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

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Abstract: -This paper presents a circular polarization plane antenna using linearly truncated triplate stripline resonator antenna. Glass-epoxy substrate is used in place of Teflon substrate for low cost fabrication. In spite the electrical dimension differs only √2 (root two), the dimensions of circular disk, its truncation, and feeding lines must be chosen precisely and accurately to get better characteristics of gain 12 dB compared to 10 dB by elliptic resonator with 4-antenna array.

Key-Words: - X-band circular polarization antenna, compact plane antenna, high permittivity dielectric material, axial ratio

1 Introduction

The authors have been attracted in microwave circular polarization plane antennas. The characteristics of wideband axial ratio and high directive gain were realized by the design using Teflon multilayer substrates.

It was found however that the conventional design brings extremely high production cost. Metalizing on the dielectric material of Teflon are not easy. And thermal pressure contact requires multiple steps for adhesive contact among different substrates of feed- and reactance-elements, and ground plate.

A novel design is given in this paper Glass-Reinforced Epoxy laminate (or glass-epoxy) substrates are introduced into practical design. This material is popular, low cost with enough reliability. Teflon substrates requires multiple processes to implement triplate stripline antenna and feeding routing wires.

This paper proposes a novel design of a plane antenna for circular polarization based on the linearly truncated circular disc of a feed element. It proved to meet the required conditions of the total size and fabrication cos of the array antenna.

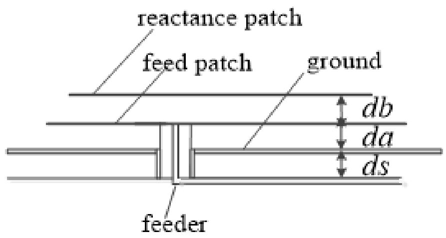

Fig. 1 Cross-sectional view of triplate stripline resonator antenna.

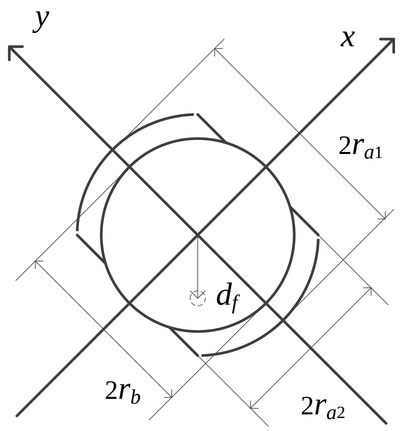

Fig.2 Feed- and reactance-elements.
Ground plate and grounded collar are abbreviated.

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 linearly truncated circular feed-element and circular reactance-element.

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

3 Four Antenna Array

3.1 Configuration of the proposed array antenna

An array antenna is shown in Fig. 3. Four unit antennas *ai*, (*i* = 1~4) are set at each quadrant around the center *O* in *X* – *Y* plane. *Z* axis is perpendicular against *X*-*Y* plane.

Each unit antenna generates right-handed polarized wave. To get right-handed polarized wave totally, each antenna must be fed by the signal with 90 degree phase delay along the left-handed circulation. d_{fX} and d_{fY} shows the position of feeding point at each unit antenna.

