An Annular-Ring Microstrip Patch Antenna for Multiband Applications

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***Abstract*—In this paper, an annular-ring microstrip patch antenna is designed and simulated using IE3D (electromagnetic simulation and optimization simulator based on MoM). The antenna is designed for dualband operation in frequency range from 4.5GHz to 9.2GHz. By introducing slots on a circular patch, a multiband antenna can be defined. The performance parameters of proposed annular-ring microstrip patch antenna such as return loss, gain, radiation pattern, bandwidth etc. are examined and a comparison is made with conventional circular microstrip patch antenna. The proposed antenna shows dual band behavior with return loss less than -19dB, VSWR <1.5 and good directivity.**

Keywords—Microstrip patch, circular, annular-ring, dualband, IE3D.

I. Introduction

Microstrip patch antennas has gained lot of interest in recent years and are being used for various wireless applications owing to their advantages like inexpensive, compact, lightweight, ease of fabrication etc. However, the microstrip patch antenna has low gain and narrow bandwidth [1] and since, a simple microstrip patch antenna resonates at a single frequency, a different antenna is required for different application.

To overcome these limitations, different techniques have been suggested such as use of SMA pin at the center of the microstrip patch antenna has introduced a second resonant frequency [2], with desired omnidirectional radiation pattern. By increasing the dimensions of rectangular stacked microstrip antenna with five patches stacked over a driven patch, decreases the VSWR of both upper and lower resonant frequency[3]. By varying the dimensions of length and width of L-shaped strip placed inside an annular-ring microstrip patch antenna [4], both antenna impedance and lower resonant frequency has been optimized.

Good return loss and improved gain has been achieved by loading a complementary split ring resonator (CSRR) in a rectangular microstrip patch antenna [1]. For dualband response, a high-permittivity section-spherical dielectric has been used as superstrate layer for circular microstrip antenna [5]. The first resonance is due to the presence of superstrate layer and second is due to circular microstrip patch. The dimension and position of duo-triangular shaped probe-fed microstrip patch antenna have been optimized to achieve bandwidth enhancement [6].

Dual-band characteristics with desired bandwidth have been obtained by fabricating a fork-shaped patch on one side of substrate and a rectangular ground plane on the other side of substrate [7]. To design circular microstrip patch antenna with 50ohm input impedance, both S and Z parameters have its dependence on the dimensions of circular patch and value of dielectric constant [8]. In addition, a center-fed circular microstrip antenna with a coupled annular-ring has attractive low profile configuration with height of 1.5mm and monopole like radiation pattern.

In this paper, firstly a circular microstrip patch antenna is designed which is further integrated to an annular-ring shaped design, to improve different parameters such as return loss, directivity etc. with multiband behavior.

II. Proposed Antenna Design

A circular patch with radius of 7mm on FR4 substrate with relative permittivity 4.3, substrate thickness of 1.47mm as shown in Fig. 1 has been designed. To improve the performance of circular microstrip patch antenna, an annular-ring design is integrated on the circular patch. Fig. 2 shows annular-ring microstrip patch antenna.

The annular-ring with inner radius 4.5mm and outer radius 7mm is etched on FR4 substrate with same specifications. A rectangular slit of length 2.6mm and width 1mm is cut at one side to further perturb the structure. For excitation of both structures, probe feed is used. The proposed antennas have been simulated using Zeland IE3D software package.

