International Journal of Computer and Information Technology (ISSN: 2279 – 0764)
Volume 05 – Issue 02, March 2016

A Microstrip-/CPW-Fed Wideband Circular-Modified Antenna for Biotelemetry Applications

Mohamed Salah Karoui[*], Hamadi Ghariani, Mounir Samet
National School of Engineering of Sfax (ENIS), Laboratory of Electronics and Information Technology (LETI), Group of Microelectronics & Medical Electronics (MEEM),
Sfax, Tunisia
[*]Email: mohamedsalah.karoui [AT] issatm.rnu.tn

Mohamed Ramdani
ESEO Graduate School of Engineering
Angers, France

Abstract— **In this paper, a monopole antenna with microstrip and coplanar waveguide (CPW) access is designed for biotelemetry applications. The proposed antenna is printed on a FR4 substrate of size 100×87×1.6mm3 and 100×76×1.6mm3, respectively. For the both configurations, a wide resonant frequency band is reported. The first one extends from 1.14GHz to 4.5GHz with an impedance bandwidth of 119.5%, whereas the second covers the range 1.16GHz – 4.32GHz with an impedance bandwidth of 115.2 % for respectively for the microstrip and CPW access is observed. The wide band properties are achieved by modifying the shape of the resonant element and using a reduced ground plane with an appropriate gap distance p. Details of the experimental and simulation results are presented and discussed.**

Keywords-Patch antennas, planar monopole, Wideband antennas, ISM band, WMTS band, Biotelemetry. Introduction (Heading 1)

I. INTRODUCTION

Recently, with the rapid progress on the communications systems and in particular on the biotelemetry systems who offer more mobility to the patient and a long-term surveillance , the requirement to widen the frequency bandwidth of the used antennas growth particularly to avoid the channels saturation at the reception.

Figure 1 shows the block diagram of the proposed implementation adopted by our research team [1]. The designed antennas will be used in the different access point, at the reception in the allocated bands.

Microstrip patch antennas are widely utilized in many modern communications systems such as personal communication systems, satellite and other wireless applications thanks to their several advantages over other antennas structures like their low profile, light weight, simplicity, robustness, low cost and ease of production.

But the principal limitation of the patch antennas resides in their small bandwidth (≈ 2-5% [2]) and relatively poor radiation efficiency [1] and especially their huge size at low frequencies.

However, since the adoption of the UWB technologies by the United States Federal communication (FCC) in 2002 [3], there is an increasing trend for the monopole-like antenna's performances to comply with the UWB requirement especially for the biotelemetry applications. Those structures must be capable to operate at extremely wide frequency band defined from 3.1 GHz to 10.6 GHz with an omnidirectional radiation pattern and reduced dimensions [3]. Lately, various types of printed Ultra-wideband (UWB) Microstrip patch antennas [4-9] and several techniques for size reduction [10-12] have been proposed. Nevertheless, for the biotelemetry application, low frequency antennas are needed and must operate below the lower frequency edge (3 GHz) at the ISM [13] and WMTS bands [14] allocated for this purpose. So the size of the antenna is the principal constraint since the dimension of a ″ ″ antenna at 700 MHz is ≈ 21.5cm then it needs specific studies.

In previous work [15], we have designed a wideband square and rectangular patch antennas with 95.8% and 76.7% impedance bandwidth, with sizes of 100×90×1.6 and 100×70×1.6 mm3 , respectively.

Also, a novel a Bell-Form monopole antenna was presented in [16] with a size of 100×92×1.6 mm3 for 127.3% impedance bandwidth.

In this paper, we propose a circular modified monopole antenna by combining half a circle with a rectangular patch and the transformation of the GND dimensions to reach the widest frequency bandwidth with the minimum size. Also, we will study the two famous feeding accesses: Microstrip and CPW access to comply with the almost applications using the frequencies in the band spreading from 700MHz to 4.5GHz.

II. ANTENNA DESIGN

The structures of the designed antennas are shown in Figure 2. These antennas are printed on a standard FR4 substrate (thickness: h = 1.6mm – permittivity: εr = 4.4)..

Since these antennas are intended for medical telemetry, the dimensions of the resonant patch were calculated in order to operate in ISM & WMTS bands, while design parameters were optimized using Ansoft-HFSS software.

