A method to miniaturize antenna structure for the 3G mobile device

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Abstract - **This paper presents a miniaturization method of planar inverted F antenna structure by folded monopole antenna placed on FR4 dielectric. The proposed antenna comprises compact size (23 × 14 × 5 mm3), easy to make and provide enough bandwidth, which covers 3G band (VSWR ≤ 2). Using the simulation program to optimize antenna structure and calculate the antenna parameters in order to verify its applicability for the 3G devices.**

Keywords - 3G; inverted F antenna; miniaturization of antenna.

I. INTRODUCTION

Currently, some practical demands such as compact size, thinness, lightweight for mobile devices have rapidly attracted high attention. In order to miniaturize the components of mobile devices, the method of antenna structure miniaturization is very important. Antenna miniaturization has been reported in a number of papers. As in [1], Davor Bonefacic proposed a design for a micro-strip antenna that works on central frequency of 2 GHz and has very small size (30 × 12.9 × 5 mm3) but the bandwidth of the proposed antenna is too narrow. Y. Kim [2] proposed a folded loop antenna system for new future handsets. M. Karaboikis [3] proposed a dual-printed inverted-F antenna diversity systems for terminal devices. K. Sarabandi [4] proposed a design of miniaturized size antenna as small as 0.05λ × 0.05λ. In [5], Mohammad Akbari presented an approach to optimize the antenna structure by creating a planar inverted F antenna (PIFA). However, the size of the antenna in [5] is still relatively large and faces a big difficulty in using for the MIMO system.

In this paper, the authors use Ansoft HFSS to analyze the planar inverted F antenna placed on a metallic plane that represents for a mobile device, with surveyed bandwidth from 1.8 GHz to 2.2 GHz (cover the 3G band: 1.9 GHz – 2.17 GHz). Then, to present a method of miniaturization F antenna structure, that can be placed in a portable device.

Next, in order to match the antenna input impedance with the feeder and to ensure its bandwidth must be wide enough to cover the 3G network band, the proposed antenna structure is optimized. Finally, the antenna parameters such as input impedance, VSWR, radiation pattern are calculated to validate the applicability of the antenna in 3G devices.

II. A METHOD OF MINIATURIZE ANTENNA STRUCTURE FOR 3G MOBILE DEVICES

A. *The structure of the 3G mobile devices*

Normally, the mobile devices have the width and the length of 60 mm and 110 mm, respectively. Its thickness is about 12 mm. Currently, the 3G mobile system of Vietnam works on frequencies from 1.9 GHz (uplink) to 2.17 GHz (downlink). The design of the antenna for these devices should take the working frequency bandwidth and the requirement on antenna compact size into account.

The goal of the antenna design must be a small size antenna pattern that can cover the whole bandwidth for the uplink and downlink.

Thus, antenna miniaturization requirements for 3G mobile devices have to ensure the following parameters:

- The antenna size must be small enough to be placed in a mobile device, its height is less than 5 mm, its length and its width are less than 40 mm;
- The input impedance of the antenna can reach 50 Ω at the central frequency (to match perfectly with the feeder);
- VSWR ≤ 2;
- The bandwidth of the antenna is large enough: (≥ 10%, ≥ 200 MHz).

B. *Structure optimization method for inverted F antenna placed on a reflected plane*

Consider the inverted F antenna placed on a metallic plane that represents for a reflected plane, which can vary the current on the antenna by varying the distance between the feeding point and the connection point to the reflected plane. However, since the antenna must be small enough to be placed in a mobile device, based on the method of modifying and optimizing the geometry as in [6], we propose a structure on inverted F antenna on reflected plane as illustrated in Fig. 1.

Fig. 1(a) describes the overall antenna associated with the metallic plane, the whole antenna structure is fixed on a FR4 dielectric plate (ε = 4.4, tanδ = 0.02), the FR4 dielectric plate is placed at the above of the ground copper measuring 86 × 40 × 0.1 mm3. The size of the FR4 dielectric plate is 40 × 14 × 5 mm3.

