Microstrip Patch Antenna with Double I Slot for Wide Band Applications

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***Abstract*:**
A double I slot microstrip patch antenna is designed and simulated in this paper. The proposed antenna is designed using Rogers RT/duriod substrate with dielectric constant 2.2 with microsrip line feed. The designed antenna works from the band 7.2GHz to 12GHz. This antenna can be used for wide band applications such as Radar, Satellite communication, biomedical application, Remote sensing etc. The performance of the designed antenna is explained in terms of return loss, resonance frequency, VSWR, radiation pattern and gain. The effect of adding slot on resonance frequency and bandwidth has been studied in this paper. Design and simulations of the antenna are implemented using High Frequency Structure Simulator Software (HFSS).

Keywords — *patch antenna, Radar, microstrip line feed, enhanced bandwidth, HFSS.*

I. INTRODUCTION

Microstrip patch antenna is a type of radio antenna with low profile, which can be mounted on a flat surface. Microstrip antennas are inexpensive to manufacture and design because of their simple geometry. Narrow bandwidth is one of the disadvantages that patch antenna suffer from [1]. The bandwidth of patch antenna can be enhanced by adding slots to the patch [2],[3],[4],[5]. The enhanced bandwidth microstrip antenna is fascinating for many applications such as Radar, Satellite communication, biomedical application, Remote sensing etc [5]. The designed antenna is suitable for x-band radar. Radar is an object-detection system that uses radio wave to determine the range, the angle, or velocity of objects. For aircraft, radar transmits radio waves to ground or sea level and receives an echo signal after time duration. Speed of vehicle and height between aircraft and ground specify the value of time [6]. Now a days communication and Radar systems development requires development of inexpensive, low profile and light weight antennas to be able to achieve high performance over a wide band of frequencies [7]. Narrow bandwidth can be enhanced by several methods, for example, slotted patch antenna [2],[3],[4],[5], increasing the substrate thickness, use of various impedance matching and feeding techniques [8],[9]. In this paper, the performance of a microstrip antenna without slot is presented. The antenna is designed at 8GHz. The effect of adding one slot and two slots on bandwidth is studied. I slot and double I slot is added to enhance the bandwidth. Through this paper, the performance of the antenna is examined using HFSS, and MATLAB program.

II. ANTENNA STRUCTURE AND DESIGN

The structure of the designed antenna consists of ground plane, dielectric substrate, and rectangular patch feeding by a microstrip line. Dimensions of rectangular patch antenna are length (L) and width (W). The antenna is designed to resonate at 8GHz. The parameters chosen to meet the design requirements are based on transmission line model equations [1] as given below. The dielectric material used for the design is RT-Duroid which has a dielectric constant of 2.2. The thickness of the dielectric substrate is 3.2mm.

The width of the patch antenna is given by:

$$w = \frac{1}{2 f_r \sqrt{\mu_o \varepsilon_o}} \sqrt{\frac{2}{\varepsilon_r + 1}}$$

Effective dielectric constant can be calculated as:

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

Length extension (ΔL):

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

The actual length of the patch is:

$$l = \frac{1}{\sqrt{\varepsilon_{reff}}\sqrt{\mu_o \varepsilon_o}} - 2\Delta l$$

The designed parameters are shown in table 1.

Table 1 : Parameters of Rectangular Patch Antenna

PARAMETERS	DIMENSIONS
Patch length(L)	10.4mm
Patch width(W)	14.8mm
Substrate length	29.2mm
Substrate width	34.2mm
Substrate thickness	3.2mm
Substrate dielectric constant	2.2mm
Substrate material	RT-Duriod

The performance of microstrip patch antenna without any slot has been explained in terms of return loss and VSWR and has been shown in Figures 1and 2 respectively.

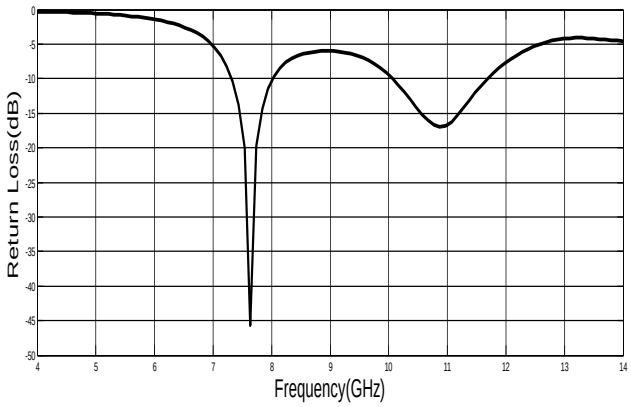

Fig.1: Return Loss

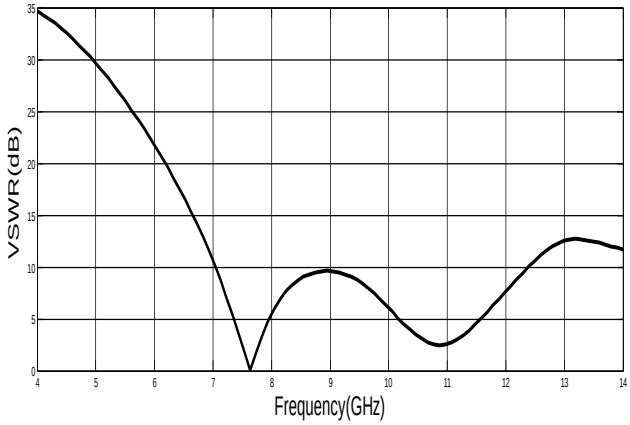

Fig.2: VSWR

It has been shown from figures 1 and 2 that the antenna resonates at 7.6367GHz and 10.9697GHz with return loss -45.7246dB, and -16.8592dB and VSWR less than 1dB.

