# ±45° Dual-polarized Reference Antenna at 800 MHz Band

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## Abstract

Usually, standard gain horn antennas have been used as a reference antenna in antenna gain comparison measurements. However, these horn antennas are not suitable for testing mobile communication base station antennas in 800 MHz band due to their big size and heavy weight. This paper introduces a reference antenna of a circular-folded dipole antenna type with a dual-polarized radiating element of ±45° on a rectangular flat reflector with the folded edges at both ends. Measured results of the proposed antenna of 280 mm (W) × 560 mm (H) × 100 mm (D) size show that this antenna has a gain larger than 9 dBi and a beamwidth of about 60° in the frequency range from 698 MHz to 960 MHz.

**Keywords:** Reference antennas, circular-folded dipole antenna, gain comparison measurements, mobile communication base station antennas testing.

## 1. Introduction

As the national metrology institute of Korea, KRISS has been establishing and disseminating national measurement standards traceable to international standards and measurement technologies in Korea. Disseminations of the established measurement standards and technologies have been accomplished through calibration and testing services, supply of certified reference materials, and education and training on measurement techniques for industry.

For more effective and direct transfer of the established measurement standards and technologies, the Center for Electromagnetic Wave of KRISS organized the 'Antenna Measurement Club' of KRISS in 2008. Main mission of this Measurement Club is to share technical knowledge of measurements and to establish networks among the club members who are interested in antenna measurements. At present 39 organizations from academic, industrial, and research organizations have joined the club.

Usually, one has been using standard gain horn antennas (SGH) as a reference antenna in antenna gain comparison measurements because SGH has a bandwidth wider than resonance type antennas, rigid structure, high-purity linear polarization characteristics, smooth gain curve than double ridged horn antennas (Table 1). However, SGH is not suitable for testing dual-polarized mobile communication base station antennas in 800 MHz band due to its big size and heavy weight. In antenna gain comparison measurements, SGH also needs to be rotated in receiving mode for polarization match when testing dual-polarized antennas and the rotation of SGH may make alignment between transmitting and receiving antennas degraded.

This year, the Antenna Measurement Club is going ahead with developing a ±45° dual-polarized reference antenna for testing mobile communication base station antennas in 800 MHz band. Purpose of developing the dual-polarized reference antenna is to provide members of the Antenna Measurement Club with a reference antenna suitable for testing dual-polarized mobile communication base station antennas used in LTE (698-790 MHz), TRS (806-866 MHz), Cellular (824-894 MHz), and GSM (890-960 MHz).

This paper introduces a dual-polarized reference antenna of a circular-folded dipole antenna type with a ±45° dual-polarized radiating element on a rectangular flat reflector with the folded edges at both ends.

Table 1: Specifications of a typical SGH and the proposed antenna in 800 MHz band

| | Typical SGH | Proposed antenna |
|---|---|---|
| Frequency Range (MHz) | 750 to 1100 | 690 to 960 |
| VSWR (Return loss (dB) | < 1.5 (> 14) | < 1.5 (> 14) |
| Gain (dBi) | 15 to 17 | 9 to 12 |
| H-plane beamwidth (deg.) | 45 to 50 | 57 to 68 |
| E-plane beamwidth (deg.) | 45 to 50 | 50 to 58 |
| Polarization | Single (Vertical) | Dual (±45°) |
| Dimensions (W×H×D (mm)) | 895×765×615 | < 300×600×100 |
| Weight (kg) | 18.4 | < 2.5 |

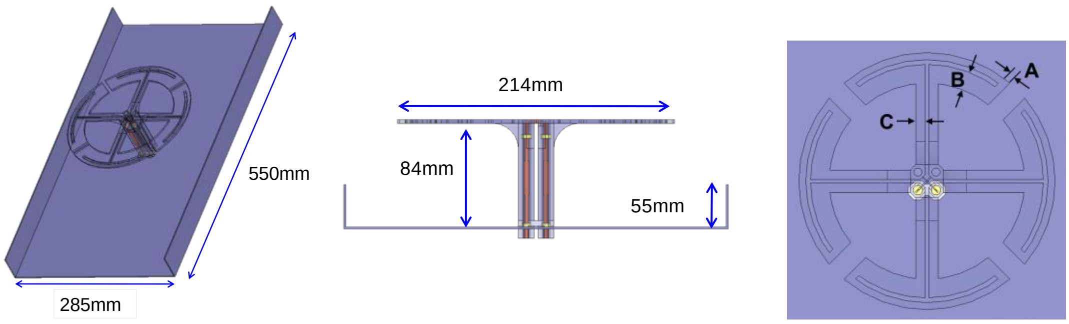
## 2. Antenna Configuration and Its Design

At the beginning of the analogue mobile communication, the communication system used vertical-polarized base station antennas utilizing vertical λ/2 dipoles while digital mobile communication system introduced ±45° dual-polarized antennas utilizing λ/2 dipoles rotated by ±45° [1-3]. Recently, mobile communication base station antennas are using ±45° dual-polarized antennas with a structure for combing the vertical and horizontal polarization characteristics [4].

