Design of Dual Frequency Antenna for Global Positioning System

Priyank Bhambhani[1]
[1]Electronics & Communication Engineering Department
[1]Lok Jagruti Institute of Technology, Gujarat, India.

Abstract—In recent years low profile, light weight antennas are preferred for the applications which need mobility. In this research the polygonal-shape Microstrip Single Patch Antenna has been designed for GPS dual resonant frequencies (GPS L1 1.575 GHz & L5 1.176 GHz band). Simulated results for main parameters such as return loss, bandwidth, radiation patterns and gains are also discussed herein. The Designing, Simulation & Optimization of this antenna is done in ADS Software. Result of the simulation shows at 1.575 GHz and 1.176 GHz, the antenna has return loss at -20.862 dB and -14.162 dB respectively. .

I. INTRODUCTION

A microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight , low profile planar configuration, low fabrication costs and capability to integrate with microwave integrated circuits technology, the microstrip patch antenna is very well suited for applications such as wireless communications system, GPS, cellular phones, pagers, radar systems, and satellite communications systems[1]. The development of small-integrated antennas plays a significant role in the progress of the rapidly expanding military and commercial communications applications. The technology to support these applications has been made possible by recent advances in high-density RF and microwave circuit packaging. As system requirements for faster data transmission in lighter compact designs drive the technology area, higher frequency design solutions with large density layouts require integration of microwave devices, circuitry, and radiating elements that offer light weight, small size, and optimum performance. Over the past two decades, microstrip patch antenna has received considerable attention for use in personal communication systems applications due to its compactness among other advantages. Intensive research has been carried out to develop new techniques to overcome the microstrip patch antennas drawbacks, the most restrictive being narrow band. The bandwidth enhancement and its return loss improvement without increasing antenna size and production process is important to apply this antenna to the modern mobile communication systems and need to be carried out. Many applications in communications and radars require circular or dual linear polarization, and the flexibility afforded by microstrip antenna technology has led to a wide variety of designs and techniques to fill this need. In recent years, the demand for compact mobile telephone handsets has grown. Handsets with size of a pocket have begun appearing in the market and, as the demand for increased electronic mobility grows, the need for small handsets will most likely increase. A small antenna size is required as one of the important factors in portable mobile communication systems. The Microstrip Patch Antennas (MPA) is widely being used because of its low volume and thin profile characteristics in applications like Global positioning System (GPS) technology, which has been widely used as a navigation system to determine the locations, mapping, tracking devices and surveying. In terms of public used, GPS receiver requires compact, lightweight, low power, low cost high reliability and with mobility capability. The size of MPA is basically determined by its resonance length and width. The reduction of the patch size can be achieved by using patch substrate material with very high permittivity and small substrate height [2]. But, in this case, the low radiation efficiency will reduce the antenna gain.

In this study, a novel polygonal-shape patch antenna optimized for simplicity in design and feeding is proposed. It has characteristic which will meet GPS system application. Parameters of the antenna such as return loss, impedance bandwidth, radiation patterns and gains are discussed in this paper. This paper shows extensive benefits of 3D view of radiation pattern facility provided by the ADS software. Furthermore, in order to satisfy the demanded precision and reliability, a high performance GPS antenna must be capable to operate at the two GPS frequencies (L1: 1.575 GHz, L5: 1.176 GHz).This demand has prompted increased investigation on microstrip radiators, with particular attention paid to improving performance and miniaturization. Microstrip antennas have enjoyed proliferate use in many circularly polarized applications due to their low- profile light weight and useful radiation characteristics [9]. A circularly polarized EM-wave is generated when an antenna radiates two orthogonal field components having equal amplitude with a quadrature phase difference between them [10],[11]. In practice, circular polarization can be done with certain methods on the radiating patch or specialized geometry. There are several methods to connect the radiating patch to feeder. The radiating patch can be connected by microstrip line, coaxial cable, or mutual coupling. Impedance matching is usually needed between feed line and radiating patch as the input impedance may differ from characteristics impedance 50 Ω. Designing a circular polarization antenna is generally much harder than linear polarization antenna as the bandwidth where antenna is circularly polarized is so narrow. In this paper, right hand circular polarized pentagonal microstrip antenna for GPS technology with the resonance frequencies at 1.55 GHz and 1.176 GHz is presented.

