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Design and Development of Pentagon Slot Loaded Microstrip Antenna for Size Reduction

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Abstract: This article describes a novel design and development of pentagon slot loaded rectangular microstrip antenna (PSRMA). This antenna operates for the frequency range from 2.76 to 9.40 GHz and showing 34.38% size reduction and exhibits broadside linearly polarized radiation characteristics. The proposed antenna is fabricated using low cost FR4 substrate material and is excited through 50 Ω microstrip line. The simulated and experimental results are in good agreement with each other. The proposed antenna satisfies the -10dB impedance bandwidth requirements covering WLAN, Wi-MAX and Radar applications.
Keywords: Pentagon, Slot loaded, size reduction, WLAN and Wi-MAX.

I. INTRODUCTION

Emerging trends in microwave communication systems often require antennas with compact size, light weight, simple in design, low cost robustness, and capable of operating more than one band of frequencies[1-2]. Modern antennas for mobile devices, especially mobile phones, must support multiple wireless services that are transmitted over different frequency bands (e.g. GSM, Bluetooth, Wi-Fi, and GPS). The microstrip antenna concept and structure of microstrip antennas including with a different types of feeds are reviewed. Numbers of investigations have been reported in the literature for dual, triple and multiband operations [3-6]. Further, the antenna can also available for wide band with miniaturised hexagonal surface and broadband with reduction of rectangular radiating patch [7-8]. It is found to be rare in the literature that the use of pentagonal slots on the patch geometry to achieve multi-resonance behavior and reduction of actual copper size of the radiating patch.

II. ANTENNA DESIGN

The proposed antenna is designed using a low cost glass epoxy substrate material of area X x Y having a thickness h = 0.16 cm with dielectric constant ε_r = 4.2. The artwork of this antenna is sketched using computer software AutoCAD to achieve better accuracy.

Figure 1 shows the top view geometry of conventional rectangular microstrip antenna (CRMA) designed for 3.2 GHz of frequency. The antenna consists of a radiating patch of length L and width W. The antenna is excited through a simple microstrip line feed of length L_f and width W_f. A 50Ω semi miniature connector is used to feed the microwave power. The quarter wavelength transformer of length L_t and width W_t is used to match the impedance between central feed point and microstrip line feed.

The design parameters of the proposed antenna are given in Table 1.

Table 1: Design parameters of PSRMA

Antenna Parameters	L	W	L_f	W_f	L_t	W_t	V
Dimensions in cm	2.24	2.91	2.183	0.317	1.372	0.078	0.58

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Figure 2 shows the top view geometry of PSRMA designed by incorporating pentagon slots in first and second quadrants and inverted pentagon slots in third and fourth quadrants of the rectangular radiating patch. The dimension of vertex V of the pentagonal slot is also shown in Table 1.

