VNU Journal of Science: Comp. Science & Com. Eng. Vol. 31, No. 1 (2015) 55–59

Dual-band Microstrip Antenna for 4G-LTE Handheld Devices

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Abstract

The evolution of wireless technology has grown dramatically. In recent years, the fourth generation, 4G-LTE, has been implemented. The 4G expansion firstly demands to construct infrastructures and devices of 4G systems, in which the antenna is an essential part of 4G devices, especially mobile phones. The antenna has to be designed to meet both frequency bands for this new technology and limited size to fit the required housing. All over the world, there are different frequency bands allocated for 4G. Therefore, the multi-band antennas would be very useful.

In this paper, a dual-band antenna that works at 1780 MHz and 2610 MHz has been proposed for 4G-LTE handheld devices. The antenna has been designed on FR4 substrate with sizes of 20 mm × 50 mm × 1.2 mm to fit the mobile casing. The simulation and measurement results of both return loss and radiation patterns have also been presented. Very good agreement between simulated ans measured data has been obtained.

Manuscript communication: received 14 January 2015, revised 09 March 2015, accepted 21 March 2015
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Keywords: dual- band antenna, 4G-LTE, microstrip antenna.

1. Introduction

4G-LTE, developed by the 3^{rd} Generation Partnership Project, is a standard for wireless data communications technology and an evolution of the previous standards. The goal of 4G technology is to increase the capacity and speed of wireless data networks using new DSP (digital signal processing) techniques and modulations. Currently, Vietnamese Network Service Providers have already accomplished the 3G coverage and provision for users, and preparing to implement 4G technology. The Authority of Radio Frequency Management also planned to provide frequency bands for this standard to be used by mobile service providers in Vietnam as shown in Table 1.

Table 1: Allocated bands for 4G-LTE standard in Vietnam

4G-LTE bands	
Low frequency band	1785-1805 MHz or 1880-1990 MHz
High frequency band	2570-2575 MHz or 2615-2620 MHz

Due to the allocated frequencies, the antenna must be redesigned to meet these requirements. In the literature, antennas for 4G/LTE mobile phones have been designed with various shapes, sizes and purposes. A dual-band antenna for 4G/LTE handsets (700 MHz/2.5-2.7 GHz) with total size of 38 mm × 50 mm (for antenna) and 82 mm × 50 mm (for the ground plane) has been presented in [1]. This antenna has been designed using FR4-epoxy substrate (the permittivity ϵ_r =4.4) with size 120 mm × 50 mm, thickness h = 0.762. An antenna in [2] was designed for LTE 700 MHz applications using FR4-epoxy and thickness of h = 1.6 mm. In [3], a plannar antenna for WWAN/LTE on FR4 with size 75 mm × 10 mm, thickness h=0.8 mm, and 200 mm × 260 mm copper plate for system ground plane has been proposed. In [4], an antenna was

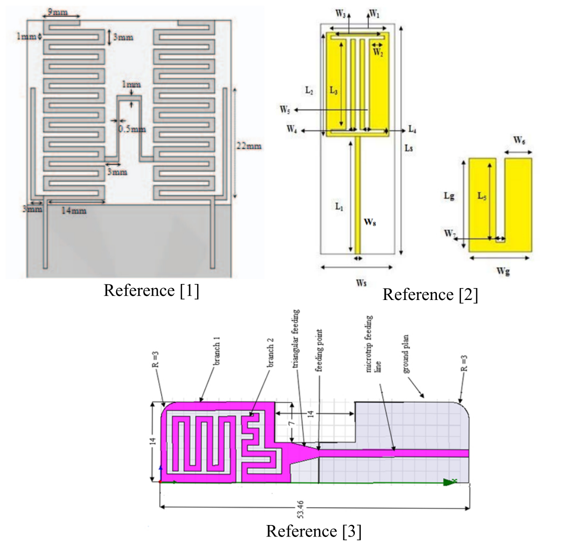


Fig. 1: Some antenna samples from literature

designed for LTE 700, GSM 850, 900, DCS 1800, PCS1900, UMIT and LTE 2300, 2500 UMTS on FR4 substrate (the permittivity ϵ_r=4.4) 120 mm × 60 mm × 0.8 mm and 34 mm × 12mm × 6.5 mm (for antenna). Reference [5] represented the antenna for multiband applications (LTE700/WCDMA/UMTS/WiMAX/WLAN). The antenna was placed on FR4 substrate ϵ_r =4.4) with the size of s1 = 112 mm × 50 mm, thickness h1 = 1 mm.

