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Design of Rectangular microstrip antenna with slots in the ground plane for C to Ku band operation

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Abstract: A Novel design of Rectangular microstrip antenna (RMSA) is designed for multiband operation with slots in the ground plane is presented. The multiband is achieved by embedding four equal slots at optimum place on the ground plane. The antenna resonets for penta band . .Further these penta bands can be converted to seven bands by removing two horizontal slots along the width of conventional rectangular microstrip antenna (CRMA) without changing the nature of radiation characteristics .The proposed antennas may find application in SAR, microwave communication systems operating at c to ku bands.

Keywords: penta, multiband,Microwave communication, C Band,Ku band.

1. INTRODUCTION

Microstrip antenna (MSAs) has gained important role in microwave communication because of their applications and attractive features such as planar , light weight,small size , east to design etc . As the microstrip antenna is planar in configuration, it enjoys all the advantage of printed circuit technology [1]. Microstrip antenna gained wide attention to operate for more than one band of frequencies and can be used each operating band independently for transmit/receive application. Multiband frequency MSAs are described by many methods in the literature to improve the impedance bandwidth of MSAs such has monopole technique [2], use of parasitic branches[3],use of coniocal radiator [4],use of dielectric resonators [5],multilayer stacking [6], meandered probe feed [7]. In this article, a simple concept has been used in designing a RMSA to achive multiband operation using microstrip line feeding [8].

2. DESIGN

The art work of proposed antennas is sketched using software Auto-CAD and fabricated through photolithographic process on low cost glass epoxy substrate materials of thickness h=1.66 mm, relative permittivity ε_r = 4.2. Figure 1 shows the geometry of CRMA designed on a substrate of area M × N using the basic equations available in the literature [9]. The Patch element 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.

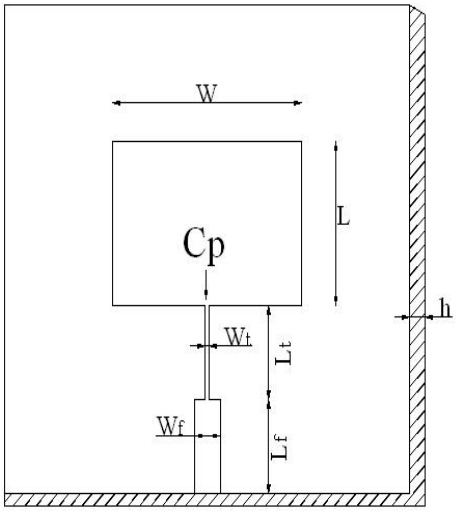

Figure 1 Geometry of conventional rectangular microstrip antenna

Figure 2 shows the geometry of Two vertical slot and Two horizontal slot loaded rectangular microstrip antenna (TVSTHSRMA). Here the Two horizontal slots are placed along the width and Two vertical slots along the length of the Ground plane.The dimension of slots are taken in terms of $\lambda_{0,}$ where λ_0 is the free space wavelengths in cm .

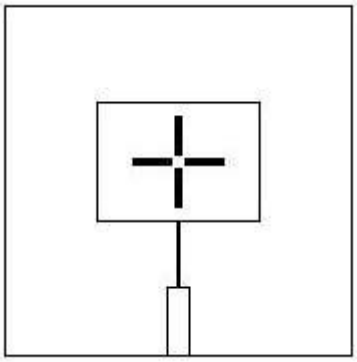

Figure 2 Geometry of TVSTHSRMA

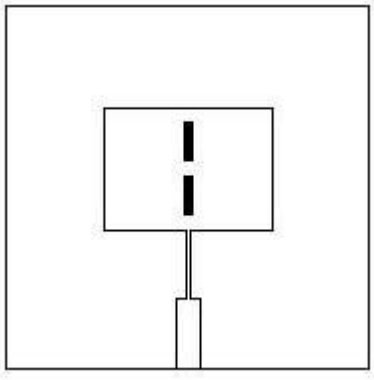

Figure 3 Geometry of TVSRMA

Further, two Horizontal slots are removed from TVSTHSRMA. This antenna is named as two vertical slot loaded rectangular microstrip antenna (TVSRMA) which is derived from TVSTHSRMA as shown in Fig.3. The design parameters of CRMA, TVSTHSRMA and TVSRMA are given in Table 1.

