# Novel Planar Antenna for Long Term Evolution (LTE)

M. Madani Fadoul, T. A. Rahman, and A. Moradikordalivand

***Abstract*—The demand for multi band antenna is increasing rapidly. This is due to accelerated growth in mobile communications globally. Systems like LTE are multiband systems utilizing variety of frequency bands thereby increasing capacity and allow for addition of many functionalities. In such multiband systems, a multiband antenna is definitely one of the key devices since it is compatible with many frequency bands such as GSM (890–960 MHz), DCS (1710–1880 MHz) and LTE2.7 MHz. In this paper, a simple low profile multiband antenna fed by transmission line is designed using computer simulation technology (CST2010) software, fabricated and tested. For the return loss, both the simulated and the measured results are presented. There is a good agreement between simulation and fabrication results.**

***Index Terms*—Base station, indoor, multiband planar antenna, short strip.**

## I. Introduction

Long Term Evolution (LTE) is an emerging broadband mobile communication technology that improves link capacity, spectral efficiency and improved link reliability thereby achieving high–speed data rate [1]. This will be accomplished by the use of multiband antennas which accommodate multi-wireless communication systems with tremendous electrical characteristic such as symmetric radiation pattern, cost effectiveness and space utilization [2], [3].

Multiband antennas have been planned to be mounted on the ceilings for indoor base station applications. These antennas have the benefit of a lower profile than the conventional quarter-wavelength monopole antenna. But these antennas have large size and narrow impedance bandwidth. In order to enhance the impedance bandwidth, bevel square monopole antenna [4]-[6] have been designed. Nevertheless all of them with a miniaturized size fail to cover the required bands, especially at the lower frequency band. On the other hand, a dual-sleeve antenna with coaxial fed is presented in [7]. But the antenna is too large to meet the indoor base station applications. In addition several printed sleeve monopole antenna is investigated [8]. But have narrow bandwidth and large size. In addition, it always have horizontal polarization which is not suitable for indoor base station applications. The dual band antennas in [9], [10] achieves low bandwidth for the frequencies of 900 MHz and 2GHz which are not wide sufficient to cover the LTE frequency bands. Again they are of high cost of fabrication because they possess a three-dimensional stacked configuration which makes them a challenge to integrate with wireless local area network (WLAN) system [11], [12]. Moreover, there are many types of antenna elements, but the most popular and extensively studied is Yagi antenna which known by its simplicity as well high gain. In contrast, it functions only in a narrowband that cannot be able to cover the active band of the LTE's applications which range between 1.7 to 2.7 GHz.

Few methods have been reported to broaden the bandwidth, by utilizing two circular elements such as a wideband planar dipole antenna with parasitic patches which exhibit acceptable radiation pattern with a broaden impedance. Furthermore, to combat the narrowband according to Yagi antenna, a novel high-gain and broadband small elements array for a slot loop antenna is investigated [2]. The antenna can cover LTE's bands at the expense of size.

Therefore some parameters are the key factors that should be considered but the size of the antenna is the Pandora's Box in designing an indoor base station antenna. However, our proposed antenna with an area of only $Length(L)110mmxWidth(W)150mm$ has a low profile structure which covers many of the LTE frequency bands with low cost of fabrication and without any additional matching circuit.

The rest of this paper is organized as follows. Section II introduced the design details of the proposed antenna. Section III presents the result and analysis of discussion, finally, a conclusion is presented in Section IV.

## II. Antenna Design

The proposed antenna is designed on low cost Flame Resistent4 (FR4) substrate with dielectric constant ($\varepsilon_r$=4.4), loss tanget ($\tan\delta = 0.05$) and thickness ($T = 1.6mm$) for LTE indoor base station applications. However, the overall dimension is $LXW = 110mmX150mm$. Generally, equation (1) specify the desired working frequency of the patch antenna. The width ($W$) of the patch is calculated by using

$$W = \frac{c}{2f\sqrt{\frac{\varepsilon r+1}{2}}} \tag{1}$$

where ($c$) the velocity of light, ($f$) the frequency of operation and ($h$) is the height of the dielectric constant and ($\varepsilon_{reff}$) is the effective dielectric constant which can be determined by

Manuscript received September 1, 2013; revised November 25, 2013. This work was supported fully by the ISLAMIC DEVELOPMENT BANK - (IDB) under IDB M.Sc Scholarship Programme in Science and Technology (www.isdb.org).

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$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{1}{2}} \quad (2)$$

The actual length of the patch $(L)$ is calculated by

$$L = L_{eff} - 2\Delta L \quad (3)$$

Whereas, the effective length of the patch $(L_{eff})$ and the length extension $(\Delta L)$ can be determined respectively using

$$L_{eff} = \frac{C}{2f\sqrt{\varepsilon_{reff}}} \quad (4)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (5)$$

Finally, the ground plane parameters Length of ground plane $(L_g)$ and width of the ground plane $(W_g)$ of the proposed antenna is calculated by using:

$$Lg = 6h + L \quad (6)$$

$$Wg = 6h + W \quad (7)$$

## III. Antenna Radiators

In order to achieve a multi band frequency, we cut the patch by creating $L1$, $L2$, $R0$, $R1$, $R2$, in a manner to increase the number of resonance frequencies. The geometry of the proposed antenna is shown in Fig. 1

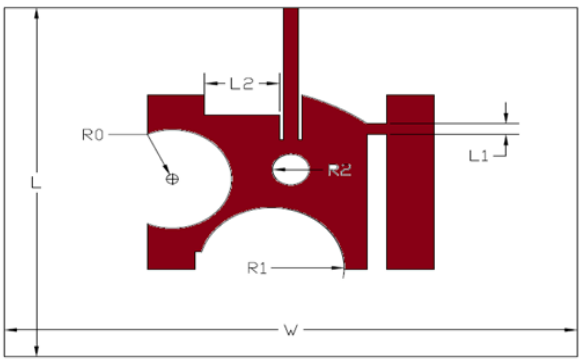


Fig. 1. The geometry of proposed antenna.

