A Compact Printed Monopole Antenna with Coupled Elements for GSM/UMTS/LTE & UWB in Mobile

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***Abstract-* In this paper, a compact printed monopole antenna with a coupled line and loop structure is proposed for GSM/UMTS/LTE and UWB in mobile application. This antenna has a monopole feeding which couples to a microstrip line and loop structures. It supports 1.7~2.7GHz for GSM1800, GSM1900, UMTS, LTE and 3.1~10.6 GHz for UWB. The proposed antenna has two structures which are coupled from monopole. One is a shorted microstrip line for a resonance of low frequency band and the other one is a loop structure for enhancement of bandwidth. With GSM/UMTS/LTE and UWB operation achieved, the proposed antenna only occupies a small space of 29 × 8 mm2 physical size. CST simulation was utilized in the design stage. The antenna was constructed on a substrate, FR-4, with the thickness of 0.8mm and relative permittivity of 4.3. The size of the substrate is 58 × 110 mm2.**

I. INTRODUCTION

Recently, wireless charging has become a hot topic in the mobile phone industry and it began to be applied to several models. Wireless charging will be generalized within a few years. USB port will be only used for Data Communication with PC. Thus, in addition to that the need is reduced, in terms of design and size, the need for wireless USB will become increasing. UWB that is described in wireless USB standard is expected to be applied to the mobile [1]. There are attempt to include UWB in USB dongles and mobile [2], [3].

For UWB, after approval of the FCC in the frequency band of 3.1~10.6GHz, many studies have been made on its application. However, to be applied to a mobile phone, more specialized environments must be considered. Already, mobile has supported several frequency bands like CDMA, GSM, UMTS and LTE. Furthermore, it must also support diversity and MiMO according to the communication method and additional services like NFC, GPS, WiFi and Wireless charging etc. Normally, LTE smartphone has 6 antennas or more. Therefore, adding antenna just for UWB is very difficult due to the reasons of a space and a number of antennas. It is the work that is meaningful for this reasons, it is to support as possible as small UWB and frequency of existing as an antenna. Recently, lots of researches have been carried out to provide small antennas for covering both UWB and existing frequency band. Various type of monopole antennas, such as an octagonal-shaped slot fed by a beveled and stepped rectangular patch with size 25 × 28mm2 [4] and ellipse-shaped monopole with size 30 × 30mm2 [5] and various type of slot antenna, such as a printed open and slot antenna with size 60 × 18.5mm2 [6], were proposed. However, they are still large to be applied to the mobile phone. In this paper, the compact printed monopole antenna with coupled elements is proposed to have 8.9GHz bandwidth(1.7~ 10.6GHz) within 29 × 8mm2 size. It supports GSM1800 (1710~1880MHz), GSM1900 (1850~1990MHz), UMTS (1920~2170MHz), LTE Band1, 2, 3, 4, 5, 9 and 25 (1710~2690MHz) and UWB (3.1~10.6GHz).

II. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed multiband antenna for the GSM/UMTS/LTE and UWB operation in the mobile phone. The antenna is printed on the both side of a FR4 substrate which has a permittivity 4.3 and a loss tangent 0.02. The proposed antenna comprises a driven inverted-L monopole on the top side and a coupled line and loop structure on the bottom side of a PCB. The antenna is confined 29 × 8mm2 rectangle on the upper part of PCB. The ground plane on the lower part of PCB has an area of 58 × 110mm2, representing a typical system board of mobile terminals. The ground plane below the radiator is partially removed for coupling between the radiator and the coupled line, and it can also be enhanced impedance matching. The feed is excited from the ground plane to the monopole directly. The length of L is the distance between loop structure's right end and coupled line.

