Design of a simple slotted Rectangular Microstrip Patch Antenna for Bluetooth Applications

G.Vyshnavi Devi, K.Pramodh Kumar , V. Rama Krishna

Department of ECE, St.Ann's College of Engineering and Technology, Chirala, Andhra Pradesh, India.

Abstract - In this paper, the design of small size, low profile patch antenna is proposed for Bluetooth applications at 2.41GHz frequency with coaxial feeding technique. The patch is Rectangular shaped with slots on the patch. The proposed antenna resonates at 2.41GHz meeting the requirements of Bluetooth applications. The proposed antenna is designed on a Rogers TMM 4(loss free) substrate with an overall size of 58.53 mm×56.53 mm. The important parameters like S_{11} parameters, VSWR and radiation pattern of the proposed antenna are presented.

Key Words*: *Patch antenna, Bluetooth,* S_{11} parameters, *Radiation pattern.

1.INTRODUCTION

Microstrip antennas are designed to have many geometrical shapes and dimensions but rectangular and circular microstrip patches have been used in many application. The microstrip patch antenna consists of conducting patch on a ground plane separated by dielectric substrate. With the help of slots, the size of microstrip patch antenna has been reduced. This effect has been done by changing the path of the current. When the slots are cut on the patch the path of the current is changed. Current travels extra path as compare to the without slot of microstrip antenna. With this concept the size of the antenna is reduced i.e. small size antenna has been used at lower frequency. The operation principal of the antenna is investigated using the coaxial feeding technique. The conducting patch can be taking any shape but rectangular shape configurations are the most length of the antenna is nearly half wavelength in the dielectric, which governs the resonant frequency of the antenna.

The Bluetooth technology provides a means of short range of wireless connections between electronic devices like mobile devices, computers and many others thereby exchanging data, voice, and video. The rapid increase in communication standards has led to great demand for antennas with low cost, low profile and size, ease of fabrication and ease of integration with the parent device. Microstrip patch antennas are widely used for many wireless applications due to their light weight, compactness, easy to integrate and ease of fabrication. Due to these advantages, microstrip antennas are widely used for the current wireless applications. Microstrip patch antenna are used for mobile phones, satellites, radio, radars, global positioning system (GPS), television, multiple input multiple output (MIMO), radio frequency identification (RFID),medical imaging and guidance of missiles are few examples of the military and industrial applications. The first Microstrip Patch Antenna was reported by Deschamp [1] and the first experimental study of Microstrip Patch Antenna was reported by Howell [2]. However, the microstrip patch antennas offer narrow impedance bandwidth and numerous techniques have been investigated and reported to enhance impedance bandwidth. These techniques include employing slot at the patch antenna such as the square-ring slot [3] and U-shaped slot [4] etc.. Other methods to increase the operation bandwidth of antennas include meandered ground plane [5], electromagnetically coupled stacked patch [6], patch antenna with integrated band pass filter [7], gap-coupled feed[8] and optimally designed impedance matching network [9,10] etc. However, these techniques follow increased system cost and complication of the system.

In the present work, a slotted Rectangular microstrip patch antenna is proposed. This antenna resonates at 2.41GHz which is used for Bluetooth applications. It produces a return loss of -15.90 dB and VSWR of 1.38. In section 2, the proposed antenna geometry is presented. In section 3, the simulation results are presented. In section 4, the parametric study of the

proposed antenna is presented by changing the Length, height and width of rectangular patch antenna.

2. GEOMETRY OF MICROSTRIP PATCH ANTENNA

Methods to feed microstrip antenna are microstrip line, coaxial probe, aperture coupling and proximity coupling [9]. In this design coaxial probe feed technique is used as it is advantageous in small size applications.

The relation between the resonant frequency and the dimensions of the antenna are given using the following formulae.

1: Calculation of the Width (W) -

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

2: Calculation of the Effective Dielectric constant.

This is based on the height, dielectric constant of the dielectric and the calculated width of the patch antenna.

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

3: Calculation of the Effective length

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad (3)$$

4: Calculation of the length extension ΔL

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

5: Calculation of actual length of the patch

$$L = L_{eff} - 2\Delta L \quad (5)$$

3. ANTENNA DESIGN

The geometry of proposed Rectangular microstrip patch antenna is shown in Figure 1. All the dimensions are taken in mm.

