COMPACT MULTI-BAND HANDSET ANTENNAS FOR SDR APPLICATION

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ABSTRACT

A compact, multi-band antenna that has been recently developed for handset application is presented. The antenna is mounted on a CDMA/GPS dual band phone and tested in each band for antenna gain/efficiency measurement. The antenna was also successfully tested for active GPS SNR in the SK-Telecom network in Korea. It is shown that the antenna generates superior gain in both operating bands, resulting in significant improvement in GPS yield rate. Equally superior performance over entire frequency bands is required for a future SDR handset system.

1. INTRODUCTION

In the past decade, SDR has been considered for many wireless communication areas [1-6]. The importance of applying SDR to wireless handsets has become more evident and requires development of the new antennas that support multi-band operation [7, 8]. Each resonance frequency must be tuned to target operating frequencies and the antenna performance including gain should be equally superior in entire bands. This is not easily achievable using conventional antennas. In this paper, a newly developed compact internal antenna meeting these criteria is presented. The antenna was installed and tested in a commercial CDMA/GPS dual band handset. It is shown that the antenna has high gain in both bands and that each frequency can be individually tunable to target frequencies.

2. ANTENNA STRUCTURE

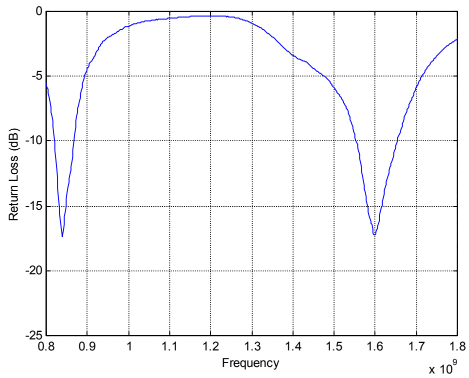
FIGURE 1 shows the antenna installed in a CDMA/GPS dual band handset. The antenna consists of a metal radiator, feed and ground legs, and a form spacer (carrier). The phone was originally developed using a conventional whip antenna. In order to avoid negative impact to the phone performance, the internal antenna was mounted on the existing feed pad (designed for the whip antenna) on the PCB without modifying PCB configuration.

FIGURE 1. Antenna Installed in a CDMA/GPS Handset

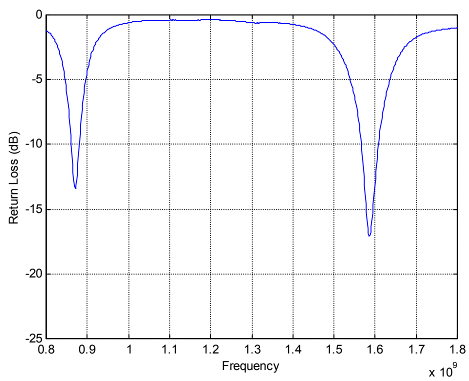
The antenna radiator is approximately 24 mm (W) x 12 mm (L). Also, the radiator is spaced at 5 mm height over the PCB leading to a physical volume of 1440 mm^3. The feed and the ground lines are physically connnected to the PCB feed/ground pads using spring metal lines. Multiple meander lines are used to tune the resonance frequencies and to maximize radiation performance. The back housing was modified slightly to completely enclose the radiator.

3. INPUT IMPEDANCE

FIGURE 2. shows the measured input return loss of the antenna. The antenna was measured in both folder open and closed positions.



(a) Folder Open



(b) Folder Closed

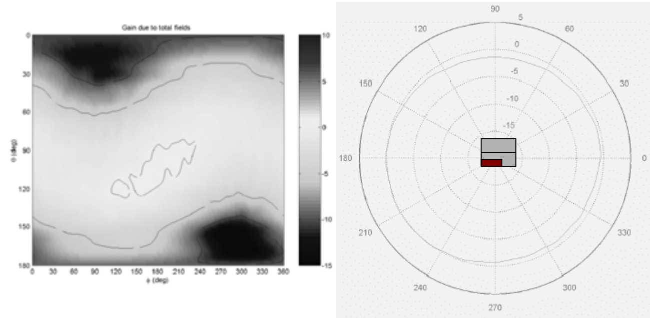
FIGURE 2. Input Return Loss

As can be seen in the figure, the antenna was tuned for CDMA (824 ~ 894 MHz) and GPS (1575 MHz) bands. The bandwidth of the antenna was affected by the folder position and is wider in the folder-open position. The coupling of the actual PCB grounds in both sections of the phone caused this effect. For instance, in the folder-closed position, the PCBs are parallel. Therefore, the currents flowing in PCBs generate negative coupling. Methods to minimize this effect are currently under investigation.

