

# Performance Analysis of circULAR Ring Slot Antenna using HFSS

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**Abstract:** A circular ring slot antenna (CRSA) with microstrip feeding technique is analysed at 2.45 GHz frequency. In order to suppress additional harmonics produced by the ring slot pattern in wide range nearly 3 to 8 GHz, a defected ground structure (DGS) is integrated into the CSRA. The proposed antenna is analysed and simulated mainly for the wireless sensor network applications. This antenna is simulated by the High Frequency Structure Simulator (HFSS). Analysing the proposed antenna and simulated results on return loss, radiation pattern and gain.

**Keywords:** Circular Ring slot Antenna (CRSA), Defected ground structure (DGS), High Frequency Structure Simulator (HFSS) v 14, harmonic suppression.

## I. INTRODUCTION

Wireless technology provides less expensive alternative and a flexible way for communication. Antenna is one of the most important elements of the wireless communication. One of the types of antenna is microstrip patch antenna. Microstrip technique is a planar technique used to produce lines conveying signals and antenna coupling such lines and radiated waves. It uses patches formed on the top surface of the thin substrate separating them from a conductive layer from the bottom surface of the substrate and consisting a ground for the line or the antenna. Microstrip antennas are particularly used as active antennas. Active antenna consists of active circuits integrated with antenna elements and feeding circuits which results a monolithic substrate. Thus provides compatibility with integrated circuits and easy to install on grid surface.

By adding filters generally either low pass or band pass filters between the active and passive components we can filter the unwanted harmonics but this increases complexity and makes circuit bulky. To suppress the unwanted harmonics, techniques of loading an additional tuning stub [1] and multiple shorting pins [2] into a patch antenna have been introduced earlier. But these are capable only to suppress only single harmonic mode. To suppress harmonics in wider range, the techniques of photonic band gap (PBG) [3] [4] and defected ground structure (DGS) [5][6] have been introduced. PGB technique requires periodic slot etched into the ground layer. But the usage of DGS which requires simple slot structures (H- shaped, U or inverted U-shaped, L-shaped) [5] [6] is very flexible to eliminate wide range harmonic suppression.

In this communication a method of loading an inverted U-shaped DGS [7] into the ring slot of a microstrip-fed CRSA antenna is proposed. By integrating the DGS with the circular ring slot, harmonic suppression over 3 to 8 GHz can be achieved. By integrating DGS into the ring slot will reduces the usage of external cascading filter circuit. A detail of antenna design is described below.

## II. ANTENNA DESIGN

The evolution of proposed slot antenna with harmonic suppression is given in fig-1. It is the combination of two simple structures those are microstrip feed CSRA and DGS.

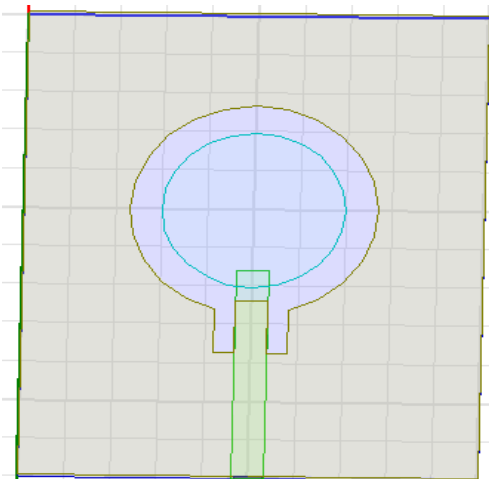


Fig1: Proposed slot antenna

The dimensions of the substrate [Width × Length × Height] are 60mm × 50mm × 0.8mm. The substrate used is FR4 substrate whose relative permittivity is 4.4 and tangent loss of 0.02.

The dimensions of the CRSA and DGS are given as follows:

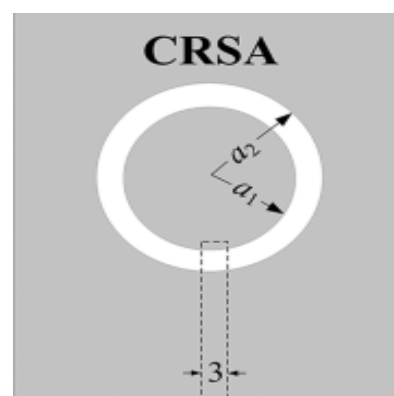


Fig 2(a): Structures of CRSA

The inner radius  $a_1 = 10\text{mm}$  and outer radius  $a_2 = 13.5\text{mm}$  and these are calculated by the formula:

$$f_0 \approx \frac{c}{\pi(a_1 + a_2)} \times \sqrt{\frac{\epsilon_r + 1}{2\epsilon_r}}$$

Where  $c$  = Speed of the light in free space.

