RECTANGULAR DIELECTRIC RESONATOR ANTENNA ON A CONDUCTOR-BACKED CO-PLANAR WAVEGUIDE

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ABSTRACT: *In this paper, we present an effective excitation of a rectangular dielectric resonator antenna (DRA) with a conductor-backed co-planar waveguide (CB-CPW). The radiation and resonance characteristics are found to vary, depending on the orientation of the DR on the coplanar feed line. The effect of finite and infinite ground planes of CB-CPW on the radiation characteristics of the rectangular DRA is studied. The orientation and position of the DR are optimized for maximum gain and bandwidth. The optimized antenna geometry offers ~10.46 dBi gain and 7.5% bandwidth with low cross-polar radiation characteristics.* Microwave Opt Technol Lett 45: 154–156, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20754

Key words: *rectangular dielectric resonator antenna (DRA); conductor-backed co-planar waveguide (CB-CPW); broadband antennas*

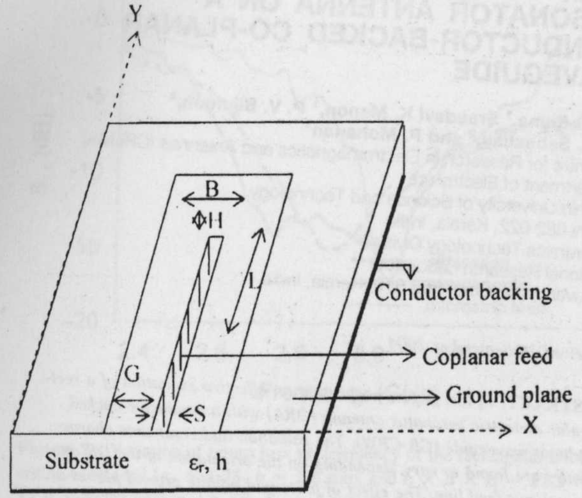
1. INTRODUCTION

Dielectric resonators (DRs) are finding wide applications in microwave engineering due to their properties such as low profile and light weight. These antennas offer better efficiency due to their inherent characteristics, especially their lack of conductor losses. This property of DRs has brought increased attention from researchers recently. DRs with $30 < \varepsilon_{dr} < 60$ are most suitable for antenna applications, so that a compromise can be made between size, operating frequency, and other antenna radiation characteristics [1]. A DR excited by a probe and placed over a ground plane can serve as an effective radiator, since the electromagnetic fields extend beyond the geometrical boundary of the cavity [2]. Coaxial probe, direct microstrip-line feed, printed CPW, soldered-through probe, conformal-strip feed, and rectangular waveguide [3] are different techniques employed to excite a DR. Printed CPWs are frequently employed as a transmission line in planar technology due to the ease of parallel and series insertion of both active and passive components with high circuit density.

In this paper, a rectangular DRA excited by using a CB-CPW is presented. The reflection and radiation characteristics of the rectangular DRA with the CB-CPW for six different orientations are studied. The orientation and position of the rectangular DRA are optimized on the CB-CPW for maximum bandwidth, gain, and cross-polar level.

2. ANTENNA GEOMETRY

The antenna is comprised of a rectangular DR of length L = 22.5 mm, breadth B = 11.9 mm, and height H = 5.55 mm, and made of low-loss ceramic material ($Ca_5Nb_2TiO_1$) with dielectric constant ε_{dr} = 48. The DR is excited by a 50Ω CB-CPW fabricated on a substrate of dielectric constant ε_r = 4.7 and thickness h = 1.6 mm. The strip width S and slot width G of the CB-CPW i



Orientation	X	Y	Z
LBH	L	B	H
BLH	B	L	H
LHB	L	H	B
BHL	B	H	L
HLB	H	L	B
HBL	H	B	L

Six orientations of the DR

Figure 1 Geometry of the proposed CB-CPW fed rectangular dielectric resonator antenna with BLH orientation (other different orientations are tabulated in the inset)

such that $2G + S$ = length of the DR. The geometry of the proposed CB-CPW rectangular DRA is shown in Figure 1.