Effect of Adding Slots on Resonance Frequency and Bandwidth

In this section, the performance of microstrip patch antenna after adding one slot and two slots has been explained. Adding slots to the patch enhanced bandwidth and this has been shown in table 2. Figure 3 shows I Slot and Double I Slot microstrip patch antenna. The dimensions of the added slot are u&v, slot length and width respectively. The optimum dimensions of slots are determined from a parametric study. It is found from the parametric study that the optimum values are 8mm and 1.2mm for slot length and width respectively.

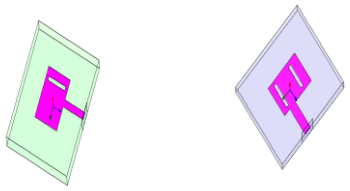

Fig.3: I Slot and Double I Slot microstrip Patch Antenna

Table 2 : Effect of Adding Slots on Resonance Frequency and Bandwidth

	Resonance Frequency (GHz)	Return Loss(dB)	Operating Band (GHz)	Bandwidth (GHz)
Rectangular patch antenna	7.6364 10.9697	-45.7246 -16.8592	7.35-8 10.1-11.6	0.65 1.5
I-Slot patch antenna	7.5 9.9	-26.4881 -30.9131	7.2-7.9 9.5-11.5	0.7 2
Double I-Slot patch antenna	9.3535	-36.6645	7.2-12	4.8

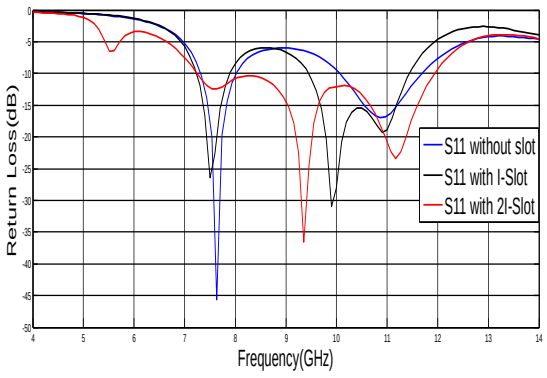

Fig.4: Effect of Adding Slots on Return Loss

It is shown that from table 2, and figure.4 that the bandwidth increases by adding slots to the patch with minimum return loss. With I-Slot, there are two bands of operation. When increasing number

of slots to two, the two bands groups to become wide band of 4.8GHz.

III.RESULTS AND SIMULATION

The results of the proposed antenna are shown in figures 5, 6, 7, and8. The results include return loss, VSWR, gain, and radiation pattern. The proposed antenna gives return loss of -36.6645dB and bandwidth of 4.8GHz (7.2-12GHz) and VSWR of 0.2551 at resonance frequency. From the results, the double I-Slot patch antenna is fascinating to work in wide band application. This antenna is able to work in X-band of radar with minimum loss.

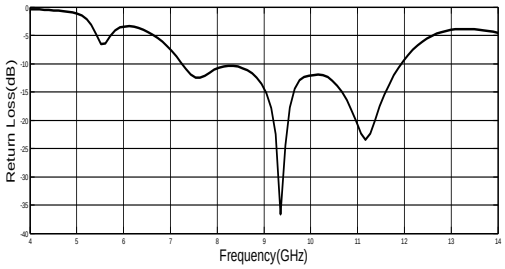

Fig.5: Return Loss of Double I-Slot Patch Antenna

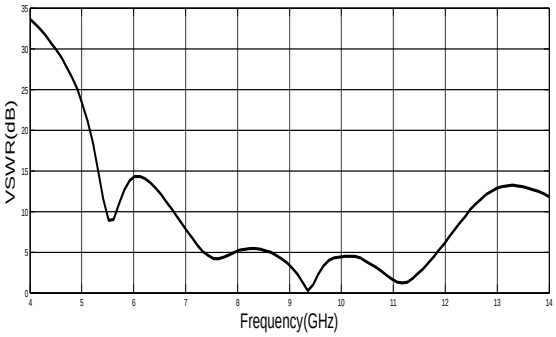

Fig.6: VSWR of Double I-Slot Patch Antenna

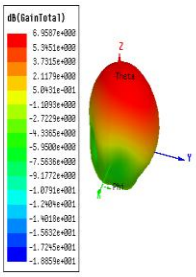

Fig.7: 3-D Gain Total for Double I Slot Patch Antenna

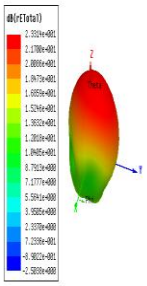

Fig.8: 3-D Radiation Pattern for Double I-Slot patch antenna

IV.CONCOLUSION

In this paper, Avery simple design of microstrip patch antenna with Double I slot at 8GHz has been designed and simulated. The effect of adding slots on resonance frequency and bandwidth and return loss has been showed. Different parameters of the designed antenna such as return loss, VSWR, radiation pattern and gain have been discussed. Bandwidth of the antenna can be increased by several ways such as increasing substrate thickness, adding slots. From the results this antenna serves wide band applications. The design of the rectangular patch antenna has been done using ANSOFT HFSS, MATLAB Program.

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