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Step Loaded with Right-angled Bend Microstrip Patch Antenna for 2.42/3.88/5.2 GHz Wireless Application

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ABSTRACT

In this paper, a tri-band microstrip patch antenna is proposed with step loaded with right angle bend for wireless application. The nature of tri band operation depends on notch dimensions as well as step dimensions. The design frequency is 5.2 GHz and the resonating frequency of this proposed antenna which shows tri band operation are as 2.42 GHz, 3.88 GHz and 5.2 GHz . Coaxial probe feed is used for feeding. It is observed that the resonance peaks of the bands are almost constant but return loss varies by varying the feed position. The comparison between experimental and IE3D simulated result shows good agreement.

Keywords: Step loaded, Right angle bend, Rectangular patch, Return loss, Resonance peak.

I. INTRODUCTION

Microstrip patch antennas are more popular for low profile, simple and less expensive to manufacture and conformable to nonplaner and planer surfaces. These antennas generally consists of a ground plane on the one side with a conducting patch of different geometry like triangular, square ,circular, rectangular and many more on other side of dielectric substrate.

For feeding the microstrip antennas there are many configurations that can be used. Because of easy to fabricate, low spurious radiation and match, co-axial line feed is used. However, it has narrow bandwidth which is useful for the applications in government security system and wireless communication. Based on this there are so many antennas have been proposed [6], [12].

A triple band rectangular microstrip antenna is proposed by using the combinations of a pair of rectangular slots, resonant U-slot and an open circuit nearly quarter-wavelength stub [2]. A microstrip patch antenna has been reported in [16], which is stub-loaded and uses the varactors for reconfiguration both frequency and polarization. For receiving the microwave power a compact rectenna with stepped- impedance dipole antenna has been proposed [3]. The effect of stub on the resonance frequency is carried out with theoretical analysis [4]. In this paper a notch loaded and step loaded with right angle band rectangular microstrip patch antenna for multi band frequency operation is simulated and tested. The effect of variation in length and width of the step on the resonance frequency and the return loss are presented. This paper also presents the effect of co-axial probe feed position on the rectangular patch. The simulation is done with the help of IE3D simulation tool.

II. DESIGN ASPECT

The width and length are the most important parameters needed for the design of the rectangular patch antenna and its accurate value affects the results very much.

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The dimensions of the microstrip patch antenna are calculated as below [5]

$$Width(W) = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

Where c is the speed of light ($3x10^8$ m/s), ε_r is the relative permittivity or dielectric constant of substrate, W is the patch width, f is the antenna design frequency and the effective relative permittivity or effective dielectric constant ε_{re} is given as

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (2)$$

The extended patch length due to fringing effect ΔL is calculated as

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{re} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{re} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (3)$$

The actual length of the patch is calculated as

$$L = \frac{c}{2f\sqrt{\varepsilon_{re}}} - 2\Delta L \quad (4)$$

III. DESIGN SPECIFICATIONS

For proposed antenna the design of rectangular patch is shown in Figure 1. By using FR4 glass epoxy material as substrate with dielectric constant 4.4, the proposed antenna is designed for design frequency 5.2 GHz. The calculated width of patch and length of patch are 17.60 mm and 13.20 mm respectively. The ground plane width and length are taken 27.60 mm and 23.20 mm respectively. Loss tangent tan ä of the dielectric substrate is 0.01 and height is 1.6 mm. Antenna is fed by using co-axial probe feed. The feed point is lie along the length on X-axis and Y-axis is taken as zero. IE3D simulation software tool is used for simulation work.

