PART II: NOVEL PLANAR MONOPOLE ANTENNA for UWB APPLICATIONS

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ABSTRACT

Miniaturization and compact Novel printed planar monopole antenna CPW feed line three half semi-elliptical (3hse) with similar ground plane is presented, design, simulation, fabrication and tasted experimentally for Ultra-Wideband (UWB) communication application especially for WLAN and HIPERLAN/2 WLAN. Generating original planar antenna has been investigated to be an effect the combine geometry shapes of the radiation element part with the same geometry shapes of the slots in the ground plane. The prototype antenna is etched on a Roger TMM4 substrate with the size (25x25x1.575)mm^3 and optimized to operate over frequency band from (3.6-20)GHz, (BW 16.5GHz), (FBW is >140.42%). The simulation and measuring results have a good agreement, large bandwidth and radiation pattern behavior an omni-directional with stable gain rich to 5 dB.

1- INTRODUCTION

Ultra wideband antennas are outdated and recent, the outdated antennas have roots in the original "Spark-gap" invented by Marconi in 1895 [1-2], but the recent antennas were beginning when Federal communication commission (FCC) in USA when allocated using the spectrum band width 3.1GHz to 10.6GHz for commercial purpose in February 2002 [3]. From this time UWB attractive the academia and industries to attention it due to merits of low profile, light weight, high secured data rate transmission can be transmitted in short rang local network and short-duration pulses and simple configuration [4-5]. Coplanar wave guide (CPW) feed printed monopole antenna is one of the among various forms of printed antenna which has simple structure and easy to fabricated and integrated with printed circuit board[6-7]. The traditional CPW feed line such as rectangular, square, circular, elliptical, triangle and pentagon have been introducing to enhance the impedance bandwidth over the spectrum 3.1GHz to 10.6GHz [8-14]. In general two parameters affect planar slot antennas impedance bandwidth, the slot width and feed structure [15]. Recently, a variety of techniques have been proposed in order to improve the slot antenna bandwidth. These techniques suggest various geometrical configurations of planar ultra-wideband slot antenna with different technology [16]. Ultra wide-Band (UWB) technology is one of the most promising solutions for future communication systems due to its high-speed data rate and excellent immunity to multipath interference [17], therefore the antenna is an important component which determines the performance of UWB system; moreover one of principle subjects in UWB is to design a compact antenna [18].

There are many methods to achieve the miniaturization feature, one of these methods is achieved by cutting the symmetrical plane along the axis for shapes which have symmetrical structure [19-20].Another method can be used to miniaturization the antenna by antipodal structure, these done by two step. First, the antenna's configuration is modified to enable direct connection with a microstrip feeder. Second, corrugated structures are utilized in the radiator and ground plane [21]. In this paper Miniaturization and compact printed monopole antenna CPW feed line three half semi-elliptical with similar ground plane is presented for Ultra-Wideband (UWB) communication application, these achieved by adjusting the ratio between the radius length of the slots in the ground plane and radius length of the radiation element more detail in next section

2- ANTENNA DESIGN

Figure 1 illustrated the steps to generating the original proposed antenna; step 3 represents the final antenna for the next coming steps. The original antenna is present which has the dimension (32x32x1.575) mm^3. Figure 2 represent the antenna reflection coefficient (S11) curves for three steps. We can note from Figure 2 step 2 can be fabricated to avoid the exist interference with another band such as wireless local area network (WLAN) IEEE 802.11a and HIPERLAN/2 WLAN operating in 5.15-5.35GHz and 5.725-5.825GHz bands in USA and 5.15-5.35GHz and 5.47-5.725GHz bands in Europe.

However these antennas can be considered large in size for the commercial purpose such as the fourth generation (4G) personal wireless communication systems (PWCS). Therefore, antenna miniaturization is a necessary task in a achieving optimal design for future wireless system. Such antennas need to efficient and able to operate over the frequency band specified by each application [22].

