



A New Compact Printed Antenna Structure for Multiple Wideband Applications

R. Dakir^{1*}, J. Zbitou², A. Mouhsen¹, A. Tribak³, M. Latrach⁴ and A. Mediavilla Sanchez⁵

¹MMII Laboratory, FST Settat University Hassan 1st, Settat, Morocco

²LITEN Laboratory, Polydisciplinary Faculty of Khouribga, University Hassan 1st, Morocco

³National Institute of Posts and Telecommunications, Rabat, Morocco

⁴RF & Hyper group, ESEO, Angers, France

⁵DICOM Laboratory, Cantabria University Santander, Spain

Email: dakir_fsts@hotmail.com

Abstract- This paper presents the design of a new compact antenna structure for multiple incorporating operation service. The proposed antenna is suitable to operate at three different frequency bands, (1.77GHz-2.67GHz), (3.1GHz-4.58GHz), and (5.5GHz-6.5GHz) with a return loss less than -10dB. The antenna structure includes a CPW fed line, the technique used to enlarge the frequency bands is the slots technique and in the same time we have developed a new antenna structure which operates in various wireless communication applications. The antenna parameters have been investigated and optimized by using CST Microwave Studio. To validate the CST Microwave Studio results before the antenna achievement, we have conducted another study by using ADS. The final circuit was achieved, measured and validated. Experimental results show that the proposed antenna with compact size of 42*32.7 mm² has good radiation characteristics and operating in specific microwave applications ISM band, WLAN, WIFI, WIMAX and RFID.

Index Terms- Microstrip antenna, Slots technique, Multi-band antennas

I. INTRODUCTION

In Recent years, the technologies of wireless communication systems have been rapidly increasing for greater capacities broadband service to support wireless devices and be operational in many frequency bands such as Global System for Mobile Communications (GSM), Worldwide Interoperability for Microwave Access (WIMAX), Wireless Local Area Network (WLAN), Industrial Scientific

Medical (ISM), Wireless Fidelity (WIFI, IEEE802.11b/g) and Radio Frequency Identification Data (RFID) applications. In order to respond to the rapidly increasing demands, an antenna should be operational in multi-frequency bands [1-4]. Therefore, the development of planar antennas with a broadband or multi-frequency operation capacities, low cost, small size, low profile, high efficiency and flexibility have become an attractive and a real challenge research in recent years [5-10]. To achieve such antennas for the specific applications, there are some methods and techniques used for designing microstrip antennas that operate in wide and multi frequency bands. In [11], a symmetrical ground plane is used to obtain multiband operations which cover various wireless applications. In [12], the use of meta-materials for the antennas design yields to multiband characteristics. In [13], they have demonstrated the multiband operation by using fractal geometry. Some monopole antennas with slot loading, such as circular ring slot [14], square ring slot [15], rectangular slot [16], are reported, providing multi-frequency band. In this paper, a novel coplanar waveguide-fed multiband monopole antenna with simple structure, small size and wide frequency bands is presented. The coplanar waveguide mechanism, geometry radiator patch and slot techniques also have many advantages over microstrip type to efficiently control the characteristics of the impedance bandwidth of the operating frequency and to ease the integration with active and passive devices for Ultra Wideband or multiband applications.



Details of the antenna design are described, and both the simulated and measured results are presented and discussed.

II. ANTENNA DESIGN

The schematic configuration of the proposed planar CPW-fed slot multi-bands antenna is shown in Fig.1. This antenna is fabricated on a FR4 epoxy substrate with a relative permittivity 4.4, and a thickness of 1.6 mm and 0.025 for loss tangent. The microstrip antenna is excited by a CPW line with 50Ω as characteristic impedance. The radiator patch antenna and the feeding are implemented on the same plane, only one layer of the substrate with a single side metallization. The dimensions of the designed antenna are 40 x 36 mm². All the design and simulated results are performed by using CST Microwave Studio and ADS” Advanced Design System”. After many optimizations of the antenna geometry, the parameters of the final structure are listed in Table.1.

