Measurement of the Direction of Arrival of Transionospheric HF Propagation

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It is planned to observe waves from ground HF transmitters such as the Super Dual Auroral Radar Network (SuperDARN) radars and the Canadian Advanced Digital Ionosondes (CADI). The waves will be measured with the Radio Receiver Instrument (RRI) on the enhanced Polar Outflow Probe (e-POP) small satellite when it makes an orbital pass through the nearby topside ionosphere. One objective will be to use measurable quantities, such as the direction of arrival (DOA) and the signal delay time, to "image" the ionospheric structures that produce backscattered or reflected signals observed at those ground facilities. Such measurements would be coordinated with simultaneous recordings at the ground facilities.

Four monopoles connected to the 4-channel RRI will be used to record incident waves originating from the coordinated ground transmitters. Two components of the electric field are to be measured using the RF voltage induced on each of four crossed monopoles connected to high-impedance preamplifiers. Signals from opposite monopole pairs normally will be combined differentially and processed as a dipole signal.

This paper is concerned with the measurement of one important wave characteristic: the DOA. An important issue in the analysis of the received antenna signals is the computational method of determining the DOA from the amplitudes and relative phase of two dipole signals. The NEC4 electromagnetic model of the spacecraft with antennas provides values of the dipole effective lengths. These, in turn, are the basis of the technique for inverting the amplitude and relative phase of voltages induced on the monopoles to the DOA of the wave. This computation is required for elliptically polarized plane CW incident waves. The polarization of the wave electric field is provided by the cold-plasma theory. Expressions have been developed for the induced dipole voltages as functions of the wave-vector azimuthal and polar angles. A numerical approach is generally required for the DOA angles inversion. It is under-specified for only two dipoles, and requires selecting the true solution from two or more possible azimuth-polar pairs throughout the 4π sr solid-angle space surrounding the spacecraft. The selection of the solution will be guided by values expected for the known ground-transmitter and satellite positions, and by other wave parameter measurements.