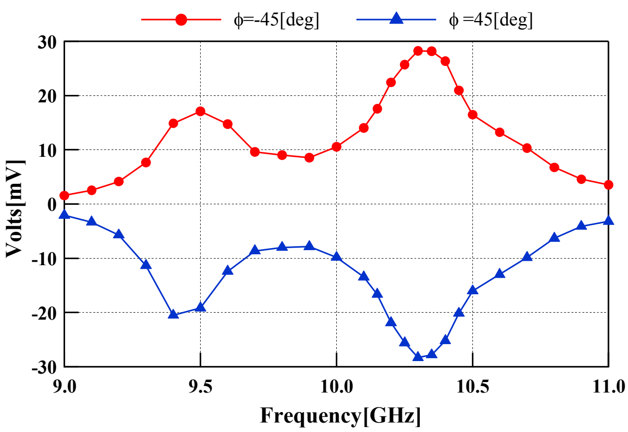


Fig. 4 Frequency characteristic of polarization discrimination

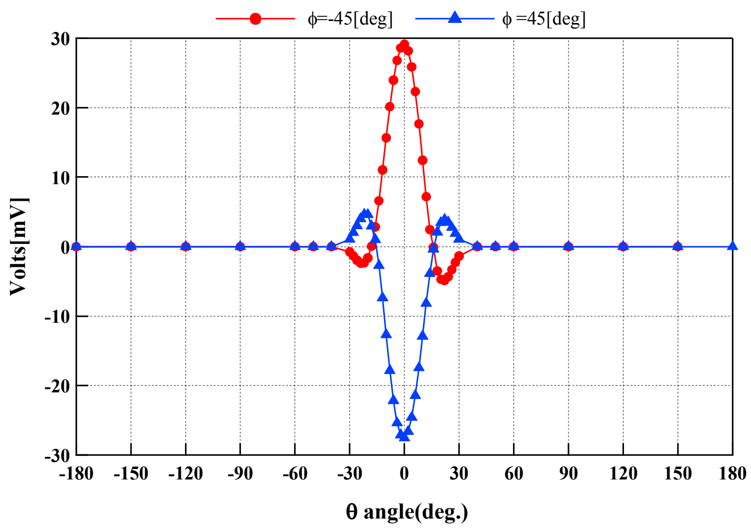


Fig. 5 Directivity at 10.31GHz

3. Conclusion

In this paper, microstrip array antenna for orthogonal linear polarization discrimination is proposed. The performance of the array antenna is confirmed by the experimental investigation. The antenna configuration is much compact as the both-sided MIC technology is used successfully. The proposed array antenna can discriminate the polarization of the received wave. Moreover, the antenna element can be easily increased i.e. the proposed array has the property of excellent design flexibility. Furthermore, it is possible to expand the functionality of the proposed array antenna to discriminate the circular polarization and estimate the polarization angle for linear polarization.

References

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