Polarimetric Backscatter Response of Targets at High Millimeter-Wave Frequencies

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The radar's antenna usually determines the total size and weight of the radar since in most applications a narrow beam is required. Reduction in antenna size can be achieved without compromising its beam performance if its operating frequency were to be increased proportionally. Hence, if higher operating frequency is selected for a given radar application, then a smaller antenna can be designed, resulting in a more compact and light weight system; however, there are variations in the free-space path loss and the target radar cross section that need to be accounted for. For short range radar applications, such as vehicle collision avoidance, concealed weapons detection, target imaging, and aircraft assistive landing, millimeter-wave (MMW) radars (predominantly operating below 100 GHz) have become increasingly the systems of choice in these applications. Limitations in hardware performance in the upper portion of the millimeter-wave frequency band (between 200 GHz and 300 GHz) and the lack of phenomenological studies of terrain have kept these frequencies off limits for the aforementioned radar applications. Recent advancements in solid-state technologies have resulted in improved RF components operating in the upper millimeter-wave frequency range and into the terahertz domain. As a result there has been renewed interest in radar systems operating in the higher MMW frequencies. Unfortunately, the literature, with regard to the radar backscatter behavior of natural terrain at these frequencies, is rather limited in terms of target types, angular ranges, and polarizations. Knowledge of the expected radar return from natural and manmade targets is important for both modeling the targets and for the design of radar systems optimized for a specific application.

The effort reported in this paper is part of a broader research effort at the University of Michigan to study the phenomenology of radar scattering at high MMW frequencies, which included the characterization of permittivity of natural and manmade materials at the upper MMW frequencies (Ibrahim, Nashashibi, and Sarabandi, IEEE-AP Symposium, 2013). In this paper, we report on an outdoor measurement campaign of different types of bare-surfaces and vegetation-covered surfaces as well as high resolution imaging of complex target scenes. These measurements were performed using newly constructed polarimetric instrumentation radar. We will report on the calibration technique and quality of measured radar data as well as properties of the measured targets/surfaces (ground truth). Furthermore we will discuss angular dependence of measured data for different targets.