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RESEARCH ARTICLE

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SINGLE AND DOUBLE U-SLOT MICROSTRIP PATCH ANTENNA WITH ENHANCED BANDWIDTH AND GAIN

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ABSTRACT

In this paper, Microstrip patch antenna using coaxial probe feed is designed for multiband applications by cutting single and double U-slots in the patch. When a single U-slot is cut in the patch, a notch is introduced within the matching band, and generate six resonating frequencies whereas If another double U-slot is cut in the same patch, antenna becomes resonates at seven resonating frequency with the increase in bandwidth, gain and directivity. The U slot patch antenna has been designed and simulated in Ansoft HFSS software. The proposed antenna is used for WLAN applications.

Keywords: HFSS, Multiband, coaxial Feed, Patch antenna, single U-slot, double U slot patch antenna.

I. INTRODUCTION

The prompt growth in communication standards has lead to greater demands for antennas with low profile, low size, fabricated with low cost and ease of integration with feeding network. Numerous applications were developed after designing of multiband antennas with required slots which makes antenna conformal with arrays, miniaturize the size of the antenna to about 37% and also reduces the usage of two or more antennas for multiband responses [1]. These days in wireless communication systems, multiband antenna has been playing an important role for wireless service requirements. So in today's scenario, antennas which can provide multiple bands are being used widely in satellite and mobile communication systems to meet the growing system complexity [2]. Microstrip patch antenna is widely considered to be suitable for many wireless applications, even though it generally has a narrow bandwidth. The antenna consists of a ground plane on one side of a dielectric substrate and a radiating patch on the other side. The patch is generally made of conducting material. The radiating patch and feed lines is usually photo etched on the dielectric substrate [3] Micro strip antenna having small size and 2D structures are widely used for it. Besides small size and 2D structure micro strip antenna has some more advantages such as lesser manufacturing cost, uncomplicated to manufacture etc. Though MSA has various advantages it has some severe disadvantages also such as low bandwidth, low gain, low efficiency etc. Several researches are in progress to remove these disadvantages. Various patch shapes such as circular, rectangular, triangular etc. are used in antenna design to enhance the bandwidth, efficiency and gain of the antenna. Moving ahead by cutting notches and slots in the patch to make different patch shapes and moreover to enhance the current path which results in better bandwidth of the antenna [4-6]. Since it is reported for the first time, the U-slot shape has been

extensively used to increase the antenna bandwidth (BW). The first reported U-slot cut rectangular MSA (RMSA), which is optimized on substrate thickness h of 0:080, gives BW of 470 MHz (812–1282 MHz, 45%) with broadside radiation pattern throughout the BW [7-8]. The U shape antenna designed not only for wideband application but also for multiple band applications with small and wide frequency ratio. Two U slots are included to provide the operating frequency bands. Dual frequency microstrip antenna for small frequency ratio applications are conferred with double U-slot etched on the radiating element. The antenna has enough freedom to control the dual design frequencies. It undertakes the applications such as WCDMA 3G and 4G LTE. A dual frequency resonance antenna is achieved by implanting U shaped slot in semicircular disk. It is analyzed by using circuit theory concept. It is found that the resonant frequency hinge inversely on the slot length and feed point while it increases with increasing the slot width and coaxial probe feed radius [9-11].

Garima et al [12] presented in there paper that when a U-slot is cut in the patch, a notch is introduced within the matching band, results in dual- band antenna. If another U-slot is cut in the same patch, antenna becomes a triple-band antenna and fetched out there different resonating frequency and directivity. And the proposed antenna can work for WLAN. Mahdi Moosazadeh and Sergey Kharkovsky [13] analyzed that L- and U-shaped slots loaded over the rectangular micro strip patch antenna is provided to obtain the required operational frequency bands for WLAN (2.4/5.2/5.8 GHz) and WiMAX (2.5/3.5/5.5 GHz). The proposed antenna can be an excellent choice for WLAN/WiMAX applications due to its small size, simple structure, good multiband characteristics, and omnidirectional radiation pattern over the above mentioned bands.