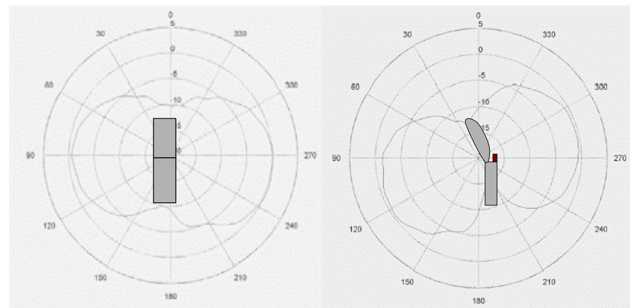
4. RADIATION CHARACTERISTICS

4.1. Passive Test Result

The antenna mounted in the handset was measured for radiation characteristics. The typical measured radiation patterns of the antenna are shown in FIGURES 3 and 4. The phone was measured in the folder-open position.

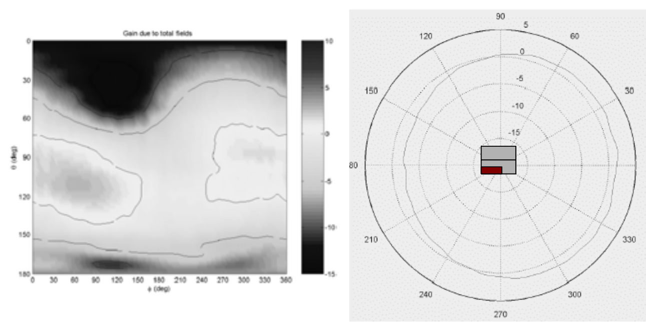


(a) 3D Contour pattern (b) H-Plane cut (θ = 90°)

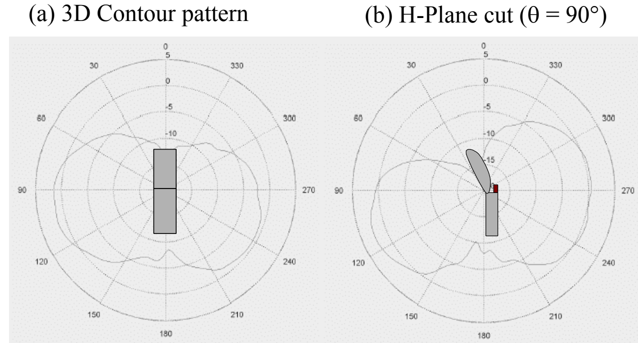


(c) E-Plane cut (ϕ = 0°) (d) E-Plane cut (ϕ = 90°)

FIGURE 3. Radiation Pattern in CDMA Band (850 MHz)



(a) 3D Contour pattern (b) H-Plane cut (θ = 90°)



(c) E-Plane cut (ϕ = 0°) (d) E-Plane cut (ϕ = 90°)

FIGURE 4. Radiation Pattern in GPS Band (1575 MHz)

The measured gain at the center of CDMA band (850 MHz) is 0.3 dBi and the gain in the GPS band (1575 MHz) is 2.8

dBi. Usually, a normal whip or dipole antenna uses harmonic resonances or matching networks to obtain dual or multi-band characteristics. Therefore, the radiated gain of the antenna in one of the operating bands is often reduced due to the field canceling effect generated by opposite surface currents in the linear radiator or from loss in the matching networks. This drawback was overcome in the new internal antenna presented in this paper. As shown in FIGURE 3 and 4, the antenna generates reasonably high gain in both bands.

For these tests, the antenna was measured in the passive mode; that is, the antenna feed was separated from the PCB feed circuit and connected to a passive test port. To insure that the results are valid when the antenna is coupled to the active phone circuit in actual operation, the phone was also measured in the active mode.

