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Rectangular Patch Microstrip Antenna with Multi-band and enhanced Bandwidth

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Abstract: The focus of this work is to present two techniques to made the antenna, resonate for multiband frequencies and to enhance the bandwidth. These techniques are loading cross slots on the patch and incorporating I slot in the ground plane without changing the dimensions of cross slots. The experimental and simulated results of proposed antennas are in good agreement with each other. The antenna parameters like return loss, impedance bandwidth, gain and radiation pattern are measured and presented. The antenna may find the application in Bluetooth, Wi-Fi and Satellite communication.
Keywords: *Bluetooth, cross slot, I slot, Multi band, Satellite, Wi-Fi.*

Introduction

In the present communication scenario microstrip antennas are becoming popular because of their numerous advantages like low profile, low fabrication cost, ease of fabrication, conformability and integration with RF devices, etc.[1- 4]. Modern communication systems such as radar, synthetic aperture radar (SAR), Global Positioning System (GPS) and multiband GSM/DCS 1800 mobile communication systems [5], are using antennas operating at definite frequency bands with a single fed. But an antenna operating at different frequency bands simultaneously is more useful and avoids the use of multiple antennas. The multiband antennas are realized by using many methods such as, multilayer stacked-patch antenna using circular, annular, triangular and rectangular patches [6-7]. Because of multiple substrate layer this antenna structure is larger which makes it difficult for the antenna to be installed in hand-held devices. In addition many techniques have been used to enhance the bandwidth. An effective technique is presented to enhance the bandwidth and reduce the size of an ultralow profile microstrip antenna by loading multi couple staggered slits on the patch and using inset fed structure two TM_{10} modes can be excited at two close frequencies [8-9]. In this paper, two techniques for the multiband frequencies and enhancement of bandwidth are studied. The first is, single layered, rectangular microstrip antenna loaded with cross slots on the patch and the second is embedding a I slot in the ground plane along with cross slots on the patch.

Antenna Design

Figure 1 shows the top view geometry of conventional rectangular microstrip antenna (CRMSA) designed for 3.2 GHz of frequency. 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 $\varepsilon_r = 4.2$. 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 artwork of this antenna is sketched using computer software AutoCAD to achieve better accuracy.

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

Table 1 : Design parameters of CRMSA

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

The proposed antenna is designed by two cross slots loaded on the radiating patch of a rectangular microstrip antenna (CRSRMSA-1). The Top view and bottom view geometry of CRSRMSA-1 is as shown in Figure 2. Two cross slots A & B are constructed by using two rectangular slots of same length 1 cm and width 0.1 cm. The antenna (CRSRMSA-2) is constructed by embedding I slot in the ground plane along with cross slots of same dimension as that of CRSRMSA-1. The I slot of width 0.2 cm is designed by two rectangular horizontal slots P & Q of same length 0.8 cm and the vertical slot R of length .2 cm, which is placed exactly below the radiating patch. The Top view and bottom view geometry of CRSRMSA-2 is shown in Figure 3.

