

Feasible Diversity Antenna Design for Dual Band Mobile Handsets

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1. Introduction

Capacity improvements can be achieved in a CDMA cellular system through the use of handsets equipped with dual antennas/receivers [1-2]. Signals received by each antennas are manipulated using various combining algorithms in the data processing in order to improve the overall received signal to interference plus noise ratio (RX SINR). The RX SINR directly impacts the amount of forward link power required from the cellular basestation. Users with improved SINR require less power to serve them, thereby allowing more users to be served in a cell. Hence the overall system capacity is improved.

The intent of this study is to demonstrate the feasibility of the diversity antenna design for existing commercial handsets and to evaluate the potential capacity improvements using field test data measured in a real cellular network.

2. Antenna Design

In general, the antenna performance of handsets is sensitive to the near components associated with specific boundary condition. Therefore, the antenna design should take into account the effect of the handset platform including the circuit board configuration, battery, and plastic cover. In this study, the mobile handset Qualcomm QCP-2700 was selected as the platform for the developed diversity antenna.

Since the dual antennas are designed for a receive diversity handset in the forward link, the function of one antenna must be for transmit and receive denoted as the primary antenna, and the other is for receive only, denoted as the secondary antenna.

QCP-2700 handset has an existing whip antenna operating at US Cell band 824 to 894 MHz and PCS band 1850 to 1990 MHz. This antenna was considered as the primary antenna operating for transmit and receive. The work on this antenna was simply to fine tune the impedance matching after adding the secondary antenna.

The secondary antenna was designed as an internal antenna. The meander line type of inverted F antenna was built on a thin flexible board, as shown in Figure

1. The dual band feature was realized by dividing the trace into two arms – one for PCS and the other for Cell band. The two traces share the common feed and grounding pads that are connected the circuit board through the pogo pins. The distance between the feed and grounding points was optimally selected such that the input impedance is 50 ohms at both resonant frequencies. The simulation tool IE3D was employed in this study. The measured return loss is shown in Figure 2.

3. Chamber Tests

The developed handset prototype was first tested in the anechoic chamber. The antenna was mounted on a two-axis positioner fixture that can generate the 3D patterns of the antenna.

The antenna gain patterns were based on the total fields combining vertical and horizontal polarized components. The test parameters of interest include the following:

- **G_max**: the peak of the antenna gain over the entire sphere.
- **G_avg($\pm\theta^\circ$)**: the spatial average of the total field antenna gain over the conic region of $\pm\theta^\circ$ about the horizon plane.
- **Efficiency Loss**: the equivalent antenna loss obtained by integrating the whole sphere 3D patterns. Note that Efficiency Loss equals $G_{avg}(\pm 90^\circ)$.
- **MEG and Correlation Coefficient ρ** : the estimated mean effective gain and the complex voltage envelop correlation coefficient of the dual antennas using the measured antenna patterns (complex polarimetric data) and Taha's statistical models of the incident fields [3]. The following urban parameters were used in the calculation:

$$m_v(\text{deg}) = 19, \sigma_v(\text{deg}) = 20, m_h(\text{deg}) = 32, \sigma_h(\text{deg}) = 64, \text{ and XPR} = 5\text{dB}$$

The definitions of testing environments are listed as follow:

- **Free Space**: only the antenna itself is tested in the anechoic chamber
- **Kuster Head**: the antenna is attached to a plastic phantom head containing liquid simulating human brain tissue.

Tables 1 and 2 summarize the radiation performance of the prototype in free space and on Kuster Head, respectively. Data show that the head loss has less impact on Whip than MLA at Cellular band. Data also show that the external Whip antenna outperforms the internal MLA about 4 dB at Cellular band, while only slightly better at PCS band.

4. Conclusions

In this study, a feasible diversity antenna design is demonstrated on a dual band commercial handset. The meander line inverted F antenna is designed, implemented, and tested. A good rule of thumb derived from these results is to

limit the average gain of the secondary (internal) antenna to be no less than 6 dB lower than that of the primary (external) antenna when the phone is in talk position next to the user's head. This was used as a performance goal for the design of diversity antennas.

Reference:

1. "CDMA forward link capacity improvements with dual-antenna handsets," QC DCN# 80-H0567-1.
2. J. Colburn, Y. Rahmat-Samii, M. Jensen, and G. Pottie, "Evaluation of personal communications dual-antenna handset diversity performance", IEEE Trans. Antena Propagat., vol. 47, pp.737-746, Aug. 1998.
3. K. Fujimoto and J.R. James, "Mobile Antenna Systems Handbook," Section 2.4, Artech House, 2nd ed, 2000.

Figures and Tables

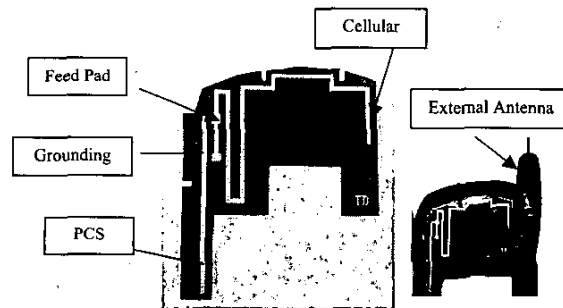


Figure 1. The designed internal diversity antenna – the detail layout and the integration with the back housing of the handset.

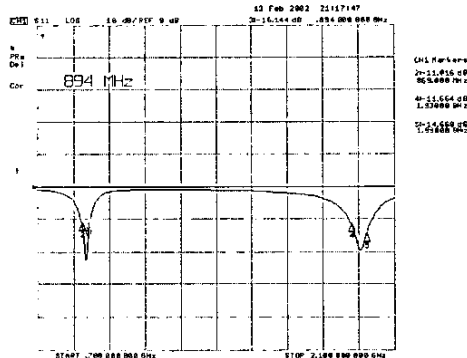


Figure 2. The measured return loss of the developed diversity antenna (for receive band only).

Table 1 Range Performance in Free Space

	G _{max} (dBi)	G _{avg} (+/- 45°) (dBi)	G _{avg} (+/- 0°) (dBi)	Eff. Loss (dB)	MEG (dBi)	Corr. Coef. ρ
Cellular Band (800 MHz)						
Internal MLA	-0.5	-3.6	-4.3	-4.8	-7.4	0.24
External Whip	2.2	-2.4	-2.3	-2.7	-4.6	
PCS Band (1900 MHz)						
Internal MLA	2.7	-2.1	-2.2	-2.3	-5.6	0.05
External Whip	2.2	-2.6	-2.0	-2.2	-5.0	

Table 2 Range Performance with Kuster Head

	G _{max} (dBi)	G _{avg} (+/- 45°) (dBi)	G _{avg} (+/- 0°) (dBi)	Eff. Loss (dB)	MEG (dBi)	Corr. Coef. ρ
Cellular Band (800 MHz)						
Internal MLA	-3.0	-8.7	-9.0	-9.4	-11.4	0.10
External Whip	-1.0	-6.1	-5.8	-5.8	-7.3	
PCS Band (1900 MHz)						
Internal MLA	2.6	-3.4	-4.1	-4.3	-6.6	0.02
External Whip	2.8	-2.9	-3.5	-3.9	-5.9	