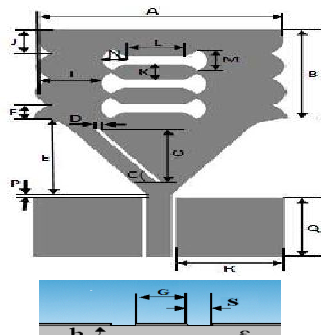


Fig.1. Geometry of the CPW antenna

Table.1.Optimized dimensions of the designed antenna (unit :mm)

Parameter	A	B	C	D	E	F
Value	32.7	15.9	45 ⁰	1.5	15.6	2.8
Parameter	G	I	J	K	L	M
Value	3	7	17	3.2	7.4	4
Parameter	N	O	P	Q	R	S
Value	1.8	10.2	1.2	13	10	0.4

III. ANTENNA PERFORMANCES

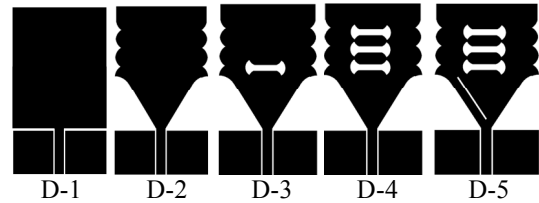
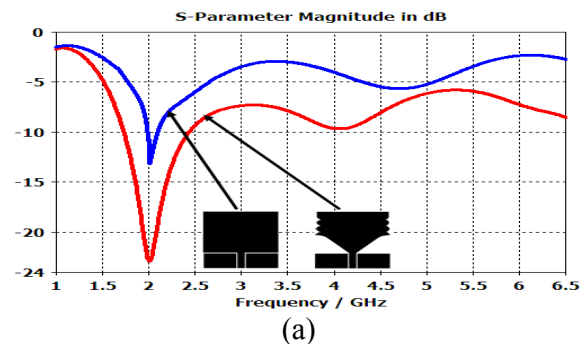
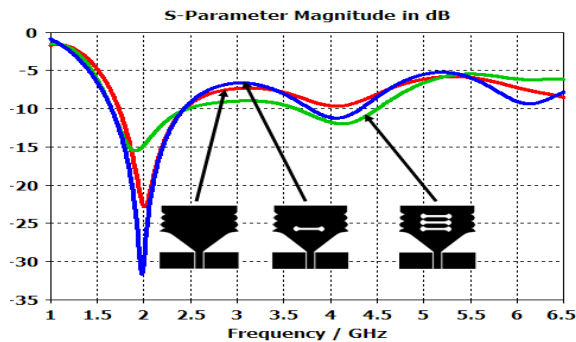


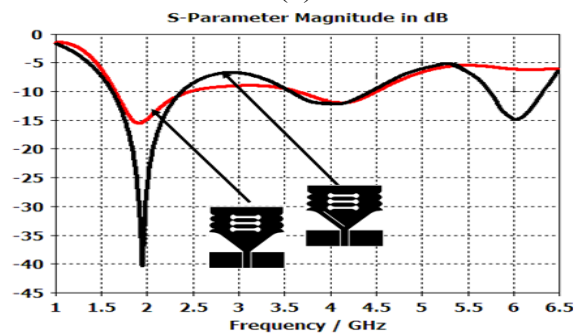
Fig.2. Design evolution of the proposed antenna

