A Design of the Multi-band Chip Antenna Using Parasite Patch for Mobile Handsets

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1. Introduction

Modern mobile phone handsets are required to operate at multiple frequency bands to provide various communication services [1][2][3]. Since these standards may be used simultaneously in many systems, a single antenna that can cover all these bands is needed. In recent years, more and more antennas are required to develop the compact-sized and low-profiled antennas for mobile communications. Recently, there has been a surge of interest on planar inverted-F antennas (PIFAs) for mobile phone applications [4][5][6][7]. In this paper it is designed that Chip Antenna using DCN (Digital Cellular Network) 824~894MHz, UHF (Ultra High Frequency) 908.5~914MHz, PCS (Personal Communication System) 1,850~1,990MHz and WCDMA(Wideband Code Division Multiple Access) 1,920~2,170MHz Band.

2. Antenna Structure

The research on multi-resonant antenna using meander line has already proposed with various methods such as using the slot spacing of meander lines, installing slits on radiation elements, changing the ground plane and using coupled lines [8][9][10][11]. The chip antenna based on the PIFA structure was designed by using this meander line miniaturization technique. Fig. 1. Shows the PCB layer structure to be actually produced. A 1.5mm thick FR-4 substrate with relative permittivity of 4.4 is placed in the middle while copper-plated layers are stacked top and bottom of the middle layer. Joints binding the layers together are connected with epoxy with relative permittivity of 5 and a 0.5mm width via. The antenna structure proposed in this paper is illustrated in Fig. 2. (a) represents each layer's plane figure, whereas (b) shows the structure's entire figure in 3D. The top layer is consist of meander lines PIFA structure to implement DCN, UHF (908.5~914MHz) Mobile RFID Band and is connected with each pad and meander line on the via-hole for maximize space efficiency. The middle layer is a radiator designed to implement a PCS and WCDMA bands, the bottom layer consists of single pad, ground pad and parasite patch.

3. Antenna Design

Although radiator (L2) was implemented by adjusting the signal line and Gap2 to meet bandwidths of PCS and WCDMA bands, it failed to satisfy the desired bandwidths. Radiator (L3) was added to obtain two resonance frequencies and combined bandwidths, but it was found that the characteristic impedance could not be optimized. The bottom layer which is added to a parasite patch on the ground can be shown an adjustment of frequency and impedance character by the connection of the radiators of middle layer and coupling. Fig. 3. Shows that relative to every change in length of the parasite patch (a) is 0.8~0.94 GHz, and (b) is impedance variation of 1.83~2.2GHz. It is found that impedance variation of high band (PCS, WCDMA) could be good condition with the length of the parasite patch. The geometry values are indicated in table 1.

Fig. 4. is the result of the Simulation for the excited surface Currents at (a) 859MHz and (b) at 1990MHz. It shows that the current is uniformly distributed in the signal line and the radiator. The fabricated antenna and test jig are shown in Fig. 5. The fabricated antenna with the dimension of 4mm height, 6mm width and 34mm length. It is mounted on the FR-4 substrate (ε=4.4) with a thickness of 1.6mm. The FR-4 substrate has a dimension of 45×90 mm, which is considered to be the ground plane of a practical mobile. The antenna has been designed by a commercial software CST simulator. Fig. 6 represents results of simulation using structural variables in Table 1 and the return loss measured after production. The experimental results show that the bandwidth for (VSWR<3) is 105 MHz (820~925MHz) in DCN and RFID band operation and 460 MHz (1790~ 2250MHz) in PCS, WCDMA band operation. It was found from the production that while the frequencies diminished and bandwidths varied due to changes in process tolerance and relative permittivity of the stacked-layer structure, the return losses were similar to those of the simulation. Fig. 7 shows the measured E2, H-plane radiation patterns of the DCN, RFID, PCS, WCDMA operating band.

4. Conclusion

The paper introduces mobile handset multi-band chip antenna based on meander line PIFA structure. The experimental results show that the bandwidth for (VSWR<3) is 105 MHz (820~925 MHz) in DCN and RFID band operation and 460 MHz (1790~2250MHz) in PCS, WCDMA band operation. The maximum gains of antenna are 1.56 dBi, 0.5 dBi, 2.97 dBi and 3.23 dBi at resonance frequencies and it has omni-directional pattern practically. The study introduced in this paper greatly enhanced mass-production of antennas based on a chip antenna structure using the SMD process rather than the existing removable internal antennas. In addition, the paper suggested applicability of multi-band antennas by miniaturizing the volume of antennas to minimize the body effect. It is expected that the structure will be useful for future mobile handset antenna design.

