

IMPACT AND ANALYTICAL STUDY OF THE PATCH AND SLOT FOR ANTENNA DESIGN

Y.P.Singh¹, M.L.Chandna², Santosh Dahal³, Abishek Haridass⁴

¹Director, ²Director,(Research & Projects) ,Somany(P.G.), Institute of Engineering & Technology, affiliated to M.D.UniversityRohtak,Haryana

³Research Scholar, Somany(P.G.), Institute of Engineering & Technology, Rewari

⁴Research Scholar, Sunrise University, Alwar

Abstract

Antenna is the backbone of the communication system. With the advent of technology a lot of innovation happens to develop the antennas. Antenna is a smart device, which not only transmit and receive but also works as a transducer. S/N ratio also Abstract depend upon the efficiency of the antenna .Patch and slot has become a very important in modern wireless communication antennas. Patch and slots are being used for performance improvement of antenna in wireless communication. with the pace and speed of the communication theory, antennas also its design also developed in an innovative ways. Keeping the above fact in mind we had tried to present a complete review on patch and slots antennas .it has been analyzed in detail, In different size and shapes of slots and patch are great interest of obtaining optimum results of antenna design , in order to allow their use in communication application. A variety of the antennas are available in the communication engineering system. Present study represent the various details and open wide the slit for more innovations.

Keywords- (patch, slot GSM900, GSM1800, GSM 2100, UMTS, IMT-2000 and PCS,

-----***-----

1. INTRODUCTION

Communication is a process in which antennas plays a vital role. With the advent of fast and cost effective technology a lot of innovation comes up in the Antennas also. The Slot and Patch is one of the need based, cost effective and also the efficient result oriented techniques. A wide variety of communication engineering communication system such as wireless computer links, remote controls, satellite mobile phones and wireless internet have shown a tremendous growth in present days and the extensive demand and need in the near future. Such situations necessitate us for development of new innovations and also for improving the existing one. Different situation demands different variety of devices and equipments. Utility and need based application make the antennas as new area of research and development. The antennas required for the various applications should be of small size, light weight, low profile, broad bandwidth, low cost and inerrable with MIC/MMIC circuits.

2. LITERATURE REVIEW & STUDY

Literature review and impactal study of the patch and slot antennas may be studied as

2.1 Patch

Mobile communication systems (GSM900, GSM1800,GSM 2100 ,UMTS ,IMT-2000 and PCS), wireless computer links,

remote controls, satellite mobile phones and wireless internet have shown a tremendous growth in present days. The antennas required for the various applications should be of small size, light weight, low profile, broad bandwidth, low cost and inerrable with MIC/MMIC circuits [1-3]. However, the microstrip antenna inherently has a low gain and a narrow bandwidth. Many applications use planar antennas such as microstrip patches, which are inherently compatible with planar systems [17]. Microstrip patch antennas are commonly used in aircraft, spacecraft, satellite, and mobile communication and missile applications due to their many attractive features such as simple structure, low production cost, light weight and robustness. Due to the advancement of technology microstrip patch antennas are used in modern printed circuit technology, MMIC design, GPS communication system, Wireless Local Area Network (WLAN), Synthetic Aperture Radar (SAR). Considerable effort has been devoted to the development and improvement of the bandwidth, return loss and reduction of size [3-11].

In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape as shown in Fig 1

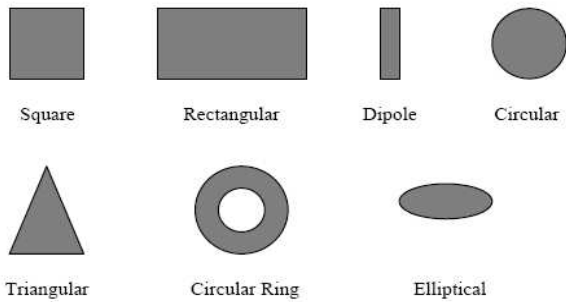


Fig.1 Common Shapes of micro strip patch elements

For a rectangular patch, the length L of the patch is usually $0.3333\lambda < L < 0.5\lambda$, where λ_0 is the free-space wavelength. The patch is selected to be very thin such that $t \ll \lambda$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003 \lambda_0 \leq h \leq 0.05\lambda$. The dielectric constant of the substrate (ϵ_r) is typically in the range $2.2 \leq \epsilon_r \leq 12$.