II. ANTENNA DESIGN

The geometry of the proposed patch antenna is shown in Figure 1. The design of the antenna is started with determination of important parameters which directly influenced the antenna performance. Polygonal geometry is chosen as the basic configuration which can make the antenna circularly polarized. Two polygonal microstrip antennas is developed separately before both of the structure is joined by feed line. Each of the polygons carries one resonant frequency to give the combined system a dual resonant frequency antenna. The results of the desired antenna of a compact band radiator for use in wireless communications applications are presented in this section. Bandwidth is specified as the frequency bandwidth in which the return loss is less than -10 db. A general model can be useful in an initial design and usually plays an appreciable role in antenna scaling. Typically, these models include the cavity model and the transmission line model for modeling of microstrip patch antenna. The transmission line analysis for a microstrip patch antenna is a well-established approach among the antenna engineers. It is general that increasing the thickness of the patch antenna will increase the impedance. However, the thicker the substrate of the

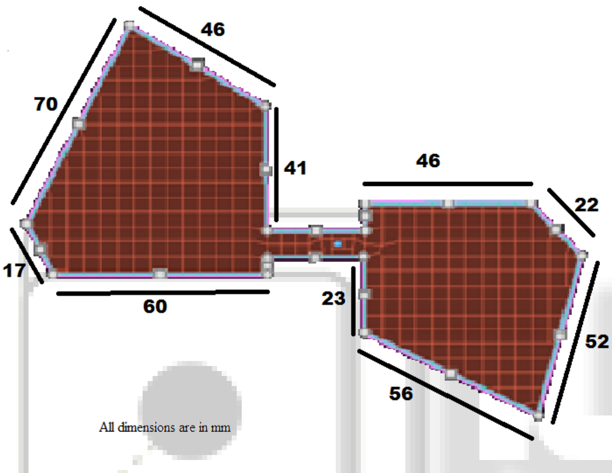


Fig. 1 Actual ADS Model (Top view of Proposed Antenna Patch)

antenna, the longer the coaxial probe will be used and, thus, more probe inductance will be introduced [3], which limits the impedance bandwidth. Consequently, a patch antenna design that can counteract or reduce the probe inductance will enlarge the impedance bandwidth.[12] The patch is supported by a low dielectric substrate with dielectric permittivity ε with material Rogers Duroid RO4003 as shown in Table 1. And it is in between patch and ground plane. The substrate is very thin. The height of the antenna substrate that is made up of Rogers Duroid RO4003 material is taken as 1mm. The material Rogers DuroidRO4003 is a dielectric component defined in the ADS library. It is having the dielectric constant as 3.38. the substrate height is of much of importance for the perfect matching of antenna impedance with the line feed impedance. If a mismatch occurs then the increase in return loss occurs and return loss is to be expected as much as less possible for better performance of antenna. More the return loss, poor the bandwidth and performance of antenna. The antenna patch can be made either of copper or gold. Here in this ADS software copper has been taken by default as the patch material. Patch material is shown in brown color in the figure 1 as in the form of polygonal shape. The pattern seems to be of two pentagons to be joined with a rectangle strip. Table 1. Showing details about the material. Patch is of copper material. Substrate is of Rogers Duroid RO4003 material with ε=3.38 the base material is also of copper.

Structure	**Material**
Patch	Copper
Substrate	Rogers Duroid RO4003
Dielectric Permittivity (ε)	3.38
Loss tangent	0.0022
Height	1 mm

Table 1. Material Used for Patch Antenna

The near to straight lines which are forming the rectangular boxes in the patch are the lines which are formed by the transmission line analysis model executed by the ADS software.

III. SIMULATION RESULTS

For simulation we used ADS, which is very good simulator for RF antennas. After simulating the design the result we got is as follows. The gain of the antenna for GPS if obtained low, then also the antenna can be used for the aid application with a purposeful result as if the gain is less means antennas directivity is less as gain and directly proportional to each other. The GPS application mainly is a receiver application as it's an application which has a purpose to receive the signals from various users or say objects.

