SOME STUDIES ON SYNTHESIS OF UNEQUALLY SPACED ANTENNA ARRAYS THROUGH TIME MODULATION

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Abstract

The synthesis of low sidelobe level (SLL) patterns using array antennas has drawn much attention in the field of terrestrial, vehicular systems, space communication, radio broadcasting, weather forecasting, radar and, sonar. However, the generation of low or ultra-low sidelobe far-field patterns is a challenging job for antenna engineers. Since the stringent requirements of high dynamic range ratios (DRR) of the static excitations to realize such patterns cannot be met due to practical limitations of conventional phased array (CPA) system. Moreover, the feed network of the antenna array, made with attenuators and phase shifters, becomes bulky and complex. In this regard, a simple and cost-effective array system is essentially required for commercial applications.

On the other hand, the philosophy of time modulation in an antenna array, known as time-modulated array (TMA) has come up intending to produce low/ultra-low SLL pattern cost-effectively by using an additional degree of freedom, namely, 'time'. However, the basic problem of such a mechanism is the generation of unwanted sideband or harmonic radiation in multiple of the modulation frequency on either side of the center operating frequency.

This dissertation mainly focused on synthesizing unequally spaced linear antenna arrays with the aid of time modulation using various nature-inspired evolutionary algorithms. In this context, firstly, a method to synthesize unequally spaced time modulated arrays (UESTMAs) with comparatively a smaller number of optimizing parameters has been investigated. The array is synthesized in two steps by separately considering the element position and on-time of the array as the optimization parameters. It is worth to be noted that for the array with fixed element position, synthesis of the desired pattern by controlling element excitation is a linear array synthesis method. Whereas, from another point of view, the synthesis of antenna array with optimum element position is the non-linear array synthesis method. Consequently, different cases of the non-linear and linear array synthesis methods such as position-only (PO), on-time only (OTO), on-time then position (OTTP), position then on-time (PTOT), and simultaneous position on-time (SPOT) have been studied. Through rigorous simulation results by employing three evolutionary algorithms namely, differential evolution (DE), teaching-

learning-based optimization (TLBO), and quantum particle swarm optimization (QPSO), it is shown that with two-step non-linear to linear synthesis method by controlling fewer optimization parameters a better-optimized pattern can be realized with less computational time.

Next, the potentiality of time-modulation is employed to synthesize different dual-beam patterns, specifically, pencil-flat-topped and sum-difference, in an unequally spaced linear array. Without a large number of phase shifters and attenuators as required to synthesize such patterns in CPAs, the desired patterns have been realized by controlling the ON-OFF status of the RF switches by using a simple, cost-effective switching circuit in the feed network. Specifically, the efficacy of the time modulation strategy is introduced for synthesizing low SLL multiple patterns in unequally spaced linear antenna arrays with a common element position while the synthesized multiple patterns differ only by switching sequence.

After comparison with state-of-the-art reported works, it is shown that the proposed approaches are efficient to provide the optimum pattern with reduced SLL as well as suppressed sideband level (SBL). All the simulations are performed using the MATLAB R2015a version and the processor used is an Intel Core™ i3-2350M CPU@2.30GHz (2GB RAM).