2.2 Example of Design of Patch Antenna

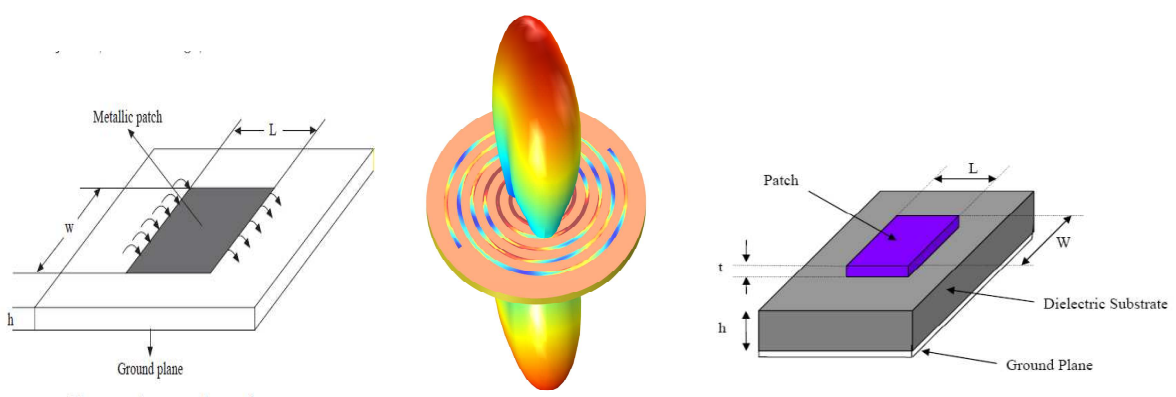


Fig.2 patch antenna design

Fig.3: Radiation Pattern

Fig.4: Structure of a Microstrip Patch Antenna

First calculate the width (W) of Microstrip patch Antenna. Width of micro strip patch antenna is given by

$$W = C / C / 2f_0 \sqrt{\epsilon_r + 1/2}$$

Substituting $C = 3 \times 10^8$ m/sec; $\epsilon_r = 4.4$ and $f_0 = 1.9$ GHz , We get $W = 48.00$ mm

Effective dielectric constant (ϵ_{reff}) is calculated as

$$\epsilon_{\text{reff}} = \epsilon_r + 1/2 + \epsilon_r - 1/2 [1 + 12h/W]^{1/2}$$

where ϵ_r is relative dielectric constant

Substituting $\epsilon_r = 4.4$, $W = 48$ mm and $h = 1.6$ mm

We get $\epsilon_{\text{reff}} = 4.14$

The effective length is given by

$$L_{\text{reff}} = C / 2f_0 \sqrt{\epsilon_{\text{reff}}}$$

Substituting $\epsilon_{\text{reff}} = 4.14$, $C = 3 \times 10^8$ m/sec; $\epsilon_r = 4.4$ and $f_0 = 1.9$ GHz . We get $L_{\text{reff}} = 38.8$ mm

The length extension is given by:

$$\Delta L = 0.412h (\epsilon_{\text{reff}} + 0.3) (W/h + 0.264) / (\epsilon_{\text{reff}} - 0.258) (W/h + 0.8)$$

$$\Delta L = 0.75$$
mm

The actual length is obtained by:

$$L = L_{\text{reff}} - 2 \Delta L$$
 Substituting the values $L = 37.7$ mm

By using above formulae we get, By using above formulae we get

$$L = 37.3$$
 mm and $W = 48$ mm

So, microstrip patch dimensions decided by using above formulae and $L = 37.3$ mm and $W = 48$ mm is calculated [13].

2.3 SLOT

Microstrip slot antennas invented in 1938 by Alan Blumlein. Slot radiators or slot antennas are antennas that are used in the frequency range from about 300 MHz to 25 GHz. They are often used in navigation radar usually as an array fed by a

waveguide. With ever-increasing demand for reliable wireless communications, the need for efficient use of electromagnetic spectrum is on the rise [18]. But also older large phased array antennas used the principle because the slot radiators are a very inexpensive way for frequency scanning arrays.

