Broadband Annular Ring Patch Antenna

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Abstract This paper investigates an annular ring microstrip patch antenna with improved bandwidth from 2.61 to 38.15% at the range of 5.95–8.43 GHz by using pin-sorted using the same feeding point in each design. The obtained frequency range lies within the C-band.

Keywords Annular ring patch antenna · Bandwidth · Gain · Antenna efficiency · Impedance

1 Introduction

Microstrip Patch Antenna (MPA) is a coaxial probe-fed antenna that offers excellent segregation between radiating elements and the feed network, thus yielding a worthy front to back ratio [1]. The major advantage of this MPA is its lightweight, thin outlining, simplicity to fabricate, accordant to mounting surfaces, low cost and capable of being assimilated in active devices [1–3]. Due to these beneficial aspects the MPAs have versatile applications such as in space technology, satellite broadcasting, tracking systems, missiles, GPS monitoring systems, remote sensing and also in aircrafts [2, 3]. A small size circular MPA compared to a rectangular one conveys similar radiation pattern characteristics, thus indicating design compactness [2]. But, this circular MPA has a major drawback due to its narrow bandwidth in the range of 1–5%, which can be overcome by cutting the slots (the mechanism used to load the antenna) in various shapes. Al-Zoubi et al. [4] observed a 12.8% increase in bandwidth for circular MPAs when coupled with annular ring structures while bandwidth enhancement of 34% detected by Chang and Lien [5] using a stacked structured annular ring patch antenna. Another alternative, for improvement of bandwidth, is pin-shorting and is probably the modest technique to expand bandwidth without implementing any structural change in the patch antenna.

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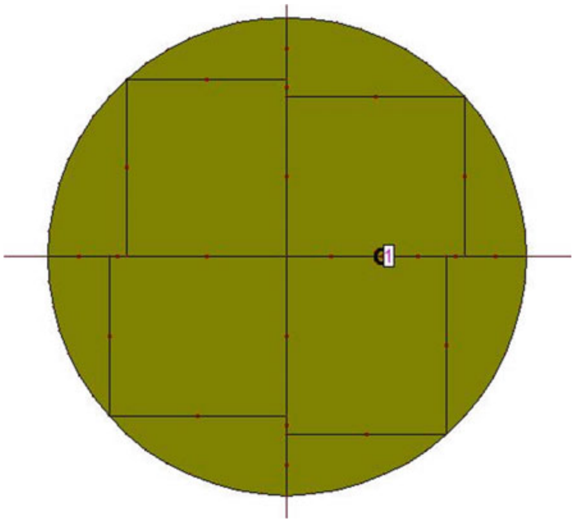
In this study, the properties of circular MPA and Annular Ring structure MPA are presented and compared. The designs have been simulated using the electromagnetic simulator, Zealand IE3D software.

2 Antenna Design

The conventional circular MPA is considered the reference antenna to compare the results that obtained from the proposed annular ring structure MPA. The geometry of the conventional circular MPA is shown in Fig. 1. The patch has the dimension of radius = 20 mm and is printed on FR4 of dielectric constant, $\varepsilon_r = 4.4$ and the thickness of the substrate, $h = 1.6$ mm. A coaxial probe is used to connect the microstrip patch at coordinates and it is made fixed for both the conventional and the proposed MPA. The coordinate of the feeding point is (8, 0).

The geometry of the proposed to extend the bandwidth probe-fed patch antenna with embedding slots and pi-shorted is shown in Fig. 2. Impedance bandwidth of 38.15% can be obtained from the modified geometry. Its main advantage of this structure is that it produces wider bandwidth than the conventional circular patch with a single and simple topology. The feeding point and the shorted-pin coordinates are (−9.6, −8.5) and (9.6, 8.2), respectively.

