Circular Polarization Antenna with Elliptic Feed-and Reactance-Elements using Glass-epoxy Substrates

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Abstract: - This paper present circular polarization stripline antenna with elliptic feed- and reactance-elements. Glasscloth-epoxy multilayer substrates were used for fabrication to realize low fabrication cost. Wideband directive gain 1GHz or more at 10 GHz. Axial ratio is 1dB or less, and directive gain is 10 dB. It was estimated that included microwave energy in the elliptic resonator is less than the energy included the linearly truncated circular disc resonator.

Key-Words: - Circular polarization plane antenna, horizontal radiation, S-type routing wire, grounded square collar

1 Introduction

Stripline array antenna provides remote sensing systems with compact and inexpensive antennas. The authors are interested in three-layered substrates to compose wideband circular polarization plane antenna. Low loss stripline antennas have been designed using fluorine resin (Teflon) substrate conventionally. The permittivity (relative dielectric constant εr) is small as 2.17 at 10 GHz X-band, so the parameter values (practical dimensions) are not needed to be strict. Metallization and multilayered substrates of the Teflon require much processing cost and times.

In this study, high *εr* dielectric substrate is used to realize wideband axial ratio, and high directive gain together with low cost fabrication cost. Therefore the authors need to clarify the problems made of high *εr* dielectric materials of the substrates. The relative dielectric constant *εr* is high 4.6, and tan δ 0.01. It is estimated that design rule is too strict compared to that of the antenna made of Teflon substrate.

So, first we tried to find out fine values of the design parameters. Secondly, the authors intended to find effective structure of feed- and reactance-elements. And we found the structure with ellipse defined by mathematical equations.

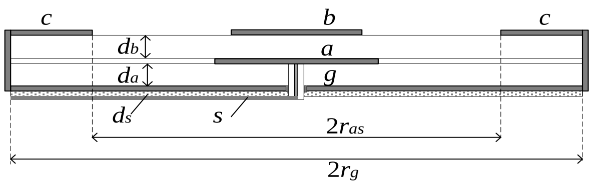

Fig. 1 Triplate stripline resonator antenna.

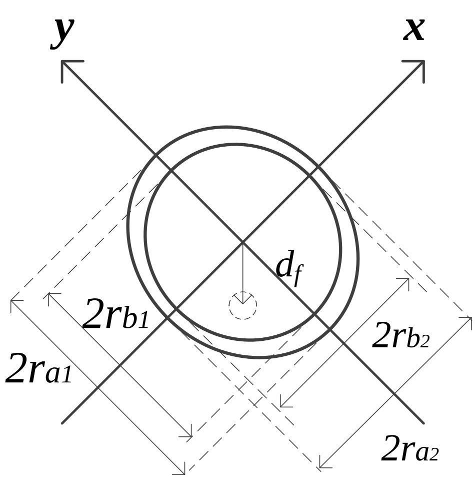

Fig. 2 Elliptic Feed- and reactance elements. Ground plate and grounded collar are abbreviated.

2 Single Antenna

Figure 1 gives a triplate stripline resonator antenna composed of feed- and reactance-elements *a* and *b*, and the ground plate *g*. The substrate *s* under the ground plate provides feeding routing wire for the antenna. Feed element *a* is fed with vertical probe through substrate *s* under the ground plate.

Collar *c* shows a λg/4 line with short termination for suppression of horizontal radiation. Figure 2 shows elliptic feed- and reactance-elements. They are defined by individual ellipses.

2*ra*1, 2*ra*2 are major and minor axes of ellipse of feed-element, which yields *x* and *y* axis-components for a rotating polarization vector.

3 4-Antenna Array

3.1 Feeding Routing Wires

An orthogonal arrangement is given in Fig. 3 by 2x2 antennas, which are settled in 1st and 4th, and 2nd and 3rd quadrants[2].

A pair of antennas are set through quarter wavelength delay line (90 degree). They are fed by parallel routing wires with half wavelength delay line (180 degree) respectively.

Specific designed routing wires for parallel feeding circuit are composed of different S-type lines. In spite that lengths of 2 S-curves are different, but the number of bendings are set equal. This gives the minimum reflection caused by cancellation of the left and the right parts of array.

