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A Hexagonal Shape Microstrip Patch Antenna for Wideband and Multiband Applications.

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Abstract- Here in this paper a compact microstrip antenna having wide-slots of hexagon shape is fed by microstrip-line for wideband and multi band operations is proposed and studied. The proposed antenna resonates the 10-dB bandwidth from 0 to 6.0 GHz, and these frequency bands cover the standard IEEE 802.11b/g (2.4-2.485 GHz) and IEEE 802.11a (5.15-5.35 GHz) for WLAN applications and 2.5 GHz (2.5-2.69 GHz), 3.5 GHz (3.3-3.8 GHz) and 5 GHz (5.25-5.85 GHz) for Wi -MAX applications. Detailed design and experimental results are shown and discussed in this paper. The antenna is simulated using IE3D electromagnetic simulator. Here in this paper the improvement in multiband and wide band behavior is investigated & discussed with VSWR<2.

Index Terms- IE3D, Microstrip line, Microstrip Patch Antenna (MSA), Multiband, Resonant Frequency.

I. INTRODUCTION

Microstrip patch antennas are low profile, conformable to planar and non planar surfaces, simple and less expensive in manufacturing using modern printed circuit technology. The main objective in the wireless communication system is the design of wideband or even multiband low profile and small antenna. One such antenna that meets these requirements is the patch Antenna [1]. There are numerous techniques such as shorting pins, introducing slots and fractal geometries that reduce the size of the patch antenna. Micro strip patch antennas (MSAs) have the advantages of being able to produce bidirectional and unidirectional radiation patterns with larger bandwidth and very low cross polarization (typically -35dB) as compared to microstrip patch antenna [2]. In, Microstrip patch antenna, the strip and slot combination offer an additional degree of freedom in the design of microstrip antennas. A microstrip patch antenna comprises a slot cut in the ground plane of the micro strip line such that the slot is perpendicular to the strip conductor of the microstrip line .The field of the microstrip line excite the slot. For efficient excitation of the slot the strip conductor is either short circuited through the dielectric substrate to the edge of the slot, as shown in figure (a) or the strip conductor is terminated in an open circuited stub beyond the edge of the slot, as shown in figure (b) [3].

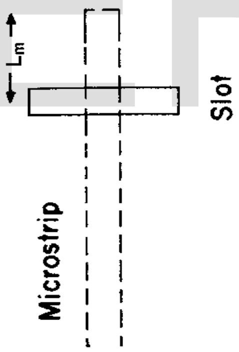

Figure 1 (b).

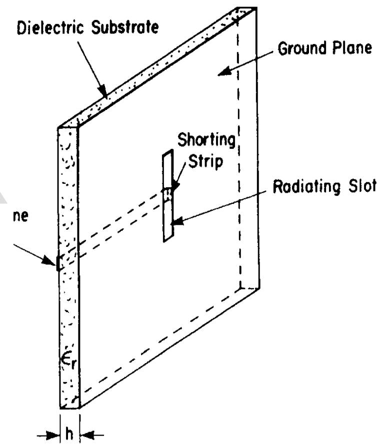

Figure 1 (a)

Centre- fed micro strip patch antenna configurations: (a) Micro strip terminated in a short circuited- stub **(b)** Micro strip terminated in an open circuited- stub

The regular MSA configurations, such as rectangular and circular patches can be modified to rectangular and circular ring, respectively, to enhance the BW. The larger BW is because of a reduction in the quality factor *Q* of the patch resonator, which is due to less energy stored

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beneath the patch and higher radiation. When a U-shaped slot is cut inside the rectangular patch, it gives a BW of approximately 40% for VSWR <2. Similar results are obtained when a U-slot is cut inside a circular or a triangular MSA [4]. But as the Antenna size reduces, its parameters such as gain, efficiency and polarization deteriorates. This occurs due to the impedance mismatching that occurs between the source and the antenna. Microstrip slot antennas have numerous promising features but they suffer from undesired modes such as the parallel plate mode excited between the ground planes of the strip line. One additional drawback is it's inherently bidirectional radiation which can be corrected by using a metallic cavity or a metallic reflector on one side. This antenna works on various frequencies between 0 GHz to 6 GHz, which includes the applications in WLAN, Satellite mobile communication & Wi-Max [5]-[6].

