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Antennas Design for Multistandard Terminals

Y. Belhadef and N. Boukli Hacene

Laboratoire de Télécommunications, Département de Télécommunication,
Faculté des Sciences de l'Ingénieur, Université Abou-Bekr Belkaïd-Tlemcen,
BP 230, Pôle Chetouane, 13000 Tlemcen-Algerie

Abstract: The present work relates to the antenna design for mobile terminals. It's about PIFA antennas (Planar Inverted- F- Antenna). The modification of the certain existing structures geometrical forms allowed the operation of those according to current standards. The design is performed by using the SuperNEC and HFSS simulators. The conception of four antennas: broadband, Bi-band, tri-band and quadriband operating at resonant frequencies used in the different communications standards (GSM900, DCS1800, UMTS, WiMAX…), are presented. The obtained results show a very good matching at the desired frequencies with a weak congestion.

Key words: PIFA antenna · Broadband · Bi-band · Tri-band and quadriband antenna

INTRODUCTION

The miniature antenna or electrically small is since many years the many work object of development. Allow the antenna integration in the communicating objects with desired dimensions always more reduced. The multiplication of the future applications considered for this type of communicating objects contributes to intensify the research devoted to the reduction of the radiation structures size. The effectiveness and the size of those become a significant question. Moreover, the operation multiband covering the bands GSM900/DCS1800, UMTS and WiMAX… is another research subject in the telephone mobile industry [1-2].

Presentation of the Planar Inverted-F-Antenna (PIFA): The planar inverted F antenna (PIFA) is a post loaded rectangular microstrip antenna fed by a probe. It is called an inverted F antenna because the side view of this antenna for air dielectric resembles the letter F with its face down. The higher plate of PIFA antenna and the fed wire located at a corner of this rectangular plate can be determined approximately from [3].

PIFA Antenna Evolved Gradually from Two ILA and IFA antennas in order to overcome certain limitations in its preceding structure, as shown in the figure 1.

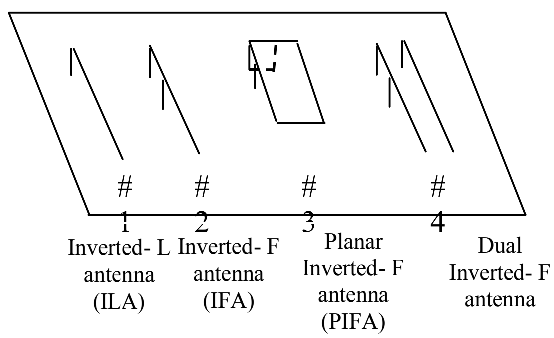


Fig. 1: The various geometries of inverted antennas.

The ILA antenna (Inverted -F antenna) consists of a short vertical monopole with the addition of a long horizontal arm at the top. Its input impedance is nearly equivalent to that of the short monopole with the addition of the reactance caused by the horizontal wire above the ground plane [4]. Generally, it is difficult to impedance match to a feed line since its input impedance consists of a low resistance and high reactance. Since loss due to mismatch decreases radiation efficiency, it is desirable to modify the structure of the ILA to achieve nearly resistive input impedance that is easily matched to a standard coaxial line.

The ILA structure is commonly modified by adding another inverted-L element to the end of the vertical segment to form the inverted-F antenna (IFA).

Corresponding Author: Y. Belhadef, Laboratoire de Télécommunications, Département de Télécommunication, Faculté des Sciences de l'Ingénieur, Université Abou-Bekr Belkaïd-Tlemcen, BP 230, Pôle Chetouane, 13000 Tlemcen-Algerie.

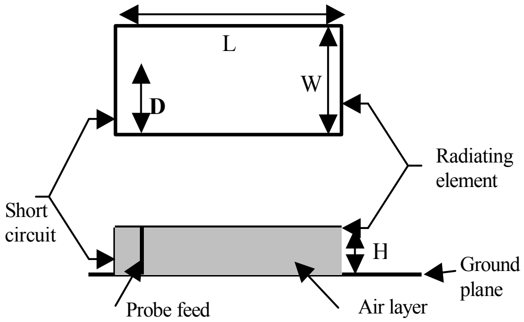


Fig. 2: The PIFA antenna structure.

