THE COMPARISON OF A TIME-DOMAIN NUMERICAL CODE (DOTIG1) WITH SEVERAL FREQUENCY-DOMAIN CODES APPLIED TO THE CASE OF SCATTERING FROM A THIN-WIRE CROSS.

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ABSTRACT

In this paper we compare, via Fourier transform, results obtained using the DOTIG1 time-domain numerical code with those obtained using several frequency-domain thin-wire codes |1| and with the experimental measurements obtained by Burton |2|, specifically applied to the scattering from a cross.

INTRODUCTION

The current induced on a crossed-wire structure (Fig. 2), when illuminated by a transient electromagnetic field, was calculated. This study was done, in the time-domain, by resolving the electric field integral equation (EFIE) using the moment method. The results were compared, via Fourier transform, with those obtained by other authors working in the frequency-domain |1|, and with experimental results |2|.

DESCRIPTION OF THE NUMERICAL METHOD

DOTIG1 resolves the electric-field integral equation (EFIE) in wire structures. Using the thin-wire approximation, this equation is as follows |3|:

$$\hat{s}\cdot\vec{E}^{i}(s,t) = \frac{1}{4\pi\varepsilon}\int_{C(s')}\left[\frac{\hat{s}\cdot\hat{s}'}{c^{2}R}\frac{\partial}{\partial t'}I(s',t') + \right.$$

$$\left. + \frac{\hat{s}\cdot\vec{R}}{cR^{2}}\frac{\partial}{\partial s'}I(s',t') - \frac{\hat{s}\cdot\vec{R}}{R^{3}}q(s',t')\right]ds' \tag{1}$$

where $\hat{s}$ and $\hat{s}'$ are tangent vectors to the wire axis, the contour of which is C, at position $\hat{s}(\vec{r})=s$ and $\hat{s}(\vec{r}')=s'$ (see Fig. 1); $I(s',t')$ and $q(s',t')$ are the unknown current and charge distributions at source point s' at retarded time $t'=t-R/c$; $\vec{E}^{i}(s,t)$ is the field applied to the observation point; $\vec{R}=\vec{r}-\vec{r}'$ and $q(s',t')$ can be expressed in terms of $I(s',t')$ by the equation of continuity.

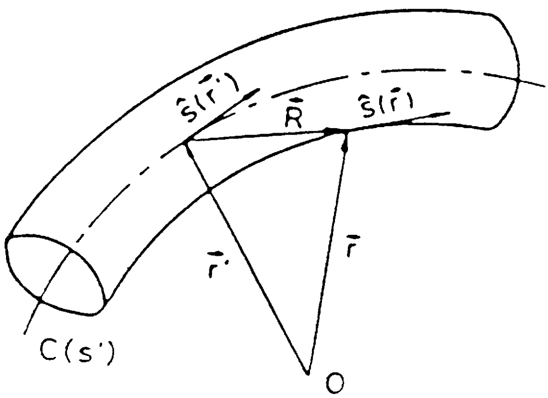

Fig. 1. Coordinates used in the thin-wire approximation.

In order to solve equation (1) we applied, with several modifications, the method proposed by Miller |3|.

The integral equation was transformed into a suitable expression to calculate the current distribution along the wire structure through numerical computation in the time-domain, using the subsectional collocation form of the method of moments with a two-dimensional Lagrangian interpolation function as a basis function, which enables us to express any space-time variable in terms of its values at the centres of the intervals |3|,|4|.

In order to develop the charge distribution term in (1), we expressed directly the charge at any point in terms of the current intensity |4|, instead of using a new interpolation function to express the charge at any space-time interval in terms of its values at the center of its closer intervals as is described in |3|.

For treating junctions, we have taken the method developed by Chao and Strait in the frequency-domain |5|, and translated it into the time-domain. The method developed by Chao and Strait consist of a wire overlapping another at a junction.

RESULTS AND CONCLUSIONS

We calculated the currents induced on a crossed-wire structure when illuminated by a Gaussian pulse as follows

$$\vec{E} = \exp\{-g^2 (t-t_{max})^2\}\,\hat{z}$$

where $g = 1.5\ 10^9\ s^{-1}$ and $t_{max} = 1.43\ 10^{-9}$ s.