II. ANTENNA DESIGN

The proposed antenna is simulated and designed on the Glass-Epoxy/FR4 substrate. The relative dielectric constant of the FR4 is 4.4 and loss tangent is 0.02, although the loss tangent of the FR4 is high but it is less expensive and easily available. The dimension of the rectangular patch is calculated at the resonance frequency at 2.4 GHz. The length of the patch is 28mm and the width is 38mm. The dimensions of the patch are calculated according the given formula as shown below.

$$W = \frac{c}{2f_0}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

$$\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2}\left(1 + \frac{12h}{w}\right)^{-(1/2)} \qquad (2)$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \qquad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \qquad (4)$$

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

c = Velocity of light in free space
f_0=Operating resonant frequency
ε_r = Relative dielectric constant
ε_{reff} =Effective dielectric constant of the substrate
h= Height of the substrate
w = Width of the substrate

The three structure of the patch antenna is designed. One is simple rectangular patch of given dimension, another one with a rectangular patch with a single hexagonal slot ,the dimension of the hexagon is 10mm and the third structure is rectangular patch with five hexagon slots, in which one hexagon has the same dimensions as in second structure and another four hexagons have dimensions of 10/3mm each. These four slots are symmetrically located at the coordinates at (9, 12), (9,-12), (-9, 12) and (-9,-12).The feeding techniques use in all the structures is the microstrip line feeding .The microstrip line has the dimensions of 3x10mm.In all the structures the microstrip line is at the same distance from the radiating edge of the patch antenna[7]. Structures of the proposed work are shown below.

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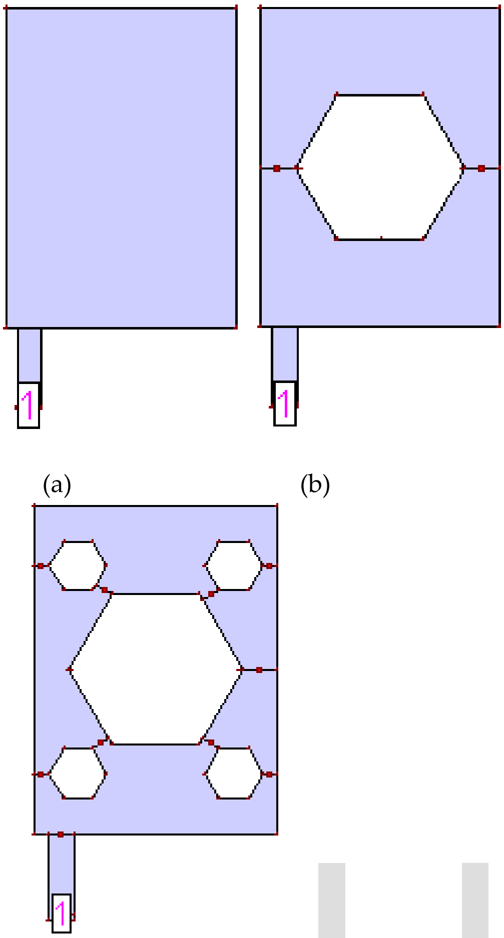

(a) (b)

(c)

Fig 2: Antenna Design (a) zero slot (b) single slot (c) five slots

The third design of antenna is fabricated and tested the simulated results related to this design. The photo of fabricated antenna is shown below.

Fig 3: Microstrip path antenna having with hexagon slot

With all these designs the resulted resonance frequencies are as listed below.

TABLE 1: Antenna designs and observed resonance frequencies

Antenna Designs	Resonance Frequencies
a	2.4,3.7 & (5.3-5.6) GHz
b	3.8 ,4.5 & (5.3-5.8) GHz
c	2.04,3.5 & (4.9-5.47) GHz

III. SIMULATION RESULTS & DISCUSSION

The proposed antenna is simulated over Integral Equation in 3 Dimension (IE3D) software as simulation tool. Characteristics of a hexagonal shape Microstrip patch antenna for wideband and multiband applications have been analyzed in term of various parameters like return loss, Total Field Gain, Directivity, Radiation pattern & VSWR etc. Multiband behavior is achieved at frequency of 2.4GHz, second band is at 3.7 GHz and third band is obtained at 5.3 GHz frequency for Microstrip antenna designed for 2.4 GHz with no slots[8]-[9]. Following are the various results obtained for the above mentioned design