M.Ravi kishore, A.Janardhana [14] investigated that multi band characteristics are achieved by embedding number of U-shaped slots on the rectangular patch; an L-probe is used to realize matching between the feed systems and radiating system in a wide frequency range. Due to the compact area occupied, the proposed antenna is promising to be embedded within the different portable devices employing WiMAX applications. Swaraj Panusa and Mithlesh Kumar [15] researches that a multiband U-slot patch antenna using coaxial feed technique has been presented and the simulated results of return loss, gain, and radiation patterns have been analyzed and the proposed antenna have achieved good impedance matching, stable radiation pattern and satisfied return loss.. The proposed antenna can be considered to achieve multiband just through etching U-slots on the patch, so it can be much easier to fabricate. So it can emerge as an excellent candidate for multiband generation of wireless communication. Kirankumar R. Urgunde, Veeresh G. Kasabegoudar [16] reviewed that a micro strip antenna with triple bands loaded by two U-slots has been presented. The addition of U-slots on patch geometry helps in achieving proper gain, radiation characteristics, and gain. The proposed antenna offers broader impedance bandwidth at second resonant frequency as we collate it with the conventional patch antenna.

In this paper, we have analyzed the two different U-slot antennas that can also be used to design patch antennas with multiple band applications using coaxial probe feed. The coaxial probe feed microstrip antenna is of big interest since it allows for the separation of the radiating element (microstrip patch) and feed network (50Ω microstrip transmission line) with a conductive layer (ground) and that delivers the shielding to an antenna from spurious feed radiation. Through the aperture in ground plane the energy is coupled to the patch. The notch is produced within the matching band, by cutting a single U slot in to the patch, resulting in dual or triple band antenna. Correspondingly, by cutting two U- slots in the patch, notches are produced within the same matching band, resulting in multiband microstrip patch antenna.

II. DESIGN DESCRIPTION

The key variables for designing the rectangular microstrip patch antenna: The formulas for calculating the length, width and value of air gap are taken from [11].

Operating frequency (f_0): The antenna resonant frequency must be picked appropriately. For a wireless application ranges from 2.25GHz to 9GHz. The center frequency covering this band is:

f_0= 5GHz

Dielectric Constant of the substrate (ε_r): The dielectric material selected for our design is Rogers RT/duriod 5880 (tm) which has a dielectric constant of 2.2. A substrate with a high dielectric constant has been selected since it reduces the dimension of the antenna.

Height of the substrate (h): It is essential that the micro strip patch antenna must not be bulky for the wideband applications. And the height of the dielectric substrate is selected as 3.45mm.

Hence the essential parameters for the design are:

f_r =5GHz

h = 3.45mm

ε_r =2.2

Step 1: Measuring the width of the microstrip patch:

The width of the microstrip patch antenna is given as [17-22].

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

Step2: Measuring the length of the microstrip patch:

The length of the microstrip patch antenna is given as:

$$\Delta L = (0.412h)\frac{(E_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(E_{reff}-0.258)\left(\frac{w}{h}+0.813\right)} \quad (2)$$

The L_{eff} effective length of the patch is:

$$L_{eff} = L + 2\Delta L \quad (3)$$

The effective length, for the given resonance frequency f_0 is given by:

$$L_{eff} = \frac{C}{2f_0\sqrt{e_{reff}}} \quad (4)$$

The resonant frequency f_0 for any mode of the rectangular microstrip patch antenna is given by James and Hall as:

$$f_0 = \frac{C}{2}\left[\left(\frac{m}{l}\right)^2 + \left(\frac{n}{m}\right)^2\right]^{1/2} \quad (5)$$

Where m and n are modes along Length and Width respectively. Using the above formulae, the dimensions of Rectangular microstrip antenna are calculated as L= 35mm and W= 45mm.

Step 3: Ideal value of air gap height:

The ideal air gap height is,

$$\Delta = \lambda_0 - h\sqrt{\varepsilon_r} \quad (6)$$

III. ANTENNA CONFIGURATION

The basic coaxial feed microstrip antenna is shown in Fig.1. The total size of the antenna is L×W×H and the overall thickness (H) of the antenna is 3.45 mm. The U slot patch antenna intended to operate at different resonant frequencies having length (Lp) and width (Wp) is formed on the dielectric substrate above the ground plane. The Rogers Rt Duroid-5880 substrate with dielectric constant (ε_r) = 2.2 and thickness (h) is 3.45 mm is used for both patch and feed substrate.

