Polarization Conversion Reflector Using a Metal-Plate-Loaded Meander Line

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***Abstract* – In this study, we propose a polarization conversion reflector using a metal-plate-loaded meander line and determine the reflector's axial ratio characteristics with a numerical analysis involving the method of moments. A relative bandwidth greater than 90% is obtained.**

***Index Terms* — Axial ratio, polarization, meander-line.**

I. Introduction

Transmission-type circular polarizers are comprised from three layers of meander-line sheets on a dielectric slab that exhibit broadband and axial ratio characteristics [1]. Here, the reflection-type circular polarization is treated [2].

In this study, we propose a polarization conversion reflector using a metal-plate-loaded meander line. The axial ratio characteristics are determined using the method of moments (MoM). In addition, we consider a broadband design and an axial ratio improvement at the desired frequency.

II. Analysis Model

Fig. 1 shows the electric fields Ei, incident to the meander line of an infinite periodic structure. The structure is comprised of three layers: a meander line, a dielectric slab, and a metal plate (see Fig. 2). E_i is resolved into the components $E_{//}$ and $E_{\perp}$, which are equal in amplitude. We assume the corresponding phases $\Phi_{//}$ and $\Phi_{\perp}$ for the reflection from the metal plate.

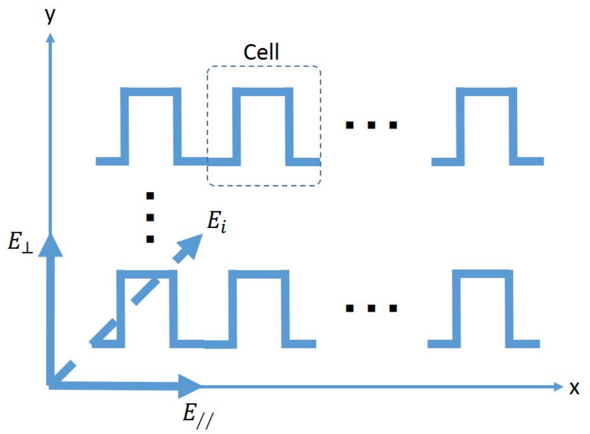

Fig. 1. Electric field incident to meander line with infinite periodic structure.

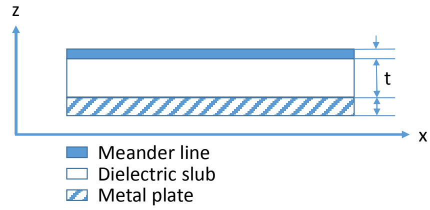

Fig. 2. Structure of three layers.

The ideal conditions to generate circular polarization are a phase difference of 90° between $\Phi_{//}$ and $\Phi_{\perp}$ and an axial ratio (AR) of 0 dB. The design parameters have great flexibility, with limitless combinations of parameters.

According to the periodic boundary condition for the MoM, one cell (period) of the infinite periodic structure is analyzed. The principal parameters of the analysis model are: the period of the x direction d1 [mm], period of the y direction d2 [mm], height of the meander b [mm], and line width of the meander w [mm] (see Fig. 3).

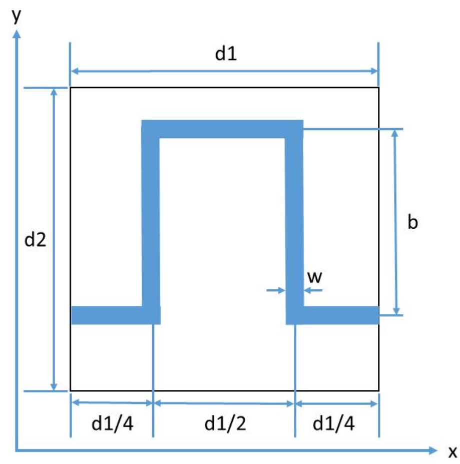

Fig. 3. Parameters of analysis model.

III. Characteristics of Axial Ratio

Our parametric study yielded two results. The relative permittivity of the dielectric slab ε_r, was 2.65, and the thickness of the dielectric t, was 3.2 mm. Fig. 4 shows the AR characteristics of the first analysis model: d1 = 5.0, d2 = 9.0, b = 3.5, and w = 0.1 mm. In the figure, we treat $\Phi_{//}$ and $\Phi_{\perp}$ as the reflection phases of the components $E_{//}$ and $E_{\perp}$, respectively. The differences of the reflection phase, that is, $|\Phi_{\perp} - \Phi_{//}|$, are also shown. The evaluation object has a bandwidth of AR ≤ 3 dB. Accordingly, the reflection phase differences $|\Phi_{\perp} - \Phi_{//}|$ are 71.0 to 109.0°. As shown in the Fig. 4(a), a bandwidth of is 11.1–20.0 GHz, i.e. 57.2% is obtained. The AR represents bimodality, therefore, the bandwidth may widen under the ideal parameters. We assume that it was caused by resonance from the meander line. To verify the resonance behavior, we calculated the normalized susceptance B. We supposed that by clearly understanding the relation between B and the reflection phase, we might fabricate a wideband design. The relations between the frequency, the normalized susceptance B, and the reflection phase are indicated in Fig. 4(b). As the frequency increases, $B_{\perp}$ behaves similarly to the LC resonance. At a low frequency, it behaves similarly to the capacitance component C. $B_{//}$ behaves similarly to the component inductance L.