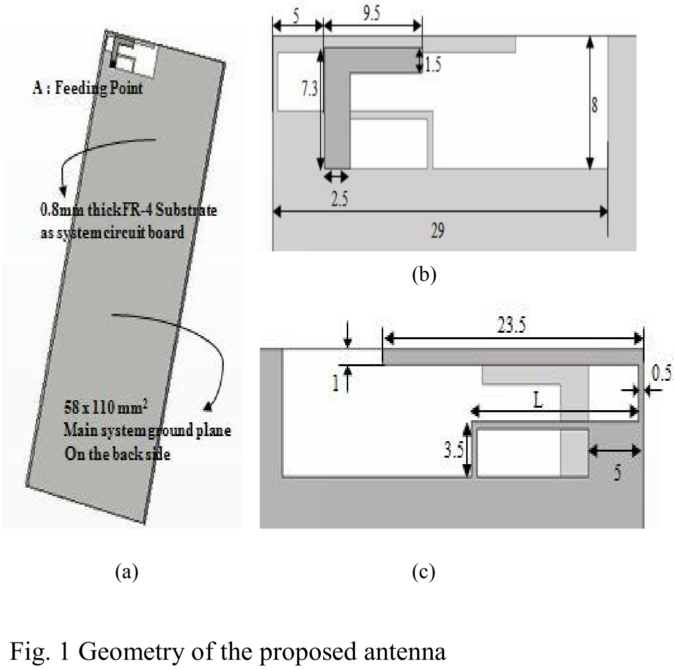


Fig. 1 Geometry of the proposed antenna
(a) Perspective view (b) Top view (c) Bottom view

III. Design Result And Discussion

Fig. 2 shows the simulated return loss of the proposed antenna. It shows ultra-wide operated bandwidth about 8.9GHz. With 3:1 VSWR (under -6dB) which is widely used for practical internal mobile application antenna. In case of UWB, with 3:1 VSWR definition is used for portable antenna [7]. Therefore, the return loss result of proposed antenna covers the desired low band 1.7~2.7GHz and UWB 3.1~10.GHz.

Fig. 3(c) shows the simulated return loss of the Ant1 (the printed monopole antenna) and the Ant2 (the printed monopole antenna and coupled line). Referring to Fig. 3(a) and (b), the Ant1 is single monopole type that has length 14.8mm only (about λ/4 at 4.2GHz). The Ant2 is capacitive coupled antenna with short strip on the bottom side of PCB. It is seen that the impedance level of the resonance at about 4.2GHz is effectively decreased owing to the use of the coupled line. The coupled line makes two resonances at about 3GHz and 10GHz. However, it cannot cover two desired band.

Fig. 4 shows the simulated return loss, compared with the Ant2, Ant3 and Ant4. The Ant3 is that the 1st loop structure is added to the Ant2. The loop structure is configured to be connected to the ground so along the left side of the monopole of the Ant2 on the bottom side of PCB. The Ant4 is that the 2nd loop structure is located along the right side of the monopole. Referring to Fig. 4 (c), it can be seen that the characteristics of the low band is widened by the addition of a loop structure. In Fig 4(d), each loop structure is large effects on the impedance matching of the low band. It improves the impedance matching for frequencies over the lower band and decreases the real part of impedance over the high band (8~10.6GHz).

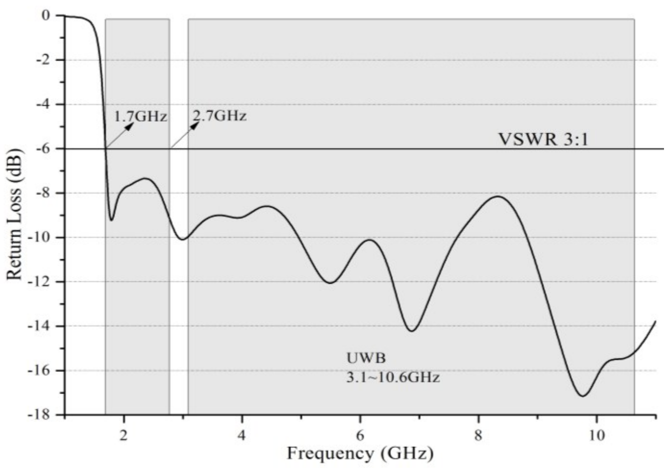
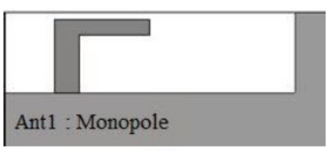
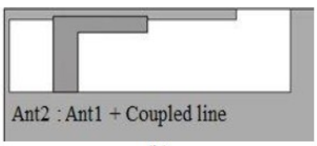