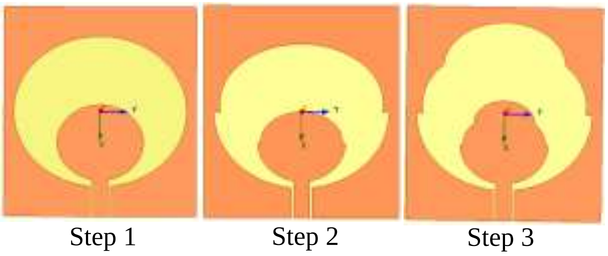


Fig 1: Generating the proposed monopole planar antenna CPW feed line three half semi-elliptical

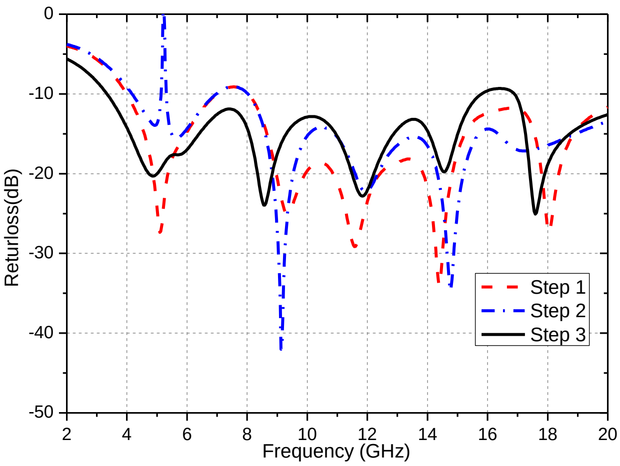


Fig.2: simulated reflection coefficient curve (S_{11}) for 3 designs by using Ansoft HFFS

There are many methods to achieve the miniaturization feature, one of these methods is achieved by using optimal antenna topology[22], therefor miniaturization planar antenna from the original antenna has been presented in this paper by adjusting the ratio between the radius length of the slots in the ground plane and the radius of the radiation element i.e. the ratio between the first half semi-elliptical slot in the ground plane which has radius R_1 with the first half semi- elliptical in radiation element which has radius R_4 and the second half semi- elliptical slot in the ground plane which has radius R_2 with the second half semi- elliptical in radiation element which has radius R_5, and the third half semi- elliptical slot in the ground plane which has radius R_3 with the third half semi- elliptical in radiation element which has radius R_6, the consistent ratio is $R_1/R_4= R_2/R_5= R_3/R_6=2$ for CPW feed line (horizontal position) and equal (1.92) for CPW line feed(vertical position) , which reduce the size of antenna 38.96% from the original antenna for (horizontal position) and 42.57% for (vertical position) .

After miniaturization the two prototype antennas are built and attached on Rogers TMM4 relative permittivity of $\varepsilon_r = 4.5$ and loss tangent $tan\delta = 0.002$ with the size (25x25x1.575) mm^3 for planar monopole antenna CPW feed line 3hse (horizontal position) and (21x28x1.575) mm^3 for planar monopole antenna CPW feed line 3hse (vertical position), both antennas excitation by 50Ω.

The final shapes of two proposed antennas as shown in figure 3 and 4, final Parameters and dimensions of two proposed miniaturized CPW feed line three-half semi-elliptical monopole antenna are tabled in 1 and 2. In table 1 and 2 (C) represent the center position of half semi- elliptical to another half semi- elliptical where the position C_1 is kept fixed, and (N) represent the ratio between the major axis radius and the minor axis radius for ellipse, in this work when N>1 the major axis is positioner on y-axis (horizontal position), while N<1 the major axis is positioner on x-axis (vertical position) (all dimension in mm).

Table 1: Parameter and dimension of the proposed planar monopole antenna CPW feed line 3hse (horizontal position).