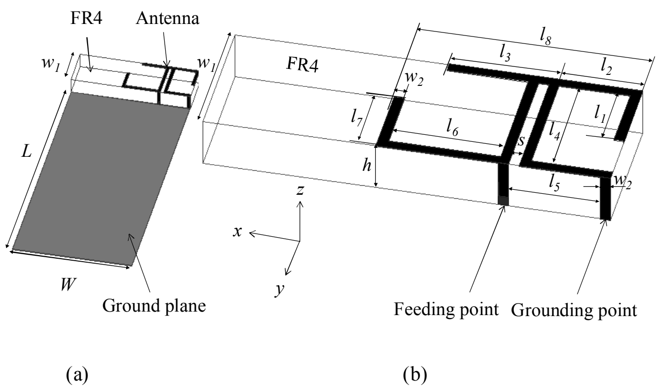


Fig. 1. Inverted F antenna placed on a metallic plane.

Antenna associated with the metallic plane in 2 points, such as the feeding point and the grounding point (the connection point to the metallic plane). This antenna structure as shown in Fig. 1(b), consists of copper strip-lines of width w_2 = 1 mm, thickness is 0.1 mm. The overall dimension of the antenna has been determined with l_8 = 23 mm (length), w_1 = 14 mm (width), and h = 5 mm (height). A gap between the feeding point and the grounding point is l_5 = 9 mm. Except for the strip-lines are connected to the metallic plane, other strip-lines are fixed on the dielectric plate and parallel to the ground. The size of the proposed antenna elements is shown in Table 1.

TABLE 1. THE SIZE OF THE INVERTED F ANTENNA AFTER OPTIMIZATION (MM)

Parameter	Value	Parameter	Value
L	86	l_2	8
W	40	l_3	11
h	5	l_4	12
s	1	l_5	9
w_1	14	l_6	11
w_2	1	l_7	7.8
l_1	7	l_8	23

Compared with the initial inverted F antenna structure, the proposed antenna has further two L shape which are formed by strip-lines l_1, l_2, l_6, l_7 and a U shape with the parameters of l_4 = 12 mm and s = 1 mm. The U shape, L shape strip-line will change the current distribution on the antenna, this in turn will change the antenna input impedance and therefore help the impedance matching with the feeder. Moreover, the optimized antenna expands bandwidth and ensures more compact size.

In the next step, the optimized antenna is investigated for the frequencies between 1.8 GHz and 2.2 GHz. Simulated results in the input impedance and VSWR of the proposed antenna are shown in Fig. 2 and Fig. 3, respectively. In Fig. 2, the antenna input impedance can reach approximately 45 Ω at the resonant frequency of 2.0 GHz. In Fig. 3, the optimized antenna bandwidth is 300 MHz (15 % compared with the central frequency), VSWR ≤ 2, therefore, the optimized antenna bandwidth covers the required bandwidth for 3G devices (270 MHz). This result shows that the proposed antenna structure has relatively wide bandwidth and can be applied to antennas for 3G mobile devices.

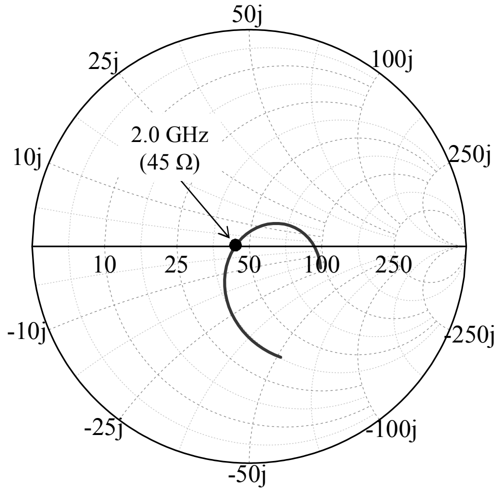


Fig. 2. Input impedence of the inverted F antenna after optimization.