The designed antenna comprised of five radiators $R0$, $R1$, $R2$, $L1$, and $L2$, which are $0.0191(mm)$, $1.0639(mm)$, $0.0825(mm)$, $0.0261(mm)$, and $0.0261(mm)$ respectively, supporting the frequencies of $500MHZ$, $GSM900(890\text{-}960)MHZ$, $DCS(1710\text{-}1880)MHZ$, and $LTE(2.7)GHZ$. In order to further lower the operation band without enlarging the antenna size, short stripped is off from $L2$ hence the $GSM900$ is created. A broadband can be formed by slightly moving down the short strip $L1$ which generates the $LTE2.7GHZ$. unfortunately, further increasing the short strip length deteriorates the lower band $500MHZ$ matching performance. In order to solve this problem by closing the Pandora's Box $R1$ is created down, which also generates the $DCS$ band. $R0$ Stripped off from the upper end is created to provide more resonance modes in the higher $LTE2.7GHZ$ without perturbing the lower band operation. Therefore, by adjusting the lengths of the five radiators properly, the desired operating bands can be obtained without loss at the feed. A 50 ohm micro-strip is used to feed the proposed antenna, which is also printed on the top layer of the substrate. A good impedance matching can be obtained without any other matching circuit.

## IV. Result and Analysis

The rectangular ground plane of the proposed antenna is designed and fabricated on a substrate with thickness $(T = 1.6mm)$, $(\varepsilon_r = 4.4)$ and , $(\tan\delta = 0.05)$. it is important to examine the return loss of the proposed antenna under $-6dB$, . The simulated and measured return loss parameters which were obtained by using an Agilent 8753ES network analyzer as shown in Fig. 3.

It demonstrates that the resonant frequency has shifted the magnitude of all the desired frequency bands. This shift originated from the $FR4$ board, which has $\varepsilon_r$ that varies from 4.0 to 4.9. Practically, a material possess varying $\varepsilon_r$ along the length or width or height, this will affect the resonant frequency and make it to shift. In addition, the other factors that shift the frequency is etching accuracy which can result from chemical materials, surface finish and metallization thickness. In another words, the discrepancies in Fig. 3 between the measured and simulated values are due to fabrication tolerance, measurement accuracy and the effects of the coaxial cable (SMA connector) which severely affect the higher frequencies [3]. Therefore, care must be exercised.

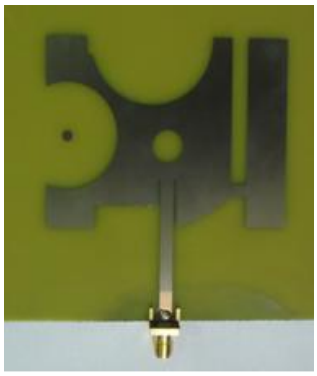

Fig. 2. The fabricated prototype.

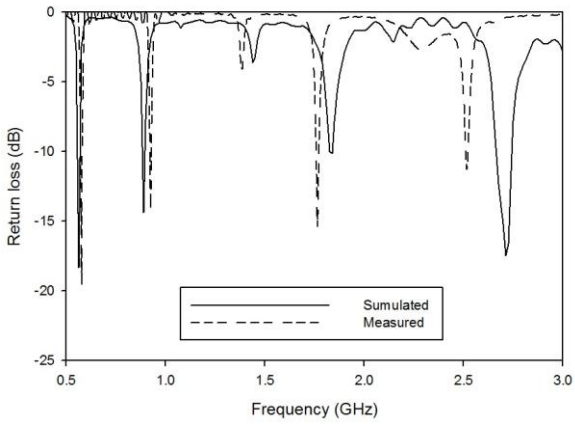


Fig. 3. The simulated and measured $S11$ parameters.

However, the fabricated antenna is shown in Fig. 2 while Fig. 4 presents the H-plane radiation pattern for the selected three frequencies 0.95, 1.75 and $2.7GHZ$ which indicates an omnidirectional radiation patterns.

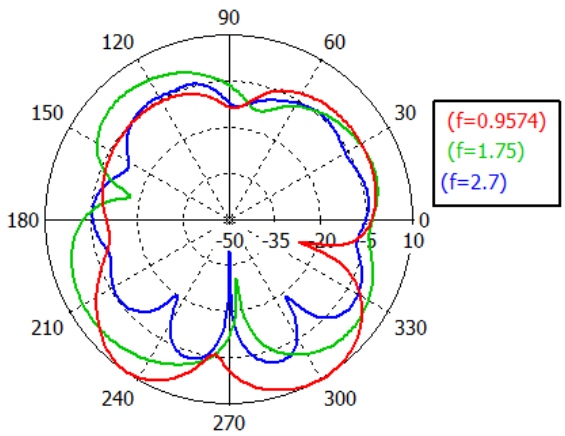


Fig. 4. The H-plane radiation pattern for the selected three frequencies $0.95, 1.75 and 2.7GHZ$.

## V. Concusion

A multiband antenna with full ground plane is etched on the opposite side of $FR4$ board substrate. A $50\Omega$ microstrip line is used to feed the antenna, printed on the same substrate. In addition, the antenna has been designed and fabricated with an area of $(110mm x 150mm)$. The simplicity of the design in achieving a multiband frequencies is considered an attractive feature. It is highly suitable for indoor base station applications, such as $500MHZ$, $GSM 900(890\text{-}960)MHZ$, $DCS(1710\text{-}1880)MHZ$, and the $LTE 2.7MHZ$.

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