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U-Slot Microstrip Antenna for Amateur Radio Application

Sk.Riyaz Hussain[1], Suresh Kalidindi[2]

Lecturer, Dept of ECE, Rajiv Gandhi University Of Knowledge and Technologies, Nuzvid, A.P, India [1]

M.Tech Student, Dept of ECE, Rajiv Gandhi University Of Knowledge and Technologies, Nuzvid, A.P, India [2]

ABSTRACT: In this paper, a design and analysis of Microstrip patch is presented. The proposed antenna has simple structure with U-slot operating for the application of Amateur radio[4]. The overall dimension of the antenna comes around 16.22mm×20.62mm×2.15mm. The impedance matching and radiation characteristics of the designed structure are investigated by using MOM based commercially available electromagnetic solver IE3D. The simulation results show that the antenna offers excellent performance for Amateur radio application ranging from 5.65-5.85 GHz with return loss of below -10 dB . The proposed antenna gives directional pattern in the E plane and Omni directional radiation pattern in the H plane over the frequency range and relatively stable.

Keywords: Microstrip, Amateur radio

I. INTRODUCTION

Recent days, there is a significant need to design antennas, which are compact in size. Dedicated antennas are in urgent demand for wireless applications, which include Amateur Radio. In times of crisis and natural disasters, Amateur radio is often used as a means of emergency communication when wire line, cell phones and other conventional means of communications fail. It uses designated radio frequency spectrum for purposes of private recreation, non-commercial exchange of messages, wireless experimentation, self-training, and emergency communication. Amateur radio operates in the frequency band 5.650GHz to 5.670GHz[6] for up-link & 5.830GHz to 5.850GHz for down-link.

Although many Computer-Aided Design (CAD) systems are developed to design antennas but rarely we see the mathematical explanation for the designing[1],[4]. There are few fundamental formulas that are available to calculate the outer dimensions of the microstrip antennas, and we don't have any clue how to find the dimensions of the inner patch. Here in this paper we used U-slot inside the microstrip patch, whose dimensions are calculated mathematically and the same is explained in the proceeding chapters

II. ANTENNA DESIGN

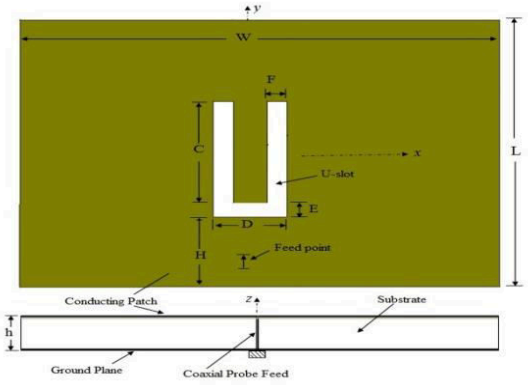

Fig. 1 Structure and configuration of Rectangular U-slot Microstrip Antenna

Fig. 1 shows the structure and configuration of the proposed U-shaped slot rectangular microstrip antenna which coverage 5.65 – 5.85 GHz frequency band.

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III. MATHEMATICAL ANALYSIS FOR ANTENNA DESIGN

Operating frequency of the antenna can be calculated from the following equation

$$f_o = (f_l+f_h)/2 \quad (1)$$

Where, f_l is the lower frequency and f_h is the higher frequency of operating band.

The guided wavelength in the substrate of the antenna is given by the following equation

$$\lambda = v_o/f_o \quad (2)$$

Where v_0=3x10^8 m/sec

The thickness of Dielectric substrate (h) is given by the following equation [2]

$$h \geq 0.06(\lambda / \sqrt{\varepsilon_r}) \quad (3)$$

A. *Microstrip Patch Antenna Dimensions*

Width of rectangular microstrip patch is given by

$$W= v_o \sqrt{(2/\varepsilon_r)} / (2f_o) \quad (4)$$

Where ε_r is the dielectric constant of the dielectric material

Effective Dielectric constant is given by [4]

$$\varepsilon_{reff} = [(\varepsilon_r+1)/2] + (\varepsilon_r -1) / [2 \sqrt{(1+12\ h/W)}] \quad (5)$$

