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Dual-slot based Rectangular Microstrip Antenna for WiMAX, WCS and C-band Satellite Applications

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Abstract: A dual-band rectangular microstrip antenna (RMSA) with two slots for wireless applications such as WiMAX (2.3 GHz), WCS (Wireless Communications Service- 2.305-2.32 GHz) and C-band (4.6480-4.8170 GHz) satellite applications is presented. The graphs for return loss, 3D radiation pattern and VSWR are obtained using Ansoft HFSS 13.0. The obtained results are satisfactory.

Keywords: Dual-band RMSA, WiMAX, WCS, C-band.

I. INTRODUCTION

In the modern age of wireless communication, an antenna plays a very significant role. The antennas should be compact to get constructed into the wireless devices and should support multi-band frequency applications while having good performance characteristics such as gain, bandwidth, return loss etc. The Microstrip Antennas (MSA) are the most commonly used antennas for compact wireless devices due to its conformal nature, light weight and easy manufacturing. But low bandwidth and gain are the major limitations of MSA [1].The MSA generally consists of a radiating metallic patch fabricated over the ground plane with the dielectric substrate included between them. Fig. 1 shows the basic geometry of a MSA.

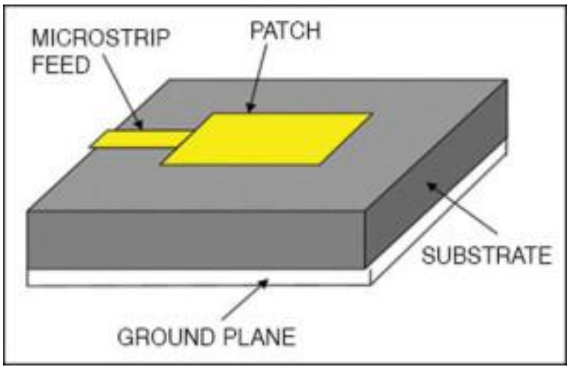

Fig. 1 Basic geometry of MSA [2]

There are various shapes and sizes of a MSA are available such as rectangular, square, circular, triangular and elliptical etc., from which the circular, square and Rectangular MSA are mostly preferred [1]. There are various feeding methods by which the MSA is fed such as Microstrip line method,Coaxial probe feed method, Aperture-coupled and Proximity-coupled method. The most easy and suitable type of feeding method is Coaxial probe method [3]. The MSA can be operated for multi-bandfrequency applications by using stubs and slots into the top patch element and ground plane [4-6]. A rectangular patch antenna for 2.4 GHz with return loss of -38 dB is presented in [7]. The design of antenna is based on FR4 substrate. The proposed antenna has a gain of 3.954 dB and suitable for wireless applications such as WLAN, Wi-Fi etc. A dual-band slotted rectangular MSA for 1.90 GHz and 2.59 GHz frequencies with return loss of -9.56 dB and -12.32 dB is presented in [8]. The design is based on Neltec NX 9240 epoxy substrate. A rectangular MSA with H and T shaped slots for 2.4 GHz is presented in [9] with gain of 8.21 dB and 6.90 dB respectively. The proposed antenna can be used for WiMAX, Wi-Fi and Digital Multimedia Broadcasting (DMB) applications.
In this paper, a rectangular coaxial-fed MSA with two slots (vertical and horizontal) are presented for dual-band operation (2.3 GHz and 4.7 GHz). The proposed antenna can cover the WiMAX (2.3 GHz), WCS from 2.305-2.32 GHz and C-band (4.6480-4.8170 GHz) satellite applications.

