Multiband Microstrip Antenna for Wireless Applications

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Abstract- **This paper presents a multiband microstrip slot antenna for wireless applications. The microstrip antennas are commonly used because of their flexibility, robustness, small size and weight, narrow beam of radiation and ease of installation and fabrication etc. The proposed antenna is designed by using substrate FR-4 lossy having permittivity 4.3. The antenna consists of a patch with 4 narrow slits and ground plane to generate a band of frequencies centered at 5.2GHz, 9.3323 GHz and 12.038GHz. The design is simulated using CST MICROWAVE STUDIO software**

Keywords - microstrip, Multiband, Patch.

I. INTRODUCTION

Microstrip antennas are widely used because off their attractive features like low profile, low weight, low cost, inexpensive to manufacture using modern printed circuit technology and also they are compatible with MMIC design [1-3]. Due to these features microstrip patch antenna has used in radar, microwave and space communication. The microstrip antennas consists of a very thin metallic strip (patch) placed above ground plane. The strip and ground plane are separated by a dielectric sheet called substrate. The radiating element and the feed lines are normally photo etched on the dielectric substrate. The radiating patch may be square, circular, elliptical, and rectangular or any shape [5-7].

To reduce the size of the antenna, substrates with higher value of dielectric constant is used [4]. Our aim is to increase the operating bandwidth and reduce the size. The proposed antenna comprises of a substrate with height 1.67mm and dielectric constant 4.3. The simulations are carried out using a tool CST MICROWAVE STUDIO. The wireless communication applications require an antenna with more than one frequency. Due to the small size, low cost and low weight this antenna is suitable for X-band radar communication, Ku-band satellite TV communication and K-band microwave communication. The main advantage of this antenna is its simplicity. Due to its simple design it can be easily designed and fabricated, so it reduces cost and time of manufacturing.

II. ANTENNA DESIGN

The antenna composed of three layers that are patch, substrate and ground. All the dimensions are done in millimeter scale. The proposed antenna is incorporated on FR-4 lossy dielectric sheet.

A. *Wideband Microstrip Antenna*

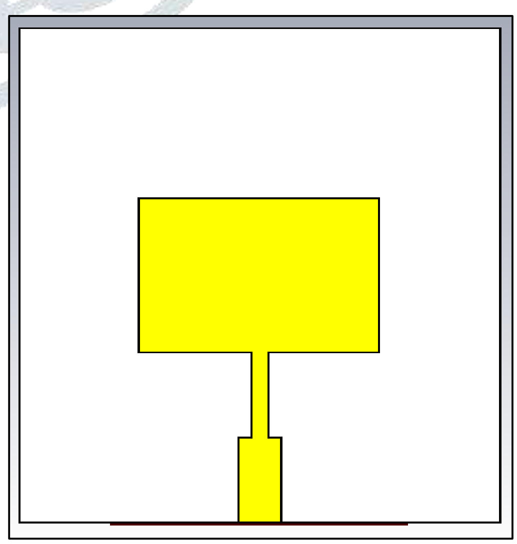

Figure 1: Microstrip rectangular patch antenna

A simple microstrip patch antenna for generating a single resonance frequency is shown in Figure 1. The basic formula for finding the length and width of the patch antennas are shown below [1].

$$w = \frac{1}{2f_r\sqrt{\mu_0 \epsilon_0}}\sqrt{\frac{2}{\epsilon_r+1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \quad ....(1)$$

$$L = \frac{c_0}{2f_r\sqrt{\epsilon_{reff}}} ....(2)$$

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+\frac{12h}{w}\right]^{-\frac{1}{2}} \quad ....(3)$$

$$\frac{\Delta L}{h} = \frac{0.412(\epsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad ....(4)$$

Where

L_{eff} = Effective length
c = Velocity of light in free space
f_r = Operating resonant frequency
ϵ_r = Dielectric constant of the sub
h = Height of the substrate

This antenna has basic parameters Dielectric Constant, ϵr=4.3, Height of the substrate, h = 1.6mm and Resonant Frequency, fr= 5.2GHz. FR-4 lossy is used as the substrate.

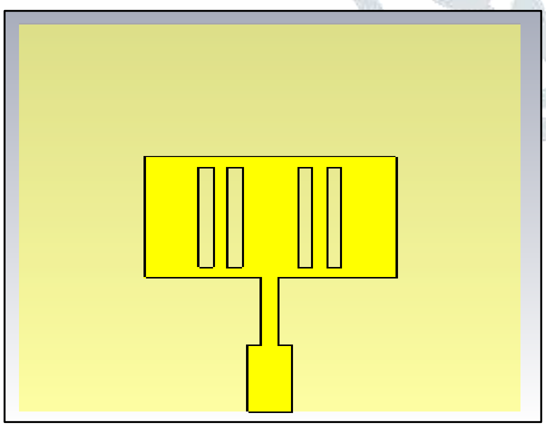

Figure2: Geometry of the antenna with slots

In this structure each slots are 1mm in width and 10 mm in length. Substrate has a finite size of length 35.4402 mm width 42.7672mm and height 1.6mm.

