53 -- 2017-03-06 18:03:46
Session 4A Paper 2
Knepp, Dennis: NorthWest Research Associates

Ionospheric Effects on a Wide Bandwidth Chirp Radar Signal

This work describes numerical techniques to generate realizations or sample functions of the received, demodulated wide bandwidth signal after two-way propagation through ionized turbulence. These signal realizations include the effect of a structured ionosphere that separates the radar and target. The underlying basis for these realizations of the received radar signal is the solution of the scalar Helmholtz equation for the ionospheric transfer function through the use of a multiple phase screen (MPS) propagation code. The formalism here includes both mean (non-structured) and structured ionization and considers a moving radar target that produces additional Doppler, pulse dilation and contraction, and conditions of filter mismatch.

In the case of ionospheric structure, the MPS code solves the parabolic wave equation and allows for direct computation of realizations of the impulse response function of the ionosphere. The MPS simulation is quite general, and may be applied to problems involving numerous, separated, layers of ionization characterized either statistically by spatially varying electron density power spectra or by deterministic specification of the actual electron density. MPS techniques can handle all levels of ionospheric disturbances from the least severe, where only small phase fluctuations occur, to the most severe case of frequency selective scintillation. For wide bandwidth signals, the MPS code is exercised for many frequencies over the bandwidth of the propagating radar signal to calculate the complete ionospheric transfer function.

In addition to dependence on the propagation channel, the receiver output also depends on the transmitted signal and the receiver characteristics. Here the transmitted signals are assumed to be chirps (linear frequency-modulated pulses). Explicit equations are given to generate realizations of the disturbed signal at several locations in the radar signal processing train. For matched filter processing we give expressions for the received signal immediately after downconversion to baseband (i.e., prior to pulse compression) and at the output of the matched filter. For the case of stretch processing an expression is given for the signal after downconversion and deramping. These analytic expressions include the effects of propagation disturbances on a pulse-by-pulse basis and are easily implemented in software. They provide a mechanism to use MPS calculations of the impulse response function to generate realizations of the radar signal at important places in the receiver processing chain.

Such realizations are useful for numerical simulation and hardware testing of radars that must operate under disturbed propagation conditions, for example HF through UHF radar in the natural equatorial or polar region. Several useful examples are presented that illustrate the effects of time- and frequency-selective ionospheric fading on demodulated chirps.