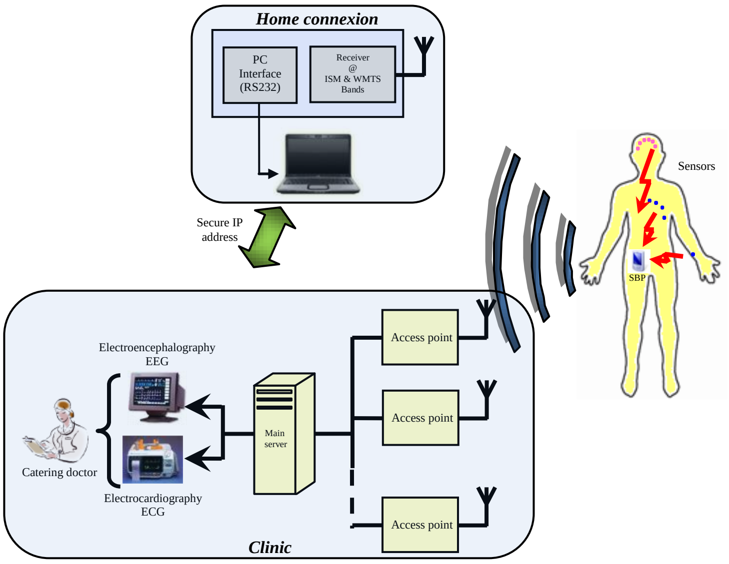
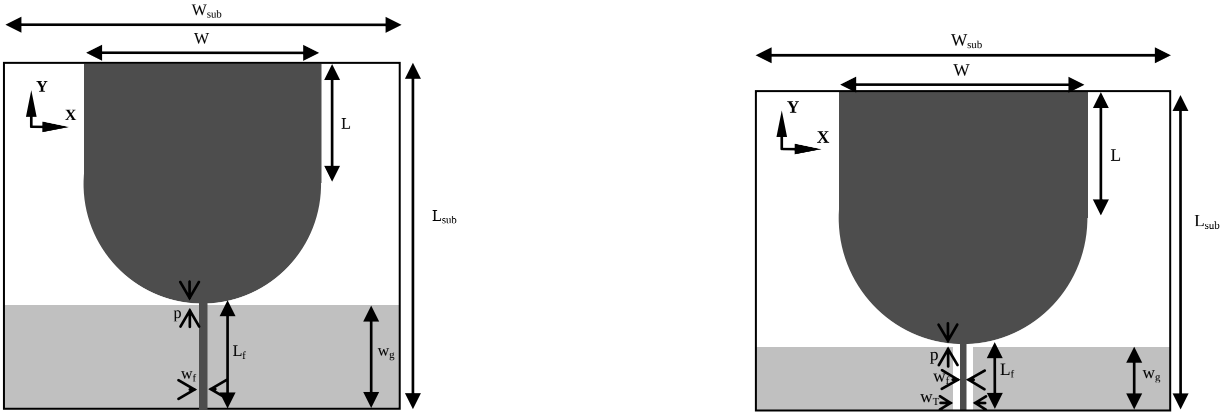


Figure 1. The block diagram of the proposed implementation.



(a)

(b)

Figure 2. Geometry of the Patch antenna: (a) Microstrip access, (b) Coplanar wave-guide (CPW) access.

The first antenna is fed by a 50 Ω microstrip line and a reduced ground plane (dimensions: Wsub×Wg) is printed on the bottom layer of the substrate, whereas the second antenna is fed by a 50 Ω CPW (coplanar wave-guide) line and a reduced ground plane (dimensions: Wsub×Wg) is printed on the top layer of the substrate.

Within the design process, the shape of the radiating element, the width of the feed line and the ground plane dimensions were studied numerically to achieve the -10dB impedance bandwidth. Moreover, a parametric study shown in Fig. 3 leads to the use of a 1 mm gap distance (p). The optimized parameters obtained for both antennas are regrouped in Table I and Table II, respectively for the antenna with microstrip and CPW access.

TABLE I. PATCH WITH MICROSTRIP ACCESS PARAMETERS

Parameters	**Data**
W_{sub}	100mm
L_{sub}	87mm
W	60mm
L	30mm
p	1mm
w_g	26mm
L_f	27mm
w_f	2.1mm

TABLE II. PATCH WITH CPW ACCESS PARAMETERS

Parameters	Data
W_{sub}	100mm
L_{sub}	76mm
W	60mm
L	30mm
p	1mm
w_g	15mm
L_f	16mm
w_f	1.5mm

III. RESULTS AND DISCUSSION

In order to reach a superior impedance matching, a parametric study was performed on the gap distance p, which is essentially responsible to the lower limit of the frequency band [3,4], as plotted in Figure 3 for the antenna with Microstrip access.