3. EXPERIMENTAL RESULTS

A rectangular DR with dimension $L \times B \times H = 22.5 \times 11.9 \times 5.55$ mm^3 is fed by a CB-CPW with infinite ground plane. For the CB-CPW, $2G + S$ is selected as 22.5 mm, the length of the DR. The variation of return loss as a function of frequency is studied for different positions of the DR along the feed line using an HP 8510C Network Analyzer. The measurements are repeated for the six different orientations of the DR upon the feed line, on an infinite ground plane. The effect of ground-plane truncation is also studied in detail. The position of the DR along the feed line is experimentally optimized for maximum bandwidth. Irrespective of the ground-plane dimensions only LBH, HLB, BLH, and HBL orientations have provided improved radiation characteristics.

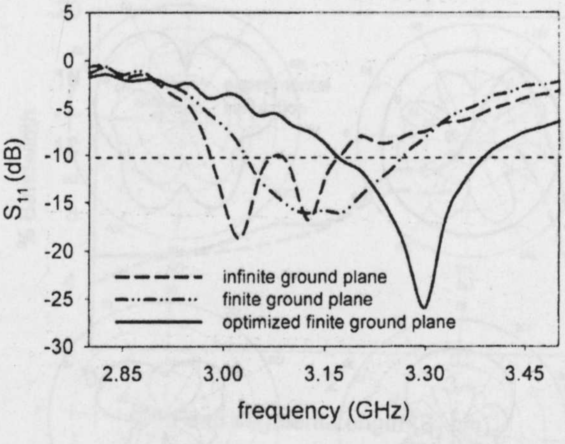


Figure 2 Variation of S_{11} with frequency of BLH orientation of rectangular DR on CB-CPW $\varepsilon_r = 4.7$, $h = 1.6$ mm, $\varepsilon_{dr} = 48$, $L \times B \times H = 22.5 \times 11.9 \times 5.55$ mm^3

When CB-CPW with finite ground plane was used to excite the DRA, a frequency shift towards the higher side was observed with better cross-polar level, as compared to the CB-CPW with infinite ground plane. The bandwidth of the DRA was found to be almost same for both ground planes. For the HLB orientation, the resonant frequency of the DRA was found to be slightly lower than the other six orientations. The reflection and radiation characteristics of the DRA on infinite and finite ground plane are shown in Table 1. From the table it can be inferred as BLH orientation gave better radiation performance compared to all the other orientations.

The BLH orientation was found to have better performance, as compared to all the other six orientations; CB-CPW with finite ground plane was optimized for this orientation. The optimized design has ground width = 10 mm, $2G + S = 22.5$ mm and feed length = 30 mm. The bandwidth offered by the optimized structure is same as CB-CPW with finite ground plane but with a frequency shift to 3.3 GHz. Typical variations of return loss of the DRA on the infinite, finite, and optimized CB-CPW for BLH orientation are shown in Figure 2.

The gain of the DRA is measured using gain transfer method. HLB, BLH, and HBL orientations of DRA is found to have an improvement in gain when excited using CB-CPW. Optimized antenna configuration offered a gain of 10.46 dBi. Gain of the DRA for BLH orientation in the optimized CB-CPW configuration is shown in Figure 3.

Figure 4 shows the measured radiation patterns in the BLH orientation of the DR on infinite and finite ground plane. The patterns of all the orientations are reasonably broad in both the principal planes. The cross-polarization is better than −32 and

TABLE 1 Radiation and Reflection Characteristics of the Rectangular DR with CB-CPW ε_r = 4.7, h = 1.6 mm, ε_{dr} = 48, $L \times B \times H = 22.5 \times 11.9 \times 5.55$ mm^3