W	25	C_1	0	R_1	9	C_4	4.2	R_4	4.5
L	25	C_2	-1	R_2	7	C_5	4	R_5	3.5
W_f	2	C_3	-5.5	R_3	5	C_6	1.6	R_6	2.5
N_1	1.25	N_2	1.5	N_3	1.5	N_4	1.25	N_5	1.5
W_g	0.25	S	1	d	0.5			N_6	1.5

Table 2: Parameter and dimension of the proposed planar monopole antenna CPW feed line 3hse (vertical position).

W	28	C_1	0	R_1	11	C_4	5.1	R_4	5.7
L	21	C_2	0	R_2	10	C_5	5.5	R_5	5.2
W_f	2	C_3	-5	R_3	7	C_6	2.6	R_6	3.6
N_1	0.85	N_2	0.85	N_3	0.85	N_4	0.85	N_5	0.85
W_g	0.25	S	1	d	0.5	N_6	0.85		

(a)

(b)

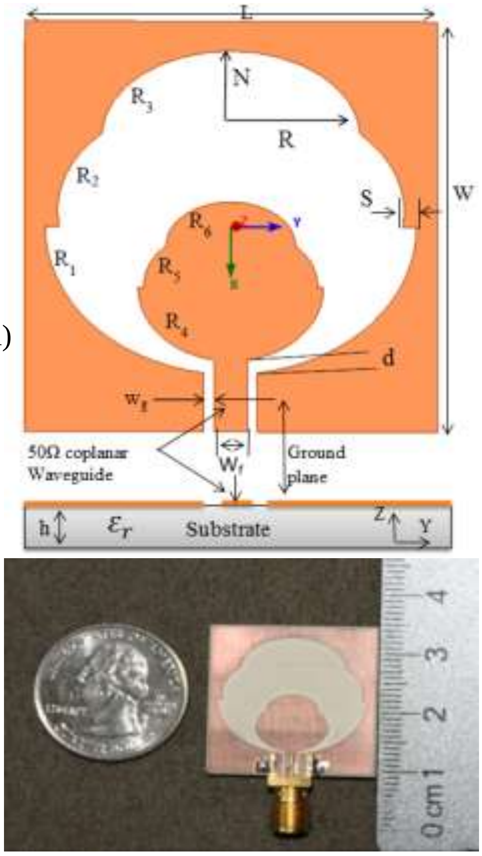
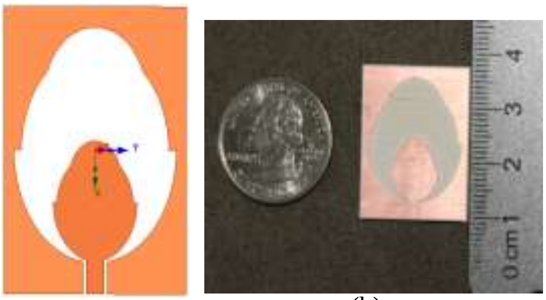


Fig. 3: (a) Geometry and (b) Photograph of the proposed planar monopole antenna CPW feed line three-half semi-elliptical (horizontal position) (25x25) mm^2



(a) (b)

Fig. 4: (a) Geometry and (b) Photograph of the proposed planar monopole antenna CPW feed line three-half semi-elliptical (vertical position) (21x28) mm^2

3-PARAMETRIC STUDY

The antenna performance is mainly affected by geometrical and electrical parameters, such as the dimensions related to the slot in the ground plane and the dimension related to the radiating patch, during the parametric study, one parameter varies while all parameters are kept fixed.

3.1 The distance (d)

The distance d is the width of the feed gap which represents the distance from the start of the radiating element to the end of slot in the ground plane which is the critical parameter which affected on the performance of antenna, Figure 5 illustrates the simulated return loss for different feed gaps (d=0.1mm, 0.3mm, 0.5mm, 0.7mm, 1mm, and 1.5mm).

