Design and Simulation of Antenna Array for Vehicle Collision Avoidance Radar System

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Abstract

Collision avoidance system is a driver assistance system with high capabilities to detect and alert the driver about any potential risk in the road. Realizing such system requires detection sensors to expose the blind spots for the driver at any time of the day under any weather condition and at an affordable cost. Automotive radar sensors exhibit an ideal and superior performance under all environmental conditions; hence, it meets the application requirements. In automotive radar system, antenna subsystem has an essential role since it is the means by which the signal is transmitted and received. Therefore, this project concerns the design of antenna arrays for the automotive radar applications. The design of an automotive radar antenna system is challenging. Some of these challenges include achieving a high gain (26-35 dB), narrow beamwidth (4°-10°) and low sidelobe level (equal or less than –20 dB). In addition to these, meeting the equipment physical constraints like size and integration on an automobile at a low cost is also considered a challenge. A high gain and a narrow beamwidth can be achieved by using antenna arrays that consists of a number of antenna elements. To meet the cost, size, weight, performance and ease of installation constraints, microstrip antennas are usually used. Therefore, a rectangular microstrip antenna with inset feed was designed, modelled and optimized to operate at the frequency of 76.5 GHz. This frequency was selected according to the ITU standardization for global harmonization of frequency allocation at 76-81 GHz for automotive radar application. However, the use of antenna arrays introduces mutual coupling between the different elements that degrades the performance, which is also studied for designed arrays to ensure that it is less than –15 dB. At the ITU designated frequency band, the wavelength is in the order of 4 mm resulting in small antennas that lower the overall cost as well as improvement in the range, velocity and angular resolution for better target identification. The microstrip antenna was analyzed using a transmission line model. The modeling and simulation of the antenna was carried out using time domain solver package to examine the antenna performance in terms of radiation pattern, bandwidth, efficiency, gain, return loss and mutual coupling between elements. The optimal rectangular microstrip antenna array was a 64-element planar antenna array of overall size of (24.64 x 24.21 x 0.467) mm3. The simulation results showed that the 64-element planar antenna array has a gain of 18.7 dB, half power beamwidth of 10.2°, a sidelobe level of –17.4 dB, a return loss of –23.3. Although not all parameters achieve the requirements, however they constitute an improvement on the results reported in the literature.