



Small Antenna Characterization in GTEM Cell

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Abstract

With the start of EM wave hazard evaluation from mobile towers, the E-field measurements become a point of increasing interest among people. Antenna characterization in terms of their radiation patterns is a key microwave measurement in precise E-field measurement. The probes used for E-Field measurements are calibrated as per IEEE 1309. This standard has been modified thrice in the last fifteen years, yet, it only discusses E-Field sensors and probes characterization and excludes antenna parametric study. In this paper, simulation of Vivaldi shape antenna is done using HFSS software and its parameters like antenna factor and gain are studied. Thereafter, measurements of these parameters are done inside GTEM cell and in free space. The simulated results are then compared with the measured results. The antenna factor and gain of the designed antenna has been calculated from this.

Index Terms— GTEM cell, Vivaldi form antenna, microstrip patch antenna, antenna measurement.

1. Introduction

The Gigahertz Transverse Electromagnetic (GTEM) Cell is a very well-known uniform field generation method used in E-field measurements and it can also be used for measurements as Electromagnetic Compatibility (EMC) chamber, which is used in radiated emission testing [1]. We have used a ETS Lindgren 5405 GTEM with field uniformity Test grid 433mm x167mm at 100mm from floor bottom. In this paper, the measurement techniques of antenna parameters (antenna factor, gain, and radiation pattern) [1,2] inside GTEM cell is utilized to characterize a designed antenna at its resonating frequency and the results are compared with theoretical results and results obtained from measurements performed outside the GTEM cell

First, a probe was placed inside the GTEM cell and an incident E-field of known magnitude level was applied [3]. The power received, which is pre-presented by the spectrum Analyzer, can be used to compute antenna parameters such as radiation pattern. In addition, theoretical calculations of antenna parameters are possible.

In addition, this study aims to develop a new concept that will result in improved performance [4,5]. This method yields the most cost-effective E-field Measurement [6,7].

2. Vivaldi Antenna design

Vivaldi antenna is a co-planar broadband antenna that is effectively a tapered slot antenna. In this study, a Vivaldi shape antenna is designed and simulated in HFSS. The simulated antenna has a Length (L)= 5cm and Width (W)= 3.5cm and FR4 substrate having a relative permittivity of 4.4, and a resonant frequency of 2.45GHz. As an example of diverse antenna shapes, the Vivaldi antenna is a co-planar broadband antenna that is effectively a tapered slot antenna. The designed antenna in HFSS is shown in figure 1(a), and the fabricated antenna is shown in figure 1(b). The results of simulation will be presented in later section.

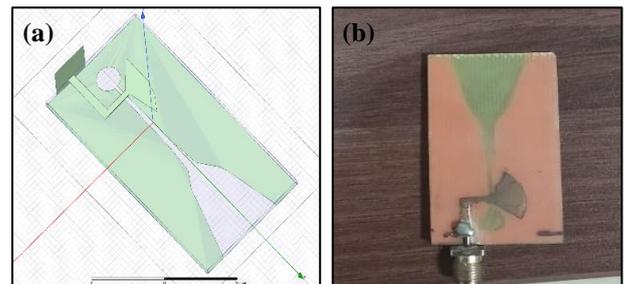


Figure 1. (a) Simulated design (b) Fabricated design of Vivaldi form antenna.

3. Measurement setups

As the available literature describes, the typical approach for generating E-field may be easily understood and studied. We utilized a TEM cell to generate the E-field in the various approaches since it was cheaper, less roomy, and available for a wide frequency range [8-10]. Measurement using an ideal isotropic probe placed in the TEM cell can allow the theoretical computation of generated E-field strength. It can be done using a formula:

$$E = \frac{\sqrt{PaZr}}{d} \quad (1)$$

Where P_a denotes the power given to the TEM cell's input, Z_r is the real portion of the characteristic's impedance, and d denotes the vertical distance between the septum and the inner wall of the TEM cell. However, if the antenna's power gain G_p is different from the desired gain $G_p=1$, equation [1] can be changed as follows:

$$E = \frac{\sqrt{PaZrGp}}{d} \quad (2)$$

The antenna's dominant mode gain in a GTEM cell is the TEM mode, which may be determined using the expression

$$Pr = Se.Ae = \frac{Ea^2\lambda^2}{Zo4\pi}Gp \quad (3)$$

Where Pr is the power received on the antenna under test for a known applied electric field Ea . Ae stands for the effective antenna aperture. Inside the GTEM cell, the impedance is $Zo=120$, and the wavelength is λ . The expression of gain is determined directly in decibels using the formula $Gp = \frac{4\pi Pr}{Pa}$, where c is the speed of light and f is the source frequency.

$$Gp[dBi] = -132.8 + 20\log f + Pr[dB] - Ea[dBV/m] \quad (4)$$

Equation (4) specifies the measurements required to acquire antenna gain at a given frequency in a GTEM cell. It can be proven that the antenna factor can be calculated by measuring the incident electric field and received power. The antenna factor is calculated as follows:

$$AF = \frac{Ea}{V} = \frac{Ea}{\sqrt{PrZL}} \quad (5)$$

or in decibels,

$$AF[dBm^{-1}] = -17 + Ea \left[\frac{dB}{m} \right] Pr [dB] \quad (6)$$

where $V = \sqrt{PrZL}$ is the antenna terminal output voltage and $Z_L = 50$ is the antenna load impedance (RF cables connected to the spectrum analyzer).