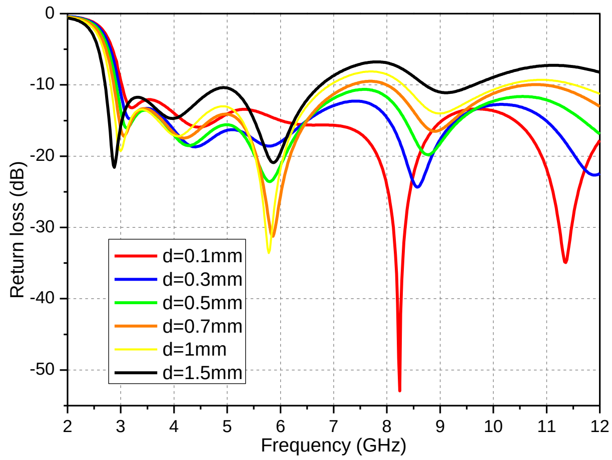


Fig.5 Simulated return loss (S_{11}) curves planar monopole antenna CPW feed line three-half semi-elliptical

It is shown in Figure 5 that the -10 dB operating bandwidth of the antenna varies remarkably with the variation of the feed gap d. It is found that good impedance matching can be obtained by enhancing the coupling between the slot and feed. The optimal feed gap is found to be between 0.3-0.7mm with the bandwidth covering an extremely wide frequency range and satisfying the spectrum of UWB from 3.1-10.6 GHZ.

3.2 Effect of the Step S (Path Length)

Another parameter which is directly effective on the bandwidth is the step S, which is related by the radius of R_2, we know that the charges are concentrated on the sharp-ended and take more time to move on the plane surfaces. Figure 6 illustrates the simulated return loss for the different radius of R_2 which makes the step S, when the path length increases or decreases from the appropriate distance, the middle and higher frequencies are greatly affected and they exhibit mismatch. Consequently, the appropriate path length is R_2=7mm to 6.5mm, i.e. when path length increasing from S=0.86mm to 1.6mm it achieves the desirable impedance matching which means the coupling between all the path length of the currents on the edge of the slot of the ground plane and all the path of the currents on the radiating element, provides a well-match traveling mode and smooth impedance transition between the feed and the radiating element. The consistent ratio between S_1 in the ground plane and S_2 in the radiated element is S_1/S_2=2.2

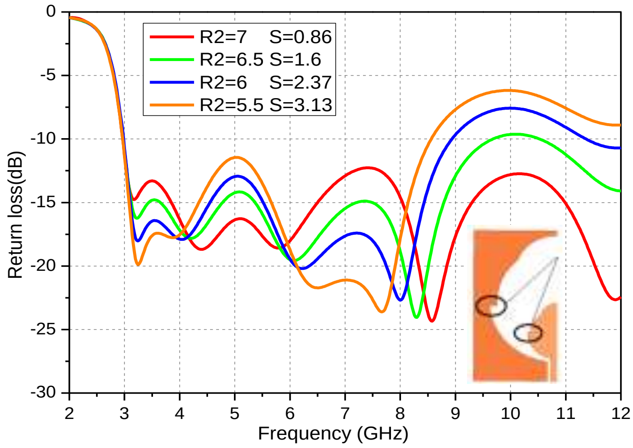


Fig. 6 Simulated return loss curves (S_{11}) for different Step S (path length) (all dimension in mm)

3-3 Effect of the Position C2

The slot of the ground plane is attached by three half semi-elliptical, the position C represents the position half semi-elliptical to another half semi- elliptical and the parameter of the position C_1 is kept fixed at position (C_1=-1 mm).The position C_2 represents the position of the edge of the slot of the second half semi-elliptical to the position of the first and third half semi-elliptical slot. Figure 7 illustrated the simulated -10dB bandwidth for different C_2, the lower edges frequency of the bandwidth is the same in the first, second and third resonance in all positions, but at the higher frequencies are shifted this is simply because the surface current will take longer path when C_2 increases, by choosing the optimum certain value of the position the impedance matching of the bandwidth occurs because the coupling between the surface currents on the edge of the ground plane with the surface currents on the radiator element and exhibits an UWB impedance bandwidth (3.1-10.6 GHz).

