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Design of a Bibands, Tribands and Quadribands Slotted PIFA Antennas

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Abstract: Currently, the majority of the mobile phones operate with integrated Bi-bands, tri-bands and/or quadribands antennas. In this paper, new configurations of slotted PIFA antennas simulated at different frequencies and which can be integrated in mobile handsets are proposed. The design tool is the CST Microwave Studio software which uses the finite integration method (FIT). The several parameters modification of the initial antenna gives multibands structures. The found radioelectric results show that the simulated structures are well adapted to the desired resonant frequencies.

Key words: Slotted PIFA Antenna · Bi-Bands · Tri-Bands · Quadribands · Radioelectric Response

INTRODUCTION

With the development of the wireless communications, the wireless communication systems progress with the varieties of the various sizes of the small devices held in the hand with the telephone networks [1- 4]. In this article, we study a miniature antenna, easily integrable and with a weak cost. It is about the planar inverted F antenna (PIFA) whose topology and the low dimensions make it possible to integrate it on various supports or in communications modules of small sizes [5, 6]. The PIFA antennas and the microstrip antennas are largely widespread in wireless devices since they can be easily integrated in the wireless handsets [7-9].

The interest for the multi-bands antennas is in perpetual growth, in particular with the aim of reducing the antenna number embarked by associating several applications on the same antenna [10, 11]. The integrated antenna in the portable phone must be adapted to each frequency according to the telephone network to cover. Indeed, the large majority of the integrated multibands structures into the mobile handsets rest on a type PIFA element to which significant modifications are brought (insertion of slits, the addition of short circuits between the radiating element and the ground plane…) [12,14-18],

Initial Antenna Structure: The design of the multibands PIFA antenna combines a conventional PIFA antenna with the patchs coupled capacitively and a pair of L form radiating element is configured on the two substrate ends. The first patch is attached to a 50Ω microstrip feed line by a strip of size 2 x 25mm and the second patch is made of a C form slot related to the substrate by a short-circuit strip. The width and the height of the short-circuit strip are 5mm and 31 mm respectively. This feeded structure is very similar to the design suggested in [13]. In this prototype, the microstrip line is printed on a substrate FR4. The thickness substrate is 1.6 mm and its dielectric constant is 4.4. The entire antenna elements are located above a ground plane of fixed size 158 x54 mm. The details of the design of antenna and its typical characteristics are presented in figure 1.

The values of the various parameters of the initial antenna, in millimeters, are given in table 1:

The following figure presents the initial antenna on the CST Microwave Studio editor.

On figures 3 - ((a), (b), (c)), one respectively presents the return loss, the real part and the imaginary part of the input impedance of the simulated antenna.

We remark that the return loss has a minimal value lower than -53 dB at the resonant frequency 1.146 GHz which gives a very good adaptation.

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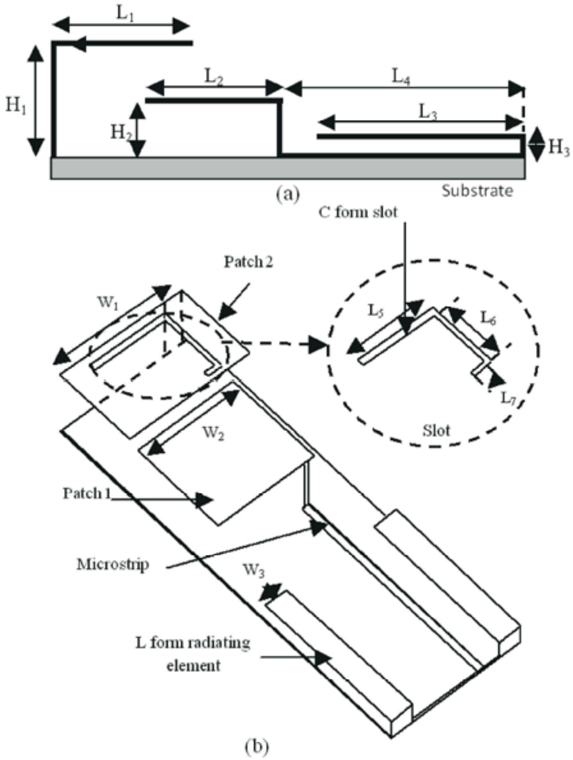