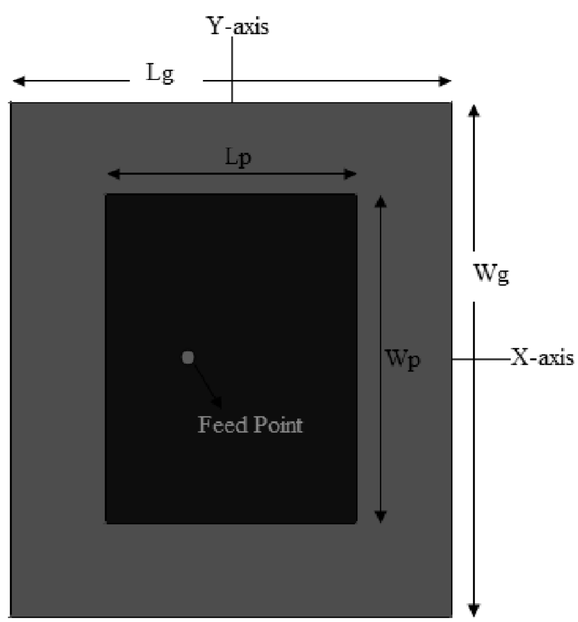


Figure 1: Rectangular patch for proposed antenna with feed point

IV. ANTENNA DESIGN PROCEDURE

For proposed antenna width and length of the rectangular patch is calculated with the help of equations 1 to 4 and taken approximately. The width and length of the ground is 10 mm more than the width and length of the rectangular patch. For making the proposed antenna the antenna is loaded with notches and step with right angle bend. The geometry of proposed antenna is shown in Figure 2 and the hard ware of proposed antenna for testing is shown in Figure 3. All specifications of proposed antenna are given in table 1.

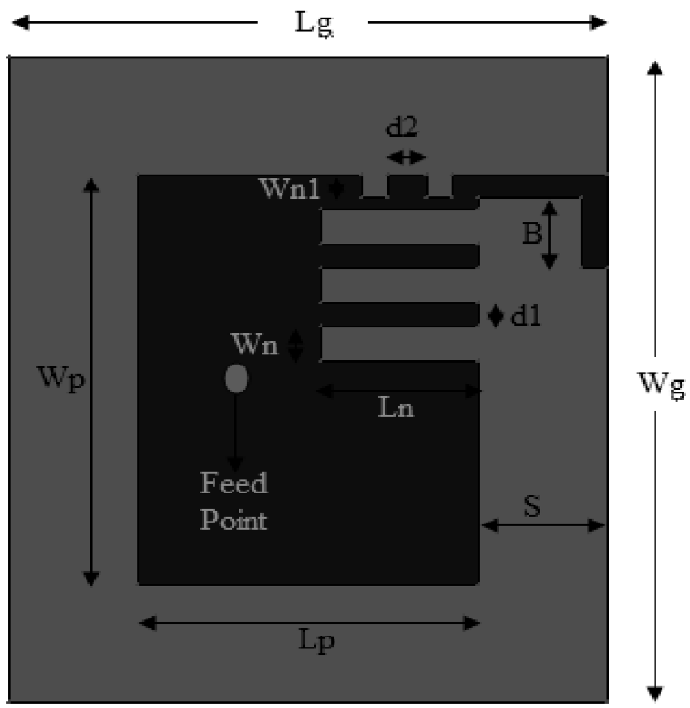


Figure 2: Geometry of proposed antenna

Figure 3: Hardware of proposed antenna

Table1
Specifications of Antenna Design

No.	*Parameters*	*Value*
1.	Design frequency, *f*	5.2 GHz
2.	Dielectric constant, ε_r	4.4
3.	Height of Substrate, h	1.6 mm
4.	Ground width, Wg	27.6 mm
5.	Ground Length, Lg	23.2
6.	Patch width, Wp	17.60 mm
7.	Patch length, Lp	13.20 mm
8.	Ln	6.1 mm
9	Wn	1.5 mm
10	Wn1	1 mm
11	S	5 mm
12	B	3.5 mm
13	d1	1 mm
14	**d2**	**2.5 mm**