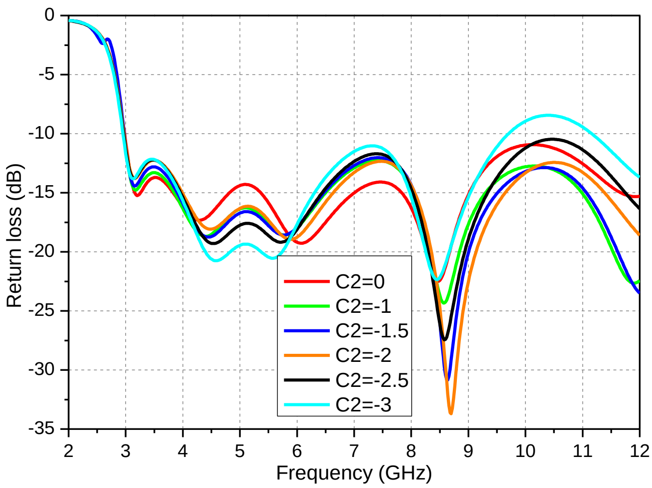


Fig. 7 Simulated -10dB curves for different position C_2 (all dimension in mm)

RESULT AND DISCUSSION

3.1 Return loss

The design, fabricated and experimental test in the Laboratories of Department of Systems Engineering in College of Engineering and information Technology at University of Arkansas At Little Rock (UALR) in USA.

To enhancement the work on the proposed antenna two software are used, (HFSS) ver.15 and (CST MWS) 2013. The S-parameters and radiation pattern were measured using an Agilent PNA-X series N5242A Vector Network Analyzer (VNA) with (10 MHz-26.5 GHz) frequency range.

Experimentally the miniaturized two antennas (3hse CPW feed line (horizontal position)) exhibits wide impedance bandwidth from 3.6-20GHz (B.W 16.5 GH) (FBW is > 140.42%) and for 3hse CPW feed line (vertical position)) from 2.36-12 GHz (B.W 9.64) (FBW is > 134.26%).

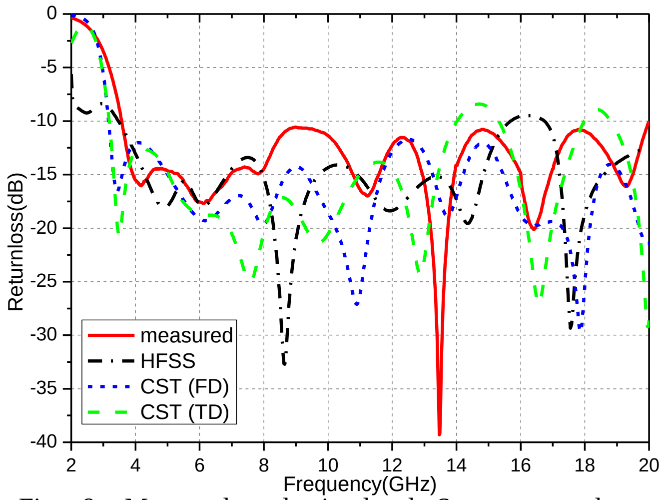


Fig. 8: Measured and simulated S_{11} curves planar monopole antenna CPW feed line three-half semi-elliptical (horizontal position) 25x25mm^2.