Fig. 1: Structure of the initial antenna.
(a)-Transversal view (b)- front view

Table 1: Parameters dimensions of the initial Antenna

Parameters	Dimensions
L_1	35
L_2	40
L_3	61
L_4	103
L_5	46
L_6	30
L_7	27
W_1	54
W_2	44
W_3	4
H_1	31
H_2	25
H_3	10

The impedance bandwidth is then 6.29 %. We also measured the value of the real part of the input impedance. It is well equal to 98 ohms and that the imaginary part is null.

Proposed Structure: We now propose structures which present a multibands operating starting from the initial antenna. The principal modified parameters are: the size of the C form slot, the size of the patch number 1, the feed

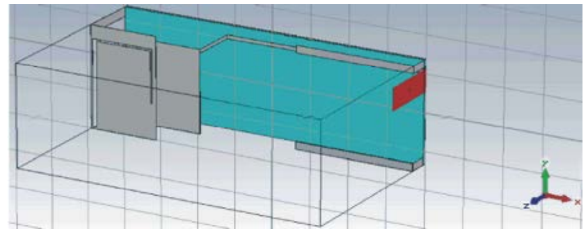
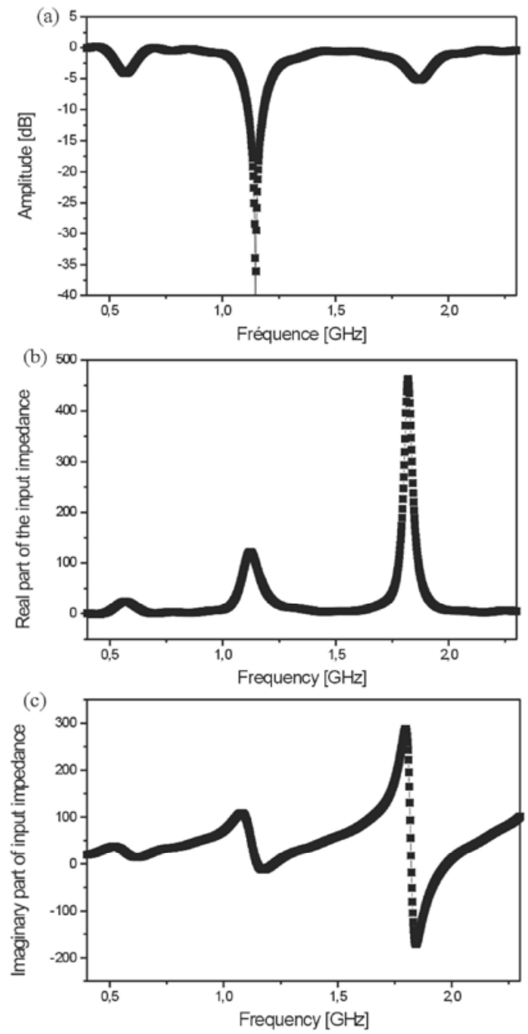


Fig. 2: Structure of the initial antenna on the CST Microwave Studio editor



Figu. 3: (a): Return loss. (b): Real part of the input impedance. (c): Imaginary part of the input impedance

position which is located at the substrate medium and the addition of two shorts-circuit at the ends of the patch 1. Figure 4 gives the general shape of the proposed antenna. The changes carried out on the initial antenna and the obtained results are presented on the following figures and tables.