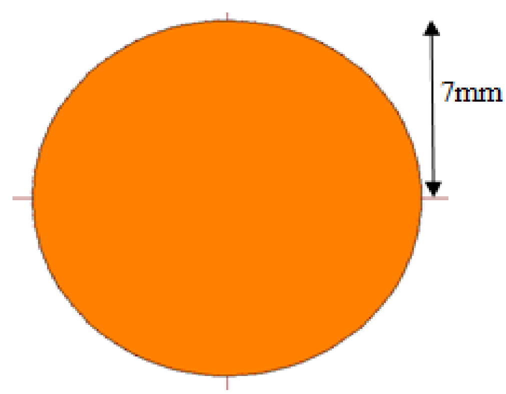

Fig. 1: Circular Microstrip Patch Antenna

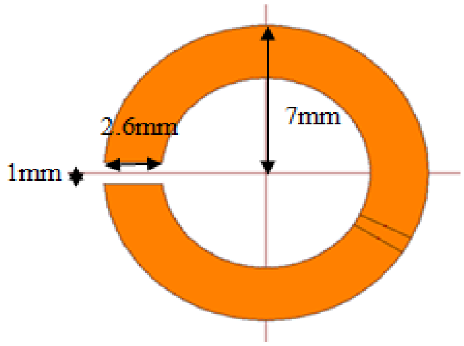

Fig. 2: Annular-Ring Microstrip Patch Antenna

III. RESULT AND DISCUSSION

The designed circular microstrip patch antenna and annular-ring microstrip patch antenna are analyzed in terms of return loss, 2D radiation pattern, VSWR (Voltage standing wave ratio) and directivity parameters and a comparison is made between them.

Firstly, the simulation results for circular microstrip patch antenna are discussed. The return loss versus frequency for circular microstrip patch antenna is shown in Fig. 3. From the figure, it is clear that antenna radiates at 5.72GHz with a return loss of -14.76dB. The bandwidth of this antenna is 233MHz.

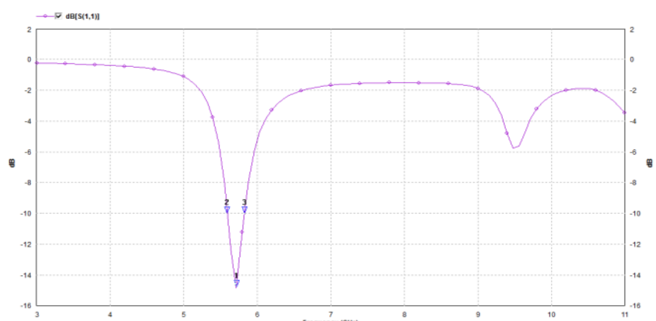

Fig. 3: Return loss of Circular Microstrip Patch Antenna

Fig. 4 and Fig. 5 respectively show the 2D radiation pattern of circular microstrip patch antenna. From elevation and azimuthal pattern gain display, gain of 3.61dBi is observed.

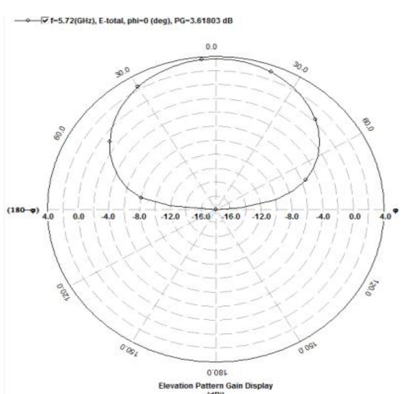

Fig. 4: Elevation Pattern Gain Display of Circular Microstrip Patch Antenna

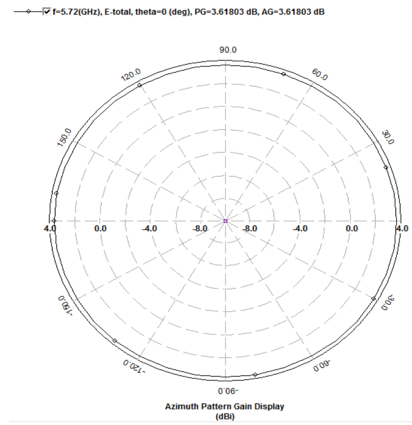

Fig. 5: Azimuthal Pattern Gain Display of Circular Microstrip Patch Antenna

Directivity of 6.67dBi at 5.72GHz is observed in Fig. 6 for circular microstrip patch antenna.

