Hamiltonian-Path Based Partially Reflected Surfaces for High Gain Circularly Polarized Printed Antennas

Xueqin Zhang(1) and Ahmad Hoorfar*(2)
(1) Beijing Institute of Pharmaceutical and Chemical
State Key Laboratory of NBC Protection for Civilian, Beijing, China
(2) Antenna Research Laboratory, ECE Dept, Villanova University,
Villanova, PA 19085

Partially reflective surfaces (PRS) are highly reflective meta-surfaces that have been reported in design of antennas for beamforming and high gain wireless applications. A simple implementation of the PRS for high gain antenna applications includes a periodic array of printed strips placed in front of an antenna at a resonant distance. The resulting configuration form an equivalent Fabry-Perot structure, where the strip array acts as a leaky wave surface that significantly enhances the directivity of the feeder antenna. While, this PRS-based antenna system provides a high gain operation, one in general would have little or no control on other antenna parameters such as the sidelobe-level. However, to optimize the side-lobe-level of an antenna for a given beam width and/or shape its far-field pattern, for example to synthesize a flat-top pattern, the PRS structures made of non-uniformly spaced (aperiodic) inclusions have been proposed [*A. Hoorfar, J. Zhu, N. Engheta, Int. Conference on Electromagnetics in Advanced Applications, Torino, Italy, September, 2003; A. Hoorfar, E. BouDaher, S. Plesnick, IEEE APS-URSI, Vancouver, Canada, 2015*].

The concept of both periodic as well as aperiodic PRS are extended in this work to other novel antenna applications, In particular, we investigate the use of PRS in achieving both high gain and circular-polarization for printed antennas. To achieve CP or dual-polarized operation from PRS, one can simply use standard square-shaped metallic inclusions which are at resonance at the frequency of operation. Assuming air dielectric, this would result in PRS elements that have a 0.5λ x 0.5λ footprint, limiting the size of the effective aperture required for a desired antenna gain. In this work we have used a resonant element, shown in Figure 1, from a family of grid-graph Hamiltonian paths and cycles, which provides dual-polarized operation at a resonant size of only 0.14λ x 0.14λ [*V. Pierro, et. al, MOTL, Vol. 48, Vo. 12, pp. 2420-2425, December 2006*]. We have investigated both uniformly spaced and non-uniformly spaced optimized PRS made of such inclusions when fed with a microstrip patch antenna designed for CP operation. Preliminary results indicate the possibility of obtaining CP or dual-pol operation with maximum gain as high as 16dBi with an aperture efficiency which is significantly better than that using a PRS with standard square-shaped metallic inclusions. Details of the proposed structures together with numerical results for various designs will be given in the presentation.

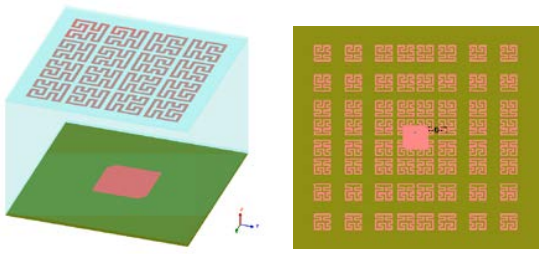

Figure 1. Periodic (left) and aperiodic (right) PRS for CP antennas using inclusions made of Hamiltonian cycles. The surfaces are fed by a microstrip patch antenna.