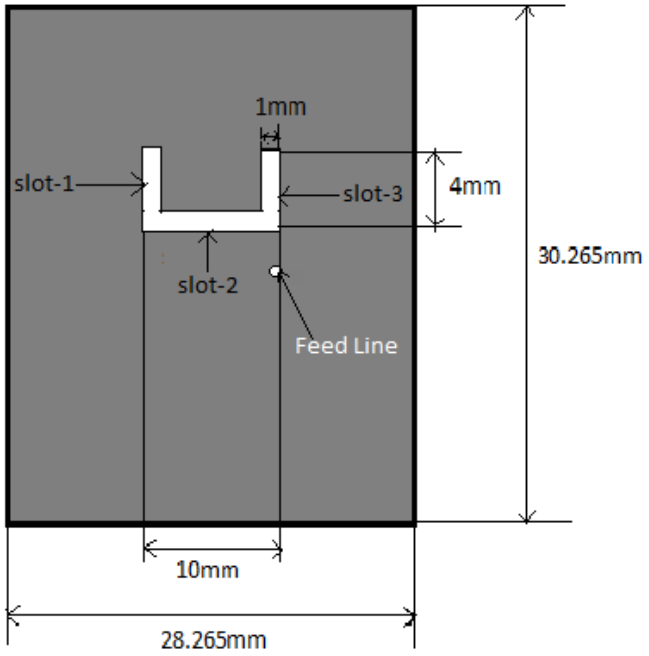

Figure 1: Proposed slotted Rectangular microstrip patch antenna

The shape of the patch is designed in such a way that it can resonate at 2.41GHz, which is the operating frequency for Bluetooth applications. The patch has a rectangular slot having the length, height, width which is shown in the figure. To resonate the antenna at 2.41GHz the length, height, width of the rectangular slot1 are taken as 1mm, 4mm, 0.1mm respectively and the length, height, width of

rectangular slot2 is taken as 10mm, 1mm, 0.1mm respectively and rectangular slot3 is transverse of rectangular slot1.

Here, the substrate selected for the design of the proposed antenna is Rogers TMM 4(loss free) of width 0.8 mm and with low permittivity (εr=4.5). The dimensions of the substrate are taken as 56.53 × 56.53 × 0.8 mm^3. The size of the ground is 56.53 × 56.53 ×0.8 mm^3.

Microstrip patch antennas can be fed by a variety of methods. These methods are classified into two categories which are contacting (direct) and non-contacting. Here the whole system is fed by a co-axial probe as it is simpler to implement.

4. SIMULATION RESULTS

The simulation results for the proposed antenna are shown in the Figure 2. The reflection coefficient is shown in Figure 2(a). The antenna resonates at 2.41GHz with return loss of 15.90 dB.The VSWR plot is shown in Figure 2(b) and the VSWR is 1.38 at 2.41 GHz. The Radiation pattern is shown in Figure 2(c) at phi=90^0.

