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A Novel Design and Development of Rectangular Microstrip Antenna for Improvement of Gain and Bandwidth

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ABSTRACT: This Paper presents the novel design and development of orthogonal cross slot loaded rectangular microstrip antenna for multiband operation. The multibands are achieved by incorporating orthogonal slot of equal length at optimum place on the conducting patch. By adding two vertical slots on the patch the impedance bandwidth is enhanced in the upper operating band retaining the nature of broadside radiation characteristics .The proposed antenna may find application in radar communication.

KEYWORDS: orthogonal, multiband, impedance bandwidth, radar communication.

I. INTRODUCTION

The microstrip antennas (MSAs) has gained much attention because of the miniaturization requirement of wireless communication system and their significant features such as small size, light weight, low profile, planar configuration etc., due to this reason MSAs are used in various application such as synthetic aperture radar (SAR), WLAN, satellite communication etc, the main limitations of MSAs are their narrow impedance bandwidth and lower gain. Multiband antennas are realized by many techniques like use of parasitic element [1], Method of moment (MOM) [2], array antenna [3], multi resonators [4] monopole technique[5],use of parasitic branches[6]modifying the ground plane[7],dielectric resonators[8],aperture coupling method[9] etc,. The antenna operating more than one band of frequencies is quite attractive because each band can be used independently for receive/transmit application.

Using only single antenna in the multi signal band is better than using the each antenna element in the separate way. Inspite of this a simple slot technique is used to construct the antenna which gives multiband .This technique enhances the bandwidth and gain without changing the nature of broad side radiation characteristics [10].

II. DESIGNING

The art work of proposed antennas is sketched using software Auto-CAD and fabricated using photolithographic process using low cost glass epoxy substrate materials of thickness h=1.66 mm, relative permittivity $\varepsilon_r = 4.2$. Figure 1 shows the geometry of conventional rectangular microstrip antenna (CRMA) designed on a substrate are of M × N which is designed by using basic equations available in the literature [11]. The antenna is designed for the resonant frequency of 4 GHz. The CRMA consists of radiating patch of length L and width W the feed arrangement consists of quarter wave transformer of length L_t and width W_t is used for better impedance matching between the microstripline feed of length L_f, width W_f and center point (Cp) along the width of the rectangle microstripline patch. At the tip of microstripline feed a 50Ω coaxial SMA connector is used for feeding the microwave power.

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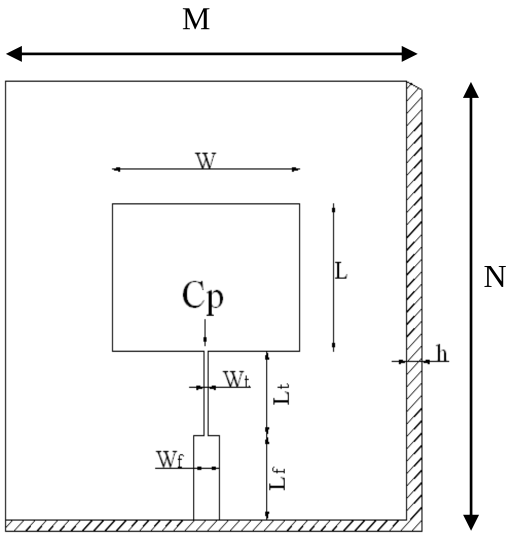

Fig 1. Geometry of CRMA

Figure 2 shows the geometry of orthogonal cross slot loaded rectangular microstrip antenna (OSRMA).Here a new concept are introduced by placing the slots one along the width and another along the length by orthogonal cross in the patch. The length of the slot is taken as Ls which is equal to 1cm and width of the slot is Ws which is equal to 0.1cm.The dimension of slots are taken in terms of $\lambda_{0,}$ where λ_0 is the free space wavelengths in cm corresponding to the design frequency of 4 GHz.

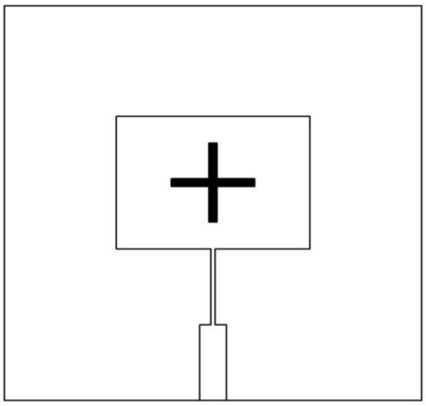

Fig 2. Geometry of OSRMA.

Figure 3 shows the geometry of added slot orthogonal cross slot loaded rectangular microstrip antenna (AOSRMA) which is derived from OSRMA. In this figure two slots are added along the length to the OSRMA. The design parameters of CRMA, OCSRMA and AOCSRMA are given in Table 1.

