Regarding the Creation and Use of Dual Antenna Factors for Use in Normalized Site Attenuation (NSA) Measurements

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Introduction

In order to assist a customer with a lower measurement uncertainty contribution, ETS-Lindgren provides customers with a Dual Antenna Factor (DAF). This paper provides an equation to calculate Geometry Specific Correction Factors (GSCF) based on the DAF. GSCF is defined in ANSI C63.5-2017 [1]. GSCF is required for calculating the theoretical site attenuation values for site validation measurements.

Definitions

Dual Antenna Factor (DAF): DAF is the sum of the pair of antenna factors when they are calibrated as a pair. DAF is obtained by subtracting the theoretical NSA from the site attenuations measured in a specific geometry. Dual AF is geometry specific, i.e., the DAF is different under different antenna calibration geometries (separation distance, polarization and antenna heights).

The outdoor metal ground plane at ETS-Lindgren's global headquarters in Cedar Park, Texas. At some 50 m x 80 m, the open area test site is part of ETS-Lindgren's A2LA accredited calibration lab, which has mutual recognition agreements with other worldwide laboratory accreditation systems, including ILAC. Laboratory equipment is NIST traceable and test processes are computer controlled for repeatability and data tracking.

Geometry-Specific Correction Factor (GSCF): Correction factor (in dB) that is calculated or measured for each frequency in a specific measurement geometry. GSCFs are subtracted from the site attenuation (SA) calculated using the theoretical model that employs near-free-space or free-space antenna factors. GSCFs include the effects of the $1/r^2$ and $1/r^3$ radiation terms (r is the distance between the antennas), non-uniform illumination of the receive antenna, mutual coupling between the transmit antenna and the receive antenna, and mutual coupling between the antennas and the ground plane [1].

Near-Free-Space Geometry (NFSG): Measurement geometry to obtain near-free-space antenna factors (NFSAFs). The measurement setup for this condition using the standard site method (SSM) is horizontal polarization, R = 10 m, $h1$ = 2 m, and $h2$ = 1 m to 4 m scanned [1].

Derivation

Based on Equation (1) in C63.5-2017 in section 5.2.1:

$$AF_1 + AF_2 = A_1 + 20\log f_M - 48.92 + E_D^{max} \qquad (1)$$

Where AF_1 and AF_2 are antenna factors of the transmit and receive antennas, A_1 is the site attenuation between the antenna pair, f_M is the frequency in MHz, and E_D^{max} is a theoretical field as defined in C63.5-2017.

Because,

$$DAF = AF_1 + AF_2 \quad (2)$$

Therefore,

$$DAF = A_1 + 20\log f_M - 48.92 + E_D^{max} \quad (3)$$

For a Specific Geometry (GS):

$$DAF_{GS} = A_{GS} + 20\log f_M - 48.92 + E_{D,GS}^{max} \quad (4)$$

For Near-Free-Space geometry (NFSG):

$$DAF_{NFS} = A_{NFSG} + 20\log f_M - 48.92 + E_{D,NFSG}^{max} \quad (5)$$

From Equation (I.1) in C63.5-2017:

$$GSCF = (E_{D,GS}^{max} + A_{GS}) - (E_{D,NFSG}^{max} + A_{NFS}) \quad (6)$$

Subtract Equations (4) from (5)

$$GSCF = DAF_{GS} - DAF_{NFSG} \quad (7)$$

Equation (7) shows that GSCF is the difference between the DAF at a specific geometry and the DAF from a near-free-space geometry.

Conclusion

GSCF can be calculated straightforwardly by subtracting the Dual Antenna Factors from a specific geometry to those from the near-free-space geometry.

Reference

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