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Design and Simulation of Microstrip Patch Antenna for Bandwidth Enhancement through Slotting

Mandeep Kaur [#1], Rajni [#2]

Abstract **-- This paper presents a comparison between conventional simple Microstrip Patch Antenna (MPA) and the Antenna design by incorporation of various types of slots. Performance parameters like Bandwidth, Gain, Directivity, Voltage Standing Wave Ratio (VSWR) and Return loss of Slotted MPA have been evaluated and compared with that obtained from conventional Microstrip Patch Antenna without slot. The results show that the bandwidth of the Microstrip Patch Antenna increases without degradation in other parameters. The modelling of the proposed antenna and parameters evaluation of proposed antenna has been implemented in Finite Element Method (FEM) based software 'High Frequency Structure Simulation' (HFSS) ver 10.0**

Key Terms **-- Microstrip Patch Antenna, Bandwidth enhancement. Voltage Standing Wave Ratio (VSWR)**

I. INTRODUCTION

The recent rapid progress in the field of wireless communication demands simple, small, reliable, economical, low profile and lightweight and mechanically robust antennas for various applications like mobile and satellite communication, phased array, electronic warfare, radar, missile telemetry, space and airborne microwave remote sensing systems etc. Microstrip Patch Antennas possess the above-mentioned desired properties [1]. So they are considered as a potential candidate for these purposes. Microstrip Patch Antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side [2].

[#1] Mandeep Kaur, M.Tech. student, in the Deptt of Electronics and Communication Engineering
Shaheed Bhagat Singh State Technical Campus (SBSSTC), Ferozepur(Punjab)(India)

Email id:- manrandhawa18@gmail.com

[#2], Rajni, Associate Professor, in the Deptt. of Electronics and Communication Engineering,
Shaheed Bhagat Singh State Technical Campus (SBSSTC), Ferozepur(Punjab)(India)

Email id: - rajni_c123@yahoo.co.in

Patch is generally square, rectangular, circular, triangular and elliptical. But the fields of application of these antennas are limited by their inherent disadvantage of relatively low-Impedance Bandwidth [3]. Several techniques are available in literature for improving the bandwidth of microstrip antennas such as the use of impedance network[4], parasitic patches stacked on the top of main Patch [5], incorporating slots [6-8] using multimode resonators [9] etc. Among these the slotting technique is simple to enhance the bandwidth as compared to the other techniques because it has the freedom to add desired slot on the radiating element of the Microstrip antenna. The slots in the Microstrip patches may be of various shapes [10-11] like U-slot, E- shaped slot, L-shaped slot, W-shaped slot etc. Based on the previous ideas, This paper presents synthesis of an antenna with different types of slots then comparison of the performance parameters of these types of slot antennas with a simple Microstrip Patch Antenna without slot.

This paper is organized in four Sections. Following introduction in Section I, geometry of proposed antenna is discussed in Section II. Section III discusses the results of the proposed antenna. Section IV gives s conclusion.

II. ANTENNA DESIGN AND STRUCTURE

The width (W) and Length (L) of the Patch is given as:

$$W = c/2f_o\,(\varepsilon_r+1)^{-1/2} \qquad (1)$$

$$L_{ef\,f} = c/2f_o\,(\varepsilon_{reff})^{1/2} \qquad (2)$$

The equation (1) gives the effective width (W) of the Patch Antenna for a given resonating frequency f_o, ε_r is the dielectric constant of substrate, c is the velocity of light (3×10^8m). Equation (2) gives the effective length (L) of the patch Antenna for a given

resonating frequency $f_{o,}$ ε_{reff} is the Effective dielectric constant.

The Microstrip Patch Antenna has a rectangular Patch Antenna with dimension 12.45 mm × 16 mm. It is mounted on a substrate of Rogers RT/ Duriod5880) ™ of dimensions 28.1 mm × 32 mm and relative permittivity ε_r =2.2 $_{and}$ dielectric loss tangent 0.009. The thickness of the substrate is taken as 0.794 mm. The antenna consists of a ground plane of 28.1 mm × 32 mm. the antenna is excited by microstrip line feeding a patch at the center of the patch element having a dimension of 2.46 mm × 8 mm in size.