[A] Return Loss curve:

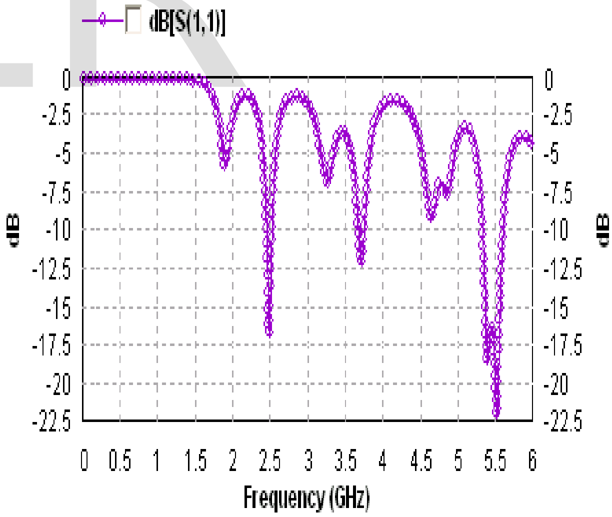

Figure (4) (i) Return loss for antenna 'a'

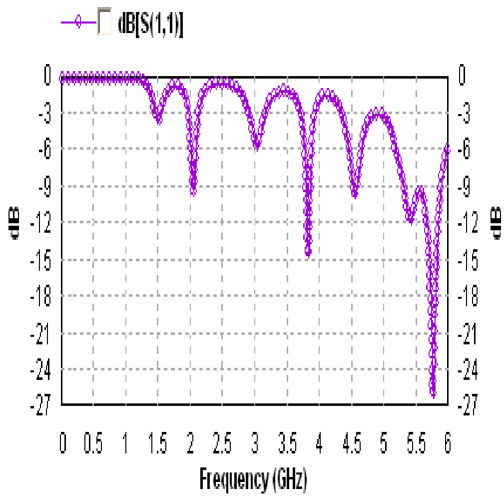

Figure (4) (ii) Return loss for antenna 'b'

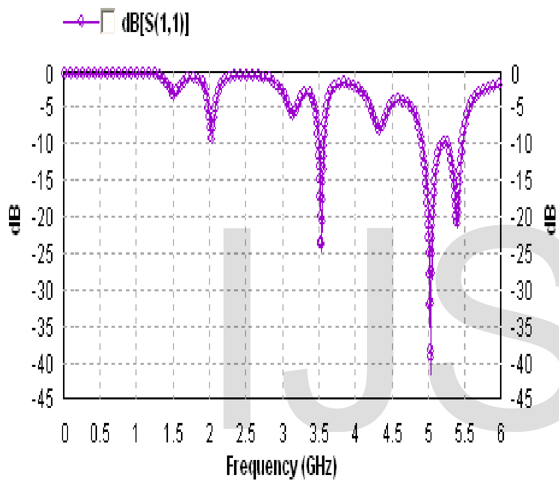

Figure (4) (iii) Return loss for antenna 'c'

[b] Comparison between simulated and measured result for antenna having five slots

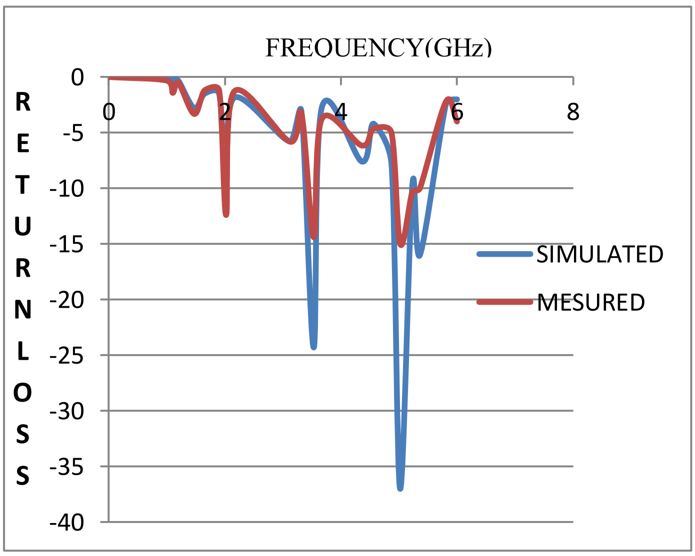

Figure (5)

