

# Circular Polarized Antenna with Controlled Current Distribution by Defected Ground Structures

Seok-Jae Lee<sup>1</sup>, Hee-Jong Lee<sup>1</sup>, Won-Sang Yoon<sup>2</sup>, Sun-Ju Park<sup>1</sup>, Jongsik Lim<sup>1</sup>, Dal Ahn<sup>1</sup>, and #Sang-Min Han<sup>1</sup>

<sup>1</sup> Soonchunhyang University,  
Asan, Chungnam 336-745, Republic of Korea  
#auspice@ieee.org

<sup>2</sup> Communication Research Center, Samsung Tales Ltd.,  
Seongnam, Gyeonggi 463-870, Republic of Korea

## 1. Introduction

From the various design requirements in microwave research area, innovative transmission line architectures have been researched for photonic bandgap structures (PBGs), electromagnetic bandgap structures (EBGs), defected ground structures (DGSs), and metamaterials [1-2]. Among the technologies, the DGS has been researched as the most popular transmission line model. Because the DGS can be modelled by analytical approaches and designed on various design shape [1, 3], the unique characteristics have applied to many kinds of microwave devices such as microwave amplifiers [4], dividers [5], filters [6] and so on. However, even though the DGS has merits to reduce microwave devices, it has difficulty in a resonator design. In case of antennas, a few approaches have been tried by merging the DGS transmission line technologies [7-10].

In this paper, a circular polarized (CP) antenna design is presented from a control of resonant characteristics by the DGS. The resonance can be controlled by adjusting current distribution on a patch antenna by using a DGS slot on a ground plane. The antenna polarization consists of time-variant current direction on the patch conductor. A circular polarized antenna need to require both bandwidths of an impedance bandwidth (BW) corresponding to the VSWR and a CP BW corresponding to the axial ratio (AR). The CP antenna design suffers from the CP BW which is more complicated design parameters such as input impedance, feedline structures, antenna shape, and phase differentiation. Because a large AR is induced by asymmetry of the current distribution between two orthogonal current, the larger one can be controlled by DGS. In this paper, current control on the DGS circular patch antenna is proposed. The controllability of the DGS antenna can enhance a new antenna design methodology.

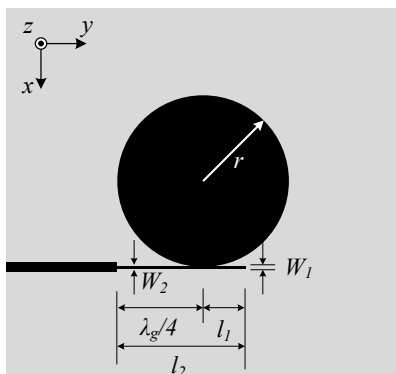


Figure 1. Configuration of the Tangential-Fed CP Antenna.

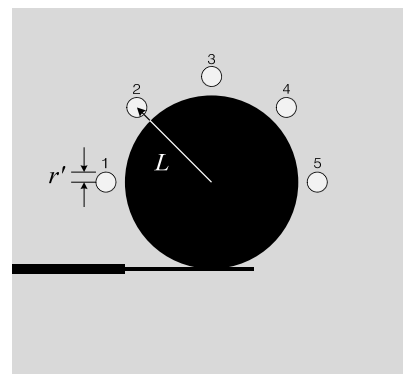


Figure 2. Geometry of the DGSs on the Circular Polarized Patch Antenna.

## 2. Effect of the DGS for Radiating Resonators

A radiation resonator with circular polarization is designed to investigate the effect of the DGS on a resonator. Because either complicated feeding structures or perturbation on a radiating patch for CP antenna designs is not suitable to evaluate the DGS effects, a tangential-fed CP antenna is designed as shown in Fig. 1 [11, 12], which contains a circular patch without perturbation. The antenna is designed on a FR4 substrate with a thickness of 1 mm, a dielectric constant of 4.4. The radius,  $r$  is 17.6mm and feedline structure with dimensions of  $l_1 = 8.6$  mm,  $l_2 = 25.6$  mm,  $W_1 = 0.6$  mm,  $W_2 = 0.5$ mm, and  $\lambda_g/4 = 17$  mm.

As shown in Fig. 2, DGSs are mounted on the ground plane of the antenna from the position 1 to the position 5, respectively. The DGS slot is designed with the circle shape of radius  $r' = 2$  mm and distance from a center of the patch  $L = 21.2$  mm. The current distributions corresponding to the DGS position are described in Fig. 3. Compared with the current distribution on the original antenna (denote the DGS position 0), the current flow is disturbed by the DGSs. Additionally, the current direction is changed to the point of the DGS. Antenna performances are measured for each DGS position. The impedance characteristics of resonant frequencies and bandwidths are a little varied of 2.338-2.358 GHz, 48-68 MHz, respectively. The minimum axial ratios (ARs) have relatively large variation of 1.92dB, 3.66dB, 0.9dB, 6.55dB, 5dB and 9.52dB from the DGS position 0 to 5, respectively.

DGS Position	Excitation Phase			
	0°	90°	180°	270°
0 (w/o DGS)				
1				
3				
5				

Figure 3. The Effects for the Current Distribution by the DGSs.