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II. DESIGN AND METHODOLOGY OF PROPOSED ANTENNA

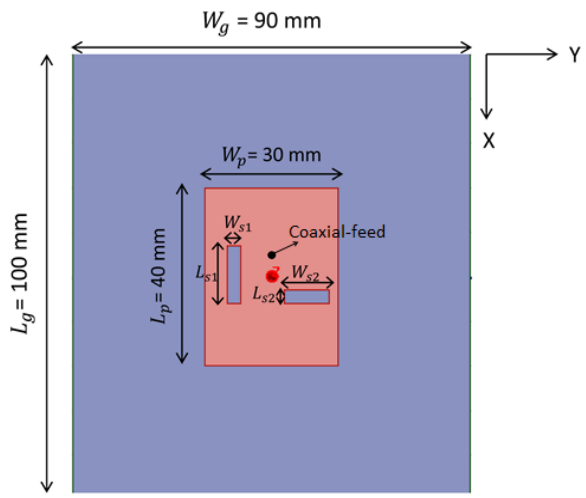

Fig. 2 Proposed antenna top view

The top view of proposed antenna is shown in Fig. 2.It consists of a rectangular top patch of dimensions $L_p \times W_p$, a ground plane of dimensions $L_g \times W_g$, a Rogers RT/duroid 5880 substrate of height h = 3.2 mm, two rectangular slots of dimensions $L_{s1} \times W_{s1}$ and $L_{s2} \times W_{s2}$ respectively and a coaxial feed. The details of all dimensions of the proposed antenna are given in Table I. The design procedure of patch antenna has been followed by using the steps described in [1] and given by the flowchart in Fig. 3 as:

Start

Specify ε_r, f_r and h

Determine Width of patch (W):

$$W = \frac{v_0}{2fr}\sqrt{\left(\frac{2}{\varepsilon_r+1}\right)}$$

Determine Effective dielectric constant (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2}$$

Determine Extension of length (ΔL):

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

Determine Length of patch (L):

$$L = \frac{v_0}{2fr\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

End

Fig. 3 Flowchart for design of patch antenna

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Here, ε_r, f_r, h and v_0 are the dielectric constant of substrate, resonant frequency, height of substrate and free-space velocity of light respectively. The calculated parameters of antenna are optimized for the desired results.

The proposed design consists of one vertical slot and one horizontal slot inserted into the top patch as shown in Fig. 2. These slots are used for dual-band operation and gain enhancement. The simple patch without any slot resonates at 2.37 GHz frequency. The first vertical slot introduces the resonant frequency of 4.8 GHz into the structure. The second horizontal slot is used to reduce the mismatch loss of 1st frequency band which occurs at 2.4 GHz and introduces a resonant frequency of 2.3 GHz with improved return loss.

TABLE I DIMENSIONS OF PROPOSED ANTENNA

Dimension	**Value (mm)**	**Dimension**	**Value (mm)**
L_g	100	L_{s1}	13
W_g	90	W_{s1}	3
L_p	40	L_{s2}	3
W_p	30	W_{s2}	10
Substrate details- Rogers RT/duroid 5880			
Length = 100 mm Width = 90 mm	Height (h) = 3.2 mm	Dielectric constant (ε_r)= 2.2	Dielectric loss tangent (δ) = 0.0009
Feed details- Coaxial probe			
inner conductor radius	0.7 mm	outer conductor radius	1.6 mm

III.RESULTS AND DISCUSSIONS

A. Return Loss

The graph of return loss values against frequency values are shown in Fig. 4.

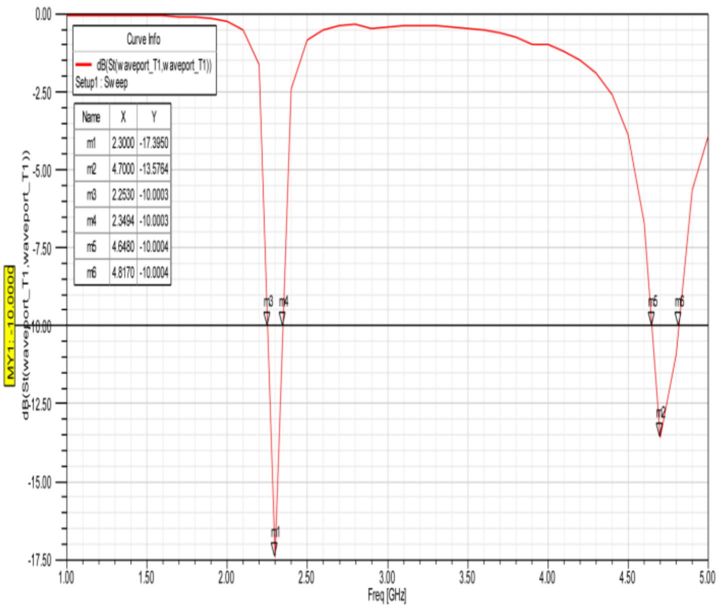

Fig. 4 Return loss vs. frequency graph

The proposed antenna resonates at 2.3 GHz with Band 1 (2.2530-2.3494 GHz) and 4.7 GHz with Band 2 (4.6480-4.8170 GHz) with impedance bandwidth (-10 dB) = 96.4 MHz and 169 MHz respectively. The obtained values of return loss for 2.3 GHz and 4.7 GHz are -17.3950 dB and -13.5764 dB respectively. The antenna can support wireless applications such as WiMAX (2.3 GHz), WCS (2.305-2.32 GHz) and Satellite C-band (4.6480-4.8170 GHz).