Fig. 1 Conventional CPA



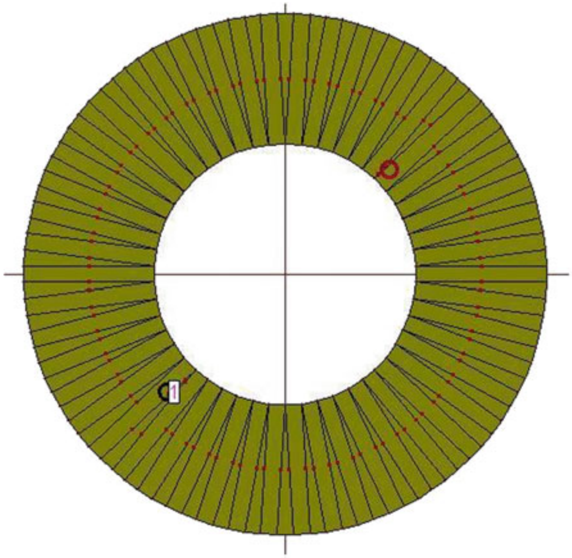


Fig. 2 Pin-shorted annular ring MPA

3 Simulated Results

3.1 Return Loss (S_{11}) and Impedance Bandwidth

The temp the Return Loss (S_{11}) shown in Fig. 3 of the conventional CPA is −21.46 dB

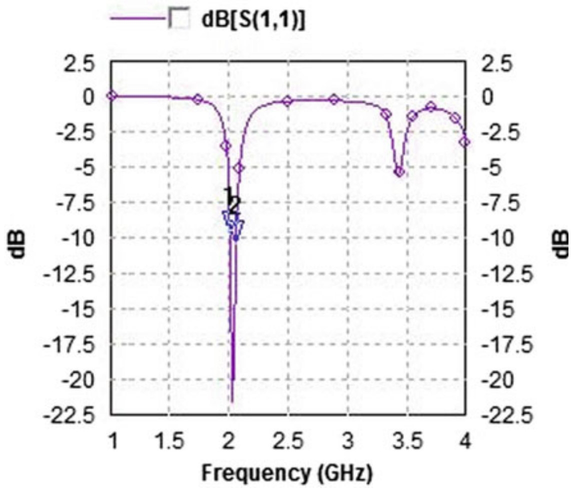


Fig. 3 Return loss (S_{11}) for conventional CPA

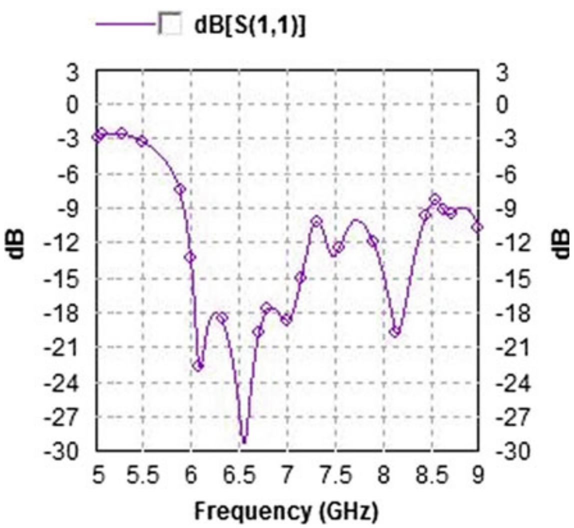


Fig. 4 Return loss (S_{11}) for pin-shorted annular ring MPA

at Resonating frequency at 2.03 GHz and the bandwidth obtained is 2.61%. For Pin-Shorted Annular Ring MPA the Return Loss (S_{11}) is −29.24 dB at 6.5 GHz and the bandwidth obtained is 38.15% which is shown in Fig. 4.

The BW of a patch antenna is calculated from the equation

$$BW = (f_h - f_l) * 100/f_r$$

where

f_h Higher Frequency at −10 dB Return Loss
f_l Lower Frequency at −10bB Return Loss
f_r Resonating Frequency of the antenna at the lowest Return Loss.

3.2 Radiation Pattern

The microstrip antenna radiates normal to its patch surface. So, the elevation pattern for $\varphi = 0$ and $\varphi = 90$ degrees are important for the measurement. The simulated E-plane and H-plane pattern, 2D pattern view the conventional CPA and the proposed pin-shorted annular ring MPA are illustrated in Figs. 5 and 6, respectively.