[c] <u>Total Field gain vs. Frequency curve</u>

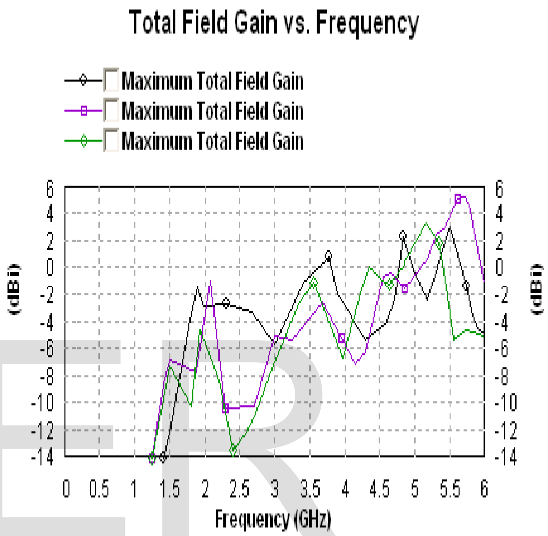

Figure (6) **(Total Field Gain vs. Frequency For zero, single and five slots)**

Black curve ---- zero slot **Violet curve** --- single slot

Green curve --- Five slots

[d] <u>Total Field Directivity vs. Frequency curve:</u>

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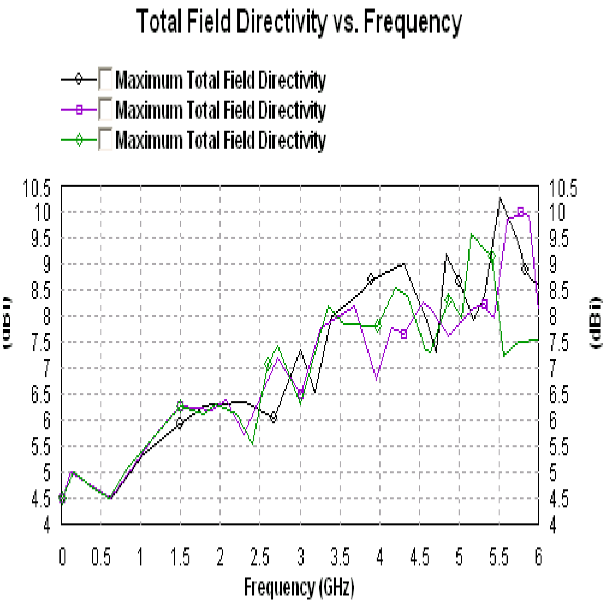

Figure (7)
(Total Field Directivity Vs Frequency For 0, 1 & 5 hexagonal slots)