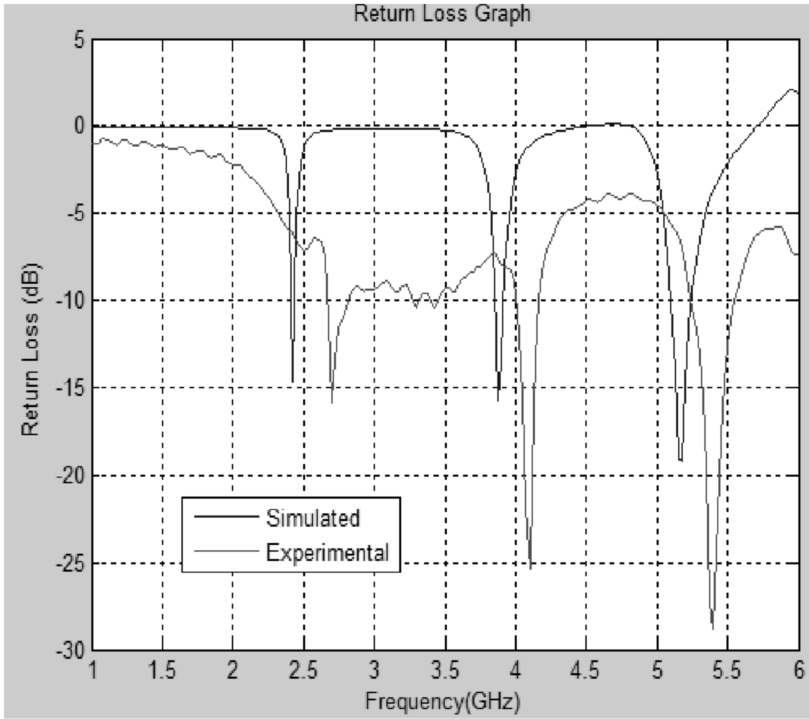


Figure 4: Return loss of proposed antenna

V. RESULTS AND DISCUSSION

Figure 4 shows both simulated and experimental return loss against frequency. It is observed that the resonance peak of experimental result is approximately near about of the resonance frequency of the simulated result. For proposed antenna the return loss is -14.58 dB at 2.426 GHz, -17.12 dB at 3.883 GHz and -20.41 at 5.164 GHz (simulated result) and -15.79 dB at 2.7 GHz, -25.3 dB at 4.1 GHz and -28.86 dB at 5.4 GHz (experimental result).