Recently, we also proposed a dual-band antenna on FR4 substrate with size 53.46 mm × 14 mm × 0.8 mm to be used in for 3G mobile handsets in Vietnam [6]. This is the starting point for the design of the 4G-LTE antenna described in this paper.

In this paper, a dual-band, omni-directional microstrip antenna for 4G-LTE handheld devices has been designed, simulated and fabricated. The antenna has ben placed on FR4-epoxy substrate, with thickness h=1.2 mm and the 2D size is 20 mm × 50 mm. The proposed sample opreates at lower band 1780 MHz and higher band 2610 MHz, with a peak gain at 2.64 dBi and 3.48 dBi, respectively. An antenna sample was then fabricated and measured in an anechoic chamber. Validation of the simulated and the measured data has been given.

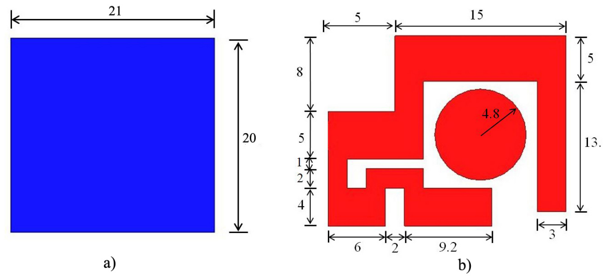


Fig. 2: Antenna design: a) bottom view and b) top view

2. Antenna Design

To obtain a dual-band, the antenna model has been designed with two appropriate folding branches. The design and simulation process together with the calculation formulas for each branch presented in [4] has been applied. The length of each branch was approximately $\lambda/4$. In addition, a circle has been added in the middle to achieve a higher gain. Finally, the patch antenna has been obtained with size of 20 mm × 50 mm × 1.2 mm, as given in Figure 2, while Figure 3 shows the designed antenna in 2D and 3D.

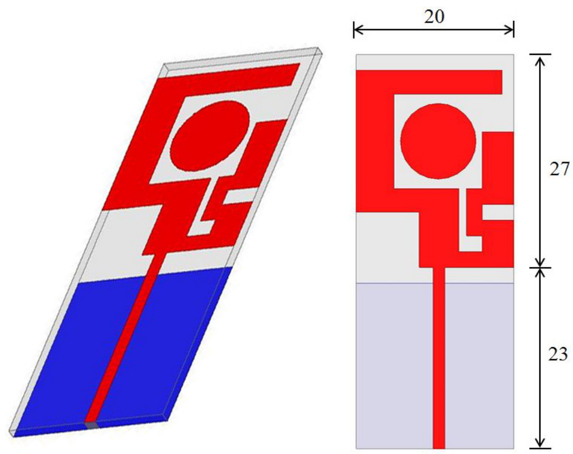


Fig. 3: The designed antenna in 2D and 3D

3. Simulation Results

The simulation has been performed by the interpolating solver within the commercial software HFSS.

3.1. Return Loss

Firstly, the simulated return loss of the designed antenna is presented in the Figure 6. As can be seen, a good return loss result has been achieved. The result indicates that the -15dB bandwidths cover the desired operation frequencies of 1780 MHz and 2610 MHz.