The addition of the extra inverted-L element behind the feed tunes the input impedance of antenna. One disadvantage of an IFA constructed using thin wires is low impedance bandwidth. Typically, a single IFA element experiences an impedance bandwidth of less than 2% of the center frequency [4]. One way to increase the bandwidth of the IFA is to replace to top horizontal arm with a plate oriented parallel to the ground plane to form the planar inverted-F antenna (PIFA). This antenna, developed by T.Taga and T. Suneskawa [5], is used as an antenna reception on the standard mobile NTT (The Japeneese cellular telephony Network) as shown in the figure 2.

More usually called PIFA (Planar Inverted -F- Antenna) in the scientific literature, they have the advantage to be compact with a broad bandwidth.

The resonant frequency for this structure is calculated from the following formula:

$$Fr = c/4(H+L) \quad (1)$$

Where: c is the speed of the light
H is the height of the radiating element.
and L is the length of the radiating element.

Comparison of the Results with the Literature

PIFA Antenna for DCS Standard: The main goal in the antenna design is to widen the bandwidth in the bodies limited thickness of the mobile terminals. To satisfy these requirements, PIFA antenna is studied. The suggested structure [6], [7] was designed and simulated at 1800 MHz by using the SuperNEC software as well as the HFSS software which uses the finite element method. The PIFA antenna geometry is indicated on figure 3. The suggested design parameters for this structure are the following: L_1 = 0.035m, W_1 = 0.025m, W_0 = 0.0035m, H = 0.006m, A=B = 0.005m, L = 0.07m and W = 0.03m.

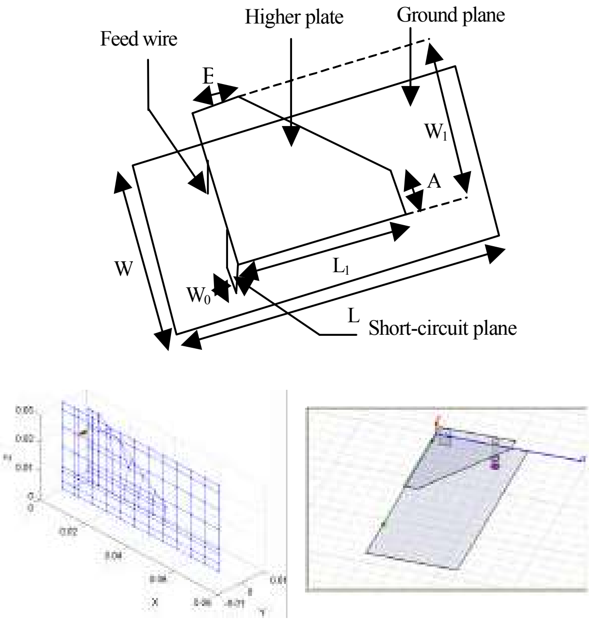


Fig. 3: PIFA antenna geometry and its structure in the SuperNEC and HFSS editor.

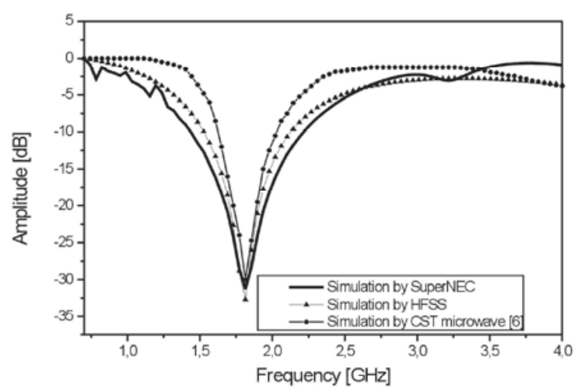


Fig. 4: The return loss.

The structure is studied using a non uniform rectangular cells grid forms in order to calculate the surface electric currents density. On figure 4, one presents the return loss of the simulated antenna by SuperNEC, HFSS and CST microwave [6].

The obtained results by SuperNEC, HFSS and CST microwave [6] are almost the same ones and show that the PIFA antenna is well matched at the resonant frequency 1800 MHz which covers the DCS band. The return loss magnitude presents a minimum at this frequency (equal-30 dB) witch corresponds to a null return loss.

