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Design of Inset-Fed Penta-Band Circular Microstrip Antenna for Wireless and X-band Communication

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ABSTRACT:In this paper, a novel inset-fed circular microstrip antenna embedding an elliptical split ring slot is designed using Ansys HFSS software and studied practically. The proposed antenna is fabricated on commercially available low cost FR-4 substrate with relative permittivity of 4.4 having physical size of 55.4 × 44 × 1.6 mm^3. The narrow elliptical split ring slot engraved at the middle of the radiating patch is optimised and the antenna resonates at five frequencies of 2.33, 3.44, 8.13, 8.67 and 10.09 GHz with -10dB impedance bandwidths of BW_1= 2.57% (2.30-2.36 GHz), BW_2=3.19% (3.38-3.49 GHz), BW_3= 5.78% (8.36-7.98 GHz), BW_4=1.96% (8.59-8.76GHz) and BW_5=12.48% (9.42-10.68GHz). The proposed antenna shows a broadside radiation characteristic with a maximum gain of 7.18 dB.This antenna finds application in wireless and X-band radar communication.

KEYWORDS:inset-fed, elliptical split ring, impedance bandwidth, penta-band antenna, wireless communication.

I.INTRODUCTION

In the present day communication, antenna covers a very large range of application in various areas, like mobile communication, internet service, satellite navigation, automobiles and radars. Particularly, they are applied to microstrip antennas (MSA) due to their characteristics like low profile, light weight, low cost and low power handling capacity [1-4].

The MSAs are becoming one of the essential candidates for both military (satellites, spacecraft and guided missiles) and commercial applications (wireless communication systems and mobile technology) [5-10]. Since then, the rapid advancement of microstrip antenna technology taking place in personal wireless communication technologies such as global positioning satellite (GPS) transmitters, Wireless Local Area Network (WLAN), Bluetooth gadgets and demands an inter connectivity of more than one frequency band into a single compact planar design. To overcome this major problem, low cost compact planar multiband microstrip antennas with acceptable radiation characteristics are required [11]. Usually, the structure of the conducting radiating patch of the antenna can be of any shape. In general, rectangular, elliptical, square, circular, triangular, polygon and annular ring shapes are considered for antenna design [12-15]. In the last few years, development of planar microstrip antennas for dual and triple-band frequency operations to cover the GPS, DSC, WLAN-IEEE bands is made. But the ability to provide an antenna with small size is an important requirement for the design and development of multiband operations.

In this paper, we present a novel inset-fed circular microstrip antenna engraved with narrow elliptical split ring slot at the top side of the radiating patch. The proposed antenna is designed to work for penta-band operation covering wireless and X-band radar communication. The details of the proposed antenna design, simulation and experimental results are presented and discussed in next sections.

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II. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed inset-fed circular microstrip antenna with embedding an elliptical split ring slot. The proposed antenna is designed by using low cost glass epoxy FR4 dielectric material with relative permittivity (ε_r) of 4.4 with thickness (h) of 1.6mm is chosen. The circular radiating patch with radius R=11.5 mm is fed by simple 50Ω inset-fed having dimensions of length L_f=17.18 mm and W_f= 3.17 mm on the top side of the substrate and bottom of the substrate as ground plane with L_g = 55.4 mm and W_g= 44 mm. For a better impedance matching between radiating patch and simple 50Ω inset-fed microstrip feed-line with width I_W= 1.53 mm and length of I_L= 5.78 mm are chosen to achieve the optimum results.

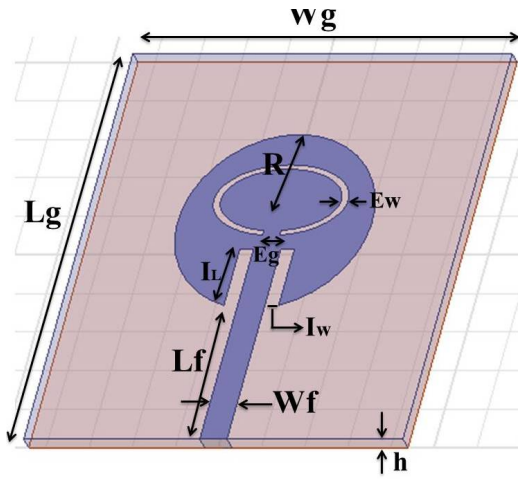

Fig. 1 Geometry of the proposed inset-fed circular microstrip antenna

Further, to achieve a penta-band operation, a narrow elliptical split ring slot is embedded on the circular radiating patch with E_w= 0.57 mm and E_g= 2 mm of length in terms of λ_0. The prototype of the proposed antenna model is designed by using commercial available Ansys HFSS electromagnetics simulation tool [16]. The optimized antenna parameters and dimensions are given in Table I.