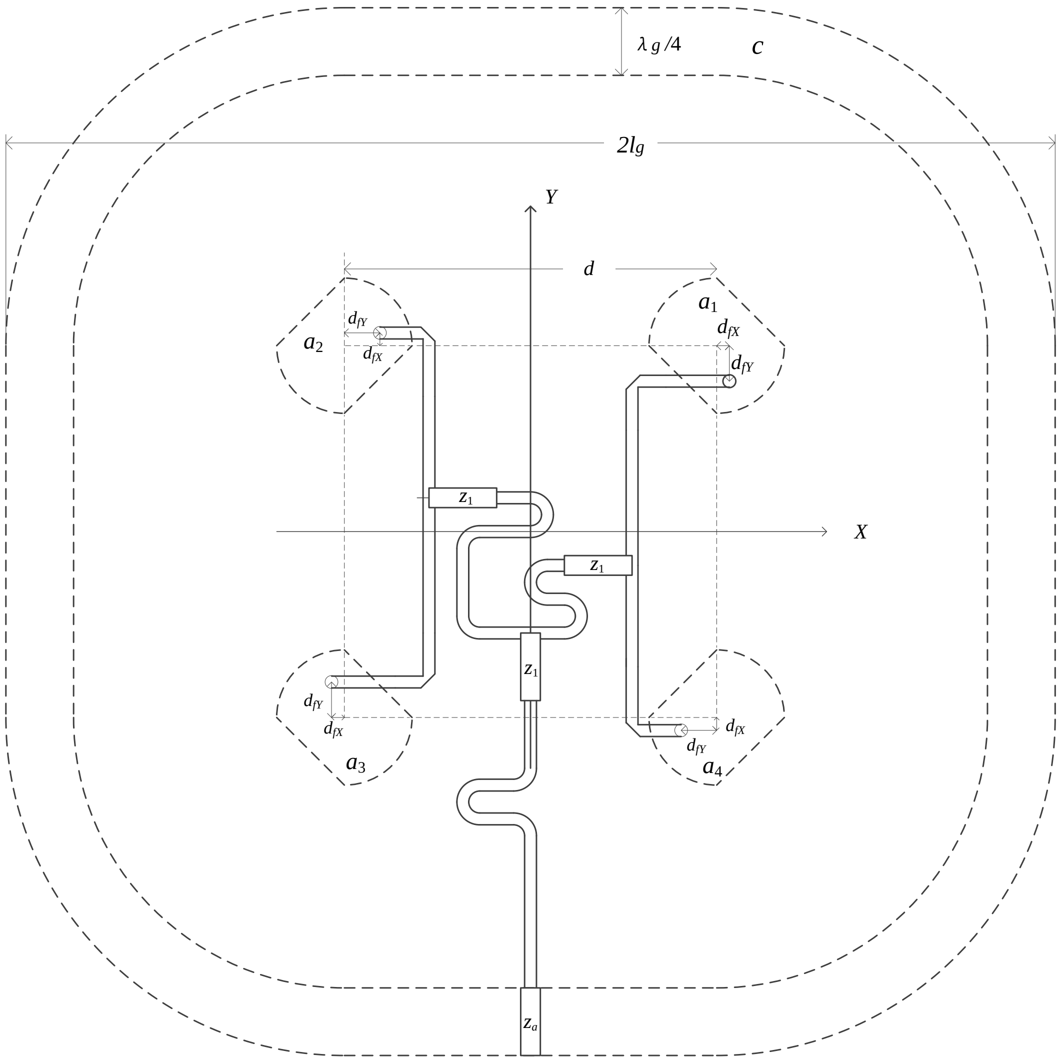

Fig. 3 Configuration of plane array antenna.
Reactance elements and dielectric substrates are abbreviated.

The length of the ground plate 2*lg* must be large enough compared to the size of total space of inner conductors.

3.2 Routing wire configuration

The design of routing wires for feeding to four antennas is shown in Fig. 3. This scheme forms a parallel composition of routing wire.

The condition of 90 degree phase difference are given between right hand elements *a*1 vs *a*4, and the left hand elements *a*3 vs *a*2. At the connection of the right and the left elements, 180 degree and 90 degree phase delay are provided by corresponding line lengths.

4 Characteristics

4.1 Design parameters

The central frequency and the bandwidth are designed for the X-band. The array antenna is composed of 4 unit antennas.

Frequency band;
central frequency f_0 = 10 GHz

Dimension of the element *a*;
length along *y* axis $2r_{a1}$ = 6.6 (mm)
cutting width $2r_{ac}$ = 1.8 (mm)
length along *x* axis $2r_{a2} = 2(r_{a1}\text{-}r_{ac})$ = 4.8 (mm)
feeding position dfX = 0 (mm),
dfY = 1.7 (mm)

Dimension of the element *b*;
diameter $2r_b$ = 5.4 (mm)

Dimension of the ground element *g* :
diameter $2l_g$ = 62.0 (mm)
Relative permittivity εr = 4.6
Dielectric tangent $\tan \delta$ = 0.010
Thickness of metal d_M = 0.035 (mm)