TABLE I: DIMENSION OF ANTENNA STRUCTURE

Parameters	Dimensions
Ground	35.7792X 27.0216
Substrate	35.7792X 27.0216
Patch	17.8896X 13.5108
Substrate Height	1.6
Width of quarter wave transformer line	1.2714
Length of quarter wave transformer line	7.4589
Width of feed line	3.1693
Length of feed line	7.4106

III. RESULTS AND DISCUSSION

The proposed antenna was analyzed and optimized with the help of CST MWS software. Tri-band microstrip slot antenna has been achieved in this design. The first band has resonant frequency 5.108 GHz with return loss -17.209dB and bandwidth 0.32933 GHz. The resonant frequency of second band is 9.3323 GHz with return loss -21.903 dB and bandwidth1.0021GHz. The third band has resonant frequency of 12.038GHz with return loss -23.053dB and bandwidth 1.2942 GHz. The plot of return loss against frequency is shown in Figure 3.

Return Loss

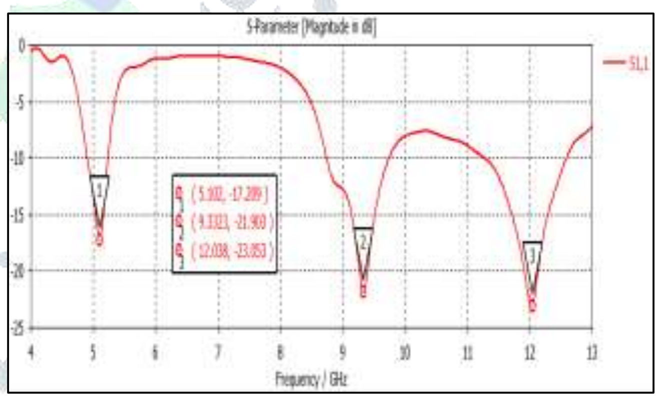

Figure 3: Return loss plot

Bandwidth

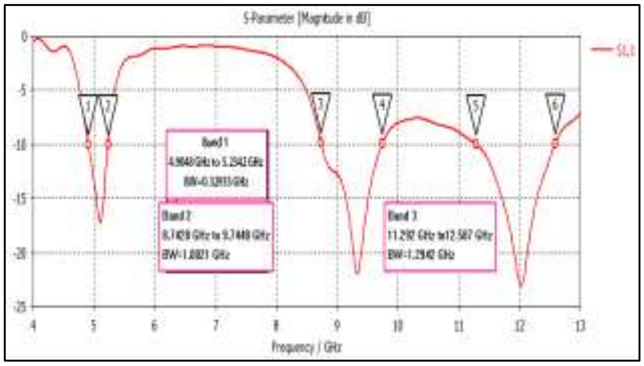

Figure 4: Bandwidth

Voltage standing wave ratio (VSWR)

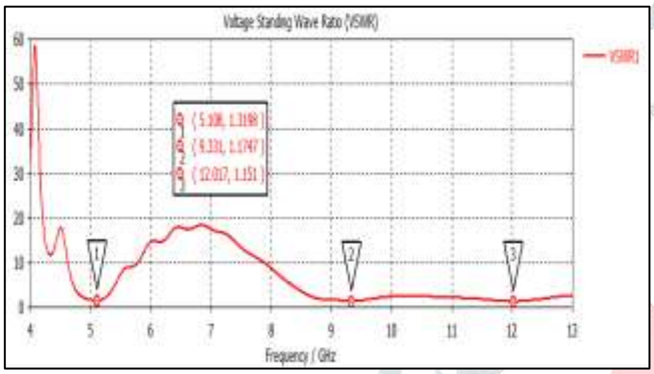

Figure 5: Voltage standing wave ratio(VSWR)

Realized gain

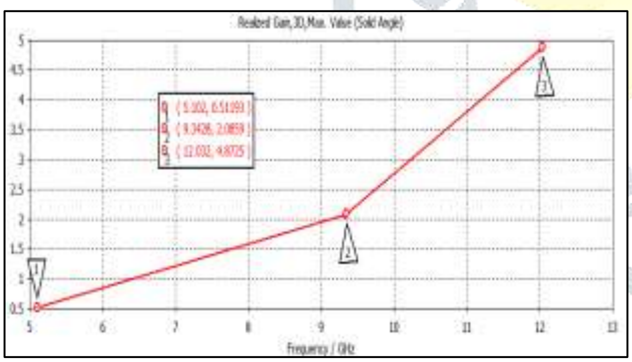

Figure 6: Realized gain

The radiation patterns of proposed antenna are also investigated. The 2D radiation pattern of proposed antenna for three different frequencies is shown in Figures 7, 8 and 9. These figures show the simulated total field radiation patterns at 5.108GHz, 9.3323GHz and 12.038GHz frequencies. It can be seen that excellent wide band radiation patterns are obtained at these frequencies. The Figures 10, 11 and 12 shows the 3D radiation patterns for the 5.108GHz, 9.3323GHz and 12.038GHz resonant frequencies respectively.

