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A NOVEL DESIGN AND DEVELOPMENT OF RECTANGULAR MICROSTRIP ANTENNA FOR C TO KU BAND OPERATION

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ABSTRACT

This paper presents the novel design and development of five open stub loaded rectangular microstrip antenna for multiband band operation. The multibands are achieved at C to KU band of frequencies by incorporating five vertically open stub 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 with minimum change in the lower operating band retaining the nature of broadside radiation characteristics .The proposed antenna may find application in WiMax, radar system applications, satellite communication and VSAT systems and in the frequency range between C and Ku.

Keywords: Open Stub, Multiband, Impedance Bandwidth, Wimax, VSAT.

1. INTRODUCTION

The microstrip antennas (MSAs) leads an important role in microwave communication system. From the last decade MSAs have gained much interest because of their significant merits such as low cost, small size, easy to fabricate, light weight etc. But the main disadvantage with MSAs is that they posses narrow impedance bandwidth, low gain and undesired radiation pattern. To overcome these drawbacks several technique have been disposed in the literature such as use of capacitive feed strip [1], cutting slots inside the MSAs [2], meandered probe feed [3], use of stacked configuration [4], use of aperture coupling [5] etc.The antenna operating with multiband of frequency are more useful because they avoid the use of two separate antennas for transmit and receive applications. In view of this a simple stub loaded technique has been used to construct the antenna to achieve multiband operation.

2. DESIGNING

The art work of proposed antennas are sketched using software Auto-CAD and are fabricated using low cost glass epoxy substrate materials of thickness h=1.66mm, relative permittivity $\varepsilon_r = 4.2$. Figure 1 shows the geometry of conventional rectangular microstrip antenna (CRMA) which is designed by using basic equations available in the literature [6]. 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 which 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. A five open stub are loaded vertically at the suitable place on the radiating patch of CRMA as shown in fig .2.This antenna is termed as vertically five open stub rectangular microstrip antenna (VOSRMA).The length and width of the stub are L_s and W_s respectively. The feed geometry of this antenna remains same as that of fig .1.

Further two slots are placed on the non radiating edge of VOSRMA with same length and width of stubs. This antenna is named as slot loaded vertically five open stub rectangular microstrip antenna (SVOSRMA) shown in fig.3.The various design parameters of proposed antennas is listed in table 1.

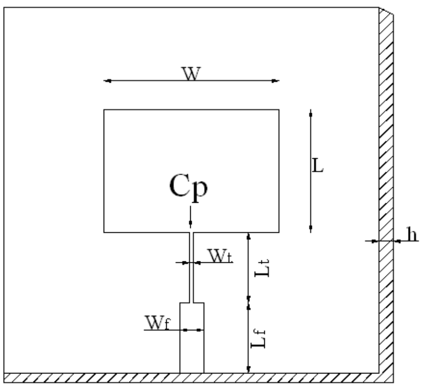

Figure1. Geometry of CRMA

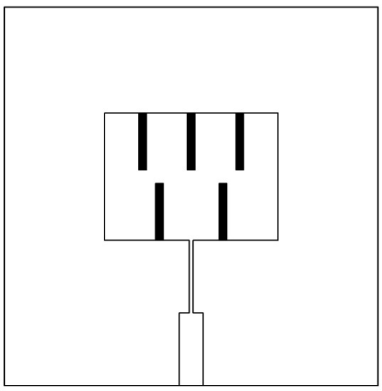

Fig. 2 Geometry of VOSRMA

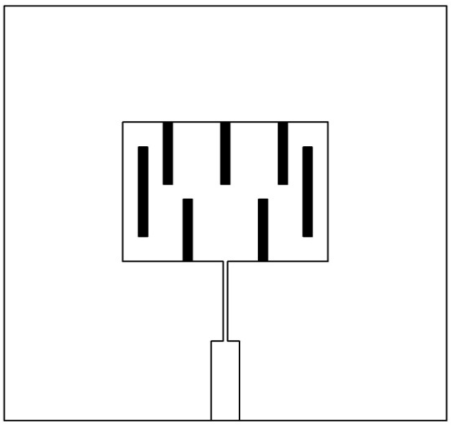

Figure 3.Geometry of SVOSRMA

Table 1. Designed parameters of CRMA, VOSRMA and SVOSRMA

L = 1.68 cm	W = 2.32
L_t = 0.96cm	W_t = 0.05
L_f = 0.75cm	W_f = 0.32cm
L_g = 0.75cm	W_s = 0.1cm

3. 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 -10 dB and f_c is the center frequency between f_1 and f_2.