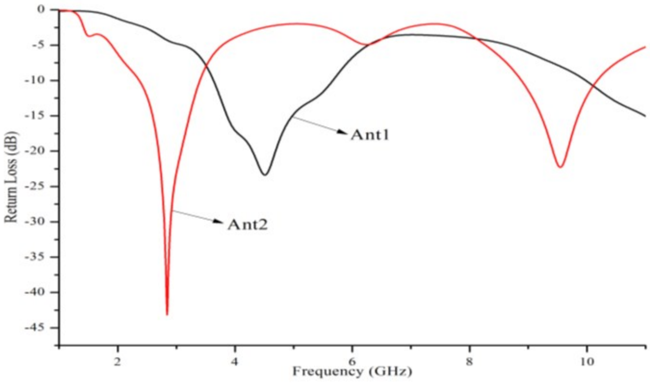
Fig. 2 Return Loss of Proposed Antenna



(a)

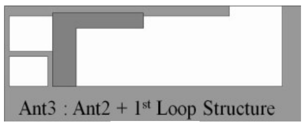


(b)

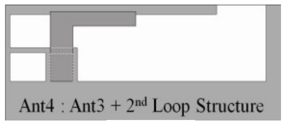


(c)

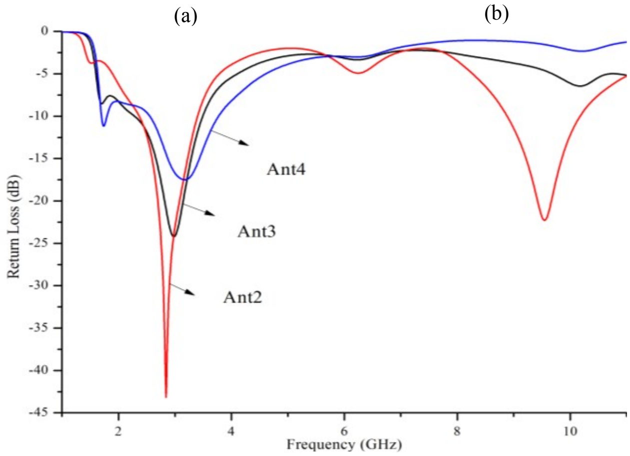
Fig. 3 (a) Ant1 Structure (b) Ant2 Structure
(c) Simulated Return Loss of Ant1 & Ant2



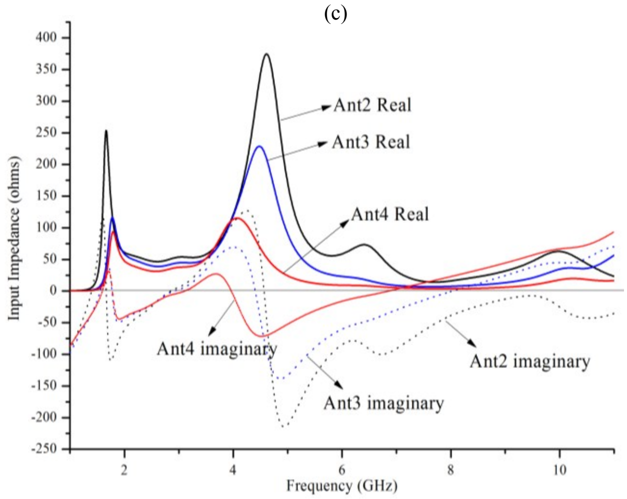
(a)