$\epsilon_r$  = Relative permittivity of the substrate= 4.4  
 $\pi(a_1 + a_2)$  = circumference of the angular ring slot antenna.

The main aim of this CSRA is to induce a fundamental mode at approximately 2.4 GHz band.

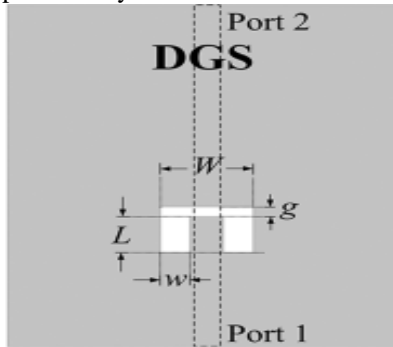


Fig 2(b): Structures of DGS

The specifications of the horizontal section of DGS are  $L=5\text{mm}$ ,  $w = 2.25\text{mm}$  and the vertical section of DGS are  $W= 8\text{mm}$ ,  $g= 0.5\text{mm}$ . The width of the feed line is taken as 3mm and the length of the feed is 27mm.

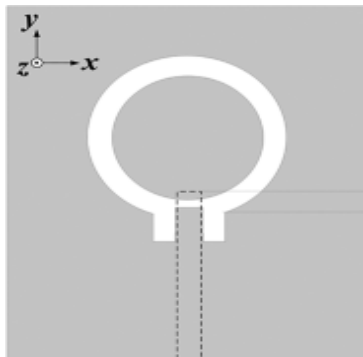


Fig 2(c): Structures of Proposed slot antenna

Simulation using High Frequency Structure Simulator (HFSS) was performed on proposed antenna and CRSA. Designed CRSA is shown below:

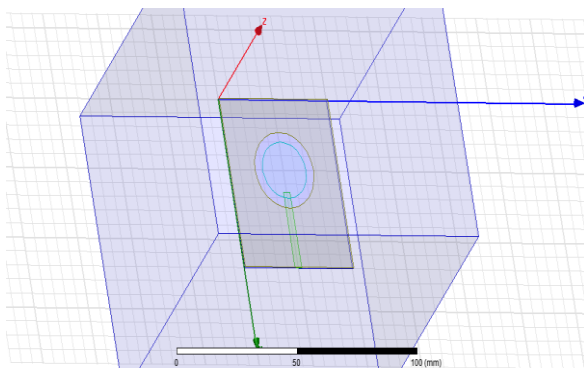


Fig 3(a): Designed CRSA

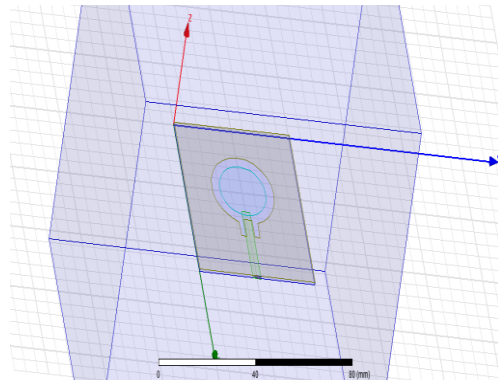


Fig 3 (b): Designed CRSA

The simulated Electric and magnetic field distributions are given below:

