A NOVEL DESIGN OF RECTANGLE AND TRIANGLE SLOTS
RECTANGULAR MICROSTRIP ANTENNA FOR IMPROVEMENT OF GAIN
AND BANDWIDTH

P.Naveen Kumar and S.Chandamma
1,2 Department of Electronics, Yuvaraja’s college, University of Mysore, Mysore, Karnataka, India

Abstract-This paper presents the novel design of rectangle and triangle rectangular microstrip antenna for multiband operation. The proposed antenna is housed in volume of 5 cm x 5 cm x 0.16cm and operates between 4 to 18 GHz. The multiband are achieved by incorporating rectangle and triangle slot of equal length at optimum place on the conducting patch. By adding two rectangle slots vertically on the patch the impedance bandwidth is enhanced in the lower operating band retaining the nature of broadside radiation characteristics. The proposed antenna may find application in radar communication.

I. INTRODUCTION

In modern communication technology, Microstrip antenna (MSAs) leads important role because of their applications and attractive 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], meandered probe feed [3], multi resonators [4], monopole technique [5] etc. 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.

II. 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 $\varepsilon_r = 4.2$. Figure 1 shows the geometry of CRMA designed on a substrate of area $P \times Q$ using the basic equations available in the literature [6]. 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 50$\Omega$ coaxial SMA connector is used for feeding the microwave power.

Figure 1 Geometry of conventional rectangular microstrip antenna
Figure 2 shows the geometry of pair of triangular slots and pair of rectangular slots rectangular microstrip antenna (PTSPRSRMA). Here the two triangular slots and two rectangular slots are placed along the width of the patch. The dimension of slots are taken in terms of $\lambda_0$, where $\lambda_0$ is the free space wavelengths in cm.

![Figure 2 Geometry of PTSPRSRMA](image)

Further, two vertical slots are added along the length of PTSPRSRMA. This antenna is named as pair of triangular slots and pair of rectangular slots II rectangular microstrip antenna (PTSPRS II RMA) which is derived from PTSPRSRMA as shown in Fig.3. The design parameters of CRMA, PTSPRSRMA and PTSPRSII RMA 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   |
III. 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 PTSPRSRMA is as shown in Fig. 5. From this figure it is seen that, the antenna resonates for quadband of frequencies BW\(_2\), BW\(_3\), BW\(_4\) and BW\(_5\). The magnitude of each operating band is found to be 4.49 %, 5.75 %, 3.66 % and 7.13 % respectively. The multiband operation is due to the independent resonance of Patch and slots inserted in the conducting patch of PTSPRSRMA [7]. By the construction of novel geometry of PTSPRSRMA, the antenna starts resonating higher than the designed frequency of 4 GHz.

Figure 6 shows the variation of return loss verses frequency of PTSPRSRMA. From this figure it is seen that, the antenna resonates for quad band of frequencies i.e. for BW\(_6\), BW\(_7\), BW\(_8\) and BW\(_9\). The magnitude of each operating band is found to be 10.32 %, 3.92 %, 3.70 % and 6.66 % respectively. It is clear from the figure that the BW\(_6\) operating bands is enhanced 2.29 times compare to PTSPRSRMA.

![Figure 4. Variation of return loss versus frequency of CRMA](image4.png)

![Figure 5. variation of return loss versus frequency of PTSPRSRMA](image5.png)
The gain of the proposed antennas is measured by absolute gain method [8]. 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,

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

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 PTSPRSRMA and PTSPRSIIRMA measured in their operating bands is found to be 2.01 and 4.50 dB respectively. Hence by the construction of PTSPRSIIRMA enhances the gain by 1.90 times more than the peak gain of PTSPRSRMA.

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.

![Figure 6. Variation of return loss versus frequency of PTSPRSIIRMA](image)

![Figure 7. E and H plane radiation patterns of CRMA measured at 3.97 GHz.](image)
IV. CONCLUSION

From the detailed experimental study it is concluded that, by using Two rectangle slots and Two triangle slots in CRMA i.e., PTSPRSRMA makes the antenna to resonate for quadband of frequencies and gives a peak gain of 2.01 dB. Further by adding two rectangle slots i.e., PTSPRSIRMA. The antenna resonates for quad bands and gives a maximum impedance bandwidth of 10.32%. This antenna also enhances the gain to 4.50 dB when compared to the gain of PTSPRSRMA without changing much in the radiation characteristics. These antennas may find application SAR and microwave communication systems operating at c to ku bands.

REFERENCES

[1] X.Wang,W.Chin, and Z.Feng, Multiband antenna with parasitic branches for laptop applications .Electron Lett 43(2007),1012-1013.
[2] D.M.Pozar “Microstrip antennas”,IEEE Proc.,Vol.80,pp.79-91,January 1992
[3] H. W. Lai and K. M. Luk, “Wideband stacked patch antenna fed by meandering probe,” *Electronics Letters*, vol. 41, no. 6, pp. 297–298, 2005.

[4] E. Chang, S. A. Long, and W. F. Richard, experimental investigation of electrically thick rectangular microstrip antennas, *IEEE Trans. Antenna Propagation*, Ap-34 (1986), 767–772.

[5] L. Liu and H.-J. Liu, compact triple slotted monopole antenna with asymmetric CPW grounds, *Electron Lett* 37 (2006), 840–842.

[6] I. J. Bhal and P. Bharatia, (1981), “Microstrip antennas”. Artech House, New Delhi.

[7] Sameena, Konda and Mulgi, “A Novel slot for enhancing the impedance bandwidth and gain of rectangular microstrip antenna”, *PIERS C*, Vol. 11, pp. 11-19, 2009.

[8] C. A. Balanis “Antenna theory”, John Wiley and Sons, 1997.