Table I: Optimized dimensions and parameters of the proposed antenna

Antenna parameters	**W**	**L**	**R**	**W_f**	**L_f**	**E_w**	**E_g**	**I_W**	**I_L**	**h**
Dimensions (mm)	55.4	44	11.5	3.17	17.18	0.57	2	1.58	6.98	1.6

III.RESULTS AND DISCUSSION

The parameters of the proposed antenna are measured using Vector Network Analyzer (VNA) (Rhode and Schwarz, Germany make ZVK model 1127.8651). Fig. 2 shows the comparison of simulated and measured return loss characteristics of the proposed antenna. From this figure it is clear that, the proposed antenna resonates for five different frequency points of fr1, fr2 , fr3,fr4 and fr5 with -10 dB return loss with impedance bandwidths of BW_1= 2.57% (2.30-2.36 GHz), BW_2= 3.19% (3.38-3.49 GHz), BW_3= 5.78% (8.36-7.98 GHz), BW_4=1.96% (8.59-8.76 GHz) and BW_5=12.48% (9.42-10.68 GHz) respectively.

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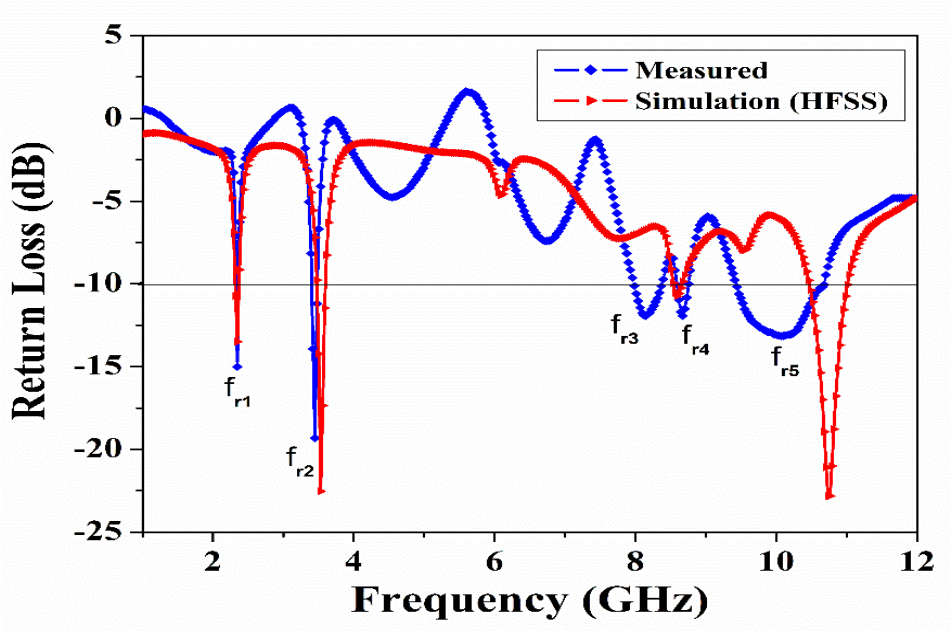
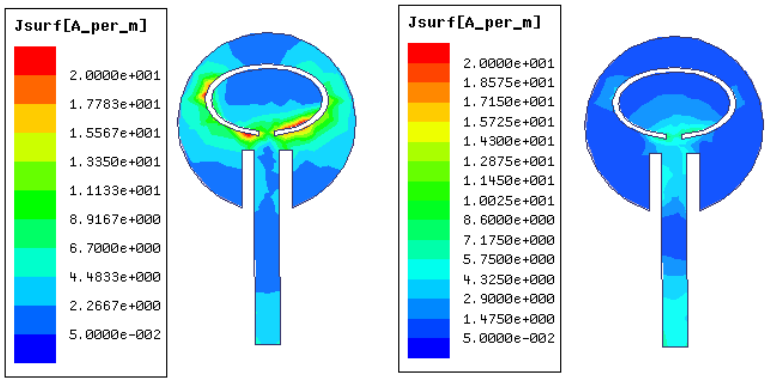


Fig. 2 Comparison of simulated and experimental return loss characteristics of proposed antenna

For better understanding the multi-band characteristics of the proposed antenna, the surface current distribution is discussed. Fig. 3(a) - 3(e) shows a simulated surface current distribution on the radiating element of the proposed antennas observed at 2.33, 3.44, 8.13, 8.67 and 10.09 GHz. The different colours represent different magnitudes of the current on the radiating patch. From the Fig. 3(a) it is observed that the more current is accumulated around the elliptical split ring slot except the radiating patch. This phenomenon leads to confirm that the good virtual size reduction of the proposed antennas.