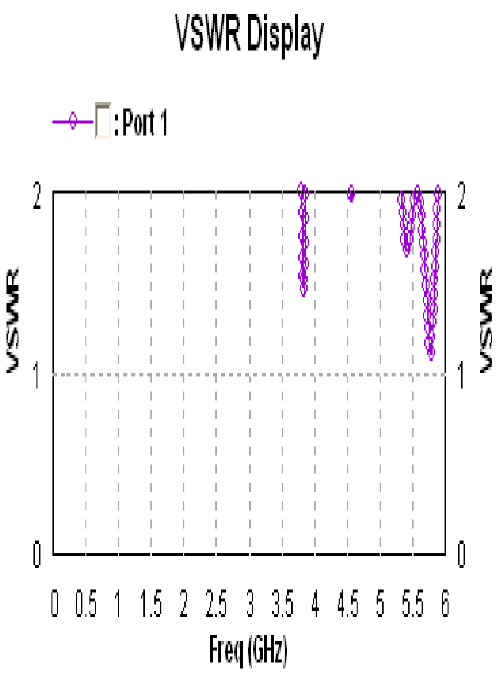

Figure (8) **(ii) VSWR for antenna 'b'**

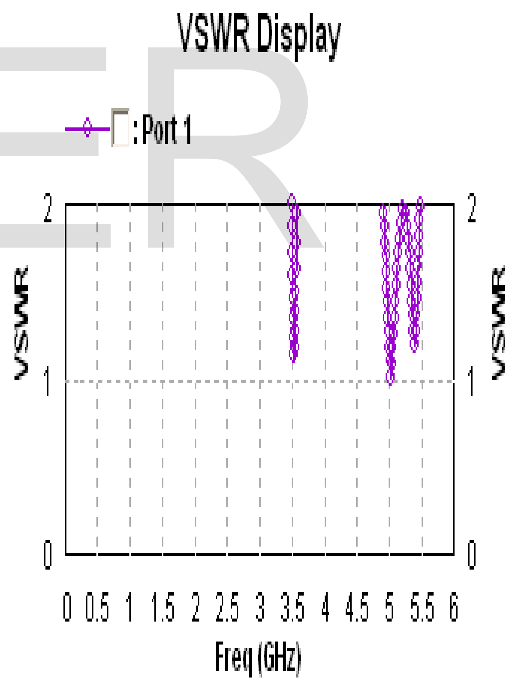

Figure (8) **(iii) VSWR for antenna 'c'**

[e] <u>VSWR curve:</u>

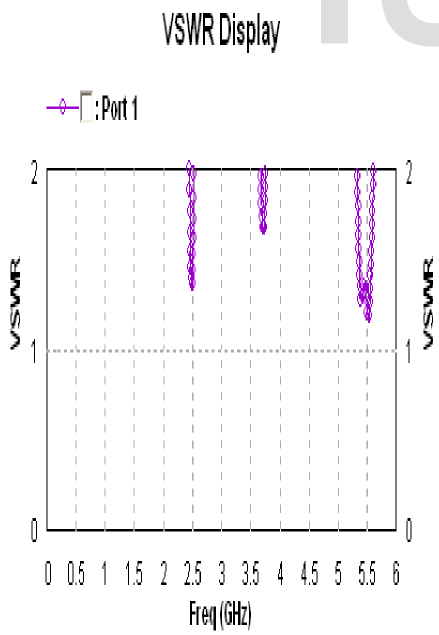

Figure (8) **(i) VSWR for antenna 'a'**

[f] <u>Radiation Pattern Curve:</u>

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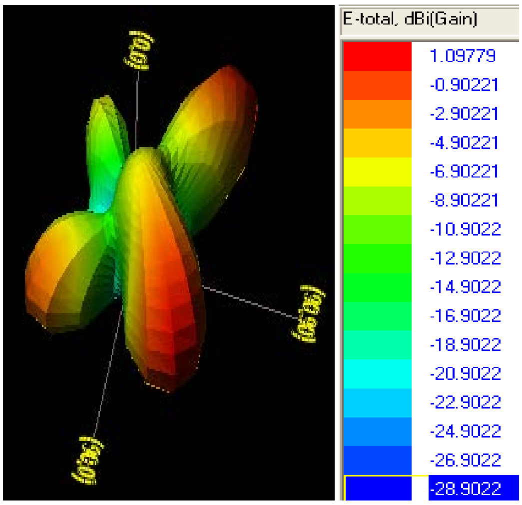

(3D Radiation pattern for zero slots at 5.39 GHz)

Figure (9) (i)

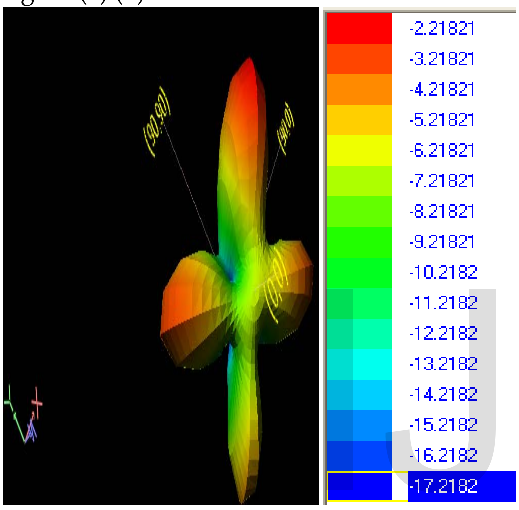

Figure (9) (ii)

(3D Radiation pattern for single slot at 4.26 GHz)

