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Rectangular Shaped Microstrip Antenna for Triple-band Operation

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Abstract: In this paper, a rectangular microstrip patch antenna for multiband operation is designed and simulated. The proposed geometry of antenna covers three frequency bands and can be used for different wireless applications. The designed antenna has simple shape of rectangular patch with a co-axial feed. The performance parameters for proposed rectangular multislot antenna such as return loss, gain, directivity, bandwidth, VSWR are studied. The proposed antenna shows maximum gain up to 6.69dBi, bandwidth above 108MHz, and maximum directivity of 10.53dBi. IE3D (Integral Equation in Three Dimensions) software has been used for design and simulation of proposed antennas.

Keywords: Microstrip, Patch, Triple-band, Slots, IE3D, Wireless Applications

I. INTRODUCTION

Microstrippatchantennas are widely used because of their advantages. Microstrip patch antennas have been studied extensively due to their attractive characteristics of low profile, light weight, robustness and ease of fabrication [1]. Multi-band antennas are of interest in many wireless applications that use different frequency bands by avoiding the use of separate antenna. Dual or multi-frequency operations are common in Radar and Satellite communications. Therefore, microstrip slot antenna has been intensively studied and various slot shapes with different performance have been developed [2].

Number of techniques can be used to make a multiband antenna. Slot technique is used to increase the number of operating frequency bands. In order to obtain six frequency bands, microstrip patch is combined with slot antenna. Slots are positioned at ground plane under the patch [3]. A stacked rectangular microstrip antenna with a shorting plate is combined with a stacked rectangular ring microstrip antenna for triple-band operation in ITS. This antenna is fed with L-probe feed [4]. By loading a pair of right-angle slots and a modified U-shaped slot in a rectangular microstrip patch, antenna bandwidth is enhanced with good radiating characteristics [5].

A half-U-slot-cut and rectangular-slot-cut are used in rectangular microstrip antenna to increase gain and bandwidth of antenna [6].The reverse L-shaped slot is connected from bottom of rectangular slot, by combining both the structures with a strip and u-shaped slot three frequency bands can be obtained [7]. Other than rectangular shape, a single layer triangle shaped planar antenna is used for multiband operation [8]. A dual band circular microstrip slot antenna consists of an offset microstrip-fed line with strip inserted closed to radiating edges of slot [9].

In this paper, slotting of the rectangular patch antenna is done to achieve multiband operation. This rectangular patch antenna has multi-slots at appropriate places to achievemultiple independent frequency bands. By proper selection of slot size, feed and tuning their dimensions multiple frequency bands can be achieved. The antenna is designed on RT duroid substrate and simulated on IE3D software by Zealand.

II. ANTENNA SPECIFICATIONS

The rectangular shape has taken as base shape of the proposed antenna. RT Duroid material has been used as substrate having thickness 3.175mm. The dielectric constant of the substrate is 2.2 and the loss tangent has been taken as 0.0009.Fig.1 show rectangular patch antenna.

Dimensions of rectangular patch are calculated for 2.4GHz frequency. Co-axial feed is used for feeding the antenna. The rectangular patch antenna having length is 40.35mm and width is 49.41mm.

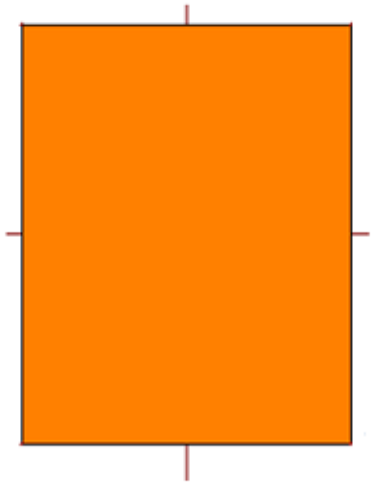

Fig.1Rectangular Patch Antenna

For triple-band operation, slots are to be etched in the rectangular patch of proposed antenna. Three slots of rectangular shape are etched to achieve multiple frequency bands. Fig. 2 shows proposedmultislot antenna.

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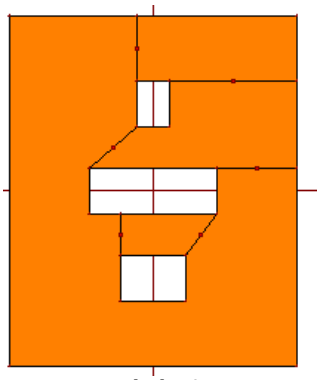

Fig.2 Multislot Antenna

III. Results and Discussion

Return loss characteristics, elevation and azimuthal pattern gain display, directivity, and VSWR are shown in respective figures. Return loss versus frequency plot is shown in Fig. 3. The return loss value describes the reduction in the amplitude of the reflected energy, as compared to the forward energy. The resonating frequencies are observed according to -10dB return loss. Firstly, simulation results of rectangular patch antenna are shown.