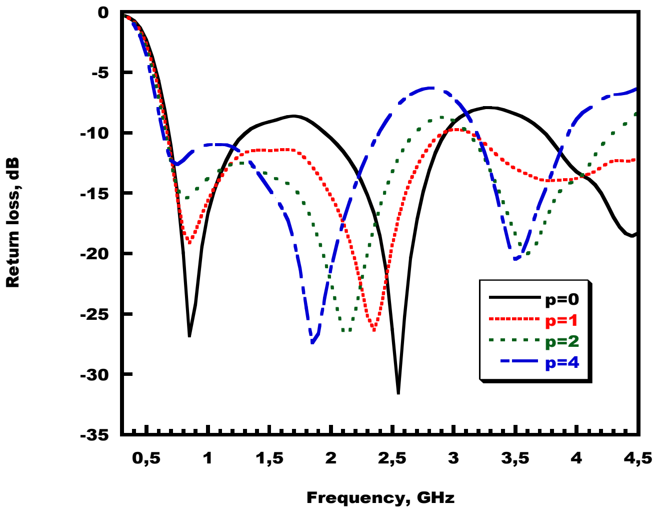


Figure 3. Microstrip Access for different gap distance p

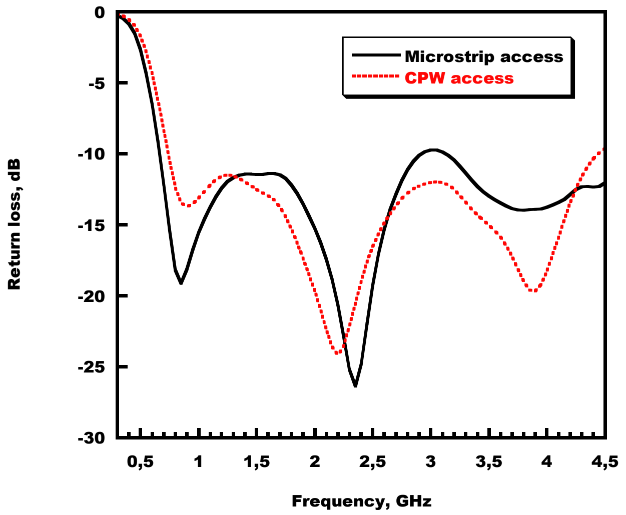


Figure 4. Microstrip & CPW Access with p= 1mm

The ideal case is evidently p = 1mm which gives the possibility to cover the majorities of the ISM & WMTS and which confirm the result obtained in [16].

In order to comply with the almost applications and to facilitates the integration of other circuits under the antenna to decrease the total dimension of a mobile terminal, a Patch antenna with coplanar wave-guide (CPW) access was simulated and compared to the initial design (microstrip access), as demonstrated in Figure 4.

As can be noticed from Fig. 4, significant correlation can be observed between the both structures but the frequency bandwidth is now equal to 3.65GHz (f_L = 750MHz, f_H = 4.4GHz) with an impedance bandwidth of 141.75%.

The prototypes of both optimized structures were fabricated according to the dimensions specified in Table 1 and Table 2, as depicted in Figure 5. The return losses of these antennas were measured over the 0.3GHz-4.5GHz frequency range with an Agilent HP 8753E vector network analyzer. Figure 6 illustrates both measured and simulated results of return losses for these structures.

As can be seen, a relatively good agreement between the simulation and the measurement can be observed for both antennas, but small discrepancies can be observed in the lower frequency band which has barely disappeared. This difference can be due to the effect of the 50Ω SMA connector (soldering parasitic which are neglected in simulation) and fabrication (tolerances, substrate permittivity and thickness, copper thickness on the bottom layer of the substrate).

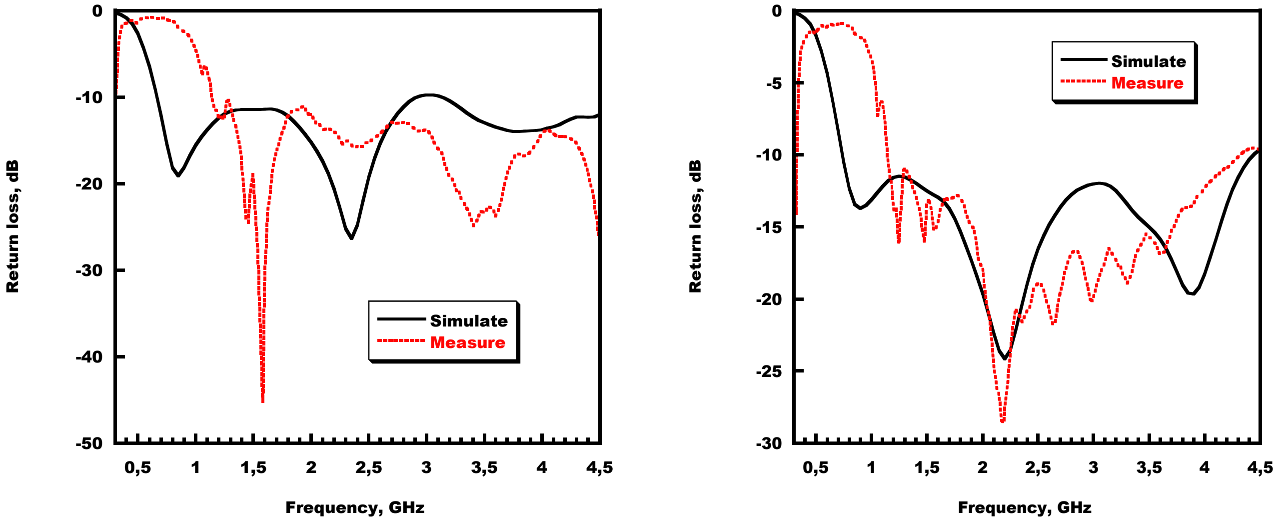
It can also be noticed that the measured Microstrip access patch antenna bears a wide resonant band that extends from 1.14GHz to 4.5GHz with an impedance matching around 119.2 % for $S_{11} \leq -10$ dB. The best impedance matching (minimum values) was obtained at 1.58 GHz (S_{11}= -45.18dB) and 3.4 GHz (S_{11}= -24.9dB). As a result, this impedance bandwidth is suitable for communication systems operating in the ISM band for biotelemetry.

