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New Compact Antenna Structures with a slot shaped and a Stub Tuning for Ultra Wide Band Applications

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***Abstract*- This paper presents the design of new compact printed broadband antennas for Ultra Wide Band applications. The antenna structures are based on the CPW-fed combined with a slot and a stub line to increase the bandwidth. The proposed antennas have been successfully designed, optimized and simulated by using Momentum software integrated into ADS "Advanced Design System" and CST Microwave Studio. The measured input impedance bandwidth of the final broadband antennas ranging from 2.1-7.3 GHz and 2.1-11 GHz. The design considerations for achieving broadband antennas and both simulated, experimental results are presented and discussed.**

***Index Terms*- Microstrip patch antennas, Coplanar Waveguide (CPW), Stub tuning, Ultra Wide band antennas.**

I. INTRODUCTION

The rapid developments in wireless communications demand new broadband antenna structures to support and widen the range of the various wideband applications of wireless radio technologies such as Bluetooth, ISM bands, Radio Frequency Identification Data (RFID), Wireless Fidelity (WIFI, IEEE802.11) and World Interoperability for Microwave Access (WIMAX). Microstrip antennas are widely used in these applications due to their attractive features such as low profile, broadband, small in size, light in weight, low cost and ease of fabrication [1-9].

In addition to this, they are extremely compatible to other radio frequency microwave integrated circuit in manufacturing and low coupling affect in installation [10-14]. To achieve such antennas and to improve the bandwidth, there are several studies that show the different techniques used [15-20]. This work presents new compact coplanar antennas broadband structures which are based on the use of the CPW-fed combined with a slot and a stub tuning to match the input impedance, large bandwidth , low radiation loss, less dissipation and the ease of being integrated with passive or active components.

II. ANTENNA STRUCTURE DESIGN

The geometries of the proposed broadband CPW fed planar antennas slot are illustrated in Fig.1. They are simulated on a FR4 epoxy substrate with relative permittivity $\varepsilon r=4.4$, thickness of h=1.6 mm, and loss tangent $\tan\delta= 0.025$. The microstrip antennas are excited by a Coplanar Waveguide with 50Ω input impedance. Here, both the antennas and the feeding are implemented on the same plane, only one layer of substrate with a single side metallization is used. All the simulations were carried out by using both ADS" Advanced Design System" and CST Microwave Studio.

After many optimizations and miniaturizations, the dimensions of the final structures are listed in Table.1.

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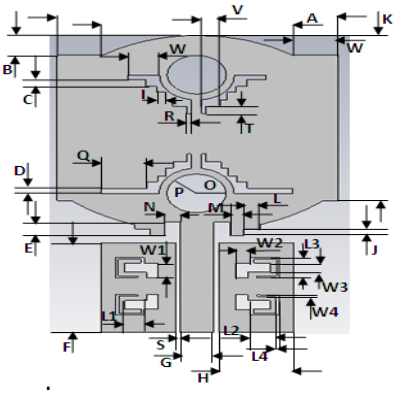
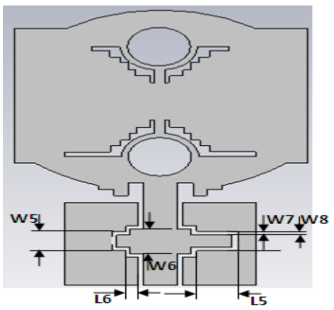


