TRIPLE BAND RECTANGULAR MICROSTRIP ANTENNA FOR S & C BAND APPLICATIONS

P. A. AMBRESH¹, SUJATA A. A² & P. M. HADALGI³

¹Central University of Karnataka, Gulbarga University Campus, Gulbarga, Karnataka, India
²Godutai Engineering College for Women, Gulbarga, Karnataka, India
³Microwave Research Laboratory, Department of Applied Electronics, Gulbarga University, Gulbarga, Karnataka, India

ABSTRACT

In this paper, triple band rectangular microstrip antenna with two vertical rhombus shaped slot (TBRMA2VRS) is designed and developed for S and C band frequency applications. The triple bands are obtained by etching two rhombus slots on the patch surface. The impedance bandwidth of secondary band is enhanced from 2.06% to 8.54% by replacing the two rhombus slots. The radiation patterns measured on microwave bench setup for the proposed antennas are found to be broadsided, linearly polarized and are similar to the pattern of conventional RMSA. The antenna design procedure and results are presented and discussed.

KEYWORDS: Frequency, Slot, Epoxy, Vector Network Analyzer, Microstrip, Power

INTRODUCTION

Recently, the use of microstrip antennas has become increasingly popular because of various inherent advantages such as light weight, simplicity of fabrication, ease of mass production, etc. The major handicap of microstrip antennas is their very narrow impedance bandwidth [1]. A number of papers have appeared in technical literature on bandwidth enhancement of microstrip antennas using additional resonators coupled to the driven element [2]-[4]. In view of this, the simplest technique of etching two vertical rhombus slots is designed and fabricated to achieve these requirements.

DESIGN ISSUE

The low cost glass epoxy substrate material of thickness $h = 1.66$ mm and permittivity $\varepsilon_r = 4.4$ is used to design the proposed antennas. In order to get better accuracy in design, the antennas are sketched using computer software AutoCAD - 2012 and are fabricated using photolithography process.

The conventional RMA is designed for the resonant frequency ($f_r$) of 3.5 GHz using the basic equations available in literature [6]-[7]. The geometry of this antenna is as shown in Figure 1 with full copper on the patch and ground plane. The antenna is designed by using the following procedure.

The patch width $W$ shown in Figure 1 is given by,

$$W = \frac{c}{2f_r} \sqrt{\frac{\varepsilon_r + 1}{2}}$$  \hspace{1cm} (1)

The length of patch is given by,

$$L = \frac{c}{2f_r\sqrt{\varepsilon_r}} - 2\Delta l$$  \hspace{1cm} (2)
The width and length of feed network is designed using the following equations.

Length of feed line is given by,

\[ L_f = \frac{\lambda_f}{4} \]  

(5)

Width of quarter wave transformer is given by

\[ W_t = \frac{8h \varepsilon_1 A}{\varepsilon^2 A - 2} \]  

(6)

Length of quarter wave transformer is estimated using the by replacing \( Z_0 \) by \( Z_l \)and is given by

\[ L_t = \frac{\lambda_f}{4} \]  

(7)

Now the two vertical rhombus shaped slot is etched on the patch plane of conventional RMSA as shown in Figure 2. This antenna is named as triple band rectangular microstrip antenna with two vertical rhombus shaped slot (TBRMA2VRS).

The dimensions of all the slots are taken in terms of \( \lambda_0 \), where \( \lambda_0 \) is the free space wavelength corresponding to the designed frequency of conventional RMA i.e. 3.5 GHz. The length and width (\( L \times W \)) of the patch are (18.99 x 26.92). The side length \( x \) is 6.7 mm. The horizontal and vertical slot lengths (\( L_1 \) and \( L_2 \)) slots are 9.5 mm and 13.4 mm.

**EXPERIMENTAL RESULTS**

For the proposed antennas the impedance bandwidth over return loss less than \(-10\) dB is measured on Vector Network Analyser (Rohde and Schwarz, Germany make ZVK model 1127.8651).