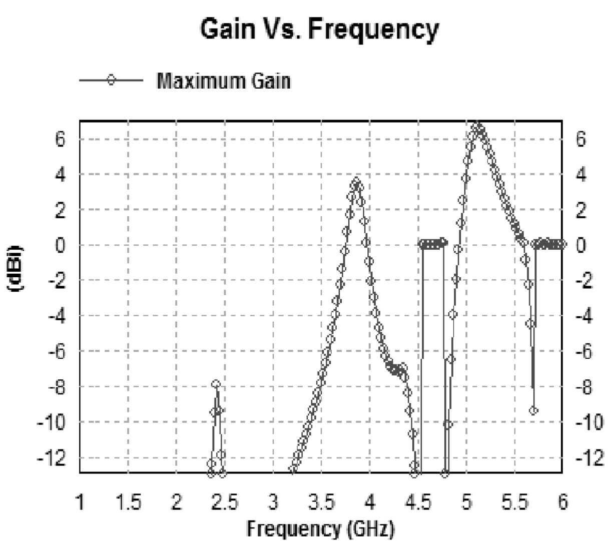


Figure 5: Gain of proposed antenna

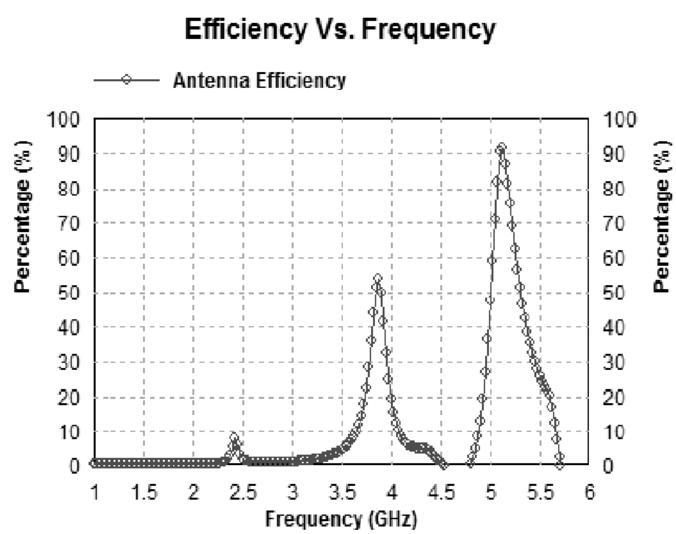
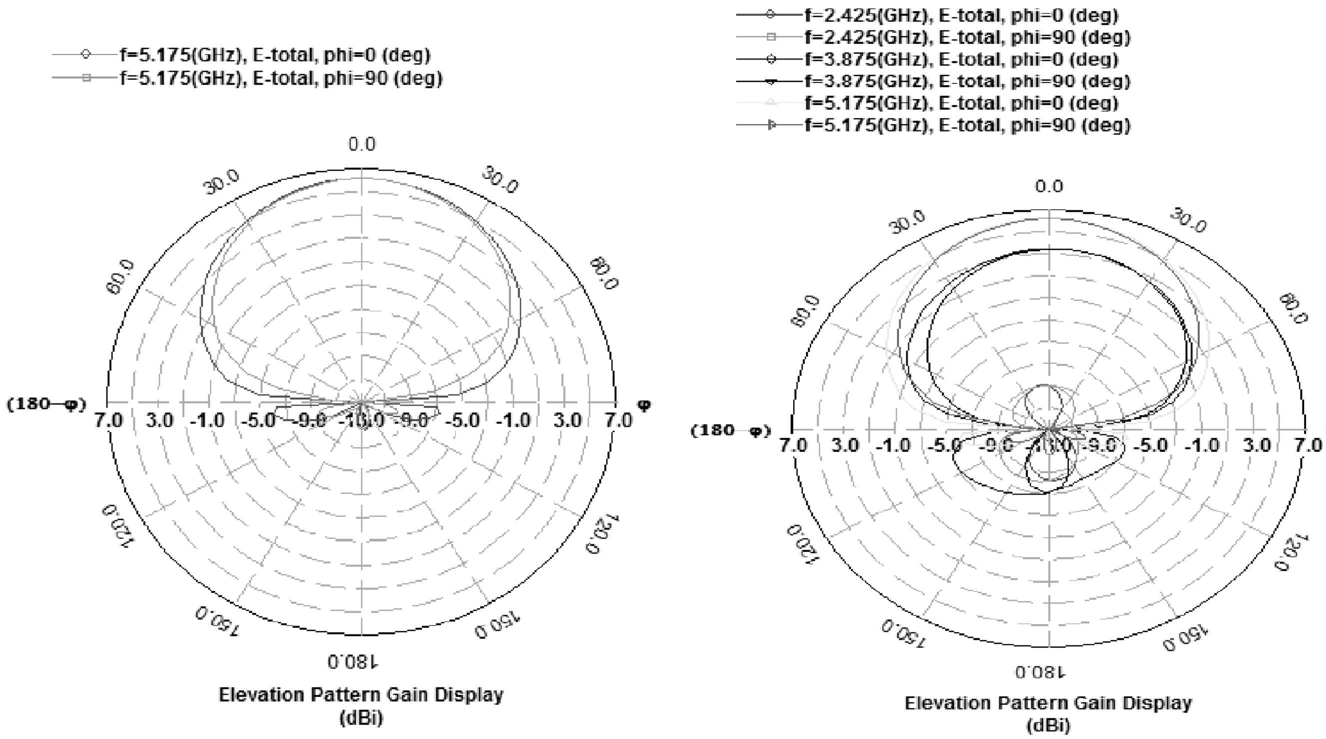


Figure 6: Antenna efficiency of proposed antenna

Figure 5 shows the gain Vs frequency graph of proposed antenna. The gain of the proposed antenna is 6.62 dBi at 5.13 GHz which is maximum. At all three resonating frequency 2.42 GHz, 3.88 GHz and 5.17 GHz the gain of proposed antenna is -7.9 dBi , 3.48 dBi and 6.16 dBi respectively.

For proposed antenna the antenna efficiency is 91% at 5.13 GHz which is the maximum value. At all three resonating frequency 2.42 GHz, 3.88 GHz and 5.17 GHz the antenna efficiency of proposed antenna is 7.8 %, 53.7 % and 81.42% respectively.



(i) (ii)

Figure 7: 2D radiation pattern of proposed antenna (i) for 2.5 GHz (ii) for 2.42,3.87and 5.2 GHz

The radiation pattern of proposed antenna for θ =0 degree and θ = 90 degree is shown in Figure 7. Radiation pattern of the antenna is unidirectional with small side lobes.

