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Effect of Pentagon Slot on Rectangular Microstrip Antenna

Jagadevi Gudda[1], P.M.Hadalgi[2]

Research Student, Department of PG Studies and Research in Applied Electronics, Gulbarga University, Kalaburagi, Karnataka, India[1]

Professor, Department of PG Studies and Research in Applied Electronics, Gulbarga University, Kalaburagi, Karnataka, India[2]

ABSTRACT: This paper presents the effect of pentagon slots on rectangular microstrip antenna. The proposed antennas operate for dual, triple and quad band as the pentagon slot is located at various quadrants of the rectangular patch without affecting the primary band. This antenna also gives the better gain of 5.99dB and exhibits broadside linearly polarized radiation characteristics. Simulated and experimental results are analyzed, presented and discussed.

KEYWORDS: Pentagon slot, rectangular microstrip antenna, dual, triple and quad band, gain.

I. INTRODUCTION

In the era of next generation networks we require a single antenna that can cover multiband frequencies. With the evolution of microstrip antenna, it is possible to approach applications requiring different frequencies can be operated simultaneously with only one antenna, which significantly reduces the size also [1 – 3]. Numerous methods and techniques have been reported by microstrip antenna designers for realizing dual, triple and quad band antennas. Dual band microstrip patch antennas for WLAN application using rectangular, triangular and pentagonal shapes of patch [4], ultra wideband antenna for high data applications [5], Hexagon shaped slot loaded unipolar microstrip antenna for virtual size reduction [6] etc. are found in the literature. But the design and development of pentagon slot loaded rectangular microstrip antenna for various band is found to be rare in the literature.

II. ANTENNA DESIGN CONSIDERATION

A low cost glass epoxy substrate material having a thickness h = 0.16cm with dielectric constant ε_r = 4.2 is used to design the proposed antenna. The artwork of this antenna is sketched using computer software AutoCad to achieve better accuracy.

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 impedances between Cp and microstrip line feed.

Figure 1 (a) to (c) shows the design configuration of the pentagon slot loaded rectangular microstrip antenna (PSRMA). The PSRMA is designed for 3.2 GHz of frequency of conventional rectangular microstrip antenna (CMRA) which is designed using Ansoft electromagnetic 3D – tool software.

A non inverted pentagon slot with vertices V is loaded in the second quadrant and inverted pentagon slot with same dimension is loaded in the third quadrant of the radiating patch respectively as shown in Figure 1 (a) and (b). Similarly Figure 1 (c) shows the rectangular patch loaded with non inverted and inverted pentagon slots simultaneously.