(a) (b)

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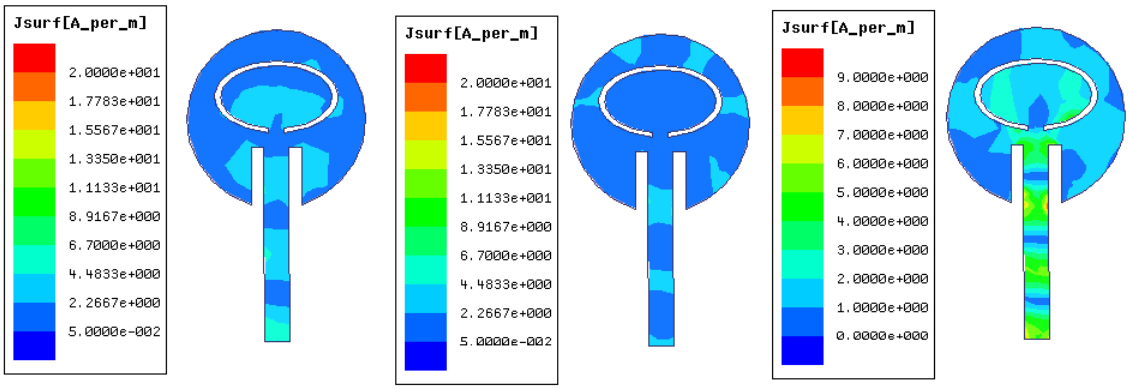
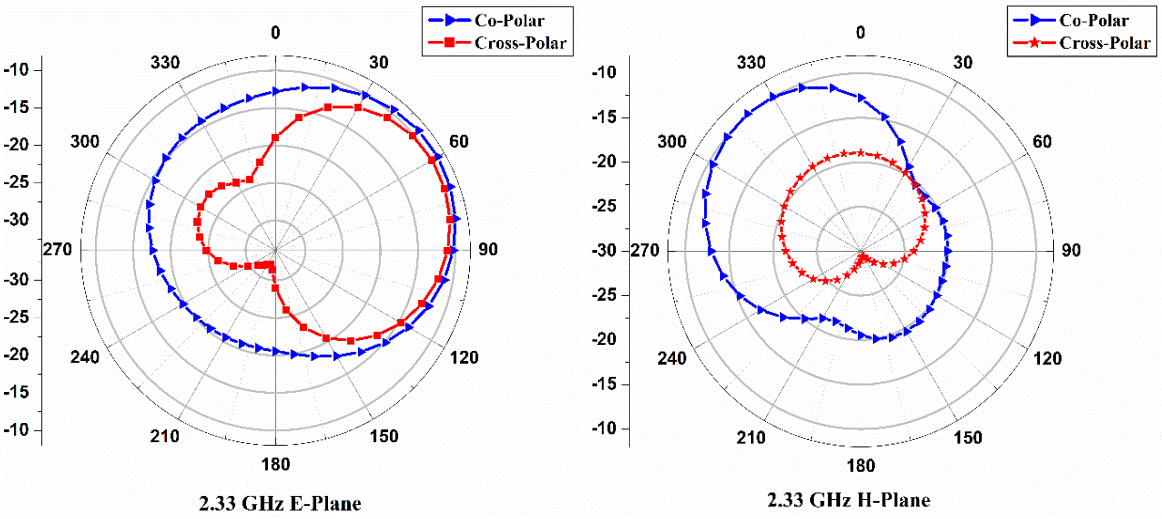


(c) (d) (e)

Fig. 3Simulated surface current distributions of the proposed penta-band antenna observed at (a) 2.33 GHz, (b) 3.44 GHz, (c) 8.13GHz, (d) 8.67 GHz and (e) 10.09 GHz

The desired normalized co-polarization and cross- polarization plots in both E-plane and H-plane radiation patterns at the resonating frequencies of the proposed antenna are shown in Fig. 4(a)-(e). The radiation patterns are observed to be broadside in nature and linearly polarized at respected resonating frequencies. Also the proposed antenna exhibits similar radiation characteristics in its remaining operating bands.