Triband Antenna for the Mobiles Phones: Figure 5 shows the antenna [8] which is assembled on a ground plane of dimensions 0.08 X 0.036 m. The antenna comprises a main

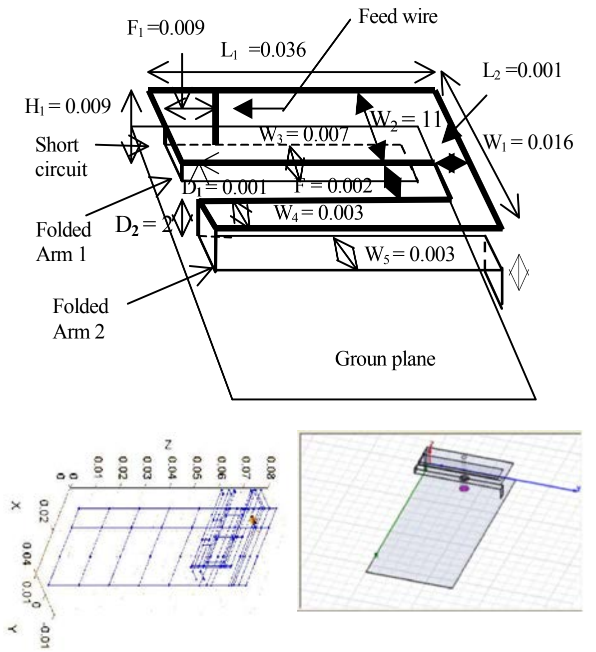


Fig. 5: PIFA antenna geometry and its structure in the SuperNEC and HFSS editor.

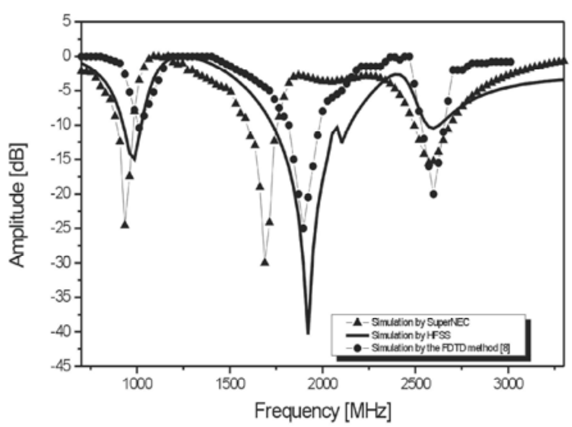


Fig. 6: The return loss.

plate in the top layer, a ground plane in the bottom layer, two folded arms downwards. The main plate is directly shorted to the ground plane by means of the shorting strip and fed via a feed wire connected to a 50 ohms transmission line. A rectangular slit is made in the main patch to divide it into two parts so as to generate a dual-frequency characteristic.

Afterwards the figure 5, the simulation of the planar antenna by three the design software gives satisfactory results. This miniature antenna covers three frequency bands according to the GSM/DCS/WiMAX standards, which makes it possible to integrate it in mobile phone handsets.

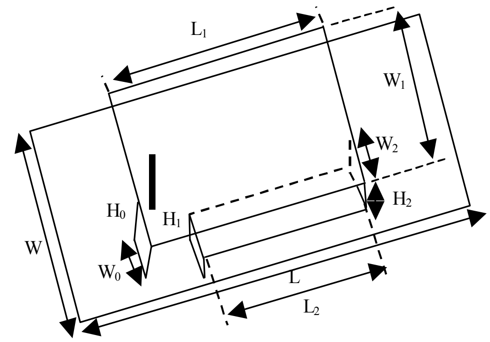


Fig. 7: PIFA antenna geometry for UMTS.

Proposed Antennas

Broadband Antenna for Technology UMTS: From the preceding antenna of figure 3, we folded part of the form L downwards radiating element to give another miniature antenna geometry integrable on small communicating objects as shows in the figure 3. Dimensions of this element are: L2=0.034m, W2=0.007m, H2=0.003m, H1=0.002m, W0=0.007m, L1 = 0.035m, W1 = 0.025m, L = 0.07m and W = 0.03m. The design is carried out using the SuperNEC simulator in three dimensions and using HFSS.

The downward radiating element folding is a type of capacitive loading inserted in the end of radiating element. It is a technique also used to have a miniature antenna. The use of this capacitive loading presents a disadvantage of increasing the quality factor. The antenna operating yields a delicate matching and a bandwidth reduction. The interest to fold up the antenna is to reduce more the space congestion. On figure 8.(a) one presents the return loss of the simulated antenna by SuperNEC and HFSS.

The design of this structure leads to a miniature antenna and broad band (40% indicated by SuperNEC) which finds its application in the mobile systems of the third generation and precisely UMTS standard. Figure 8.(a) shows that the adaptation is well carried out since the return loss S11 reaches a level near to -33 dB at frequency 2110 MHz, therefore the return loss to the antenna entry is null.