The goal of this study is to design a new compact antenna structure for multi frequency wide band microwave applications. The design evolution of the proposed antenna is presented in Fig.2 the conception of the planar antenna with multi frequency operation capabilities is due to the multiple resonances introduced by the combination optimization of the geometry antenna, cutting notched and slot shaped on the radiator patch technique and CPW-feed line width. Therefore, Fig 3 shows the simulated return losses for successive cases of the conception of the final tri-band antenna. From Fig 3, we can clearly see that the proposed antenna is designed through three steps. Firstly, for a reference rectangular plane, the geometry radiator patch was modified to further improvement of the bandwidth of the antenna as exhibited in Fig.3.a. Secondly by adding a three parallel slot shaped on the radiator patch, the dual-band antenna is obtained (Fig3.b). At the end, the final tri-band antenna is achieved by using a slanted rectangular slots with an angle of 45° (Fig.3.c).Thus, the matching input impedance of the final antenna structure is achieved respectively in frequency bands 1.71-2.49GHz, 3.5-4.4.35GHz and 5.65-6.25GHz with a return loss less than -10 dB. The simulated values are given in Table.2.





(b)



(c)

Fig.3. The return loss vs frequency of the proposed antenna for different cases on CST

Table.2. The bandwidths of the proposed antenna for different cases

	Bandwidth (GHz)	Impedance Bandwidth
D-1	2-2.04/BW=0.4	2.24%
D-2	1.75-2.48/BW=0.73	34.5%
D-3	1.74-2.48/BW=0.74	35%
	3.75-4.4/BW=0.65	15.9%5
D-4	1.74-2.5/BW=0.76	35.84%
	3.6-4.5/BW=0.9	22.22%
D-5	1.74-2.46/BW=0.72	34.28%
	3.5-4.5/BW=1	25%
	5.7-6.3/BW=0.6	10%

Before the achievement of the antenna and to compare CST results of the final proposed antenna with another simulator, we have used ADS which is based on Method of Moments (MoM). After the simulation, the following result is shown in Fig.4.

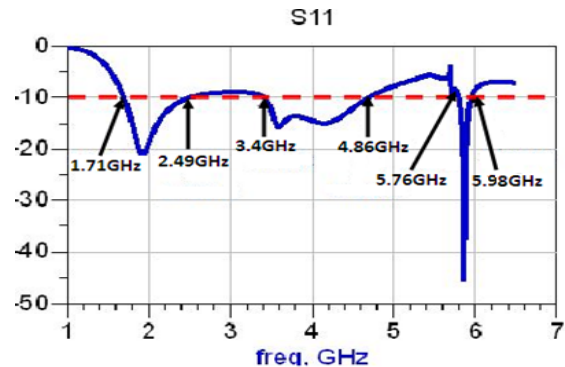


Fig.4. The return loss vs frequency of the proposed antenna in ADS

Fig.5. illustrated the simulated Voltage Standing Wave Ratio (VSWR) versus frequency of the final proposed antenna structure. It is noticed that the VSWR less than 2 for the frequencies throughout matching bands. The variation of the antenna gain versus frequency is shown in Fig.6.