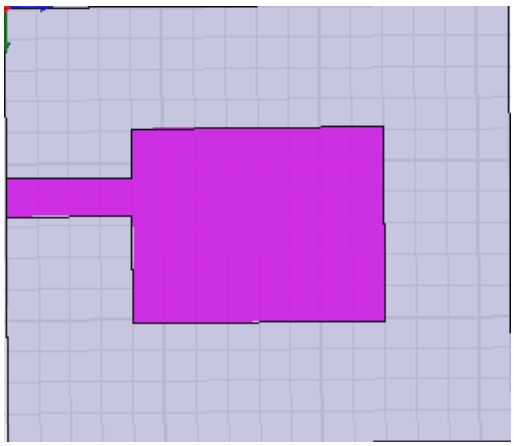

Fig 1: TOP VIEW OF SIMPLE PATCH ANTENNA

In order to improve the Bandwidth, different shapes of slots are incorporated in microstrip patch antenna.

1) U- Slot Patch Antenna

The antenna is excited by Microstrip line feeding a patch at the center of the patch element having a dimension of 2.46 mm× 8 mm in size.

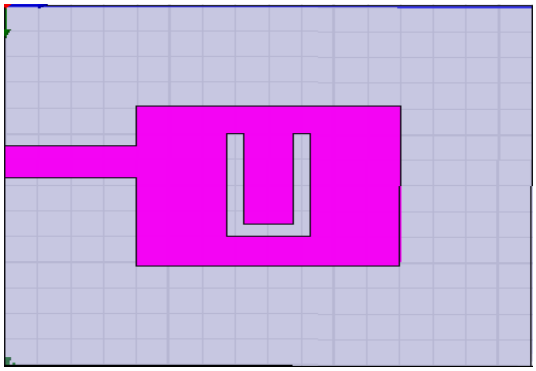

Fig 2: TOP VIEW OF U SLOT PATCH ANTENNA

Fig 2 shows the geometry of proposed U slot Microstrip Patch Antenna. The side arm of U-shaped slot has the dimensions of 8 mm × 1mm and the base arm of U shaped slot has dimensions of 5 mm × 1 mm.

2) C Slot Patch Antenna

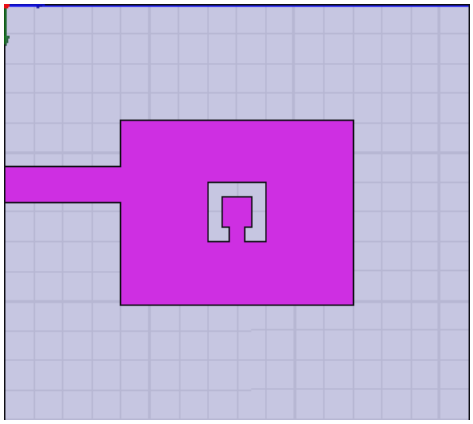

Fig 3: TOP VIEW OF C SLOT PATCH ANTENNA

The arms of the C- shape slot have the dimensions of 4mm x 1mm, the gap between the two arms is of 1mm.

3) L Slot Patch Antenna

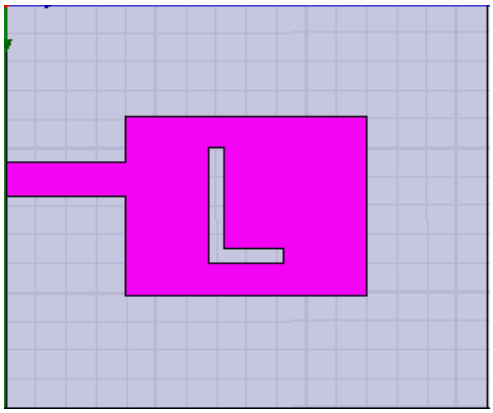

Fig 4: TOP VIEW OF L SLOT PATCH ANTENNA

The side arm of L-shaped slot has the dimension of 8 mm × 1 mm and the base arm of L-shaped slot has the dimensions of 5 mm × 1 mm.

4) Square O Slot Patch Antenna

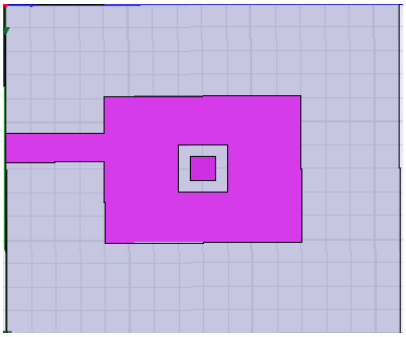

Fig 5: TOP VIEW OF SQUARE SLOT PATCH ANTENNA

The Square-shaped slot has the dimensions of each arm as 4mm × 1 mm.