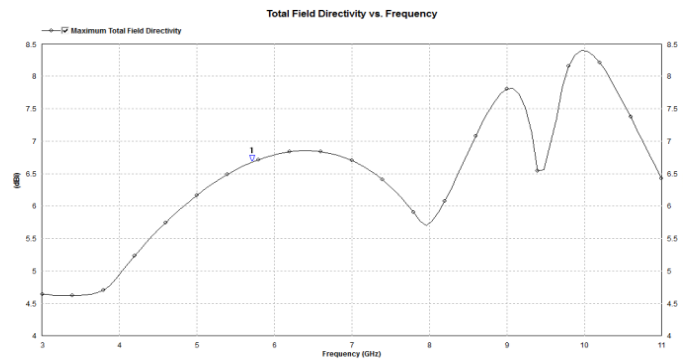

Fig. 6: Directivity of Circular Microstrip Patch Antenna

For circular microstrip patch antenna, VSWR of 1.44 is observed at resonant frequency of 5.72GHz as shown in Fig. 7.

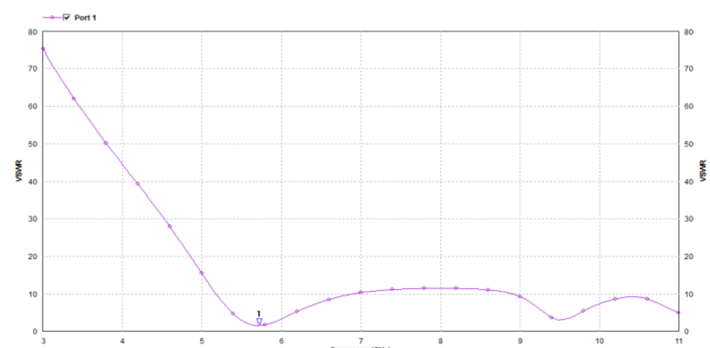

Fig. 7: VSWR of Circular Microstrip Patch Antenna

Now, the simulation results for annular-ring microstrip patch antenna are discussed. First are the return loss characteristics of annular-ring microstrip patch antenna. The return loss versus frequency graph show that the antenna resonates at two resonant frequencies viz. 4.62GHz and 9.05GHz showing dual band behavior with return loss: -19.70dB and -20.83dB respectively as shown in Fig. 8. Bandwidth of 102MHz and 292MHz is observed at these resonant frequencies.

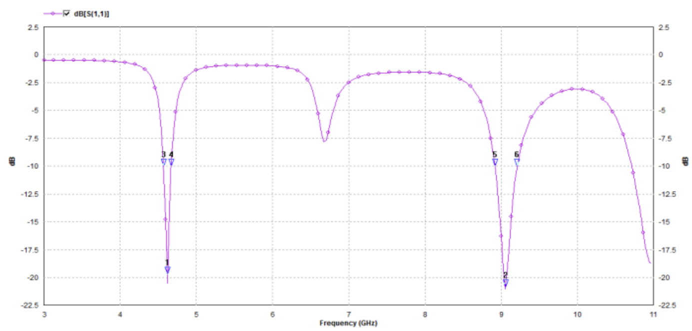

Fig. 8: Return loss for Annular-Ring Microstrip Patch Antenna

Fig. 9 and Fig. 10 respectively show 2D radiation pattern-elevation and azimuthal pattern gain display of annular-ring microstrip patch antenna. From the 2D radiation pattern, gain of 1.92dBi and 0.75dBi is observed at resonant frequencies of 4.62GHz and 9.05GHz.