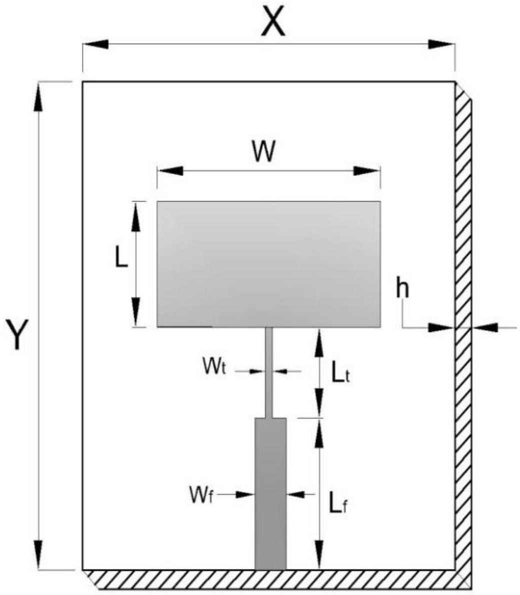

Figure 1. Top view geometry of CRMSA

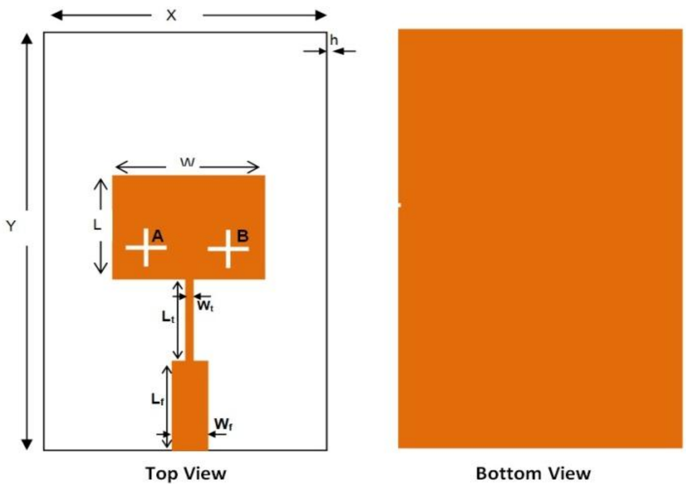

Figure 2. Top view and Bottom view Geometry of CRSRMSA-1

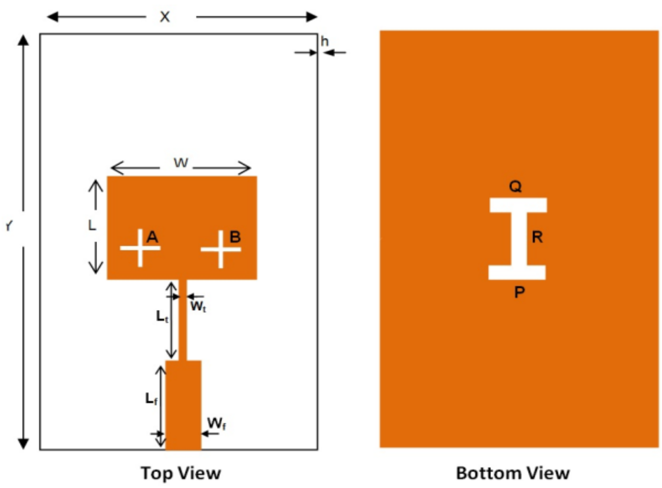

Figure 3.Top view and Bottom view Geometry of CRSRMSA-2

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Experimental results and discussion

The simulation of the proposed antennas is carried out by using Ansoft HFSS software. 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[10],

$$\mathbf{BW= (f_H – f_L/ fr)×100\%} \qquad (1)$$

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

Figure 4 shows the return loss versus frequency plot of CRMSA. It is clear from this figure that, the resonating frequency f_r of CRMSA is found to be 2.98 GHz with minimum return loss of -20.17 dB with a impedance bandwidth of 2.34 % . From this figure it is observed that a reasonable agreement between the simulation results and measured data is seen, this validates the design of conventional CRMSA.