On figures 8. ((b), (c)), one presents the radiation diagram in 2D and 3D polar coordinates.

In the plan E (φ = 0), we notice that the radiation diagram consists of two l obes, one of large opening and the other of small opening what means that the diagram is omnidirectional in a plane half on the other hand it is almost omnidirectional in the plan (φ=90). The layout in 3D gives a better exploration of the radiation diagram.

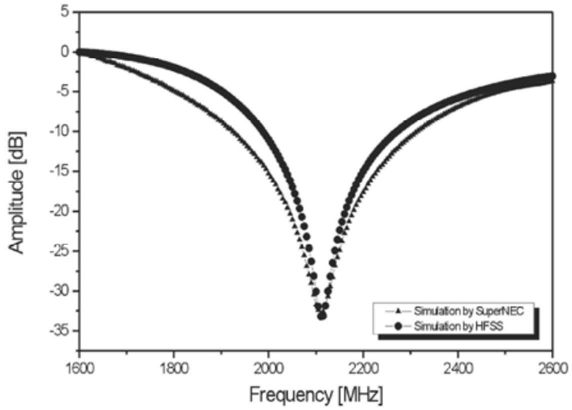
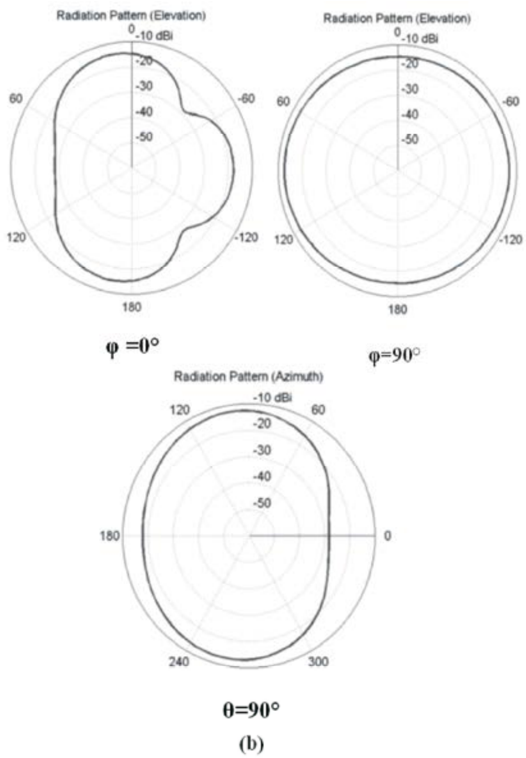
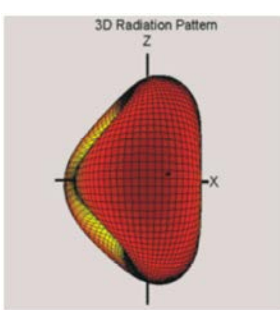


Fig. 8a: The return loss.





(c)

Fig. 8b: 2D radiation pattern at 2110 MHz
c: 3D radiation pattern at 2110 MHz

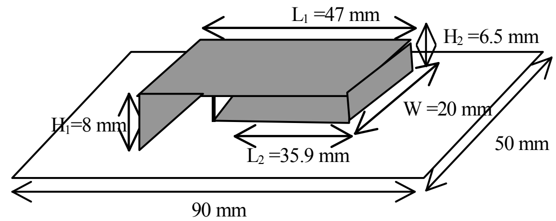


Fig. 9: Dual band antenna.

Bi-Band Antenna for Two Standards GSM/WiMAX: The dual band antennas are studied recently because of the request of a communication system which handles two protocols or different communication systems such as GSM, DCS, PCS, GPS etc. The structure of figure 9 presents a radiating element folded downwards. This antenna can potentially cover the two bands GSM and WiMAX.

The structure design suggested gives a bi-band antenna operating on two distinct frequency bands according to GSM and WiMAX standards. The presented results by two software (Figure 10.(a)) are almost identical and bring back to a perfect adaptation at the resonances frequencies.

On figures 10. ((b), (c)), one presents the radiation diagram in 2D and 3D polar coordinates.

For the plan φ=0 the radiation takes the two lobes shape. This resembles the diagram of the preceding figure. For the plans φ=90° and θ=90° one observes that the radiation is almost omnidirectional. In the same way into present the radiation diagram in 3D at frequency 3170 MHz.