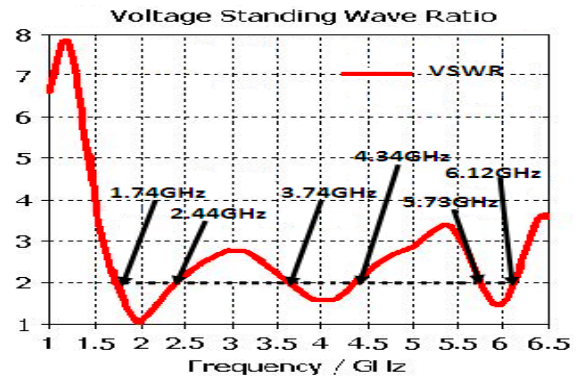


Fig. 5. VSWR vs frequency

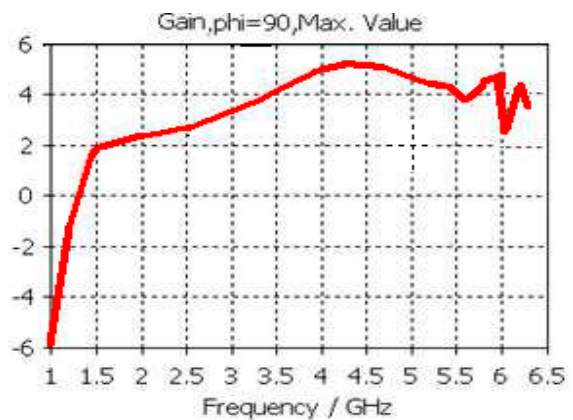


Fig.6. Gain vs Frequency



Fig.7 exhibits the simulated surface current distribution of the proposed antenna at 1.8GHz, 3.8GHz and 5.8 GHz. It is observed that the surface currents are highly concentrated around the shaped slot at 1.8GHz 3.8GHz and distributes along de radiator patch 5.8GHz.

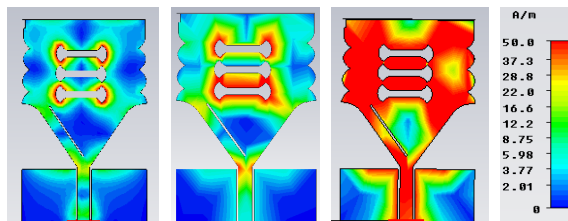


Fig.7. Simulated Surface current distribution of the final proposed antenna at (a) 1.8 GHz, (b) 3.8GHz, and (b) 3.8GHz

IV. ACHIEVEMENT AND MEASUREMENT

After the comparison of simulation results in CST and ADS, we have achieved the antenna structure by using LPKF machine. The photograph of the fabricated antenna is shown in Fig.8. It was measured in anechoic chamber by using VNA R&S@ZVB20 from Rohde & Schwarz.



Fig .8. The fabricated antenna structure and the 3.5 mm used calibration Kit.

After the conception and the achievement of the proposed antenna, we have done the comparison of the different results as shown in Fig.9.

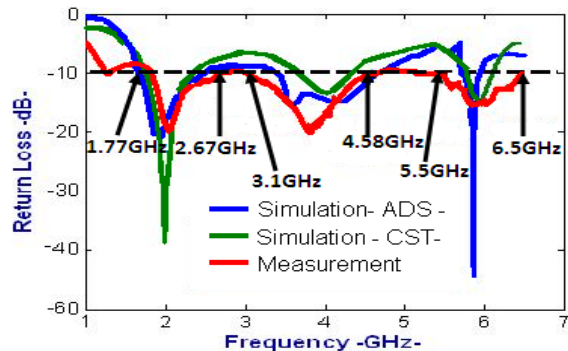


Fig.9. Comparison of simulated and measured return loss

As illustrated in Fig.9, we conclude that we have an agreement between simulation and measurements results. After the antenna measurements we deduced that we have an antenna structure validated for multiple frequency wide bands; 1.77GHz to 2.67GHz, 3.1GHz to 4.58GHz and 5.5GHz to 6.5GHz. The measured input impedance and bandwidth of the achieved antenna structure is shown in Table.3. Moreover, the structure is a compact structure and is suitable for WLAN / WIMAX/ISM-Band and RFID applications.

Table.3. The measured bandwidth of the proposed antenna

Input impedance (GHz)	Measurement input impedance		
		1.77-2.67	3.1-4.58
Frequency center (GHz)	0.9	1.48	1
Bandwidth (%)	40.54	38.54	16.66

In Table.4, Comparison of the final validated low cost miniature compact antenna with other multi-band or UWB antenna structures [17-21].

Table.4. Comparison of antenna size among proposed antenna and other compact antennas

Published literature	Size comparison (propose/ literature)
Ref.[17]	87%
Ref.[18]	65.81%
Ref.[19]	51.8%
Ref.[20]	37.22%
Ref.[21]	27.42%

The simulated and measured far-field radiation pattern characteristics of the proposed



antennas in E-plane and H-plane at 1.8GHz and 3.8GHz are investigated in Fig.10. The measured results shows that the good omni-directional patterns in the E-plane and the nearly bidirectional patterns in the H-plane are obtained for all frequency bands.

