Measurement Characteristics of LTE-MIMO Antenna for 4G Mobile Handy Terminal

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1. Introduction

In recently, mobile communication technology is developing toward the 4th generation communication technology. The LTE (Long Term Evolution) is the leading candidate technology in the 4th generation mobile communication. The LTE technology is combined with the MIMO (Multiple Input Multiple Output) technology and this coupled technology has a high-quality data transfer rate and an expended channel capacity [1]. The MIMO antenna technology is applied by a mobile handy terminal for 4th generation. The 4G mobile handy terminal antenna is composed a main antenna and a sub antenna. Main antenna has to satisfy not only conventional operating frequency service such as CDMA (824~849 MHz), GSM900 (880~960 MHz), DCS (1,710~1,880 MHz), USPCS (1,850~1,990 MHz), WCDMA (1,920~2,170 MHz), and WiFi (2,400~2,499 MHz) but also LTE (698~798 MHz) frequency band. In order to realize the maximum channel capacity, the 4G handy terminal antenna must employ the sub antenna operated LTE frequency band. LTE frequency band by reference [2] has from 1 to 43 channels with respect from 699 to 3,800 MHz. Authors consider only for the LTE class 13 and 14 band in this paper, because many mobile companies use these channels for 4G mobile service. However, because the LTE class 13 and 14 band have a relatively low operating frequency band (746~798 MHz) for the current mobile handy terminal applications, it may still be difficult to obtain a wide bandwidth and high isolation because of two closely located antennas within the limited space [3]. In order to solve the above problems, authors have been simulated for structure of main and sub antenna, and for feeding position of two antennas, iteratively. As a result, high isolation between main and sub antenna, and bandwidth satisfying for the LTE class 13 and 14 have been realized experimentally.

2. Antenna structure

Fig. 1 shows a photograph of the prototype mobile handy terminal structure that is considered PCB board, polyamide case and battery for high reliability of the proposed antenna performance. As shown in Fig. 1 (b), the main antenna and the sub antenna are considered the PIFA (Printed Inverted-F type Antenna) structure and the meander line structure for miniaturization, because antenna operated at the LTE class 13 and 14 band is required the short electrical length about 100 mm (λ/4). As shown in Fig. 1 (c), PCB board with 8 mm thickness is divided by two parts: one part is a FR-4 epoxy which is located on the main antenna and the sub antenna, and other part is a conductor used for ground plane.

Fig. 2 shows main antenna structure with reconfigurable operation. When resonant frequency generated at the LTE class 13 and 14 band is uniquely appeared by chip resistance of 56 [Ω], chip capacitance of 56 [pF], chip inductance of 56 [nH] and 0.6 [v] supplied from battery as shown in Fig. 2 (b). However, if only voltage of 0.6 [v] is not supplied by battery, the LTE band in main antenna is disappeared. Therefore, voltage control in main antenna is very important for the LTE band appearance.

Fig. 3 shows a sub antenna structure for the LTE class 13 and 14 band. The sub antenna printed on polyamide has 7 mm x 62 mm x 5 mm. In order to compensate on an electrically resonated length at limited space of mobile terminal, the PIFA and the meander line structure are considered in design.
3. Measurement

In order to verify the performance of a fabricated antenna as shown in Fig. 1, VSWR and isolation have been measured by VNA (Vector Network Analyzer, E5071, Agilent Technologies). Radiation pattern, gain and ECC (Envelope Correlation Coefficient) have been also measured in anechoic chamber for antenna reliability.

Fig. 4 shows the measured VSWR, and the measured isolation between main and sub antenna. In Fig. 4 (a), the measured VSWR of the sub antenna has been observed from 746 MHz to 798 MHz with respect to the reference level of VSWR 3:1. This bandwidth had satisfied for the LTE class 13 and 14 band. When voltage of 0.6 [v] has been supplied to main antenna, wide bandwidth of 690 ~ 1,100 MHz has been also observed and satisfied the LTE band. The observed isolation level was about -13 dB below at the LTE class 13 and 14 band as shown in Fig. 4 (b). This level is enough for practical use.

Fig. 5 shows the radiation patterns of main and sub antenna measured at the LTE class 13 and 14. The amplitude levels of the measured radiation patterns of each antenna have been observed with the similar level in spite of various frequencies. The measured radiation patterns of two antennas have been also observed an omni-directional pattern.