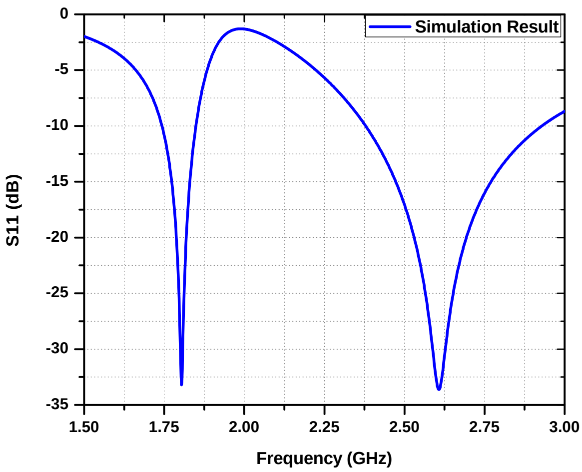


Fig. 4: Simulation result of return loss

The simulation result of the return loss is summarized in Table 2.

Table 2: Simualtion result of S_{11}

Parameters	Simulation result	
Resonant Frequency	1780 MHz	2610 MHz
Bandwidth (VSWR≤1.43)	60MHz (1.77GHz-1.83GHz)	298MHz (2.47GHz-2.77GHz)

3.2. Radiation Pattern

The simulation results of radiation pattern in E plane and H plane at 1780 MHz and 2610 MHz are given in Figure 5. As shown, the designed antenna has omnidirectional radiation pattern.

4. Antenna Fabrication and Measurement Results

In order to validate the design, the proposed antenna model has been fabricated using PCB. Figure 6 demonstrates the fabricated antenna.

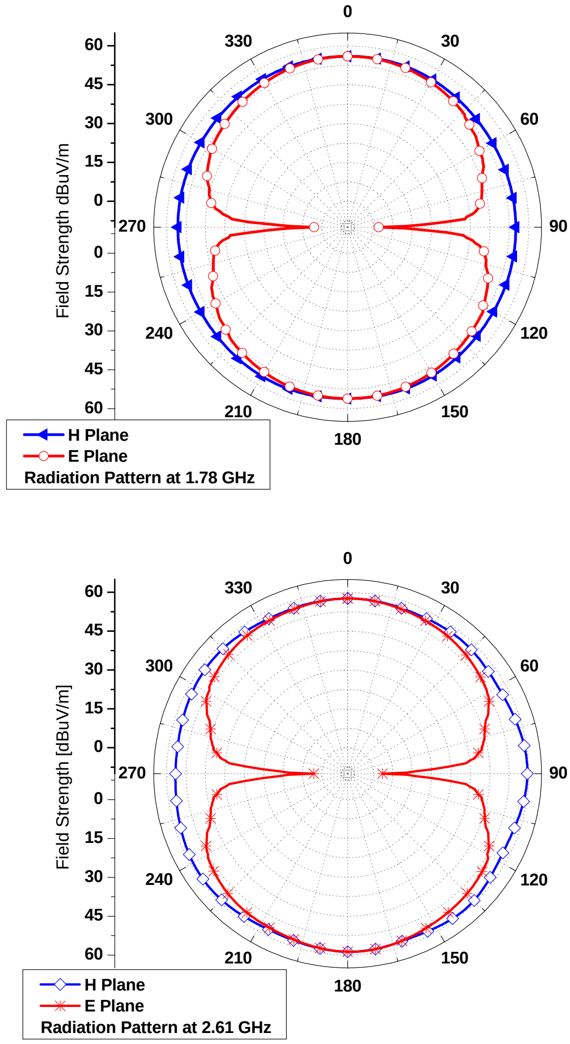
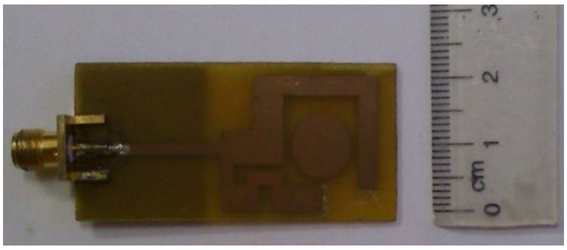


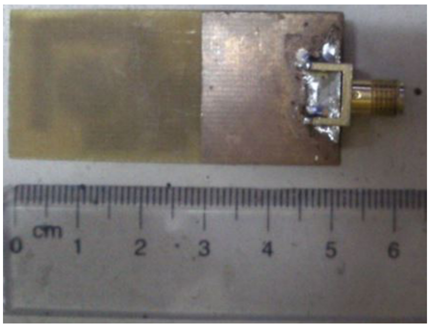
Fig. 5: Simulation result of radiation pattern

The measurement has been taken by using the vector network analyzer in an anechoic chamber (Figure 7).