In parallel, measurement results obtained for the CPW access patch antenna are very significant, particularly considering the reduction of the total antenna length (resulting from the optimization procedure). Its bandwidth ranges from 1.16GHz to 4.32GHz with an impedance matching around115.2 % for $S_{11} \leq -10$dB. The best impedance matching was obtained at 2.19GHz (S_{11}= -28.6dB) which matches quite well with simulation results.

Also, measurement results demonstrate that there is a certain correlation between both structures contrary to the simulation results already obtained but the structure with CPW access provides a much better S_{11} values along the obtained bandwidth with a reduced size which make it a judicious choice in high frequency applications from 1.16GHz to 4.32GHz.

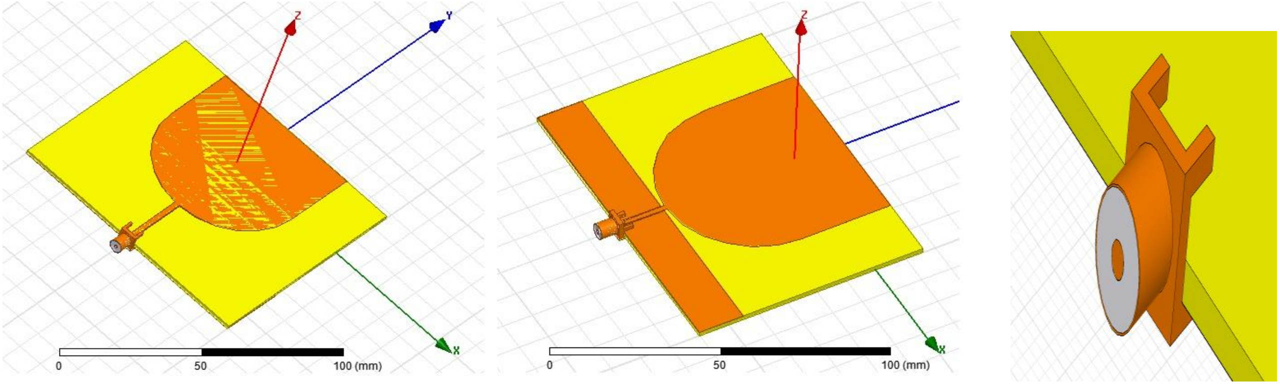
(a) (b)

Figure 5. . Picture of the fabricated antennas: (a) Microstrip access, (b) Coplanar wave-guide (CPW) access.



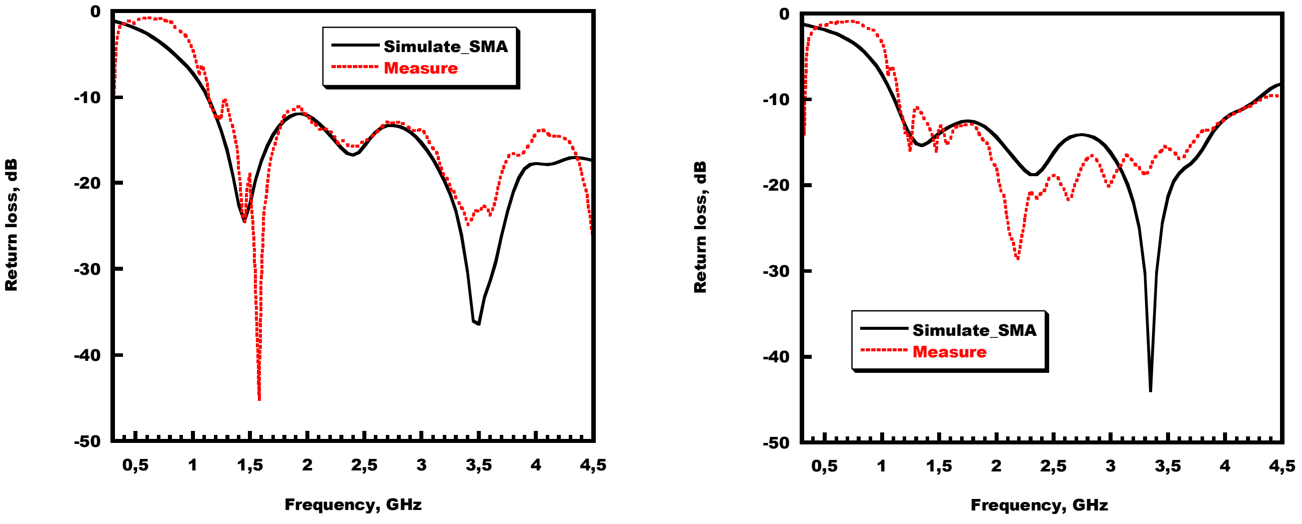
(a) (b)