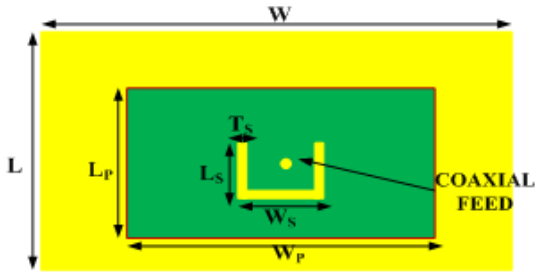


Fig. 1 Geometry of U slot microstrip patch antenna

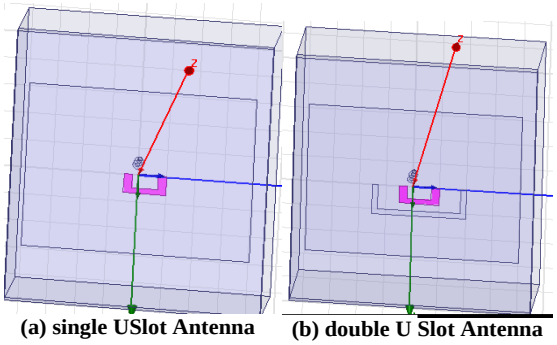
Table 1 Proposed parameters of single U-slot patch antenna

parameters	Unit (mm)
L	35
W	45
L_P	25
W_P	30
L_S	10
W_S	10
T_S	0.5

III. RESULTS AND DISCUSSION

The proposed antenna has been set up and experimentally studied with the help of Ansoft HFSS software. To design the single U slot and double U

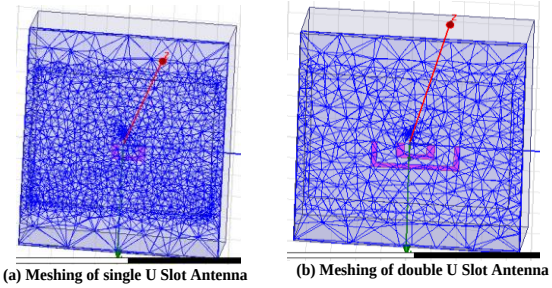
slot microstrip patch antenna the processing speed of the computational machine is 2.8 GHz with 2 GB RAM.



(a) single USlot Antenna (b) double U Slot Antenna

Fig. 2: Schematic diagram of single U Slot and double U slot antenna.

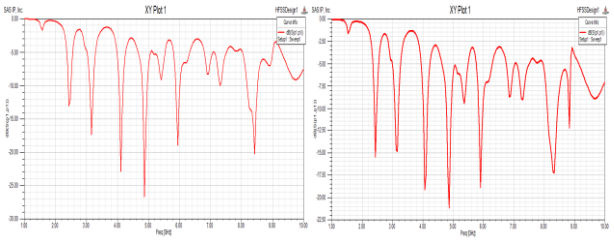
To obtain good results Tetrahedral meshing is preferred for simulating the model. The characteristic impedance (Z0) of the simulated design comes out to be 50Ω (approx) as shown in Figure.3. Theoretically, the value of Z0 is 50 Ω that shows small existence of standing waves while propagation of RF signals.



(a) Meshing of single U Slot Antenna (b) Meshing of double U Slot Antenna

Fig. 3: Meshing diagram of single U Slot and double U slot antenna.

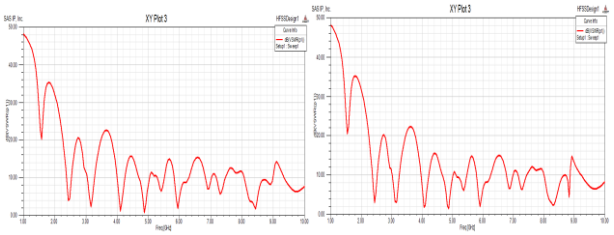
The proposed single U-slot microstrip patch antenna and double U-slot microstrip patch antenna shows significantly good gain and directivity values. The S-parameters and frequency plot measured -10dB return loss stacking, gain and directivity at different resonant frequencies as shown in Fig.4 (a) and (b). The Figure 4 shows the plot between return losses versus frequency. In fig 4(a) it can be seen that for single U slot antenna at six resonating frequencies and on the other hand double U slot antenna fig 4(b), the return loss at seven different resonating frequencies respectively and which useful for X and Ku band applications.