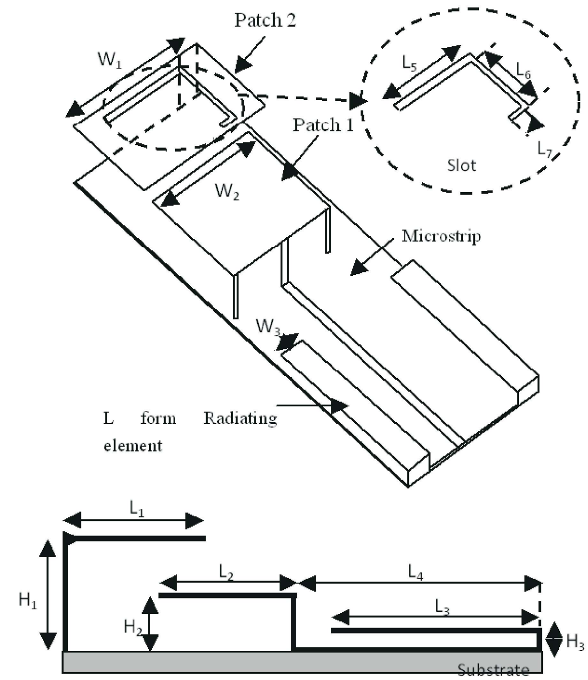


Fig. 4: General structure of the proposed antenna

Table 2: Parameters dimensions of the Bi-band antenna

Paramètres	Dimensions
L_1	35
L_2	40
L_3	61
L_4	103
L_5	46
L_6	30
L_7	28
W_1	54
W_2	44
W_3	4
H_1	24
H_2	16
H_3	10

The changes of the principal elements of the Bi-band antenna are: L7 = 28mm, H1 = 24 mm, H2 = 16 mm, the width of the microstrip line which becomes equal to 3 mm and the addition of two shorts-circuit at the ends of the patch 1 with a width of 2 mm. All dimensions of the Bi-bands antenna are shown in the Table 2.

For the tri-band antenna the modified parameters are: L2 = 41mm, L4 = 101mm, L7 = 32 mm and W2 = 18mm. The all parameters dimensions of the antenna used to obtain a tri-band system are shown in table 3.

Table 3: Parameters dimensions of the Tri-band antenna

Paramètres	Dimensions
L_1	35
L_2	41
L_3	61
L_4	101
L_5	46
L_6	30
L_7	32
W_1	54
W_2	18
W_3	4
H_1	24
H_2	16
H_3	10

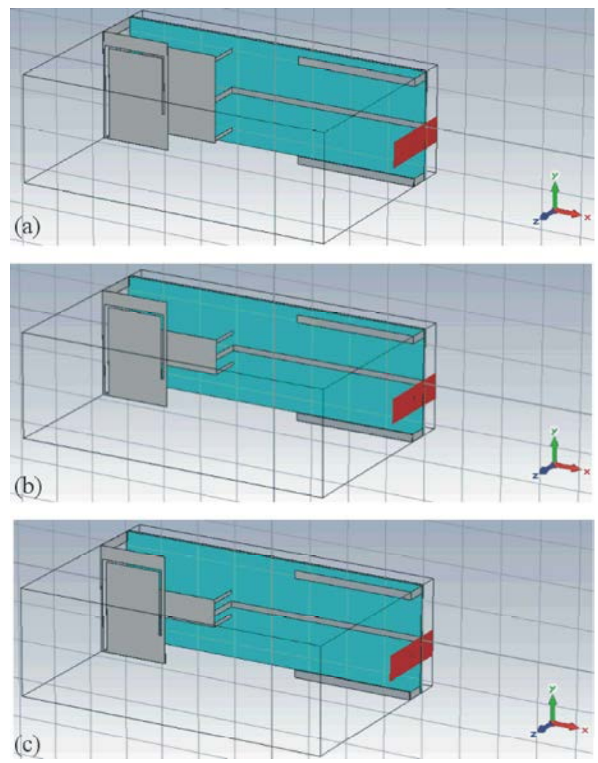


Fig. 5: Structure of the multiband antenna on the CST Microwave Studio editor.
(a): Bibands antenna (b): Tribands antenna (c): Quadribands antenna

For the last proposal antenna, we changed only the width W1 (W1 = 14 mm) of patch 1 to have a quadriband antenna starting from the tri-band antenna.

On the following figure one presents the three structures proposed: Bi-bands (a), tri-bands (b) and quadribands (c) on the CST Microwave Studio software editor.