Length of rectangular microstrip patch is given by

$$L=L_{eff} -2\Delta L \quad (6)$$

Where L_{eff} is Effective Length of the rectangular microstrip antenna, it is given by

$$L_{eff} = v_o / (2f_o \sqrt{\varepsilon_{reff}}) \quad (7)$$

ΔL is Length Extension, it is given by

$$\Delta L = 0.412h\ [(\varepsilon_{reff}+0.3)((W/h)+0.264)] / [(\varepsilon_{reff}-0.258)((W/h)+0.8)] \quad (8)$$

B. *Ground Plane Dimensions*

Length of the ground plane is given by

$$L_g=6h+L \quad (9)$$

Width of the ground plane is given by

$$W_g=6h+W \quad (10)$$

C. *Slot Dimensions*

Thickness of the slot is given by[3]

$$E=F= \lambda/60 \quad (11)$$

Slot width is given by the following equation

$$D= [v_o / (f_{low} \sqrt{\varepsilon_{reff}})] - 2(L+2\Delta L-E) \quad (12)$$

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Selection of C is given by the

$$C_1/W \geq 0.3 \text{ and } C_2/D \geq 0.75 \quad (13)$$

D. Bandwidth of the Antenna

Bandwidth of the antenna is given by the following equation

$$BW = 3.77[(\varepsilon_r - (1/\varepsilon_r \text{ ^2 })) (W/L) (h/\lambda_o)] \quad (14)$$

From the mathematical analysis we have obtained the specifications for the antenna that operate effectively in 5.650 – 5.850 GHz and those dimensions are tabulated in the below Table 1 by taking the dielectric constant $\varepsilon_r = 2.2$. For this antenna U-Slot[9] is placed at the centre of the antenna as shown in the Fig. 1. The U-Slot is placed at a height of H = 5mm from the bottom edge. Probe is feed down to the U-Slot to get optimum results.

TABLE I
SPECIFICATIONS OF THE ANTENNA FOR AMATEUR RADIO APPLICATION

Lower frequency of operating band (f_l)	5.650 GHz
Higher frequency of operating band (f_h)	5.850GHz
Resonant Frequency (f_o)	5.75 GHz
Height of Dielectric substrate (h)	2.15 mm
Percentage Bandwidth (%BW)	3.47%
Width of the patch (W)	20.62 mm
Length of the patch(L)	16.22 mm
Ground plane dimension L_g	29.12 mm
Ground plane dimension W_g	33.52 mm
Slot thickness (E & F)	0.86 mm
Slot Width (D)	2.39 mm
Section of C	6.18 mm

Dimensions for microstrip antenna for Amateur Radio application, which operates at the 5.650 – 5.850 GHz band (5.650 - 5.670 GHz for Up-Link & 5.830 – 5.850 GHz for Down-Link) will require Band width of about 3.47% and W X L is 20.62 X 16.22 mm. The dimensions of the Amateur Radio Antenna are noticeably compact size.

IV. RESULTS

Fig. 2 shows the return loss curve for the proposed Amateur Radio Antenna. From the return loss curve we can say that the antenna can operate efficiently in 5.56 – 5.90 GHz with a percentage bandwidth of 5.9%. The required band - width for Amateur radio application is 3.47%, hence we got more than the required bandwidth. From the below Fig. 2 return loss is about 19db near 5.75 GHz thus we can say it can operate more efficiently at the resonant frequency.

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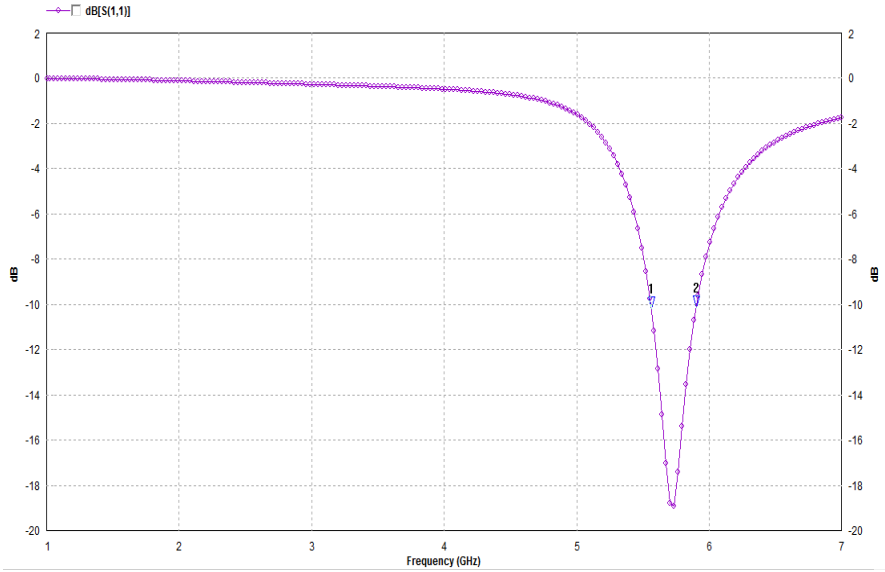

