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A Novel Loop Antenna Design Integrated with Metal Ring for Mobile Device Application

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***Abstract* – A novel loop antenna design which is integrated with the exterior metal ring of a mobile device for GSM900/1800 operation is proposed. The proposed loop antenna consists of an impedance transformer which is printed on a 1.0 mm FR4 substrate and the exterior metal ring of a mobile device. The loop antenna is fed from the end of the impedance transformer, and then was connected with the exterior metal ring to excite a half-wavelength loop resonant mode. Through the adjustment of the length and width of impedance transformer, the good impedance bandwidth was obtained. Due to its integrated structure with exterior metal ring and simple design concept, the proposed antenna is very suitable for the GSM900/1800 antenna application of a mobile device, especially in a mobile smart phone. Besides, the good antenna efficiency and radiation performance were obtained. Details of the proposed antenna and experimental results are presented and discussed.**

***Index Terms* — Loop antenna, Integrated antenna with metal ring, Mobile phone antenna.**

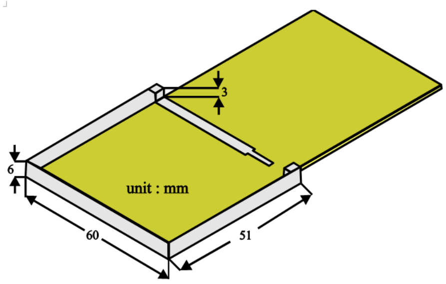
I. Introduction

Recently, the outward appearance of the mobile device is becoming more and more important, especially in consumer wireless products such as mobile smart phone, tablet and notebook. For achieving the impressive outward appearance, different kinds of mechanical technologies were applied in mobile device, including whole metal cover, metal insert molding technology, plastic housing with surrounding metal ring…etc. It leads that the antenna design are more difficult in these environments with metal parts. Conventional antenna design method including patch antenna, PIFA antenna [1] and loop antenna [2], even the slot antenna [3] were studied to apply in these metal environments. And how to reduce the influences from the metal components or enhance the antenna performance becomes a big challenge for the antenna designer. In this paper, we present a novel loop antenna design which is integrated with the exterior metal ring of a mobile device. The proposed antenna includes two portions: first portion is a impedance transformer with a length close to quarter wavelength of 900 MHz. It is easily printed on a 1.0 mm FR4 substrate. In general, it should be printed on the system circuit board of the mobile device and located near to the center position of the system circuit board longer edge. The second portion is the surrounding metal ring of the mobile device which is connected to the impedance transformer and treated as the major radiator of the proposed loop antenna. The metal ring will extend along the outward surface of mobile device from the point that is connected to the impedance transformer to the opposite center position of the system circuit board longer edge and then connected to the system ground plane. These two portions form a loop antenna structure, it can generate a half-wavelength loop and a one-wavelength loop dual resonant modes. Through the adjustment of the length and width of impedance transformer, the good impedance bandwidth was obtained. And it can cover GSM900/1800 operation bands. Besides, in order to suit for different dimensions of the metal ring, a tuning method is also presented. Details of the dimensions of the proposal antenna are described.

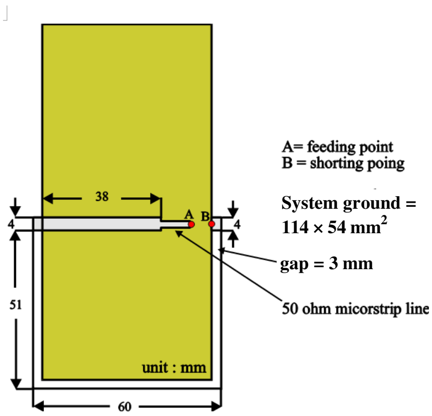
II. Antenna Design

Fig. 1 shows the geometry of the proposed loop antenna design integrated with the exterior metal ring. In this case, the ground plane size is 114 × 54 mm^2 and the thickness of FR4 substrate is 1.0 mm. It can be treated as the system circuit board of a mobile device. The impedance transformer is located near the center position of the system circuit board longer edge and with a dimension 38 × 4 mm^2. The proposed loop antenna is fed from one end of the impedance transformer, and the other end of the impedance transformer is connected to the surrounding metal ring. The total length of the metal ring is 170 mm, and it is fabricated by a 0.2 mm thickness and 6 mm width copper. The detail bending size is also shown in Fig.1. The metal ring is extended from the connection point with impedance transformer to the opposite center position of the system circuit board longer edge and then connected to the system ground plane. To avoid the interference from the system circuit, it needs 3 mm gap between the system ground and the metal ring. The total length of the metal ring is close to the half-wavelength of the 900 MHz, and one-wavelength of 1800 MHz. It can generate the dual loop resonant modes to achieve the GSM900/1800 dual-band operations.