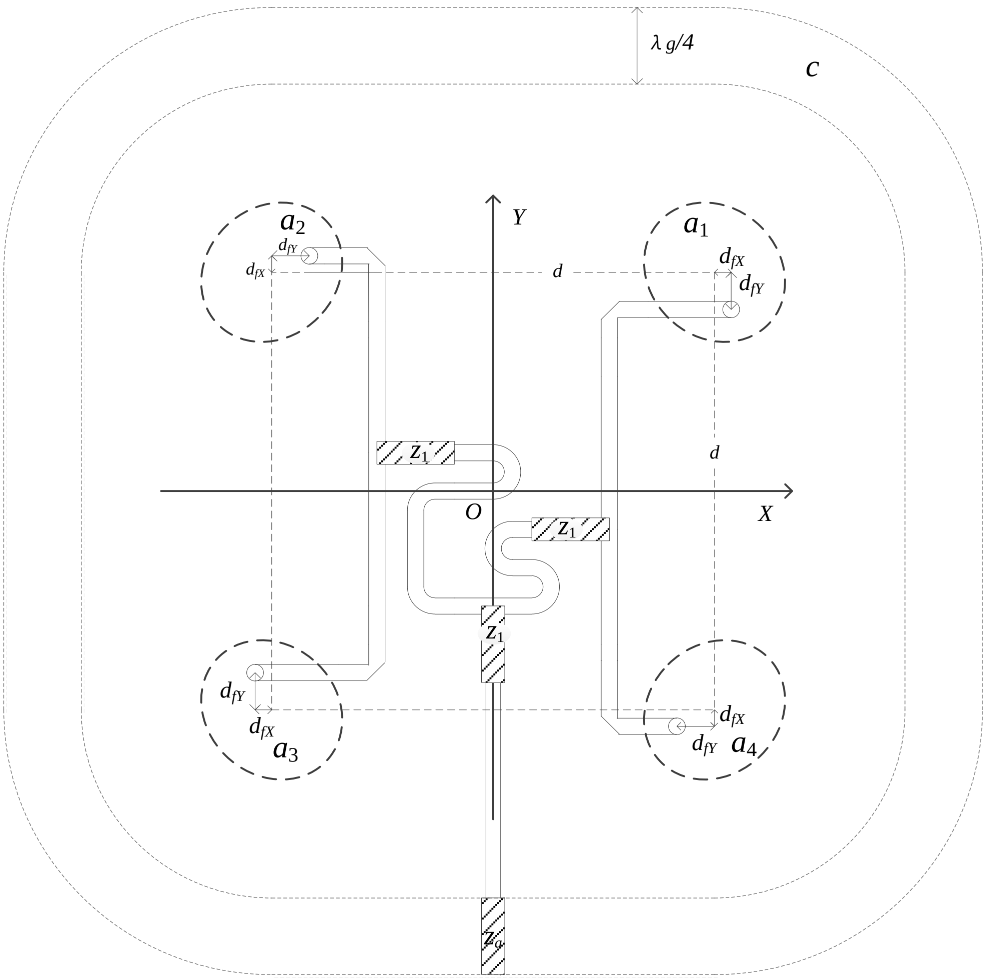

Fig. 3 Configuration of 4-antenna array and the feeding routing wires.
Dotted lines show a collar of short termination λg/4 lines for suppression of horizontal radiation.
lx defines the position of the collar.

The dotted line in Fig. 3 shows a collar composed of a quarter wavelength line with short temination at the peripheral of space. It provides the function to supress microwave radiation along horizontal directions. The suppressed microwave energy for horizontal direction (*x*-*y* plane) is added to radiation along vertical direction (*z* axis), and enhances directive gain of antenna array effectively[7][8].

The total numbers of antenna for an array is reduced almost half of the required number of design using conventional technologies.

3.2 Design of 4-antenna array

(1) Design target

The central frequency and the bandwidth are given as follows;

Central frequency f_0 = 10GHz

Bandwidth *W* = 1 GHz

Glass-epoxy substrates are used, and the dimensions of the three-layer substrates are;

Dielectric substrate εr = 4.6,
tan δ = 0.010

(2) Antenna Structure

Triplate stripline is composed as;

Thickness (*da*, *db*, *ds*) = (1.0, 1.0 , 0.4)

(3) Array structure

Antenna spacing *d* = 20(mm)

Array size including square collar 2*lg* = 42 (mm)

(4) Antenna size and feed point

parameter	The Best data for single (mm)antenna	content
2*ra*1	6.8	feed element
2*ra*2	5.9	feed element
2*rb*1	5.6	reactance element
2*rb*2	5.2	reactance element
df	1.7	feed point
	0.87	ellipticity *ra2/ra1*
	0.93	ellipticity *rb2/rb1*

4 Characteristics Evaluation

The evaluation was given by 3D computer simulation CST. Return loss, input impedance real and imaginary, axial ratio, and directive gain are shown in Fig. 4, 5, 6, 7, and 8. Wideband axial ratio and high directive gain were confirmed by this configuration and design.

Four different conditions in Fig. 4-7 correspond to different position of collars (quarter wavelength line termination at the peripheral of array) *lx* = 1.1~ 1.6 (mm). The best data was given by the blue lines *lx* = 1.1 in Fig. 4-7, and red line in Fig. 8.