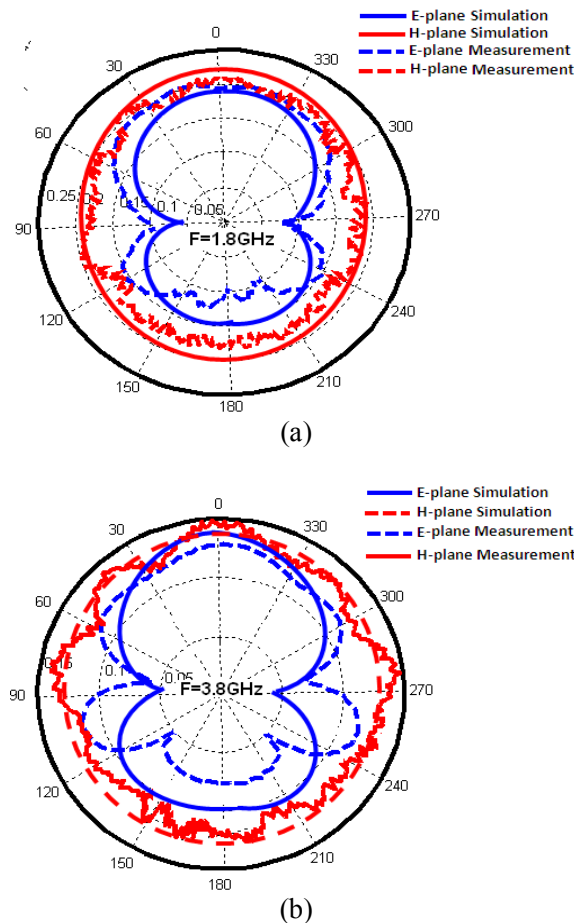


Fig.10. Measurement and Simulation radiation patterns of the proposed antennae at (a) 1.8GHz and (b) 3.8GHz

V. CONCLUSION

In this study, we have designed and validated a new low cost printed multi-band antenna structure, suitable to operate in wide frequency bands. As described in this paper conception, optimization and simulation results are performed by using two electromagnetic simulators. The slots technique used in this work is a simple way to optimize and to control the frequency band. The measured and simulation

results are in agreement which validates the antenna structure for 1.77GHz-2.67GHz,3.1GHz-4.58GHz and 5.5GHz-6.5GHz operating in specific microwave applications ISM band, WLAN, WIFI, WIMAX and RFID.

ACKNOWLEDGMENT

We thank Mr. Angel Mediavilla Sanchez Director of DICOM Laboratory in Santander in Spain and Mr. Mohamed Latrach Professor in ESEO France, for allowing us to use and to perform simulations by using softwares and measurement on the VNA and anechoic chamber.

REFERENCES

- [1] A-F.Sun, Y-Z. Yin,S.H. Jing et Mehadji ABRI "BroadBand CPW-fed Antenna With Band-Rejected Characteristic For Wlan-Wimax Operation," Vol 22, pp 47-54, 2011.
- [2] Liao,W. and Q.W.Chu ,"CPW-fed square slot antenna with lightning-shaped feedline for broadband circularly polarized radiation,"Vol 18,pp 61- 69,2010.
- [3] Mohammad Tariqul Islam, Mohammed Nazmus Shakib,Norbahiah Misran, Tiang Sew Sun "Broadband Microstrip Patch Antenna" European Journal of Scientific Research ISSN 1450-216X Vol.27 No.2?pp.174-180,2009.
- [4] M. A. Saed "Reconfigurable Broadband Microstrip Antenna Fed by A Coplanar Waveguide", PIER 55, pp 227-239, 2005.
- [5] Q. Chen, H. L.Zengh,T. Quan and X.Li "Broadband CPW Feed Circulary Polarized Antenna With Equiangular Tapered-Shaped Feedline For Ultra-Wideband Applications,Vol.26,83-95,2012.
- [6] Ping Jack Soh,Guy A.E Evaluation of Flexible CPWFed Ultra Wide-Band Textile Antennas, 2011 IEEE Intrnational FR and Microwave Conference,Vol 60 ,58- 62,2011.
- [7] X.Y. Teng, X. M. Zhang,Y. Wang,Y. Li,Q. F. Dai,and Z. Zhang "A Compact CPW-fed Omni-Directional monopole Antenna For Wlan and Rfid Applications ", progress In Electromagnetic research letters,Vol.32,91-99,2012.



