

Adaptively Matched Dual Band GPS Antenna for Plasma Environments

Xiuzhang Cai, Ali Üyrüş, Abdulkadir C. Yücel*, Amir Mortazawi, and Eric Michielssen

Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI 48109, USA

Re-entry vehicles oftentimes experience diminished electromagnetic sensing and communication capabilities due to the buildup of dense plasmas produced by interactions of the vehicle surface with the atmosphere. Under extreme conditions, a thin but very dense plasma shell formed around the vehicle blocks all communication. During the communication blackout, the vehicle navigates via inertial motion sensors. That said, these sensors are prone to error accumulation and consequently incapable of accurately pinpointing the position and orientation of the vehicle for extended periods of time. Therefore, robust GPS antennas that are insensitive to plasma loading are crucial for improving re-entry vehicles' navigational accuracy.

GPS patch antennas on space vehicles often rely on single feed and asymmetric patch arrangements to achieve right hand circular polarization. Although these antennas are highly compact, they exhibit narrow polarization/axial ratio and impedance bandwidths. While operating in a plasma environment during re-entry, their performance is negatively affected by (i) polarization mismatch (Qian et. al., *Progress Electromagn. Res.*, 52, 173-183, 2005), (ii) impedance mismatch (Zhao et. al., *Int. J. Antennas and Propagat.*, 2013, Article ID 823626, 1-8, 2013) and (iii) signal attenuation. While effects (i) and (ii) can be mitigated through careful design, no practical measures to combat (iii) have been developed to date.

Here, a novel dual (L1 + L2) band dual-feed GPS antenna for operation in variable plasma environments during re-entry is proposed. The antenna exhibits an axial ratio bandwidth exceeding 100 MHz in both the L1 and L2 bands; this feature addresses the concern (i) above. The antenna consists of two stacked cavity-backed patches that are positioned in proximity of two capacitively coupled feeds; a carefully designed radome separates the antenna from the plasma. To address the concern (ii) above, the antenna is fed through a tunable matching network with a feedback system. This is accomplished using varactor diodes within a feedback system consisting of a single band sensing antenna, a return loss measurement circuit, and a controller. The return loss of the sensing antenna is measured to estimate the antenna impedance in the plasma environment, which is then used by the controller to set the proper bias voltage to the varactor diodes and achieve an approximate impedance match. Together, the network and feedback system are shown to enhance the antenna's return loss from -5dB to -20dB under variable plasma loading experienced during re-entry.