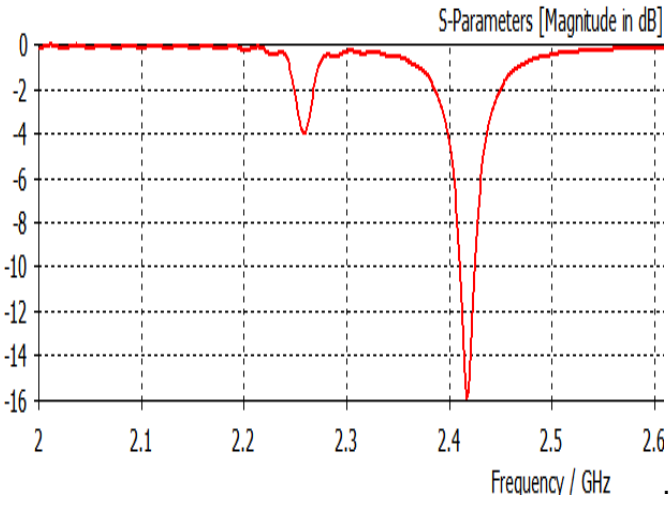

Figure 2(a): Return loss of the proposed antenna

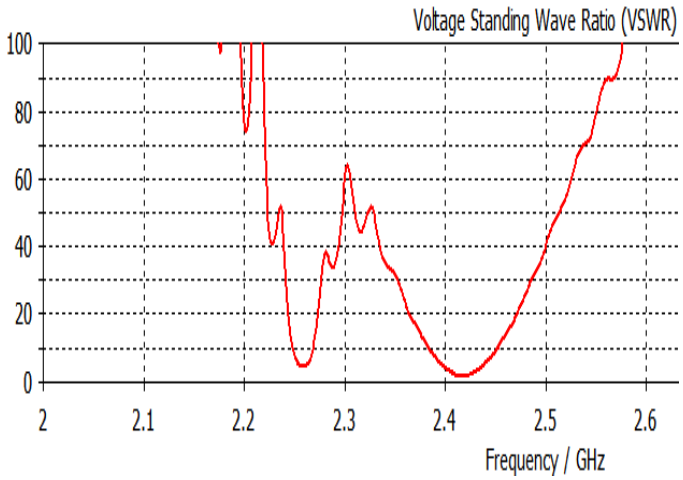

Figure 2(b): VSWR plot of the proposed antenna

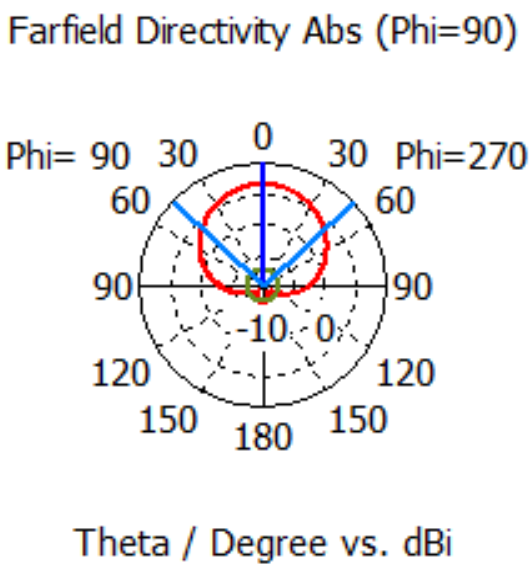

Figure 2(c): Radiation pattern of the proposed antenna

Figure 2: Simulation Results of the proposed antenna

6. CONCLUSION

A Rectangular microstrip patch antenna with slot has been designed and simulated, which can be used for Bluetooth applications. The performance properties are analyzed for the optimized dimensions and the proposed antenna works well at the required 2.41GHz Bluetooth frequency band.

7. References

[1] G. A. Deschamps "*Microstrip microwave antennas*," 3rd USAF Symposium on Antennas, 1953.

[2] J. Q. Howell "Microstrip antennas," *IEEE Antenna Propag Soc Int Symp*, Vol. 20 pp. 177–18, 1980.

[3] S. Sadat, M. Fardis, F. Geran, and G. Dadashzadeh, "A compact microstrip square-ring slot antenna for UWB applications," *Progress In Electromagnetics Research*, Vol. 67, 173–179,2007.

[4] K. F. Lee, K. M. Luk, K. F. Tong, S. M. Shum, T. Huyn and R. Q. Lee, "Experimental and Simulation Studies of the Coaxially Fed U–slot Rectangular Patch" *IEEE Proceedings of Microwave Antenna Propagation*, Vol. 144, No. 5, October 1997, pp. 354–358.

[5] J. S. Kuo and K. L. Wong, "A Compact Microstrip Antenna with Meandering Slots in the Ground Plane," *Microwave and Optical Technology Letters*, Vol. 29, No.2, April 20 2001, pp. 95–97.

[6] H. R. Hassani and D. M Syahkal, "Study of Electromagnetically Coupled Stacked Rectangular Patch Antenna,"IEEE Proceedings of Microwave Antenna Propagation, Vol. 142, No. 1,February 1995, pp. 1–15.

[7] M. H. Badjian, C. K. Chakrabarty, C. H. Goh and S.Devkumar, "An Impulse UWB Patch Antenna with Integrated Bandpass Filter," Proceedings of the 6th National Conference on Telecommunication Technologies and the 2th Malaysia Conference on Photonics, Putrajaya,26–28.

[8] P. S. Hall, "Probe Compensation in Thick Microstrip Patches,"*Electronics Letter*, Vol. 23, No.11, 1987, pp. 606–607.

[9] H. F. Pues and A. R. Van De Capelle, "An Impedance-Matching Technique for Increasing the Bandwidth of Microstrip Antennas," *IEEE Transactions on Antennas Propagation*, Vol. 37. No. 11, November 1989, pp. 1345–1354.

[10] K. W. Loi, S. Uysal and M. S. Leong, "Design of Wideband Microstrip Bowtie PatchAntenna," Proceedings of Institute Electrical Engineering Microwave Antenna Propagation,Vol. 145, No. 2, 1998, pp. 137–140.

BIOGRAPHIES

G.Vyshnavi Devi, Studying B.Tech 3rd Year in St.Ann's College of Engineering and Technology, Chirala, Andhra Pradesh, India.

K.Pramodh Kumar, Studying B.Tech 3rd Year in St.Ann's College of Engineering and Technology, Chirala, Andhra Pradesh, India.

V.Rama Krishna, Studying B.Tech 3rd Year in St.Ann's College of Engineering and Technology, Chirala, Andhra Pradesh, India.