Dual-band/Broadband Circular Polarizers Designed with Cascaded Dielectric Septum Loadings

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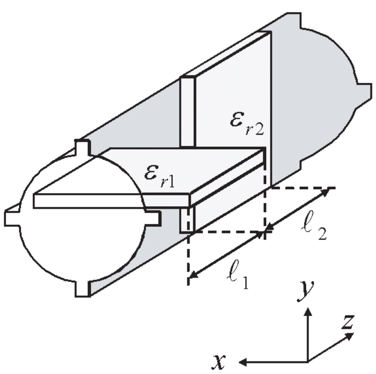
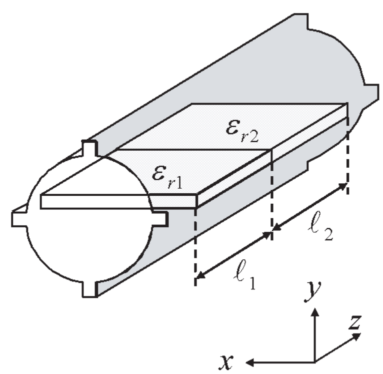
Abstract—A simple method is presented in this paper for realizing a dielectric septum-loaded type circular polarizer with either dual-band or a single broadband response. Two dielectric septum sections with different dielectric constants and lengths that introduce various phase delay to the x- and y-polarizations of the electric field in the same frequency range are cascaded orthogonally to obtain a dual-band response. A single wideband response can also be achieved if two dielectric septum sections are cascaded in parallel instead. Simulations in Ansoft HFSS show that flatter phase response and wider bandwidth can be obtained by the proposed polarizer comparing to single section ones. Moreover, a dual-band response can only be achieved with a two-section design. Taking advantage of dielectric septum-loaded type circular polarizers, the fabrication error or inaccurate dielectric constants can easily be compensated by adjusting the lengths of dielectric septum sections.

1. Introduction

Circular polarizers have been widely studied and discussed because of the important roles they play in communication systems. Groove- or iris-type circular polarizers [1–2] are robust but require precise fabrication processes. Metal septum-type circular polarizers [3] are easy and effective to design and modify but suffer from large signal reflection. A circular polarizer designed with a dielectric septum loading is proposed [4] with simple design procedure and easy compensation of fabrication error while keeping signal reflection level in an acceptable range. This paper gives a further study on dielectric septum-loaded type circular polarizers by extending its concept to two dielectric septum sections. Two orthogonally cascaded dielectric septum sections lead to a dual-band polarizer while a single wideband design can be achieved with two septum sections cascade in parallel.



(a)

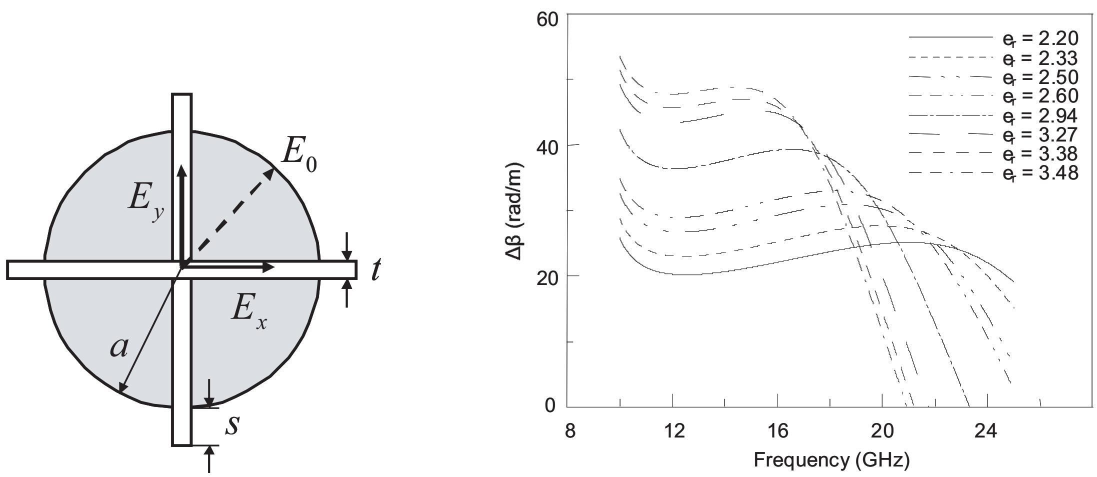


(b)

Figure 1: Three dimensional view of the circular polarizer with (a) two orthogonally cascaded septum sections and (b) two septum sections cascaded in parallel.