Tri-bands Antenna for the Standards GSM/ UMTS/ WiMAX: The cellular telephone with multiple frequency bands is necessary for the frequency spectrum limitation. The standards GSM/UMTS/WiMAX are available for the majority of the communication service suppliers. The antenna with these multiple bands is required for the cellular telephone manufacturers. The antenna geometry proposed is presented in figure 11. It is obtained by modification of the figure 9.

On figure 12.(a), one presents the return loss variations according to the frequency.

We propose a simulated PIFA structure at three different resonance frequencies which finds its application in three distinct systems correspond respectively to GSM/UMTS/WiMAX. The design was carried out by SuperNEC and HFSS. The results obtained indicate that the conceived structure is well adapted and can be used on a rather broad frequency band.

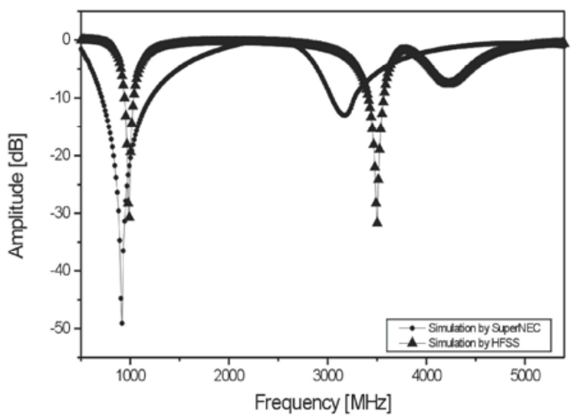
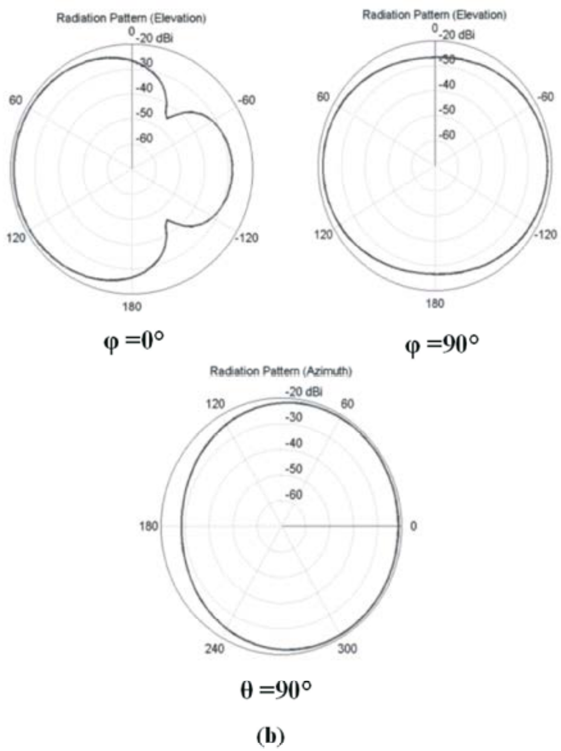


Fig. 10a: The return loss.



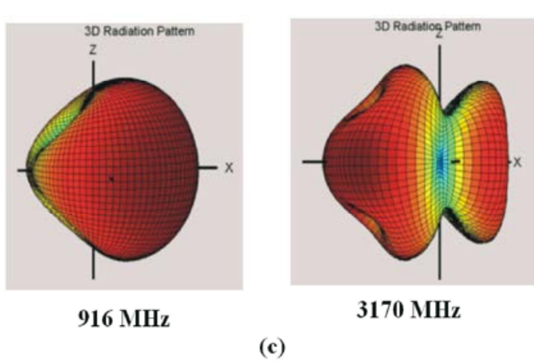


Fig. 10b: 2D radiation pattern at 916 MHz

c: 3D radiation pattern at 916 MHz and 3170 MHz.

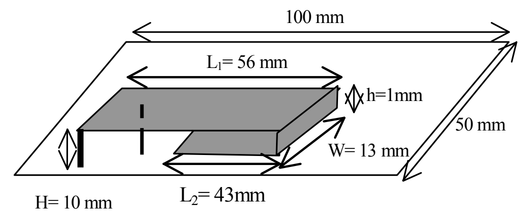


Fig. 11: Tri-band antenna.

