Optimization of GPS Antenna Arrays for CRPA Applications

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The Global Positioning System (GPS) has become essential in various applications that provide both location and time information for moving objects. This system, however, fails to track accurate positions when the power of unwanted interference is stronger than that of the GPS satellite signals. Controlled reception pattern antenna (CRPA) arrays have been proposed to eliminate unwanted interferences by placing adaptive pattern nulls in the interference directions, and they are now widely adopted in many applications (e.g., multipath and interference mitigation, anti-jamming, and signal-to-noise ratio (SNR) improvement of the system). A common implementation of CRPA arrays includes a reference antenna element at the center of the array with surrounding auxiliary antenna elements. The arrays are then often equipped with a space-time adaptive process (STAP) algorithm in order to generate adaptive patterns. However, when the arrays are employed in extremely small space in terms of wavelengths, they may fail in their function, since the performances of each individual element, such as radiation gain, circular polarization (CP) properties, and wide-beam elevation coverage, are significantly degraded by mutual coupling among antenna elements. Consequently, optimization and miniaturization of an individual antenna element are significantly important to achieve low mutual coupling with high radiation gain. In addition, optimization of the array configuration should also be considered in CRPA arrays to improve the capability of forming adaptive pattern nulls to the intended directions.

In this paper, we propose an optimization method of CRPA antenna arrays for dual-band GPS operation. The method includes the individual antenna design procedure using a high dielectric constant with two microstrip patches. The optimum dielectric constant of the substrate will be carefully determined by considering the reflection coefficient, mutual coupling, and radiation gain. The five identical antenna elements will then be installed on a rectangular ground plate (15 cm × 15 cm). A high rejection rate for unwanted interferences will be achieved by further optimizing the element positions using a genetic algorithm (GA) in conjunction with the FEKO EM simulator developed by EM Software and Systems. To verify the suitability for small CRPA arrays, we will present the average radiation gain (θ = -60°, 0° < ϕ < 360°) as well as interference mitigation performances. A field test will also be conducted by using a commercial GPS receiver to measure SNR values for real satellite signals in an open-site area.

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