Fig. 2 Return loss curve for Amateur Radio Antenna

Fig. 3 shows the VSWR curve for the proposed Amateur Radio Antenna. From 5.54 GHz to 5.91 GHz the VSWR is less than 2 and It has VSWR = 1.24 near the resonant frequency

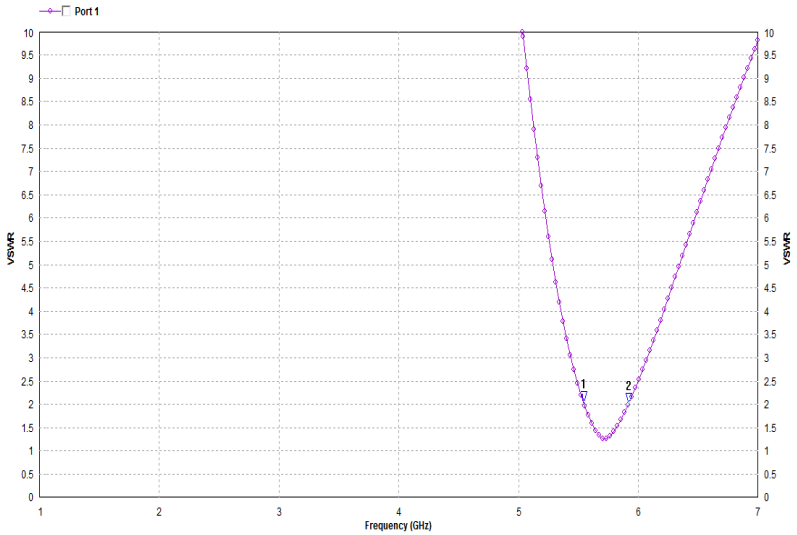

Fig. 3 VSWR curve for Amateur Radio Antenna

Fig. 4 shows the Gain Vs Frequency curve for Amateur Radio Antenna. It has a gain of about 6.57dB at resonant frequency.

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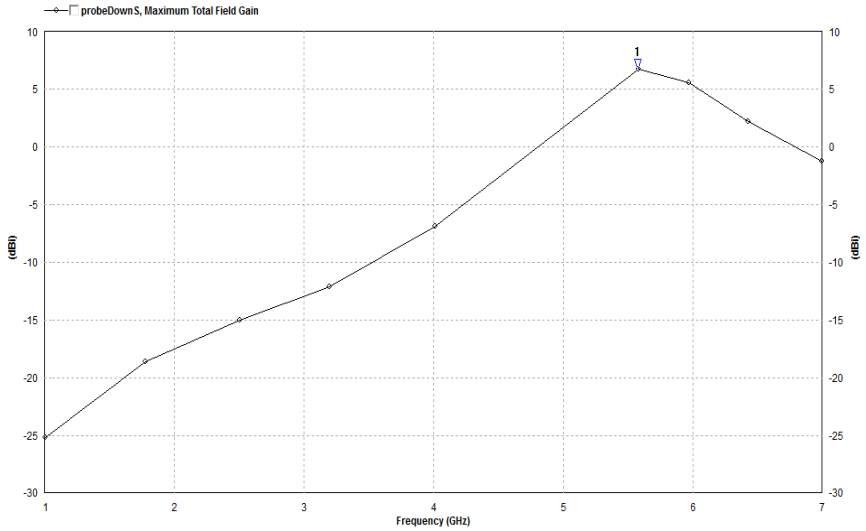

Fig. 4 Gain Vs Frequency for Amateur Radio Antenna

Fig. 5 shows the Directivity Vs Frequency curve for Amateur Radio Antenna. It has a directivity of about 8dB at resonant frequency.

