

Single-Target Calibration Technique for Dual-Antenna Monostatic Polarimetric Radar

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Polarimetric radar systems have become essential sensors in a wide range of applications in military, security, autonomy, and remote sensing of the environment. Examples include concealed weapons detection, detection of foliage camouflaged targets, detection of power transmission lines, target classification algorithms, and retrieval of landcover parameters, such as, vegetation biomass and soil moisture. Recently, there has been renewed interest in the use of polarimetry in support of autonomous vehicles at both W-band (76-81 GHz) and J-band (220-250 GHz) for applications such as traffic scene interpretation, road condition assessment, debris detection, and vehicle self-localization. The success of these applications that utilize polarimetric radars relies on the ability of the radar to measure the scattering matrix of targets of interest accurately. Polarimetric radars are imperfect sensors and as such any systematic distortions that may be present in them will result in an erroneous target response if these distortions were not corrected for in the measured data. Systematic distortions include both polarization leakage between the orthogonal polarization ports of the antenna system and channel imbalances between the different transmit and receive channels of the radar. Often, channel imbalances are due to losses in passive components and variations in amplifier gain. Over the past 4 decades, various calibration techniques were developed for polarimetric radars. The goal of these techniques is to first determine the systematic distortions in the system and then correct for these distortions in the measured radar data. In these techniques, the common approach is to use the polarimetric radar to measure external targets whose scattering matrices are known (also called calibration targets) and use the acquired responses to determine the radar's systematic distortions. In the most general case, three calibration targets with known and independent scattering matrices are needed to determine the systematic distortions, which can be a challenging task especially when the calibration targets have RCS values that are orientation-sensitive, hence are prone to setup errors, and when the calibration is performed in an outdoor setting. Under certain conditions, such as having a polarimetric radar with a single antenna system that possesses symmetry in its transmit and receive modes, a simplified calibration technique can be implemented that requires only a single calibration target (K. Sarabandi, and F.T. Ulaby, "A convenient technique for polarimetric calibration of radar systems," *IEEE Trans. Geosci. Remote Sensing*, vol. 28, No. 6, Nov. 1990.).

In this paper, we present a calibration technique intended for monostatic polarimetric radars consisting of two different transmit and receive antennas. The technique is suited for outdoor calibrations and lends itself to new polarimetric radars developed at MMW frequencies. The proposed technique is an improved version of the calibration technique mentioned earlier (Sarabandi and Ulaby, 1990). The improved calibration technique requires a single metallic sphere as a calibration target. It calculates the calibrated scattering matrices of unknown targets accurately, without the need for estimating all distortions in the radar system. The presentation at the conference will introduce the distortion model of the monostatic polarimetric radar and outline the improved calibration procedure. In addition, it will demonstrate the accuracy of the improved calibration technique by presenting the calibration results of 3 different microwave and millimeter-wave radars.

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