3.1 Antenna gain and antenna factor measurement using GTEM cell setup

Figure. 2 shows the schematic of the experimental set up used for antenna gain and antenna factor measurement [11]. The measurements were carried out in GTEM cell. The wideband microstrip antennas were positioned horizontally in the center of the test volume on a Styrofoam table (center third of the septum height). Because the antenna axis was parallel to the electric field vector, there were no polarization mismatch losses. The antenna dimensions were small enough in comparison to the septum height to satisfy the requirement for electric field uniformity[12].

A coaxial cable was used to link the antenna to the spectrum analyzer. The vertical portion of the wire was placed beneath the dipole (between the RF absorbers), while the rest was put down on the cell's floor. The minimum electric field disruption was ensured by this type of wire arrangement [13]. The measurements were carried out over the microstrip antenna's entire operational frequency range (900 MHz – 2.8 GHz), as specified by the manufacturer. The 100 MHz frequency step was chosen, resulting in 9 frequency points in the defined frequency band.

The microstrip antenna measurement configuration was identical to the microstrip antenna measurement setup. Inside the GTEM cell, the location of patch antennas. Because the resonance frequency of antennas was set to 2.4 GHz, the tests were carried out over a frequency range of 2 GHz to 2.8 GHz. The 100 MHz frequency step was chosen, resulting in 9 frequency points in the defined frequency band.

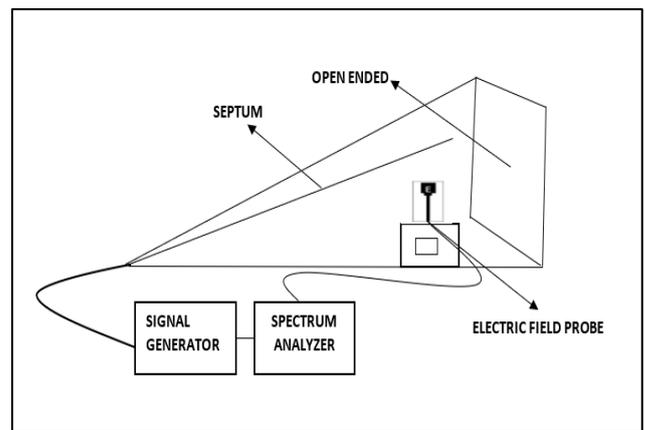


Figure 2. Measurement setup for gain and antenna factor measurement of the Vivaldi form of microstrip antenna: a) schematic view made).

4. Results

Table 1. Antenna gain for Vivaldi antenna

		Measured		Simulated	
		G dB	f GHz	G dB	f GHz
VIVALDI	In GTEM	2.4	2.55	2.26	2.5
	Outside GTEM	2.9	2.55		

Table 1 lists the measured and simulated antenna gain for the Vivaldi antenna. It can be observed from this table that the gain inside and outside the GTEM cell are 2.4 dB and 2.9 dB respectively at 2.55 GHz.

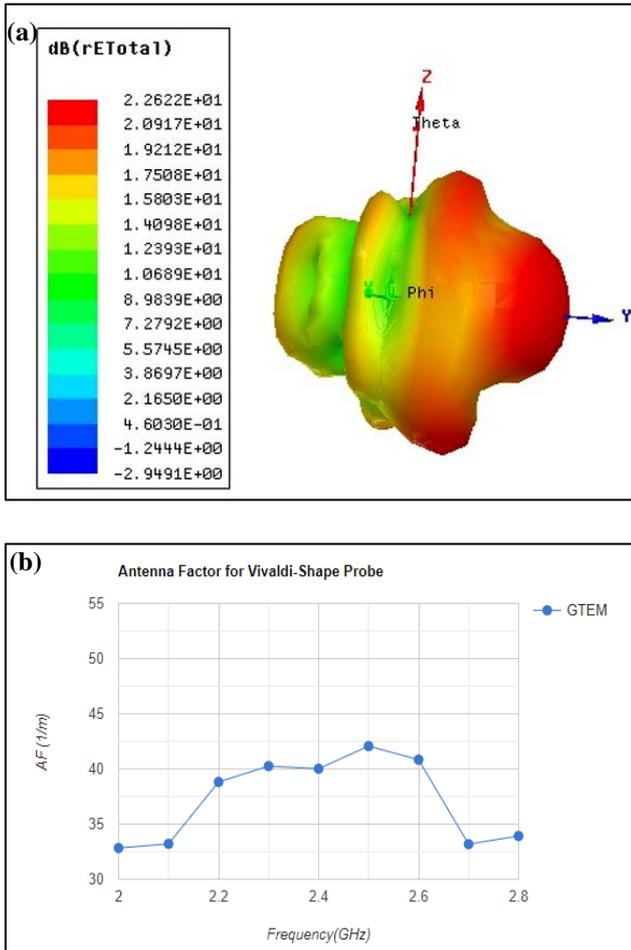


Figure 3. (a) Simulated Gain plot of Vivaldi form of the antenna (b) Antenna factor plot with measure data

From the simulated Gain plot shown in figure 3(a), we can observe that the achieved Antenna gain is 2.26 dB. From the Antenna factor plot shown in figure 3(b), we can observe that at 2.45 GHz antenna factor is 42.5 dBm^{-1} .

5. Conclusion

A Vivaldi-shaped antenna with a resonance frequency of 2.45 GHz was simulated and then fabricated. The gain and antenna factor for the same was measured using a GTEM cell. The results were compared to those obtained in a low-reflective indoor setting using free-space measurement methods. The antennas function well at the resonant frequency, according to the results. Evaluation of tiny antenna gain patterns using GTEM cells is practical and cost-effective. It appears that the GTEM cell is sufficient for applications for smartphones at the resonant frequency, the measured gains, and antenna factor correlates well with simulation and theory, indicating that the GTEM cell is suitable.

6. References

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