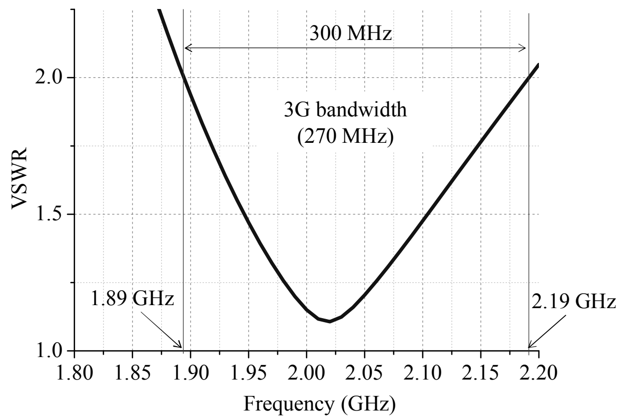
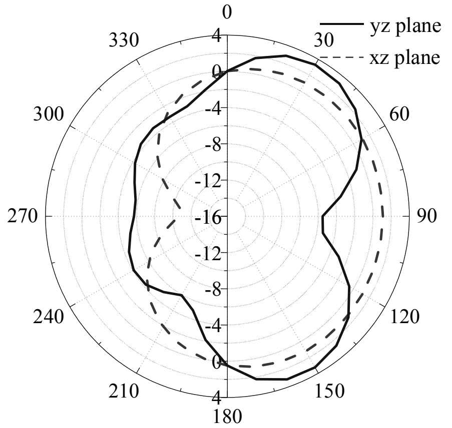
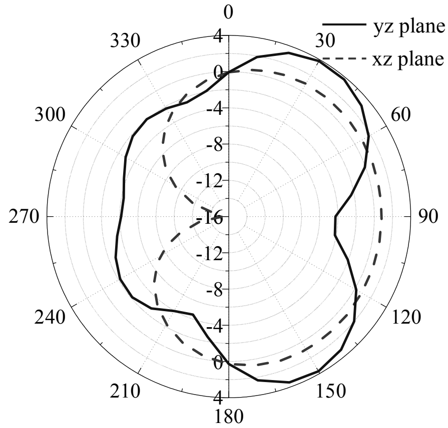


Fig. 3. VSWR of the inverted F antenna after optimization.

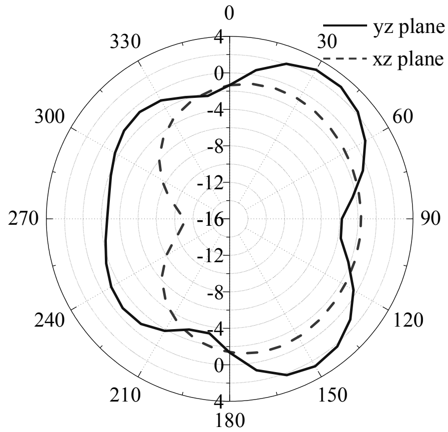
The radiation pattern in the xz and yz planes for the frequencies at 1.9 GHz, 2.0 GHz and 2.17 GHz are plotted in Figs. 4 (a), (b) and (c), respectively. The solid line to the yz plane, dashed to the xz plane.



(a)



(b)



(c)

Fig. 4. Antenna radiation pattern (a) f = 1.90 GHz, (b) f = 2.0 GHz, (c) f = 2.17 GHz.

It can be seen from Fig. 4 that the antenna can achieve its maximum gain in the yz plane. At the central frequency of 2.0 GHz, antenna gain reaches its maximum of 3.9 dBi.

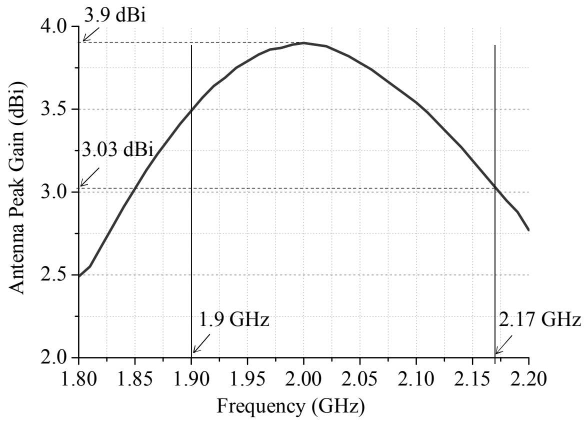


Fig. 5. Antenna maximum gain in yz plane.

The peak gain of the antenna within the working frequency bandwidth is shown in Fig. 5. From the figure, everyone can see that the antenna gain is relatively equal and is greater than 3 dBi in the whole bandwidth of the device.

III. CONCLUSION

This paper presents a method of miniaturization antenna structure for 3G devices by using planar inverted F antenna. Some achieved results are:

i) Compact antenna structure (23 × 14 × 5 mm3).

ii) Broadband 300 MHz (15%, VSWR ≤ 2) and covers the 3G bandwidth.

iii) Gain is relatively equal and is greater than 3 dBi in the whole bandwidth of the 3G device.

In the future, the authors continue to miniaturize the antenna structure to reduce the antenna thickness while ensuring the bandwidth requirements and other technical parameters.

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