(a) Antenna I



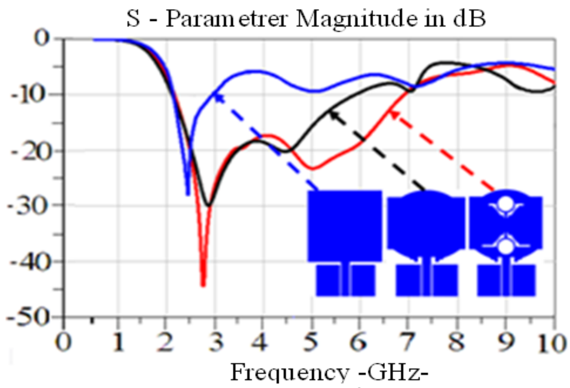
(b) Antenna II

Fig.1. Geometries of the proposed antennas

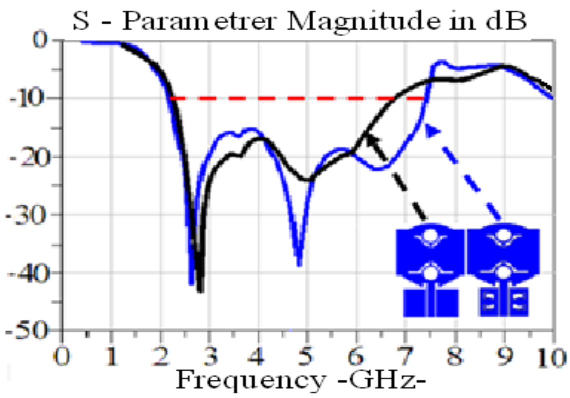
Table.1: Optimized dimensions of the proposed antennas (unit: mm)

Parameter	A	B	C	D	E	F	G
Value	8.1	4.2	0.8	0.5	1	13	3.2
Parameter	I	J	K	L	M	N	O
Value	0.5	0.5	21	1.2	1	1.1	3.8
Parameter	Q	R	S	T	U	V	W
Value	5.2	0.5	0.4	1	1.6	1.2	2.9
Parameter	L2	L3	L4	W1	W2	W3	W4
Value	2.7	2.9	0.2	1.4	1.6	1.2	0.4
Parameter	W6	W7	W8	L5	L6	L7	W5
Value	3.9	0.9	2.9	4	0.6	1.2	1.1
Parameter	H	P	L1				
Value	7	4	2.1				

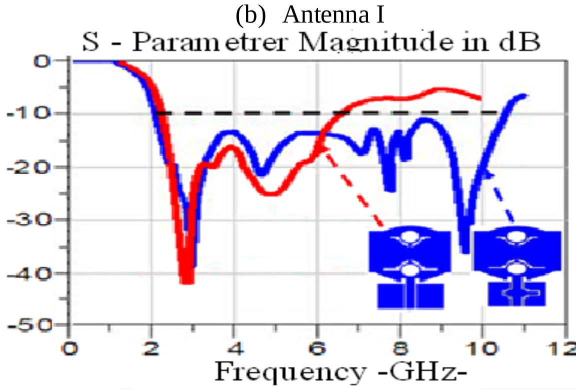
The antenna structure designed is based on rectangular radiator patch with a CPW feed line. To enlarge the bandwidth of a microstrip patch antenna reference, we can use the combination of the antenna geometry, slot techniques and stub tuning. The return loss results of the antennas simulated by using the optimization techniques integrated in electromagnetic simulation ADS are shown in Fig.2.



(a) Antenna reference



(b) Antenna I



(c) Antenna II

Fig.2. The return loss vs Frequency of the proposed antennas in ADS

First, for a simple rectangular plane, the modification of the radiator patch the use of shaped slot will improve the bandwidth of the antenna. As shown in Fig.2 (a), the simulated bandwidth is 4.1 GHz (2.1-7 GHz) with a return loss less than -10dB. Second, the effect of shaped slot in the ground plane on the input impedance bandwidth of the antenna is shown in Fig.2 (b),

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the matching input impedance is achieved in a range of frequency band between 2.1GHz and 7.4GHz with return loss below-10dB for final antenna structure n°1. Third, the stub tuning is another critical design parameter influencing the antenna characteristics. As shown in Fig. 3(c), the matching input impedance is achieved a frequency band ranging between 2.1 GHz and 10.8GHz with return loss below-10dB for final antenna structure n°2.

