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Design and Development of Slotted Rectangular Microstrip Antennas for Hepta Band Operation

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ABSTRACT: Design and development of slotted rectangular microstrip antenna is proposed for hepta band operation with notch-band property. Two rectangular slots are placed on the radiating patch from its vertical edges for providing different surface current paths so as to produce six resonant modes. Both slots are kept at a distance of 0.2 cm from the non radiating edges of the patch. The antenna enhances the bandwidth of 4.81 % with a gain of 2.77 dB. Further the antenna is modified by increasing the width of the slots gives seven resonant modes and it enhances the bandwidth of 11.58 % in BW_7 with peak gain of 3.56 dB. The antenna also rejects WLAN frequency interference between BW_7 and BW_8. Both antennas shows broad side radiation characteristics. The proposed antenna may find application in microwave communication systems.

KEYWORDS: Microstrip Antenna, Slot, hepta band, Broad side.

I. INTRODUCTION

Microstrip antennas (MSAs) are finding increasing applications in modern microwave communication systems because of their low profile, light weight compact size, simple in design, low cost, planar configuration, easy to fabricate and capable of operating more than one band of frequencies is quite useful because each band can be used independently for transmit receive applications. The multiband operation with notch band operation is an additional advantage, the MSAs are the better choice for these requirements. The dual, triple quad and multi band microstrip antennas are reported [3-8], design and development of notch-band antenna [9-12] etc. In this study conventional rectangular microstrip antenna designed and developed by loading rectangular slots on the radiating patch for hepta and notch-band and operation. This modification does not affect the broad side radiation characteristics.

II. DESIGN OF ANTENNA GEOMETRY

The proposed antenna is designed for 3 GHz of frequency using the equations available for the design of conventional rectangular microstrip antenna in the literature [2].The art work of the proposed antenna is sketched by using computer software Auto-CAD and it is fabricated by using photolithography process on low cost FR4-epoxy substrate material of thickness of h = 0.16 cm and permittivity ε_r = 4.4. Figure 1 shows conventional rectangular microstrip antenna (CRMSA). In Fig.1 the area of the substrate is $L \times W$ cm. The length and width of the rectangular patch are L_p and W_p respectively. The feed arrangement consists of quarter wave transformer of length L_t and width W_t which is connected as a matching network between the patch and the microstripline feed of length L_f and width W_f. A semi miniature-A (SMA) connector is used at the tip of the microstripline feed for feeding the microwave power. The ground plane of area same as that of the substrate is placed at the bottom surface of the radiating patch.

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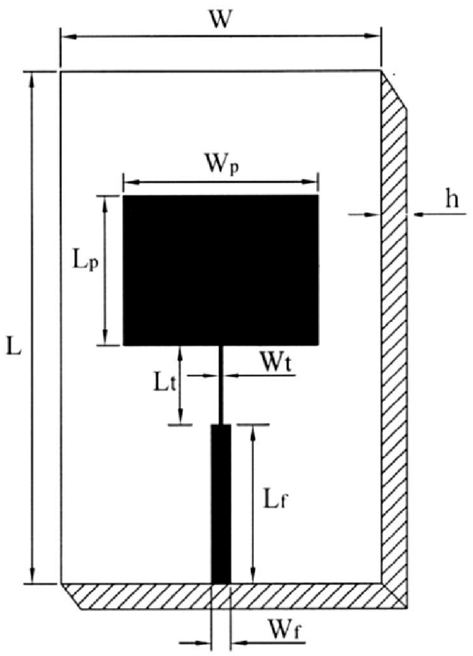

Fig. 1 Top view geometry of CRMSA

In Figure 2 rectangular slots are placed on the patch from its vertical edges (SRMSA) for providing different surface current paths so as to produce five resonant modes. The length and width of slots are L_s and W_s respectively and both rectangular slots are kept at a distance of 0.2 cm from the edges of the radiating patch. The other geometry of Fig. 2 remains same as that of Fig.1.The SRMSA further modified by increasing the width of slot from 0.41 cm to 0.65 cm keeping other geometry same. The design parameters of the proposed antennas is shown in Table 1.