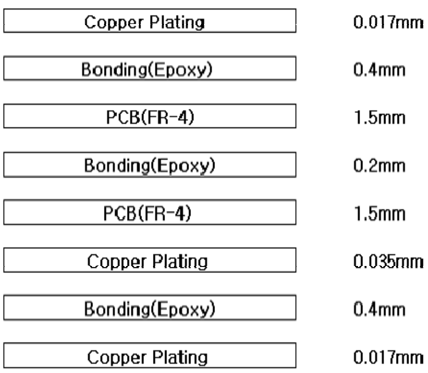


Figure 1: PCB Multi Layer structure

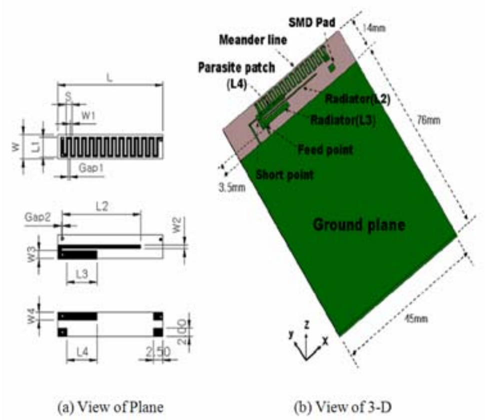
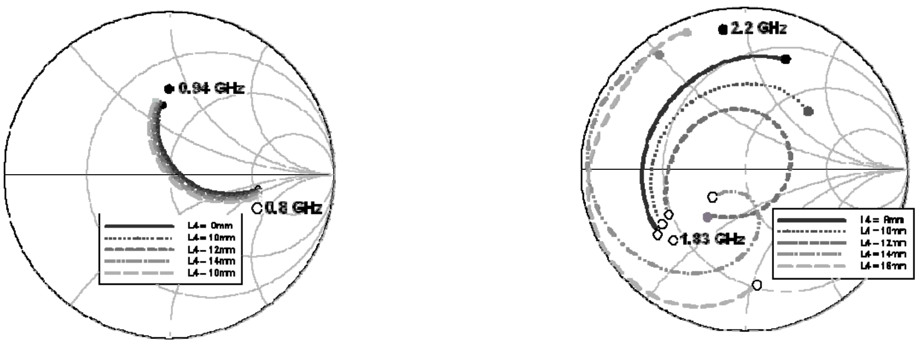


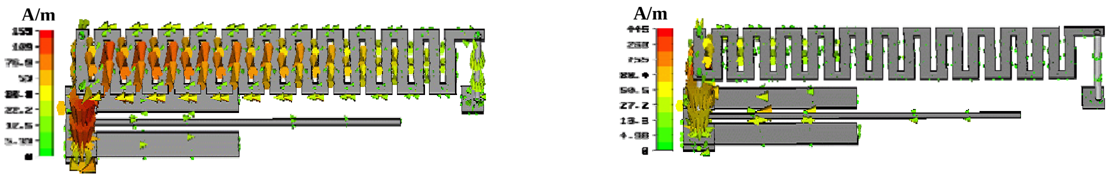
Figure 2: Geometry of the proposed antenna



(a) Impedance variation(0.8~0.94GHz)

(b) Impedance variation(1.83~2.2GHz)

Figure 3: Impedance variations with the different parasite patch (L4) length (8~16mm)



(a) Current distribution in the DCN band(859MHz)　　(b) Current distribution in the PCS and WCDMA band(1990MHz)

Figure 4: Simulated surface current distributions at (a) 859MHz and (b) at 1990MHz