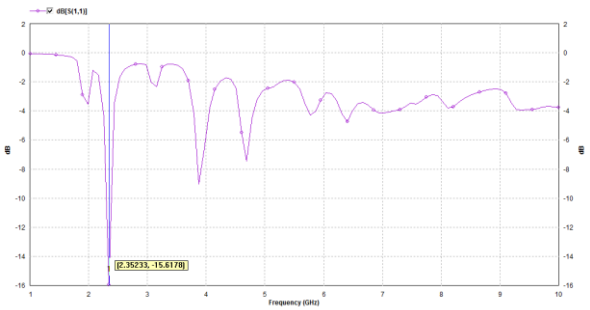

Fig.3 Return Loss of Rectangular Antenna

Return loss characteristics show that the resonant frequency is 2.35GHz. At this frequency the return loss is less than -15.61dB.It has bandwidth of 82MHz at 2.35GHz frequency.

Two dimensional radiation patterns of rectangular patch antenna are defined in terms of elevation pattern gain display and azimuthal pattern gain display. The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates.The maximum achievable gain at 2.35 GHz is 6.87dBi is displayed in Fig. 4 and 5.

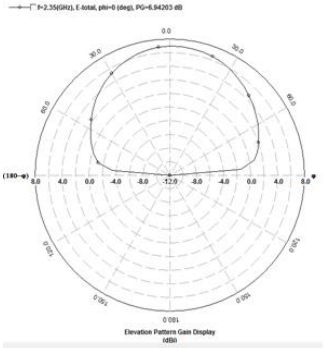

Fig.4 Elevation Pattern Display of Rectangular Patch Antenna

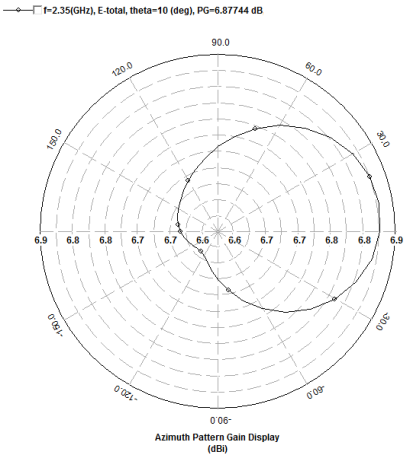

Fig.5 Azimuthal Pattern Display of Rectangular Patch Antenna

Directivity is ameasure of how directional radiationpattern is.Fig. 6 showsdirectivity versus frequency plot. The maximum directivity is 7.75dBi for rectangular patch antenna at resonant frequency 2.35GHz.

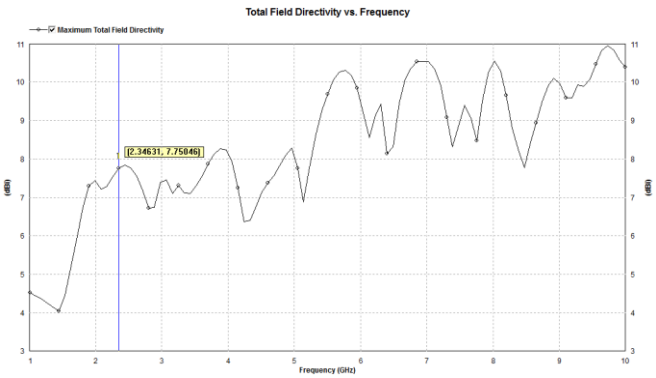

Fig.6 Directivity of Rectangular Patch Antenna

InFig.7 VSWR (Voltage Standing Wave Ratio) versus frequency is shown. The rectangular patch antenna having VSWR value 1.60 is shown.

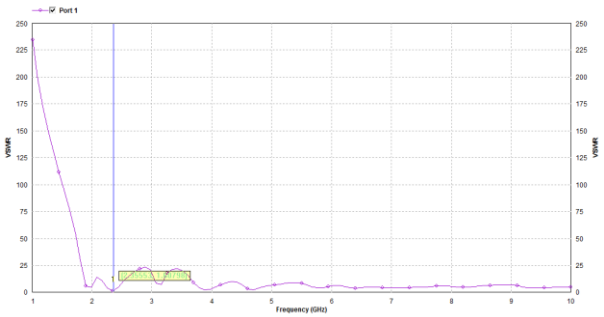

Fig.7VSWR of Rectangular Patch Antenna

Now, simulation results of multislot antenna are discussed. Fig.8 shows the return loss of proposedmultislot antenna. From this figure it can be find that the antenna resonates at three different resonant frequencies 5.41GHz, 6.31GHz and 7.29GHz and the return loss at these resonant frequencies is -24.51dBi, -10.79dBi and -17.56dBi respectively.At resonant frequencies of 5.4GHz, 6.31GHz and 7.29GHz multislot antenna has bandwidth of 331MHz, 108MHz and 313MHz.

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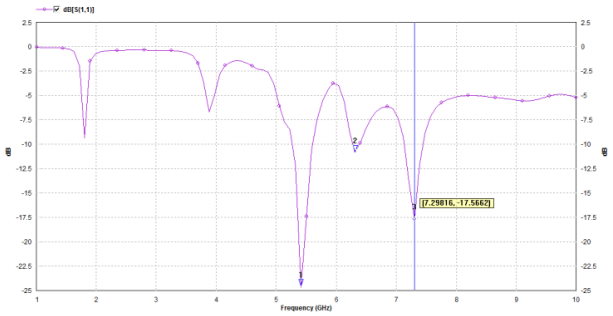

Fig.8Return Loss of Multislot Antenna

The elevation pattern gain display and azimuthal pattern gain display of multislot antenna are shown in Fig. 9 and 10.