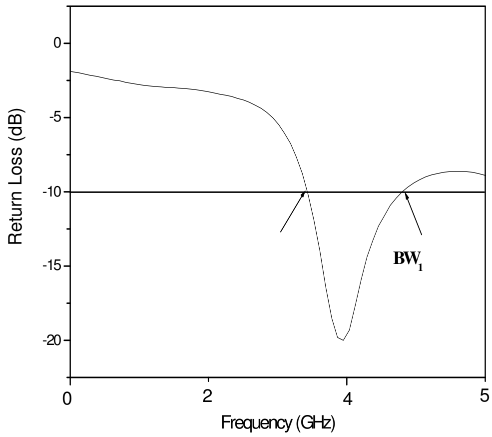

Fig.4 Variation of return loss versus frequency of CRMA

The variation of return loss versus frequency of VOSRMA is as shown in fig. 5. From this figure it is seen that, the antenna resonates for multiband of frequencies i.e., for BW_2, BW_3, BW_4, BW_5, BW_6 and BW_7. The magnitude of each operating band is found to be 1.91 %, 4.24 %, 8.37 %, 0.68 %, 3.71% and 2.81 % respectively. The multiband operation is due to the fundamental resonance of patch and the current along the edges of open stubs [7]. By the construction of novel geometry of VOSRMA, the antenna start resonating higher than the designed frequency of 4 GHz. Figure 6 shows the variation of return loss verses frequency of SVOSRMA. From this figure it is seen that, the antenna resonates for quad band of frequencies i.e. for BW_8, BW_9, BW_{10} and BW_{11}. The magnitude of each operating band is found to be 3.73%, 2.57 %, 1.59 % and 13.93 % respectively. It is clear from the figure that, the upper operating band BW_{11} is enhanced from 3.71 % to 13.93 % i.e., BW_6 and BW_7 shown in fig.5 are merges together to become BW_{11} as shown in fig.6 which is 3.75 times more than the impedance bandwidth of VOSRMA .Hence the use of slots on the patch along with open stubs are quite effective in tuning the operating bands of antenna

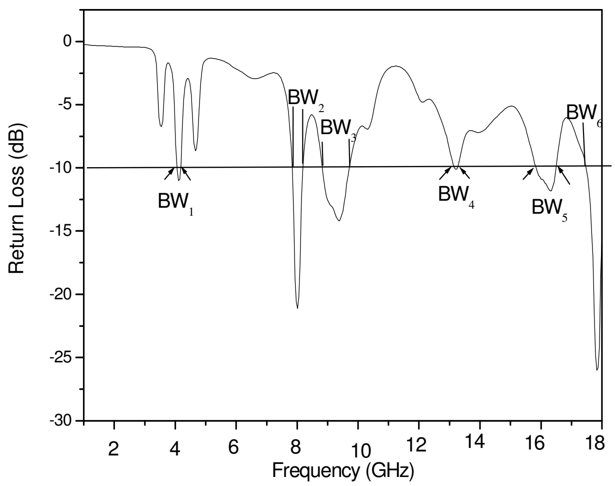

Fig. 5 Variation of return loss versus frequency of VOSRMA

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,

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

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 VOSRMA and SVOSRMA measured in their operating bands is found to be 2.35 and 3.95 dB respectively. Hence by the construction of SVOSRMA enhances the gain by 1.68 times more than the peak gain of VOSRMA.

