Design and Optimization of Vehicle Rear Window Antennas

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A FM radio receiver is by far the most common device in a commercial vehicle and its performance of good signal reception is dominantly determined by an antenna, which is generally a monopole that protrudes outside the vehicle. Recently to improve the durability and appearance, and to reduce the wind noise of this pole type FM antenna, an internal on-glass antenna that is directly printed on a rear or quarter window are widely adopted by new vehicles. The internal on-glass antenna, however, often exhibits low radiation gain and narrow matching bandwidth characteristics, since the antenna is printed on the lossy dielectric material of the window glass and the conductivity of the stripline is also restricted due to its dual function as heat rays.

To improve its antenna performance, the rear window antenna usually has multiple vertical lines between horizontal heat rays. By loading these vertical lines, the current distributions are altered so as to increase the vertical antenna gain and to improve the impedance matching with the FM Radio tuner. Although loading the vertical lines is the key technology in determining the performance of on-glass antennas, in-depth research on this topic has not been undertaken to date.

In this paper, we report on the design of the rear window antenna. Especially we focus on optimizing the vertical lines, and will present the optimum design parameters such as number of vertical lines, lengths, and position of the lines. There exist some design limitations due to aesthetic reasons of vehicles. For example, the vertical lines should be placed symmetrically, and the number of the line can not exceed a certain number. We obtain optimum parameters under these design restrictions using a Pareto genetic algorithm in conjunction with a full wave EM simulator. In the optimization process, two objective functions are used to maximize the matching bandwidth in FM band and to increase the averaged vertical antenna gain. To verify the optimized result, the optimum design is printed on a rear window of a commercial vehicle and their antenna performances such as the bandwidth, radiation pattern, and antenna gain are measured. The results show that the average vertical gain and the matching bandwidth are improved as the number of vertical lines is increased. The prototype antenna built on a commercial vehicle with three vertical lines exhibits the average gain of - 3 dBi, bandwidth of 15.86 MHz ($|\Gamma| < 3$ dB), and the radiation pattern close to a simple monopole.