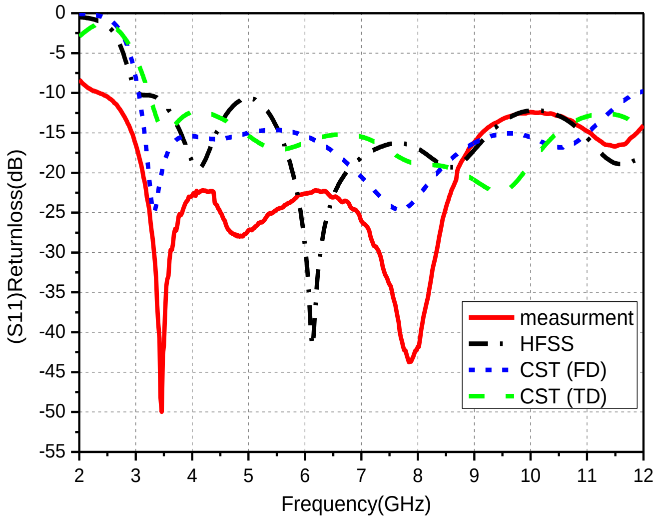


Figure 9: Measured and simulated S_{11} curves planar monopole antenna CPW feed line three-half semi-elliptical (horizontal position) 25x25mm^2.

Figure 8 and 9 illustrate measured and simulated S_{11} curves planar monopole antenna CPW feed line three-half semi-elliptical (horizontal and vertical position).

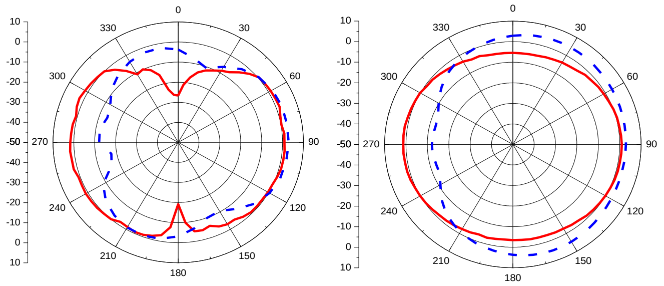
Table 3: Measured and Simulated -10dB bandwidth of two antennas

	CPW feed line 3hse (original antennas) 32*32	CPW feed line 3hse (horizontal position) 25*25	Microstrip feed line 3hse (vertical position) 21*28
Measured (GHz)	----	3.5-20 16.5	2.36-12 9.64
Bandwidth	----	140.42%	134.26%
Simulated (GHz)	3.1-20 16.9	3.3-20 14.54	3-12 9
Bandwidth	146.32%	136.73%	120%

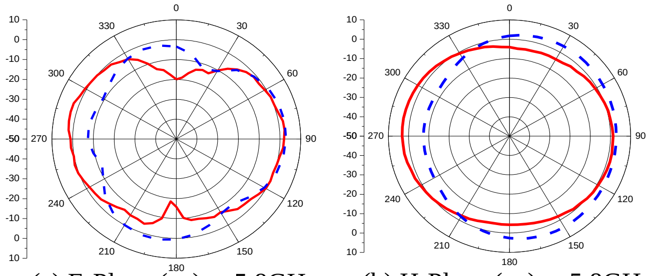
4-2 Radiation Pattern and application

The radiation pattern and gain were measured by using substitution method with an antenna of known gain. The Antenna Under Test (AUT) (known gain) was placed is the higher-frequency ETS -Lindgren Model 3126 Sleeve Dipole antennas include a radome. The radome provides improved dielectric properties for superior high frequency performance, the first dipole (AUT) is 5.2 GHz in the range and the other is 5.8 GHz, this dipole positioner and aligned to a horizontally polarized horn antenna (receiver).The positioner and aligned with horn is adjusted by laser device.

For WLAN applications that covers the frequency band of the IEEE 802.11a (5.15-5.35) GHz and (5.725-5.825) GHz and HIPERLAN/2 WLAN are present, experimentally the antennas CPW/Microstrip line feed exhibit good radiation pattern behavior in both E-plane and H-plane an omni-directional with stable gain reach to 5dB. Table 4 illustrated measured and simulated gain for two prototype antennas.