(a) Return loss of single U Slot Antenna (b) Return loss of double U-Slot antenna

Fig. 4: Return loss vs Frequency of single U Slot and double U slot antenna

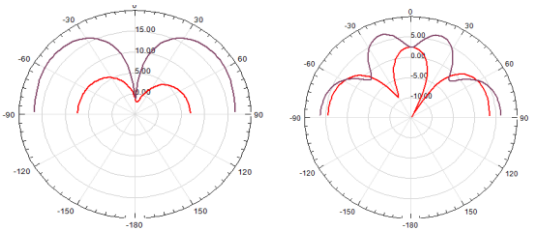
For single and double U slot antenna, VSWR versus frequency plot shows less than 2 dB for 4 to 10 GHz frequency and for 1-3 GHz it is more than 2 dB value respectively as shown in Fig. 5.



(a) VSWR of single Slot Antenna (b) VSWR of double U-Slot Antenna

Fig. 5: VSWR vs Frequency of single U Slot and double U slot antenna.

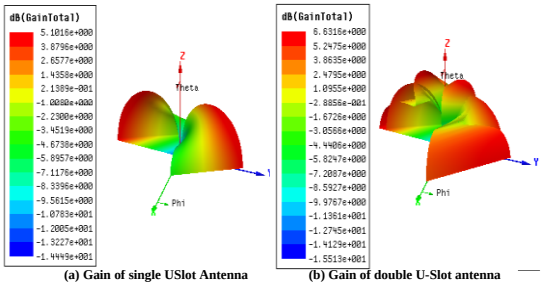
The radiation patterns of the proposed single slot and double U-slot antenna at different resonant frequencies are shown below in fig. 6 correspondingly, which shows that the single U slot antenna is bidirectional in nature and double U slot antenna is bidirectional in nature with improvement.



(a) Radiation Pattern of single U Slot (b) Radiation Pattern of double U-Slot

Fig. 6: Radiation pattern of single U Slot and double U slot antenna.

The 3 D polar plot of single U slot antenna and double U- slot antenna is shown in fig. 7 showing overall radiation characteristic. Maximum gain of 6.631 dB is observed for double U slot antenna and 5.106 dB is observed for single U slot antenna respectively.



(a) Gain of single USlot Antenna (b) Gain of double U-Slot antenna

Fig. 7: Gain of single U Slot and double U slot antenna.

IV. CONCLUDING REMARKS

In this paper a single and double U-slot patch antenna is used for providing wideband characteristics we have shown that cutting of single and double U-slots in the patch antenna, results in multi band applications. The single U slot antenna operates six different frequencies and whereas double U slot patch antenna operates at seven different frequencies and can be used for wireless and WLAN applications. Even though this paper presents simulation based results, it can be determined that U double U slot antenna is more capable as compared to the single slot antenna. The gain and directivity of Double U slot antenna is 6.6316 than that of single U slot antenna.

REFERENCES

[1]. M. Siva Ganga Prasad, P. Poorna priya, J. Lavanya, M. S. Rajeev Trivedi, K. Manideep, V. V. Vamsi siva Krishna. "Design of dual and triple band antennas using U-slots on stacked patches", International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.3, pp-824-829, May-June 2012.

[2]. Swaraj Panusa and Mithlesh Kumar. "Multi-Band U-Slot Microstrip Patch Antenna with Defective Ground Base", International Journal of Electronic and Electrical Engineering. ISSN 0974-2174 Vol.7, No.10, pp. 1127-1132 November 2014.

[3]. A.Gnandeep Reddy, K. Gopivasanth Kumar,T. Kartheek, G. Krishna Teja, G. Lakshman Chandra. " Design and Simulation of a L and U Shaped Slot Compact Planar Monopole Antenna", International Journal of Science, Engineering and Technology (IJSET) Vol 3, pp- 535-538 2012.

[4]. B.K Ang and B.K chung. "A wide band E-shaped Microstrip Patch Antenna for 5-6 GHz Wireless Communications", Progress in Electromagnetic Research, PIER.75 pp 397-407 ,December 2007.