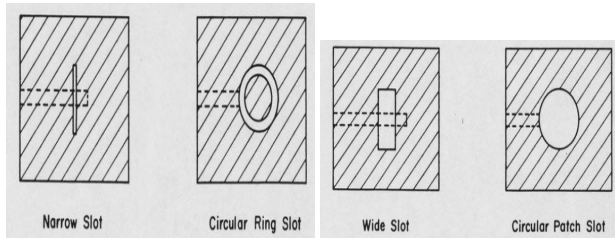


Fig.5 Types of slot in antenna

This slot behaves according to Babinet's principle as resonant radiator. Jacques Babinet (1794 - 1872) was a French physicist and mathematician, formulated the theorem that similar diffraction patterns are produced by two complementary screens (Babinet's principle). This principle relates the radiated fields and impedance of an aperture or slot antenna to that of the field of a dipole antenna. [12]. It can also provide the merits of low profile, low cost, small size, easier integration with other circuits and conformability to a shaped surface. Nowadays, numerous slot antenna designs for 2.4/5GHz dual-band WLAN operations have been reported in the literatures [19-24]. Slot antennas are an about $\lambda/2$ elongated slot, cut in a conductive plate (Consider an infinite conducting sheet), and excited in the center.

Microstrip slot antenna is very simple in structure. It consists of microstrip feed that couples electromagnetic waves through the slot above and slot radiates them. A microstrip-fed slot antenna offers a better isolation between the feed and the material under measurement compared to the microstrip-fed microstrip antenna [14]. They are more flexible in integration with other active and passive devices in a hybrid MIC and MMIC design. Furthermore, they are capable of producing Omni-directional radiation patterns by simply inserting quarter-wave thick foam and reflector.

2.4 Designing of Slot Antenna

We find the great use of the Slot antennas for fixed stations, satellite ground stations and beacons, with proper mounting, a slot antenna can also be used for 'microwave mobile'. With a 16-slot total, the antenna can have 10-12 dBi gain. The first step in construction of the antenna is to select a section of waveguide which covers the desired frequency. Waveguide dimensions for several microwave bands are listed in (table 1.) If your waveguide doesn't match the dimensions exactly, go ahead and run the program. The program will tell you if the waveguide is too small (if you attempt to operate a waveguide

below its cut off frequency, it will have unacceptable SWR and losses).

Table 1 – Waveguide Dimensions

Usable Frequency (GHz)	Typical Waveguide	Long Dimension "a" Inches	Short Dimension "b" Inches
1.12-1.7	WR650	6.500	3.250
1.7-2.6	WR430	4.300	2.150
2.2-2.3	WR340	3.400	1.700
2.6-3.95	WR284	2.840	1.340
3.3-4.9	WR229	2.290	1.145
3.95-5.85	WR187	1.872	.0872
4.9-7.05	WR159	1.590	.0759
7-11	WR102	1.020	0.510
8.2-12.4	WR90	0.900	0.400
10-15	WR75	0.750	0.375
18-26.5	WR42	0.420	0.170

The program file references the slot antenna dimensions shown in Fig 4. Note that all calculated dimensions (from the Math Cad program) are given in both inches and millimetre.

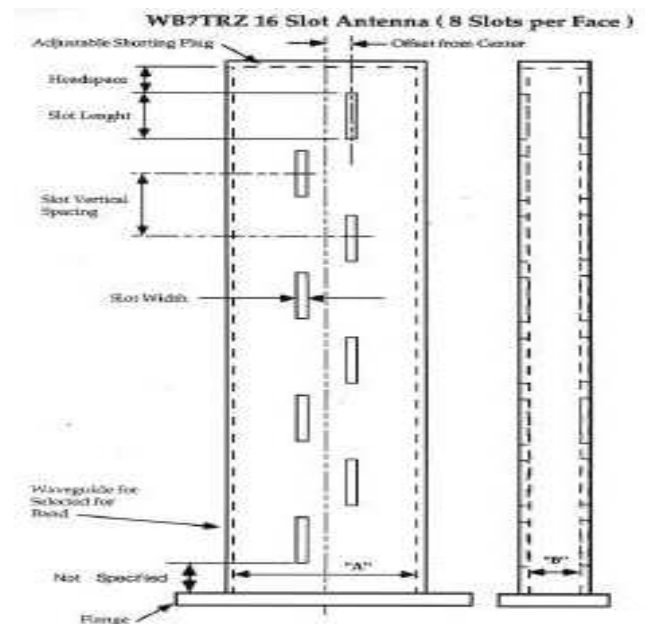


Fig.6 Front View of Waveguide Slot Antenna

2.4.1 Machining The Slots

2.4.2 Drill Press

"Just" drill many overlapping holes, then file out the slots to the desired dimensions.

