Characteristic Mode Analysis Applied to the Design of Vehicular HF Antennas

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In this paper we present the results of characteristic mode analysis applied to the design of low-profile vehicular HF antennas. The aim of this study is to facilitate the development of antennas supporting all three modes of propagation: near vertical incidence skywave (NVIS), long range skywave and surface wave. Vehicular platform imposes severe constrains on antenna size, such that the antennas are electrically small at lower end of HF frequency range. It is well known that there is the fundamental limit on bandwidth of electrically small antennas. Besides they have small radiation resistance, while the proximity of lossy ground leads to low radiation efficiency. The combination of all these constrains makes the design process quite challenging.

In order to improve electrical performance of HF vehicular antennas, the utilization of a vehicle's body as a part of the antennas may be beneficial. This makes overall size of antenna system larger and thus relaxes the size constrains imposed on the design. We analyze the antenna placement on the vehicle and methods of coupling to the vehicle by the means of characteristic modes. Characteristic modes are current's standing waves supported by a radiating structure. Various ways to excite desirable mode are considered. The results outline the trade-off between bandwidth and efficiency to be resolved. The analysis shows that the most significant characteristic current corresponds to that of a horizontal electric dipole. The far field pattern due to this current can be used for NVIS, along with the directive long range skywave and surface wave modes. The excitation of currents on the entire vehicle's body leads to lower radiation efficiency since current at the bottom face couples to the ground. On another hand, excitation of currents on upper face only helps to improve efficiency at the expense of bandwidth. Though only modeling results are presented, measurement of practical antennas is under way.