

An Improved Small-Size Multiband LTE/GSM/UMTS/WLAN Antenna for Mobile Phone

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Abstract. A planar monopole antenna having small-size, dielectric-loaded yet providing two bands for covering the seven-band LTE/GSM/UMTS/WLAN operation in the mobile phone is presented in this letter. The small-size yet wide band operation is achieved by adjusting the locations of antenna and RF Ground; the antenna is covered by a thin FR4 layer which gives a shorter guided wavelength and wider band-width for each resonant mode to achieve antenna size reduction. The occupied volume of the antenna is only $20 \times 18 \text{ mm}^2$. The proposed antenna is suitable for slim mobile phone applications.

Introduction

Multiband communication systems achieve immense attention in both academic and industrial communities of telecommunications because of possessing simple hardware configuration, high data transmission rates, low cost, high-precision ranging, and low power consumption. The long term evolution (LTE) system will be the global standard of the next generation wireless communication [1], which provides many benefits for the users while it brings new challenges to the device manufacturers and service providers. One of the challenges is the internal antenna design since the dimension of the device is pushing to be smaller and smaller per the industry design requirement. In the past years, dielectric resonator antennas (DRAs) have received agreeable consideration for multiband antenna due to remarkable characteristics such as different excitation mechanisms, high radiation efficiency, wide-impedance bandwidth, especially, compact antenna size [2].

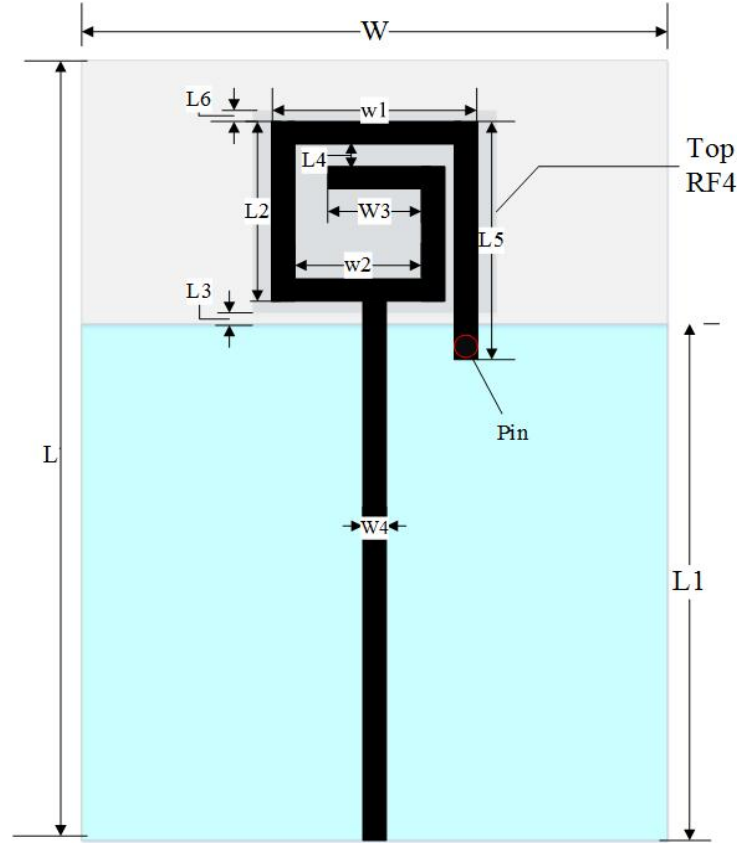
Many efforts have been delivered to overcome the difficulties of integrating antennas in the mobile phones, multiband antennas, which have to cover not only conventional GSM/DCS/PCS/WCDMA bands but also newly added bands 2500 MHz [3]-[5]. When a planar radiating plate is used, it is reported that a planar monopole with a size of $30 \times 50 \text{ mm}^2$ (1500 mm^2) can have a wide operating band for the mobile phone [6]. However, the large size of 1500 mm^2 will greatly limit its applications in the internal mobile phone antennas. In [7], the antenna includes a monopole element and a loop element with a shorting pin, both are printed on FR4 substrate with low-cost and easily available dielectric. The antenna is driven by a 50- micro-strip line, and it operates from about 2.7 to 5.9 GHz, a loop antenna for 2.45-GHz WLAN band, and a folded monopole/loop antenna for DCS 1.8-GHz band in [7]. However, it just provides WCDMA and WLAN bands operation frequencies.

In this letter, $L1$ (the length of ground) is a variable quantity while the distance between the radiator and the system ground plane of the mobile phone remains unchanged. Detailed effects are discussed in the part of III. Further, the height of this system is 1.75 mm, which is promising for applications in the modern slim mobile phone. Details of the proposed antenna are presented.