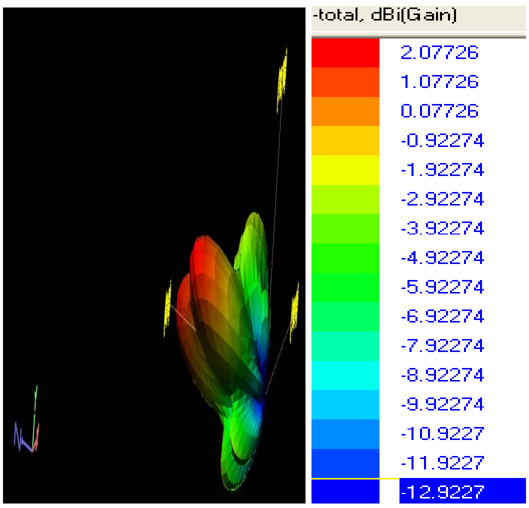

Figure (9) (iii)

(3D Radiation pattern for iteration 2 at 5.32 GHz)

VI. CONCLUSION

In this work three structure of rectangular patch antenna is studied. Three structure of patch antenna with zero slot, single hexagon slot and five hexagon slots are simulated and the geometry with five slots is fabricated. As the number of slots increased, the bandwidth is increased [10]-[11]-[12]. These antennas are used in IEEE 802.11 a, b, g, and Wi-Max applications [13]. In addition, the proposed antennas also have simplicity in structure, compact size and good radiation performances [14]-[15].

REFERENCES

[1] Constantine A. Balanis, "Antenna Theory-Analysis and Design", John Villey & Son, INC, Third Edition 1995.

[2] Axelrod A.M Kisliuk, and JMaoz, "Broadband Microstrip-Fed Slot Radiator", Microwave Journal, June 1989, pp.81-94.

[3]Bahl, I., P.Bhartia, and R. Garg, *Microstrip Antenna Design Handbook*, Artech House, 2001.

[4] Girish Kumar, K.P Ray, "Broadband Microstrip Antennas", Artech House, London. Edition 2003.

[5]Wi-MAXForum, http://www.wimaxforum.org/home/, last visited on May 10, 2014.

[6] Ritosa P. , T. Korosec, J. Tratnik, L. Naglic, and B. Batagelj,Adaptive Wi-MAX subscriber antenna for 2.6 GHz and 3.45 GHz," *EUROCON 2009*, 46-51, St. Petersburg, Russia,May 2009.

[7] Ray, K. P., D. M. Suple and N. Kant, "Perturbed Hexagonal Microstrip Antenna for Circular Polarization," *IEEE*, 978-1-4244-4819-7/09, 2009.

[8] Ghaderi, M.R., Mohajeri, F., "A Compact Hexagonal Wide-Slot Antenna with Microstrip-Fed Monopole for UWB Application", Antennas and Wireless Propagation Letters, IEEE, Volume 10, June 2011, pp 682 – 685.

[9] H. Sabri and Z. Atlasbaf, "Two Novel Compact Triple-Band Microstrip Annular-Ring Slot Antenna For PCS-1900and WLAN Applications", *Progress In Electromagnetics Research Letters, Vol. 5, 87–98, and 2008.*

[10] Werner, D. H. and R. Mittra, *Frontiers in Electromagnetics*, IEEE Press, New York, 2000.

[11] K. Nithisopa1, J. Nakasuwan1, N. Songthanapitak, N. Anantrasirichai, and T. Wakabayashi, "Design CPW Fed Slot Antenna for Wideband Applications" PIERS ONLINE, VOL. 3, NO. 7, 2007, pp 1124-1127.

ISSN 2229-5518
[12] Y.Sung,"Bandwidth Enhancement of a Microstrip Line-Fed Printed Wide –Slot Antenna with a Parasitic Centre Patch",IEEE Transactions on Antennas & Propagation,Vol. 60,No. 4,April 2012,pp 1712-1716.

[13] W.S.Chen,B.Y Lee,P.Y Chang, "A compact microstrip- line- fed slot antenna with dual band notched for Wi-Max operation," *PIER*, Vol. 16, 13-23, 2010.

[14] Mohammad A. Dorostkar, Mohammad T. Islam, and Rezaul Azim, "design of a novel super wideband circular hexagonal fractal antenna" *Progress In Electromagnetics Research, Vol. 139, 229-245, 2013*

[15] C.J. Wang, S.W. Chang, "Studies on Dual-Band Multi-Slot Antennas", *Progress in Electromagnetics Research, PIER 83, 293–306, 2008*