MEASURING ANTENNA PARAMETERS

IN A GHz TRANSVERSE ELECTROMAGNETIC (GTEM) CELL

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Summary

In the past, constant cross-section TEM (Crawford) Cells have been used for measuring antenna factors (the ratio, in dB of the incident field to the terminal voltage) for low frequency EMI measurement antennas, including monopoles and loops, and much smaller, higher frequency probes, such as isotropic UHF and microwave EM field probes. The typical method has been to place the antenna to be calibrated in the center of the test volume, at a point where the field strength is uniform and known. The output voltage from the antenna was then compared to the known field strength to determine its antenna factor. This calibration method has several limitations. The TEM Cell had to be at least six times as large as the antenna being calibrated, and the Crawford cell has an upper frequency bandwidth limitation based on its dimensions; thus, larger (practical measurement) antennas could not be tested at higher frequencies. Also, because of several other complications, passive loop and monopole antennas were never used to transmit for gain measurement, even though they could have been.

This has changed. Using a GTEM (Gigahertz TEM) cell allows accurate "far field" calibration of any antenna that can be placed in the test volume of the GTEM, from a few Hertz up to approximately 26 GHz, the highest frequency that can be used to excite current GTEMs. Since the GTEM exhibits a high degree of reciprocity, passive antennas can be used to transmit as well as receive during their calibration and active antennas can be calibrated in a known field, in contrast to the more traditional methods in IEEE Std 291.

The method of calibrating an antenna in a GTEM is to place the antenna in the center of the test volume, aligned such that the linearly polarized antenna is oriented vertically between the septum and the floor of the GTEM. The GTEM is then excited at its input port with a known RF voltage. The output voltage is measured at the connector port of the antenna. Testing has been conducted with a small log periodic antenna covering the frequency range of 300 MHz to 1.0 GHz. A spectrum analyzer with a tracking generator was used for the measurements. The test results are tabulated in Table I. As can be seen from the numerical data, good agreement is shown between antenna

factors for the same antenna calibrated in the GTEM and over a ground plane in accordance with ANSI C63.5.

The GTEM calibrated values in Table I are based on the usual equations for setting up fields in the cell and the definition of antenna factor, *i. e.*:

$$E = V_{in} / h_e$$

and

$$AF = 20 \log (E / V_o)$$

$$= 20 \log (V_{in}) - 20 \log (V_o) + 20 \log (1/h_e)$$

where E = the electric field strength in the test volume, and

h_e = height of the septum in the test volume

V_{in} = Input voltage of the GTEM, and

V_o = output voltage from the antenna.

If a passive antenna is used to transmit in the GTEM, the apparent antenna factor can be determined for any height above a ground plane.

This data is also shown in Figure 1. The graphical presentation also illustrates good agreement between the two sources of data.

Given that there is good agreement between the GTEM and ground plane measurement of antenna factors, the following general conclusions are presented.

1. The GTEM appears to be an extremely viable alternative to more traditional antenna factor measurement methods.

2. The advantages of a GTEM for antenna factor determination parallel its advantages for traditional EMC measurements:

   - Ambient signals are not a factor.

   - Measurements may be carried out at a convenient location.

   - There appears to be a modest technical advantage in using the GTEM. Electromagnetic field impedance in the GTEM is that of free space, 377 ohms. Only in true far field conditions can this be claimed for ground plane measurements.

There could be a multitude of other uses for the GTEM, including antenna pattern measurements, radar cross section measurements and field intensity measurements for other than EMI measurement purposes.

TABLE I

Comparison of Antenna Calibration Data
between
Ground Plane Calibration and GTEM! Calibration

Frequency	C63.5 AF (Ground Plane)	Vin - Vo	Septum Height Correction	GTEM! AF	Delta
MHz	dB (1/m)	dB	dB (1/m)	dB (1/m)	dB
300	14.4	12.3	3.04	15.3	0.94
400	16.5	14.4	3.04	17.4	0.94
500	17.2	15.9	3.04	18.9	1.74
600	18.7	17.1	3.04	20.1	1.44
700	20.9	18.5	3.04	21.5	0.64
800	22.1	19.9	3.04	22.9	0.84
900	23.6	20.3	3.04	23.3	-0.26
1000	24.7	21.5	3.04	24.5	-0.16

Average Difference ■ 0.7 dB
Standard Deviation of Difference ■ 0.7 dB

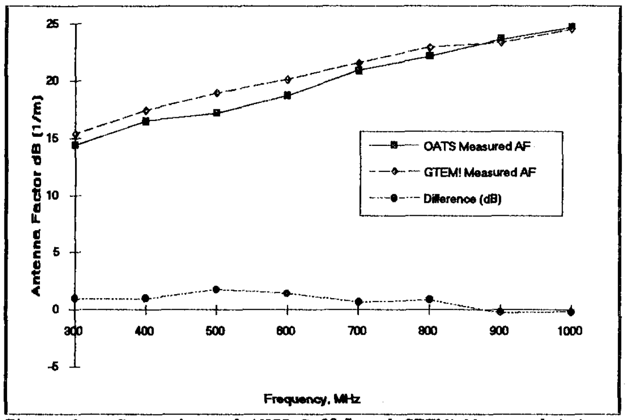

Figure 1. Comparison of ANSI C 63.5 and GTEM! Measured Antenna Factors