2. Theory

Figure 1 shows the geometry of the proposed circular polarizers, in which two dielectric septum loadings cascaded either orthogonally (Figure 1(a)) or in parallel (Figure 1(b)) are inserted in the middle of the waveguide. Slots on the waveguide wall are needed for precisely locating the dielectric septum. An incident wave E_0 oriented at 45° relative to the dielectric septum can be decomposed into two equal orthogonal projections as shown in Figure 2(a). These two components will propagate through the septum regions with different propagation constants. The electric field component which is in parallel with the septum is strongly perturbs. As a result the effective dielectric constant for this component is greater and vice versa. If the relative dielectric constants and the lengths of these two septum regions are allowed to be different, various phase differences between the two field components will be introduced by the two septum regions in the same frequency range, as shown in Figure 2(b). If these parameters are chosen properly, a dual-band circular polarizer as well as a single broadband circular polarizer can be achieved.



(a) (b)

Figure 2: Field components and propagation constants. (a) Cross-sectional view of the circular polarizer and (b) Propagation constant for various dielectric constant.

Table 1: Specifications and design parameters of the circular polarizers.

Polarizer prototype		**Dual-band**	**Broadband**
Operation band (GHz)		11.7–12.7, 19.7–20.2	11.7–20.2
Septum orientation		Orthogonal	Parallel
Waveguide radius (mm), a		8.7	8.7
Slot dimensions (mm),	s	2.2	2.2
	t	1.57	1.57
Septum lengths (mm),	l_1	207.7	34.9
	l_2	125.7	23.7
Septum materials,	ε_{r1}	2.94	2.2
	ε_{r12}	3.48	2.94

3. Design of Dual-band/broadband Circular Polarizers

Table 1 shows the specifications and the design parameters of the circular polarizers. Waveguide radius is firstly determined by the strategy proposed in [4] to obtain a flatter phase response in the desired frequency ranges. For physical strength and precise location of the dielectric septum, the slot on the waveguide wall can also be determined. Once the cross-sectional dimension of the waveguide is determined, propagation constants with various dielectric septums inserted are then calculated.

To design a dual-band circular polarizer, the prototype shown in Figure 1(a) is utilized. By properly choosing the length and relative dielectric constants of the two septum sections, a 90° and a 270° phase differences can be obtained at the center frequency of the lower and upper operation bands, respectively.

On the other hand, if the second prototype (Figure 1(b)) is used, a single broadband circular polarizer can be designed by properly placing the maximum variation point of phase difference in the desired frequency range. Figure 3 shows the simulation results by Ansoft HFSS for the frequency response of phase difference of the designed dual-band and broadband circular polarizers.

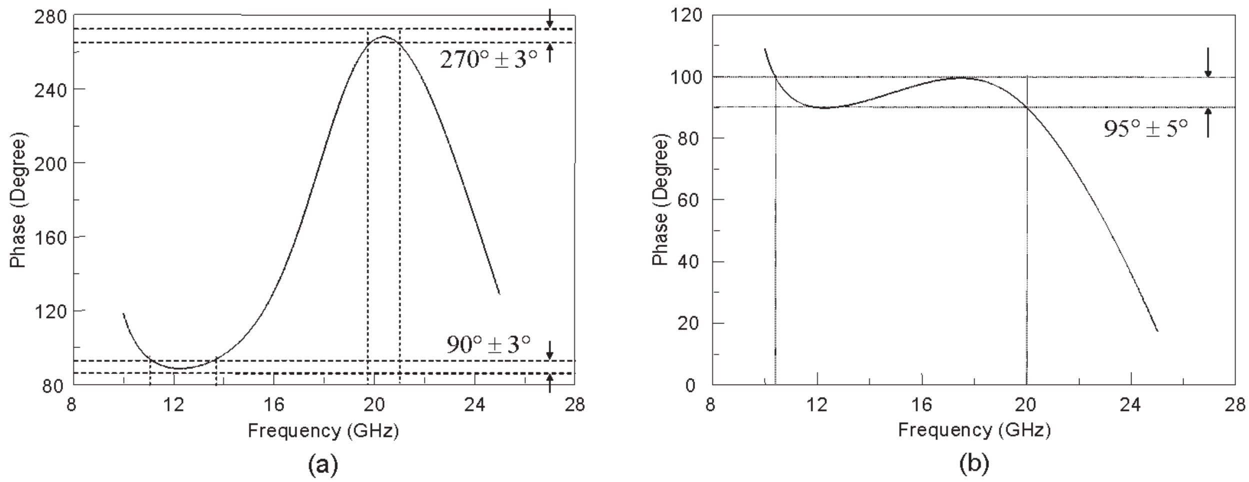


Figure 3: Phase difference of the polarizers with (a) dual-band and (b) a single broadband responses.

4. Conclusion

Circular polarizers with two cascaded dielectric septum loadings for dual-band and broadband applications are proposed. Simulations results by Ansoft HFSS shows that for the broadband design not only the flatter phase response near the center frequency but also a broader bandwidth are obtained comparing to single section ones [4]. A dual-band design that can never be achieved with single dielectric septum section is also accomplished in this paper. These circular polarizers are currently under fabrication and the measurement results will be presented later in the conference.

Acknowledement

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