Distance between *a* and *b* elements d_a = 1.2 (mm)
Distance between *g* and *a* elements d_b = 1.2 (mm)
Distance between *s* and *g* ds = 0.4 (mm)

4.2 Characteristics of the 4-Antenna Array

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

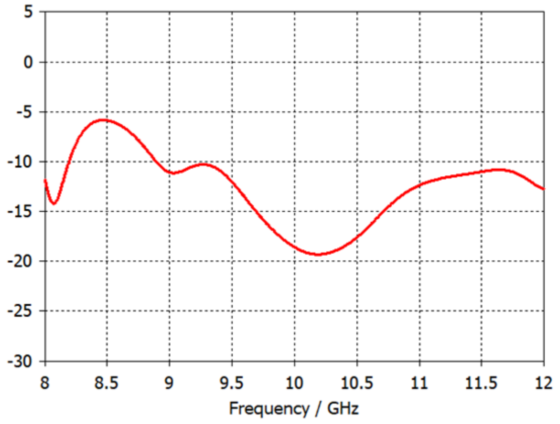

Fig. 4 Return loss.

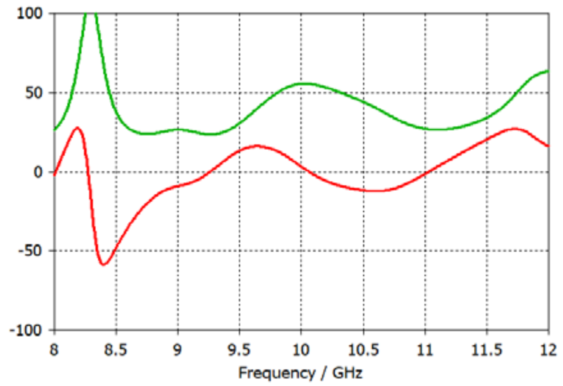

Fig. 5 Input impedance.
Green line: real part.
Red line: imaginary part

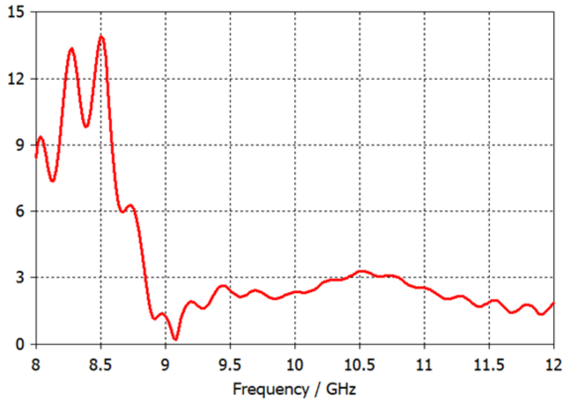

Fig. 6 Axial ratio.

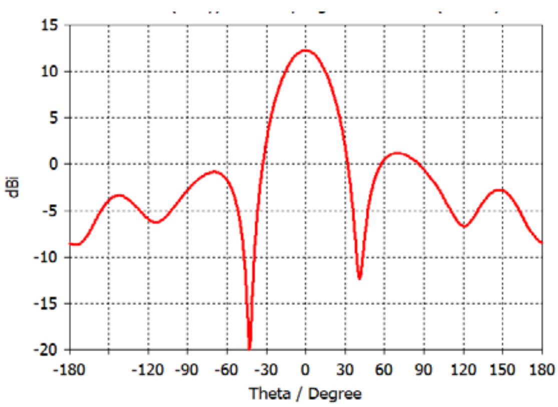

Fig. 7 Farfield gain (φ = 90 °).

5 Conclusion

This paper presented the results of the studies on a design way of X-band circular polarization plane antenna using glass-epoxy substrates. It was confirmed that the fabrication cost was remarkably reduced compared to the design using Teflon substrates.

The relative permittivity of glass-epoxy εr = 4.6, which is only two times higher than that of Teflon εr = 2.17.

But it was not easy to decide the optimum values corresponding to the best performance of antennas and the array. So it is noted that the design of the structure and parameter values become so severe on high permittivity materials.

We will try statistical approach to find the optimized parameters of antennas for practical antennas in remote sensing system.

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