The variation of return loss verses frequency of RMA is as shown in Figure 3. From the figure it is clear that, the
antenna resonates at \( f_1 = 3.8 \) GHz of frequency which is very much close to the designed frequency of 3.5 GHz and hence validates the design. From this graph, the experimental impedance bandwidth is calculated using the formula,

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

where, \( f_2 \) and \( f_1 \) are upper and lower cut-off frequencies of the band respectively when its return loss reaches \(-10\) dB and \( f_c \) is the centre frequency between \( f_1 \) and \( f_2 \).

The bandwidth of conventional RMA is found to be \( BW_1 = 2.06 \) %. Figure 4 shows the variation of return loss verses frequency of RMARS. The antenna resonates at two bands with resonant frequencies of \( f_{r1} = 3.08 \) GHz, \( f_{r2} = 5.30 \) GHz and \( f_{r3} = 6.19 \) GHz with corresponding impedance bandwidths of \( BW_1 = 2.92 \% \), \( BW_2 = 8.54 \% \), and \( BW_3 = 7.54 \% \). The triple bands are obtained due to independent resonance of patch and combined effect of all the rhombus slots [5]. The increase in impedance bandwidth shows that the slots are quite effective for improvement of impedance bandwidth [1].

For the measurement of radiation pattern, the antenna under test (AUT), i.e. the proposed antennas and standard pyramidal horn antenna are kept in far field region. The AUT, which is the receiving antenna, is kept in phase with respective transmitting pyramidal horn antenna. The power received by AUT is measured from \(-90^\circ\) to \(+90^\circ\) with the steps of \(10^\circ\).

The co-polar and cross-polar radiation patterns of the proposed antennas are measured in their primary bands. The radiation patterns of conventional RMSA and TBRMA2VRSs is measured at 3.8 GHz and 5.3 GHz and are shown respectively in Figure 5 and Figure 6. From these figures, it is clear that, the patterns are broadsided and linearly polarized suitable for wireless applications.

The gains \( G(\text{dB}) \) of proposed antennas are measured by absolute gain method [5].

\[
G(\text{dB}) = 10 \log \left( \frac{P_r}{P_t} \right) - (G_t) \text{ dB} - 20 \log \left( \frac{\lambda_\text{c}}{4\pi R} \right) \text{ dB}
\]

Where 
- \( P_t \)– Power transmitted by pyramidal horn antenna,
- \( P_r \)– Power received by antenna under test (AUT),
- \( G_t \)– Gain of pyramidal horn antenna,
R – Distance between transmitting antenna and AUT

The gains of conventional RMA and RMARS are found to be 2.7 dB and 6.8dB respectively. Hence the enhancement of antenna gain from 2.7 dB of conventional RMA to 6.8 dB of TBRMA2VRS is achieved.

![Figure 5: Radiation Pattern of Conventional RMA Measured at 3.6 GHz](image)

![Figure 6: Radiation Pattern of TBRMA2VRS Measured at 5.3 GHz](image)

CONCLUSIONS

From the detailed study it is concluded that by using the four rhombus slots on the patch plane of rectangular microstrip antenna, dual bands are obtained. In the dual band response, the secondary band is appearing without changing much the resonant frequency of primary band of conventional RMSA. Further, when two vertical rhombus slots are replaced on conventional RMSA, it is found that, the impedance bandwidth of secondary band is enhanced from 2.06 % to 8.54 % without change in the broadside radiation pattern. This technique also enhances the gain from 2.7 dB to 6.8dB.

ACKNOWLEDGEMENTS

Authors thank the Department of Science and Technology(DST), Government of India, New Delhi, for sanctioning Vector Network Analyzer to this Department under FIST Project and also providing financial assistance to Ambresh P.A under Rajiv Gandhi National fellowship- Junior Research Fellowship (RGNF- JRF & SRF) [No.F.14 (SC)/2009(SA-III) dated 18 November 2010] scheme by University Grants Commission, New Delhi.

REFERENCES


