A Simple Monopole Antenna for Hepta-band LTE/WWAN Metal-framed Mobile Phone

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***Abstract* –A simple monopole antenna for hepta-band LTE/WWAN (824 ~ 960/1710~2690 MHz) Metal-framed mobile handset is proposed. Two slits are applied at the upper part of the metal frame. And the metal frame between slits is used for monopole antenna itself. The proposed monopole antenna structure is simple, slim and it has just one feed-line. For producing multiple resonances, impedance matching methods with lumped elements are used. Shunt chip inductor, chip capacitor matching circuit generates resonant modes at 850 MHz and 1700MHz. Band-stop matching circuit and the coupling effect between the metal frame and the antenna widen the low and high frequency bandwidth respectively. Thus, the proposed antenna covers GSM850, GSM900 (824~960 MHz) and GSM1800, 1900, UMTS2100, LTE2400, 2600 (1710~2690 MHz).**

***Index Terms* — mobile antenna, monopole antenna, band-stop filter, metal-framed, slit**

I. INTRODUCTION

With the expeditious growth of mobile industry, there is lots of growing demands to be considered as a mobile phone antenna designer. Smaller size, light weight, multifunction, multiband and good designs are examples. To satisfy above demands, metal frame is one of the good solutions with the solidity and stylish looking. However, the metal frame near the mobile antenna leads to undesired coupling effects and degrades the impedance matching. Accordingly, it reduces the bandwidth of the antenna. In particular, the low frequency bandwidth is more degraded by the metal frame. Thus, it is necessary to overcome this problem of metal frame. And there are several ways to achieve the good performance with metal frame [1] - [3].

In this paper, a multiband monopole antenna with two slits at the lower part of the metal frame is proposed. The metal frame between two slits is used for the monopole antenna itself. The suggested antenna can cover the GSM850/900 (824~960 MHz) operation using the notch filter that can make a low frequency bandwidth enhancement. And the coupling effects between the antenna and the metal frame broadens the high frequency bandwidth to be able to cover the GSM1800, 1900, UMTS2100, LTE2400, 2600 operation (1710~2690 MHz).

II. ANTENNA DESIGN

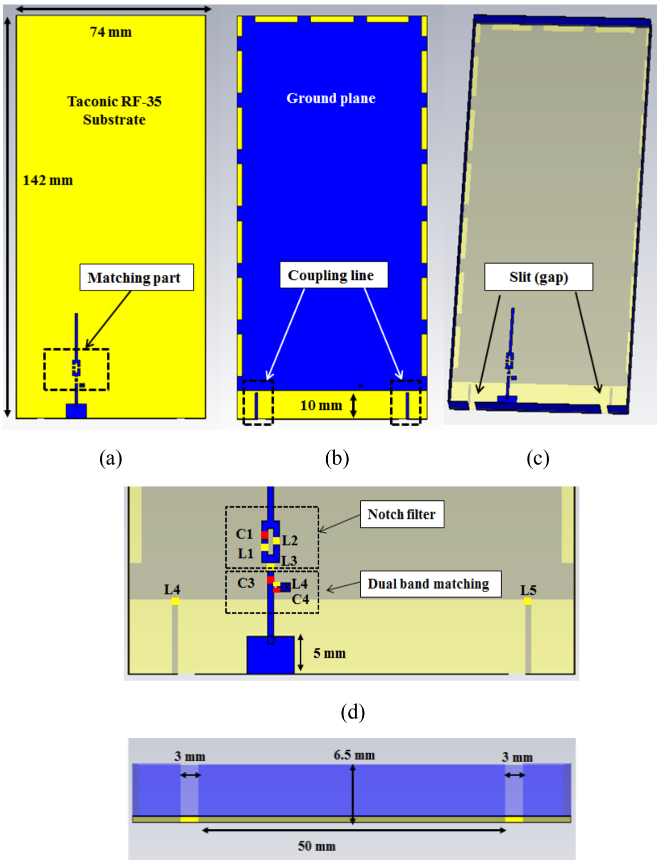


Fig.1. Proposed antenna configuration

(a) Top (b) Bottom (c) Tilt (d) Matching part (e) Antenna part

Fig. 1 shows the geometry of the proposed antenna with the metal frame. As illustrated in Fig 1(a), a 0.79 mm thick taconic RF-35 substrate of relative permittivity 3.5, loss tangent 0.0018 is used as the system circuit board. The system circuit board of 142 x 74 mm^2 is embraced by the metal frame whose thickness is 0.03 mm. And its height which is equal to the height of the monopole antenna is 6.5 mm. There are 50 ohm feeding line, matching part and the connection part for monopole antenna on top part of the board.