To compare these results with another simulator, we have conducted another simulation by using "CST Microwave Studio" for 3D electromagnetic simulation which is based on the finite integration technique (FIT). After the simulation, the following results are shown in Fig.4:

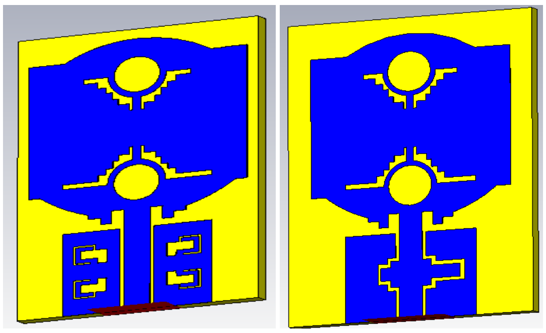
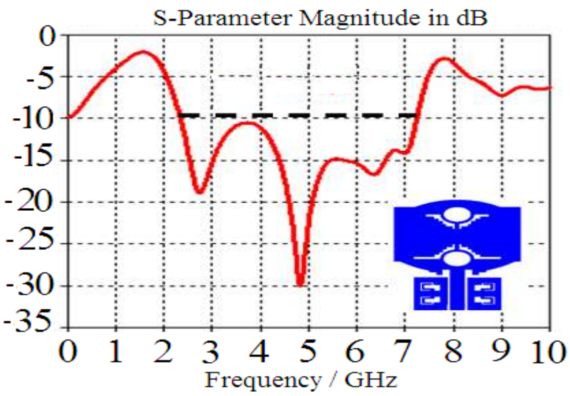
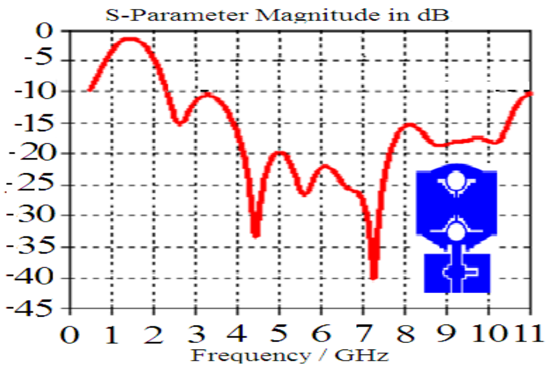


Fig.3. The 3D antenna structures on CST

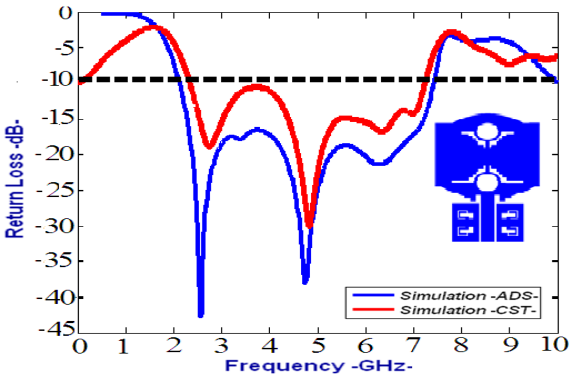


(a) Antenna I

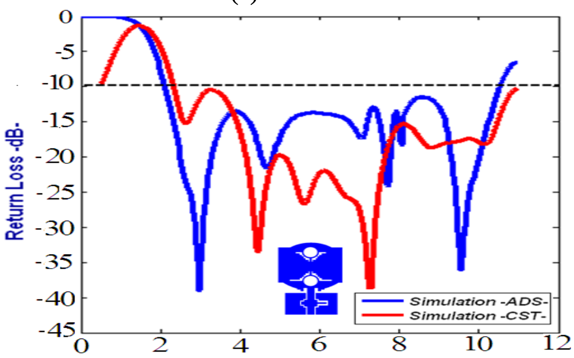


(b) Antenna II

Fig.4. The return loss vs frequency of the proposed antennas in CST



(a) Antenna I



(b) Antenna II

Fig.5. Comparison of the simulated and measured return loss

It is clearly observed that the simulation results in ADS and CST are in agreement. Fig.6 shows the simulated VSWR of the proposed antennas. It can be seen that the simulated results give a VSWR ≤ 2 for 2.2-7.3 GHz, and2.2-10.9 GHz.