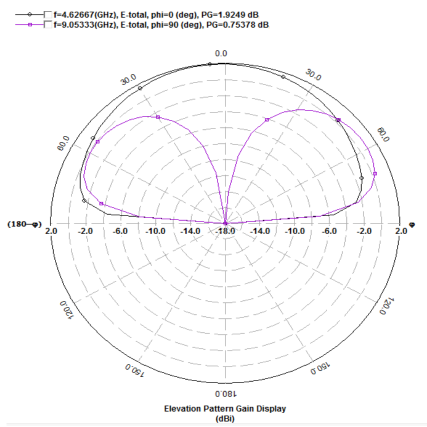

Fig. 9: Elevation Pattern Gain Display for Annular-Ring Microstrip Patch Antenna

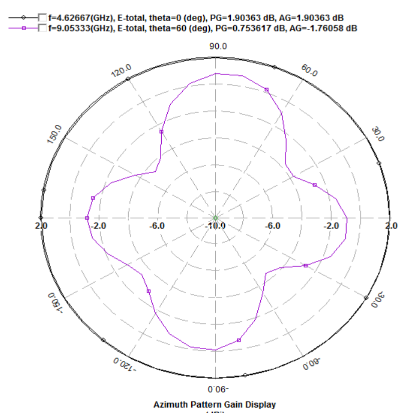

Fig. 10: Azimuthal Pattern Gain Display for Annular-Ring Microstrip Patch Antenna

For annular-ring microstrip patch antenna, maximum directivity of 6.51dBi and 7.12dBi is observed at the resonant frequencies as shown in Fig. 11.

VSWR of 1.24 and 1.20 is observed at resonant frequencies of 4.62GHz and 9.05GHz as shown in Fig. 12.

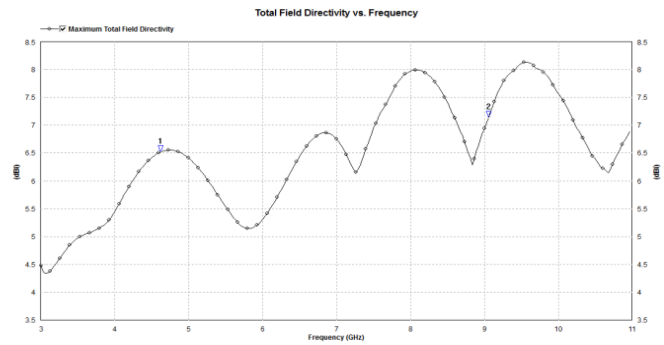

Fig. 11: Directivity of Annular-Ring Microstrip Patch Antenna

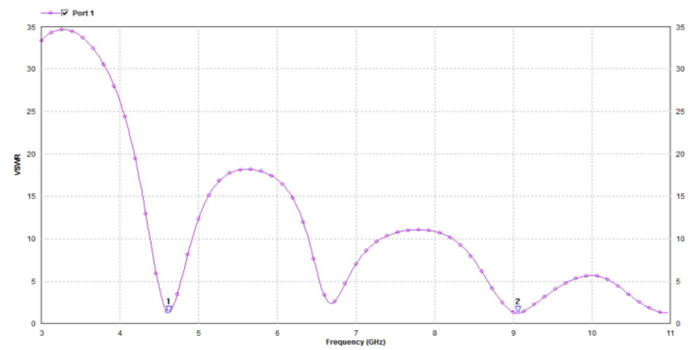

Fig. 12: VSWR of Annular-Ring Microstrip Patch Antenna

Comparison of circular microstrip patch antenna and annular-ring microstrip patch antenna in terms of performance parameters is given in Table 1. As compared to circular microstrip patch antenna, annular-ring microstrip patch antenna shows dual band operation with improved return loss characteristics.

Table 1. Comparison of Circular Patch and Annular-Ring Microstrip Patch Antenna

Parameters	Circular Microstrip Patch Antenna	Annular-Ring Microstrip Patch Antenna	
Resonant Frequency	5.72GHz	4.62GHz	9.05GHz
Return Loss	-14.76dB	-19.70dB	-20.83dB
Gain	3.61dBi	1.92dBi	0.75dBi
Bandwidth	233MHz	102MHz	292MHz
Directivity	6.67dBi	6.51dBi	7.12dBi
VSWR	1.44	1.24	1.20

IV. CONCLUSION

In this paper, a detailed study of circular microstrip patch antenna and annular-ring microstrip patch antenna is presented. After the introduction of slots on circular microstrip patch antenna, return loss improves from -14.76dB to less than -19dB with addition of two resonant frequencies at 4.59GHz and 9.05GHz with acceptable values for all antenna parameters. For annular-ring microstrip patch antenna, VSWR is < 1.5 and within acceptable level. The annular-ring microstrip patch antenna is an interesting configuration for use in dualband wireless applications.

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