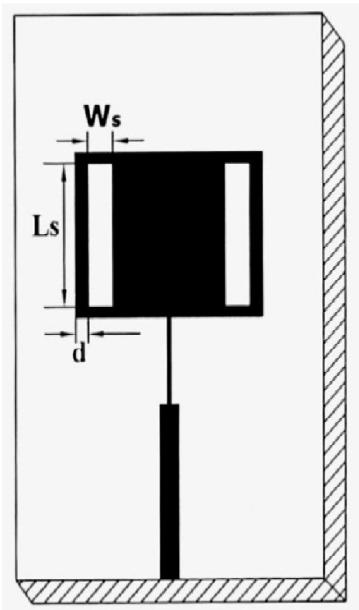

Fig. 2 Top view geometry of SRMSA when W_s = 0.41

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Table 1
Design parameters of proposed antenna

Antenna parameter	L	W	L_p	W_p	L_f	W_f	L_t	W_t	L_s	W_s
Dimensions in cm	8.0	5.0	2.34	3.04	2.48	0.3	1.24	0.05	2.04	0.41

III. EXPERIMENTAL RESULTS AND DISSCUSION

The antenna bandwidth over return loss less than -10 dB is tested experimentally on Vector Network Analyzer (Rohde & Schwarz, Germany make ZVK model 1127.8651). The variation of return loss verses frequency of CRMSA is as shown in Fig. 3. From this graph it is seen that, the antenna resonates at 2.92 GHz which is very close to the designed frequency of 3 GHz. The experimental bandwidth (BW) is calculated in percentage using the equations,

$$BW = \left[\frac{f_2 - f_1}{f_c}\right] \times 100\ \% \qquad (1)$$

were, f_1 and f_2 are the lower and upper cut of frequencies of the band respectively when its return loss reaches – 10 dB and f_c is the centre frequency of the operating band. The impedance bandwidth of CRMSA is found to be 2.40 %.

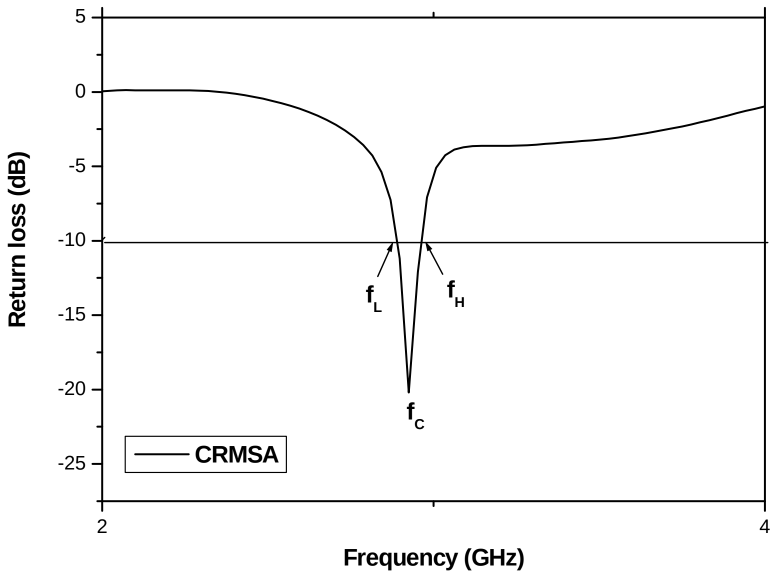

Fig. 3 Variation of return loss versus frequency of CRMSA

The variations of return loss versus frequency of SRMSA is as shown in Fig. 4. From this figure it is seen that, the antenna operates for five bands of frequencies BW_1 and BW_5. The magnitude of these operating bands measured for BW_1 and BW_5 is found to be 66 MHz (2.29 %), 90 MHz (1.82 %), 250 MHz (4.41 %), 330 MHz (4.81 %) and 370 MHz (4.265 %) respectively. Hence by using two parallel slots in SRMSA the bandwidth increases by 1.77% in BW_5. These enhancements are due to the simultaneous resonance of slots along with the patch. This antenna shows useful single notch-band i.e. 4.97 to 5.54 GHz between BW_2 and BW_3 which is the interference of WLAN frequency range.