In the case of the second analysis model, wherein d1 = 4.0 mm, d2 = 6.0 mm, b = 1.0 mm, and w = 0.2 mm, a bandwidth of 6.8–18.8 GHz, i.e., 93.8% is obtained (see Fig. 5(a)). Compared with Fig. 4(a), the bandwidth is widened in Fig. 5(b), $B_{\perp}$ behaves similarly to the capacitance component C. $B_{//}$ behaves similarly to the LC resonance at a low frequency. As the frequency increases, $B_{//}$ behaves similarly to the inductance component L.

The results indicate that for a metal-plate-loaded meander line, the axial ratio and reflection phase are influenced by d1, d2, b, and w. The reflection phase and normalized susceptance B are related. Depending on the parameters, the behavior of B becomes that of the LC resonance, inductor L, or capacitor C.

IV. Conclusion

We proposed a polarization reflector using a metal-plate-loaded meander line and presented the results of our numerical analysis.

A broadband design and axial ratio improvement are expected by controlling the reflection phase flexibly. Future studies are planned to continue the parametric studies and verify the theoretical calculations.

References

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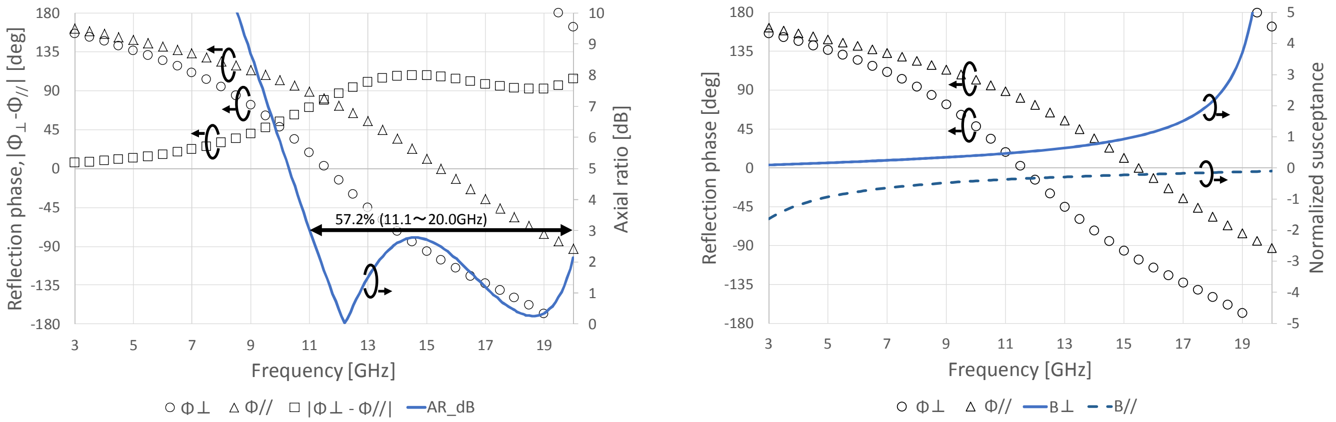
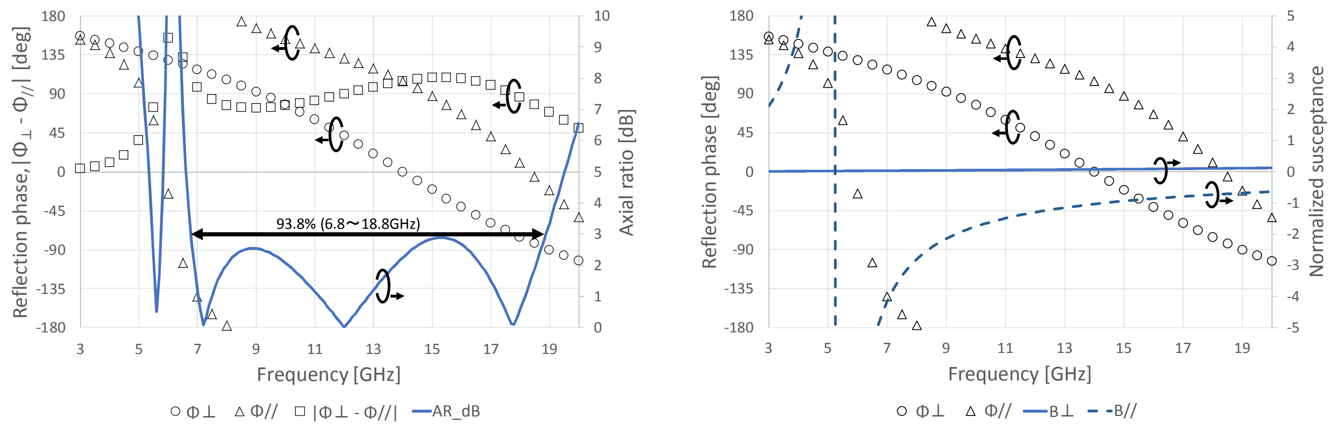


(a) Reflection phase and axial ratio.

(b) Reflection phase and normalized susceptance.

Fig. 4. Results for d1 = 5.0, d2 = 9.0, b = 3.5, and w = 0.1 mm.



(a) Reflection phase and axial ratio.

(b) Reflection phase and normalized susceptance.

Fig. 5. Results for d1 = 4.0, d2 = 6.0, b = 1.0, and w = 0.2 mm.