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Transient Electromagnetic Field Reconstruction from Sets of Non-Periodic Oscillations

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Arbitrary transient electric field shapes are generated in free space utilizing a set of transient signals with proper shape, amplitude, and time shift. Akin to wavelets in signal processing, brief, non-periodic oscillations are superimposed at a pre-selected location in space to effect destructive and constructive interference. With a properly chosen signal set, an entirely different frequency or shape is generated. Two methods have been employed to find optimum signal sets, the Discrete Wavelet Transform (DWT) and Particle Swarm Optimization (PSO). While the DWT approach dictates constant time step and rectangular matching between wavelets, PSO is not restricted in this manner, allowing for more flexibility in choosing amplitudes and signal delays.

Using PSO, a signal may be constructed that closely matches a desired shape in time or frequency domain through time shift and amplitude modification of a number of non-periodic oscillations. This previously postulated approach has been experimentally verified utilizing a Transverse Electromagnetic (TEM) Horn Antenna array, which has been designed and implemented due to its wide frequency response necessary to transmit and receive short non-periodic signals. The frequency response of the transmitting horn antenna was exploited by applying a Gaussian input pulse, which was a-priori simulated and is now confirmed to produce a desired bipolar output. For ease of control, the pulse is generated digitally, run through a data pattern generator, and converted to an analog signal driven by a clock. This pulse is then amplified and transmitted from multiple synchronized antennas, added in the far-field, and superimposed.

As expected, the resulting received signal has been found to increase in amplitude by a factor relative to the number of transmitting antennas. To date, a synchronization accuracy of better than 100ps between individual channels has been achieved. The generation of arbitrary signals in the 100 MHz to GHz regime is demonstrated.

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