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A waveform extending the maximum unambiguous velocity for weather radars using solid-state power amplifiers

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For a fixed wavelength, the product of the maximum unambiguous measurement range and velocity in a pulsed radar system must be constant; thus, increasing one necessarily decreases the other. This so-called range–velocity ambiguity is a long-standing trade-off and problem presenting a significant detriment to weather radar data quality. This problem is exhibited by the inability to accurately measure atmospheric velocities naturally possible to the range extent required by current fixed operational weather radars.

Several techniques have been traditionally employed to address this problem, such as range and/or velocity unfolding. These approaches, however, introduce trade-offs between practical limits on measurement extent and quality.

The use of solid state power amplifiers (SSPAs) in weather radar systems facilitates new approaches to address the problem of range–velocity ambiguity. Because SSPAs have approximately 100 times greater duty cycle than traditional magnetron or klystron transmitters, new waveforms consisting of rapidly repeated relatively long pulses are possible. Additionally, SSPAs allow for the cost-effective use of alternating and simultaneous polarization transmission eliminating the need for dual transmitters or high-speed waveguide switches.

A new waveform and associated moment estimators designed for dual-polarization, SSPA-based weather radar systems to measure higher mean radial velocities is presented. In this method, a complex waveform is created using a very short and a relatively longer pulse repetition time (PRT) between pairs of pulses transmitted at alternating polarizations. This technique allows for a maximum unambiguous velocity in excess of 100 m/s and a maximum unambiguous range of 150 km for C-band operation without the need for an additional velocity unfolding algorithm. The methodology de-couples the maximum unambiguous velocity from the pulse repetition interval (PRI) between pulses. Thus, this PRI may be selected to achieve the required maximum unambiguous range, reducing the occurrence of data quality degradation due to multi-trip echoes, while preserving the high maximum unambiguous velocity to accurately measure high-impact weather phenomena.

Results from simulations using data collected from the C-band weather radar located at Kumpula, Finland, will be presented to demonstrate the efficacy of the methodology.