## 3. DGS Antenna Design with Circular Polarization

The effect of the DGS on a radiating resonator has been applied for the CP antenna improvements. The tangential-fed CP antenna with the DGS positioned at 2 is designed. In Fig. 4, the current distributions of the DGS CP antenna are compared with the CP antenna without a DGS at adjacent frequencies. In case of the CP antenna without the DGS, the currents at the excitation phase of 90° and 270° are stronger than those of 0° and 180°, which makes large AR in circular polarization. However, the proposed DGS CP antenna has relatively equal current strength for each excitation phases at 2.358 GHz. Therefore, the current distribution control by the DGS can be expected to improve a CP bandwidth from ARs.

To evaluate the performance improvements, the return losses and axial ratios are measured. From the Fig. 5, the CP bandwidth is improved from 16 MHz to 20 MHz, while the impedance bandwidth keeps almost the same values 2.318-2.386 GHz to 2.322-2.396 GHz. In addition, the minimum AR is improved from 1.92 dB to 0.9 dB. The radiation patterns are checked for two CP antennas on an x-y plane as shown in Fig. 6. The tangential-fed CP antenna has Right-Handed CP (RHCP). The

RHCP peak gains of the CP antennas with/without DGS are 1.72 dB and 1.66 dB, while the cross polarization rejection levels are -11.1dB and -10.9dB, respectively. Therefore, the proposed DGS CP antenna can improve the circular polarization characteristics with almost the same impedance characteristics and radiation pattern, compared with the CP antenna without DGS.

DGS Position @ freq.	Excitation Phase			
	0°	90°	180°	270°
w/o DGS @ 2.372 GHz				
with DGS 2 @ 2.372GHz				
w/o DGS @ 2.358 GHz				
with DGS @ 2.358GHz				

Figure 4. Current Distributions for CP antenna with/without DGS.

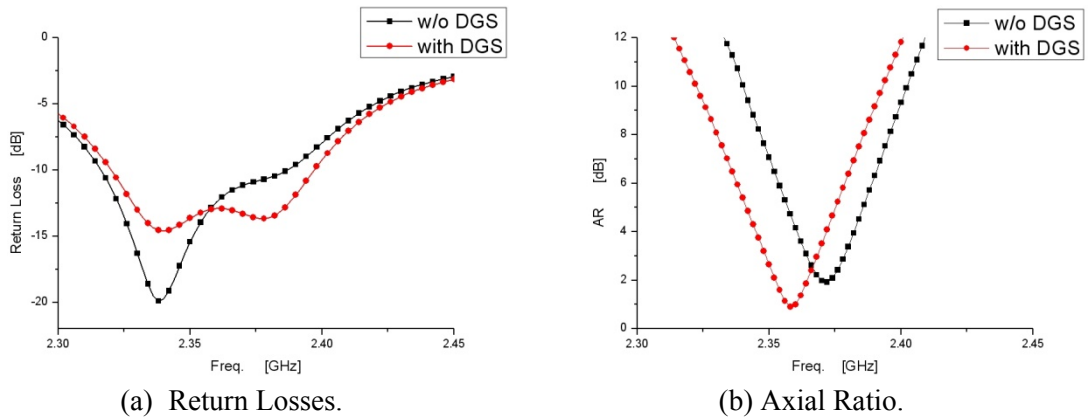


Figure 5. Comparison of the CP Antenna Performances.

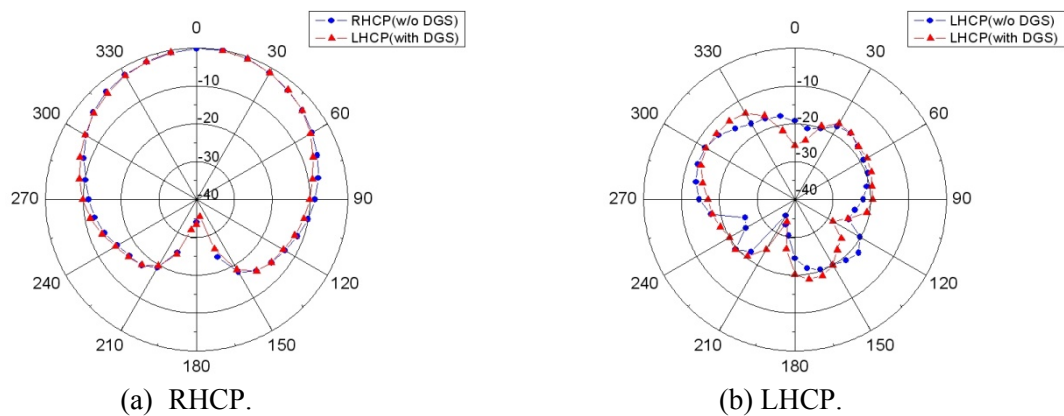


Figure 6. Radiation Patterns of the CP Antennas.

## 5. Conclusions and Discussions

In this paper, a CP antenna design with improved CP performance is presented from the controllable current distribution by the DGS. It could be confirmed that the current distribution can be controlled by adjusting a DGS slot on a ground plane. In addition, the current direction can be controlled by the position of DGS slots. The proposed antenna has improved CP performance without change the impedance and radiation characteristics. The other shapes of the DGS such as a rectangle, a square, and a triangle are expected to achieve various DGS effects. This investigated research can be one of the promising DGS research candidates for radiating components.

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