3.3 Other Parameters

Positioning The Comparative study of a conventional CPA and Annular Ring MPA with and without pin-short after the simulation is given in Table 1.

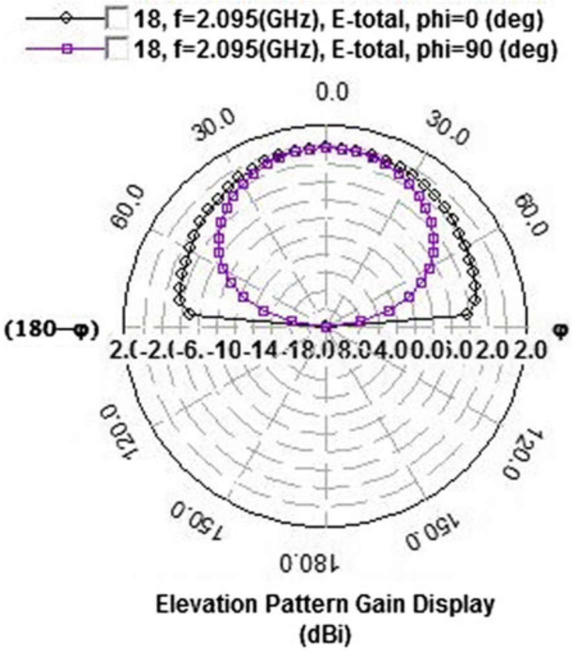


Fig. 5 Radiation pattern for conventional CPA

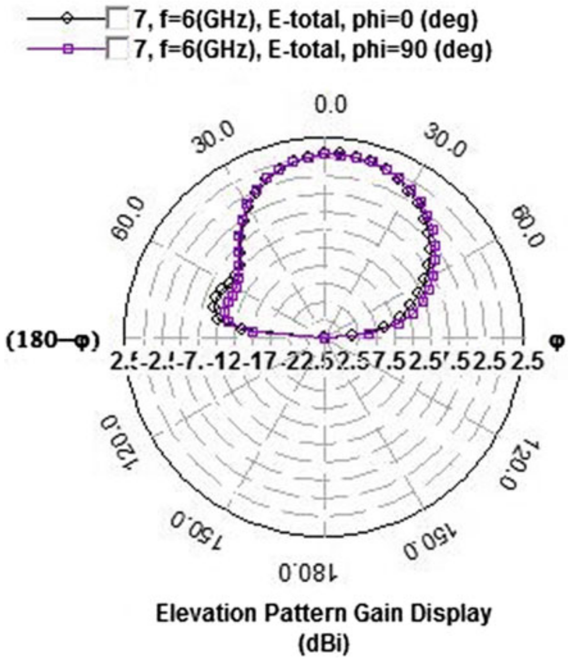


Fig. 6 Radiation pattern for pin-shorted annular ring MPA

Table 1 Comparative results

S. No.	Parameter	Conventional CPA	Annular ring without pin-short	Annular ring with pin-short
1.	Gain (dBi)	−1.57	6.12	3.1
2.	Antenna efficiency (%)	18.44	39.74	38.15
3.	Impedance (Ω)	$55.3 + 8.5i$	49.66–0.59i	$47.35 + 2.05i$

4 Conclusion

The Pin-Shorted Annular Patch MPA is observed to have acquired the highest bandwidth and also the bandwidth has increased by 14.6 times than the conventional CPA. Considerable enhancement in gain from −1.57 to 3.1 dBi is detected, while the impedance of both nearly matched. Due to the insertion of a circular slot and pin-shorting technique, most of the parameters improved including a drastic enrichment observed in the Return Loss (S_{11}). These factors led to a change in current density on the circular patch and the path was also increased, hence the resonating frequency of the antenna changes from 2.03 to 6.5 GHz.

Thus, on modifying the conventional CPA the proposed circular annular ring patch antenna provided superior bandwidth of 38.15%. Also, the antenna was detected to remain stable over the entire bandwidth and finally, the most beneficial part is this antenna can be used for C-band applications.

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