A PLASMA CYLINDER EMERGENCE EFFECT ON THE ELECTROMAGNETIC FIELD IN A WAVEGUIDE

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Investigation of an electromagnetic field transformation caused by a plasma cylinder appearance inside a waveguide at some moment of time is implemented using the Volterra integral equation approach.

We consider a flat waveguide between two parallel perfectly electric conducting plates. It is assumed that until zero moment of time the waveguide had been filled with some homogeneous dielectric medium. At zero moment of time, homogeneous time-varying cold plasma having a constant plasma frequency appears inside a cylinder of some finite radius that is co-axial with the driving current. A vertical driving line current that may have arbitrary time dependence excites the initial field. This current is considered as a sort of emitter model and can be turned on at arbitrary moment, either before or after plasma appearance.

We analyze the axially symmetric electromagnetic field in time domain. Here, the integral equation is formulated by virtue of the time-spatial Green's function in the cylindrical system of coordinates. This equation can be solved by the resolvent method, as it is a Volterra integral equation of the second kind. The exact and explicit expression for the resolvent operator of the integral equation has been derived for the case when the plasma density changes in time abruptly. The obtained resolvent operator allows considering an arbitrary time dependence of the plasma density that can be modeled by the step-like functions.

The resolvent operator consists of two terms. One of them corresponds to the similar problem when the whole waveguide is filled abruptly with homogeneous plasma. The other is caused by the influence of the cylindrical boundary of plasma only. In the case of excitation of the waveguide by the step current, the spectrum of oscillations has resonance peaks at the plasma frequency and at the eigenfrequencies of the plasma cylinder. Amplitudes of the peaks at the eigenfrequencies decrease with resonance number. No resonances are observed in the field outside the cylinder.