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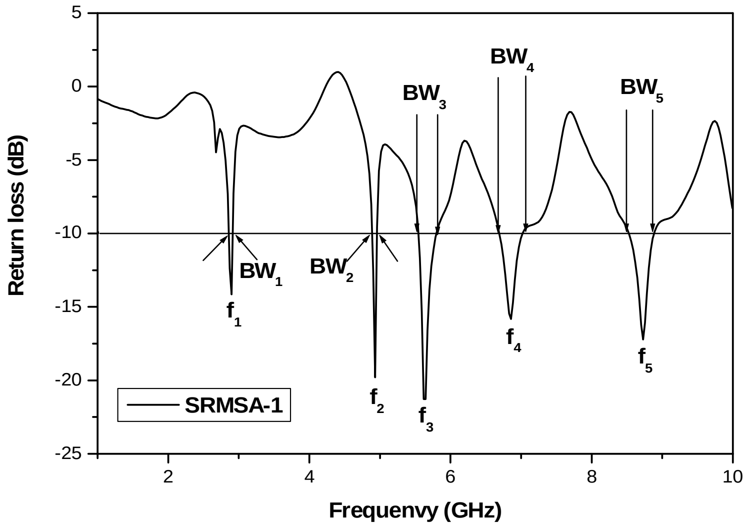

Fig. 4 Variation of return loss versus frequency of SRMSA when $W_s = 0.41$

Figure 5 shows the variation of return loss verses frequency of SRMSA when $W_s = 0.65$ cm. From this figure it is seen that, the antenna operates for seven bands of frequencies BW_6 t o BW_{12} for resonating modes f_6 to f_{12} respectively. These multi resonant modes are achieved due to different surface current paths by loading rectangular slots on the patch The magnitude of these operating bands measured at BW_5 and BW_7 is found to be 120 MHz (4.22 %), 130 MHz (2.70 %), 710 MHz (12.55 %), 240 MHz (3.53 %), 300 MHz (4.12 %), 830 MHz (9.20 %) and 1.32 GHz (11.58 %) respectively. Hence by increasing the width of two parallel slots in SRMSA the antenna resonates for seven bands instead of five bands and also it increases the bandwidth in all the bands, the highest bandwidth found in BW_8 which is 5.23 times more as compared to CRMSA and 2.61 times more than that of SRMSA of Fig. 2. The antenna also retains useful single notch-band i.e. 4.87 to 5.30 GHz between BW_7 and BW_8 which is the interference of WLAN frequency range.

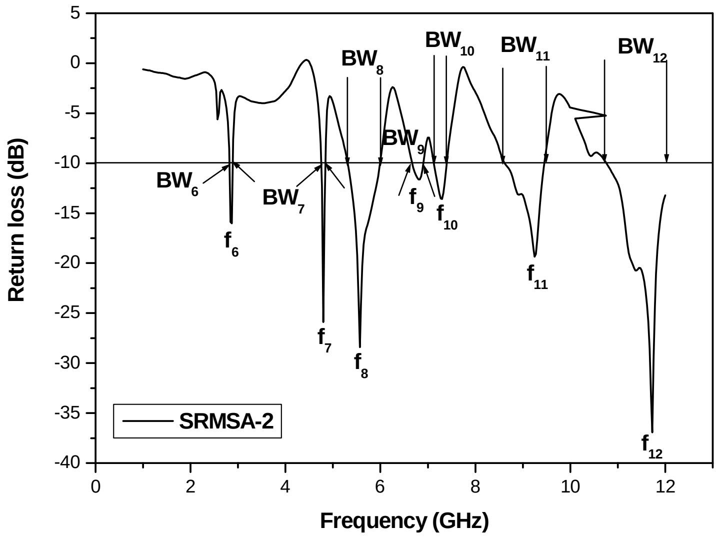

Fig. 5 Variation of return loss versus frequency of SRMSA when $W_s = 0.65$

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The gain of the proposed antennas is measured by absolute gain method. The power transmitted 'P_t' by pyramidal horn antenna and power received 'P_r' by antenna under test (AUT) are measured independently. With the help of these experimental data, the gain (G) dB of AUT is calculated by using the formula,

