Electric Field Radiation from the Tapered-Impedance Half Impulse Radiating Antenna

Felix Vega, Fernando Albarracin, Abdul R. Baba, Adamo Banelli, Chaouki Kasmi
Directed Energy Research Center, Technology Innovation Institute, Abu Dhabi, United Arab Emirates
fernando.albarracin@tii.ae

Abstract**—**This work presents experimental results from a radiation test of the tapered impedance half impulse radiating antenna (TI-HIRA) when fed by a commercial 50-Ω pulsed generator. The design of a prototype and the measured electric field waveform are presented.

Keywords- electric field measurement, impulse radiating antenna, tapered impedance converters.

I. INTRODUCTION

During the last decades, the impulse radiating antenna IRA, has been widely used for radiating high-amplitude electromagnetic pulses for EMC and IEMI studies. The half-IRA (HIRA), is the monopolar version of the IRA and is implemented by introducing a ground plane in the horizontal symmetry plane [1]. In the conventional operation of a HIRA, a constant-impedance TEM transmission line composed with coplanar-plate feeders illuminates a parabolic metal dish with a spherical wave, to finally generate the main radiated pulse. A correlation between optimal illumination of the dish and feeder size constrains the HIRA input impedance to values close to 100 Ohm [2]. Therefore, a commercial unbalanced 50-Ω generator would need an external wideband impedance transformer to feed the HIRA. As an alternative, the authors introduced the tapered impedance HIRA (TI-HIRA) [1] by integrating a TEM feeder whose characteristic impedance changes as a function of the radial distance from the focal point to the dish aperture. The TI-HIRA is sketched in Fig. 1a.

II. TI-HIRA DESIGN

The impedance of a TEM feeder arm, when the exponential progression is selected, can be computed as

$$Z(r) = Z_1 e^{\alpha r} = 60\pi \frac{K(m(r))}{K(1-m(r))}, \tag{1}$$

where r is the radial distance measured from the focal point, the exponential coefficient is $\alpha = (1/F)\ln(Z_2/Z_1)$. Z_1 is the arm impedance at, Z_2 is the terminating impedance at the reflector side, F is the focal length. $K(m(r))$ is the complete elliptic integral of the first kind, and $m(r)$ is a parameter defining the impedance of the TEM feeder [1]. Once F, Z_1, and Z_2 are defined, $m(r)$ is numerically solved for each value of r in (1). The feeder geometry is sketched in Fig. 1b. The aperture angles of the feeder arm, β_1, and β_2, become a function of r, computed as

$$\beta_1(r) = 2\tan^{-1}\left(m(r)^{0.25}\tan\left(\frac{\beta_0}{2}\right)\right), \quad \beta_2 = 2\tan^{-1}\left(m(r)^{-0.5}\tan\left(\frac{\beta_1(r)}{2}\right)\right) \tag{2}$$

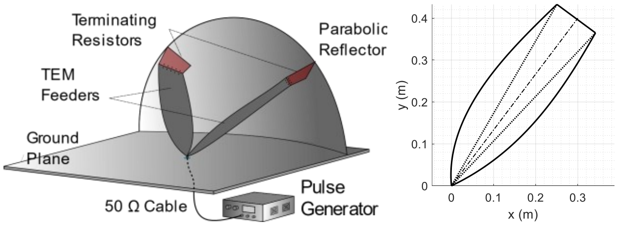

Figure 1. (a) TI-HIRA. (b) Feeder geometry: Exponential impedance arms (continuous line) and constant impedance arms (dashed line).

A dish with a diameter of 1.2 m and F = 0.46 m is used. Z_1 and Z_2 are 100 Ω and 200 Ω, respectively. Note that the TI-HIRA input impedance is expected to be the parallel connection of two feeding arms i.e., 50 Ω.

III. RADIATION TEST RESULTS

A 50 Ω solid-state pulsed generator, with a peak voltage of 14 kV, a risetime of 100 ps, and a pulse width of 3 ns is used to drive the TI-HIRA prototype in a semianechoic environment. On the receiving side, a B-dot free-field magnetic field sensor, with an equivalent area of $9 \cdot 10^{-6}$ m^2 was used. The B-dot is connected to a 6 GHz oscilloscope through an ultra-wideband balun. The receiving chain was placed inside a shielded box and powered via UPS. A comparison of the measured and the simulated electric field waveform on boresight, reduced to 1 m, is presented in Fig. 2. Small discrepancies can be observed in the prepulse area. As it can be seen there is excellent agreement between the experimental and simulated results.

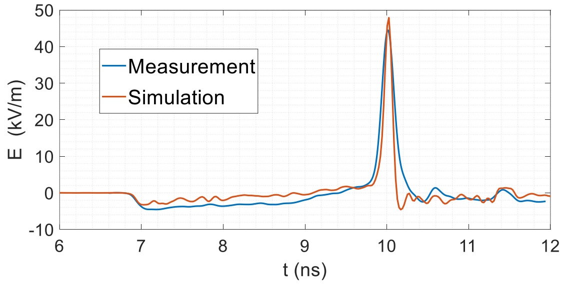

Figure 2. TI-HIRA Electric field waveform, reduced to 1 m.

REFERENCES

[1] F. Vega, F. Albarracin-Vargas, C. Kasmi, and F. Alyafei, "The Tapered Impedance Half-Impulse Radiating Antenna," *IEEE Trans. Antennas Propag.*, vol. 69, no. 2, pp. 715–722, Feb. 2021, doi: 10.1109/TAP.2020.3016496.

[2] E. G. Farr and C. E. Baum, "Prepulse Associated with the TEM Feed of an Impulse Radiating Antenna," *Sens. Simul. Notes 337*, Mar. 1992.