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Compact Square Microstrip Patch Antenna loaded with notch for Radar Applications

Ramesh Kumar Verma[1] and D.K.Srivastava[2]

[1,2] *Dept. of Electronics & Communication Engg. Bundelkhand Institute of Engg. & Technology, Jhansi, UP, India.*

Abstract: *A compact square microstrip patch antenna loaded with notch is presented in this paper. In this work a square microstrip patch antenna is design at frequency 2.60Ghz and loaded by two notch so that the bandwidth of square microstrip antenna is improved upto 29.01% and antenna is resonating at 1.807GHz with -19.45dB return loss. The size of proposed antenna design is reduced by 51.99% corresponding to 1.807GHz frequency. The proposed antenna design has frequency band in the frequency range 1.709GHz to 2.289GHz. This frequency band is suitable for radar and other wireless communication applications. The gain of proposed antenna has been improved up to 3.1866dBi and antenna efficiency is 95.59%. The 3dB beam width of the antenna is (71.639,134.042)deg. The proposed slotted microstrip antenna is directly feed by 50 ohm probe feed. The proposed antenna is simulated by IE3D simulation software based on method of moments.*

Keywords: *Compact, Notch, bandwidth, microstrip Patch, gain, probe feed.*

I. INTRODUCTION

Microstrip patch antenna possesses many advantages such as low profile, light weight, and small volume. The rapid development and mobility of wireless communication devices has increased the demand of compact microstrip antennas with high gain and wideband operating frequencies. The major drawback of microstrip antenna is its narrow bandwidth and lower gain[1].The size of antenna is extremely important for most wireless communication systems. But it is desired that the reduced size antenna have equivalent operation in comparison with ordinary developed antenna[2]. Many techniques have been used to reduce the size of antenna, such as using dielectric substrates with high permittivity[3], Increasing the electrical length of antenna by optimizing its shape[4], Utilization of strategically positioned notches on the patch antenna[5]. Various shapes of slots and slits have been embedded on patch antennas to reduce their size. These perturbations that are embedded on the antenna are used to increase the surface current path. To decrease the resonant frequency of an antenna for a given surface area, the current path must be maximized within the area [5].
In the present work, the bandwidth of microstrip antenna is enhanced by cutting notch in the patch which is directly feed by 50ohm probe feed of diameter 0.3mm. The design frequency of proposed antenna is 2.60GHz. The size of antenna is reduced by shifting the resonance frequency towards the lower value. The frequency band of proposed antenna is between 1.709 - 2.289 GHz which is suitable for radar and other communication applications. The proposed antenna has been designed on glass epoxy substrate (ε_r=4.4)[7]. The substrate material has large influence in determining the size and bandwidth of an antenna. Increasing the dielectric constant decreases the size but lowers the bandwidth and efficiency of the antenna while decreasing the dielectric constant increases the bandwidth but with an increase in size.

II. ANTENNA DESIGN

For designing a rectangular Microstrip patch antenna, the length and width are calculated as below [6,7]

$$w = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \tag{1}$$

Where c is the velocity of light($3x10^8$ m/s), ε_r is the dielectric constant of substrate(4.4), f_r is the antenna design frequency(2.60GHz), W is the patch width, and the effective dielectric constant ε_{reff} is given as [6,7]

$$\varepsilon reff = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \tag{2}$$

At h=1.6mm

The extension length ΔL is calculated as [6,7]

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+.264)}{(\varepsilon_{reff}-.258)(\frac{W}{h}+0.8)} \tag{3}$$

By using the above mentioned equation we can find the value of actual length of the patch as [6,7]

$$L = \frac{c}{2fr\sqrt{\varepsilon reff}} - 2\Delta L \tag{4}$$

The length and the width of the ground plane can be calculated a [6,7]

$$L_g = 6\text{h} + L \tag{5}$$

$$W_g = 6\text{h} + W \tag{6}$$

Here, Square patch is considered and to determine the length of square patch, the area of square patch is equated to area of rectangular patch for which Length and Width is obtained using above equation[9]

III. ANTENNA DESIGN SPECIFICATIONS

The design of proposed antenna is shown in fig.1. The proposed antenna is design at 2.60GHz frequency by using glass epoxy substrate of a dielectric constant 4.4 The calculated patch width and length are 35.11 mm and 27.13 mm respectively. The proposed antenna design with a square patch of length and width 30.80 mm having equal area to rectangular patch of width 35.11 mm and length 27.13 mm. The square ground plane length and width are 40.40 mm. Height of the dielectric substrate is 1.6 mm and loss tangent tan δ is 0.0013. Antenna is feed through 50 ohm probe feed of diameter 0.3mm at point(7,11). Simulation work is done by using IE3D simulation software. All the specifications are given in the table1.