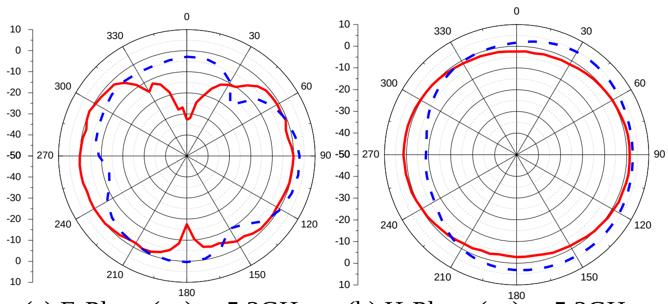


(a) E-Plane (yz) at 5.2GHz (b) H-Plane (xz) at 5.2GHz

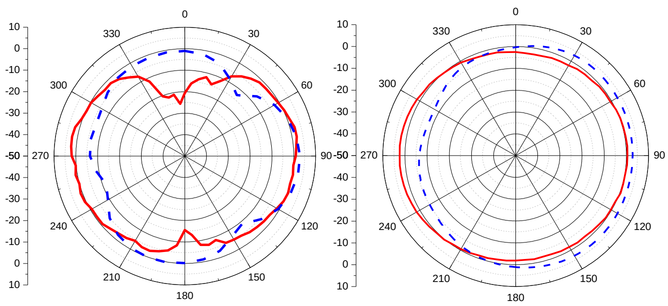


(a) E-Plane (yz) at 5.8GHz (b) H-Plane (xz) at 5.8GHz

Fig. 10: Measured (red line) and simulated (blue line) radiation pattern of the planar monopole antenna of CPW line feed 3-half semi-elliptical (horizontal position) at 5.2 GHz and 5.8GHz.



(a) E-Plane (yz) at 5.2GHz (b) H-Plane (xz) at 5.2GHz



(c) E-Plane (yz) at 5.8GHz (d) H-Plane (xz) at 5.8GHz

Fig. 11: Measured (red line) and simulated (blue line) radiation pattern of the planar monopole antenna of CPW feed line 3-half semi-elliptical (vertical position) at 5.2 GHz and 5.8GHz.

. Table4: Measured and simulated gain for two prototype antennas.

	CPW feed Line 3hse (original antennas) 32*32		CPW feed Line 3hse (horizontal position) 25*25		CPW feed Line 3hse (vertical position) 21*28	
At 5.2GHz	E-plane	H-plane	E-plane	H-plane	E-plan e	H-plane
Measured (dB)	--	--	5	2	5	0.5
Simulated (dB)	5	4	5.2	1.12	3.02	0.43
At 5.8GHz	E-plane	H-plane	E-plane	H-plane	E-plan e	H-plane
Measured (dB)	5	3	5	4	5	3
Simulated (dB)	--	--	2.73	2.71	3.17	1.26

CONCLUSION

Miniaturization and compact printed monopole antenna CPW feed line three half semi-elliptical with similar ground plane is presented for Ultra-Wideband (UWB) communication application, these achieved by adjusting the ratio between the radius length of the slots in the ground plane and radius length of the radiation element more detail in next section. Good agreement with maintain reasonable radiation characteristic and able to operate across a very large impedance bandwidth, omni-directional radiation pattern in E-plane and H-plane, constant gain can be achieve by miniaturized the same planar antenna from the original antenna by adjusting the ratio between the slots of the ground plane and the radiation element. . These features make it good candidate for UWB application especially for WLAN communication.

REFERENCES

[1] H.G.Schantz, "A brief history of UWB antennas", Aerospace and Electronic system Magazine, IEEE vol.19, Issue 4, p.22-26, 2004.

[2] Z.N.Chen, "UWB Antennas: Design and application", 6th inter. Conf. of information, signal processing and communication in system, p.713-716,13-16 Dec.2007.

[3] First Report and order in the matter of Revision of part 15 of the commission Rules Regarding Ultra-Wideband Transmission system, Released by Federal communication commission ET-Docket 98-153. April 22, 2005.

[4] G.M.Yang, R.H.Jin, G.B.Xiao, " UltraWideband (UWB) Antennas With Multiresonant Split-Ring Loops". IEEE Trannsaction on Antennas and Propagation, vol.57,No.1, January 2009.

