Design of Practical Pulse Compression Waveforms for Polarimetric Phased Array Radar

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The Advanced Technology Demonstrator (ATD) radar system is being developed through a joint collaboration of the National Oceanic and Atmospheric Administration, the Federal Aviation Administration, Lincoln Laboratory, General Dynamics Mission Systems, and the University of Oklahoma. This proof-of-concept radar system consists of an active, S-band, electronically scanned, dual-polarization phased array radar, and it makes use of pulse compression waveforms to meet sensitivity and range-resolution requirements. It is well known that the range weighting functions (RWF) associated with the use of pulse-compression waveforms exhibit range sidelobes that extend beyond the range-gate spacing, and may result in contaminated measurements from adjacent range locations. Even if a pulse-compression waveform is theoretically designed to have acceptable RWF sidelobe levels, practical effects introduced by the system may increase these sidelobe levels beyond acceptable limits. In order to meet strict range resolution requirements, practical system effects should be accounted for in the waveform design process. Typical solutions include the design of pre-distorted waveforms or mismatched filters. On one hand, waveform pre-distortion may result in better performance in terms of RWF sidelobe levels at the price of reduced sensitivity; o. On the other hand, due to the down-sampled nature of the received data, the use of a mismatched filter to compensate practical effects may not be very effective compared to pre-distorting the transmit waveform. Furthermore, system distortions may be different for the horizontal and vertical polarizations, which can impact the quality of polarimetric-variable estimates. In this paper, we characterize the distortions introduced by the ATD on pulse compression waveforms, we provide design considerations to address practical system effects, and we illustrate the performance of practical waveforms with real data. Results of this work are expected to lead to the design of pulse-compression waveforms for the ATD that are able to meet demanding range-resolution requirements by incorporating system effects in the design process.

Keywords: Pulse Compression, Phased Array Radar, Dual-Polarization Radar, Weather Radar