The variation of return loss with frequency is shown in Figure 8 for different value of the step width (Wn1) from the upper corner of the radiating patch. It is observed that by increasing the width of the step,

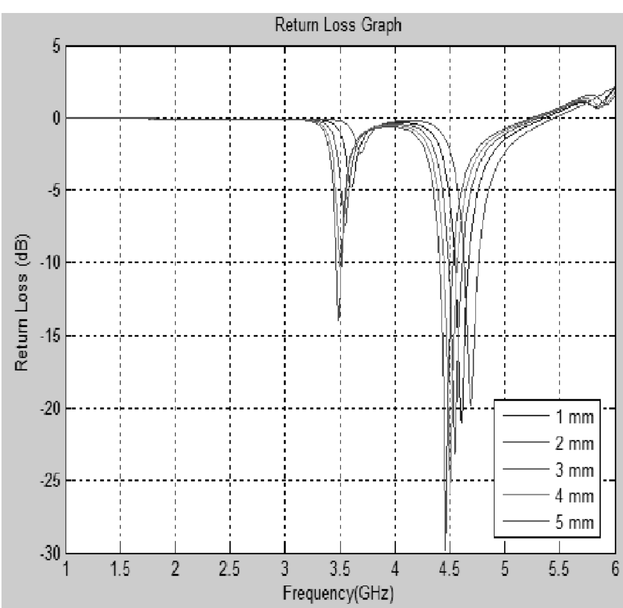


Figure 8: Return loss with the variation in width of the step

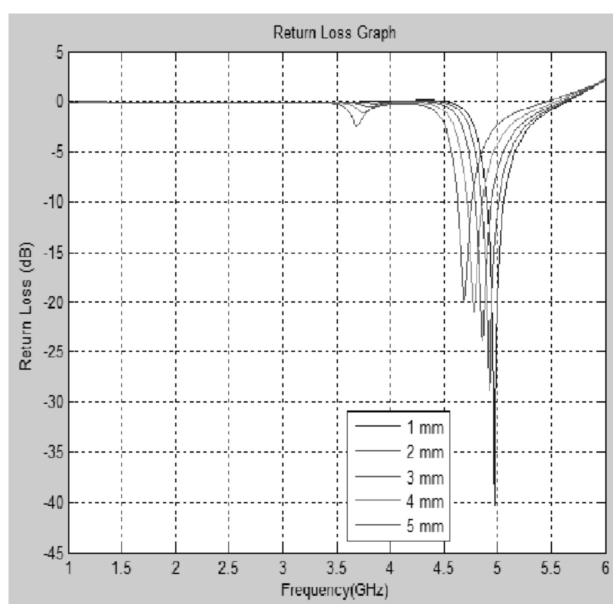


Figure 9: Return loss with the variation in length of step

the resonance frequency of the bands shifted towards the lower frequency side and the return loss become more negative.

The return loss variation with frequency for different value of the step length (S) is shown in Figure 9. It is observed that by increasing the length of the step from the radiating side of the patch, the resonance frequency shifted towards the lower frequency side as well as the return loss become more positive. By increasing the width of the band (B), it is observed that the resonance frequency of the existing band shifted towards the lower frequency side and the return loss of the existing band firstly become more negative but after some increment of width the return loss started to become more positive which is shown in Figure 10. It is also observed that an extra band appear at the upper frequency side and its return loss become more negative and shifted towards the lower side frequency.