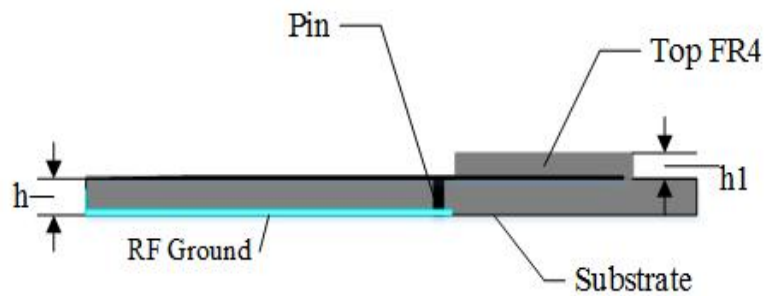
Proposed Antenna

Fig. 1 shows the geometry of the DRA modified structure. The antenna built on the FR4 substrate with permittivity is 4.4 and loss tangent is 0.02, and FR4 is low-cost and easy processing. The antenna is composed of a loop element with a shorting pin and a monopole element; a loop is connected with the ground by a 0.8mm diameter copper cylinder. For simple design, $w4$ is a fixed value. The resonant

high frequencies of the antenna are motivated by a monopole element. A stronger resonance is formed because a coupling occurs between the loop and the monopole, when the two elements exist together. The bandwidth of low frequencies is controlled by moving this grounding element, The RF Ground volume is $36 \times 56 \text{ mm}^2$, and the whole volume is reduced 4% than [7]. The antenna is covered by Top FR4 layer which height is 0.75mm, and we can learn from [7] that the band width will be increased by this way.



(a)



(b)

Fig.1 Geometry of the antenna; (a) top view and (b) side view. Where $w=56\text{mm}$, $w_1=18\text{mm}$, $w_2=10\text{mm}$, $w_3=8\text{mm}$, $w_4=2\text{mm}$, $L=62\text{mm}$, $L_1=36\text{mm}$, $L_2=20\text{mm}$, $L_3=1\text{mm}$, $L_4=2\text{mm}$, $L_5=24\text{mm}$, $L_6=1\text{mm}$, $h=1\text{mm}$, $h_1=0.75\text{mm}$.

Results and Discussions

Fig.2 shows a good s_{11} response of the antenna without modified. However, the band width is just satisfied for WLAN/WCDMA operation. RF Ground affects antenna greatly as the Fig.3 shows, it depicts that bandwidth and return loss of low and high frequencies are influenced significantly by

increasing length of L1 due to obtaining more field excitation inside the inserted DRA. Fig.3 also shows that there is not enough bandwidth for low frequencies when L1 is variable in this range. In the meantime, the performances for high frequencies are also poor. There is no proper length for operation frequencies when only the length of L1 is changing.

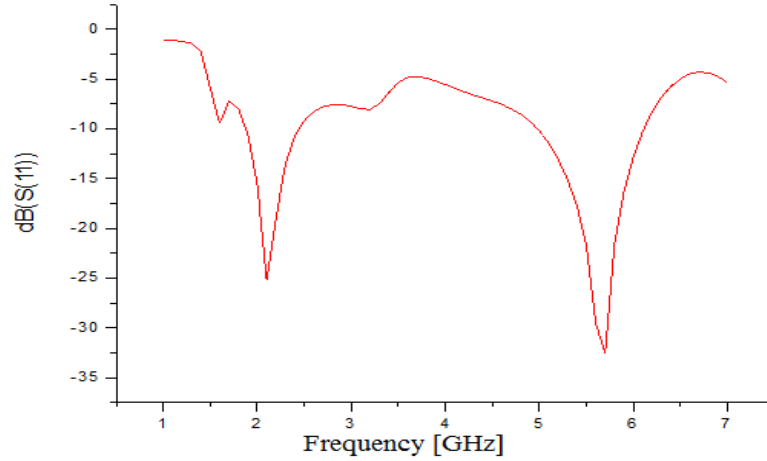


Fig.2. HFSS simulated s11 response of the antenna without modified.