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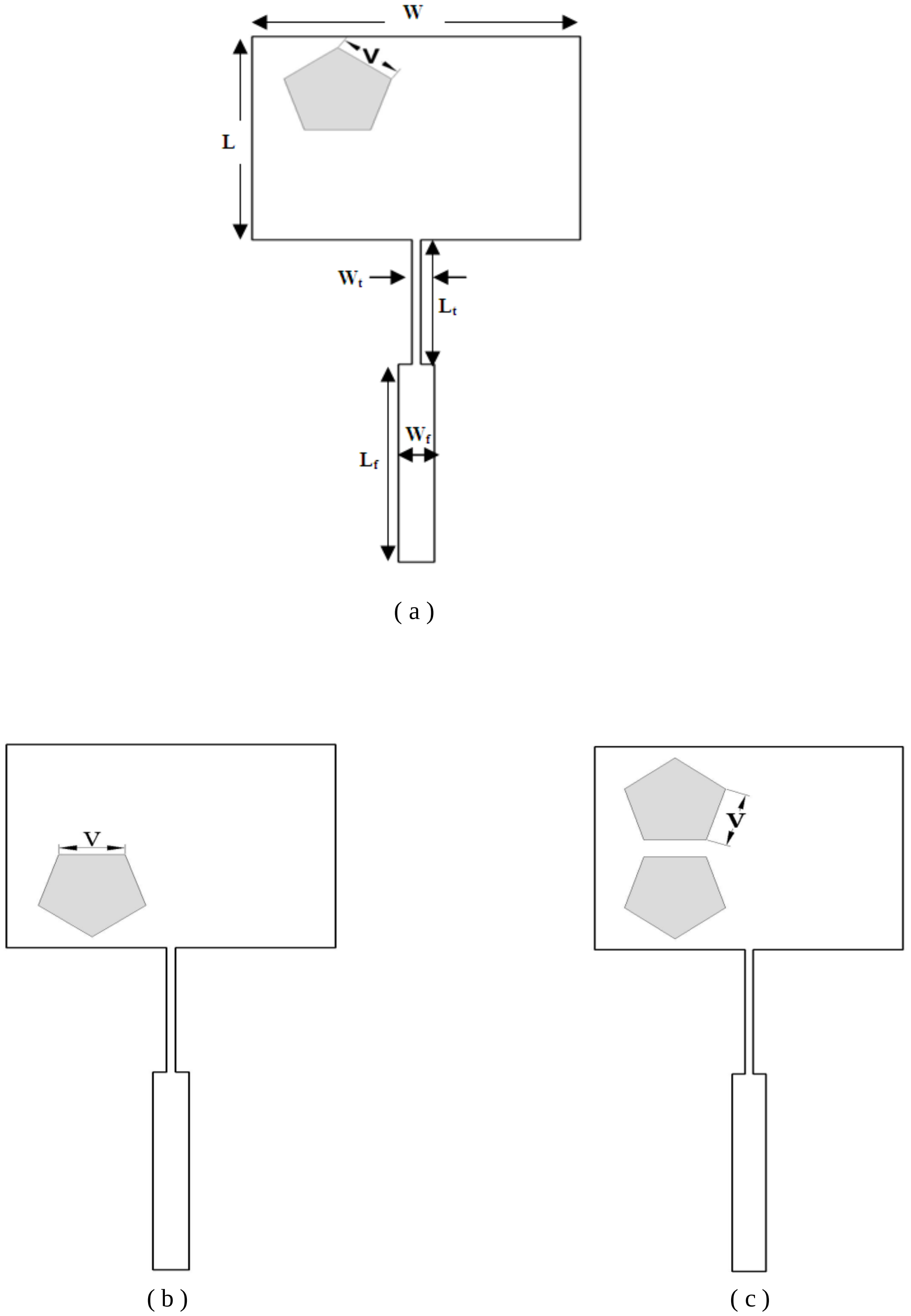

Fig. 1Geometry of PSRMA (a) when slot is loaded in the second quadrant, (b) when slot is loaded in third quadrant and (c) when slot is loaded both in second & third quadrants respectively.

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

Table-1 : Design parameters of PSRMA.

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

III. EXPERIMENTAL RESULTS AND DISCUSSION

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

$$BW = \left[\frac{f_H - f_L}{f_r}\right] \times 100\,\% \qquad (1)$$

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

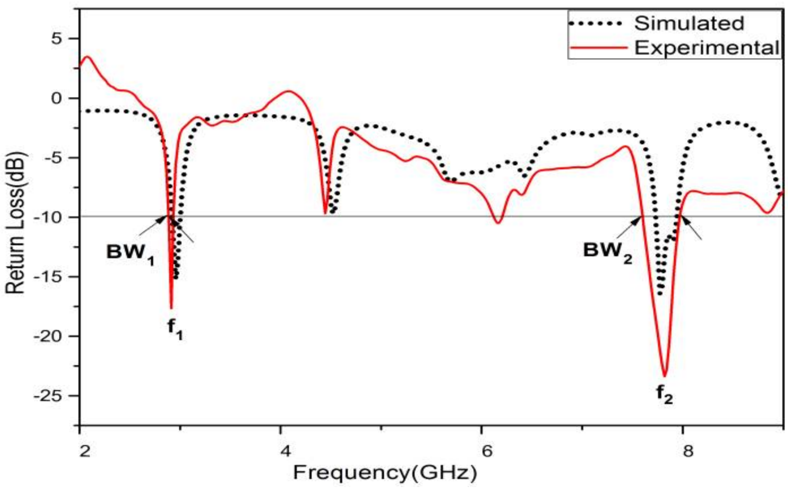

Fig.2 Return loss versus frequency of PSRMA when slot is loaded in the second quadrant

The variation of return loss versus frequency of PSRMA when non inverted pentagon slot is loaded in second quadrant of rectangular patch is as shown in Figure 2. From this figure it is seen that, the antenna operates for two frequency bands BW_1 (2.92 – 2.84 GHz) = 2.77% and BW_2 (7.96 – 7.57 GHz) = 5% for the resonating frequencies of f_1 and f_2 respectively. These frequency bands are due to independent resonance of the patch and pentagon slot on the radiating patch. The BW_1 is considered as primary band because its resonating frequency f_1 is close to f_r (2.98 GHz) of CRMA. The BW_2 is considered as secondary band. Further, it is seen from Figure 2 that, the simulated result of PSRMA is also shown, which is in good agreement with experimental result.

