Studying the propagation of ELF waves in the Marsian ground-ionosphere waveguide using an FDTD method with application to the ground tomography

Pawel Rzonca, Andrzej Kulak, and Janusz Mlynarczyk
AGH University of Science and Technology, Department of Electronic, Poland

Research on propagation of ELF waves in the ground-ionosphere waveguide has been conducted in order to develop methods for solving inverse problem, which enable measurement of physical parameters of the Marsian ground [1]. It was assumed that the Marsian ground has multi-layer structure with layers characterized by low conductivity. The ELF field penetrates the soil to the depth of several dozen kilometers, that is much more that at Earth. This has a strong impact on dispersive properties of group velocities and attenuation in the waveguide. It is assumed that dust storms and dust devils generate short impulses of ELF field that can propagate over long distances, on the order of megameters. They can be recorded by ELF observation station located on the Marsian surface. The waveforms of these impulses are closely connected with the propagation parameters of the waveguide and should enable identification of ground structure and its components.

Ground contribution to the parameters of the waveguide was examined using analytical solutions in [2]. Its contribution to the propagation of impulses and Schumann resonances on Mars was further studied in [3,4]. Studies presented here show impact of local ground structure on vertical electric dipole radiation in the ground-ionosphere waveguide. Modeling of impulse propagation in the time domain was performed using cylindrical coordinates. Solutions for large distances were corrected using the focusing factor. As approximation of the conductivity profile of ionosphere, a “double-knee” model [5] was used. Computation was performed with space steps dr = 10km, dz = 1 km and time step 1 us. Two examples of two-layer ground with different depth of the first layer (10km and 40km) were implemented. Impact of highly and weakly conducting plate on the radiation of the source was also studied. Validation of the model was based on a well studied analytical solution [3].

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