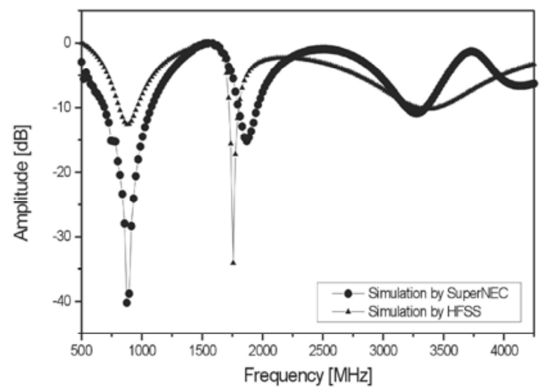


Fig. 12a: The return loss.

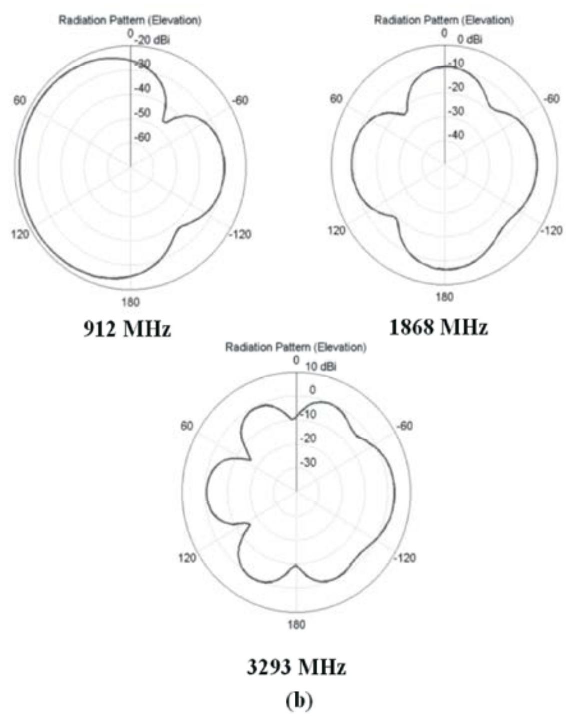


Fig. 12b: Radiation diagram for the plan E

On figures 12. ((b), (c)), one presents the radiation diagram in 2D (plane E) and 3D polar coordinates.

In the plan E, for the frequency 912 MHz the r adiation diagram consists of two different openings lobes; on the other hand for frequencies

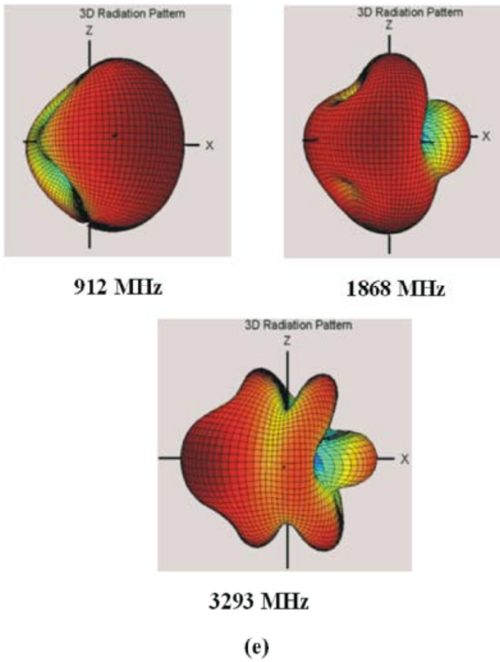


Fig. 12c: Radiation diagram in 3D.

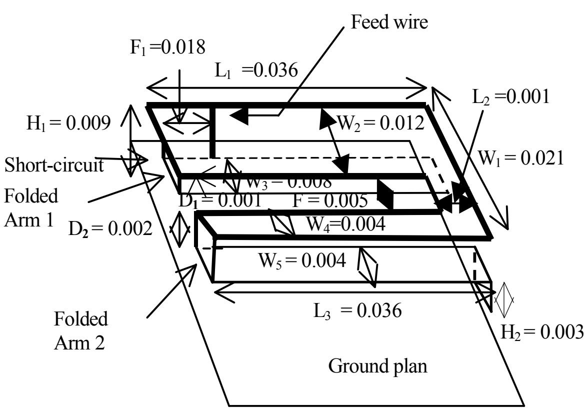


Fig. 13: Quadriband antenna structure.

1868 and 3293 MHz the diagram consists of four and six lobes respectively with slightly similar openings.