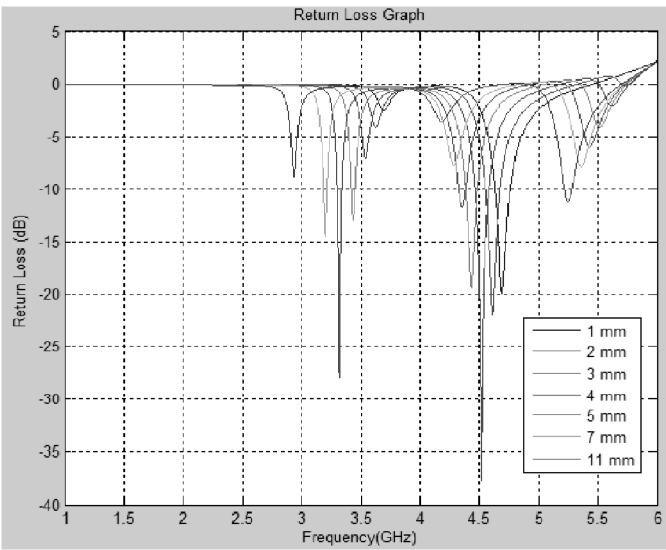


Figure 10: Return loss with the variation in width of band

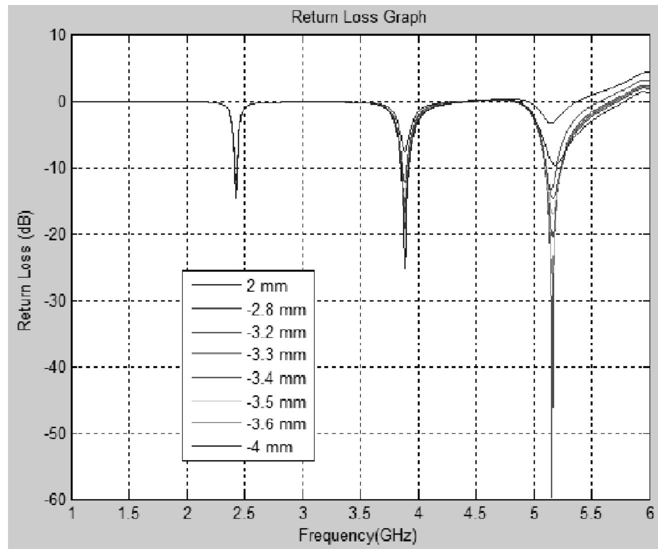


Figure 11: Return Loss for different value of feed position

In proposed patch antenna the actual feed position is (X= -3.4 mm, Y=0) from center of the patch. From Figure 11 and table 2, it is observed that as the feed position is varied the resonance peak of both lower and middle band is constant and the upper band is almost constant. The return loss of both the lower and middle band is decreases where as the return loss of upper band decreases first then increases.

Table 2
Variation of return loss with the coaxial feed position

Feed Position From Center (mm)	*L.R.F(GHz)*	*R.L(dB)*	*M.R.F(GHz)*	*R.L(dB)*	*U.R.F(GHz)*	*R.L(dB)*
2	2.42	-12.82	3.88	-7.69	5.15	-3.33
-2.8	2.42	-13.68	3.88	-12.18	5.15	-13.55
-3.2	2.42	-14.44	3.88	-15.29	5.16	-59.74
-3.3	2.42	-14.51	3.88	-16.19	5.16	-26.1
-3.4	2.42	-14.57	3.88	-17.12	5.16	-20.41
-3.5	2.42	-14.57	3.88	-18.2	5.16	-17.09
-3.6	2.42	-14.57	3.88	-19.18	5.17	-14.75
-4	**2.42**	**-14.76**	**3.88**	**-25.3**	**5.18**	**-9.67**

The design frequency is 5.2 GHz. The length and width of the patch for this design frequency is 13.2 mm and 17.6mm respectively. With this dimensions of patch and notch and step loaded with right angle bend the proposed microstrip rectangular patch antenna is resonatened at 5.2 GHz, 3.88 GHz as well as 2.42 GHz resonating frequency. The rectangular patch antenna which should be resonated at 2.42 GHz has length and width 29.2 mm and 37.72 mm respectively. This proposed antenna has triple resonating frequency 2.42 GHz, 3.88GHz and 5.2 GHz and shows compatibility i.e. reduces the patch dimensions.

VI. CONCLUSION

A tri band rectangular microstrip patch antenna has been successfully designed & fabricated. It is concluded that the structure of the band for both simulated and experimental result of proposed antenna is nearly equal. It is concluded that the resonance peak of the band is almost constant and the return loss is varies by varying the co-axial probe feed position along X-axis keeping Y-axis to zero. It is also concluded that the resonance frequency and the return loss of the band depends on the width and length of the step.The proposed antenna can be used for wireless communication.

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