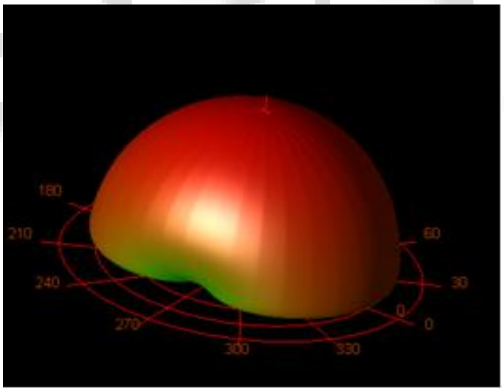
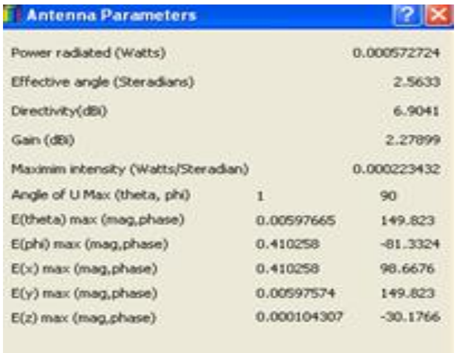


Fig .2 Radiation Pattern of the antenna

Hence when it's said that power handling capability of the microstrip antenna is lower than other antennas, then such a disadvantage can be neglected on the basis of receiver application, as it's an receiver application then it doesn't have to transmit power.

So in that case low power handling capability is not an issue for using microstrip patch antenna for GPS application. Figure 4. shows the Return Loss (S11) plot of the design and For the whole range from 1.173GHz to 1.181GHz the Return loss is less than -10 dB and at frequency 1.176 GHz it's minimum and the value is -14.162dB &For the whole range from 1.573GHz to 1.583GHz the Return loss is less than -10 dB and at frequency 1.575 GHz it's minimum and the value is –



Antenna Parameters

Power radiated (Watts)		0.000572724
Effective angle (Steradians)		2.5633
Directivity(dBi)		6.9041
Gain (dBi)		2.27899
Maximim intensity (Watts/Steradian)		0.000223432
Angle of U Max (theta, phi)	1	90
E(theta) max (mag,phase)	0.00597665	149.823
E(phi) max (mag,phase)	0.410258	-81.3324
E(x) max (mag,phase)	0.410258	98.6676
E(y) max (mag,phase)	0.00597574	149.823
E(z) max (mag,phase)	0.000104307	-30.1766

Fig .3 Parameters of the designed antenna in ADS

20.862dB As seen from the figure 4, the return loss is less than -10db at frequency 1.176 GHz and 1.575 GHz. This is a standard level of return loss which can be allowed for any frequency of operation to be worked upon if it has return loss less than -10db. The parameters that affect the return loss are the imperfect impedance matching of the micro strip line feed and the microstrip patch antenna impedance.

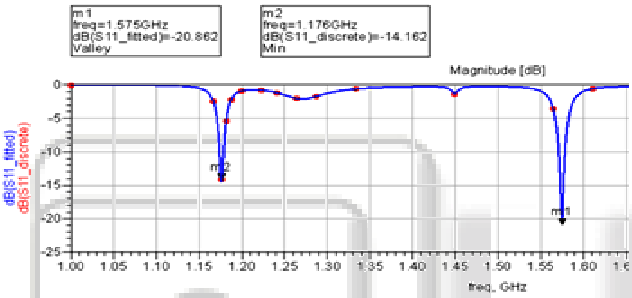


Fig .4 Return Loss (S11) parameter of the antenna

It should be as much as less possible means more negative the value of return loss as better as the performance. The bandwidth that is measured at the -10db level of return loss in the above Figure of return loss versus frequency yields a band width of 10 MHz and 8 MHz of frequency band for which the concerned designed antenna is giving same values of concerned parameter for measuring the performance of antenna. Figure 2 shows the Radiation Pattern of the design. The various parameters can be calculated from this 3Dimensional radiation pattern. Figure 3 shows the window for dual frequency operation for all the Radiation pattern values for gain, directivity power radiated. Same way patterns for other frequencies can be generated. At resonant frequencies of 1.575 GHz and 1.176 GHz, the antenna had return loss at -20.862 dB and -14.162 dB respectively. The simulated impedance bandwidths (10dB return loss) are 10 MHz at 1.575 GHz and 8 MHz at 1.176 GHz.