Quabriband Antenna: It is advisable to develop the compact aerial, conserved low thicknesses of good performances in adaptation terms and radiation effectiveness. Moreover, the multi-bands antennas concept became necessary because it makes it possible to gather several functions in the same radiating structure. This last solution makes it possible to reduce the aerial number and to cure the obstruction and cost constraints. The suggested PIFA structure is conceived from that of figure 5, by modifying certain dimensions of the antenna in order to change its operation.

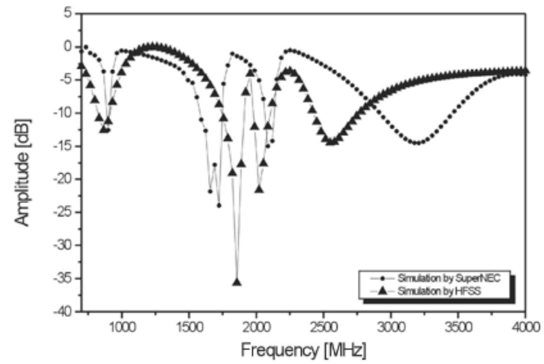


Fig. 14a: The return loss.

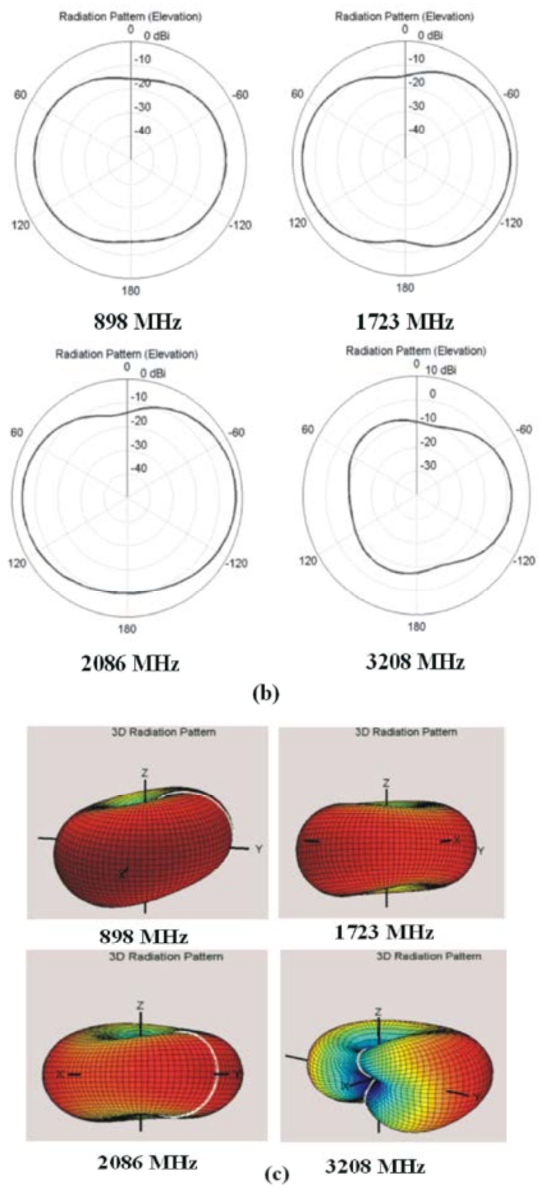


Fig. 14b: Radiation diagram for the plan E
c: Radiation diagram in 3D.

On figure 14.(a), one presents the return loss variations according to the frequency.

This structure simulation allows achieving a quadriband antenna operating in multi-standards (GSM/DCS/UMTS/WiMAX). A good matching is obtained for the chosen frequencies.

On figures 14.((b), (c)), one presents the radiation diagram in 2D and 3D polar coordinates.

On figure14.(b), the radiation diagrams are almost omnidirectional in the plan E.

CONCLUSION

In this paper, we presented several antennas structures which can be integrated on mobile handsets allowing receiving several mobile telecommunications standards. The modification of the certain existing structures geometrical forms allowed the operation of those according to current standards. The designed of four PIFA antennas allow to function respectively to the standards UMTS, GSM/WiMAX, GSM/UMTS/WiMAX and GSM/DCS/UMTS/WiMAX. The design was made using the SuperNEC designs software and HFSS. A good agreement was obtained between the various results. Those translate a good matching to the desired frequencies with a more reduced congestion.

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