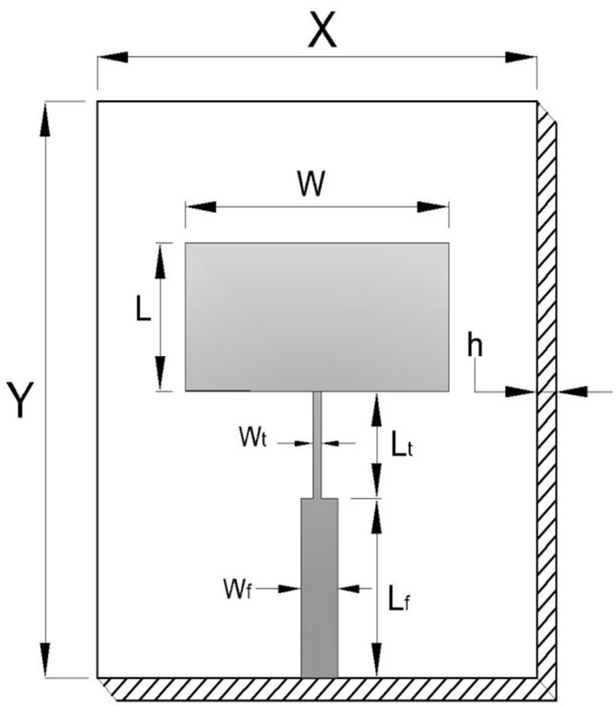

Fig. 1 Top view geometry of CRMA

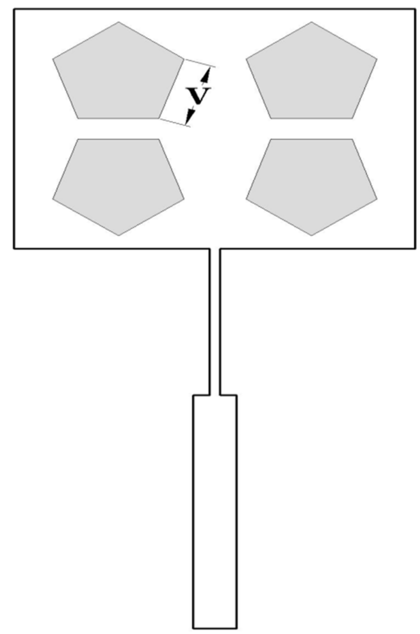

Fig. 2 Top view geometry of PSRMA

III. RESULTS AND DISCUSSION

The simulation of the proposed antenna is carried out by using Ansoft electromagnetic 3D-tool. The fabricated antenna bandwidth over return loss less than -10 dB is measured experimentally by using Vector Network Analyzer (Rohde & Schwarz, Germany make ZVK model 1127.8651). The experimental bandwidth is calculated by using the formula,

$$BW= (f_H – f_L/ fr)*100\% \quad (1)$$

where f_H and f_L are upper and lower cut off frequencies respectively, when its return loss reaches -10 dB and fr is the resonance frequency between f_H and f_L.

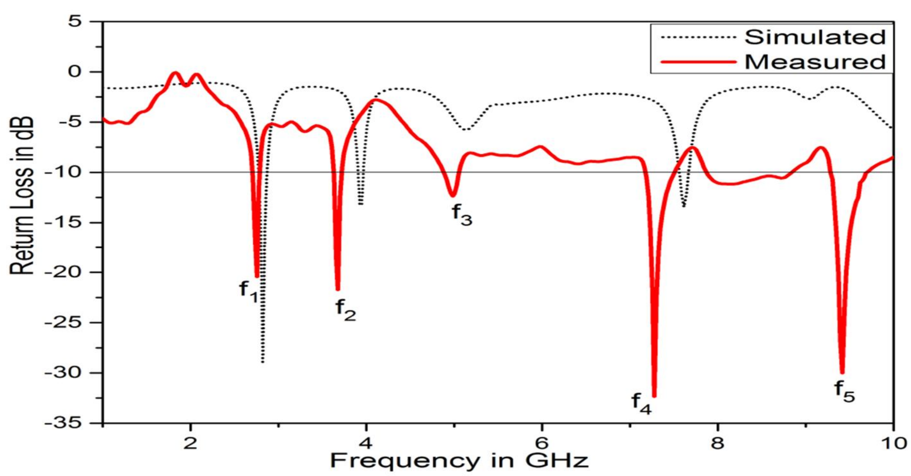

Fig. 3 Variation of return loss versus frequency

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The variation of return loss versus frequency of PSRMA is as shown in Figure 3. From this figure it is observed that, the antenna operates for five frequency bands i.e., BW_1 (2.79 - 2.69 GHz) = 3.62%, BW_2 (3.71 - 3.62 GHz) = 2.44% , BW_3 (5.06 - 4.85 GHz) = 4.20% , BW_4 (7.50 - 7.16 GHz) = 4.67% and BW_5 (9.68 - 9.28 GHz) = 4.25% for the resonating frequencies of f_1, f_2 , f_3, f_4 and f_5 respectively. The minimum return loss obtained for proposed antenna are -20.47 dB, -21.54 dB, -12.3 dB, -32.32 dB and -30.00 dB respectively. These frequency bands are due to independent resonance of the patch and pentagon slots on the radiating patch. The BW_1 is considered as primary band because its resonating frequency f_1 (2.76 GHz) is close to f_r (2.98 GHz) of CRMA. Further, it is seen from Figure 3 that, the simulated result of PSRMA is also shown, which is in good agreement with experimental result. Hence, by placing the pentagon slots in all quadrants of the rectangular patch the antenna is made to operate for penta bands.