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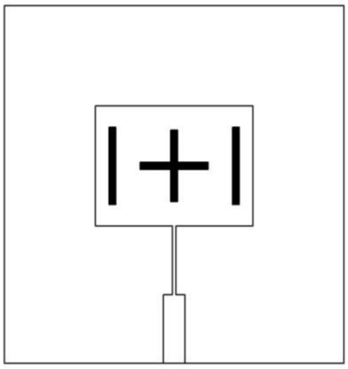

Fig 3. Geometry of AOSRMA

Table 1. Designed parameters of CRMA, OSRMA and AOSRMA.

Designed parameters of proposed antennas In cm	
L	1.68
L_t	0.96
L_f	0.75
L_g	0.75
W	2.32
W_t	0.05
W_f	0.32
W_s	0.1

III. EXPERIMENTAL RESULTS

The impedance bandwidth over return loss less than -10dB for the proposed antennas is measured on vector network analyzer. The variation of return loss versus frequency of CRMA is as shown in Fig. 4. It is clear from this figure that, the antenna resonates for the design frequency of 4 GHz. This validates the design concept of CRMA. Further from Fig. 4 it is seen that, the antenna resonates for single band of frequency BW_1. The magnitude of BW_1 is found to be 3.50 %. This is calculated using the equation,

$$\text{Impedance Bandwidth} = \left[\frac{(f_2 - f_1)}{f_c}\right] \times 100\ \%$$

where f_2 and f_1 are the upper and lower cutoff frequencies respectively, when its return loss reaches -10dB and f_c is the center frequency between f_1 and f_2.

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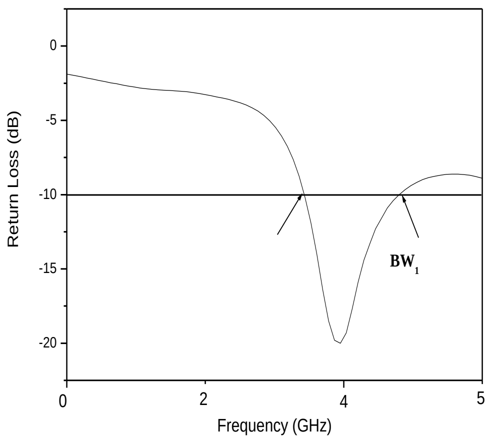

Fig 4. Variation of return loss versus frequency of CRMA.

The variation of return loss versus frequency of OSRMA is as shown in fig. 5. From this figure it is seen that, the antenna resonates for hexaband of frequencies BW_2, BW_3, BW_4, BW_5, BW_6 and BW_7. The magnitude of each operating band is found to be 0.66 %, 2.36 %, 4.22 %, 3.14 %, 3.15% and 3.95 % respectively. The multiband operation is due to the independent resonance of Patch and slots inserted in the conducting patch of OSRMA . By the construction of novel geometry of OSRMA, the antenna starts resonating higher than the designed frequency of 4 GHz.

Figure 6 shows the variation of return loss verses frequency of AOSRMA. From this figure it is seen that, the antenna resonates for multi band of frequencies i.e. for BW_8, BW_9, BW_{10}, BW_{11}, BW_{12}, BW_{13} and BW_{14}. The magnitude of each operating band is found to be 1.83 %, 10.18 %, 2.82%, 1.94%, 2.75%, 8.13% and 1.22% respectively. It is clear from the figure that the upper operating band BW_9 is enhanced from 2.36% to 10.18% i.e., BW_3 and BW_4 are merges in the Fig. 5 together become BW_9 as shown in Fig.6 which is 4.31 times more than the bandwidth of OSRMA. Further the upper operating band BW_{13} is enhanced from 3.97 % to 8.133% as shown in
Fig 6

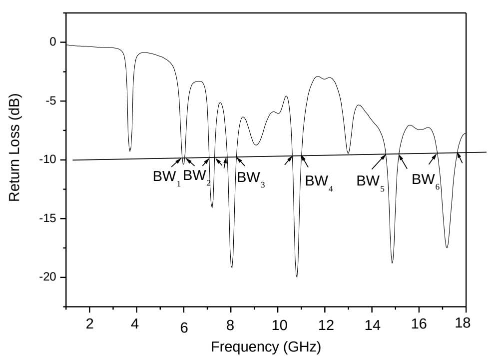

Fig 5. Variation of return loss versus frequency of OSRMA.

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

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

where G_t is the gain of the pyramidal horn antenna and R is the distance between the transmitting antenna and AUT. Using above equation the peak gain of OCSRMA and AOCSRMA measured in their operating bands is found to be 2.02 and 4.25 dB respectively. Hence by the construction of AOCSRMA enhances the gain by 2.10 times more than the peak gain of OCSRMA.