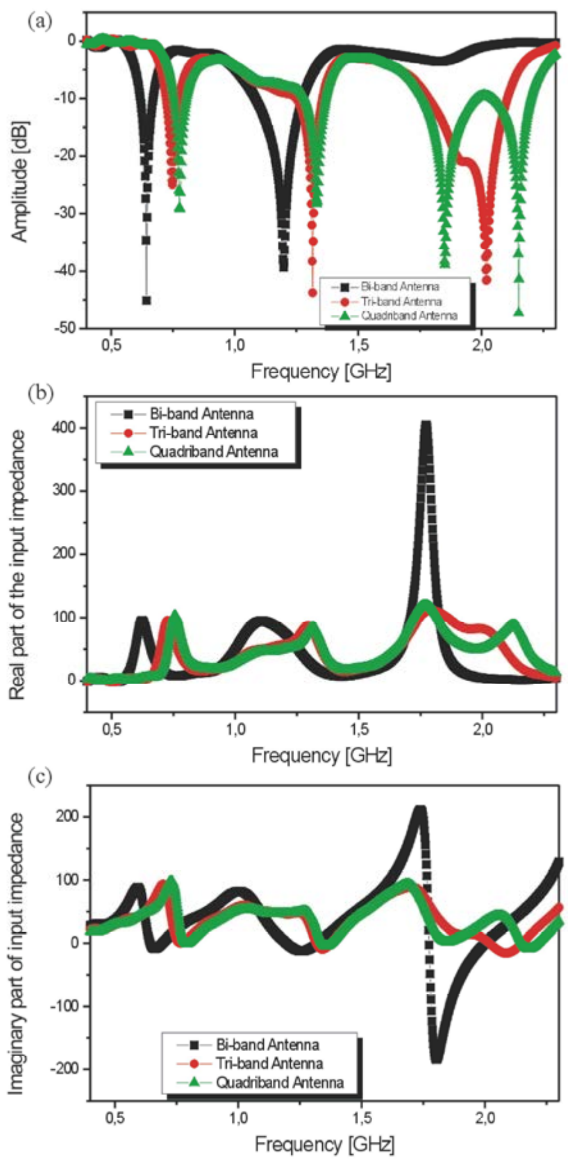


Fig. 6: (a): Return loss. (b): Real part of the input impedance. (c): Imaginary part of the input impedance.

On figures 6 - ((a), (b), (c)), one respectively presents the return loss, the real part and the imaginary part of the input impedance of the three antennas Bi-bands, tri-bands and quadribands proposed.

The simulation results of the Bi-band antenna show that the return loss gives two peaks with levels equal to the -45 dB and -39.3 dB for the two resonant frequencies 0.643 and 1.198 GHz respectively. The impedance bandwidth for these frequencies is 8.27 % and 16.6 % respectively. Therefore, we note that the real part of the input impedance is equal to 74.3 and 76 ohms at the two resonant frequencies respectively and the imaginary part is almost null. Thus, the adaptation is completely realized.

Figure 6.(a) shows that the return loss presents three peaks of -24.95 dB, -43.74 dB and 41.6 dB obtained at the resonant frequencies 0.747, 1.315, 2.018 GHz respectively. The bandwidth for these three frequencies is about 7.37 %, 9.09 %, 16.28 % respectively. For the real part of the input impedance, one notes that it is well equal to 74.5, 78, 80 ? for the three resonant frequencies, the reflexion at the entry of the antenna is null.

For the quadriband antenna, it appears well adapted to the resonance frequencies 0.778, 1.33, 1.85 and 2.15 GHz. The peaks of return loss of -29.17, -28.27, -38.87 and -47.29 dB are observed for these frequencies respectively. One note that a bandwidth of 6.84%, 6.98%, 13.34% and 8.66% for each resonance frequency respectively is obtained. Real and imaginary part of the input impedance presented on the figures 4.((b), (c)), gives a well adaptation of the quadriband antenna which finds its application in cellular systems GSM, MBWA, DCS and UMTS.

CONCLUSION

In this article, we presented antenna structures operating in several telecommunications standards, intended for applications in mobile and wireless communications. The design of certain miniature antennas of type PIFA allowed the operation of those according to current standards. The proposed structures give the Bi-bands, tri-bands and quadribands antennas operating on distinct frequency bands according to the various standards.The presented results show a good adaptation to the resonances frequencies.

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