In addition, suitable adjustment for the width and length of impedance transformer can obtain the good impedance matching in dual resonant modes and wide operation bandwidth. Besides, in order to suit for different dimensions of the metal ring, the connection point of metal ring and impedance transformer and shorting point of the metal ring can be shifted to meet the resonant frequency requirement. The connection point of the metal ring and impedance transformer will be shifted if the total length of metal ring is too large. In the same concept, the shorting point of metal ring will be extended if the total length of metal is too small.



(a)



(b)

Fig. 1(a). Geometry of the proposed loop antenna with the metal ring of a mobile device. (b) top view of the proposed loop antenna.

III. Results And Discussion

Fig. 2 shows the measured and simulated return loss for the fabricated prototype of proposed antenna. From the results, two operating bands are obtained. Determined from 3 : 1 VSWR, the lower band has a bandwidth of 90 MHz (880 MHz ~ 970 MHz). For the higher band, a bandwidth of 300 MHz (1630 MHz ~ 1930 MHz) is obtained.

In Fig. 3, the connection point of metal ring and impedance transformer is shifted 3 mm to reduce the total length of metal ring. And it is observed that the center frequencies of two resonant modes are shifted to the higher frequency. In the same concept, the shorting point of metal ring can be extended 12 mm to increase the total length of metal ring (Fig. 4). In Fig. 5, it is found that the center frequencies of two resonant modes are shifted to the lower frequency.

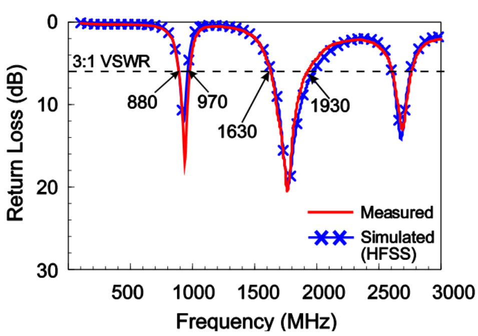


Fig. 2. Measured and simulated return loss for the proposed antenna.

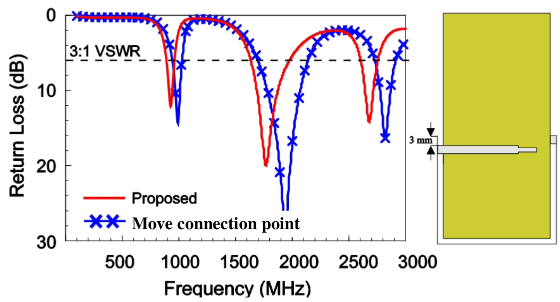


Fig. 3. Measured return loss comparison of the proposed antenna and that 3 mm movement for the connection point.

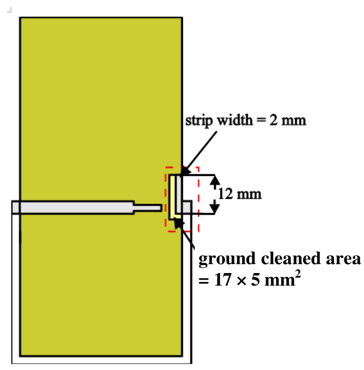


Fig. 4. Geometry of shorting point of metal ring with 12 mm extension.

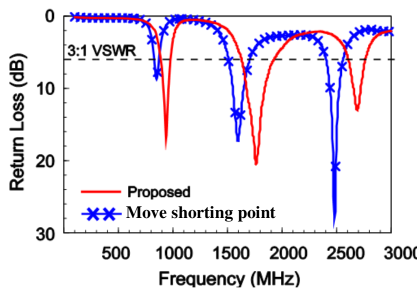


Fig. 5. Measured return loss comparison for the proposed antenna and that 12 mm movement for the shorting point.

IV. Conclusion

A novel loop antenna integrated with the metal ring of a mobile device has been proposed and studied. The proposed antenna uses an impedance transformer to connect with the surrounding metal ring as the major radiator of the loop antenna. Through the adjustment of the length and width of impedance transformer, the dual loop resonant modes include a half-wavelength and one-wavelength can be excited and also good impedance bandwidth can be obtained.

References

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