Figure 6. Measured and simulated results of return losses: (a) Microstrip access, (b) Coplanar wave-guide (CPW) access.



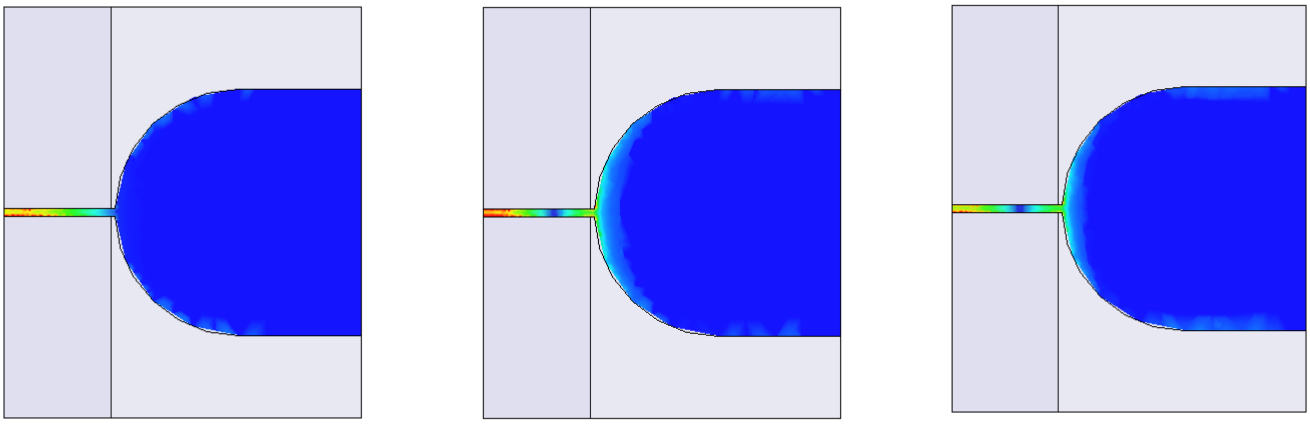
(a) (b) (c)

Figure 7. Picture of the simulated antennas: (a) Microstrip access, (b) Coplanar wave-guide (CPW) access, (c) The design of the SMA in HFSS.



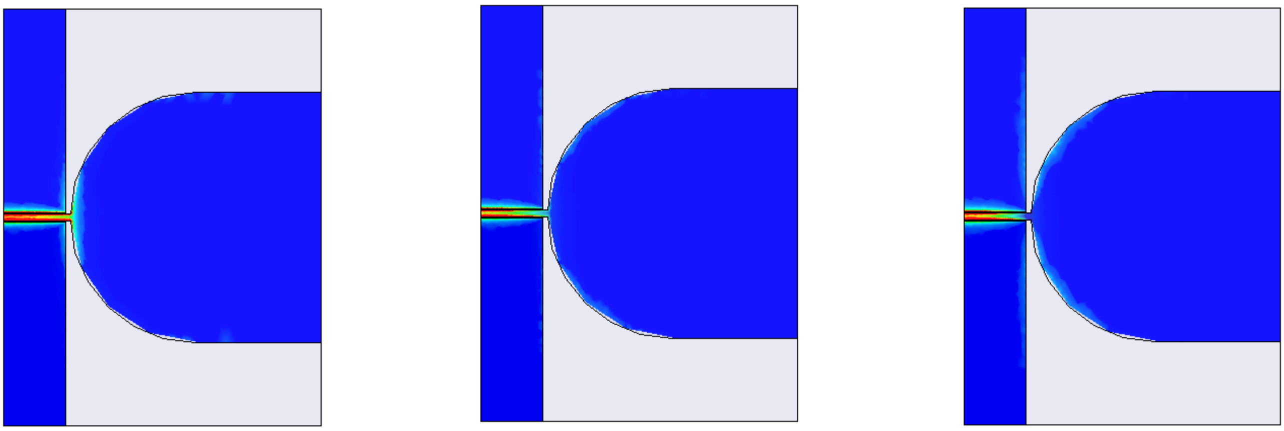
(a) (b)

Figure 8. Measured and simulated results of return losses: (a) Microstrip access, (b) Coplanar wave-guide (CPW) access.