(b)



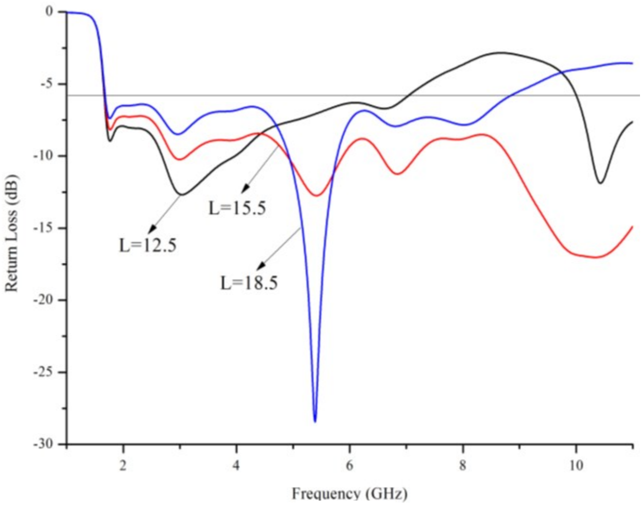
(c)



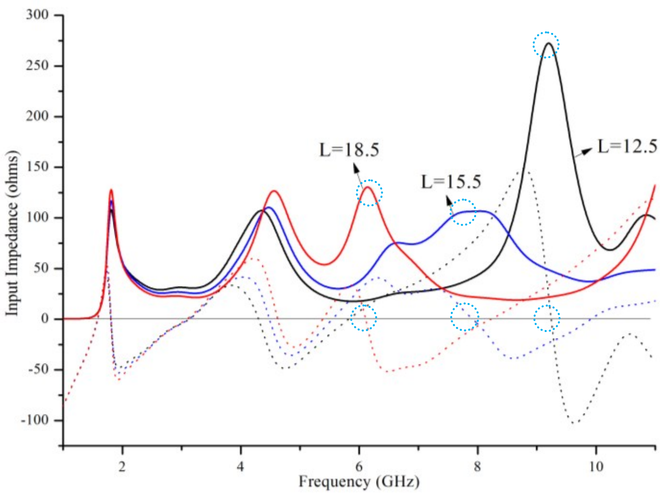
(d)

Fig. 4 (a) Ant3 Structure (b) Ant3 Structure
(c) Simulated Return Loss of Ant2, Ant3 & Ant4
(d) Input Impedance for the Ant2, Ant3 & Ant4

As can be seen from Fig 4(d) input impedance graph of the Ant4, 2nd loop structure improves both of real and imaginary part of the input impedance. Fig 5 shows the effect of the length L of the 2nd loop structure width. Simulated results of the return loss and input impedance for the length L varied from 12.5 to 18 mm are presented. Large effects on the antenna's whole band are seen, especially at higher frequency. The input impedance of above 6GHz is greatly dependent on the width of 2nd loop structure. When the length L is decreased, the resonance point above 6GHz moves higher frequency band. When the length of L is 15.5mm, return loss result of antenna is under -6dB at the desired band. Fig 6 shows the simulated return loss of comparison between Ant4 (L=15.5mm) and proposed antenna with filling the ground in 1st loop structure. Proposed antenna has a more good return loss performance on low frequency band (under 2.5GHz).