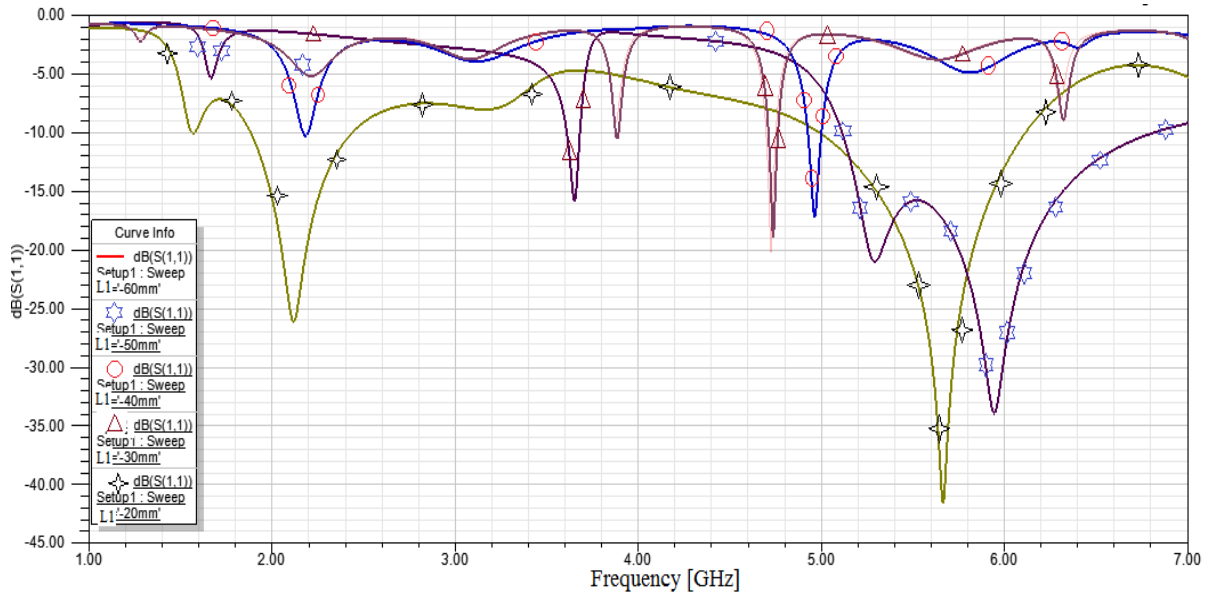


Fig.3. Reflection coefficient for various lengths of RF ground (L1).

In this letter, there is a fixed value (L3) between Top FR4 and RF ground, so, the radiator and RF Ground have an invariable relative location. The radiator's location is variable on the FR4 substrate with the length of RF Ground. The manipulation of the GND plane geometry as shown in Fig.4. This time, a good performance is created by changing the length of RF Ground and L3 is set to 1mm. The picture shows that bandwidth both of high and low frequencies are improved so immense that it can covers the seven-band LTE/GSM/UMTS/WLAN operation. The antenna covers GSM1800/LTE1900/WCDMA/LTE2300/WLAN/LTE2500 operation frequencies when L1 is 40mm or 36mm in low frequencies. The length of L1 is 36mm has a better s11 response than L1 for 40mm. When L1 is 24mm, antenna at the high frequencies has a better return loss than L1 for other values, but the bandwidth is narrow at the low frequencies. Summing up the above, 36mm is optimal value

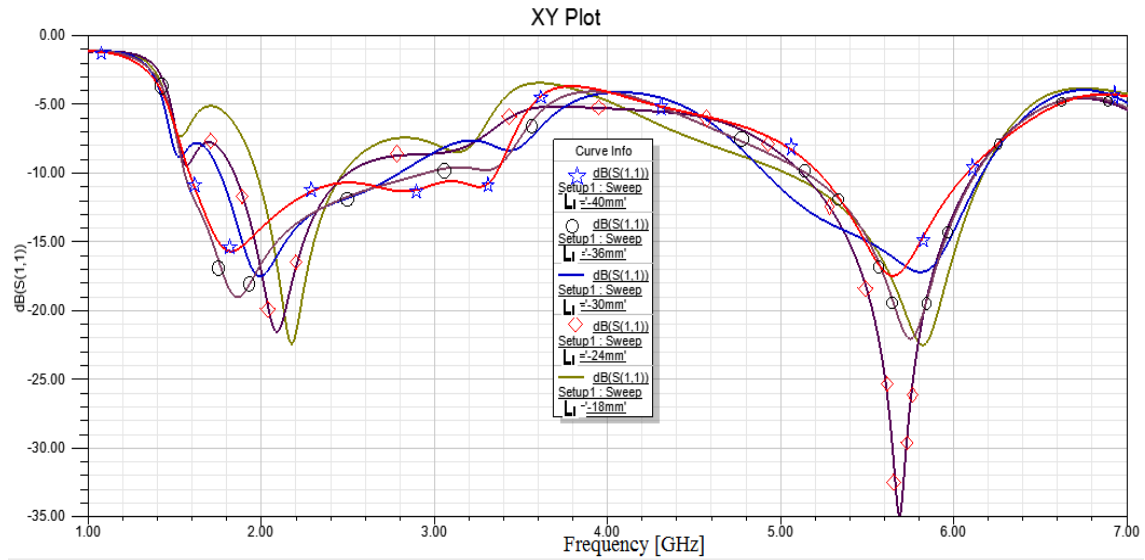


Fig.4 Simulation modal of the antenna with different length of ground plane.

for L1. As the FR4 substrate width is changed, both of the s11 response and the bandwidth of the lower band are affected significantly as shown in Fig.5. It can be seen from Fig.5 that good return loss and bandwidth are generated when w is 56mm, most importantly; the whole volume is reduced about 4% than in the [7] proposed.