Designed parameters of proposed antennas In cm	
L	1.68
L_t	0.96
L_f	0.75
W	2.32
W_t	0.05
W_f	0.32
W_1	0.1

3.EXPERIMENTAL DETAILS

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.

The variation of return loss versus frequency of TVSTHSRMA is as shown in Fig. 5. From this figure it is seen that, the antenna resonates for petaband of frequencies BW_2, BW_3, BW_4, BW_5, and BW_6 . The magnitude of each operating band is found to be 1. %, 2.02 %, 2.02 %, 4.01% and 1.11% respectively. The multiband operation is due to the independent resonance of Patch and slots inserted in the conducting patch of TVSTHSRMA [10]. By the construction of novel geometry of TVSTHSRMA, the antenna starts resonating higher than the designed frequency of 4 GHz.

Figure 6 shows the variation of return loss verses frequency of TVSRMA. From this figure it is seen that, the antenna resonates for seven band of frequencies i.e. for BW_7, BW_8, BW_9, BW_{10}, BW_{11}, BW_{12} and BW_{13} . The magnitude of each operating band is found to be 1.34 %, 7.61%, 5.93 %, 1.23 %, 1.81% ,2.55 %, and 7.13% respectively. It is clear from the figure that the each operating bands is enhanced compare to TVSTHSRMA

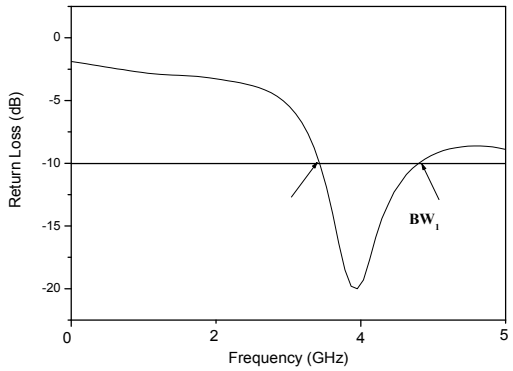

Fig 4. Variation of return loss versus frequency of CRMA

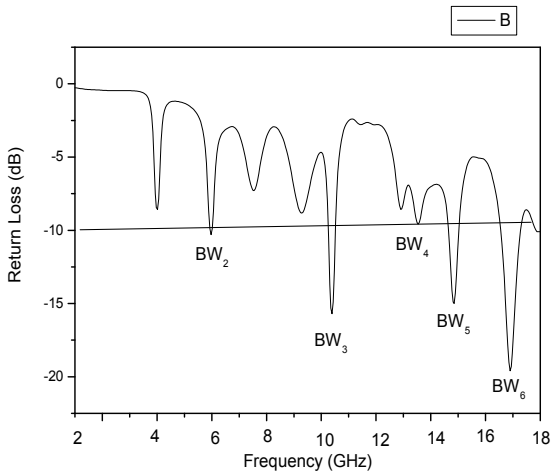

Fig 5. Variation of return loss versus frequency of TVSTHSRMA

The gain of the proposed antennas is measured by absolute gain method [11].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 TVSTHSRMA and TVSRMA measured in their operating bands is found to be 1.55 and 3.45 dB respectively. Hence by the construction of TVSRMA enhances the gain by 1.90 times more than the peak gain of TVSTHSRMA..

The radiation patterns of antenna are measured in an anechoic chamber. The co 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

