Receiving Antennas Analyzed with FDTD and the Theorem of Reciprocity

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***Abstract*— By using the theorem of reciprocity, the equivalent circuit of a receiving antenna illuminated by plane waves is deduced from a single FDTD simulation. This circuit is used to analyze the antenna's temporal response to an arbitrary incident plane wave, when connected to an arbitrary load.**

Keywords : receiving antenna ; reciprocity ; FDTD

I. FDTD SIMULATION OF A TRANSMITTING ANTENNA

The presented work is based on the Gorf3D software (Ref. [2]). However it may be easily extended to any software able to simulate the radiation of an antenna. Gorf3D is a general purpose FDTD (Finite Differences in Time Domain) tool. Two of its features make it particularly well suited for antenna analysis : a voltage source to feed the radiating structure and a near field to far field transformation to compute the radiation of the antenna.

II. RECEIVING BEHAVIOUR DEDUCED BY RECIPROCITY

The reciprocity theorem is a powerful tool in electromagnetism. For example, it links the short circuit current of an antenna illuminated by a plane wave to the far field radiated by the same antenna when it is transmitting (Ref. [1]). The short circuit current is the first part of the Norton equivalent circuit of the receiving antenna (Fig. 1). The second part is the input impedance. This impedance is easily derived from the simulation of the radiating antenna.

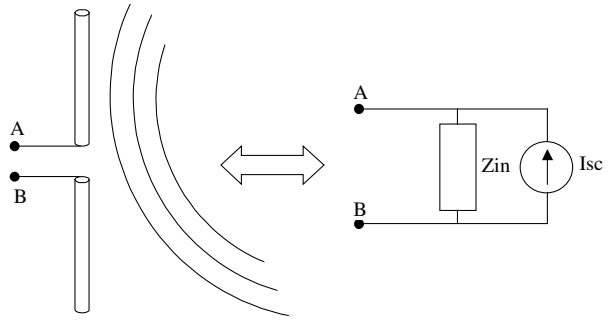

Figure 1. Receiving antenna Norton equivalent circuit. Zin is the antenna input impedance. Isc is its short circuit current and depends on the direction of incidence of the plane wave

In addition, since FDTD is a time domain method, both parameters of the equivalent circuit can be computed over a large frequency spectrum. In other words, a single FDTD run simulating an antenna radiating in many directions provides all the information required to predict the behavior of the antenna when illuminated by plane waves coming from those directions.

III. GRAPHICAL USER INTERFACE

In order to use the full flexibility of the receiving antenna equivalent circuit, a graphical user interface has been developed. First, it is a diagnostic tool visualizing the input impedance and the radiation characteristics of the antenna. Second, it allows the user to define the direction of incidence, the polarization and the waveform of the incoming plane wave. The user can also set the load of the antenna. Third, it applies the reciprocity theorem and presents the current flowing through the load in both frequency and time domains.

Fig. 2 is a snapshot of the user interface. Note that in this example, what is called "antenna" is in fact a more complex structure including the radiating element, a feeding cable, a building and a ground plane.

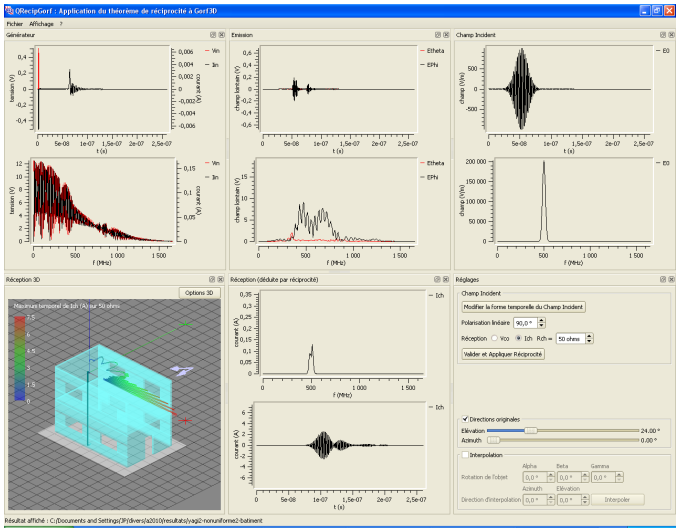

Figure 2. Example of results presented by the tool, including a 3D visualization showing the influence of the direction of incidence.

REFERENCES

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