Standard Gain Horn Computations Versus Measured Data

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***Abstract* - Specially designed pyramidal horn antennas known as standard-gain horns are accepted as gain standards throughout the antenna community. The unknown gain of an AUT is determined by comparing its gain to that of a standard gain horn. Slayton of the US Naval Research Laboratory in 1954 developed a design method and gain curves for standard gain horns. This paper examines the ability of modern numerical electromagnetic modeling to predict the gain of these horns and possibly achieve greater accuracy than with the NRL approach.**

Keywords: Standard Gain Horns, SGH, Gain, Calibration

I. Gain-Transfer Technique

Specially designed pyramidal horn antennas known as standard-gain horns are accepted throughout the antenna community as gain standards. The unknown gain of an AUT is determined by comparing its gain to that of a standard gain horn. Slayton of the US Naval Research Laboratory in 1954 [1] developed a design method and gain curves for standard gain horns (SGH). Slayton's approach results in a closed form expression for the gain in terms of Fresnel integrals. Measurements by institutions around the world [2] have shown that Slayton's formula has an accuracy of ± 0.5 to ± 0.25 dB depending on the frequency range of the horn. If greater accuracy is desired then the horn must be sent to a calibration laboratory such as NIST which quotes measured gain uncertainties of 0.2 dB from 1 to 75 GHz using near-field scanning and 0.10 dB from 2 to 30 GHz using the three antenna and range extrapolation methods combined [3].

Detailed measurements of standard-gain horns reveals the presence of a ripple in gain as a function frequency that do not exist in the smooth gain curves predicted by Slayton's approach. This paper examines the ability of modern numerical electromagnetic modeling to predict the gain of these horns and possibly achieve greater accuracy than from Slayton's approach.

II. Slayton Method

The IEEE definition of gain of an antenna in a given direction is the ratio of the radiation intensity (power per unit solid angle) in that direction to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically. This definition does not include losses from impedance and polarization mismatches.

Slayton modeled the aperture distribution of the horn as a dominate TE_{10} mode amplitude distribution with a quadratic phase distribution that is different in the E- and H-plane directions. He obtains the far-field from this aperture distribution in closed form in terms of Fresnel integrals, and his method predicts gain that monotonically increases with frequency.

Slayton also determined the horn aperture dimensions and the length of the flare once the desired gain and the input waveguide dimensions are specified. His method determines the horn dimensions such that (a) the specified gain is achieved, (b) the gain is maximum when the slant length of the horn is held fixed, and (c) the horn has equal half-power beamwidths.

Slayton's approach neglects diffraction that occurs at the edges of the aperture and reflections from the waveguide-to-flare junction. These diffracted and reflected fields interfere with the field produced by the assumed aperture distribution and create a ripple in gain versus frequency.

III. FEKO Modeling

Several commercial computational electromagnetic codes are available for determining the performance of a wide variety of antennas. The software program FEKO which is a Method of Moments based code was used for the following analysis. The SGH was modeled as an infinitely thin and perfectly conducting structure. Figure 1 shows a typical triangular mesh used in the calculations. Edge lengths for the triangular mesh elements were varied from λ/7 to λ/14, and it was determined that λ/10 triangles provide sufficient accuracy.

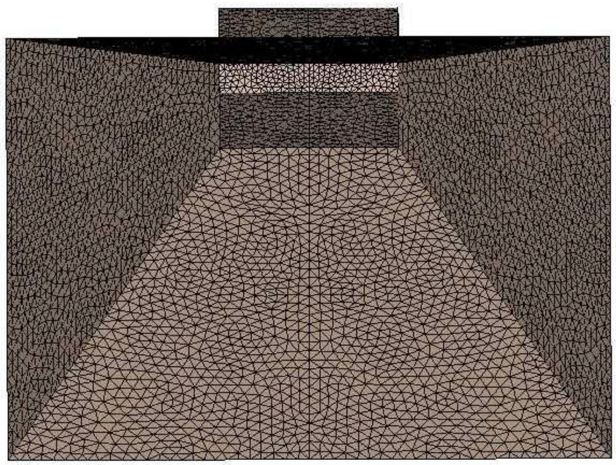

Figure 1. Typical mesh for SGH calculations.

IV. Results

A WR-137 standard gain horn was chosen to compare predicted and measured gain. The three-antenna method will be used to measure the horn at MI Technologies. This comparison will be shown during the paper presentation. Figure 2 shows a comparison between spherical near-field measured and FEKO calculated gain. Excellent agreement between the computed and measure gain is shown. Notice that the locations of the peaks and valleys in the gain versus frequency curve are accurately predicted by FEKO while Slayton's approach predicts a smooth, monotonically increasing gain versus frequency.

V. SUMMARY

FEKO modeling of standard gain horn is able to predict the gain ripples versus frequency as observed in the measured data. In contrast, Slayton's approach predicts a smooth, monotonically increasing gain versus frequency curve. Measured data using a three-antenna method will be shown and compared with FEKO calculations during the paper presentation.

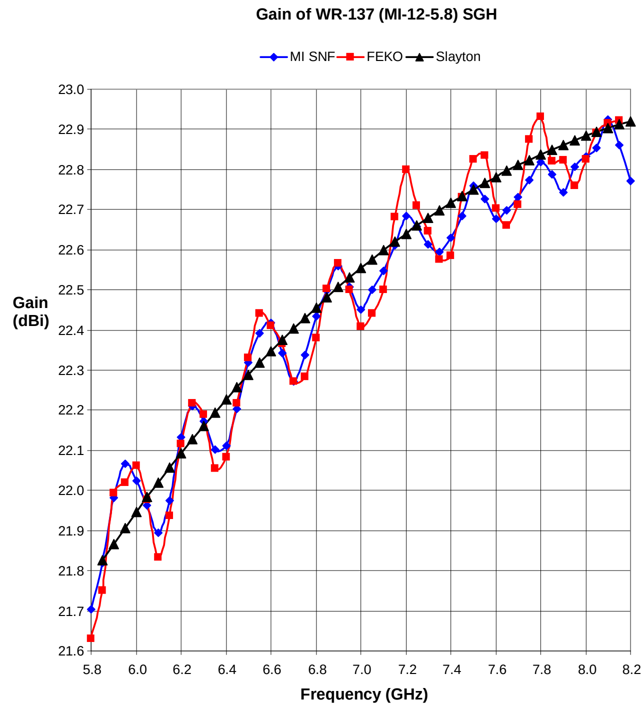

Figure 2. Calculated versus measured gain of a WR-137 standard gain horn.

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