$$(G)\ dB = 10\log\left(\frac{P_r}{P_t}\right) - (G_t)\ dB - 20\log\left(\frac{\lambda_0}{4\pi R}\right) dB \qquad (2)$$

where, G_t is the gain of the pyramidal horn antenna and R is the distance between the transmitting antenna and the AUT. Using equation (2), the peak gain of CRMSA, SRMSA when $W_s = 0.41$ and SRMSA when $W_s = 0.65$ measured in their operating bands is found to be 0.90 dB,2.77 dB and 3.56 dB respectively.

The co-polar and cross-polar radiation pattern of CRMSA, SRMSA when $W_s = 0.41$ and SRMSA when $W_s = 0.65$ is measured at 2.92, 2.89 and 2.87 GHz and are shown in Fig 6 to 8 respectively. The obtained patterns are broad side in nature.

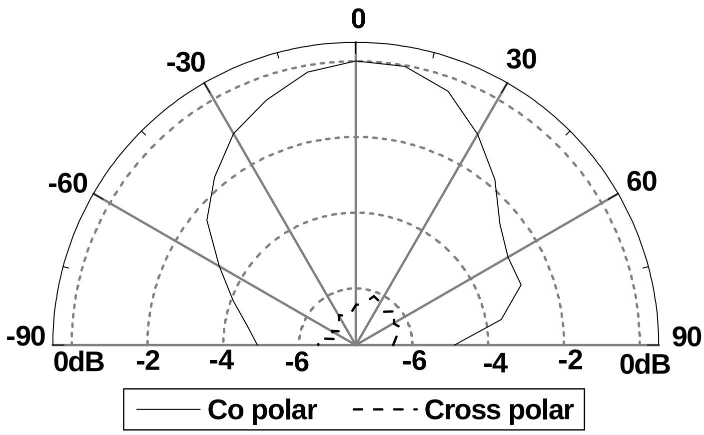

Fig. 6 Radiation pattern of CRMSA measured at 2.92 GHz

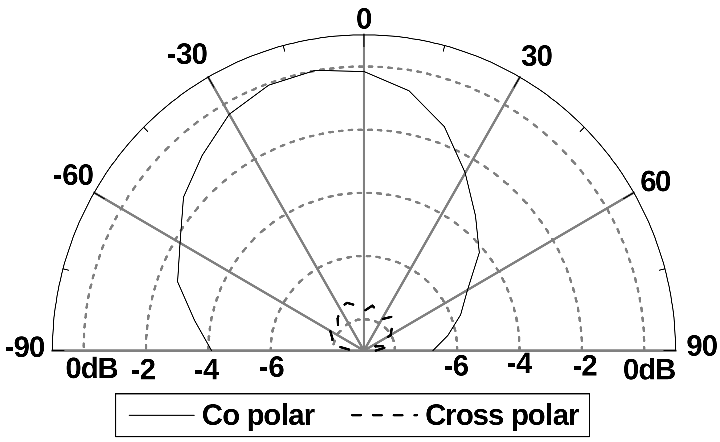

Fig. 7 Radiation pattern of SRMSA when $W_s = 0.41$ measured at 2.89 GHz

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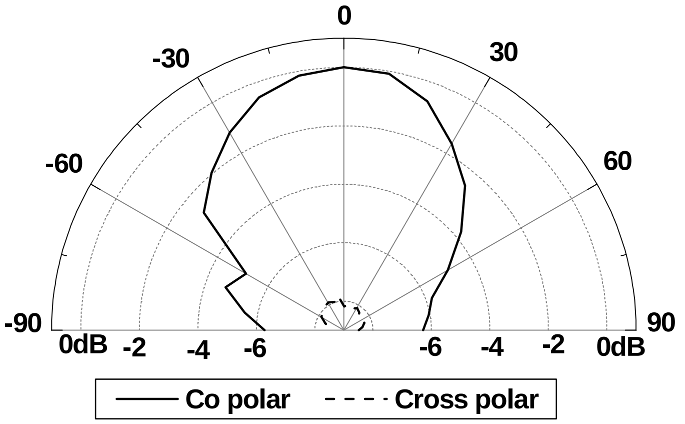