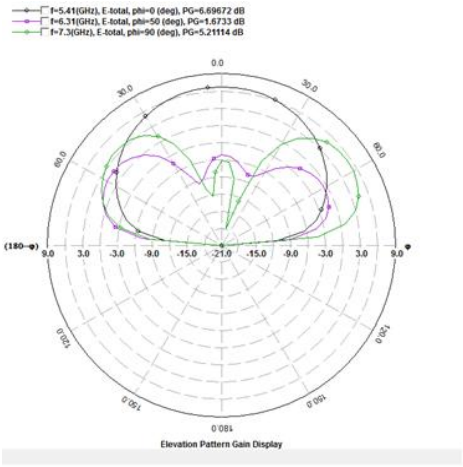

Fig.9 Elevation Pattern Display of Multislot Antenna

The maximum achievable gain at these frequencies is 5.4GHz, 6.31GHz and 7.29GHz is 6.69dBi, 1.67dBi, and 5.21dBi shown in Fig. 9 and 10.

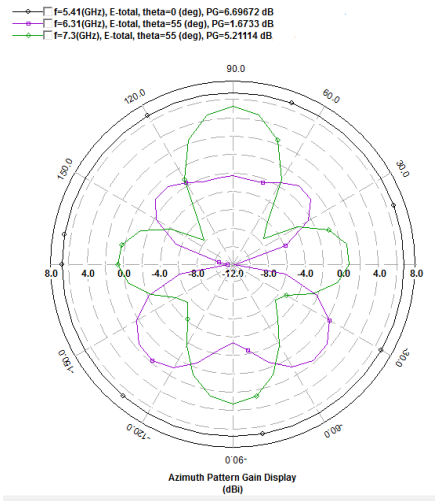

Fig.10. Azimuthal Pattern Display of Multislot Antenna

Fig.11 shows the maximum directivity of10.53dBi, 8.63dBi and 10.45dBi for multislot antenna at resonant frequencies of 5.41GHz, 6.31GHz and 7.29GHz respectively

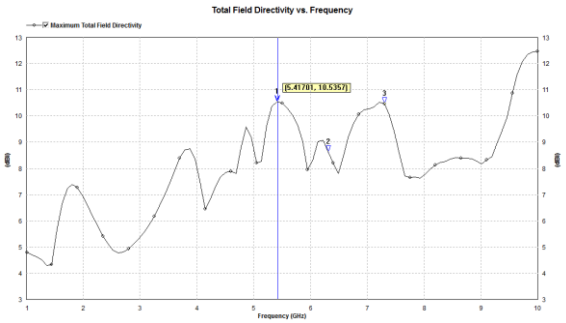

Fig.11. Directivity of Multislot Antenna

VSWRhaving value 1.13 at 5.41GHz, 1.81 at 6.31GHz and 1.30 at 7.29GHz of frequency as shown in Fig. 12 .

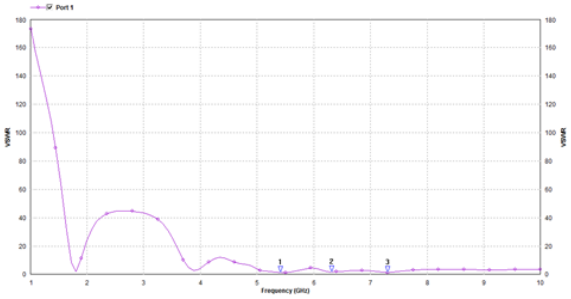

Fig.12.VSWR of Multislot Antenna

Comparison of performance parameters of rectangular patch antenna and multislot antenna is given in Table 1. Proposed antenna shows three frequencies for triple band operation with good performance of parameters.

TABLE 1
COMPARISONOF VARIOUS ANTENNA PARAMETERS

Parameters	**Rectangular Patch Antenna**	**Multislot Antenna**		
Resonant Frequency	2.35GHz	5.41GHz	6.31GHz	7.29GHz
Return Loss	-15.61dB	- 24.51dB	-10.79dB	-17.56dB
Gain	6.87dBi	6.69dBi	1.67dBi	5.21dBi
Bandwidth	82MHz	331MHz	108MHz	313MHz
Directivity	7.75dBi	10.53dBi	8.63dBi	10.45dBi
VSWR	1.60	1.13	1.81	1.30

IV. CONCLUSION

In this paper, rectangular patch antenna and multislot antenna are discussed in detail. The proposed multislotantenna resonates at three different frequencies 5.41GHz, 6.31GHz and 7.29GHz with suitable antenna parameters. This means multiband antenna can be designed with the help of slotting. This multislot antenna can be used as triple-band antenna in various wireless applications like Wi-Fi, Radar, and UWB applications.

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