ALEXANDRIA UNIVERSITY


Faculty of Engineering

Electrical Engineering Department


# Optimization and Beamforming of Smart Multiband and Wideband Fractal Antenna Arrays in Interfering Environment

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# ABSTRACT

A modern design of fractal antenna arrays, called fractile array, which exhibits a fractal boundary contour within a tiled plane, is explored for enhanced array performance. In this thesis, the Eisenstein fractile array is introduced to exploit the unique geometrical features of fractiles that allow multiband and wideband operation and avoid grating lobes in the radiation pattern even, in some cases, when the array elements spacing is greater than the half wavelength. To alleviate the large number of elements and the high Side-Lobe Level (SLL) occurred at large scales, the Genetic Algorithm (GA) optimization technique is investigated for thinning the proposed antenna array by estimating the optimal set of "on" and "off" elements corresponding to the minimum SLL without degrading the directivity of the radiation pattern. Also, the proposed array configuration is designed with adaptive beamforming capability using the Least Mean Square (LMS) technique. The effectiveness of the proposed GA-LMS approach is investigated by performing several MATLAB simulations under various set of array configurations. Results reveal that the suggested thinned Eisenstein fractile antenna array using GA-LMS approach is superior in terms of multiband and wideband performance, array element reduction, SLL reduction, grating lobe elimination, and beamforming capability. The performance of the adaptive beamforming is enhanced by proposing a new adaptive beamforming method based on discrete Kalman filter with high performance and low computational requirements. The proposed Kalman filter-based beamformer is compared with the LMS and the Recursive Least Squares (RLS) techniques under various parameter regimes, and the results reveal the superior performance of the proposed approach in terms of beamforming stability, Half-Power Beam Width (HPBW), maximum SLL, null depth at the direction of interference signals, and convergence rate for different Signal to Interference (SIR) values. Also, the results demonstrate that the suggested approach not only achieves perfect adaptation of the radiation pattern synthesis at high jamming power, but also keep the same SLL at different operating frequencies. This shows the usefulness of the proposed approach in multiband smart antenna technology for mobile communications and other wireless systems. This also elucidates the robustness of the suggested fractile array as a promising design for multiband, wideband, compact, inexpensive, and adaptive smart antennas in modern wireless systems.