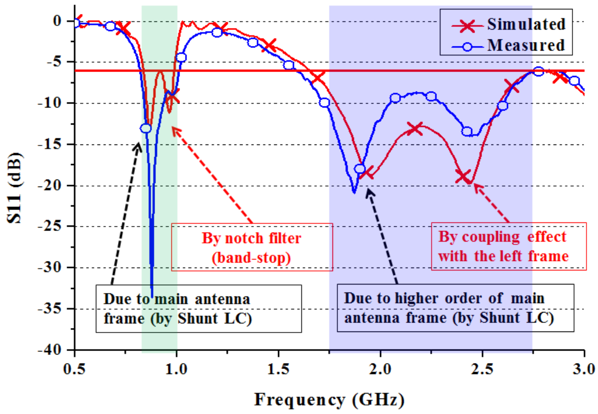


Fig.2. S11 Plot of the proposed antenna

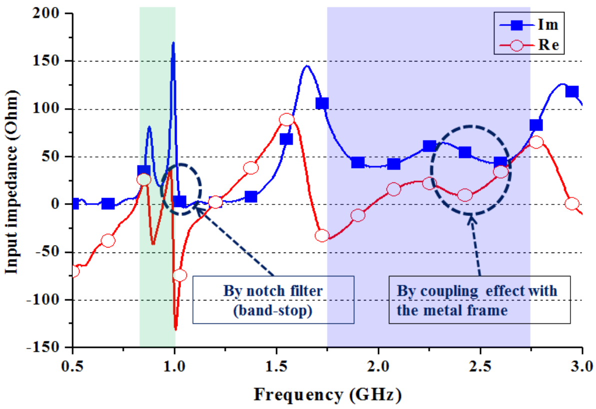
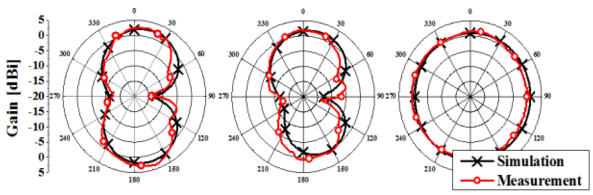
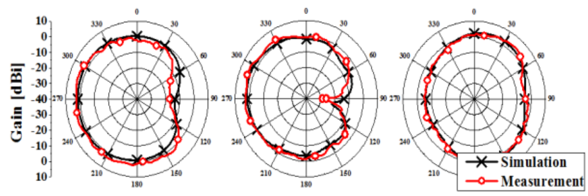


Fig.3. Simulated impedance chart of the proposed antenna



(a)



(b)

Fig.4. Measured free radiation patterns of the proposed antenna
(a) 900 MHz, E_θ, E_ϕ, H plane
(b) 2.45 GHz, E_θ, E_ϕ, H plane

Seen from Fig. 1(b), behind the board, the ground plane is connected partially by ground connection to reduce the coupling effect between the board and the metal frame. And no ground portion in the lower part of the board is 10 mm. Two coupling lines to broaden the high frequency bandwidth are existed at both side of no ground portion. Fig. 1(c) shows the entire structure in detail by tiled side of the proposed antenna.

Fig. 1(d) shows the matching part which has LC distributed matching part with lumped elements and antenna connection part. At first, a three-element notch filter formed by L2, 2.7 nH chip inductor in parallel connection with C1, 1.4 pF chip capacitor and L1, 10 nH in series is employed on the system circuit board. It can serve a narrower 3 dB band-stop bandwidth than the conventional two-element band-stop matching circuit [4]. The proposed band-stop matching circuit can generate a parallel resonance at about 1000 MHz and extend a low frequency bandwidth as shown in Fig. 2, 3. After the notch filter, there is a matching circuit for a dual bandwidth. C3, 0.9 pF chip capacitor in series is connected with Shunt L4, 6.8 nH chip inductor and Shunt C4, 0.4 pF chip capacitor. This matching circuit generates resonances at about 850 MHz and 1.7 GHz. And L3 is just 2.7 nH chip inductor for matching.

Fig. 1(e) shows two slits whose gap distance is 3 mm at the lower part of the metal frame. Between the slits, monopole antenna is presented. Its length is 50 mm. Without matching circuits and the metal frame, this proposed antenna generates just a single resonant mode.

III. Result and Discussion

The suggested antenna is not only simulated with the aid of CST MWS, but fabricated and measured. Fig.2 shows the simulated and measured return loss data. The resonance by shunt L, C matching circuit and band-stop filter cover the low frequency bandwidth. (811~1016 MHz) And the higher order resonance mode by shunt L, C and the coupling effect between the monopole antenna and the left side metal frame beside the monopole antenna cover the high frequency bandwidth (1670~2698 MHz). As seen Fig. 3, impedance chart of the proposed antenna explain a role of band-stop matching circuit and the coupling effect with the metal frame. Band-stop matching circuit makes a zero-crossing point of imaginary part at the about 1GHz. And the coupling effects cannot make a zero-crossing point at about 2.5 GHz. But it makes a 50 ohm sum with real and imaginary part to make a resonance which extends the high frequency band.

Fig. 4 plots the 2-dimensional radiation patterns at 900 MHz, 2.45 GHz of operation frequencies. Each frequency has E_θ, E_ϕ, H plane pattern. Over the low and high-band, the measured antenna max gain is about 2.3 ~ 2.7 dBi and 2.8 ~ 3.6 dBi. And its radiation efficiency is about 75% in the low-band and 85 % in the high-band.

IV. CONCLUSION

The proposed monopole antenna has a simple structure which is used easily for a metal-framed mobile phone. And it has just one feeding line and the matching circuit part by lumped elements to cover hepta-band. And S11, antenna peak gain, and radiation pattern are presented, which can meet the requirement for mobile phone.

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