B. VSWR

The results for VSWR are shown in Fig. 5. The VSWR values are 1.3121 for 2.3 GHz and 1.53 for 4.7 GHz respectively.

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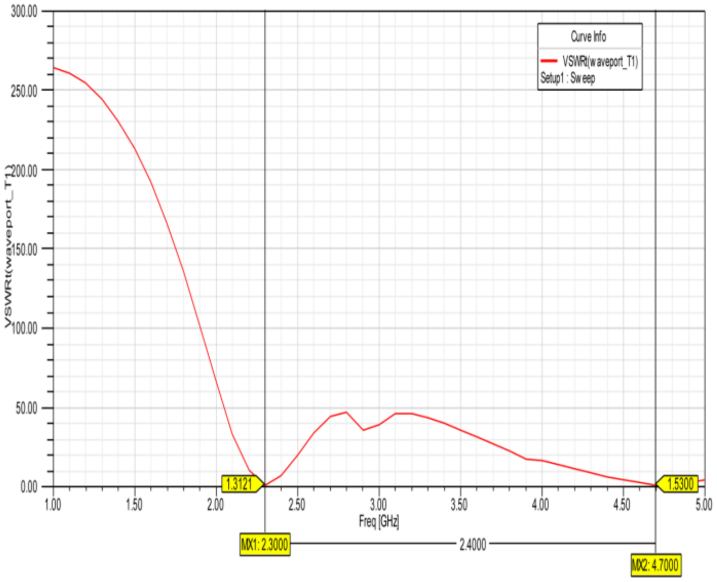

Fig. 5 VSWR vs. frequency graph

C. 3D Radiation Pattern
The three-dimensional radiation pattern with gain (dB) of proposed antenna is shown in Fig. 6 and Fig. 7.

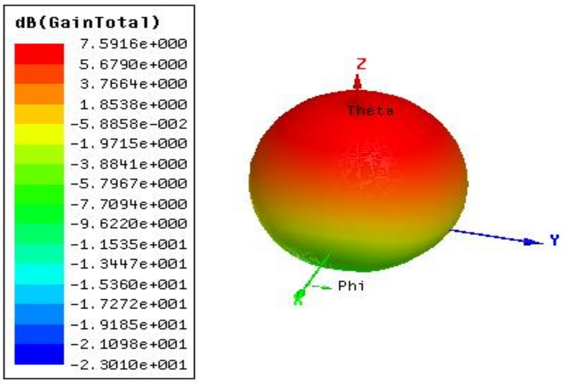

Fig. 6 3D radiation pattern for 2.3 GHz

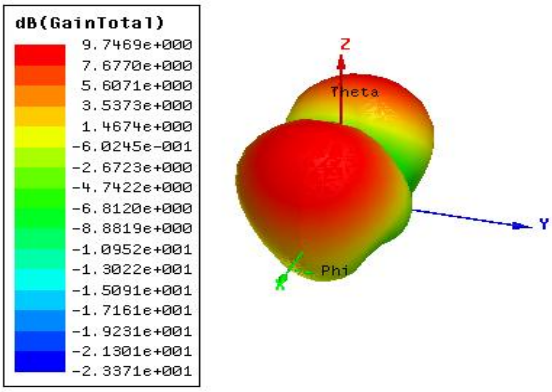

Fig. 7 3D radiation pattern for 4.7 GHz

From Fig. 6 and Fig. 7, it is shown that radiation pattern of antenna is quite directional for 2.3 GHz and nearly omni-directional for 4.7 GHz frequency. The maximum value of gain for 2.3 GHz and 4.7 GHz is 7.5916 dB and 9.7469 dB which is more than as depicted in [10].

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IV. CONCLUSION

A dual-slotted rectangular patch antenna is presented in this paper. The antenna resonates at 2.3 GHz and 4.7 GHz frequency with return loss of -17.3950 dB and -13.5764 dB respectively. The gain of antenna at 2.3 GHz and 4.7 GHz is 7.5916 dB and 9.7469 dB respectively, which is more than as depicted in [10]. The antenna is useful for WiMAX, WCS and C-band satellite applications.

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