IV CONCLUSION AND FUTURE SCOPES

Microstrip antennas have become a rapidly growing area of research. Their potential applications are limitless, because of their light weight, compact size, and ease of manufacturing. The low profile polygon-shape patch is presented in this paper. Simulations and results of the polygonal shape microstrip patch antenna have provided a useful design for an antenna operating at the dual frequency of 1.176 GHz & 1.575 GHz for the GPS applications. The reflection coefficient is below −10dB from 1.173 GHz to 1.181 GHz and 1.573 GHz to 1.583 GHz, at the same time, the antenna is thin and compact with the use of low dielectric constant substrate material.

REFERENCES

[1] C.A. Balanis, Antenna Theory, 2nd ed. New York: John Wiley & Sons, Inc., 1997.
[2] R. Bancroft, Microstrip and Printed Antenna Design, Prentice Hall of India, 2006
[3] Wi S.H., Kim J.M., Yoo T.H., Lee H.J., Park J.Y., Yook J.G., Park H.K. Bow-tieshaped meander slot antenna for 5 GHz application . in Proc. IEEE Int. Symp. Antenna and Propagation. 2, 456–459,2002
[4] J. R. James, P. S. Hall, and C. Wood, Microstrip Antenna Theory and Design, Peter Perigrinus, London, 1981.
[5] B. L. Ooi, M.S. Leong, and Q. Shen, "A novel equivalent circuit for E-shaped slot patch antenna," in Proc. IEEE Antennas and Propagation Society Int. Symp., 2001, vol. 4, pp. 482-485, 8-13 Jul. 2001.
[6] K. C. Gupta and A. B. Norwood, Microstrip Antenna Design,Norwood, MA: Artech House, 1988.
[7] X. -X. Zhang and F. Yang, "The study of slit cut on the microstrip antenna and its applications", Microwave Opt. Technol. Lett., vol. 18, no. 4, pp. 297-300, Jul. 1998.
[8] Shobhit K. Patel, Y.P.Kosta “E-shape Microstrip Patch Antenna Design for GPS Application” Institute of Nirma University, 08-10 Dec, 2011, IEEE.
[9] X. L. Bao and M. J. Ammann, “Dual-Frequency Circularly-Polarized Patch Antenna With Compact Size and Small Frequency Ratio,” IEEE Transaction on Antennas and Propagation, vol. 55, pp. 2104-2107, July 2007.
[10] J. Bahl, P. Bahrtia, Microstrip Antenna, pp. 24, 1982.
[11] B. S. Sullivan, “Design of Circularly Polarized Omnidirectional Microstrip Sounding Rocket Antennas for Telemetry and GPS Applications,” University of Alaska Fairbanks, pp. 7-10, 2001.
[12] Muhammad Fadhli Bukhori, Norbahiah Misran, Mohammad Tariqul Islam, Mawarni Mohamed Yunus and Mohammed Nazmus Shakib, Design of Microstrip Antenna for GPS Application, IEEE International RF and Microwave Proceedings, Malaysia, pp. 464-466, Dec 2008.
[13] Bhambhani Priyank Narendra, Microstrip Patch Antenna Design for GPS Application Using ADS Software, ICRD-ETS-2013, pp. 111-114, Apr 2013
[6] K. C. Gupta and A. B. Norwood, Microstrip Antenna Design,Norwood, MA: Artech House, 1988.
[7] X. -X. Zhang and F. Yang, "The study of slit cut on the microstrip antenna and its applications", Microwave Opt. Technol. Lett., vol. 18, no. 4, pp. 297-300, Jul. 1998.
[8] Shobhit K. Patel, Y.P.Kosta “E-shape Microstrip Patch Antenna Design for GPS Application” Institute of Nirma University, 08-10 Dec, 2011, IEEE.