Fig. 6 shows the measured gain and the ECC calculated by the measured electric field of main and sub antenna. The measured gain of main and sub antenna appears above -3.8 dBi. These gain levels are sufficient for practical use with comparison of commercial target level of – 6 dBi. The ECC calculated by the measured electric field of main and sub antenna is indicated by Eq. (1) [4]. In eq. (1), $\rho_e$ is envelope correlation coefficient. $\sigma_1$ and $\sigma_2$ are the standard deviation of the elevation angle of arrivals for main antenna and sub antenna, respectively. $P_\theta(\theta, \Phi)$ and $P_\phi(\theta, \Phi)$ are the angular density functions of the vertically and horizontally polarized components of the incident field, both contributing to the total incident field. XPR is the cross-polarization power ratio.

Therefore, the ECC of Fig. 6 (b) was calculated by eq. (1). The observed average ECC level shows about 0.5 below at the LTE class 13 and 14 band. This level is enough for practical use with comparison of commercial target level of 0.6.

$$\rho_e = \frac{|R_{12}|^2}{\sigma_1 \cdot \sigma_2}$$ (1)

$$R_{12} = \sum_{j=1}^{N_\phi} \sum_{i=1}^{N_\theta} (XPR \cdot E_{\theta 1_{i,j}} \cdot E_{\phi 2_{i,j}}^* \cdot P_{\theta 1_{i,j}} + E_{\phi 1_{i,j}} \cdot E_{\phi 2_{i,j}}^* \cdot P_{\phi 1_{i,j}}) \sin \theta_i \cdot \Delta \theta \cdot \Delta \phi$$ (2)

$$\sigma_1 = \sum_{j=1}^{N_\phi} \sum_{i=1}^{N_\theta} (XPR \cdot E_{\theta 1_{i,j}} \cdot E_{\theta 1_{i,j}}^* \cdot P_{\theta 1_{i,j}} + E_{\phi 1_{i,j}} \cdot E_{\phi 1_{i,j}}^* \cdot P_{\phi 1_{i,j}}) \sin \theta_i \cdot \Delta \theta \cdot \Delta \phi$$ (3)

$$\sigma_2 = \sum_{j=1}^{N_\phi} \sum_{i=1}^{N_\theta} (XPR \cdot E_{\theta 2_{i,j}} \cdot E_{\phi 2_{i,j}}^* \cdot P_{\theta 1_{i,j}} + E_{\phi 2_{i,j}} \cdot E_{\phi 2_{i,j}}^* \cdot P_{\phi 1_{i,j}}) \sin \theta_i \cdot \Delta \theta \cdot \Delta \phi$$ (4)

Therefore, the ECC of Fig. 6 (b) was calculated by eq. (1). The observed average ECC level shows about 0.5 below at the LTE class 13 and 14 band. This level is enough for practical use with comparison of commercial target level of 0.6

4. Conclusion

This paper presents measurement characteristics of LTE-MIMO antenna for 4 G mobile handy terminal. The considered LTE band is the class 13 and 14 in this research. Main antenna is operated reconfigurable by voltage control. The measured bandwidth of proposed antenna has been observed about 53 MHz (746~798 MHz) for VSWR 3:1. The measured isolation between main antenna and sub antenna has been showed about – 13 dB below at LTE band. This level is enough for practical use. The ECC calculated by eq. (1) shows an average 0.5 below at the LTE band. It is verified that the proposed antenna has very good performance as the LTE-MIMO antenna by measurement.
5. Figures

(a) Fabricated antenna photograph     (b) Detail structure of Fig. 1 (a)           (c) PCB board

Figure 1: A proposed prototype mobile handy terminal structure.

(a) Top view                             (b) Bottom view           (c) Planar structure of (a) and (b)

Figure 2: Main antenna structure.

(a) Top view               (b) Bottom view        (c) Planar structure of (a) and (b)

Figure 3: Sub antenna structure for the LTE class 13 and 14 band.
Figure 4: The measured VSWR, and the measured isolation between main and sub antenna.

Figure 5: The radiation patterns measured at the LTE class 13 and 14 band.

Figure 6: The measured gain and ECC of main and sub antenna.

References

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