5) E Slot Patch Antenna

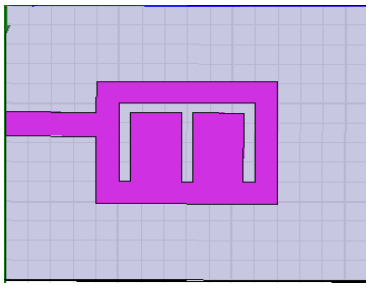

Fig 6: TOP VIEW OF E SLOT PATCH ANTENNA

The base arm of E-shaped slot has the dimensions of 12mm × 1mm and side arms have the dimensions of 8 mm × 1 mm.

1) H Slot Patch Antenna

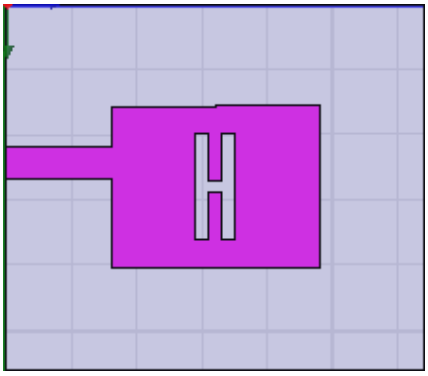

Fig 7: TOP VIEW OF H SLOT PATCH ANTENNA

The side arms of H-shaped slot have the dimensions of 8mm × 1mm and the base arm has the dimensions of 5 mm × 1 mm.

1) I Slot Patch Antenna

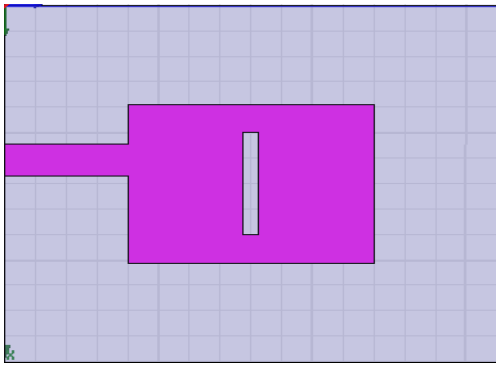

Fig 8: TOP VIEW OF I SLOT PATCH ANTENNA

The I-shaped slot has the dimensions of 8 mm × 1 mm

8) Circular O Slot Patch Antenna

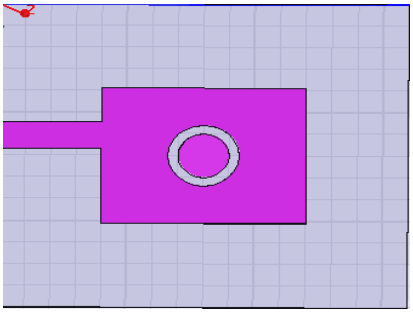

Fig 9: TOP VIEW OF O SLOT PATCH ANTENNA

The radius of the outer circle is 2.8 mm and the radius of inner circle is 2 mm.

III. RESULTS AND DISCUSSIONS

In this section of paper, a comparison of different types of slot patch antenna with simple without slotting patch antenna has been shown in Table 1. This table shows that the Bandwidth get increased with the slotting.

Table1: Comparison of Different types of Slot Antennas

Type of Antenna	Return Loss (dB)	Reso-nating Freq (GHz)	BW (MHz)	VSWR	Gain (dB)	Directi-vity (dB)
Simple Patch	-25	10	110	1.13	7.1	7.1
I Slot	-26.67	9.91	170	1.10	7.08	7.16
H Slot	-28.56	9.60	150	1.13	4.74	4.95
O Slot	-34.75	9.6	160	1.3	5.3	5.4
L Slot	-32.24	7.17	200	1.10	6.62	6.69
Square Slot	-26.62	9.61	160	1.12	5.53	5.59
E slot	-22.28	9.56	140	1.38	4.26	4.42
C Slot	-24.06	6.76	160	1.13	4.42	4.61
U Slot	-30	9.78	150	1.17	5.92	6.11

The maximum Bandwidth is obtained by the L type slot, with this type of slotting the Bandwidth is increased by 90 MHz from the conventional simple Microstrip Patch Antenna.

IV. CONCLUSION

The idea of different types of Slotted Microstrip Antenna is demonstrated in this paper. With slotting the Bandwidth of microstrip Patch Antenna can be increased with minimum Return Loss achieved. The proposed antennas are simple in design and fabrications.

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