Figure 3 shows the variation of return loss versus frequency of PSRMA when inverted pentagon slot is loaded in the third quadrant of rectangular patch. From this figure it is observed that the antenna operates for three frequency bands BW_3 (2.98 – 2.86 GHz) = 4.16%, BW_4 (4.49 – 4.36 GHz) = 2.92% and BW_5 (7.88 – 7.61 GHz) = 3.4% for the resonating frequencies of f_3, f_4 and f_5 respectively. These triple bands are obtained due to independent resonance of the patch and pentagon slot on the radiating patch. It is seen from the figure that the change in the construction of PSRMA does not affect much the primary band resonant frequency f_1 and secondary band resonant frequency f_2 of Figure 2 but

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introduces an additional resonating frequency f_4 in between f_3 and f_5. Further, it is clear from Figure 3 that, the simulated result of PSRMA is in good agreement with experimental result.

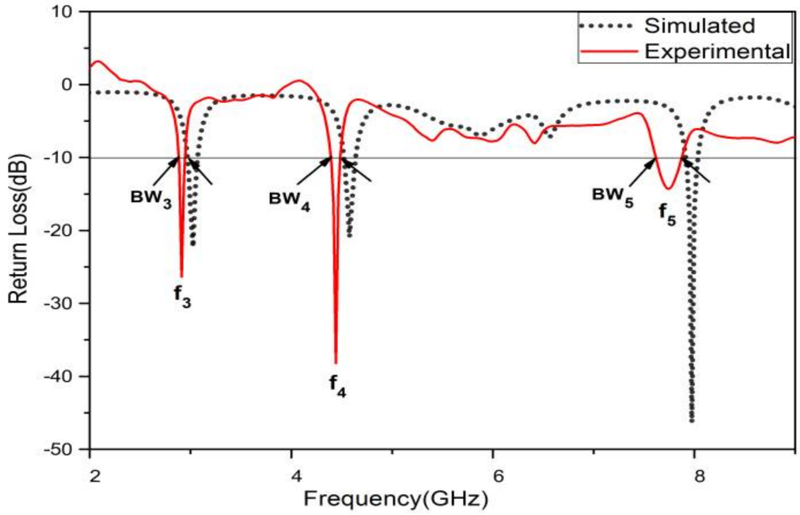

Fig. 3 Return loss versus frequency of PSRMA when slot is loaded in the third quadrant

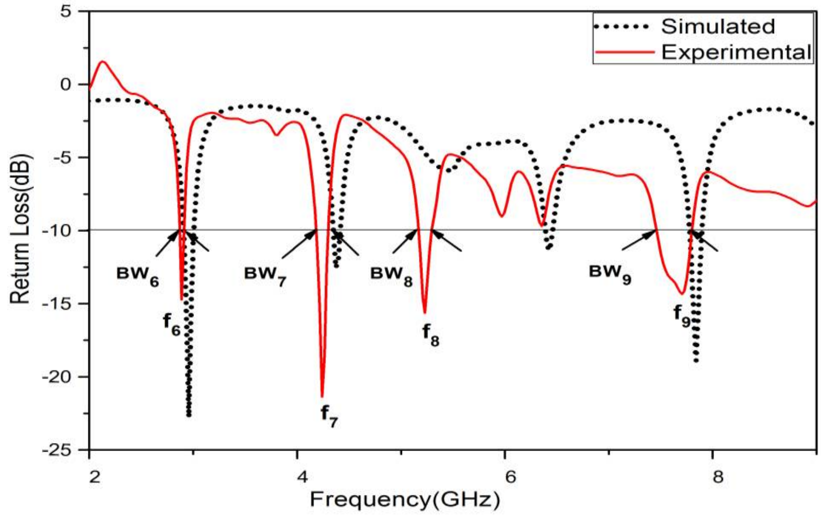

Fig. 4 Return loss versus frequency of PSRMA when slot is loaded both in second third quadrant