2.4.3 Milling Machine

Milling Machine is the fast procedural machine, which is basically, the ideal method: who is turn is efficient fast and accurate, less prone to mistakes.

2.4.4 Feeding The Slot Antenna

The simplest feed for the slot antenna is to use a coaxial to waveguide transition.[25]. There shall not be any distortion, impact and also other factors, which may affect the signal.

CONCLUSIONS

Present study, determine the application of patch and slot antenna in the wide field of communication. In particular role of patch and slot in antenna design for wireless communication is addressed. Although this research report is providing the little innovation but may be highly helpful for the researcher's engaged in either academic or industrial R&D in the field of antenna design in wireless communication.

REFERENCES

- [1]. Raj Kumar, J. P. Shinde and M. D. U plane Effect of Slots in Ground Plane and Patch on Microstrip Antenna Performance International Journal of Recent Trends in Engineering, Vole 2, No. 6, November 2009, pp 34-36
- [2]. K. R. Carver and J. W. Mink, "Microstrip antenna technology," IEEE Trans, AP-29, pp. 2-24, Jan. 1981.
- [3]. R. Gag, "Progress in Microstrip antennas ", IETE Technical Review, Vol. 18, No.2 & 3 pp .85-98, March-June 2001.
- [4] X.L.Bao and M.J.Ammann, "Compact annular-ring embedded circular patch antenna with a crossslot ground plane for Circular Polarization" Electron.Lett. Vol.42. No.4, Feb. 2006.
- [5] .S.Bhunia, S.Biswas, D.Sarkar, P.P.Sarkar, "Experimental investigation on dual-frequency broad band microstrip antenna with swastika Slot", Indian Journal physics, Vol-81.No.4, pp-497-499, April 2007.
- [6]. S.Bhunia, D.Sarkar, S. Biswas, P.P.sarkar, B.Gupta., K.Yasumoto "Reduced Size Small Dual-Frequency Microstrip Antenna" Microwave & optical Technology Letters. Vol. 50, No.4, pp. 961-965, April 2008.
- [7]. S.Bhunia, P.P.Sarkar, "Reduced Sized Dual Frequency Microstrip Antenna" Indian J. Phys Vol.83, No.10, pp- 1457-1461 October 2009.
- [8]. L. Guo, S. Wang, X. Chen, and C.G. Parini, Study of compact antenna for UWB applications, Electron Lett 46 (2010), 115–116.
- [9]. K.G. Thomas and M. Sreenivasan, Compact CPW-fed dual-band antenna, Electron Lett 46 (2010), pp 13–14.
- [10]. C.Y.D. Sim, W.T. Chung, and C.H. Lee, Compact slot antenna for UWB applications, IEEE Antenna Wireless Propag Lett 9 (2010), pp 63–66.
- [11]. S. Sarkar, D. Sarkar, A. Das Majumdar, P. P. Sarkar, S. Mondal, S. Biswas, "Miniaturization of Rectangular Microstrip Patch Antenna Using Optimized Single –Slotted ground plane" Microwave & Optical Technology Letters. Vol.53, No.1, pp.111-115, January, 2011.
- [12]. <http://www.radartutorial.eu/06.antennas/an30.en.html>.
- [13]. R.D. Kanphade, D.G. Wakade and N.T. Markad, Square Patch Antenna: A Computer Aided Design Methodology, International Journal of Electronics and Communication Engineering. ISSN 0974-2166 Volume 4, Number 5 (2011), pp. 483-489
- [14]. H. G. Akhavan and D. Mirshekar-Syahkal, "Slot Antenna for Measurement of Properties of Dielectric at Microwave Frequencies", National Conference on Antennas and Propagation, no. 461, 30 March – 1 April 1999.
- [15]. Hyunseok Ko, Yoo Jin Kim, Maria Q. Feng and Franco De Flaviis pin switched microstrip slot antenna array for 3d microwave reflection tomography,
- [16]. Mohammad Tariqul Islam, Mohammed Nazmus Shakib, Norbahiah Misran, High Gain Microstrip Patch Antenna, European Journal of Scientific Research ISSN 1450-216X Vol.32 No.2 (2009), pp.187-193.
- [17]. S. A. Malipatil, S. L. Mallikarjun, P. M. Hadalgi and P. V. Hunagund, STUDY ON INTEGRATED WAVEGUIDE SLOT ANTENNAS, S. A. Malipatil et al. / International Journal of Engineering Science and Technology (IJEST), ISSN : 0975-5462 Vol. 3 No. 7 July 2011, pp 5912 -5915.
- [18]. Dimitrios Peroulis, Kamal Sarabandi, and Linda P. B. Katehi, Design of Reconfigurable Slot Antennas, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 53, NO. 2, FEBRUARY 2005, pp. 645-654.
- [19]. Wang Ren, "Compact 2.4/5-GHz Dual-band Annular-ring Slot Antenna with Circular Polarization", Microwave and Optical Technology Letters, vol.51, pp.1848-1852, 2009.
- [20]. JinSen Chen, Dual-frequency Annular-ring Slot Antennas Fed by CPW Feed and Microstrip Line Feed", IEEE Transactions on Antennas and Propagations, vol.53, pp.569-571, 2005.
- [21]. V.Stojkovic and G.Wlison, "A small planar inverted-F antenna for applications in wireless communication", In proceeding of IEEE International Symposium on Antennas and Propagation, pp 454-457, 2002.
- [22]. H. Y. David Yang, "Miniaturized dual-band printed antennas for wireless communications" In proceeding of IEEE International Symposium on Antennas and Propagation, pp 450-453, 2005.
- [23]. F. Jolani, A. M. Dadgarpour, and H. R. Hassani, "Compact M-slot folded patch antenna for WLAN", Progress in Electromagnetics Research Letters, vol.3, pp35-42, 2008.
- [24]. WenChung Liu, "Broadband Dual-frequency Cross-shaped Slot cpw-fed Monopole Antenna for WLAN Operation", Microwave and Optical Technology Letters, vol.46, pp353-355, 2005.
- [25]. Slot Antenna Design Stephen Bell, KB7TRZ,
- [26]. http://ethesis.nitrkl.ac.in/992/1/Complete_Thesis.pdf
- [27]. www.comsol.com

