Study on Horn Antenna Beamwidth in RE102 and RS103 Test

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1. Introduction

Safety-related I&Cs and electrical facilities of nuclear power plants are verified for electromagnetic suitability, and domestic nuclear power plants are verified by applying regulatory guide(KINS/RG-N03.09), The electrical and magnetic compatibility (EMC) emission tests and immunity tests for safety related equipment (including SWC) shall be conducted in accordance with Reg. Guide 1.180 (Rev.1), while electrostatic discharge (ESD) tests should follow IEC 61000-4-2 (2008). For EMC verification testing, methods such as MIL-STD-461E and IEC 61000-4 series can be used.

2. Methods(RE102/RS103 Antennas)

In this section, we will review the antenna beamwidth for two tests of EMC verification - RE102(Radiated Emissions, Electric Field) and RS103(Radiated Susceptibility, Electric Field) tests.

The RE102 test measures radiated emissions(electric field) in the frequency range of 2 MHz to 10 GHz. This test is applied to measure emissions of enclosures and all interconnecting cables for equipment and subsystems. The types of antennas used for RE102 measurements are listed below:

Antenna Type	Frequency	size
Rod Antenna	2MHz ~ 30 MHz	104cm rod
Biconical Antenna	30 MHz ~ 200 MHz	137cm tip to tip
Double ridge horn Antenna	200 MHz ~ 1 GHz	69.0 by 94.5 cm opening
Double ridge horn Antenna	1 GHz ~ 10 GHz	24.2 by 13.6 cm opening

EUT(Equipment Under Test) boundary : EUT + cable(2m)

- 2MHz ~ 200MHz : EUT boundary(Antenna position

  N = (EUT Boundary(meters) / 3), rounded up to an integer

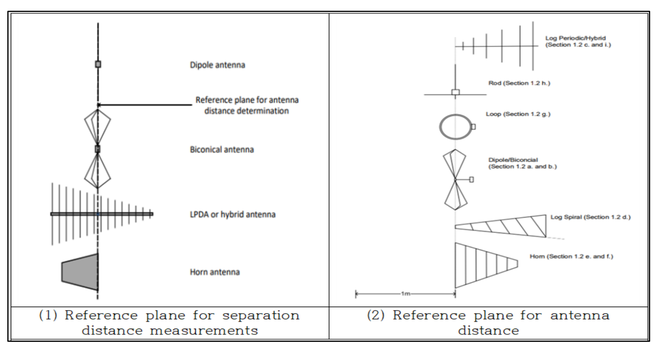
- 200MHz ~ 1GHz Test : EUT + 35cm(within the 3 dB beamwidth of the antenna

- 1GHz ~ 10GHz Test : EUT + 7cm(within the 3 dB beamwidth of the antenna)

The RS103 radiated susceptibility test(electric field) applies to equipment and subsystem enclosures as well as all interconnecting cables. Selecting antenna location and number of antennas is similar to RE102, placing the antennas within the 3dB beamwidth.

3. Results(Horn Antenna 3dB Beamwidth)

A (double) ridge horn antenna is an antenna with directivity and its positioning should be selected considering the 3 dB beamwidth in vertical/horizontal measurements.



(1) Reference plane for separation distance measurements (2) Reference plane for antenna distance

Figure 1. ANSI C63.5-2017, SAE ARP958

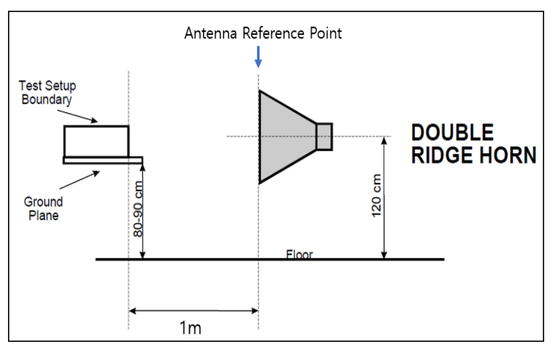


Figure 2. Antenna positioning

The number and location of (double) ridge horn antenna will depend on the results of calculating the 3 dB beamwidth, so we intend to review the antenna reference points accordingly

