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In the last years, there has been a renewed interest towards the use of time-modulated arrays (TMAs) thanks to the simplicity in reconfiguring the average pattern of the antenna just modifying the on-off sequence controlling a set of radio-frequency (RF) switches. TMAs have been originally introduced for the generation of low and ultra-low sidelobe patterns for radar arrays [1] thus avoiding the implementation of impracticable excitation tapering with high dynamic range ratios. However, they haven't received a large diffusion because of the power losses due to the generation of harmonic radiation at multiples of the time-modulation frequency. As a matter of fact, the periodic modulation of the static excitations causes a shift of the radiated power in the sideband radiation (SR) [2] with a consequent reduction of the directivity of the pattern at the carrier frequency.

Recently, thanks to the significant development of stochastic optimization algorithms boosted by the growing computational resources available with modern personal computers, several approaches have been proposed to deal with the synthesis of time-modulated arrays while keeping low the power losses in the SR. Both single-agent techniques (e.g., Simulated Annealing [3]) and evolutionary-based optimization methods (e.g., Differential Evolution [4] and Particle Swarm Optimization [5]) have been effectively applied. In such a framework, TMAs have been used for the generation of shaped beams as well as of sum and difference patterns for search-and-track antenna systems [6]. Moreover, they have demonstrated being suitable for the synthesis of pulse Doppler radars [7] and phase switch screens [8].

This contribution is aimed at reviewing the last advances in the synthesis of TMAs also showing that the introduction of additional degrees of freedom available in the time domain and suitable for the definition of the pulse sequence enables the synthesis of TMAs with improved performance. More specifically, besides the control of the durations of the time pulses controlling the RF switches for the definition of a desired pattern at the carrier frequency, also the optimization of the switch-on instants has been taken into account. Such a strategy allows to spread the energy lost in the SR on the whole visible range thus lowering the interferences, to generate and shape the harmonic patterns, and to avoid the instantaneous reduction of some pattern features [9].

References

[1] W. H. Kummer, A. T. Villeneuve, T. S. Fong , and F. G. Terrio, "Ultra-low sidelobes from time-modulated arrays," *IEEE Trans. Antennas Propag.*, vol. 11, no. 6, pp. 633-639, Nov. 1963.

[2] J. C. Brégains, J. Fondevila, G. Franceschetti, and F. Ares, "Signal radiation and power losses of time-modulated arrays," *IEEE Trans. Antennas Propag.*, vol. 56, no. 6, pp. 1799-1804, Jun. 2008.

[3] J. Fondevila, J. C. Brégains, F. Ares, and E. Moreno, "Optimizing uniformly excited linear arrays through time modulation," *IEEE Antennas Wireless Propag. Lett.*, vol. 3, pp. 298-301, 2004.

[4] S. Yang, Y. B. Gan, and A. Qing, "Sideband suppression in time-modulated linear arrays by the differential evolution algorithm," *IEEE Antennas Wireless Propag. Lett.*, vol. 1, pp. 173-175, 2002.

[5] L. Poli, L. Manica, P. Rocca, and A. Massa, "Handling sideband radiations in time-modulated arrays through particle swarm optimization", *IEEE Trans. Antennas Propag.*, in press.

[6] P. Rocca, L. Manica, L. Poli, and A. Massa, "Synthesis of compromise sum-difference arrays through time-modulation," *IET Radar, Sonar & Navigation*, vol. 3, no. 6, pp. 630-637, Dec. 2009.

[7] G. Li, S. Yang, and Z. Nie, "A study on the application of time modulated antenna arrays to airborne pulsed doppler radar," *IEEE Trans. Antennas Propag.*, vol. 57, no. 5, pp. 1578-1582, May 2009.

[8] A. Tennant and B. Chambers, "Time-switched array of phase-switched screens," *IEEE Trans. Antennas Propag.*, vol. 57, no. 3, pp. 808-812, Mar. 2009.

[9] L. Manica, P. Rocca, L. Poli, and A. Massa, "Almost time-independent performance in time-modulated linear arrays," *IEEE Antennas Wireless Propag. Lett.*, vol. 8, pp. 843-846, Aug. 2009.