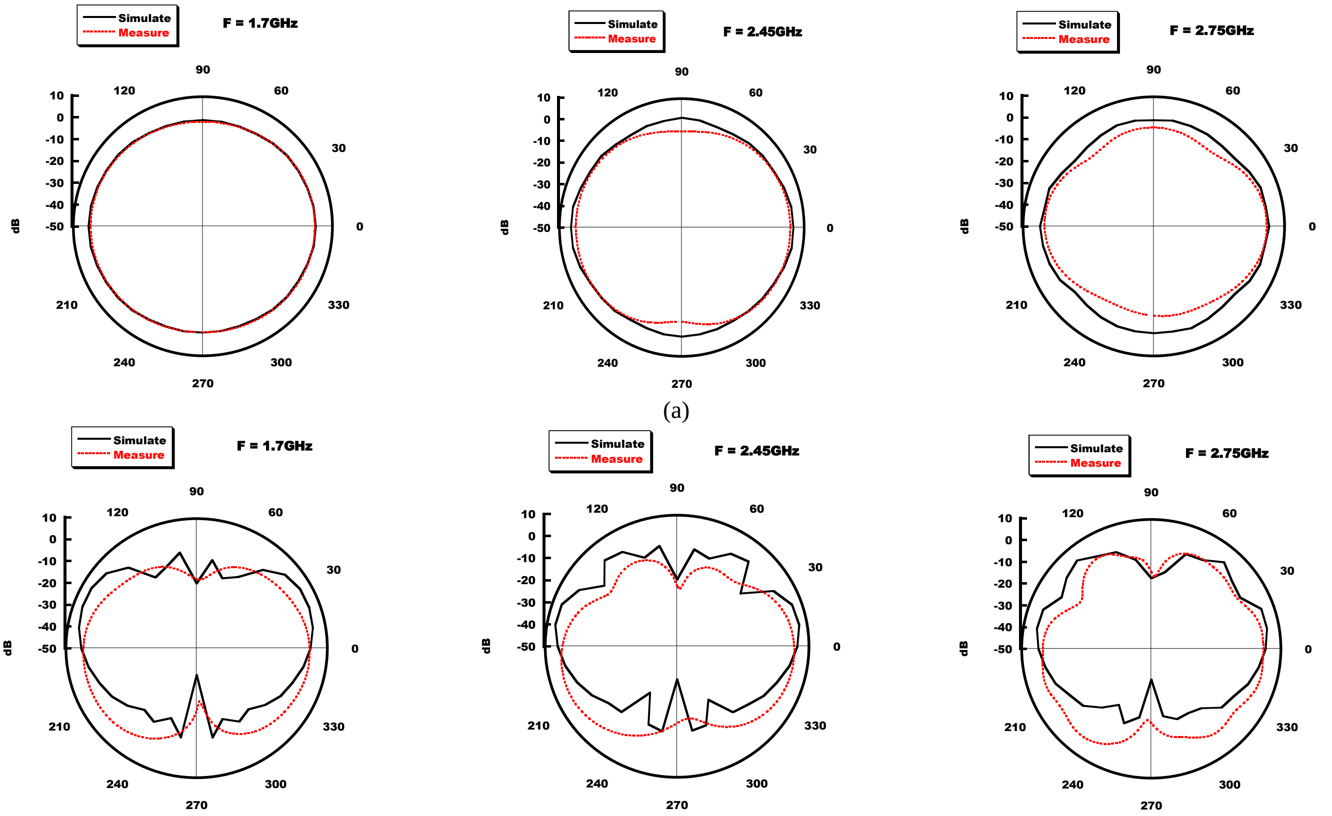
a- F_1= 1.7GHz b- F_2= 2.45GHz c- F_3= 2.75GHz

Figure 9. Simulated current distribution (Microstrip Access)



