Innovative Double Spiral LP-RLSA Design

Agnese Mazzinghi*[(1)], Matteo Albani[(2)], Angelo Freni[(1)]
(1) Department of Electronics and Telecommunications, University of Florence
Via di S. Marta, 3, 50139 Florence, Italy, a.mazzinghi@gmail.com
(2) Information Engineering Department, University of Siena
Via Roma 56, 53100 Siena, Italy

In the ’80s, Goto et al. proposed the design of a planar, high gain, high efficiency, low return loss circular polarized antenna, called Radial Line Slot Array (RLSA), realized by a radial cavity with spirally arranged slots cut into its upper metal plate. Then, they applied the same concept also for linear polarization (M. Ando, T. Numata, J.Takada, N. Goto, IEEE Trans. Antennas and Propag., 36, 1675-1680, 1988) by using a different slot arrangement, that takes the form of concentric rings. However, the LP-RLSA typical geometry has as drawback a really poor return loss (P.W. Davis and M.E. Bialkowski, IEEE Trans. Antennas Propag., 45, 1123-1129, 1997). Indeed, each slot pair ring is radially distant a wavelength from the adjacent rings and the slots in a pair are arranged with a reciprocal distance of half the wavelength, thus all the reflected contributions sum up in phase at the input port, with a serious degradation of return loss. To mitigate the entity of the reflections at the feed point, the slots are often designed to guarantee weak coupling among them (i.e. electrically short slots). However, the counterpart is that a significant amount of power reaches the rim of the antenna without being radiated with a significant decrease in radiation efficiency. The residual power has to be absorbed by terminating the waveguide with a matched absorbing load because its reflection at the rim would result again in poor return loss also degrading the antenna radiation. In fact, if the radially outward traveling wave gives rise to the co-polar field then the reflected inward traveling wave radiates the cross-polar field. Accordingly, the reflection coefficient should be as small as possible for high polarization purity. To remedy these problems, several solutions have been proposed by compromising with antenna complexity or performances: beam-tilting, combination of CP-RLSA with polarizers, introduction of additional not-radiating canceling slots, use of parasitic dipoles and also beam broadening.

In the approach proposed here, the basic idea is to lower the reflection coefficient not by compensating it locally, one slot or pair of slots at a time, but by making it low globally. Thus, we propose a double spiral configuration, that takes advantage of the intrinsically low reflection coefficient proper of spirally arrayed CP-RLSA, where the linear polarization is obtained by the superposition of the radiation due to each spiral RLSA, one designed to radiate with RHCP and the other one with LHCP. Moreover, the radial line is terminated on a metallized rim so that the residual power not radiated beyond the slots is reflected and radiated again coherently by the slots. As a matter of fact, when we consider the wave reflected by the rim, the RHCP spiral radiates a LHCP field and vice versa, thus enforcing the radiation of the same linearly polarized field with high polarization purity.