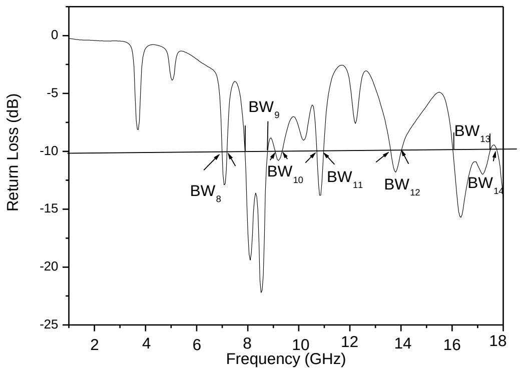

Fig 6. Variation of return loss versus frequency of AOCSRMA.

The radiation patterns of antenna are measured in an anechoic chamber. The co-polar and cross-polar patterns in E-plane and H- plane of the antenna are presented in Fig. 7-9. From these figures it is clear that, the E and H plane patterns are broad sided and are nearly same with each other.

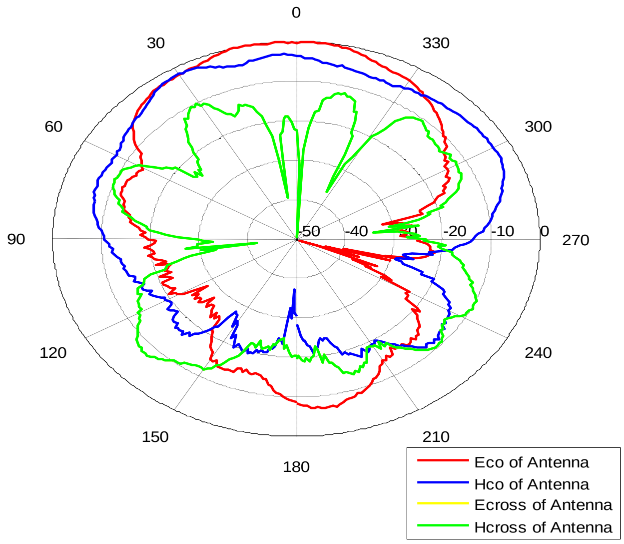

Fig 7. E and H plane radiation patterns of CRMA measured at 3.97 GHz.

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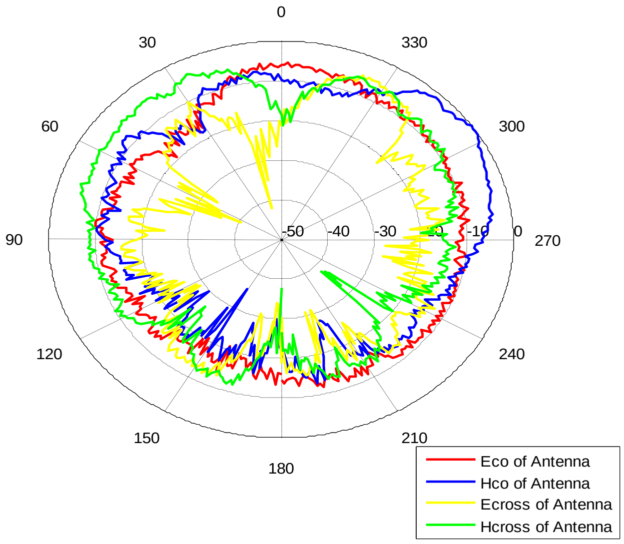

Fig 8. E and H plane radiation patterns of OCSRMA measured at 8.021 GHz.

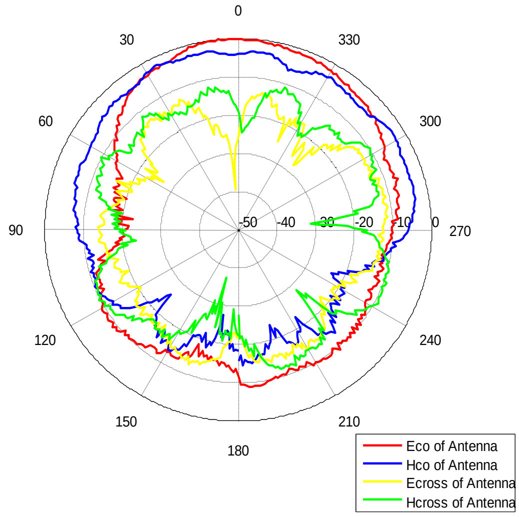

Fig 9. E and H plane radiation patterns of AOCSRMA measured at 8.02 GHz.

IV. CONCLUSION

From the detailed experimental study it is concluded that, by using orthogonal cross slot in CRMA i.e., OCSRMA makes the antenna to resonate for hexaband of frequencies and gives a peak gain of 2.02 dB. Further by adding two slots to the OCSRMA i.e., AOCSRMA the antenna resonate for seven band and enhances the gain to 4.25dB when compared to the gain of OCSRMA without changing much in the radiation characteristics. These antenna may find application in radar communication.

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