The geometry of the cross is shown in Fig. 2. The length of the arms are $l_1 = l_3 = l_4 = 0.25$ m and $l_2 = 0.5$ m, and the radius of all the elements is 0.0185185 m |1|.

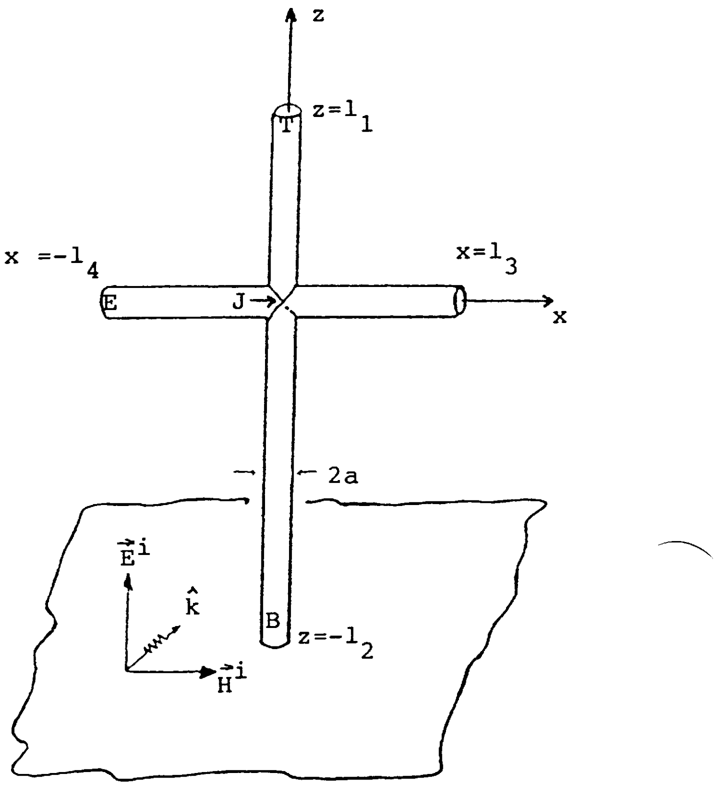

Fig. 2. Geometry of the crossed dipole scatterer

In order to compare the DOTIG1 results with those obtained in the frequency-domain, the ratio of Fourier transform of the current and incident field in each segment of the cross was calculated. Figs. 3 to 5 show, in a continuous line, the current magnitude in db and phase calculated with DOTIG1 for the horizontal and vertical portions of the cross and wavelength $\lambda = 1$ m , and, in a discontinuous line (- - - -), the measured values of these variables. In each figure, we have also represented one of the other authors results (-.-.-.-.). Calculated values were plotted and adjusted vertically on each graph to obtain the most favorable match to the measured values. The bottom, junction, top and end of the cross are labeled B, J, T, and E respectively. (See Fig. 2).

All the thin-wire codes compared for the crossed-dipole scatterer are method-of-moment applications of a thin-wire integral equation with different basis functions and testing methods . We have choosen the three most representative methods given by Adler: BIGANT, NEC3 and SYRACUSE |1|.

The graphs show that neither the DOTIG1 results nor any other numerical codes coincide with the experimental results.

1. DOTIG1 did not predict the shape of the horizontal arm current magnitude to the same extent as BIGANT, but DOTIG1 results were similar to those obtained by NEC3 and SYRACUSE.

2. For the vertical current amplitude, DOTIG1 results came as close to the experimental results as did BIGANT and NEC3. (In this case, SYRACUSE presented a bigger difference when compared with the experimental measurements).

3. DOTIG1 is reasonably close to the experimental results in the phase of the two wires.

We can therefore conclude, that the DOTIG1 code, is a valid one, in light of the experimental results observed and in light of those obtained by other thin-wire codes.