Theoretically, reference antennas need to be as similar as possible to AUT (Antenna Under Test) for getting lower measurement uncertainties in antenna gain comparison measurements. For testing ±45° dual-polarized mobile base station antennas, this paper proposed a reference antenna that is improved to meet the specifications in Table 1 from conventional ±45° dual-polarized mobile base station antennas [5]. As compared with conventional mobile base station antennas, the proposed antenna has a wide bandwidth and a small antenna gain (i.e. small size and broad radiation pattern) for a short measurement distance between transmitting and receiving antennas in antenna gain comparison measurements.

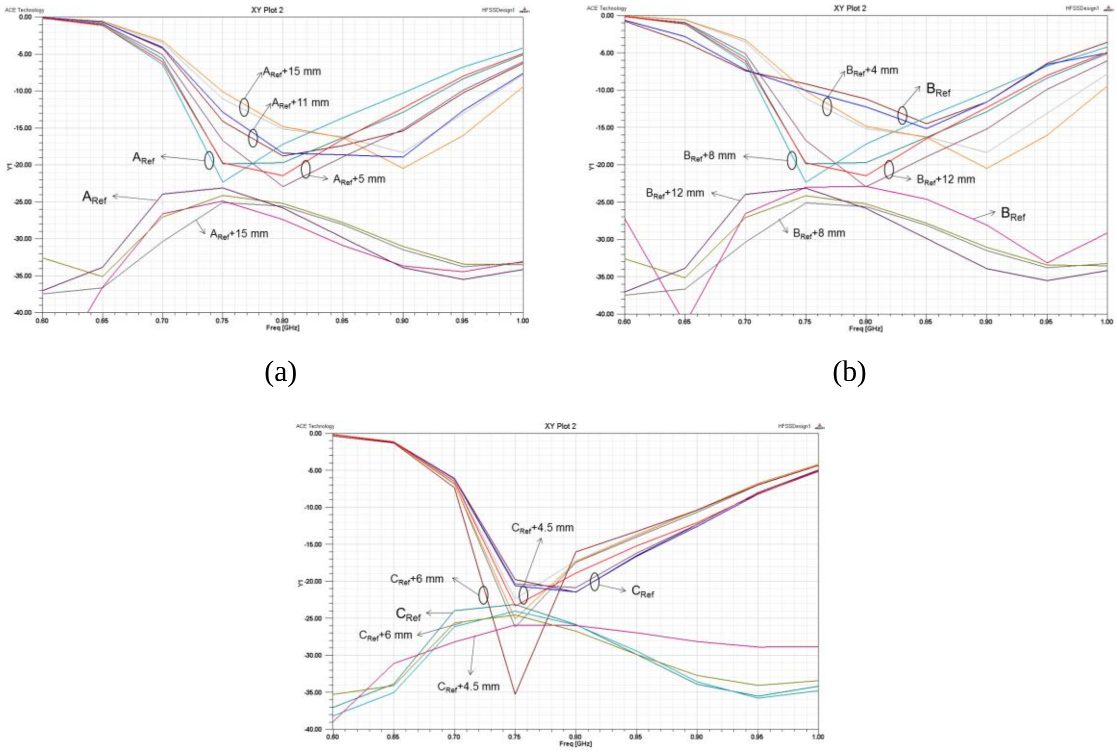
The proposed antenna has a dual-polarized radiating element placed λ/4 above a rectangular flat reflector, as shown in Figure 1. It adapts a radiating element of a circular-folded dipole antenna type for a broad bandwidth and dual-polarized vector synthesis technique for the ±45° dual polarizations [6]. The rectangular reflector has the folded edges at both ends. Upper-side arms of the two circular-folded dipole antennas are each connected to the inner conductors of two separate coaxial lines while lower-side arms are connected to the outer conductors of the coaxial lines (i.e., the ground).

There are three key design parameters in the proposed antenna, i.e., gap (*A*) of the dipole, width (*B*) of the circularly folded line and width (*C*) of the feeding part, as shown in Figure 1(c). The proposed antenna is simulated with HFSS with the condition that the antenna is made of brass of 3 mm thickness, diameter of the radiating element is 214 mm, separation distance of the element from the reflector is 84 mm, size of the reflector is 285 mm (W) × 550 mm (H) × 55 mm (D), and diameters of the outer and inner conductors of the 50 ohm coaxial line are 7.0 mm and 2.5 mm, respectively.




(a) (b) (c)

Figure 1: (a) Antenna configuration. (b) Cross section of radiating element. (c) Design parameters.




(a) (b)

(c)

Figure 2: Dependences of the return loss and isolation on (a) *A*, (b) *B*, and (c) *C*.