[5] W.Liu, C.Wu and Y.Tseng," Parasitically Loaded CPW-Fed Monopole Anntenna for Broadband operation".IEEE Transaction on Antenna and Propagation, vol.59, No.6,June 2011.

[6] W.Zeng, J.Zhao, "Band-Notched UWB printed monopole Antenna Fed by Tapered coplanar waveguide", proceeding of 2010 IEEE International conference on Ultra-Wideband (ICUWB 2010).

[7] R.A.Moody and S.K.Sharma,"Investigation on Co-Planar Waveguide Fed Pentagon Shape Planar Monopole Ultru-Wide bandwidth (UWB) Antenna on Foam Substrate Providing invariant radiation patterns " IEEE Antennas and Propagation Society International Symposium (APSURSI), 2010.

[8] N.Gunavathi, S.Raghavan,"A CPW-fed octagon shaped Antenna for 5GHz WLAN and Higher Band UWB Applications. 2nd international conference on computing , communication and Network Technologies 2010.

[9] C.Li, C.Chiu," A CPW-Fed band-notched slot Antenna for UWB application", IEEE, Antennas and Propagation Society International Symposium, 2008.

[10] E.S.Angelopoulos, A.Z.Anastopoulos, and D.I.Kaklamani,"Circular and Elliptical CPW-Fed slot and Microstrip-Fed Antenna for Ultra-Wideband Application", IEEE Antennas and wireless propagation letter, vol.5, 2006.

[11] A. Bostani, T.Denidni, "Design of a New Ultra Wideband Antenna with Band Rejection in WLAN frequencies" IEEE ,Antennas and Propagation Society International Symposium, 2008.

[12] R.Saleem, A.K. Brown, " Invers parabolic step sequence Ultra Wideband Antenna", IEEE, Loughborough Antennas and propagation conference, UK 2009.

[13] J.William, R.Nakkeeran,"Development of CPW-Fed UWB printed slot Antenna".IEEE, Communications (NCC), National Conference on, 2010

[14] D.Tran, F.M.Tanyer,A.Vorobyov,I.E.Lager and L.P.ligthart," A Novel CPW-Fed optimized UWB printed Antenna", EuMA, proceeding of th 10th European conference on wireless Technology, Germany 2007.

[15] A.A.Jamali, A.E.Gaafar, and A.A.Abd Elaziz,"Spiral Tuning Stub CPW-Fed UWB Slot Offset, Edge Cleft and Edge Slotted Antennas". Wireless Engineering and Technology, vol.2.p.p 146-152, 2011.

[16] R. Yahya and T.A.Denidni," Compact CPW-Fed Antenna with UltraWideband and Dual Polarization". IEEE, Mediterranean Microwave Symposium (MMS), pp.110-112, 2011 11th

[17] M.A. Peyrot-Solis , G.M.Galvan-Tejada and H.Jardon-Aguilar,"State of the Art in Ultra-Wideband Antennas".2nd International Conference on Electrical Engineering (ICEEE) and XI Conference on Electrical Engineering (CIE 2005).

[18] T.Tang, D.Lin, G.Liou, J.Horng, C.Li,"A Compact Slot UWB Antenna with CPW-fed".IEEE, Antennas and Propagation Society International Symposium, p.p. 5143-5146, 2007

[19] S.Hong, J.Choi, "Miniaturization of an Ultra Wideband Antenna with two spiral Element", ETRI Journal, Volume 31, No.1, February 2009.

[20] L.Guo,"Study and Miniaturization of Antenna for Ultra Wideband communication system", Ph.D.theises, University of London, UK 2009.

[21] A.M. Abbosh, "Miniaturized Microstrip-Fed Tapered-Slot Antenna With Ultra Wideband Performance". IEEE Antennas and wireless propagation letters, vol.8. P.p. 690-692, 2009.

[22] N.Behdad "High-Performance, Multi-Functional, and Miniaturized Integrated Antennas ". Ph.D thesis, University of Michigan 2006