High Efficiency Hexagonal Short Backfire Antenna with Hard Walls for GPS Satellite Antennas

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Short Backfire Antennas (SBFAs), first published in 1965 (H. W. Ehrenspeck, “The Short Backfire Antenna,” Proc. IEEE, Vol. 53, No. 8, pp. 1138-1140, Aug. 1965), have seen wide use in terrestrial, maritime and space-based applications due to their relatively high directivity and low profile. Typical SBFA height is 1/8 that of comparable end-fire elements like the Yagi for the same nominal 15 dBi directivity, and typical SBFA aperture diameter is on the order of 2λ. Achievable SBFA aperture efficiency is 84% at a single frequency, and about 75% average for a dual-band application like that of the L1 (1.575 GHz) and L2 (1.227 GHz) GPS frequencies. In an array application, an additional 10% aperture efficiency loss will occur due to packaging of circular SBFA elements, bringing the overall GPS L-band array aperture efficiency down to 67%.

This paper describes the study of a high efficiency, dual-band hexagonal SBFA with substantially higher aperture efficiency or gain than the conventional SBFA. This can be achieved by placing electromagnetically hard impedance boundaries on the inside of the metal walls of a conventional SBFA (E. Lier, M.G. Bray, “High Efficiency Short Backfire Antenna as Common Product Array Antenna Element”, patent pending). In a recent paper (Bray, Lier, “High Efficiency Short Backfire Antenna Using Electromagnetically Hard Walls”, submitted to IEEE Antennas and Wireless Propagation Letters) a full wave analysis was performed, showing significantly improved directivity and cross-polarization of a circular SBFA with strip-loaded hard walls compared to the performance of a conventional SBFA. In this paper, the same approach is applied to a hexagonal SBFA for L-band GPS satellite antenna applications. The hexagonal aperture has two advantages over the circular, the flat walls are compliant with low cost manufacturing, and the 10% (0.42 dB) array packaging efficiency loss suffered by circular antenna elements is avoided.

Figure 1 shows the CST Microwave Studio model of a hexagonal SBFA with hard strip-loaded walls fed by a stacked patch antenna via a single feed probe, eliminating the need for a 90° hybrid to generate left-hand circular polarization (LHCP). The antenna was optimized to operate at L1 and L2 GPS bands. Achievable aperture efficiency for SBFAs with strip-loaded walls is close to 90% in both bands, and relative cross-polarization within the GPS field-of-view (±14°) is below -30 dB. With further design optimization we expect to obtain well over 90% aperture efficiency in both bands.

Due to the high power requirements for the space-based GPS antenna, the feed element is designed for low loss and for mitigation of high power effects such as corona and multipaction. Also, bleed-off paths for electrostatic discharge from the subreflector and parasitic patch are considered in the design, while the strips are grounded to the bottom of the reflector. The paper will discuss alternative feed designs, optimization approach for high antenna efficiency and low axial ratio performance, implementation trades for low mass and low manufacturing cost, and applications.

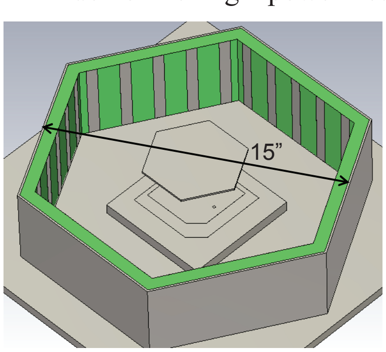

Figure 1: Hexagonal SBFA cavity fed by single probe stacked patch antenna for LHCP.