Doppler Spectrum of a Moving Human Body at J-band for Automotive Radar Detection Applications

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Radars operating at J-band (220-325 GHz) are being investigated for next generations of driver-less cars because of the higher resolution and smaller size advantages they offer. Unlike other automotive sensors (like optical and infrared systems), radars offer an advantage of being able to operate in all weather conditions and provide accurate range and speed measurements of the target. The higher millimeter-wave operating frequencies will factor down the size-resolution product of the radar by a nine-fold compared to the current automotive radars operating at 77 GHz. A couple of experimental studies have been conducted to investigate the performance and the response of different objects to the radar signal at the proposed frequency band. One study considered the response of different vehicles to the radar signal (A. Alaqeel, A. Ibrahim, A. Nashashibi, H. Shaman, and K. Sarabandi, "A Phenomenological Study of Radar Backscatter Response of Vehicles for the Next Generation Automotive Radars," 2018 IEEE International Geoscience and Remote Sensing Symposium, pp. 4063- 4065). The radar backscatter response, scattering centers on vehicles, and the statistical behavior of the return signal are examined in this work. In another study, the polarimetric backscatter response of surfaces encountered in traffic environments are surveyed (A. Alaqeel, A. Ibrahim, A. Nashashibi, H. Shaman, and K. Sarabandi, "Near-Grazing Radar Backscattering Measurements of Road Surfaces at 222 GHz," 2017 IEEE International Geoscience and Remote Sensing Symposium, pp. 2322-2324).

One great advantage of operating at higher frequencies is the fine measurement of Doppler frequency, since it has inverse proportionality to the wavelength. Unlike the Vector Network Analyzer based radar system used in the referenced works, a newly developed instrumentation system at the University of Michigan has enabled the measurement of Doppler frequency (A.Y. Nashashibi, B. Alazem, and K. Sarabandi, "Fully Polarimetric FMCW Instrumentation Radar at 228 GHz," 2017 IEEE AP-S International Symposium and USNC/URSI Radio Science Meeting, pp. 35-36). This radar is a compact fast fully-polarimetric Frequency-Modulated Continues Wave (FMCW) instrumentation radar that operates at 222-228 GHz. Based on many measurements that were performed on vehicles, only single Doppler component is usually observed. On the contrary, Doppler measurements of a moving person show many Doppler components due to different speeds of body limbs. The Doppler spectrum of a moving body can be used by automotive radars to recognize pedestrians from other objects of comparable radar cross section. In this work, many measurements of a moving person at different speeds are measured and the spectrum of the Doppler frequency components is isolated from the measurement background. To achieve the Doppler resolution needed, multiple FMCW waveforms are stitched together in a special way. The aim is to identify the spectrum signature of a moving human body at different states; walking, running...etc., and as it is observed from different directions. In the meeting, an introduction to the instrumentation radar will be presented along with its capabilities and limitations, the measurements setup and the processing procedure will also be explained, and the test results and findings will be summarized.