Height-Constrained Cylindrical Helical Antennas for Satellite-based M2M Communications

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Both practical considerations and government regulations are beginning to limit the height of terminal antennas used in satellite-based M2M applications to less than 2.5 cm. For Orbcomm-based systems that operate at downlink and uplink frequencies of 138 and 150 MHz (or a wavelength of 2 m), respectively, 2.5 cm corresponds to a terminal antenna height of just over one-hundredth of a wavelength. Realizing antennas that meet the operating frequency, efficiency and bandwidth requirements of such systems is very difficult, particularly in light of: 1) the manner in which close proximity to a large ground plane reduces the radiation resistance of the antenna and 2) the Chu-Harrington limit on the operating bandwidth of the antenna. In particular, the bandwidth of such height-constrained antennas barely covers the uplink or downlink passbands of the Orbcomm system so separate transmit and receive antennas are required.

Small multi-arm cylindrical helical antennas appear to offer a practical way of realizing effective and efficient small antennas with operating bandwidths that approach the Chu-Harrington limit. However, no existing design is yet capable of meeting the new height and bandwidth requirements for Orbcomm terminal antennas that have recently been introduced. Here, we examine two ways in which these performance goals might be achieved using height-constrained cylindrical helical antennas. First, we consider the manner in which retaining the height limitation but relaxing the footprint restriction affects both the Q-limits described by Best and Gustafsson and the bandwidths of practical antennas. Second, we consider the possibility of using shunts within the helical structure to induce one or more secondary resonances in the response of such an antenna so that a single antenna may be used for both uplink and downlink. We find that adding such structures introduce asymmetries into the antenna radiation pattern and must be carefully considered. However, our results point the way towards antenna designs that can meet the demanding practical requirements of modern satellite-based M2M communications systems.