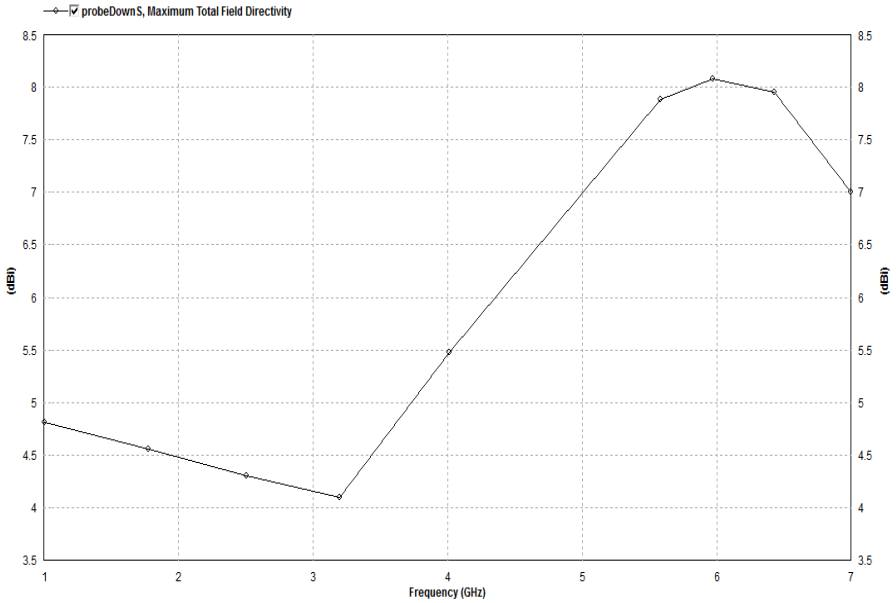

Fig. 5 Directivity Vs Frequency for Amateur Radio Antenna

Fig. 6 shows the Antenna Efficiency Vs Frequency curve for Amateur Radio Antenna. It has a efficiency of about 75% at resonant frequency.

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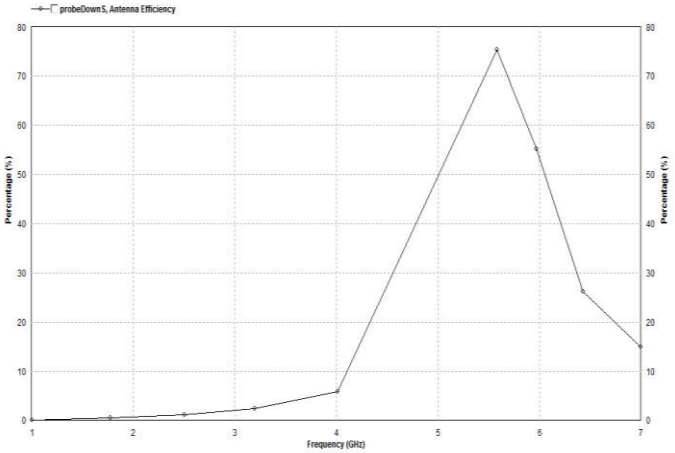

Fig. 6 Antenna Efficiency Vs Frequency for Amateur Radio Antenna

From all the above curves we can say that the Amateur Radio Antenna can operate more efficiently with more than required bandwidth, 1.24 VSWR, 6.7dBi gain, 8dB directivity and 75% antenna efficiency.

V. CONCLUSION

By using Mathematical analysis we have designed the U-Slot microstrip antenna for Amateur Radio application which operates in the frequency band 5.650GHz to 5.670GHz for up-link & 5.830GHz to 5.850GHz for down-link with compact size, efficiency of about 75%, gain 6.7 db, percentage bandwidth 5.9%, required bandwidth for Amateur radio application is 3.47%, hence we got more than the required bandwidth.

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BIOGRAPHY

Sk.Riyaz Hussain was born in Andhra Pradesh, India in 1986. He received the Masters degree from NIT TRICHY with specialization as Communication Systems in 2010. Now he is Lecturer (2010-Till Date) in, Department of Electronics and Communication Engineering, RGU-IIIT, Nuzvid. His main research interest includes the analysis and design of multi band antennas and wireless Communications.