Figure 2 shows dependences of the return loss and isolation between two input ports of the designed antenna on *A*, *B*, and *C* for $A_{Ref}$ = 5 mm, $B_{Ref}$ = 12 mm, $C_{Ref}$ = 5 mm. Figure 2(a) shows that bandwidth (return loss > 15 dB) is about 100 MHz (725 MHz - 830 MHz) for $A = A_{Ref}$, $B = B_{Ref}$, $C = C_{Ref}$ and the operating frequency range and bandwidth increase and the isolation is slightly improved as *A* increases from $A_{Ref}$ to $A_{Ref}$+15 mm. Figure 2(b) shows that return loss and bandwidth at $B = B_{Ref}$+12 mm and isolation at $B = B_{Ref}$+8 mm are more improved when *B* increases from $B_{Ref}$ to $B_{Ref}$+12 mm. Figure 2(c) shows that as C increases from $C_{Ref}$ to $C_{Ref}$+6 mm, return loss increases while bandwidth decreases. Better isolation can be obtained for $C = C_{Ref}$+4.5 mm.

## 3. Measurement Results

The proposed antenna is constructed with the optimized design parameters of *A* = 15 mm, *B* = 25 mm, *C* = 5 mm, as shown in Figure 3, and the radiating element and $\lambda/4$ balun of the antenna are made of brass and the reflector of 280 mm (W) × 560 mm (H) size is made of aluminium of 2 mm thickness. Two 50 ohm semi-rigid cables comprise the feeding line, of which one end is connected to the balun and the other end is equipped with 7/16 DIN connector.

Return loss and isolation were measured using a vector network analyzer in a tapered anechoic chamber. Measured return loss is larger than 14 dB in the frequency range from 698 MHz to 960 MHz, as shown in Figure 4(a). This frequency range covers the operating frequency ranges of LTE, TRS, Cellular and GSM. Isolation between two input ports is larger than 18 dB. Figure 4(b) shows the H-plane radiation patterns at the center frequency of 825 MHz. Beamwidth and antenna gain in the H-plane are 58° to 67° and 9 dBi to 12 dBi respectively as shown in Figure 4(b), while 58° to 61° and 9 dBi to 12 dBi in the E-plane. One may find that antenna gain is high at 700 MHz range because a reference antenna used in testing the proposed antenna is out of its operating frequency range.

## 4. Concluding Remarks

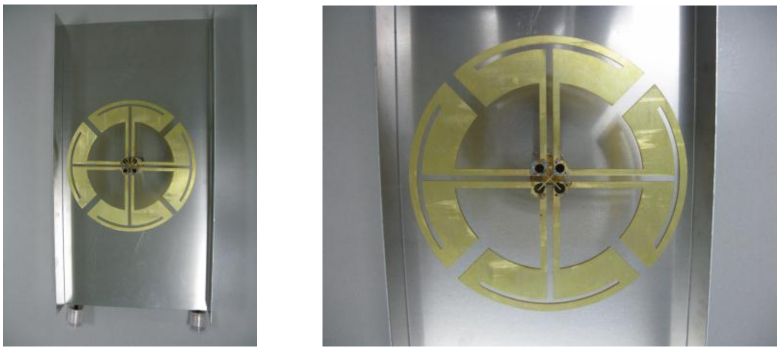
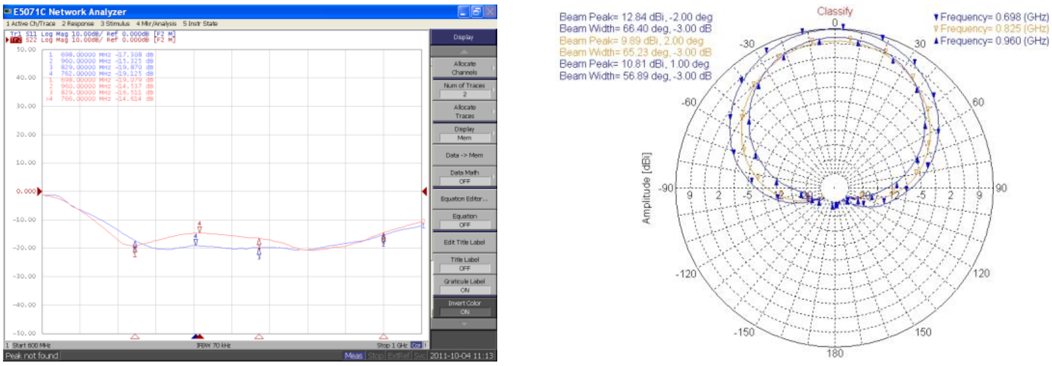


Figure 3: Constructed antenna and radiating element.




(a) (b)

Figure 4: Measured results. (a) Return loss. (b) H-plane radiation pattern at 825 MHz.

In this paper, a dual-polarized reference antenna modified from conventional mobile base station antennas is proposed for testing ±45° dual-polarized mobile communication base station antennas in 800 MHz band. The reference antenna is a circular-folded dipole antenna type with a ±45° dual-polarized radiating element on a rectangular flat reflector with the folded edges at both ends. Measured results of the proposed antenna of 280 mm (W) × 560 mm (H) × 100 mm (D) show that this antenna has a gain larger than 9 dBi and a beamwidth of about 60° in the frequency range from 698 MHz to 960 MHz covering the operating frequency ranges of LTE, TRS, Cellular and GSM.

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