IV. ANTENNA DESIGN PROCEDURE

All the dimensions of proposed antenna should be calculated by using the equations 1, 2, 3, 4, 5 and 6. Design frequency of proposed antenna is 2.60GHz. The proposed microstrip antenna is loaded with two notch. The geometry of proposed antenna is shown in fig.1. During the designing of proposed antenna on IE3D, ground plane is starting from (0,0) at lower left corner. The probe feed of 50 ohm is placed at point(7,11) to achieve maximum bandwidth.

Table1**: Antenna design specifications.**

S. No.	**Parameters**	**Value**
1.	Deign frequency f_r	2.60 GHz
2.	Dielectric constant ε_r	4.4
3.	Substrate height **h**	1.6 mm
4.	Patch width **Wp**	30.80 mm
5.	Patch length **Lp**	30.80 mm
6.	Ground plane width **Wg**	40.40 mm
7.	Ground plane length **Lg**	40.40 mm

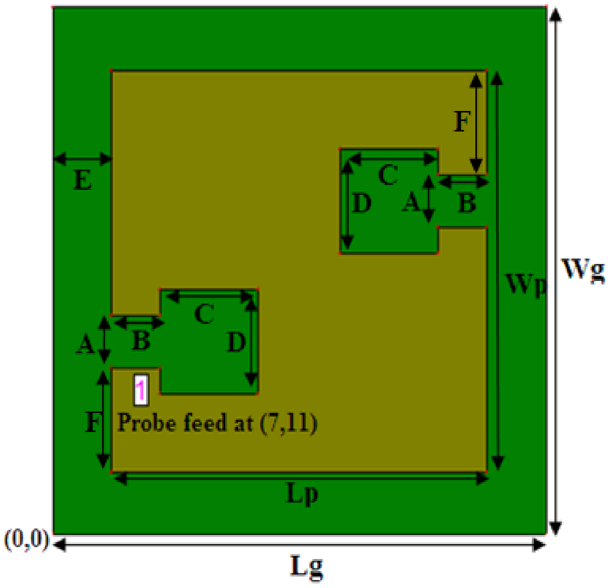

Fig.1. **Geometry of proposed Microstrip antenna**.

Table 2:**Antenna parameters.**

S.No.	Parameters	Value(mm)
1	A	4
2	B	4
3	C	8
4	D	8
5	E	4.8
6	F	8

V. SIMULATION RESULT AND DISCUSSION

In this work the square microstrip patch antenna is design at frequency 2.60Ghz. The area of the antenna patch is 952.53mm^2 for 2.60GHz frequency. The bandwidth of square microstrip antenna is enhanced by two notch loading. The fractional bandwidth of proposed antenna is 29.01% and antenna is resonating at 1.807GHz with -19.45dB return loss. The area of antenna patch corresponding to 1.807GHz frequency is 1984.43mm^2. Thus the size of proposed antenna design is reduced by 51.99% corresponding to 1.807GHz frequency. The antenna efficiency of proposed design is 95.59 %. The maximum gain of the antenna has been improved up to 3.1866 dBi and the VSWR of the antenna is in between 1 to 2 in entire frequency band.

The simulation performance of proposed microstrip patch antenna is analyzed by using IE3D simulation software. The antenna performance specifications return loss, VSWR, gain, smith chart and radiation pattern of proposed antenna is shown in the fig. 2 to 6