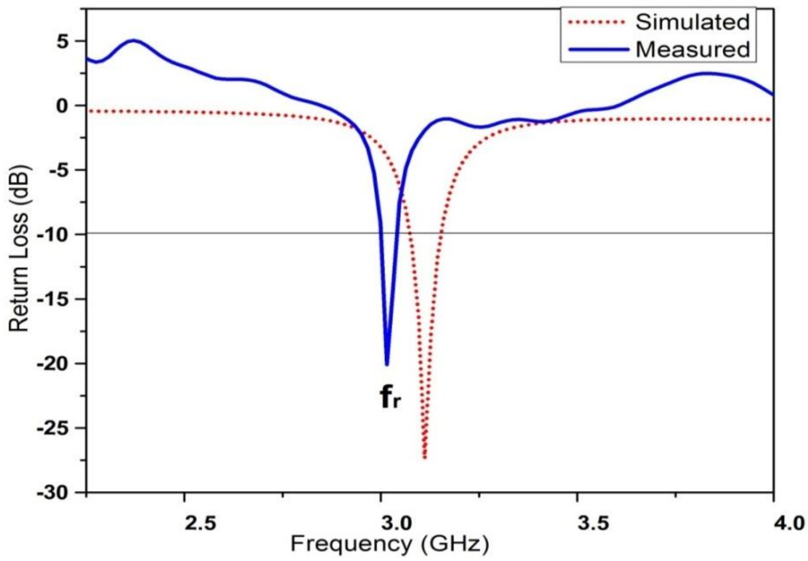

Figure 4. Variation of return loss versus frequency of CRMSA

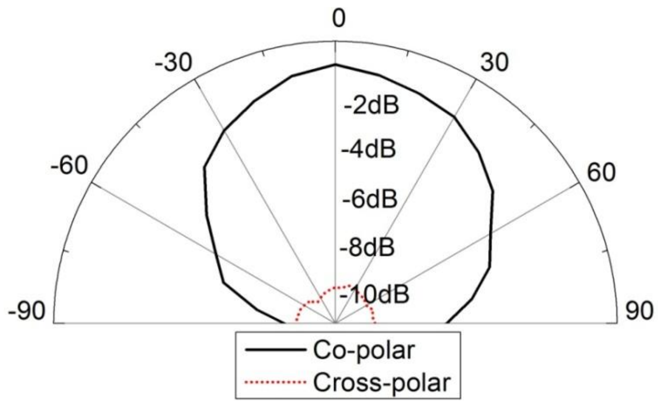

Figure 5. Radiation pattern of CRMSA measured at 2.98 GHz

Figure 5 shows the co-polar and cross-polar radiation pattern of CRMSA measured at resonant frequency 2.98 GHz. From this figure it is seen that, the pattern is broadside and linearly polarized.

Figure 6 shows the variation of return loss versus frequency response of CRSRMSA-1. From this figure it is seen that the antenna resonates for five frequency bands f_1 = 2.45 GHz, f_2 = 4.51 GHz, f_3 = 5.09 GHz , f_4 = 6.87 GHz and f_5 = 9.06 GHz with minimum return loss of -13.80 dB, -14.35 dB, -19.42 dB , -11.85dB and -22.59 dB, giving the impedance bandwidths of 2.04%, 2.66% , 4.91% , 2.03% and 14.57% respectively. The f_1 resonating mode is due to the fundamental resonance of the patch, f_2 f_3 , f_4 and f_5 are due to the effects of cross slots on the radiating patch. The experimental results and simulation results are in good agreement with each other shown in Figure 6. The peak gain of an antenna is 4.77dB.

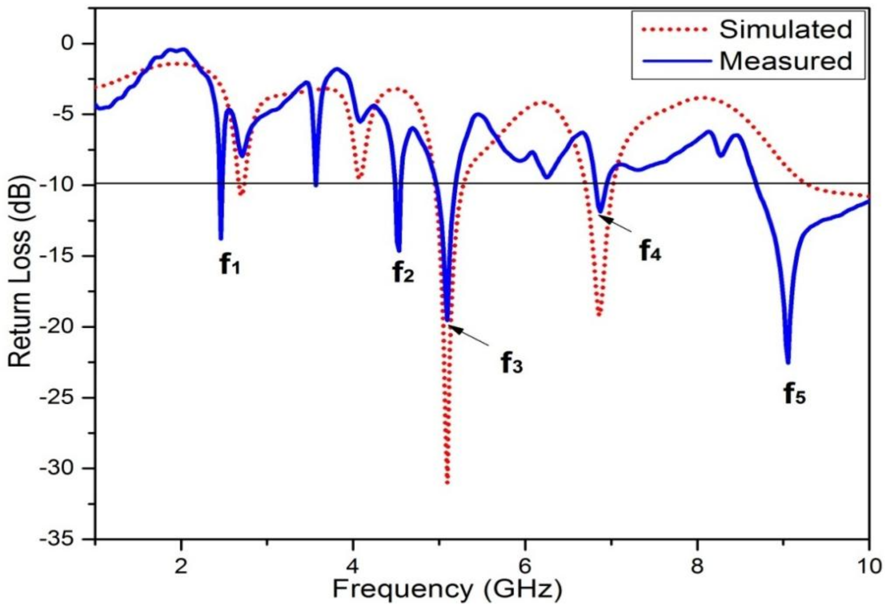

Figure 6. Variation of return loss versus frequency of CRSRMSA-1 with cross slots on the patch

The variation of return loss versus frequency response of CRSRMSA-2 is shown in Figure 7. From this figure it is seen that the antenna resonates for two frequency bands with three resonating frequencies i.e., at f_1 = 2.42 GHz, f_2 = 4.86 GHz, and f_3 = 6.54 GHz with minimum return loss of -10.47 dB , -19.89 dB and -20.97 dB with their respective impedance bandwidths of 9.50% and 9.17%. With the I slot in the ground plane, second, third and fourth frequency bands of CRSRMSA-1 are merged and a wide frequency band of 9.50% is obtained which is shown in Figure 7. Also, it is seen from this figure that the experimental results and simulation are in good agreement with each other and the peak gain of this antenna is 7.78 dB at its resonating mode. The antenna may find the application in Bluetooth, Wi-Fi and satellite communication.

