Design of the Hexa-band Planar Inverted-F Antenna using the Matching Ground

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Abstract

In this paper, a planar type inverted-F antenna working as multi-band is proposed. By use of matching ground the proposed antenna composed of several slits on the radiation patch provides operation over the quarter and hexa band wide. These bands include GSM900/DCS/PCS/WCDMA/WiMAX/WLAN, which are the key spectrums in cellular communications.

Keywords : PIFA Hexa-band operation Matching ground

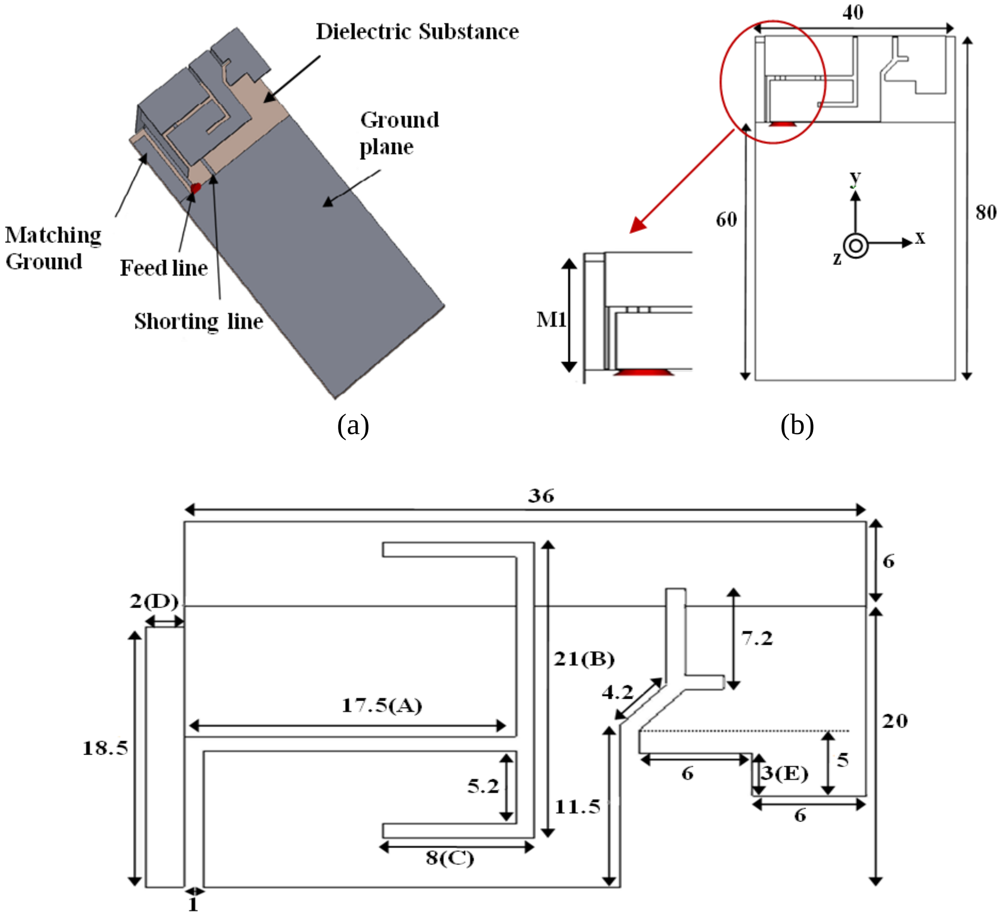
1. Introduction

The rapid progress in mobile communication requires that the mobile device should have many functions and compact size. This has led to a great demand for designing multiband antennas for compact mobile device. The traditional shape of the multi-band antennas for handset device can be divided into two groups which are the folded monopole antenna and the planar inverted-F antenna [1-4]. Between them, the planar inverted-F antenna is being adopted extensively as handset antennas more than folded monopole type because of its advantages of compact structure, low-profile, easy fabrication, low-manufacturing cost, and easy integration with portable devices. Furthermore, it can easily achieve the characteristics of the multi-band by adding the slits on the patch or radiator branches. However, a major shortcoming of the PIFA is its narrow impedance bandwidth. Hence, it has been a necessity to increase the number of slots on the patch or the number of radiator branches to obtain the multi-band operation, and it bring about the complex antenna design.