BIOGRAPHIES:

1. Prof.(Dr.) Y.P. Singh, currently working as Director, Somany P.G. Institute of Technology and Management , Rewari, Haryana. He has also worked about 27 years as Lecturer, Dean of academics, Principal , Director in many Engineering institutions and organization. He has also served with Training and Technical Deptt.,Govt.Of Delhi, almost for 17 years. He has about 42 research paper published in National and 52 papers published in international journals in his credit. He has been selected and awarded by Govt. of Delhi as “Best Technical Teacher-2004”. Also he has been conferred “Outstanding Teachers Awards “ 2012& 2013 respectively. He has been awarded with Outstanding Teacher Award 2012 and 2013 also. He is also an expert and Master Trainer for the Teachers, empanelled by SCERT/NCERT. And CSTT, MHRD, Govt of India. .He is also the guide of research scholar for almost dozen of Universities. His area of Research is mobile and wireless communication, digital signal processing, Development of algorithms for the Data processing.

2. Prof. M.L.Chandna: Currently working as a Director (Research+Projects) with Somany (P.G.) Institute of Technology and Management. He has Teaching and admin experience of about 42 Years , Beside he has worked 36 years as a faculty in Electronics and communication Engg. with Delhi College of Engg., Bawana,New-Delhi. He is One of the outstanding and eminent Professor in the field of Microwave communicationEngg.He also pioneer to Design and Development of the low cost utility based Electronics Projects .His area of Research is microwave engineering , mobile and wireless communication, digital signal processing, Critical study based on Soft Computing.

3. Er. Santosh Dahal : Working as a faculty in Electronics and Communication Department in Somany (Post Graduate) Institute of Technology and Management affiliated to Maharshi Dayananad University, Rohtak.

4. Abhishek Haridass: Post Graduate in Electronics and Communication Engineering and Computer Science Engineering and currently pursuing his research from Sunrise University , Alwar. His area of research is internet services through Li-Fi. He has published four research papers in his account.