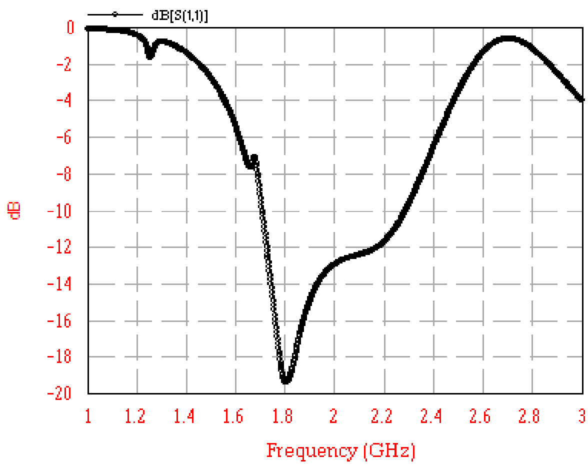

Fig.2. **Return loss v/s frequency graph.**

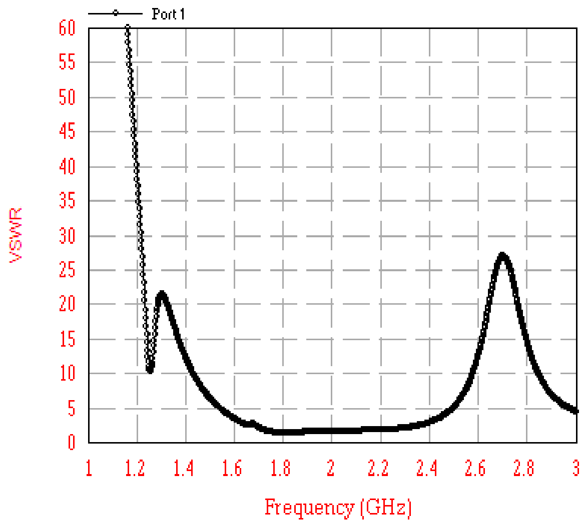

Fig.3**. VSWR of proposed antenna**

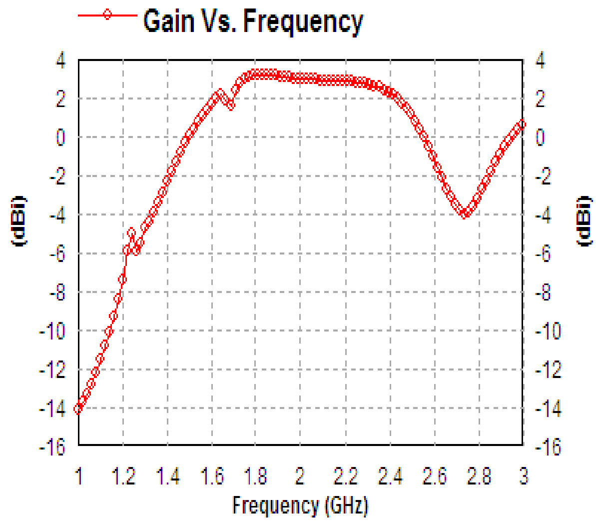

Fig.4**. Gain Vs frequency graph**

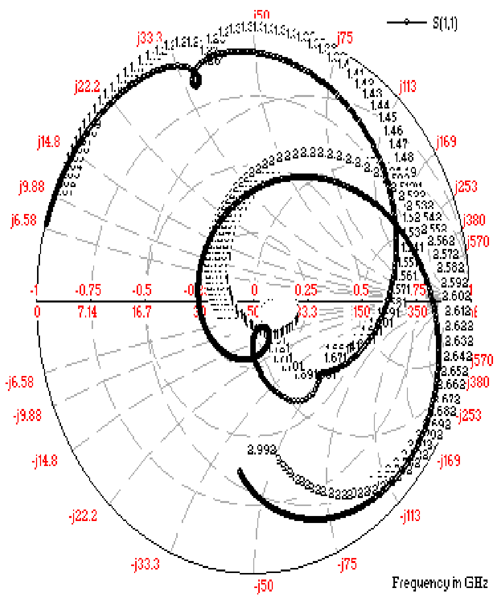

Fig.5**. Smith chart.**

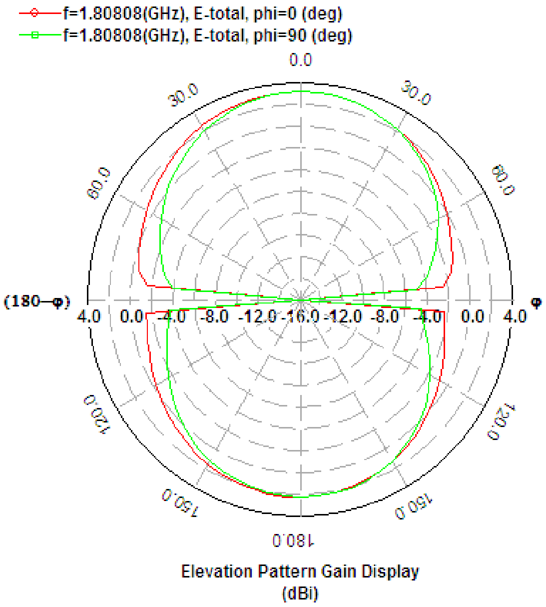

Fig.6. **2D Radiation pattern of proposed antenna**

VI. CONCLUSION

The characteristics of proposed notched antenna has been studied. In general, the impedance bandwidth of the traditional microstrip antenna is only a few percent (2% -5%) [8]. Therefore, it becomes very important to develop a technique to enhance the bandwidth and reduced the size of the antenna. The size of proposed antenna design is reduced by 51.99% corresponding to resonance frequency 1.807GHz. Proposed antenna improved the fractional bandwidth upto 29.01% and antenna is resonating at 1.807GHz. The VSWR of the antenna is 1.239 at resonance frequency. The proposed antenna design has maximum radiating efficiency and gain 96.69 % and 3.1866dBi respectively.

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