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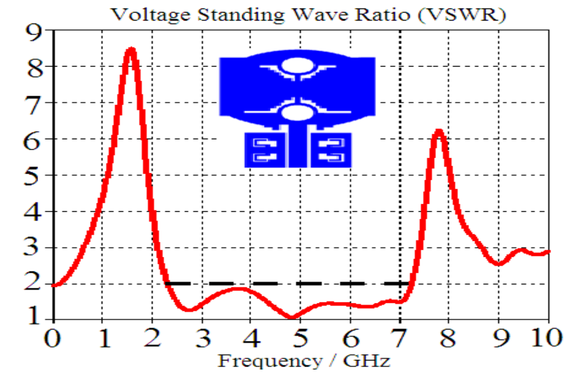
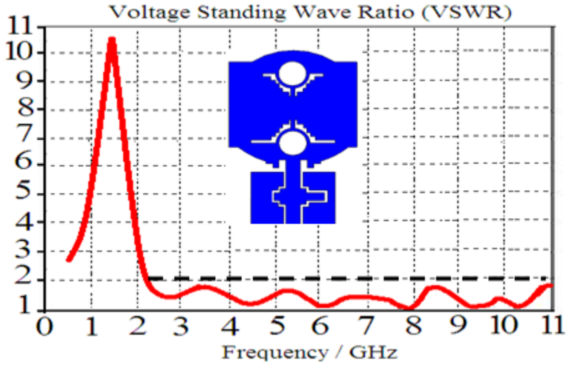


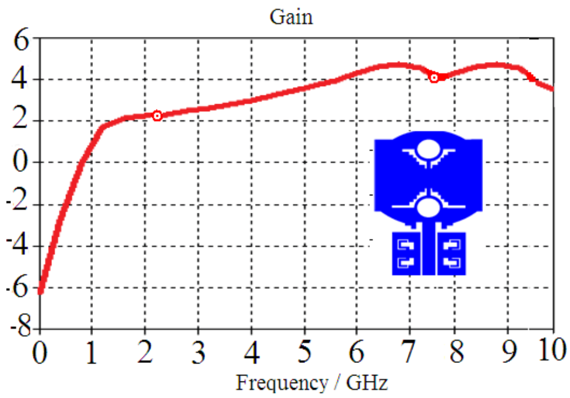
(a) Antenna I



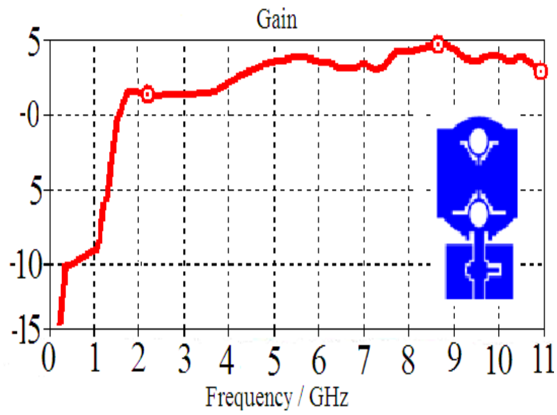
(b) Antenna II

Fig.6. VSWR vs frequency

The simulated antenna gain within the operating band has been plotted in Fig.7. It can be observed that the maximum gain variation is about 4.8 dBi for structure n° 1 and 5 dBi for structure n° 2.



(a) Antenna I



(b) Antenna II

Fig.7. Simulated Gain of the proposed antennas in CST.

Fig.8 shows the simulated surface current distribution of the proposed antennas. It can be seen that the surface currents are highly concentrated around the feed line and bottom side of the radiator patch for structure n°1 but for structure n°2 they are concentrated around the shaped slot, stub line and the border radiator patch sides.