In this paper, a novel approach that is used to broaden the impedance bandwidth of conventional multi-band PIFA is presented. In particular, a matching ground [5] part is introduced into the ground plane side of the radiator patch. The bandwidth of partial bands of the initial PIFA design is enhanced by varying the length of the matching ground part; it comes to add the operating bands. The finally proposed PIFA can generate six operating bands to cover GSM900 (900-960 MHz), DCS (1710-1880 MHz), PCS (1880-1990 MHz), WCDMA (2100-2170 MHz), WiMAX (2300-2400 MHz), WLAN (2400-2485 MHz) operation. The antenna design was simulated using the commercial EM tool software (Microwave Studio of CST). The antenna model has been fabricated and its return loss was measured.

2. Antenna geometry

Figure 1(a) shows the geometry of the proposed PIFA which is comprised of a thin metal plate and a loss FR-4 substrate (with ε_r=4.5, thickness=0.4mm). The folded radiator patch occupied an area 20*36*6 mm^3. It is put on the top part of the antenna, and some slits is inserted into the patch to operate the GSM/DCS/PCS/WLAN bands. The matching ground which is the key point in this study is etched on the top part of antenna substrate. There are ground plane, matching ground, feed line, and shorting line only on the top plane of substrate, but the bottom plane of substrate is none metal region. The dimensions of the proposed antenna are shown in Fig. 1(b) which describes the top view of the antenna. And Fig. 1(c) shows the spread view and its dimensions of the radiator patch. In figure, the slit *A*, *B*, *C* corresponds to the GSM900 band that can be tuned to the desired value with adjustment of distance between feed line and shorting line. Similarly, the slit *D* is both the DCS and the PCS bands, and the slit *E* is the WLAN band, too. The *M* 1 as a length of the matching ground plays a role of the key parameter for the two supplementary bands such the WCDMA and the WiMAX.



(a) (b)

(c)

Figure 1 : The geometry and dimension of the proposed PIFA.
(a) 3D view, (b) Top view, (c) Spread view.

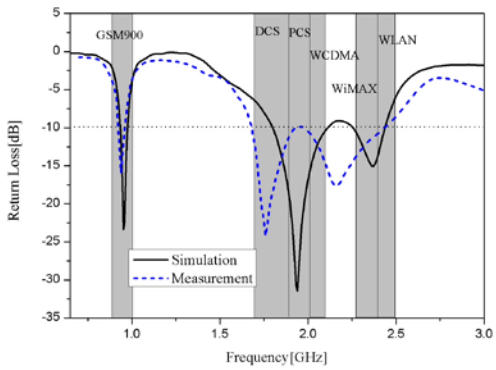


Figure 2 :Return loss of the multi-band antenna.

Figure 2 shows the simulated and measured return losses of the proposed PIFA. As seen in Fig. 2, three resonant modes at about 900, 1700, and 2200 MHz are successfully exited, respectively. The measured impedance bandwidth (VSWR ≤ 2, RL ≤ -10dB) of the each resonant mode covers the GSM900/DCS/PCS/WCDMA/WiMAX/WLAN bands.

To demonstrate the effect of the matching ground on the antenna, parametric study for the dimension *M* 1 as shown in Fig. 1(b) was conducted. Figure 3 shows the simulated return loss as a function of *M* 1, when *M* 1 varied from 16.5 to 18.5 mm is presented. It can be seen that antenna impedance bandwidth at the WCDMA and the WiMAX bands is enhanced by increasing the parameter *M* 1, while keeping the DCS/PCS/WLAN bands. In other words, it is clearly shown how the bandwidth is enhanced compared with the design before the matching ground variation. This wideband characteristic of the matching ground was reported in other type antenna [5]. The aforementioned result reveals that the target band in multi-band PIFA with multi-slits can be supplemented without the additional slits. Moreover, the GSM900 band is almost unaffected by the matching ground. This might lead to the controllability of the only target band. Figure 4 shows the effect of distance between feed line and shorting line, where distance varied from 5.5 to 8.5 mm. For a lager value of distance, it can be seen that GSM900 band shifts to lower frequency maintaining the other bands. It is evident that variation of the matching ground has no effect on the GSM900 band.