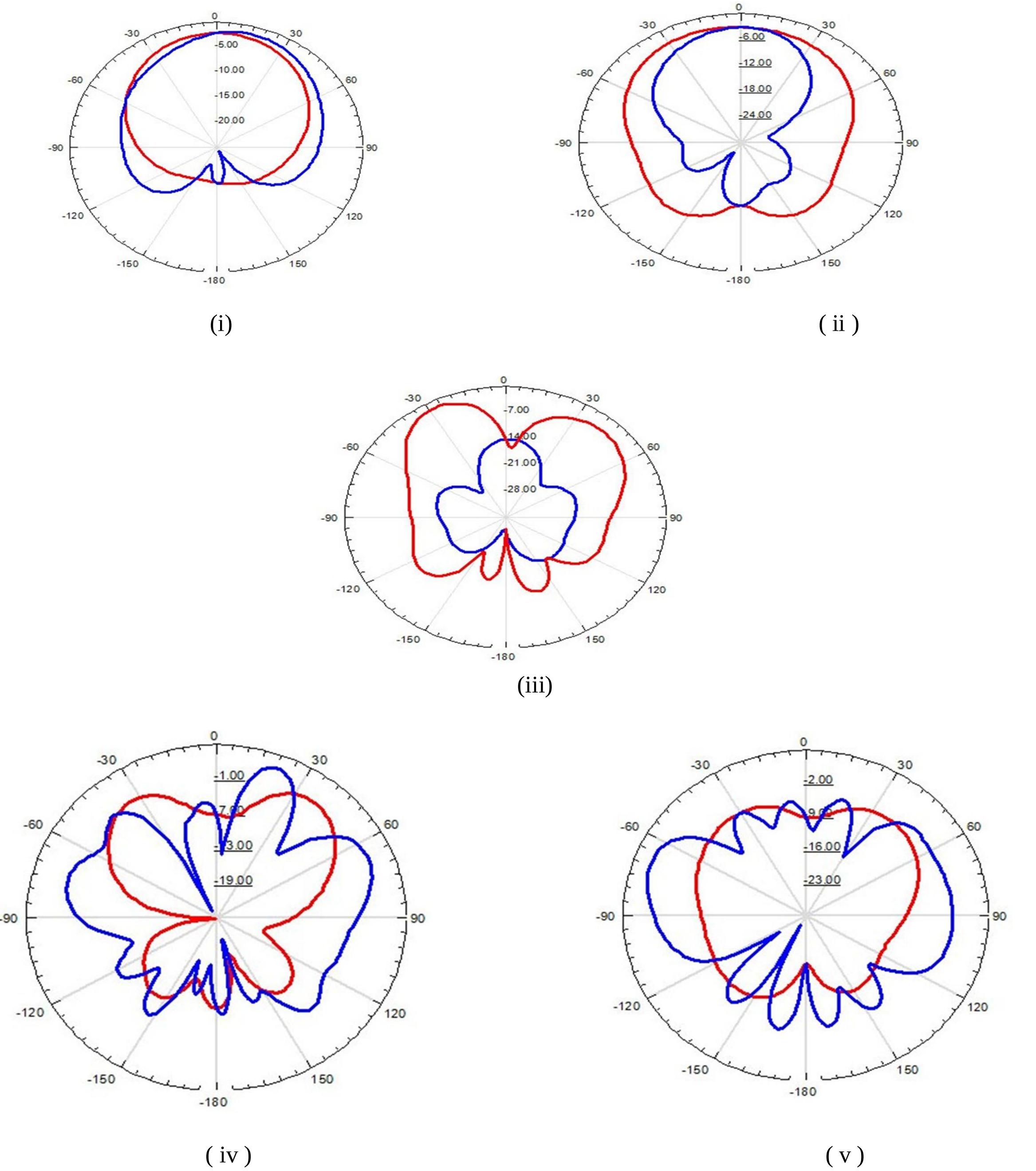

Fig. 4 E and H plane Radiation Patterns of PSRMA at (i) 2.76GHz, (ii) 3.69GHz, (iii) 4.99 GHz (iv) 7.27 GHz and (v) 9.40 GHz respectively

Figure 4 (i) to (v) shows E - Plane and H - Plane co-polar radiation patterns of PSRMA at 2.76 GHz, 3.69 GHz, 4.99 GHz, 7.27 GHz and 9.40 GHz respectively. From the figures it is seen that radiation patterns are broadside and linearly polarized.

IV. CONCLUSION

A novel design of proposed antenna is realized by CRMA which is capable of operating for penta bands from 2.76GHz to 9.40GHz with linearly polarized radiation characteristics. The proposed antenna gives copper size reduction of about 34.38%. This antenna may find application in WLAN, Wi-MAX and fourth generation mobile communication system as well as for radar.

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