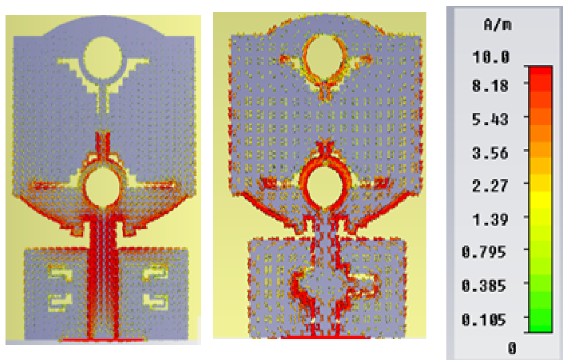


Fig.8. Surface current distribution of the proposed antennas @2.4GHz in CST

The simulated 2D Far-field radiation patterns of the antennas on E-plane and H -plane at 2.45 GHz and 5.8 GHz of the proposed antennas are presented in Fig.9. The simulated results shows that the good omnidirectional patterns in the E-plane and the nearly bidirectional patterns in the H-plane are obtained for all frequency bands.

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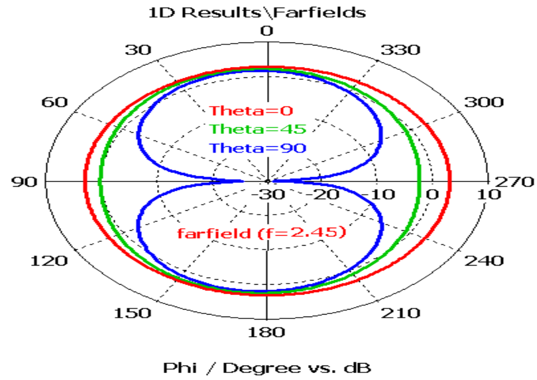
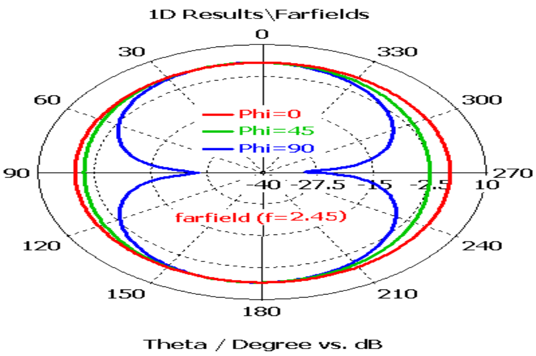
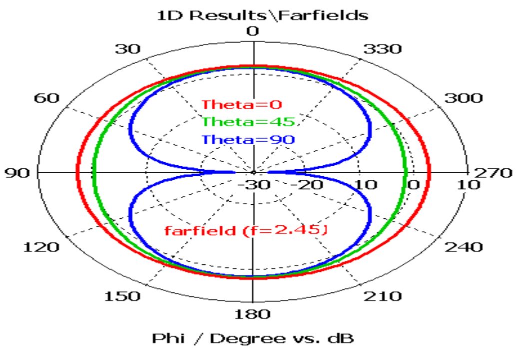


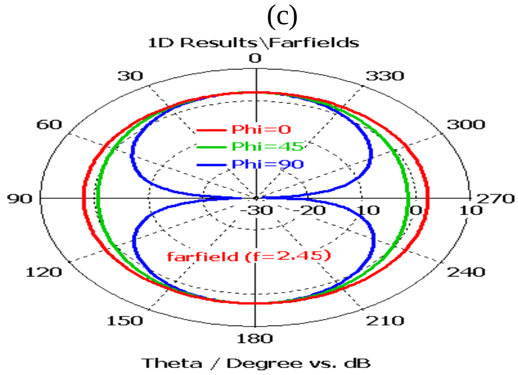
(a)



(b)