2D Radiation Pattern 1

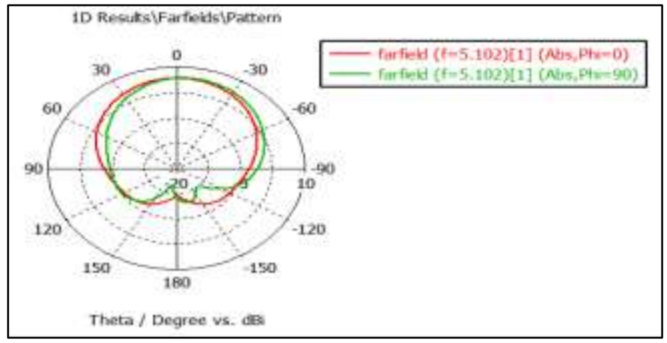

Figure7: E-Plane and H-Plane at 5.102 GHz

2D Radiation Pattern 2

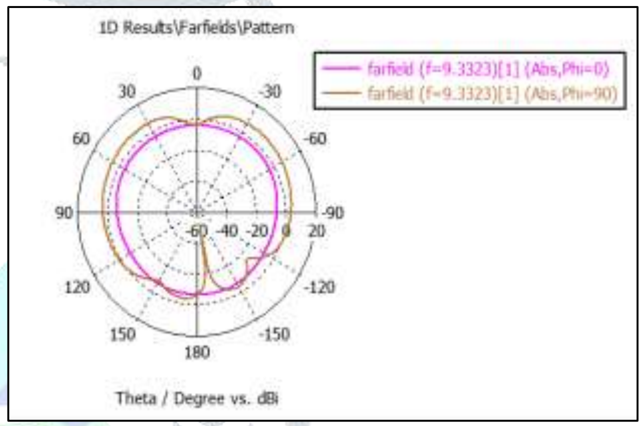

Figure 8: E-Plane and H-Plane at 9.3323 GHz

2D Radiation Pattern 3

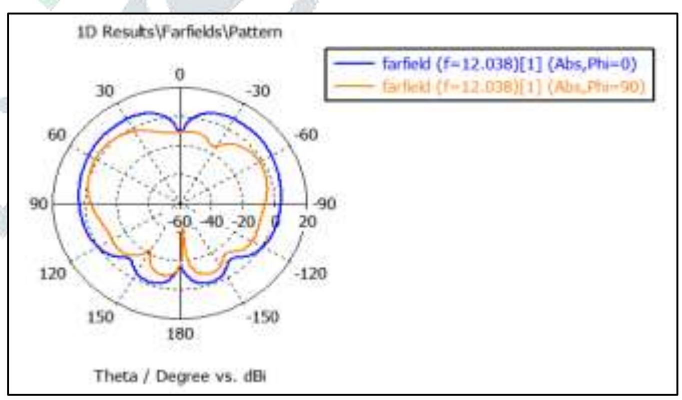

Figure 9: E-Plane and H-Plane at 12.038 GH

3D Radiation Pattern 1

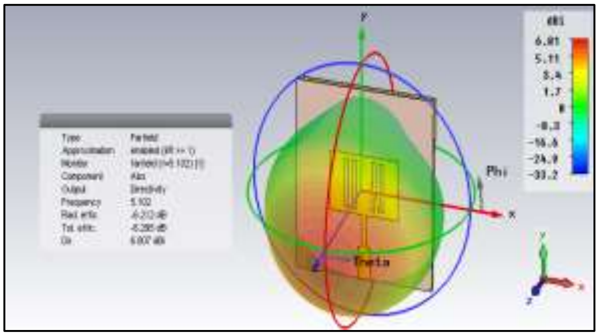

Figure 10: 3D view of radiation pattern at 5.102 GHz

3D Radiation Pattern 2

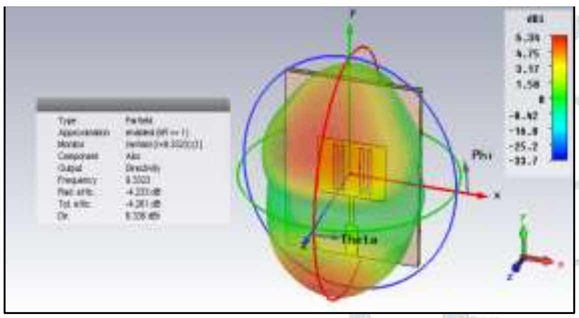

Figure11: 3D view of radiation pattern at 9.3323 GHz

3D Radiation Pattern 3

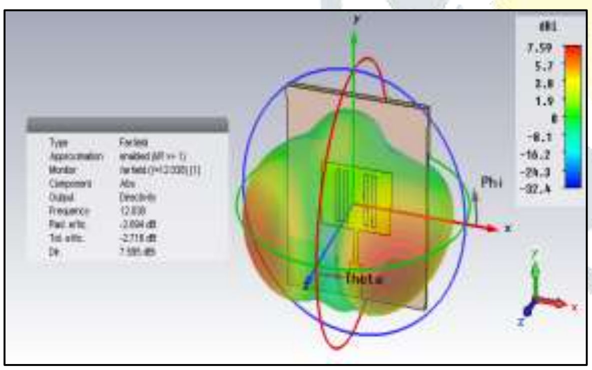

Figure12: 3D view of radiation pattern at 12.038 GHz

Gain of the antenna gives the measure of the efficiency of the antenna and its directional capabilities. Gain is defined as the ratio of radiation intensity in a particular direction to the radiation intensity obtained if power is radiated tropically by the antenna. In this case we get 0.51193 dB, 2.0859dB and 4.8725 dB gains at 5.108GHz, 9.3323GHz and 12.038GHz frequencies.

TABLE II:
ANTENNA PARAMETERS

Parameters	**Simulated results**		
Frequency	**5.108GHz**	**9.3323GHz**	**12.038GHz**
Return Loss (dB)	**-17.209dB**	**- 21.903dB**	**-23.053dB**
Gain (dB)	**0.51193**	**2.0859**	**4.8725**
Directivity (dB)	**6.807**	**6.336**	**7.595**
Radiation efficiency	**-6.212dB**	**-4.233dB**	**-2.294dB**

IV. CONCLUTION

The aim of this work is to design and simulate a multiband microstrip slot antenna operating in three different frequency bands. The proposed antenna employs microstrip feeding technique. For the realization of the antenna, 4 narrow slits are inserted in the patch. The design of this work gives the following results; the first band has a resonant frequency of 5.108 GHz with return loss -17.209 dB and bandwidth of 0.32933 GHz and is suitable for mobile communication, wireless LAN and radar communication. The resonant frequency of second band is 9.3323 GHz with return loss - 21.903dB and bandwidth of 1.0021GHz