a- F_1= 1.7GHz b- F_2= 2.45GHz c- F_3= 2.75GHz

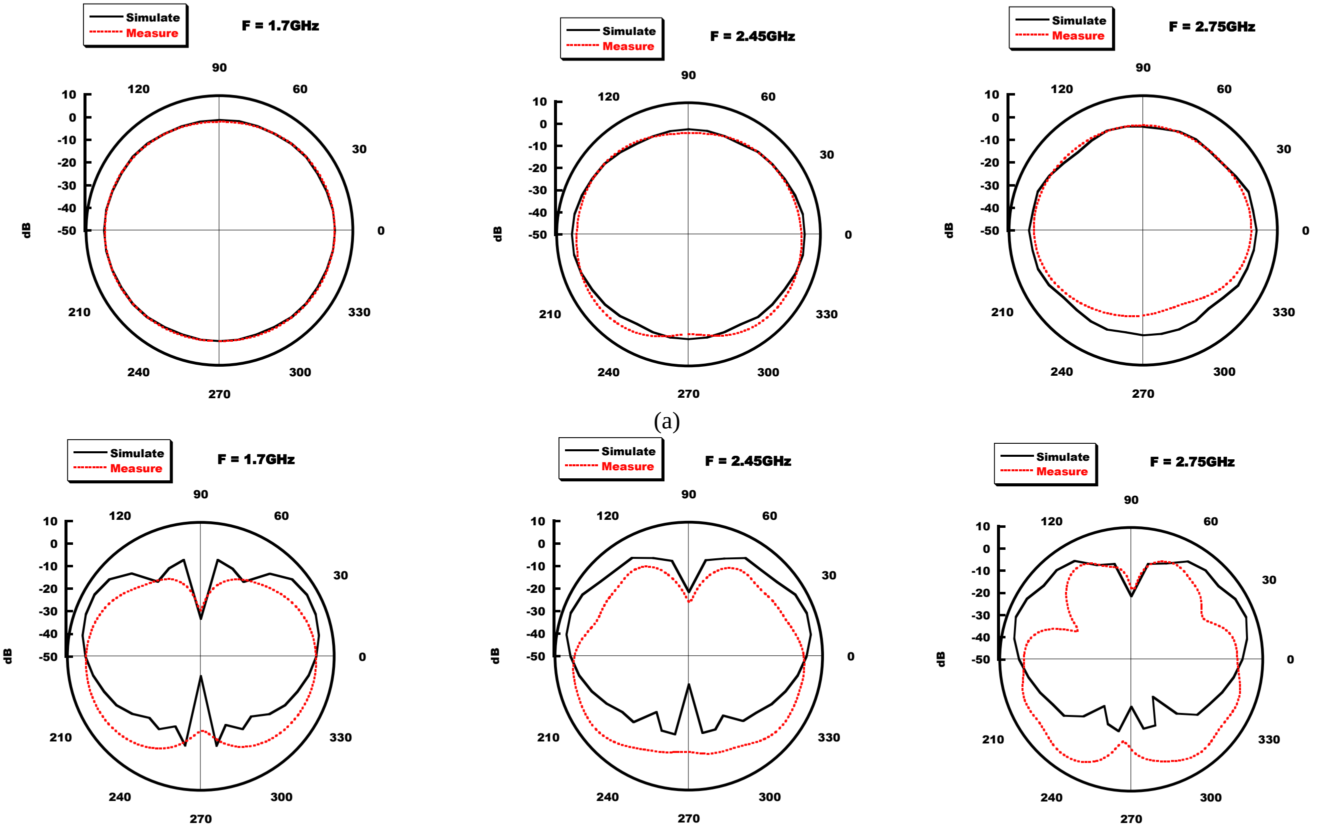
Figure 10. Simulated current distribution (CPW Access)



(a)

(b)

Figure 11. Simulated & Measured radiation patterns at resonant frequencies 1.7GHz, 2.45GHz and 2.75 GHz (Microstrip access): (a) (X-Z) plane, (b) (Y-Z) plane.



(a)

(b)

Figure 12. Simulated & Measured radiation patterns at resonant frequencies 1.7GHz, 2.45GHz and 2.75 GHz (CPW access): (a) (X-Z) plane, (b) (Y-Z) plane.

However, due to the difference between the measured and simulated results especially at low frequencies, the simulation was performed and the SMA connector was introduced in our project for both antennas as shown in Figure7. Figure 8 illustrates both measured and new simulated results of return losses for these structures.

As can be seen, an excellent conformity between the simulation and the measurement can be observed for both antennas, which confirm the effect of the SMA connector at low frequencies.

To complete study of far field performance of the proposed antennas, from return loss results in Figure 8, simulated current distribution at three resonant frequencies was illustrated in Figure 9 and Figure 10 respectively for the microstrip and coplanar wave-guide (CPW) access antennas. As can be seen, w obtained the same profile for these resonant frequencies.

The measured far-field radiation patterns of the both prototypes; picked in an anechoïd chamber; in the (X-Z) and (Y-Z) planes, at the resonance frequencies 1.7 GHz, 2.45GHz and 2.75GHz, are shown in Figure 11 and Figure 12 for respectively the microstrip-access and CPW-access antennas. The proposed structures exhibit nearly omnidirectional radiation pattern within their working frequency band especially in the (X-Z) plane.

Also, good agreement between the simulated and measured radiation patterns for the two structures at all frequencies. The maximum gain values are obtained for f1 = 2.45GHz (Gmicrostrip = 3.15dBi & GCPW = 2.72dBi) mainly in the (Y-Z) plane.