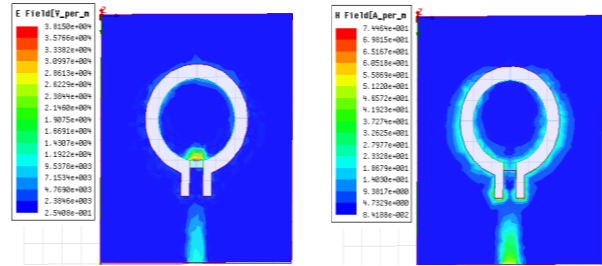


Fig 4: Simulated E and H field distributions at 2.45 GHz

### III. MEASURED RESULTS

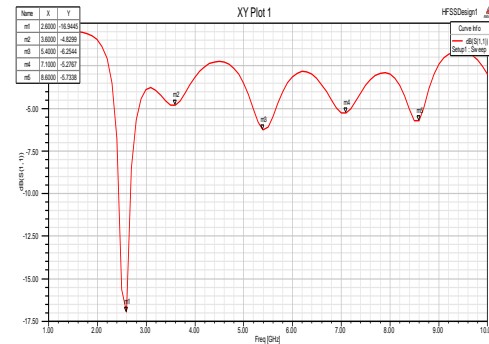


Fig 5: Simulated  $S_{11}$  for CSRA

In CSRA the mode-1 (m1) occurred at 2.6 GHz frequency. The other four harmonics are occurred at frequencies 3.6 GHz (mode-2), 5.4GHz (mode-3), 7.1 GHz (mode-4) and 8.6 GHz (mode-5).

By integrating DGS with CRSA the harmonics are suppressed in a wide range. In the obtained result nearly 5 to 8 GHz band is suppressed. By varying the feed position and width we can get the initial mode frequency at 2.4 GHz because WLANs are mainly applicable at 2.4 GHz only. This result is shown below:

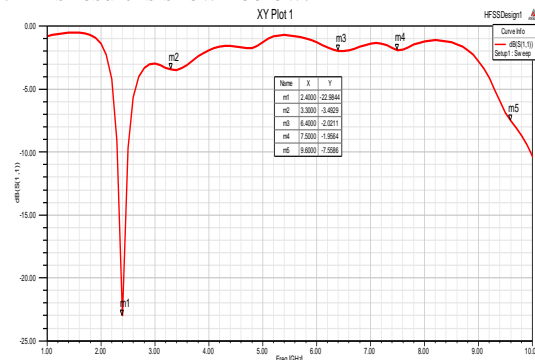


Fig 6: Simulated  $S_{11}$  for proposed antenna (Return Loss)

The proposed antenna will not affect mode-1 at 2.4 GHz which satisfies the standard value of wireless sensor networks. The harmonic at Mode-m3 is reduced as much as 3 dB. The simulated 10 dB impedance bandwidth of the proposed antenna was between 2.3 to 2.5 GHz.

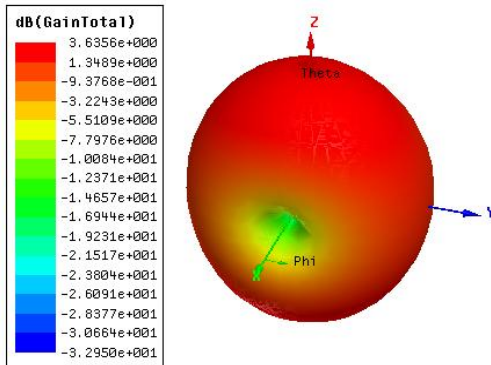


Fig 7: 3D Polar Plot

From the above 3D Polar plot the over all gain obtained is 3.6356 dB.

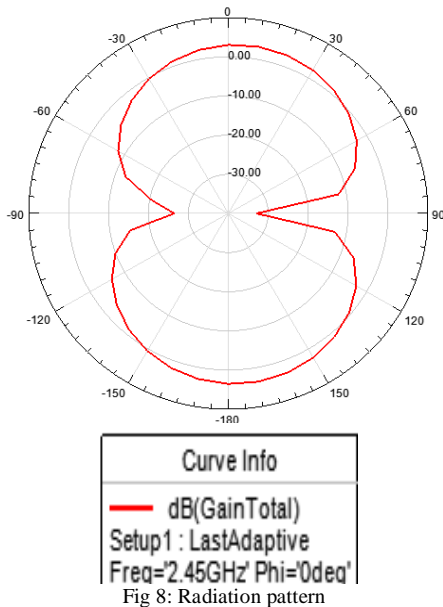


Fig 8: Radiation pattern

#### IV. CONCLUSION

This study provides an insight in determining the performance of CSRA with and without DGS. A fundamental mode can exhibit a 10-dB impedance bandwidth between 2.3 and 2.5 GHz with an operating frequency of 2.4 GHz. From this result it is observed that CSRA with DGS is applicable in wireless sensor networks such as WPANs and WLANs.

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#### BIOGRAPHIES



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