and is suitable for NJFA, satellite communication and military applications. The third band has resonant frequency of 12.038 GHz with return loss - 23.053dB and band width of 1.2942 GHz and is suitable for radar and satellite communications. The proposed antenna shows low return loss and gain at the frequencies 5.108 GHz, 9.3323 GHz, 12.038 GHz.

V. REFERENCE

[1] Rajendra Soloni, Rajappa H S and Chandrappa D N "Design and analysis of multiband reconfigurable microstrip patch antenna with switchable element" in Advances in Computing, Communications and Informatics (ICACCI), IEEE, 13-16 Sept. 2017, DOI: 10.1109/ICACCI.2017.

[2] Chandrappa D.N., Mrs.Vani R.M. and P.V. Hunagund "Design and Implementation of Slotted Reconfigurable Microstrip Antenna for Wireless Application", International Journal of Electronics and Communication Engineering. ISSN 0974-2166 Volume 6, Number 3 (2013), pp. 233-239

[3] Chandrappa D.N, P.A.Ambresh, P.V.Hunagund.,"Design of compact reconfigurable multy frequency microstrip antennas for wireless applications" International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE),Vol. 2, Issue 9, September 2013.

[4]Chandrappa D N**,** Ambresh P A, Vani R M, P V Hunagund.,"Multi-slots Reconfigurable MicrostripAntenna with Capacitive Loading Technique"., International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Issue 1, Jan. 2014

[5]Rekha DC, Rajappa.H.S, RajendraSoloni and Chandrappa.D.N ”Design of dual band microstrip patch antenna for RFID” International Journal for Research Trends and Innovation, Volume 2, Issue 5, pp 253-257, 2017.

[6] Jobins George and Shehana Pareeth ”Multiband Microstrip patch Antenna using parallel slots for wireless applications” International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) – 2016, pp 3614-3619, 2016.

[7] J. H. Kim and C. G. Christodoulou, "A simple reconfigurable microstrip antenna for wideband applications," *2010 IEEE Antennas and Propagation Society International Symposium*, Toronto, ON, 2010, pp. 1-4