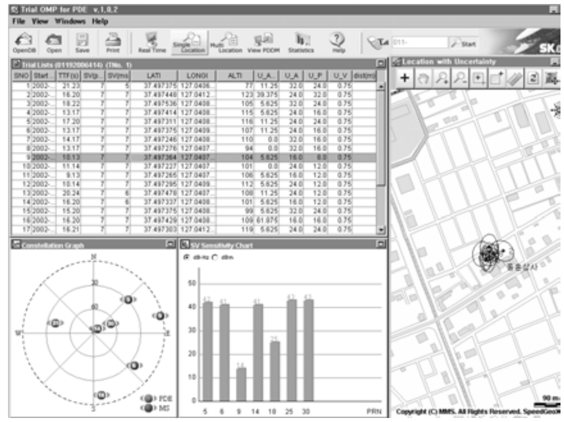
4.2. Active Test Result

The phone equipped with internal antenna was measured in the operational SK-Telecom CDMA/GPS network in Korea. First, a CDMA-based comparison drive test was conducted against the existing whip antenna in an urban metropolitan area. The test result indicated that on the average the internal antenna performed 1.7 dB better than the existing retracted whip antenna.

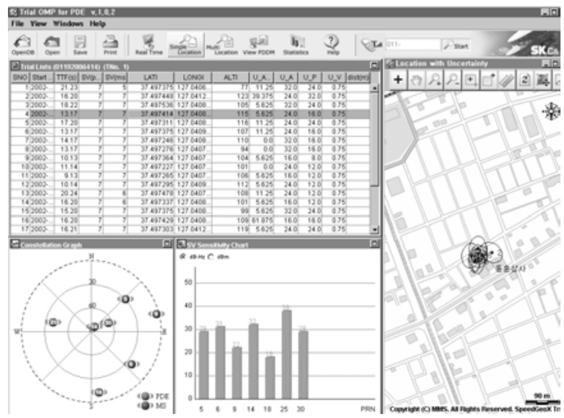
In the GPS band, the active phone with internal antenna was tested for SNR in an outdoor environment using a direct satellite link and compared to the phone with the existing whip antenna. FIGURES 5-a and b illustrate the GPS test software window. Small dots indicate the detected satellites and bars indicate the measured SNR value from each satellite. The test was repeated 50 times with a specific time gap to minimize the test error. FIGURE 5-c also shows the average SNR values from each satellite. It is observed that phone with the internal antenna has 2 dB higher total average SNR value than the phone with the retracted whip antenna, and 0.5 dB higher SNR value than the phone with the extended whip antenna.

The improvement in SNR values in the GPS link also improves the yield rate in an indoor GPS test environment. The yield rate is a measure of the probability for detecting location using the GPS link during a certain time period. The test was conducted inside a building where the direct satellite communication could not be easily established. After 50 measurements, the yield rate measured using the retracted whip antenna was 53.3 % while the phone with the internal antenna generated 66.7%.

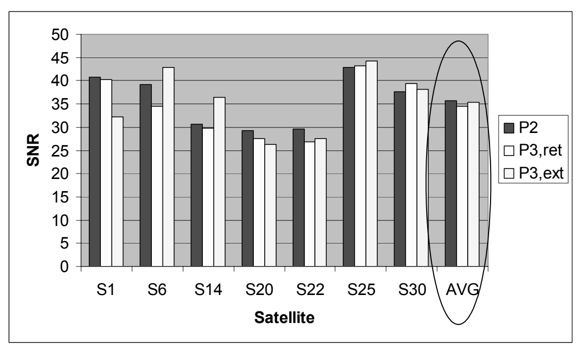
Therefore, in both CDMA Cellular and GPS active tests, we conclude that the internal antenna had superior performance to the whip antenna, without causing negative coupling effect between the antenna and the PCB circuit when the phone was activated.



(a) For the phone with the internal antenna



(b) For the phone with the retracted whip antenna



(c) Summary of the GPS active test
(P2: Internal antenna, P3: Retracted whip antenna, P4, Extended whip antenna)

FIGURE 5. GPS Active Test Result

5. CONCLUSION

A new multi-band internal antenna was presented. The antenna was mounted in an actual CDMA/GPS dual band phone and tuned for those operating frequencies. In a passive antenna test, the antenna generated superior gain in both bands. The phone was activated and measured in an actual SK-Telecom CDMA Cellular/GPS network. The result showed the antenna improved the phone performance in both bands. Particularly, the internal antenna improved the GPS yield rate by 13.4 % in an indoor test.

An SDR handset will require highly performing multi-band antenna. This new compact internal antenna can be one of the strongest solutions since it has many advantages including compact size, multi-band operation, and superior performance in entire bands.

Although in this paper, the antenna was tuned for CDMA/GPS bands, it should be emphasized that each resonance frequency of the antenna is independently tunable. That is, the antenna can be used not just for CDMA/GPS system but also for any wireless communication system to which SDR can be applied.

6. REFERENCES

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