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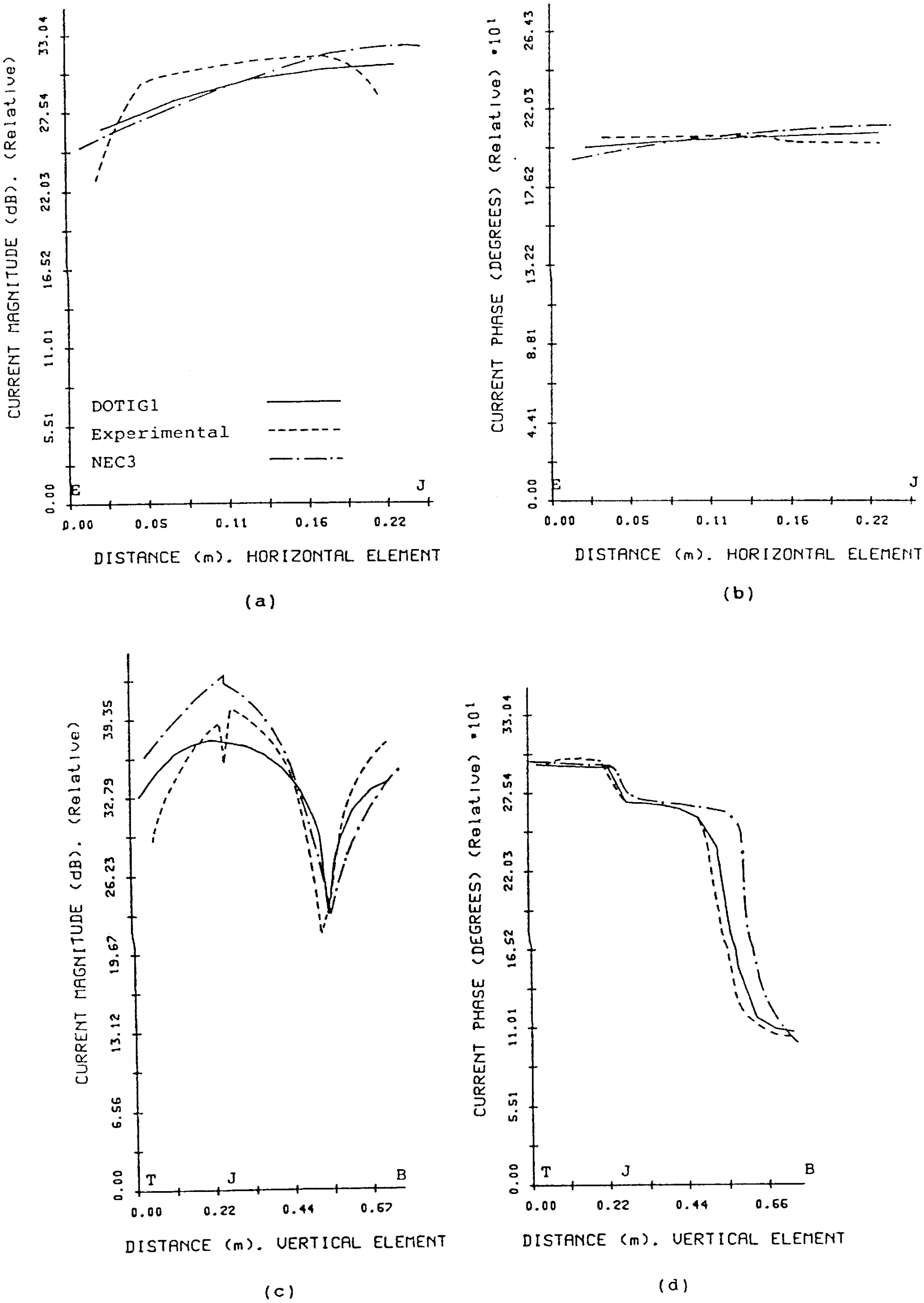

Fig. 3. a) Current magnitude in db and b) phase, for the horizontal element; c) Current magnitude in db and d) phase, for the vertical element. ——— DOTIG1 results, -------- experimental results, and —·—·—·- NEC3 results.