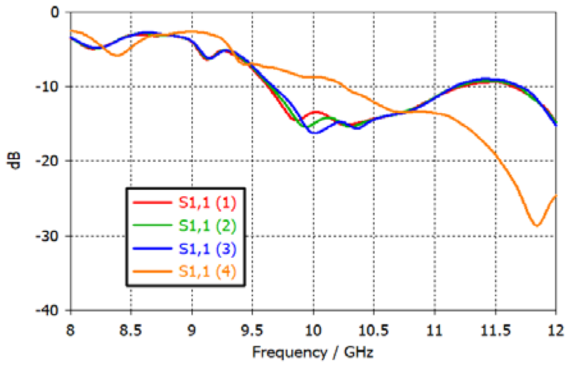

Fig. 4 Return loss.

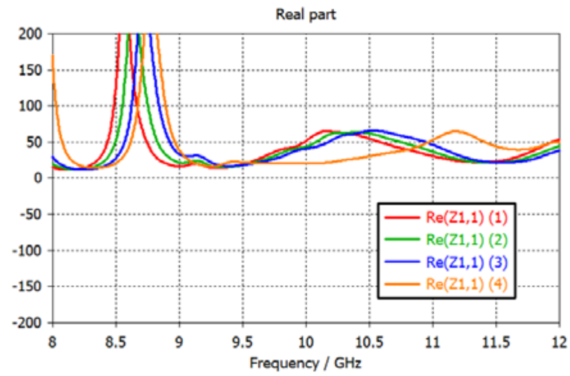

Fig. 5 Real part of Impedance.

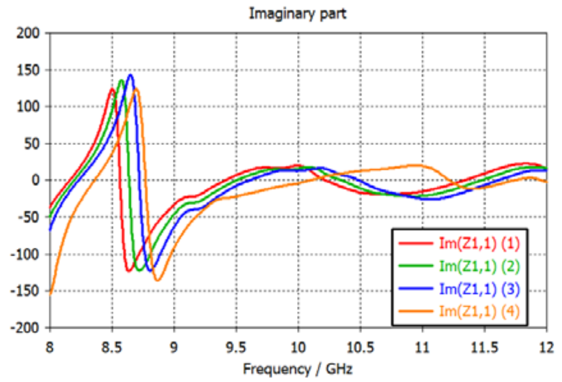

Fig. 6 Imaginary part of Impedance.

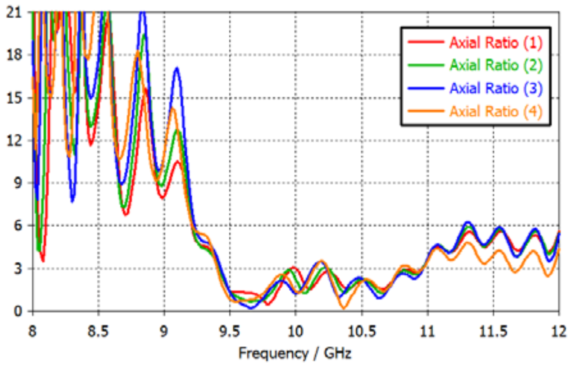

Fig. 7 Axial ratio of circular polarization.

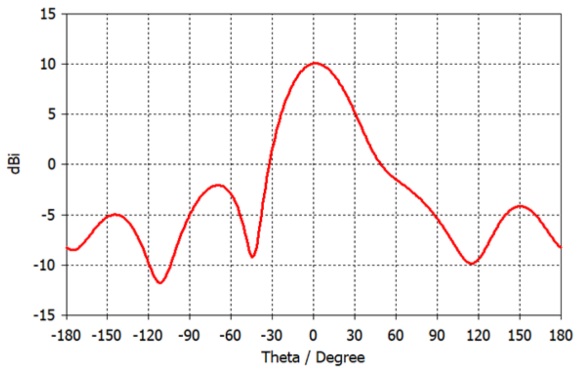

Fig. 8 Directive gain at $\varphi = 90°$.

5 Conclusion

The authors have studied effectivity comparing antennas of circular disc resonators with linear truncation and elliptic resonators.

Required precision and accuracy of design parameters to have sufficient performances are found almost equivalent between two different structures.

According to this study, the cost of fabrication of antenna array could be effectively reduced for design using glass-epoxy compared to using Teflon for multiple layers of substrates. It is expected that low loss dielectric material could be developed comparable to that of Teflon.

Acknowledgment

This work was supported by MEXT/JSPS KAKENHI Grant Number 17K00067, and the scholarship donations given by Musasino Co. Ltd, and Joint Research 2019-ISMCRP-2023.

The authors express their sincere gratitude for effective supports and advices by the Director-General. Prof. H. Tsubaki,, ISM and Prof. N. Kashiwagi, ISM.

And the authors express their sincere gratitude for kind supports by Mr. M. Abe, CEO, and Mr. M. Kise, General manager of R&D, Musasino Co.Ltd.

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