Radiation Pattern Anomalies in the Broadband CP Reconfigurable E-shaped Patch Antenna

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The evolution of wireless communications towards wideband systems has motivated research worldwide to develop new high performance antenna designs. In particular, one class of antennas that has gained popularity are broadband CP reconfigurable patch antennas. Such antenna designs not only minimize the dependence on antenna orientation, but they also provide additional functionality for diversity and MIMO systems. Recently, an asymmetric E-shaped patch antenna was introduced as a new design candidate for wideband CP applications. This design has shown much promise in providing a wide S_{11}/AR bandwidth by introducing asymmetric slots into the E-shaped design. Polarization reconfigurable designs using MEMS switches have also been demonstrated. The typical design approach for this and other CP patch antennas optimizes the S_{11} and the AR towards broadside. In this paper, we will show that this approach can lead to E-shaped designs with peculiar beam tilts in the pattern at upper frequencies. The direction of these beams change for RHCP/LHCP polarization states, making beam tilt compensation more difficult to achieve for all configurations. We investigate this beam tilt further to understand its origin and possible compensation techniques for single radiator and array applications.

To explore this phenomenon, we first revisit the physics behind the CP radiation within the CP E-shaped patch, and then we discuss the implementation of this wideband reconfigurable CP patch antenna which was optimized using Particle Swarm Optimization to obtain roughly 16% S_{11}/AR bandwidth. We believe these bandwidths to be wider than the other common single layer, single feed designs having bandwidths of only 5-7% for similar geometries. With this design, we will present the beam tilt anomaly and understand it by examining the aperture near-fields and currents present on the patch. We also investigate this beam tilt in the array environment, where the tilt is noticeably more pronounced.

One of the fundamental results that this study demonstrates is that the bandwidth of the CP E-shaped patch no longer becomes limited by simply the impedance matching and the AR. Rather, the radiation pattern stability becomes another limiting factor, since most applications require similar radiation patterns for all frequencies. In an effort to widen the bandwidth of the CP E-shaped patch further, some possible design remedies to remove the beam tilt are explored. Particularly for array applications, it is shown that element rotation can be used to point the tilted beams towards the broadside direction for both RHCP and LHCP states. The last approach we discuss utilizes complex optimization procedures which emphasize the radiation patterns. By incorporating the pattern into the fitness function, one can also minimize the severity of the beam tilt for single element applications.