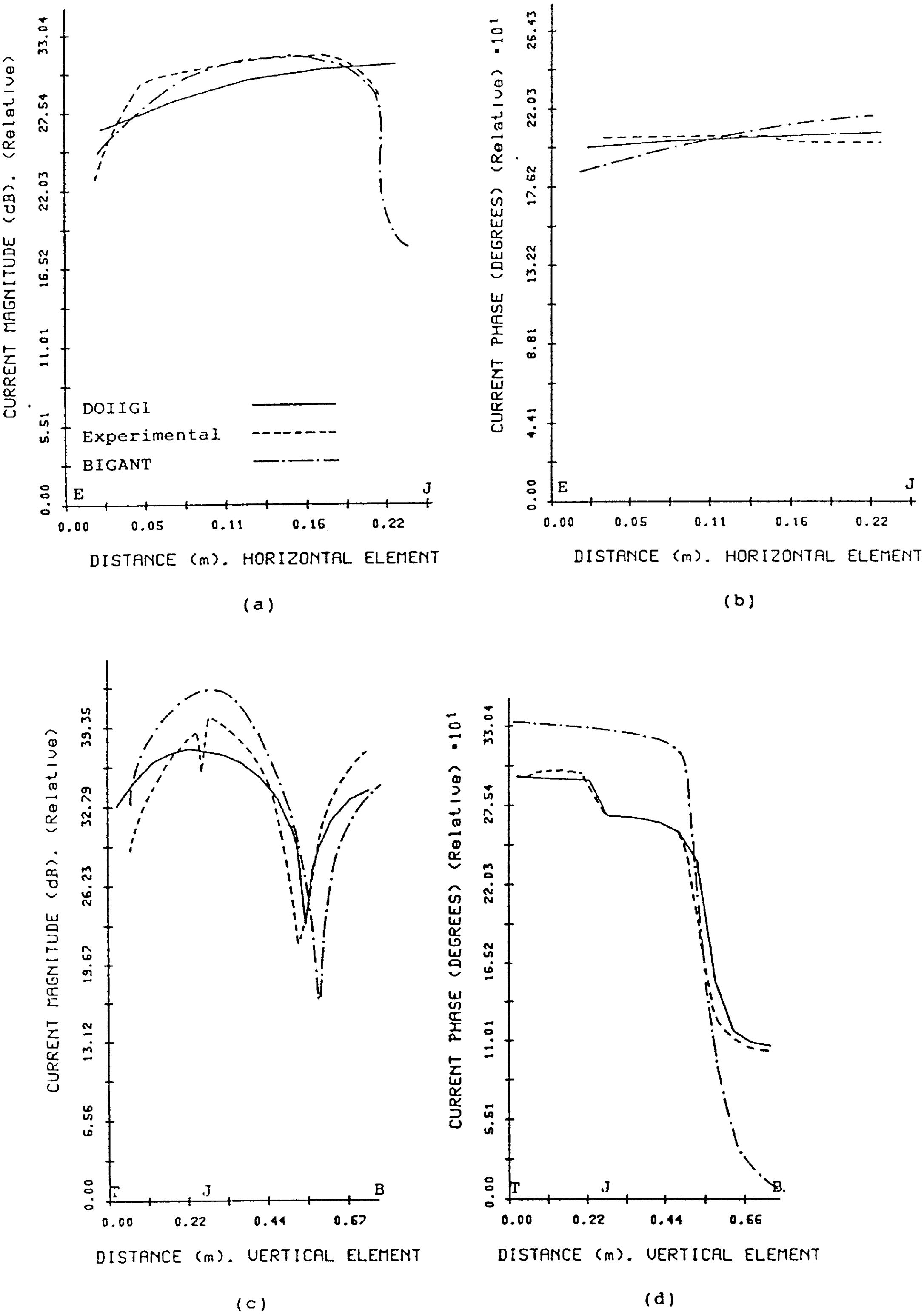

Fig. 4. a) Current magnitude in db and b) phase, for the horizontal element; c) Current magnitude in db and d) phase, for the vertical element. ——— DOTIG1 results, ------- experimental results, and —·—·— BIGANT results.