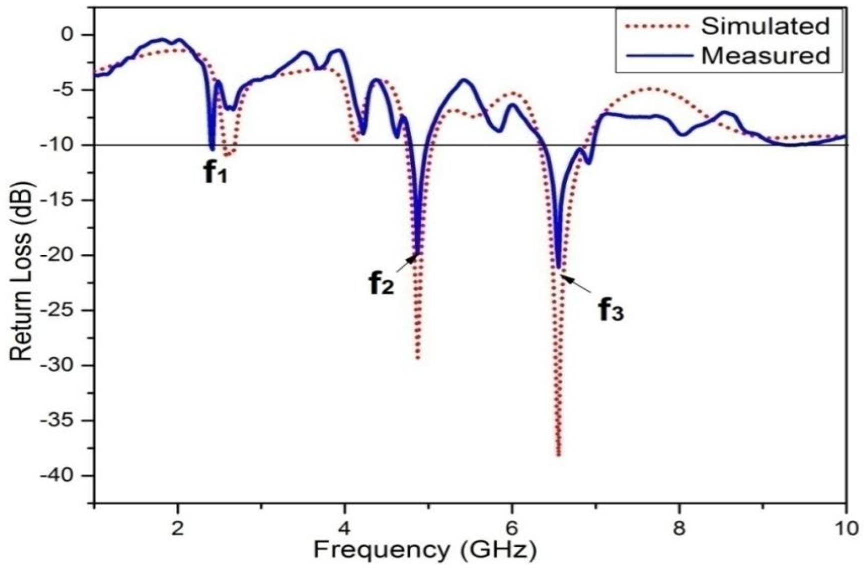

Figure 7. Variation of return loss versus frequency of CRSRMSA-2 with cross slots on the patch and I slot on the ground plane

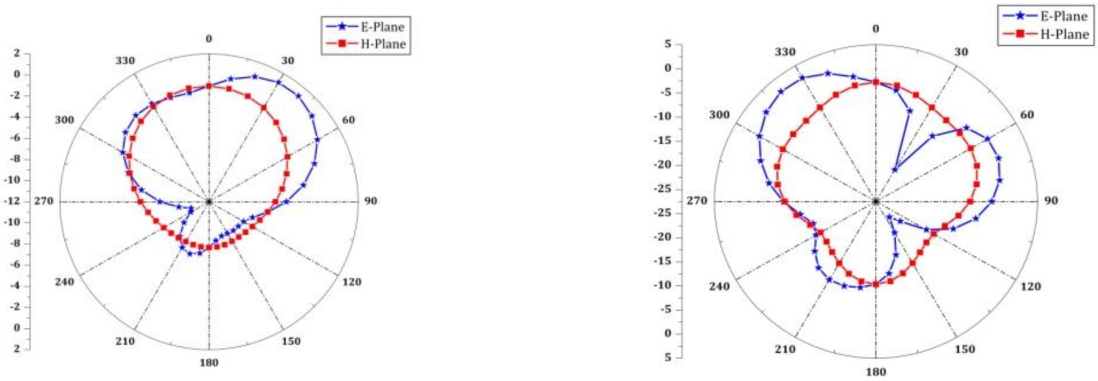

Figure 8. Radiation patterns of CRSRMSA measured at (a) 2.45 GHz and (b) 4.86 GHz

Figure 8 shows the E and H-plane radiation patterns of CRSRMSA-1 and CRSRMSA-2 measured at resonant frequencies (a) 2.45 GHz and (b) 4.86 GHz respectively. From the figure it is seen that, the patterns are nearly omni directional in both E and H plane.

Conclusion

The proposed antenna CRSRMSA-1 with two cross slots on the radiating patch gives multi bands resonating from 2.45 to 9.06 GHz while the construction of CRSRMSA-2 gives wide bandwidth of 9.50%. The radiation patterns show nearly omni directional characteristics in both E-plane and H-Plane with peak gain of 7.78 dB is achieved at its resonating mode. The antenna may find the application in Bluetooth, Wi-Fi and satellite communication.

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