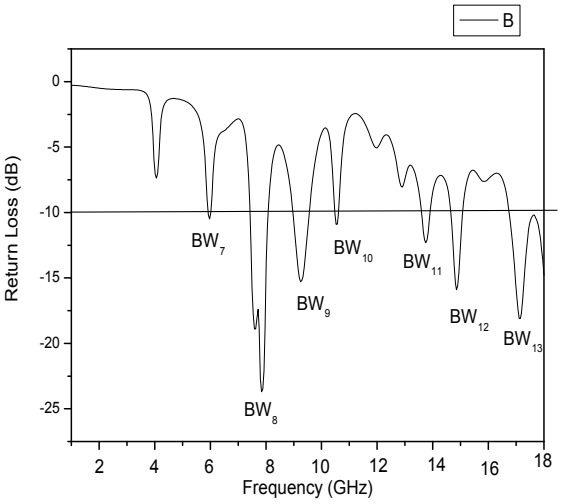

Fig 6. Variation of return loss versus frequency of TVSRMA

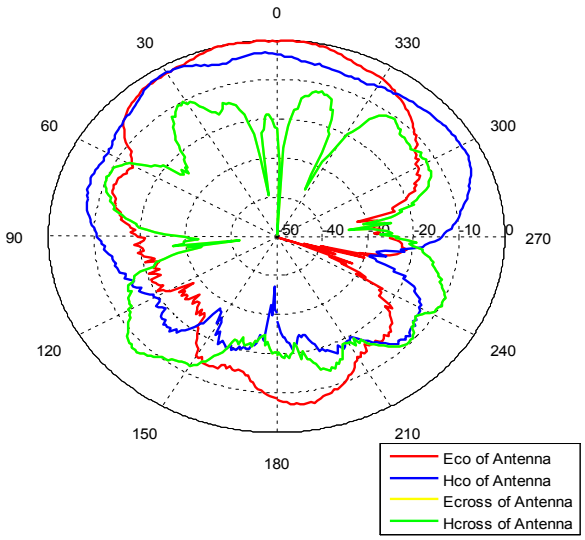

Fig 7. E and H plane radiation patterns of CRMA measured at 3.97 GHz.

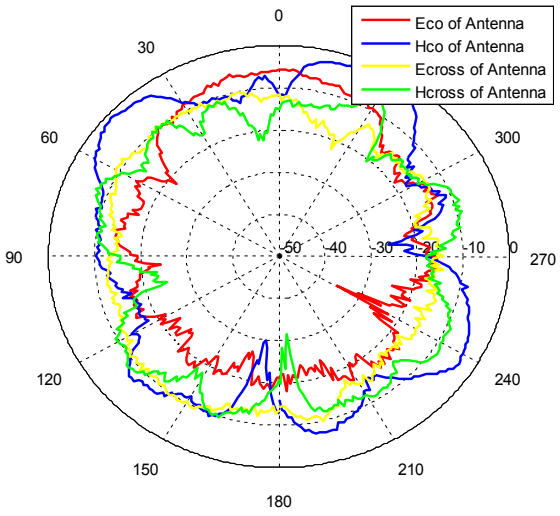

Fig 8. E and H plane radiation pattern of TVSTHSRMA measured at 10.5 GHz.

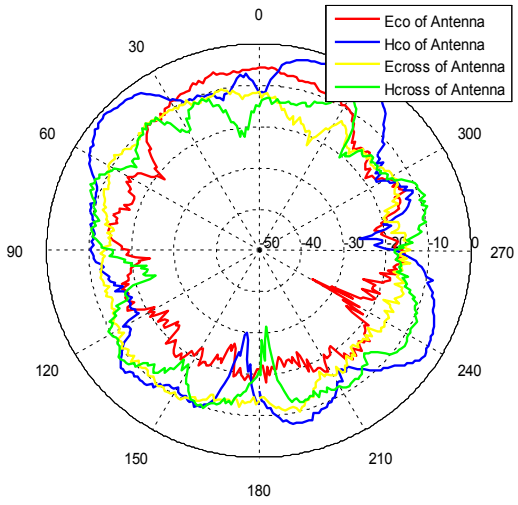

Fig 9. E and H plane radiation patterns of TVSRMA measured at 7.9 GHz.

4. CONCLUSION

From the detailed experimental study it is concluded that, by using Two vertical slot and Two horizontal slot loaded rectangular microstrip antenna in CRMA i.e., TVSTHSRMA makes the antenna to resonate for pentaband of frequencies and gives a peak gain of 1.65 dB. Further by removing two Horizontal slots i.e., TVSRMA. The antenna resonates for seven bands and gives a maximum impedance bandwidth of 7.61%. This antenna also enhances the gain to 3.45 dB when compared to the gain of TVSTHSRMA without changing much in the radiation characteristics. These antennas may find application SAR and microwave communication systems operating at c to ku bands.

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