[5]. M. Jamshidifar, J. Nourinia, Ch. Ghobadi, and F. Arazm, "Wideband Fractal Butterfly Patch Antenna", Iranian Journal of Electrical And Computer Engineering, Vol. 7, No. 2, p.p. 134-136, Summer-fall 2008.

[6]. Amit Kumar Gupta, R.K. Prasad, Dr. D.K. Srivastava. "Design and Development of Dual E-Shaped Microstrip Patch Antenna for Bandwidth and Gain Enhancement", International Journal of Electronics and Communication Engineering and Technology (IJECET), Vol.3, Issue 3, pp 34-42 October-December 2012.

[7]. Amit A. Deshmukh and K. P. Ray. "Analysis of Broadband Variation of U-Slot Cut Rectangular Microstrip Antennas", IEEE Antennas and Propagation Magazine, Vol. 57, No. 2, April 2015.

[8]. T. Huynh and K. F. Lee, "Single-layer Single-Patch Wideband Microstrip Antennas", Electron. Lett. Vol. 31, No. 16, pp. 1310–1312, August. 1995.

[9]. Ahmed Khidre, Kai-Fong Lee, Atef Z.Elsherbeni,and Fan Yang. "Wide Band Dual-Beam U-Slot Microstrip Antennas", IEEE Transaction on Antennas and Propagation, Vol.61 No.3, March 2013.

[10]. S.Murugan, E.Sathish kumar,and V. Rajamani, "Design And Analysis Of Double U Slot Loaded Dual Frequency Microstrip Antenna", Progress in Electromagnetics Research C, Vol.45,101-112, 21013.

[11]. P.Vetriselvi, Sathiyamoorthy Murugan., Dr.V.Rajamani. "Design of Wideband U-Slot Microstrip Antennas", International Journal of Innovative Research in Science Engineering and Technology (IJIRSET), Vol. 3, No. 3, March 21014.

[12]. Garima, Amanpreet Kaur, Rajesh Khanna. "Dual and Triple Band U-Slot Microstrip Patch Antennas for WLAN Applications",

International Journal of Advanced Research in Computer and Communication EngineeringVol. 2, Issue 5, May 2013.

[13]. Mahdi Moosazadeh and Sergey Kharkovsky. "Compact and Small Planar Monopole Antenna with Symmetrical L and U Shaped Slots for WLAN/WiMAX Applications", IEEE Antennas and Wireless Propagation Letters, Vol.13, 2014.

[14]. M.Ravi kishore, A.Janardhana. "Design & Performance Analysis of Double U-Slot Microstrip Antenna for WiMAX Application", International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 3, Issue 8, August 2014.

[15]. Swaraj Panusa and Mithlesh Kumar. "Multi-Band U-Slot Microstrip Patch Antenna with Defective Ground Base", International Journal of Electronic and Electrical Engineering Vol.7, No. 10, pp. 1127-1132 December 2014.

[16]. Kirankumar R. Urgunde. "A Double U-Slots Microstrip Antenna for Triple-bands Operation", International Journal of Computer Applications Vol.126, No.3, September 2015.

[17]. Khodaei, G. F., J. Nourinia, and C. Ghobadi. "A practical Miniaturized U-slot patch antenna with enhanced bandwidth", Progress in Electromagnetics Research B, Vol. 3, 47-62, 2008.

[18]. Yang, S.-L. S., A. A. Kishk, and K.-F. Lee. "Frequency Reconfigurable U-slot Microstrip Patch Antenna, IEEE Antennas and Wireless Propagation Letters, Vol. 7, 127-129, 2008.

[19]. P.Driessen."Gigabit/s indoor wireless systems with directional antennas", IEEE Transactions on Communications, Vol.44, No.8, pp. 1034–1043, Aug.1996.

[20]. Aaron K. Shackelford, kai- fong Lee, and K.M Luk. "Design of small size wide bandwidth micro strip patch antenna", Department of Electrical Engineering, IEEE Antennas and Propagation Magazine, Vol.45, No.1, February 2003.

[21]. Kuo-Hui Li. "Multibeam Antennas for Indoor Wireless Communications", IEEE Transaction on Communications, Vol.50, No.2, February 2002.

[22]. C. A. Balanis. "Antenna Theory analysis and Design", 2nd ed.Hoboken, NJ, USA: Wiley-Interscience, pp.814, 2005.