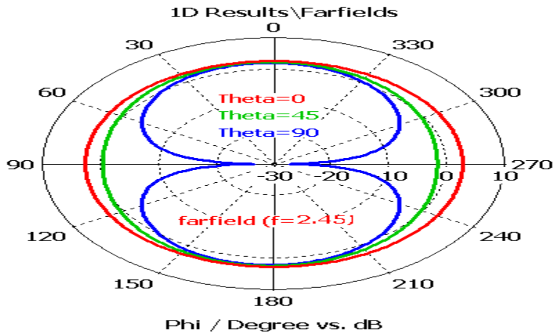


(c)

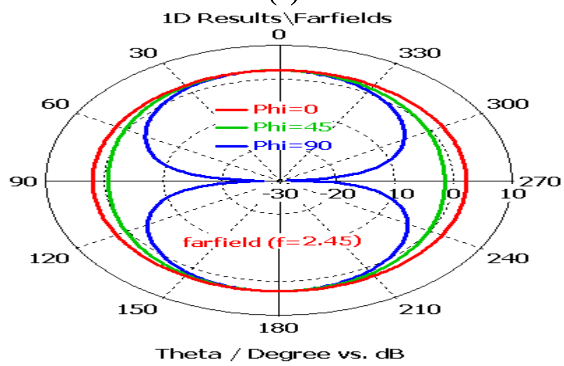


(d)

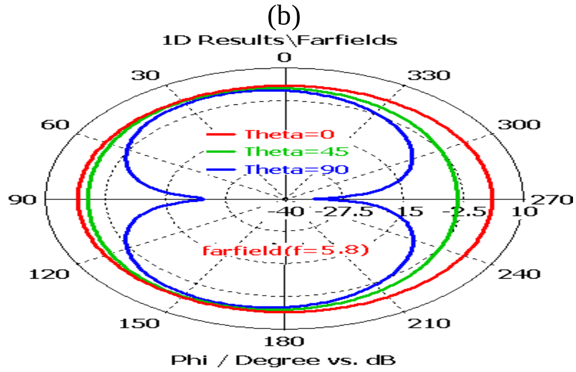
(a_1) Antenna I



(a)



(b)



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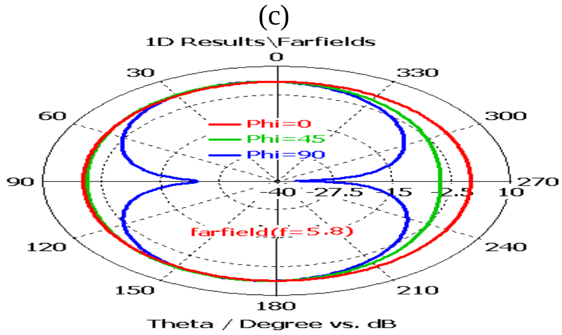

(d)

(b_1) Antenna II

Fig.9. Simulated radiation pattern for the proposed antennas on E-plane and H-plane @ (a) 2.45GHz and (b) 5.8 GH

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III. EXPERIMENTAL RESULTS AND DISCUSSION

After the conception, optimization of the broadband antenna structures by using ADS and CST, the different circuits of the investigated broadband antennas have been achieved by using LPKF machine and measured to verify the performance of the results obtained from simulation. The photographs of these antennas are shown in Fig.10. The return loss was measured by using Vectorial Network Analyzer (VNA) R&S@ZVB20 from Rohde& Schwarz, and the radiation patterns were measured in Anechoic chamber as shown in Fig.11.