Figure 5 plots the simulated radiation patterns at the three resonant frequencies 950, 1950, and 2400 MHz. The radiation patterns of the proposed PIFA are omni-directional shown in Fig. 5. These patterns are similar with those observed for the conventional mobile antenna.

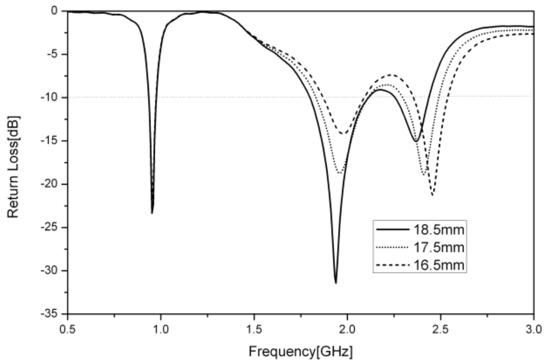


Figure 3: Simulated return losses in terms of the length *M* 1 of the matching ground.

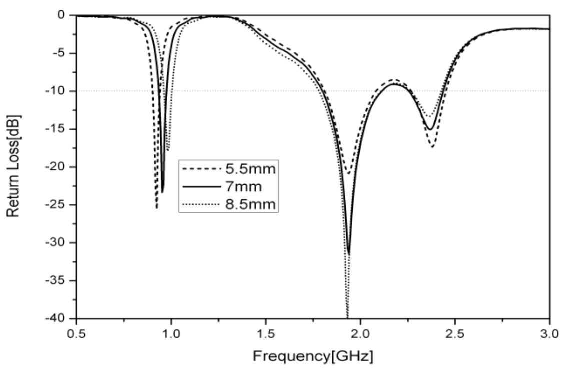
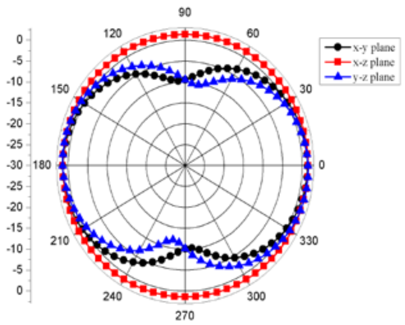
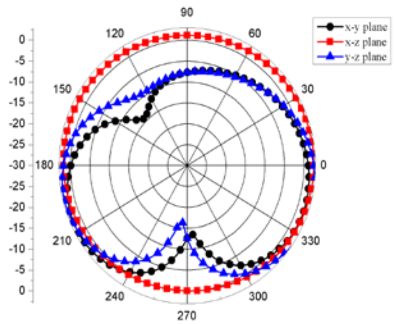


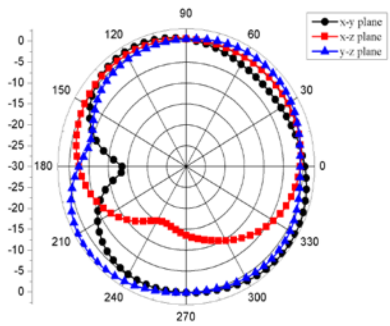
Figure 4: Simulated return losses in terms of the distance between feed line and shorting line for GSM900 band.



(a) 0.95GHz



(b) 1.95GHz



(c) 2.4GHz

Figure 5: Radiation pattern of the proposed PIFA at the GSM900/DCS/WLAN bands

3. Conclusion

This paper presents the design strategy for the multi-band PIFA with the matching ground. The final design structure is conventional multi-band PIFA with the slits on the patch for mobile devices. With the proposed design method, which uses the matching ground on the antenna, the primitive quarter-band PIFA operating at GSM900/DCS/PCS/WLAN band is expanded to hexa-band PIFA adding the WCDMA/WiMAX band. Furthermore, the matching ground not influenced the other bands the except for target bands. The proposed design method would be useful to design an internal antenna for the planar-shaped mobile devices.

References

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