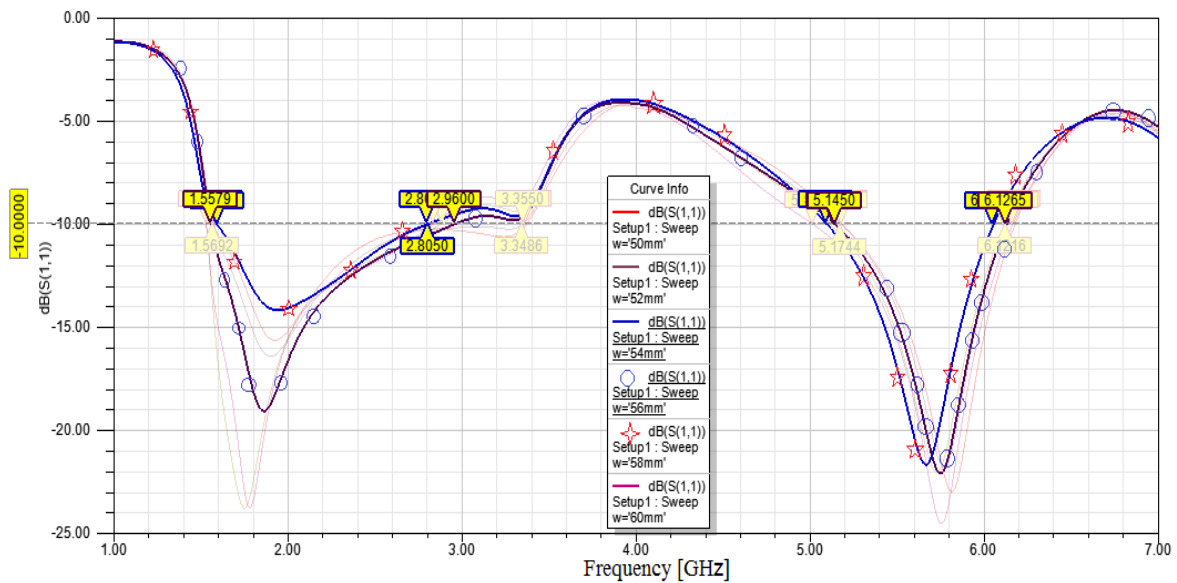


Fig.5 Simulated S-parameters with different widths of RF Ground.

The antenna impedance bandwidth is shown in Fig.6. The antenna has a very wide impedance bandwidth, where two “circles” can be observed, markers m1-m2 and m3-m4, corresponding to the low band and high band, respectively. The low band circle, from m1 through m2, has a potential to cover an even wider bandwidth. The antenna has a decent matching in the range of frequencies of the letter proposed.

Conclusions

In this letter, we proposed a small-size, dielectric-loaded yet providing two bands for covering the seven-band LTE/GSM/UMTS/WLAN operation in the mobile phone is presented. The proposed

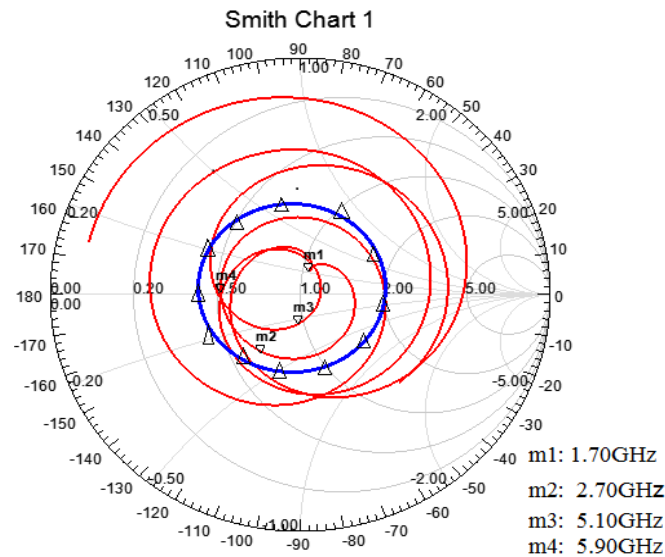


Fig.6 Simulated antenna impedance on the Smith chart. The frequency ranges from 1.7GHz to 2.7GHz , and from 5.10GHz to 5.90GHz ,where corresponding frequencies are marked.

design is able to cover 4G LTE bands required by the telecommunications service providers. The RF Ground plane plays an important role in this design as the bandwidth is affected by the ground plane length especially in the low-band (1.7GHz-2.7GHz). The proposed antenna is suitable for slim mobile phone application.

Acknowledgment

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