Fig. 8 Radiation pattern of SRMSA when W_s = 0.65 measured at 2.87 GHz

IV.CONCLUSION

From the detailed experimental study, it is concluded that, the SRMSA when W_s = 0.65 is realised from conventional rectangular microstrip antenna is quite capable in producing hepta band operation capable of enhancing the impedance bandwidth of 11.58 % which is 4.825 times more as compared to CRMSA and 2.4 % times more than that of SRMSA when W_s = 0.41 and gives peak gain of 3.56 dB. The antenna also capable of rejecting the interference of WLAN frequency range between BW_7 and BW_8 (i.e. 4.87 to 5.30 GHz) and gives broad side radiation characteristics. The antenna has simple structure and use low cost substrate material FR4.These antennas may find application in microwave communication systems.

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REFERENCES

[1] Constantine A. Balanis, Antenna theory analysis and design, John Wiley, New York, 1997.
[2] I. J. Bahl and P. Bharatia, Microstrip antennas, Dedham, MA: Artech House, New Delhi, 1981.
[3] Jia- Yi Size, Kin-lu Wong, “Slotted rectangular microstip antenna for bandwidth enhancement”, IEEE Trans Antennas and Propagat vol. 48, no. 8, pp.1149-1152, 2000.
[4] S.Maci, G. Biffi Gentili P. Piazzesi and C.Salvandor,, Dual-Band Slot Loaded patch antenna,” IEEE Proc. On Microwave Antenna Propagation, no.142, pp. 0225- 232, 1995.
[5] K. L. Wong and K. B. Hsieh, Dual Frequency Circular microstrip antenna with a pair of Arc-shaped Slot,” Microwave Opt Technol Lett vol. 19, pp.410-412 1998..
[6] S.Hong and K.Chang, ”Single-feed triple-frequency rectangular microstrip patch antenna with pairs of spur lines, ”Electron lett.vol. 42, no.12, pp. 673-674,2006
. [7] A. Sahaya Anselin Nisha and T. Jayanthy, “Design and Analysis of Multiband Hybrid Coupled Octagonal Microstrip Antenna for Wireless Applications”, Res. J. Appl. Sci. Eng. Technol., 5(1): 275-279, 2013
[8] C. W. Jung, I. Kim, Y. Kim and Y. E. Kim. “Multiband and multifeed antenna for concurrent operation mode”. Electron lett, 43(11), pp.600-602, 2007.
[9] M. Naser-Moghadasi, L. Asadpor and B. S. Virdee, “ Compaect Ultra-Wideband slot antenna with band-notch property” Microwave and Optical Technology Letters, vol. 54, no. 8, pp.1829-1832, August 2012.
[10] Huiqing Zhai, Jinxia, Ou, Tong Li, Guihong Li Long Li and Changhong Liang, “A compact ultra-wideband antenna with two band notches” Microwave and Optical Technology Letters, vol.55, no. 3, pp.583-586, March 2013.
[11] Mohammad Ojaroudi and Nasser Ojaroudi, “Low profile slot antenna with dual band-notched function for UWB systems” Microwave and Optical Technology Letters, vol.55, no. 5, pp.951-954, May 2013.
[12] Jie Xu, Dongya Shen, Jianfeng Zheng, Xiupu Zhang and Ke Wu, “A novel miniaturized UWB antenna with four band-notches” Microwave and Optical Technology Letters, vol. 55, no. 6, pp.1202-1206, June 2013.

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