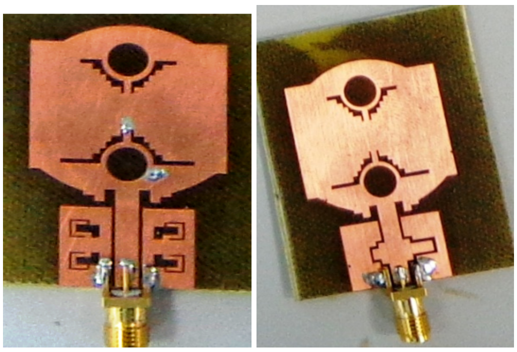


Fig.10. Photographs of the achieved broadband antennas

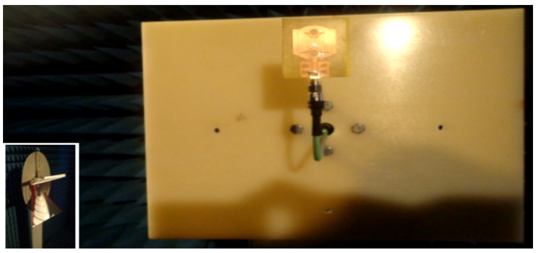
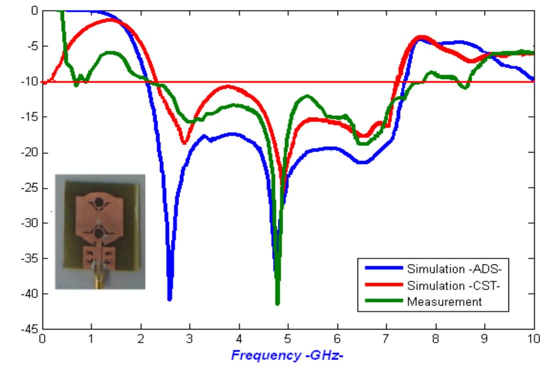
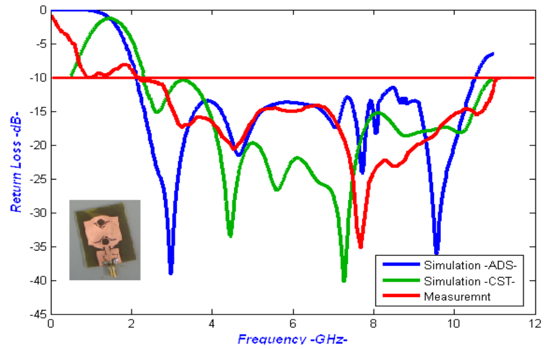


Fig.11. Anechoic chamber

The measurement results, compared with the simulation of the planar broadband antennas configuration are presented in Fig.12. It is clearly observed that the simulation results are in agreement with measurement. This allows the validation of two broadband antennas operating from 2.1 GHz to 7.5 GHz and 2.1 GHz to 11 GHz respectively. A comparison between measured and simulated input impedance bandwidth is shown in Table.2.



(a) Antenna I



(b) Antenna II

Fig.12. Simulated and measured return loss vs frequency

Table.2 Comparison between simulated and measured bandwidth of the proposed antennas

		Simulation		Measurement
		ADS	CST	
Bandwidth (GHz)	Antenna I	2.1-7.4 BW=5.3	2.2-7.3 BW=5.1	2.1-7.5 BW=5.4
	Antenna II	2.1-10.8 BW=8.7	2.2-11 BW=8.8	2.1-11 BW=8.9
Frequency Center (GHz)	Antenna I	4.75	4.75	4.75
	Antenna II	6.45	6.6	6.55
Impedance Bandwidth (%)	Antenna I	111.75	107.37	112.75
	Antenna II	134.88	133.33	135.87

The measured radiation patterns of the proposed antennas in E-plane and H-plane at frequencies 2.45 GHz and 5.8 GHz are presented in Fig.13.

