Steerable Array Antennas with Dielectric Phase Shifters for 77 GHz Automotive Radar Applications

Abstract

The 77 GHz collision avoidance radar in automobile requires the beam scanning mechanism. In this paper, a new design is proposed for a mechanically controllable millimeterwave phase shifter and array antennas. Numerical simulations using Ansoft HFSS and Designer have been conducted. We have demonstrated that a movable dielectric slab placed to a coplanar waveguide (CPW) could be used as a phase shifter for automotive radar applications at 77 GHz. The effective dielectric constant and the characteristic impedance are calculated as a function of the movable dielectric slab position on the CPW transmission line. One of the advantages of this newly proposed phase shifter design is that the whole antenna can be designed without using solid state phase shifter or MEMS devices. The length of the dielectric material onto a CPW is 1.82 mm, 3.64 mm, and 5.46 mm which corresponds to 180^0, 360^0, and 540^0, respectively. The required dielectric constant of ε_r=5.60 can be designed using a common ceramic material. The microstrip transmission line to WR-12 waveguide transition for initial feeding point has been studied. Seven element patch array antennas were investigated for this application. The array antenna was designed to scan with a phase difference of -90^0 to $+90^0$ with an expected beam scan angle of -20^0 to $+20^0$. The element separation was set to 2.922 mm which corresponds to 0.75λ. The left and right dielectric slabs alternatively and repeatedly inserted into the CPW. In addition, the preset delays lines are added to minimize the number of dielectric slabs. We have designed the proposed antenna on a duroid 5880 substrate (ε_r=2.2) with the thickness of 10 mil (0.254 mm).