

# An Optically Transparent Two-Element Wideband Array Antenna with Unidirectional and Tilted Beam For Ground Vehicles

M. Kashanianfard\* and K. Sarabandi

University of Michigan, Ann Arbor, MI, 48105,

<http://www.eecs.umich.edu/>

Wireless communication between vehicles is affected by some of the adverse effects of the communication channel such as multi-path fading, attenuation, non-line-of-sight, etc. To mitigate some of these effects, operation at lower frequencies (UHF and VHF) is often preferred for ad hoc communication networks. One draw back of operating at these frequencies for mobile platforms is the size of the antenna. In addition, for situations where different channels or space diversity are needed, the close proximity of many such antennas results in co-site interference and other undesired issues. One way to avoid such problems is to embed the antenna in the body of the platforms. However, placing the radiating element very close to a metallic surface will significantly affect the antenna's input impedance and radiation pattern. Vehicle's windshield and other windows are good candidates for embedding the antennas since they cover a relatively large surface area and are well above the ground (the higher the antenna, the lower the path loss).

Embedding the antenna in the windows of the vehicle imposes additional requirements such as optical transparency and unidirectionality (radiation inside the cabin is unwanted). To compensate for the tilt angle of the windshield, a two element phased array can be used. The array design is particularly challenging since the array elements are backed by the window cavity which creates a strong coupling between them and therefore affects the radiation pattern and the impedance matching of the array antenna. Furthermore, the maximum acceptable distance between the antenna and the reflecting element (determined by the thickness of the window glass) is close to one fifteenth of a free space wavelength at the lowest frequency and the entire antenna array has to fit in a  $0.4\lambda_0$  by  $0.5\lambda_0$  screen. Since the antenna has to be placed close to a ground plane, the input impedance matching of the antenna for the desired bandwidth of 2.5:1 is extremely difficult.

In this paper, a planar two element array antenna is designed to be embedded in the described window. A rigorous numerical optimization of the design parameters is performed and transmission line based matching circuits are designed to enhance the impedance matching and produce the required phase shift between the array element. A number of balun designs are used and their effect on the radiation pattern and input impedance of the antenna is studied. The optical transparency of the antenna is improved by replacing the bow-tie antenna elements with a wire mesh of the same shape.