Reconfigurable RF Front-Ends for Collocated DSRC and Millimeter-Wave Vehicle to Vehicle Communication

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In recent years, vehicle crashes have taken nearly 40,000 lives in the U.S. (National Highway Traffic Safety Administration (NHTSA)). To reduce traffic hazards, research in self-driving and semi-autonomous vehicles have been focused towards improving the safety of drivers. Current vehicles are equipped with technologies like automotive RADAR, LiDAR, Camera, GPS to enhance safety driving. However, future autonomous vehicles cannot solely rely on these technologies as they suffer from few drawbacks. For instance, LiDAR and Camera provide false information due to signal attenuation during severe weather conditions like snow and fog. As well, RADAR and LiDAR require line-of-sight (LOS) communication for accurate positioning and hence experience failure in detection of hidden vehicles.

The Federal Communications Commission (FCC) has already allocated ~ 10 MHz bandwidth in Dedicated Short Range Communications (DSRC) frequency spectrum, *viz.* 5.850-5.925 GHz, for vehicle to vehicle (V2V) communication. DSRC enables information sharing among vehicles but is limited to a maximum data rate of 27 Mbps. Nevertheless, connected vehicles with advanced safety requirement demand much higher data rate for effective high speed communication such as video streaming of traffic and road accidents. In addition, more bandwidth is required to accommodate multiple simultaneous users. The need for high data rate and the bandwidth availability in the millimeter-wave (mm-wave) spectrum created more interest to implement 5G vehicular communication at 28GHz. Also, mm-wave RF radios are smaller in size implying inconspicuous integration on cars. However, communication in the mm-waves is often challenged by the high path loss and attenuation due to rain. Therefore, there is need for novel RF front ends to compensate for such shortcomings.

In this paper, we introduce a novel reconfigurable RF transceiver architecture operating at 5.9 GHz (DSRC) and 28GHz (5G V2V). The proposed system consists of a dual band phased array, reconfigurable transceiver front-end, and digital beamforming for both 5.9 GHz and 28GHz. We have already developed a simple, low-cost dual-band array for both DSRC and 5G V2V. The array is low profile (*viz.* $0.5\lambda_{30GHz} \times 0.5\lambda_{30GHz} \times 0.39\lambda_{30GHz}$) and achieves near theoretical gain at 5.66 - 6.74 GHz (DSRC) and 18.58 - 33.9 GHz (5G V2V). In the conference, the complete dual-band RF front-end will be presented with link budget and noise analysis by optimizing the number of elements, gain, range, and linearity for effective communications. The system will be optimized for both short and long range communication scenarios in rural and urban environments.