- [8] Ren, W., "Compact dual-band slot antenna 2.4/5GHz WLAN Applications," progress In Electromagnetic Research Vol.58, No.4, 1031-1038, Apr. 2010.
- [9] S. Papantonis and E. Episkopou, "Compact dual-band printed 2.5-shaped monopole antenna for WLAN application" progress In Electromagnetic Research C Vol.24, 57-86, 2011.
- [10] Ren, W., "Compact tri-band square slot antenna with symmetrical L-strips for WLAN/WiMAX applications" IEEE Antennas Wireless Propagation Lett., Vol.10, 462-465, 2011.
- [11] Y.-C. Lee and J.-S. Sun, "Compact printed slot antennas for wireless dual- and multi-band operations," Progress In Electromagnetics Research, Vol. 88, 289-305, 2008.
- [12] Zhu, J., M. A. Antoniadis, and G. V. Eleftheriades, "A compact tri-band monopole antenna with single-cell metamaterial loading," IEEE Transactions on Antennas and Propagation, Vol. 58, No. 4, 1031-1038, Apr. 2010.
- [13] A. K. Panda and Asit K. Panda, "A novel design of multiband square patch antenna embedded with gasket fractal slot for WLAN & Wi-Max communication," Int. J. Advances in Engg. & Tech. (IJAET), vol. 3, no. 1, pp. 111-116, 2012.
- [14] Ren, W., "Compact dual-band slot antenna for 2.4/5 GHz WLAN applications," Progress In Electromagnetics Research B, Vol. 8, 319-327, 2008.
- [15] Hu, W., Y.-Z. Yin, P. Fei, and X. Yang, "Compact tri-band square-slot antenna with symmetrical L-strips for WLAN/WiMAX applications," IEEE Antennas Wireless Propagation Lett., Vol. 10, 462-465, 2011.
- [16] Chen, J. S., "Dual-frequency annular-ring slot antennas fed by CPW feed and microstrip line feed," IEEE Transactions on Antennas and Propagation, Vol. 53, No. 1, 569-571, 2005.
- [17] L. Kang, Y.-Z. Yin, H. Li, W.-J. Huang, and S.-F. Zheng, "Dual-wideband symmetrical g-shaped slotted monopole antenna for WLAN/WiMAX applications," Progress In Electromagnetics Research Letters, Vol. 17, 55-65, 2011.
- [18] A. Bhargava, S. Ghosh, S. Kumar, and "A multi-U Slotted Rectangular Micro-strip Multi-band" International Journal of Engineering and Advanced Technology (IJEAT), Volume-2, April 2013.
- [19] R. Dakir, J. Zbitou, A. Mouhsen, A. Tribak, A.M. Sanchez, M. Latrach "A Low Cost Broadband Antenna" International Journal of Electronics Communication and Computer Engineering, Volume 2, July, 2013.
- [20] V. R. Nag, G. Singh "Design and Analysis" of Dual Band Microstrip patch Antenna with Microstrip feed line and slot for multi-band Application in Wireless Communication. International Journal of Computer Science and Information Technology & Security, Vol. 2, No.6, December 2012.
- [21] A. Kuar, N. Saluja, J.S. Ubai "A hexagonal multi-band fractal antenna using for wireless applications" International Journal of Electronics and Computer Science Engineering, pp.2107-2111, September, 2012.]