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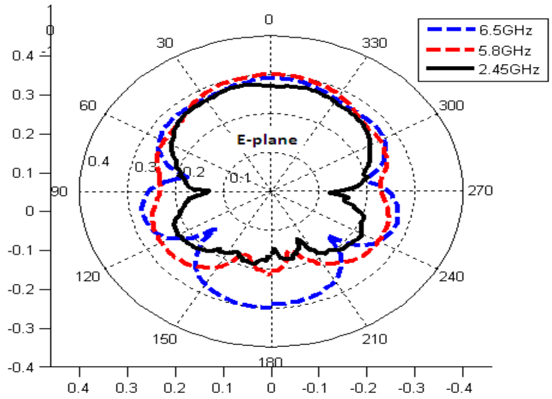
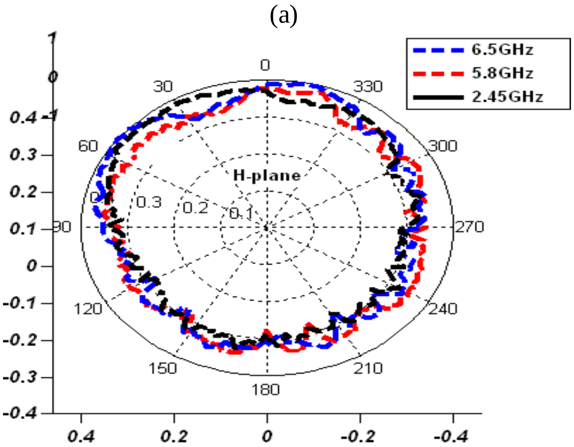
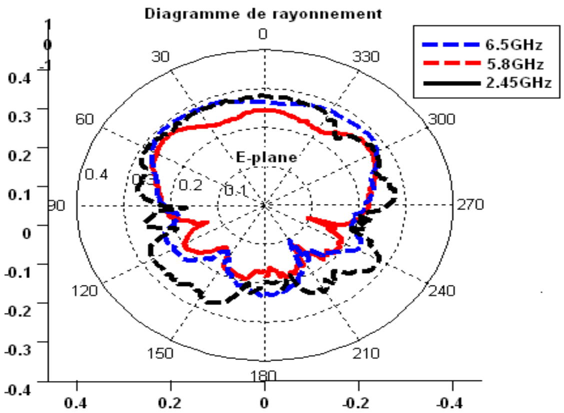


(a)

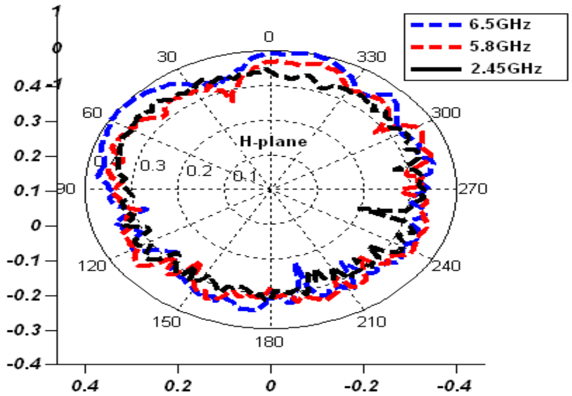


(b)

Antenna I



(c)



(d)

Antenna II

Fig.13. Radiation pattern at 2.45GHz and 5.8GHz on E-plane and H-plane.

Table.3. presents a comparison between the performance of the proposed antennas and some recently developed UWB antennas [15] and [20-23].

Table.3 The proposed UWB antenna is compared with some recently published UWB antennas.

References	Size comparison (propose/ literature) %	Bandwidth (%)
[20]	25.55	73.03
[21]	48.61	88.76
[22]	57.5	61.49
[15]	52.15	51.68
[23]	100	24.15

IV. CONCLUSION

In this paper, two broadband antennas structures are developed. The optimization, simulation and measurement results are in agreement which validate the novel compact antenna structures with a bandwidth of 5100 MHz (2.2-7.3 GHz) for antenna n° 1 and 8600 MHz (2.2-10.8 GHz) for antenna n° 2.These antennas are fed with CPW line which permits to associate them with printed circuit broad .To develop these structures we have used the slot technique and stub tuning to increase the bandwidth.

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Microwave Group in ESEO France, for providing support and assistance to perform simulations by using softwares and measurements on the VNA and Anechoic chamber.

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