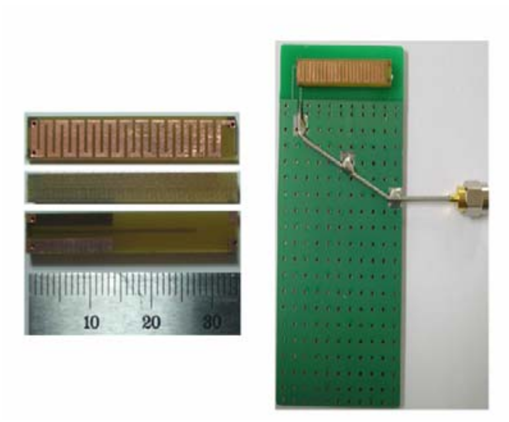


Figure 5: The photograph of the fabricated antenna

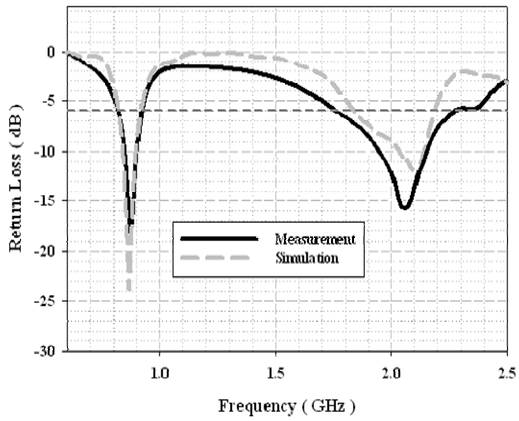


Figure 6: Simulated and measured return loss

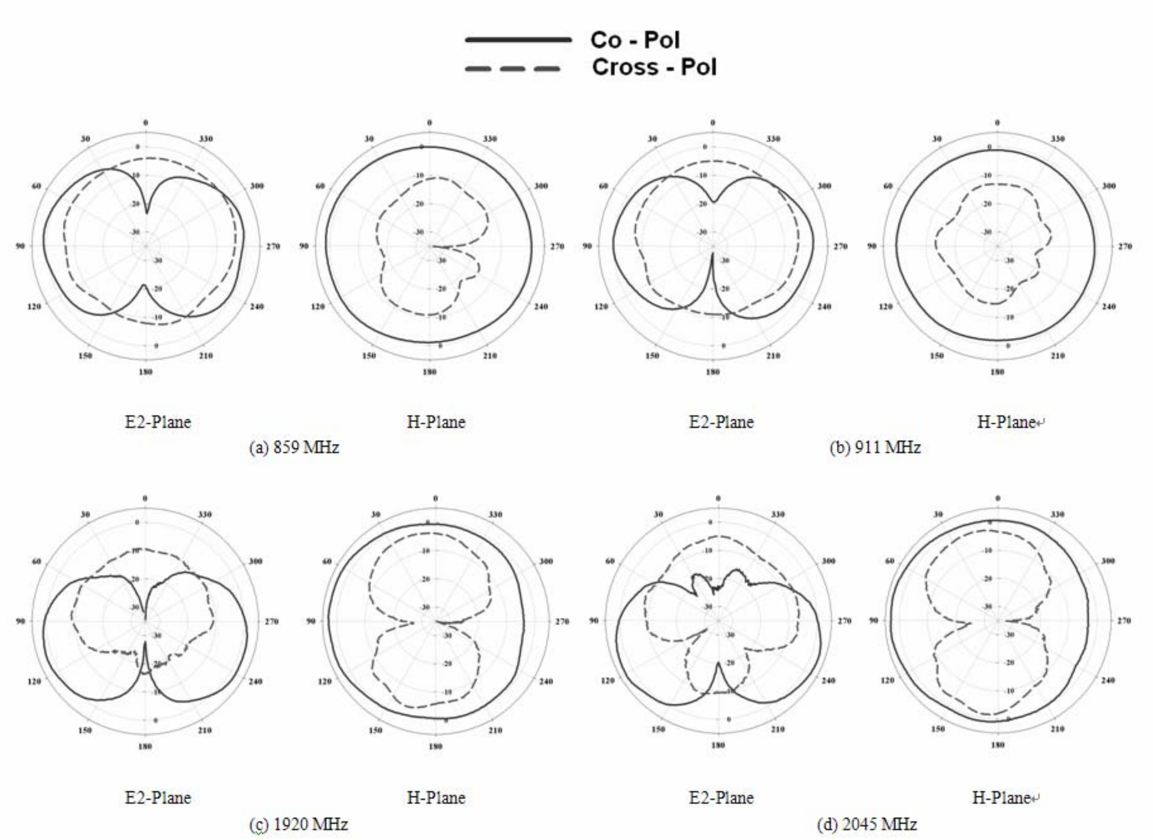


Figure 7: The measured radiation patterns of the proposed antenna

Table 1: Font Sizes for Papers

L	34 mm	Meander line Length	L3	11.5 mm	Line Length
S	1.6 mm	Meander line Section Length	W3	1.7 mm	Line Width
W1	0.8 mm	Meander line Width	L4	11.5 mm	Line Length
Gap1	0.45 mm	Meander line Gap	W4	1.7 mm	Line Width
L2	26 mm	Line Length	Via-H	0.5 mm	Layer & Via-hole Width
W2	0.3 mm	Line Width	Pad	2.5 × 2 mm	SMD PAD Size
Gap2	0.2 mm	Line & Singal Line Width			

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