(a)

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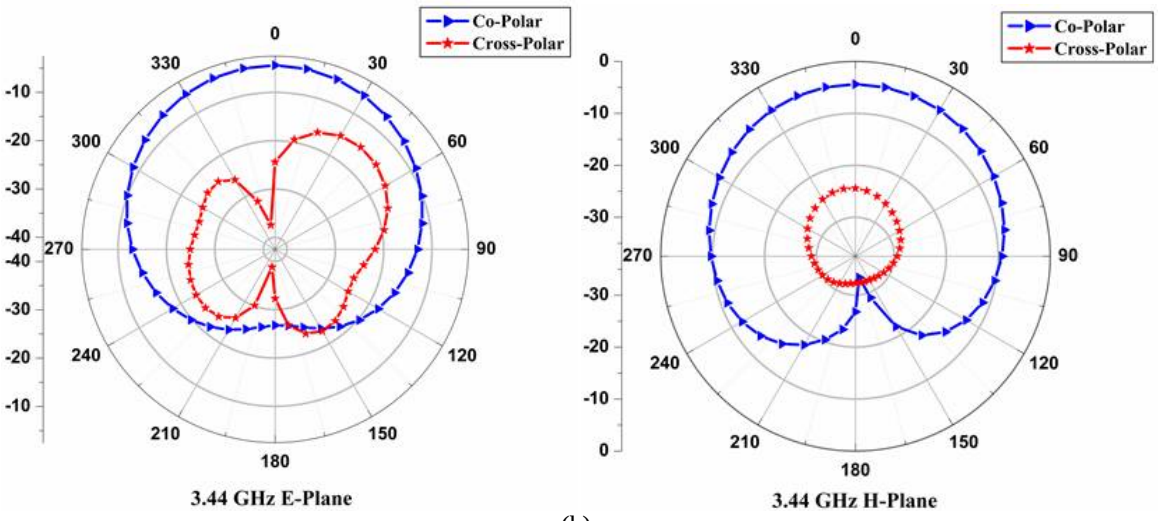
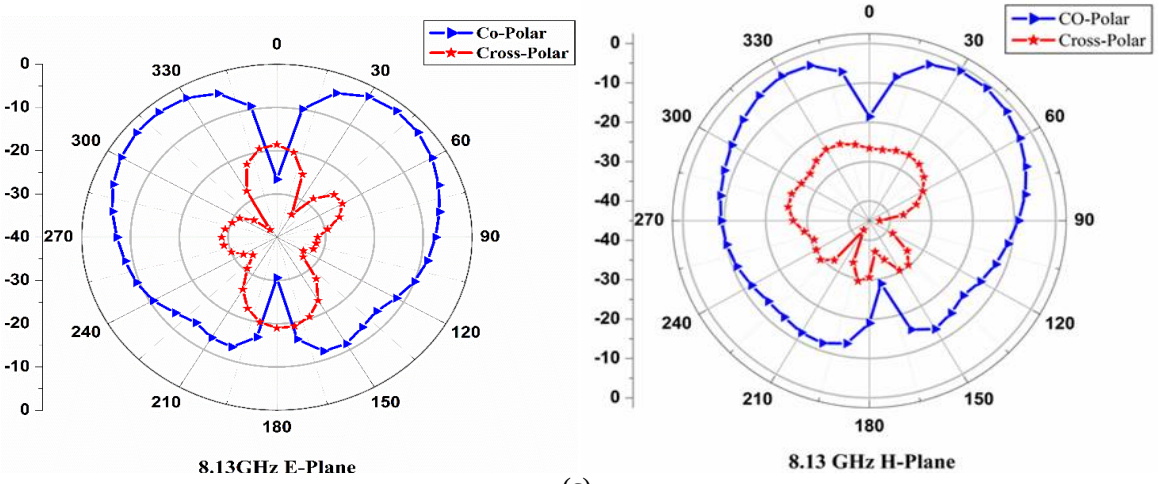
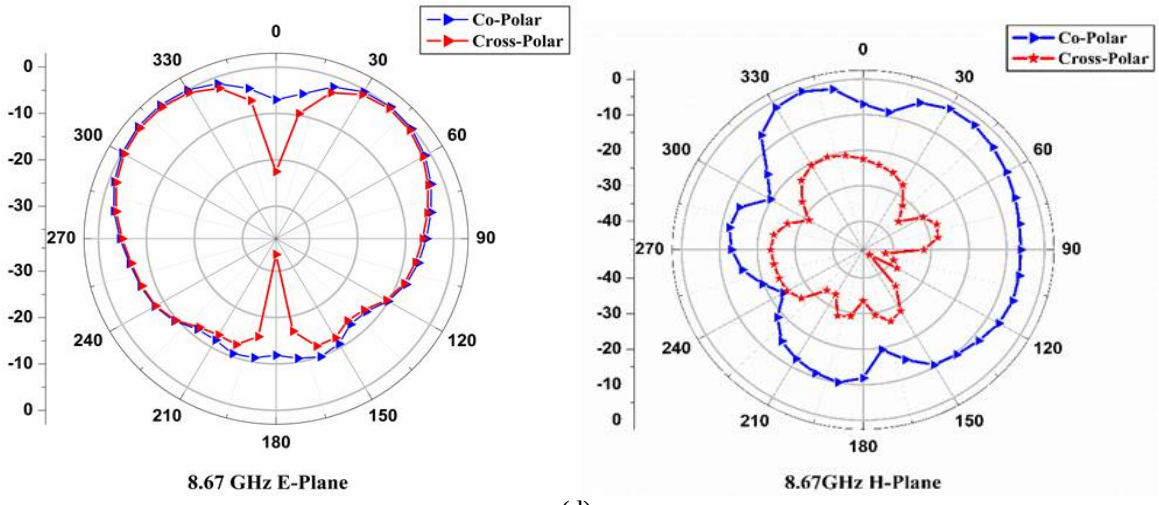


