Equivalent Circuit Model Based on Spectral Green's Function Representation for Photo-Conductive Slot Antennas

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Abstract—**The generation of THz signals resorting to photosensitive semiconductors has been the object of various analysis in the recent years. Typically, such sources consist in a optically pumped semiconductor which is coupled to an antenna to generate THz power. In this paper a theoretical model, based on a spectral Green's function formulation, for infinite slot fed by a THz photoconductor generator is shown. An equivalent circuit model is then derived, which gives a description of the involved THz power generation and radiation mechanisms. Such model is a useful engineering tool for the analysis and the design of photo-conductive slot antennas.**

I. INTRODUCTION

THE basic mechanism for the THz power generation is typically achieved by resorting to optically pumped photoconductor materials. In detail, when an optical source impinges on a photoconductor with appropriate carrier frequencies, electrons-holes pairs are generated due to the electrons jump from the valence band to the conduction band, resulting in a change of the conductivity of the material. These charges are accelerated by an electric field induced by applying a biasing voltage between an anode and a cathode located close to the photosensitive area [1].

The optical pumping source typically operates in two different modes; i.e., the Continuous Wave Mode (CWM) [1]-[2] or the Pulsed Mode (PM) [1], [3]. The conductivity of the photoconductive material changes periodically in time accordingly to the laser operating mode and to the recombination time of the carriers in the photoconductor. Consequently a time varying current is induced by the bias and fed the antenna which is connected at the electrodes.

The performances of such devices are affected by various phenomena, i.e., the interaction between the optical source and the semiconductor, the carrier recombination times, the geometrical parameters of the active gap which feeds the antenna, and the electromagnetic radiative properties of the entire structure. In order to take into account of all these aspects, equivalent circuit model have been proposed in the literature for analyzing the Photo-Conductive Antennas (PCA) by using approximations as quasi-static models and considering lumped circuit elements.

In this work a characterization of the PCA based on spectral Green's function formalism is shown for the first time. The formulation proposed in this work has been developed for infinite slots printed at the interface of two different homogeneous dielectric media and it can be used for analyzing the radiating feed of lens antennas. The model can be applied both for the CWM and for the PM. We expect that the proposed solution will provide more accurate results respect to those present in the literature.

II. RESULTS

In this section we present a preliminary result. We compare the proposed model against a result showed in [2] (Fig. 1).

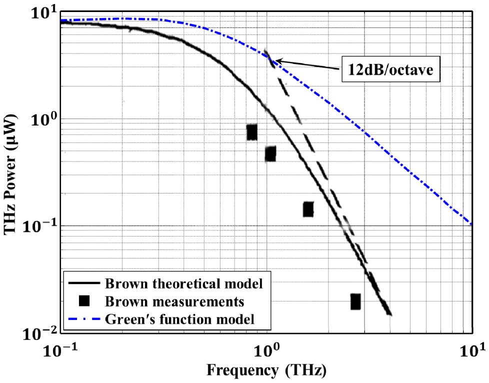

Fig. 1. Comparison of the power radiated by the slot inside the silicon, computed by the proposed model, against the results discussed in [2].

In detail, the black solid line refers to the power estimated by the theoretical model in [2] for a PCA which consists of a silicon lens fed by a logarithmic spiral antenna. The photo-conductive gap size is 10μm × 10μm, with an interdigit structure in which the distance between the electrodes is 0.9μm. The black square markers refer to the relevant measurements. The blue dash-dotted line refers to the power estimated by the proposed solution inside the silicon, without taking into account of radiation efficiency of the lens antenna. We considered a slot whose width is of 1μm, in order to get the same distance between the electrodes used in [2], and fed by a photo-conductive gap of size 1μm × 1μm. All the other parameters are the same used for the results discussed in [2]. Although the presented solution is different from that in [2], we obtain the same order of magnitude of radiated power. From Fig. 1 one can also see that the proposed model predicts higher values of radiated power at higher frequencies. Moreover, the curve predicted by the proposed model decays less steeply. More numerical results, along with the theoretical formulation, will be presented during at the conference.

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