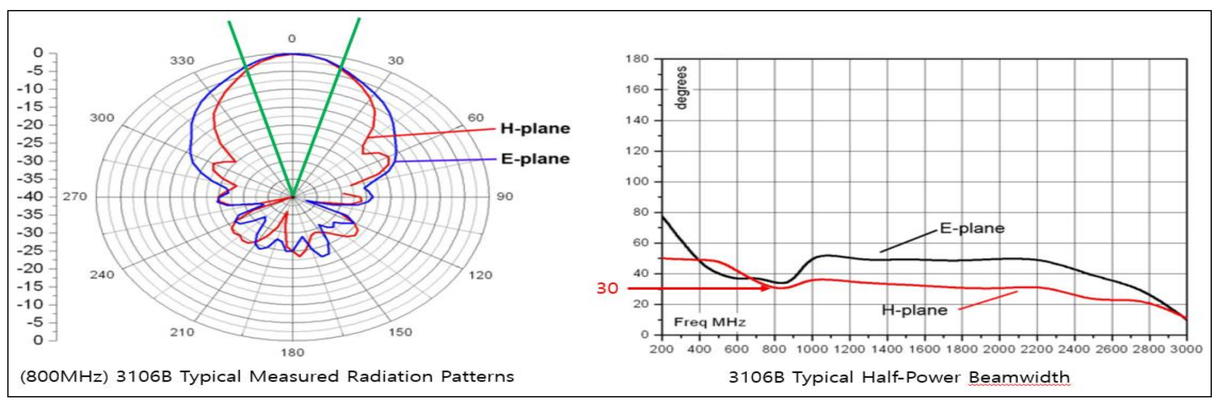


Figure 3. 3106B Antenna(200MHz~1GHz)

The difference in 3 dB beamwidth calculated at antenna reference points is as follows(3106B Antenna depth: 0.89m).

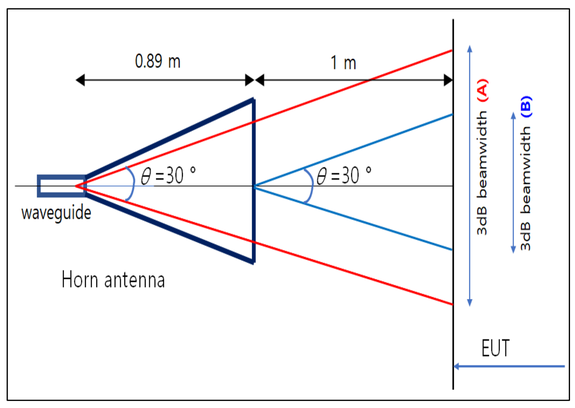


Figure 4. horn antenna 3dB Beamwidth

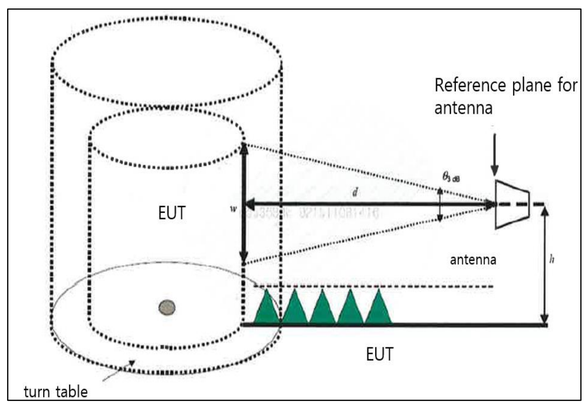


Figure 5. CISPR 16-2-3

The Horn antennas (e.g., model 3106B), which measure frequencies in the range of 200 MHz to 1 GHz, have a depth of 0.89 meters and calculate the 3 dB beamwidth for two cases(A&B), as shown in Figure 3.

(Case A: Figure 3) 3dB beamwidth(x)

$\theta = 30°$, $\theta * 0.5 = 15°$

3dB Beamwidth at Antenna-EUT 1.89m distance

$x = 2 * (1 + 0.89)\text{m} * \tan(15) = 1.012\text{m}$

(Case B: Figure 3) 3dB beamwidth(x)

$\theta = 30°$, $\theta * 0.5 = 15°$

3dB Beamwidth at Antenna-EUT 1m distance

$x = 2 * (1 + 0)\text{m} * \tan(15) = 0.536\text{m}$

The difference in beam width between Case A and Case B is approximately 1.8 times. If we apply Case A, there will be cases where measurement points are missing. If EUT is a 2 meter setup, in case A there will be three antenna locations and five antenna locations in case B for the 3106B antennas. The impact of considering vertical positions according to MIL-STD-461G can also be considered significant.

In CISPR 16-2-3 Measurement of disturbances and immunity - Radiated disturbance measurement, the distance value used for calculating beamwidth is calculated at the antenna end without considering the length of the antenna, with respect to the reference point of the antenna ↔ EUT(Equipment Under Test). And, in accordance with the ANSI C63.5-2017 Antenna Calibration Technical Document, considering the distance measurement between antennas and the reference plane for antenna distances, excluding the length of the antenna, calculating at the end of the antenna is appropriate.

4. Conclusions

The bandwidth of horn antennas is affected by their physical length dimensions, dipole distance and depth, as well as hood size. These characteristics determine the design specifications of the antenna, resulting in frequency bands and radiation patterns among others. The common reference point for horn antennas is found at the end of the antenna opening according to documents such as CISPR 16-2-3. Additionally, when performing EMC test according to MIL-STD-461G, vertical beamwidth should be considered in the RE102 test.

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[4] C63.5-2017 - American National Standard for Electromagnetic Compatibility--Radiated Emission Measurements in Electromagnetic Interference (EMI) Control--Calibration and Qualification of Antennas (9 kHz to 40 GHz), 2017

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