(b)



(c)



(d)

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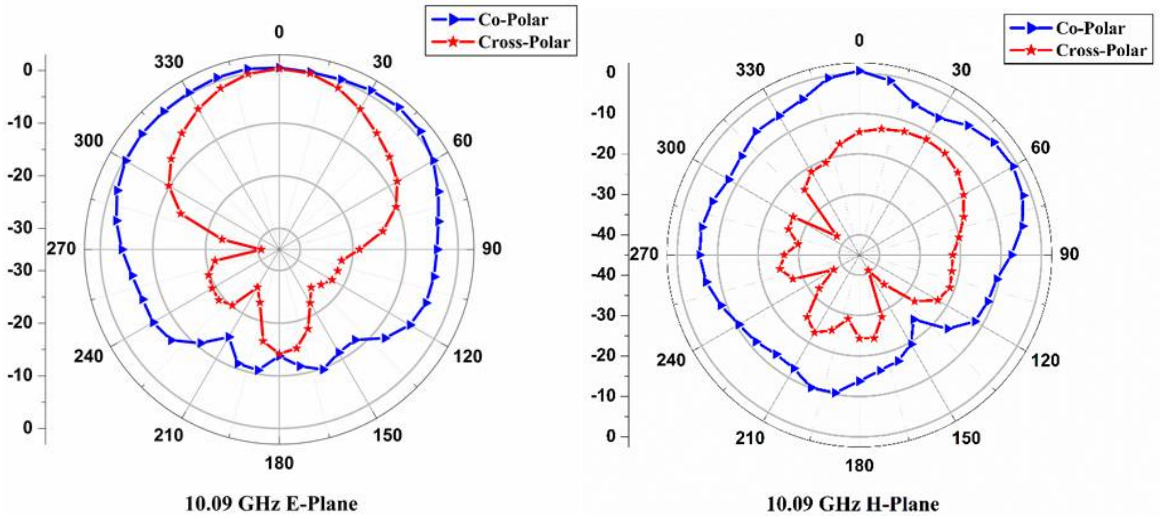

(e)

Fig. 4 Typical co-polarization and cross- polarization in E-plane and H-plane radiation patterns of the proposed antenna measured at (a) 2.33 GHz, (b) 3.44 GHz, (c) 8.13GHz, (d) 8.67 GHz and (e) 10.09 GHz

IV. CONCLUSION

A design of novel inset-fed circular microstrip antenna embedding an elliptical split ring slot is studied for penta-band frequency application. From the detailed experimental study, it is concluded that, a simple elliptical split ring slot at the radiating circular patch makes the antenna to operate for penta-band of frequencies with a maximum bandwidth of 12.8%. The proposed antenna shows broadside radiation pattern characteristic with a maximum gain of 7.18 dB. The proposed antenna is simple in its construction and is a low cost. Hence, the proposed antenna may finds application in wireless and X-band radar communications.

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