IV. CONCLUSION

In this paper, a wideband Circular-modified patch antenna with two feeding lines (microstrip access & CPW access) aimed at several wireless services, especially medical telemetry, is designed and fabricated. The improvement of it impedance matching was verified and discussed. A reduced size was obtained by optimizing the global geometry of the antennas especially the feed line, whereas a broadband behaviour was achieved mainly by modifying the shape of the resonant element and using a reduced rectangular ground plane. It was verified that the gap distance has an influence on broadband impedance matching; a typical value is 1mm. The fabricated antennas exhibit a good impedance matching that extend from 1.14 GHz to 4.5GHz and from 1.16GHz to 4.311GHz, respectively for the Microstrip and CPW fed antenna, with a significant gain which can reach 3.15dBi. Also, the size reduction for the substrate-width with the CPW access is acceptable (12.6% of size reduction in comparison with the microstrip access, and 17.4% compared to the Bell-Form).

Their wide impedance bandwidth, relatively high gain, satisfactory radiation characteristics, low fabrication cost, easy integration and simple feeding make these antennas good choices for many communication systems, particularly biotelemetry. But despite all this advantages, the difference between the simulation and measurement results due to the SMA connector as it was observed in this work, remain the major limitation of these structures especially at the lower frequency band. So, this discrepancy must be improved in the future work to include all WMTS bands.

REFERENCES

[1] M.S. KAROUI, Etude, conception et réalisation des antennes réceptrices large bande pour la biotélémétrie, *Doctoral dissertation*, University of Sfax.

[2] C. A. BALANIS, *Antenna theory analysis and design*, John Wiley & Sons, Inc, second edition 1997.

[3] FCC, Ultra-WideBand operation FCC report and order, Technical report US 47 CFR Part 15, FCC (Federal Communication Commision), 2002.

[4] S. TOURETTE, N. FORTINO, G. KOSSIAVAS, Compact UWB printed antennas for low frequency applications matched to different transmission lines, Microwave and optical technology letters, vol 49, No.6, June 2006.

[5] K. P. RAY, Y. RAMGA, Ultrawideband printed elliptical monopole antennas, IEEE transactions on antennas and propagation, vol. 55, No. 4, Avril 2007.

[6] R. ESHTIAGHI, R. ZAKER, J. NOURONIA, C. GHOBADI, UWB semi elliptical printed monopole antenna with subband rejection filter, International journal AEU of electronics and communications, ELSEVIER, 2009.

[7] X. ZHANG, W. WU, Z.H. YAN, J. B. JIANG, Y. SONG, Design of CPW-Fed monopole UWB antenna with a novel notched ground, Microwave and optical technology letters, vol 51, No.1, January 2009.

[8] D. TRAN, F.M. TANYER-TIGREK, A. VOROBYOV, I.E. LAGER, L.P. LIGTHART, ″A novel CPW-fed optimized UWB printed antenna″, Proceeding of the 10th European conference on wirless technology, Munich GERMANY, October 2007.

[9] J. LIANG, C.C. CHIAU, X. CHEN, C.G. PARINI, Printed circular disc monopole antenna for ultra-wideband applications, Electronics letters, vol.40, No. 20, 30 September 2004.

[10] H. RMILI, J. M. FLOC'H, Design and analysis of wideband double-sided printed spiral dipole antenna with capacitive coupling, Microwave and optical technology letters, vol 50, No.5, May 2008.

[11] A. K. SHACKELFORD, K. F. LEE, K. M. LUK, Design of small size wide-bandwidth microstrip patch antennas, IEEE antennas and propagation magazine, vol. 45, No. 1, February 2003.

[12] R.M. VANI, S.F. FARIDA, P.V. HUNAGUND, A study on rectangular microstrip antenna with group of slots for compact operation,Microwave and optical technology letters, vol 40, No.5, 5 March 2004.

[13] S.D. Baker, S.W. King, et J.P. Welch, Performance measures of ISM-band and conventional telemetry, IEEE Engineering in Medicine and Biology Magazine, 23(3):27--36, May/June 2004.

[14] Federal Communications Commission (FCC), Report and Order Amendment of Parts 2 and 95 of the Commission's Rules to Create a Wireless Medical Telemetry Service, FCC 00-211, 12 June 2000.

[15] M. S. KAROUI, H. GHARIANI, M. SAMET, M. RAMDANI, R. PERDRIAU, "Bandwidth Enhancement of the Square / Rectangular Patch Antenna for Biotelemetry Applications", International Journal of Information Systems and Telecommunication Engineering , Vol. 1, No. 1, pp. 12-18, February 2010.

[16] M. S. KAROUI, H. GHARIANI, M. SAMET, M. RAMDANI, "A CPW-Fed Wide Ban Bell-Form Antenna for Biotelemetry Application", Wulfenia Journal, Vol. 22, No. 5, pp. 83-89, May 2015.