Extension of Successive Projection Method to Tapered Leaky-Wave Antenna for Shaped-Beam Pattern Synthesis

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The problem of beam shaping is one of the hottest topics in cellular and satellite communications. Over the years many solutions have been developed to shape the radiation pattern of antennas. Despite all the efforts there still exist many issues with the current configurations such as weight, dimensions, cost and complex beam forming networks. Hence it is desirable to develop a new class of antennas that offer more degrees of freedom in terms of implementing aperture distribution so as to achieve the desired footprint pattern with less complexity.

Tapered leaky wave antennas (LWA) seem like qualified candidates for this purpose since they inherently are of high gain, light weight, low manufacturing costs and simple feeding networks.

In this paper, we investigate for the first time potentials of tapered LWAs to synthesize shaped-beam radiation patterns. Another novelty aspect of our work is the use of successive projection algorithm for the optimization purpose. We started off by formulating our pattern-synthesis problem by sets of inequalities. These inequalities indicate the conditions that must be met in the pattern and the aperture domains. The main goal of optimization is set to find an intersection point of all these subsets since it will include the best solution that satisfies all the conditions. To enhance the computational efficiency of the algorithm we have benefited from the fast Fourier transformation (FFT) for pattern calculations. The use of FFT is justified in view of the resemblance exists between LWAs and continuous linear arrays. The search for the best solution begins by projecting the FFT-computed pattern onto the mask defined by the prescribed pattern constraints. The corresponding leaky mode propagation and leakage rates, i.e. $\beta(x)$ and $\alpha(x)$, are then updated after being projected onto the subset describing continuity constraints required for traveling waves. The new pattern is then calculated from this new set of $\alpha(x)$, $\beta(x)$, and the above steps will be repeated iteratively until the intersection point is reached. To perform the above successive projections, particular projection operators, i.e. functionals must be defined. Finding appropriate mathematical expressions for these operators is a challenging task since the mapping has to preserve the continuity and slope of functions as well as preventing abrupt changes so that practical realization of LWA is possible. Using this method we focus on the synthesis of a flat-topped beam for wide angular range of $[30^\circ\ 60^\circ]$ using a LWA of length 10λ, (λ being the free space wavelength). Simulation results of shaped-beam patterns together with the optimized $\alpha(x)$ and $\beta(x)$ functions will be presented during the symposium.