The first validation has been done by comparing the simulation result of the return loss from HFSS and the measured one as presented in Figure 8. It can be observed that a good agreement in terms of resonant frequency has been obtained, whereas, a slight difference in bandwidth and return loss has been shown. It can be explained either by the tolerance of measurement or by the slight disrepancy of the dielectric constant of the FR4-epoxy substrate that has been used in the antenna sample.



(a) Top view



(b) Bottom view

Fig. 6: The fabricated antenna sample

Fig. 7: Antenna measurement using a vector network analyzer in an anechoic chamber

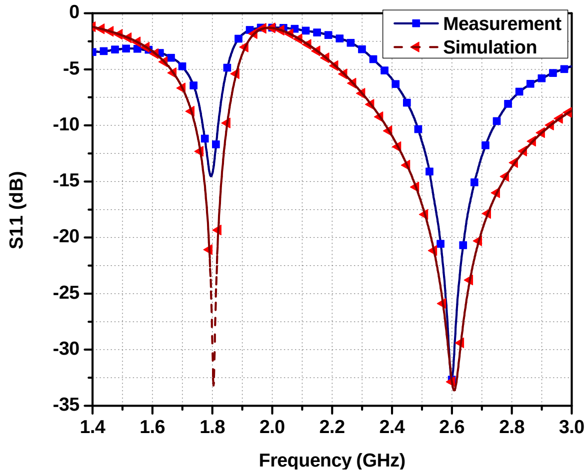
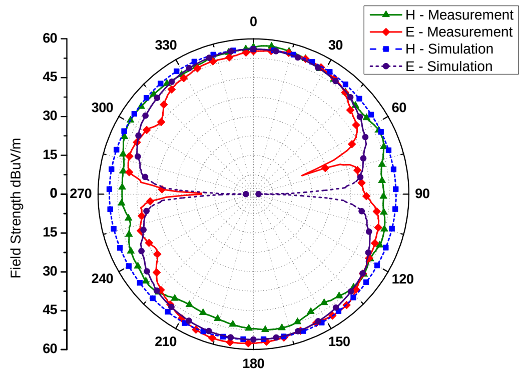
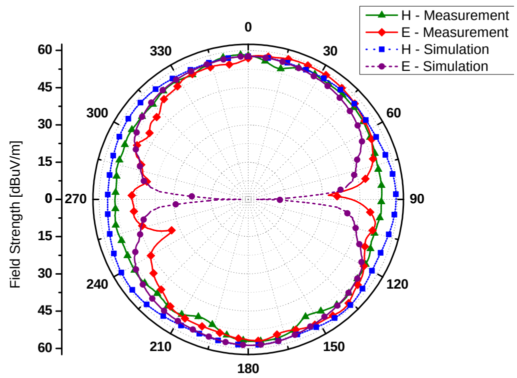


Fig. 8: Comparision of the simulated and the measured return loss



(a) at 1780 MHz



(b) at 2610 MHz

Fig. 9: The radiation pattern results from measurement and simulation

Finally, the simulation data of the radiation pattern and the measured one has also ben compared as presented in Figure 9.

5. Conclusions

A dual-band microstrip antenna for 4G-LTE handhel devices has been designed and fabricated. The proposed antenna has quite good simulation results with wide bands and good gain at both low and high resonant frequency. The validation of the designed antenna model with measurement has been done and good agreement has been given.

Acknowledgement

This work has been partly supported by Vietnam National University, Hanoi (VNU), under Project No. QGTD.13.05.

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