(a)



(b)

Fig. 5 Effect of 2nd loop structure length L
(a) Simulated Return loss (b) Input impedance

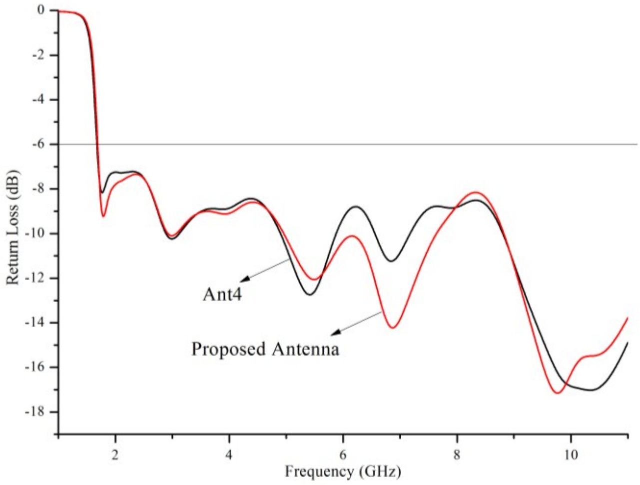
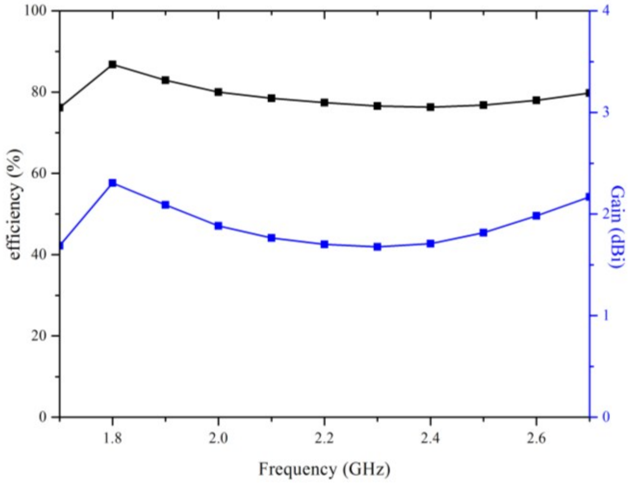
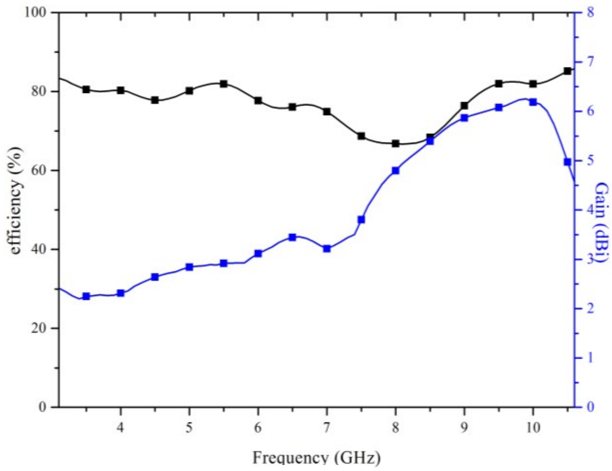


Fig. 6 Comparison between ant4 (L=15.5mm) and proposed antenna



(a)



(b)

Fig. 7 The radiated efficiency and antenna gain
(a) Low band (1.7~ 2.7GHz)
(b) UWB (3.1~ 10.6GHz)

The simulated radiation efficiency and antenna gain are shown in Fig 7. The simulated radiation efficiency over the lower band (1.7~2.7GHz) and UWB is, respectively, about 76 ~ 87% and 66.7 ~ 85.8%. The simulated gain is about 1.68 ~ 2.3dBi and 2.2 ~ 6.25dBi over the lower band and UWB. Good radiation characteristics are generally obtained for the proposed antenna.

IV. CONCLUSION

This paper presents a new compact printed monopole antenna with a coupled line and loop structure for mobile. Using a coupled line and loop structure to improve the desired impedance matching bandwidths, which can generate one wide operating band about 1.7~10.6GHz to cover GSM1800, GSM1900, easily printed on the non-ground region of the system board of the mobile at low cost and occupies a very compact region of 28 × 8 mm2 only. It has a wide bandwidth performance and good radiation efficiency higher than 70% over the full operating bandwidth, the proposed antenna is attractive for mobile industry.

ACKNOWLEDGMENT

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