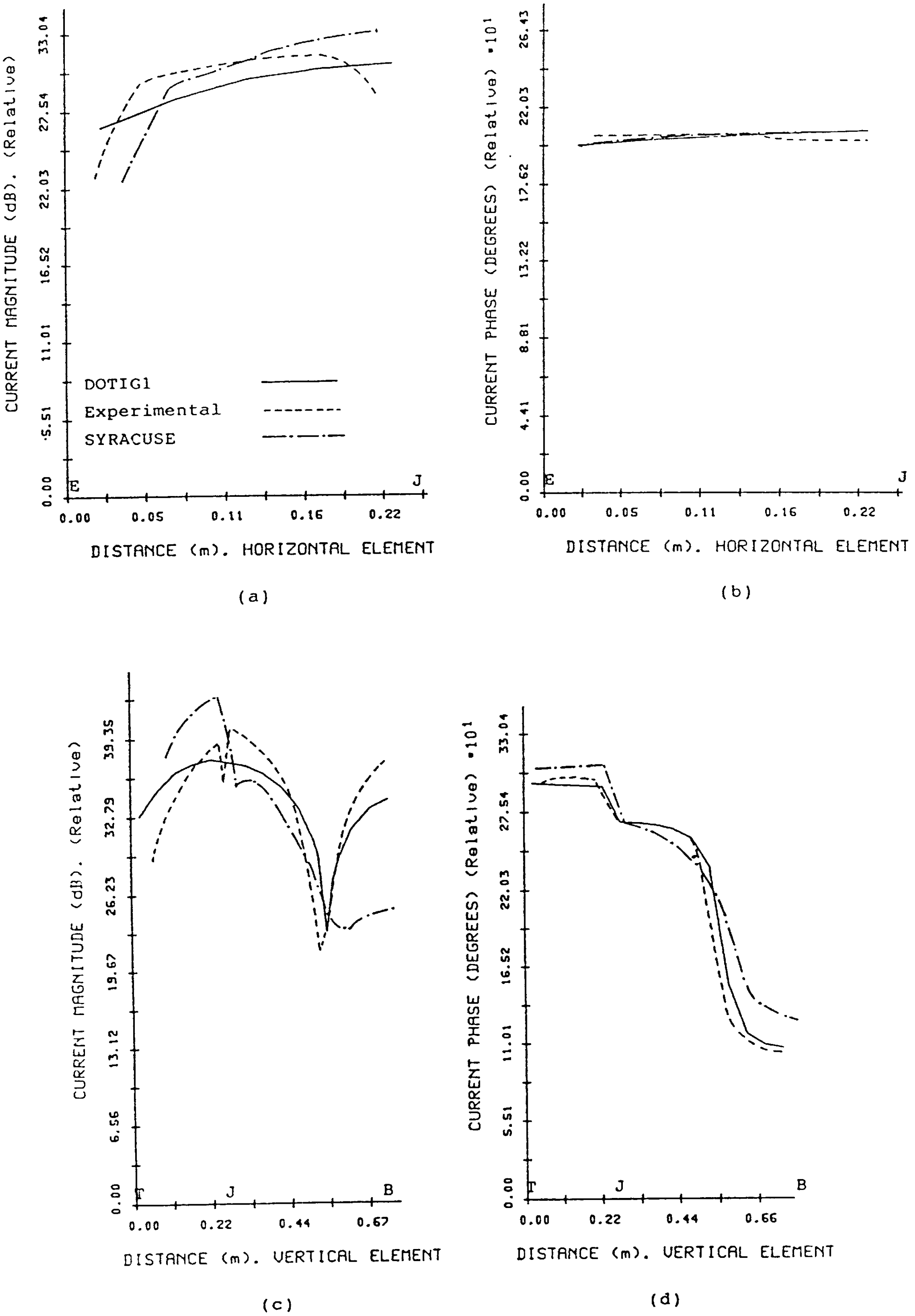

Fig. 5. a) Current magnitude in db and b) phase, for the horizontal element; c) Current magnitude in db and d) phase, for the vertical element. ——— DOTIG1 results, ------ experimental results, and —·—·— SYRACUSE results.