Figure 4 shows the variation of return loss versus frequency of PSRMA when non inverted and inverted pentagon slots are loaded in the second and third quadrant of rectangular patch respectively. From this figure it is observed that the antenna operates for four frequency bands BW_6 (2.90 – 2.86 GHz) = 1.36%, BW_7 (4.30 – 4.18 GHz) = 2.83%, BW_8 (5.30 – 5.14 GHz) = 3% and BW_9 (7.82 – 7.45 GHz) = 4.79% for the resonating frequencies of f_6, f_7, f_8 and f_9 respectively. Again, it is observed from this figure that the change in construction of PSRMA does not affect much the resonant frequencies f_1 and f_2 of Figure 2 but introduces two additional resonant frequencies f_7 and f_8 in between resonant frequencies f_6 and f_9. Further, it is clear from Figure 4 that, the simulated result of PSRMA is in good agreement with experimental result.

Hence by placing the pentagon slot in second, third and both in second & third quadrants of the rectangular patch the antenna is made to operate for dual, triple and quad bands.

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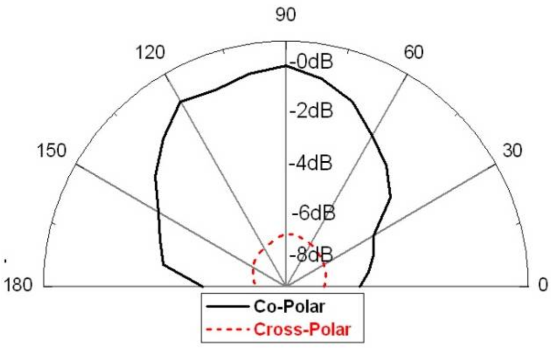

Fig. 5(a) Radiation pattern at 2.9GHz with slot in second quadrant

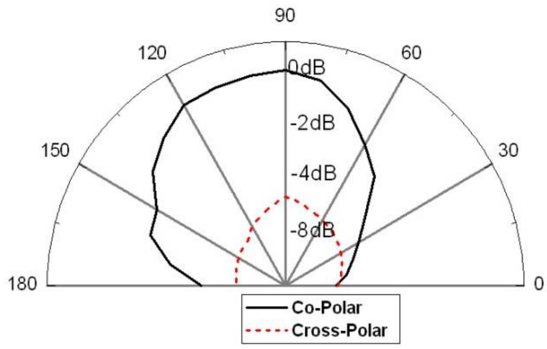

Fig. 5(b) Radiation pattern at 2.88GHz with slot in third quadrant

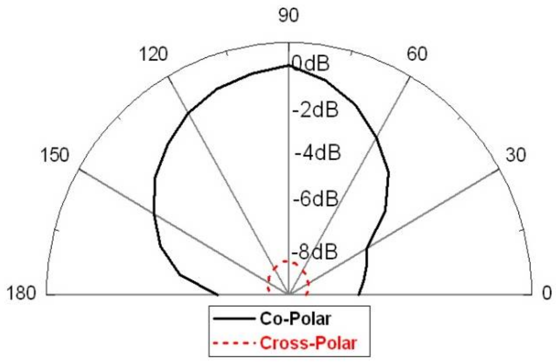

Fig. 5(c) Radiation pattern at 2.88GHz with slot in second and third quadrant

Figure 5(a) to (c) shows co-polar and cross-polar radiation patterns of PSRMA for pentagon slot inserted at Second quadrant, third quadrant and both in second and third quadrants respectively. From the figures it is seen that radiation patterns are broadside in nature and linearly polarized.

IV.CONCLUSION

A novel design of proposed antenna is realized by CRMA which is capable of operating for dual, triple and quad bands between 2.88GHz to 7.80GHz without change in linearly polarized radiation characteristics with broader side in nature. Moreover the substrate material is low cost glass epoxy material. The proposed antennas give better gain, the antenna with slot in second and third quadrant gives the gain of 5.99dB. This antenna may find applications in WLAN, Wi-Max and fourth generation mobile communication systems.

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