	Infinite Ground Plane				Finite Ground Plane			
Orientation	Freq. [GHz]	% BW	Gain [dBi]	Cross-Polar Level [dB]	Freq. [GHz]	% BW	Gain [dBi]	Cross-Polar Level [dB]
LBH	3.1	6	5	−13	3.425	6	8.2	−24
BLH	**3.1**	**6.4**	**9.745**	**−32**	**3.175**	**7.4**	**9.3**	**−38**
HBL	3.15	7.8	7.144	−20	3.175	7	8.641	−20
HLB	2.75	5	8.32	−16	2.85	5	10.03	−22
BLH orientation on optimized ground plane					**3.3**	**7.5**	**10.46**	**−28**

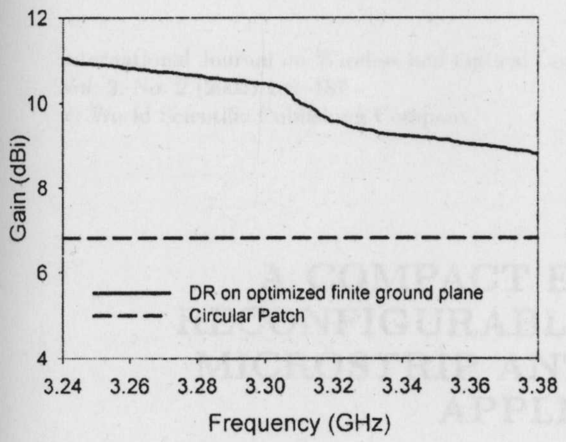


Figure 3 Gain of rectangular DR in BLH orientation $\varepsilon_r = 4.7$, $h = 1.6$ mm, $\varepsilon_{dr} = 48$, $L \times B \times H = 22.5 \times 11.9 \times 5.55$ mm^3

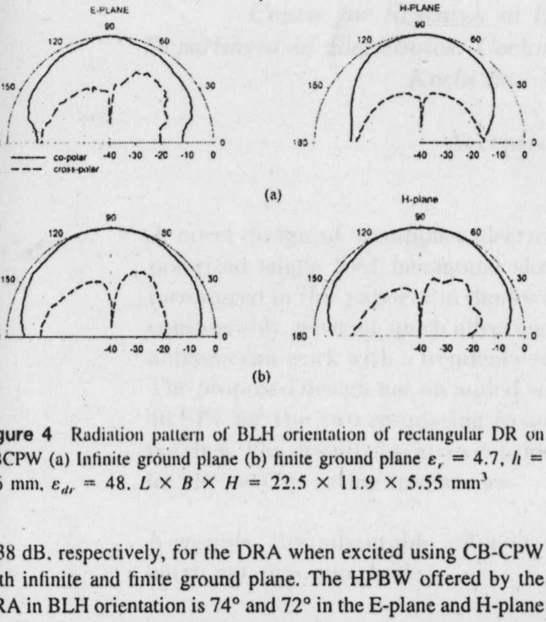


Figure 4 Radiation pattern of BLH orientation of rectangular DR on CBCPW (a) Infinite ground plane (b) finite ground plane $\varepsilon_r = 4.7$, $h = 1.6$ mm, $\varepsilon_{dr} = 48$. $L \times B \times H = 22.5 \times 11.9 \times 5.55$ mm^3

−38 dB, respectively, for the DRA when excited using CB-CPW with infinite and finite ground plane. The HPBW offered by the DRA in BLH orientation is 74° and 72° in the E-plane and H-plane for the infinite ground plane, whereas for the finite ground plane BLH orientation offered a HPBW of 136° and 124° for the E-plane and H-plane. The optimized antenna configuration shows the same radiation characteristics as that of the DRA on the finite ground plane.

4. CONCLUSION

Reflection and radiation characteristics of rectangular DR on CB-CPW have been presented in this paper. Six possible orientations of rectangular dielectric resonator have been studied in detail. The experimental results showed that the orientation of DR on the feed line plays an important role for improving the radiation and reflection characteristics of DRA. The optimized rectangular DRA offered high gain, broad bandwidth, and low cross-polar level characteristics.

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