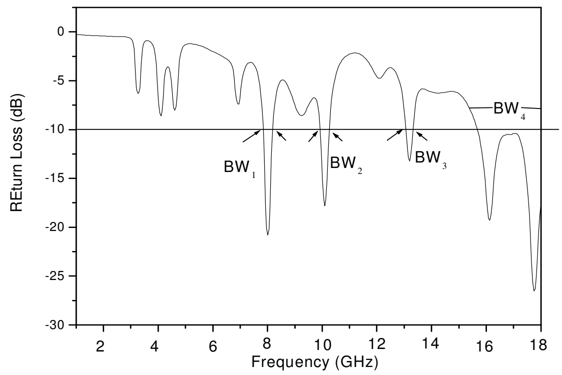

Fig. 6 Variation of return loss versus frequency of SVOSRMA

The radiation patterns of antenna are measured in an anechoic chamber. The typical co-polar and cross-polar patterns in E and H- plane of the antenna are presented in Figs. 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.

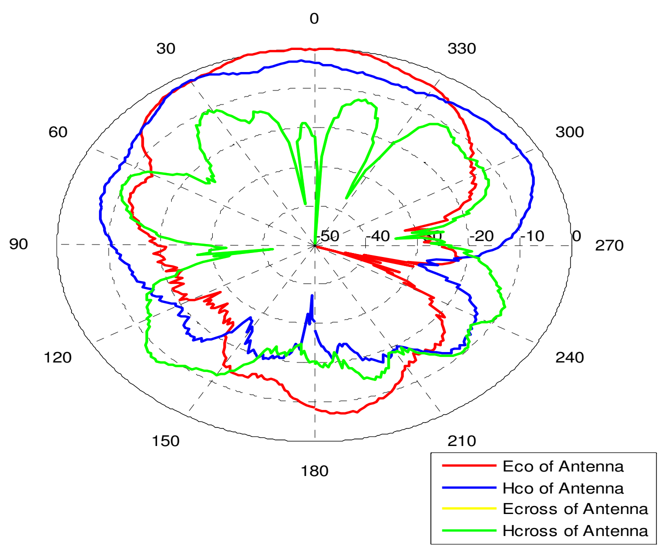

Fig. 7 E and H plane radiation patterns of CRMA measured at 3.97 GHz.

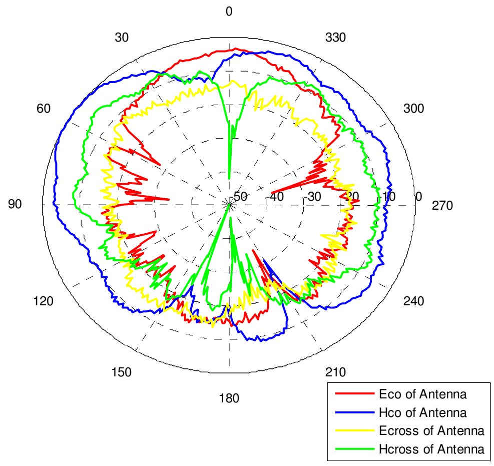

Fig. 8 E and H plane radiation patterns of VOSRMA measured at 8.02 GHz.

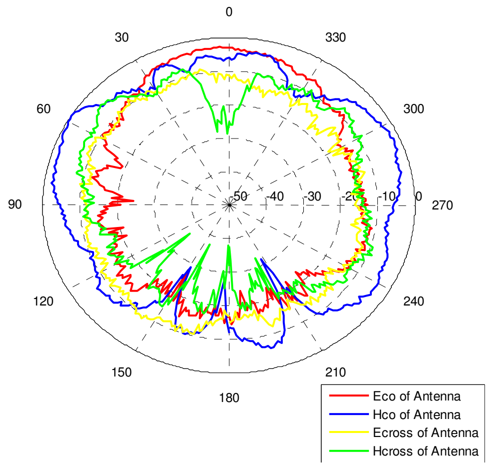

Fig. 9 E and H plane radiation patterns of SVOSRMA measured at 8.02 GHz.

4. CONCLUSION

From the detailed experimental study it is concluded that, the proposed antennas use low cost substrate material and are simple in their design and fabrication. The multiband are obtained by constructing the antenna in the form of VOSRMA. Further these multiband are converted to quad bands and enhancement in the upper operating band to 13.93% is possible by using vertical slots on the patch.The proposed antennas operates at discreate bands in the frequency range of C to KU..These antenna may find application in WiMax, radar system applications, satellite communication and VSAT systems and in the frequency range between C and Ku.

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