A Pulsed Beam Algorithm for Transient Radiation from Extended Apertures

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The wideband discretized-phase-space beam summation representation introduced in the first part of this sequence [1] has several attractive features that make it amenable for an extension into the time domain (TD): (a) The same beam lattice is used for all frequencies; (b) The iso-diffracting Gaussian basis provides the "snuggest" frame representation for all frequencies; (c) The propagation parameters of the resulting beams are frequency-independent and need to be calculated only once at a reference frequency. These properties have been utilized in a recent paper to derive a new TD representation for radiation from extended apertures, wherein the field is expanded in a discrete lattice of shifted and tilted pulsed beam (PB) propagators. The excitation coefficients of these PBs are extracted from the aperture source distribution via the new "discretized local slant stack transform."

The present theory completes the analogy between the frequency and time domain spectral representations. In the frequency domain, the spectral framework is provided by the spatial windowed Fourier transform formulation which is discretized via the *frame formulation*. In the TD, the non-windowed formulation is based on the *slant stack transform* (SST) where the field is described as an angular spectrum of time-dependent plane waves, while the windowed approach is based on a *local-SST* comprising a phase-pace continuum of PBs that emerge from all points in the aperture and in all directions. In our recent paper, we introduced a *discretized local-SST*. From a broader perspective, it is a new "discrete local Radon transform" in $\mathbb{R}^3$ that may be relevant in other disciplines, such as image processing.

This new TD formulation is further developed here. The emphasis is on an effective treatment of the time coordinate, which may comprise many time scales of variation. This efficacy is achieved using temporal frame based expansion which comprises interpolation kernels. In this procedure the aperture field is analyzed using spatial-temporal window functions comprising a variety space-time scales of variations. Each scale is treated separately using the discretized local-SST in order to define the parameters of the discretization. The hierarchy of temporal and spatial discretizations is such that a set of the PBs trajectories and parameters are constructed first for the highest space-time scale, and then its decimated versions are used for all other scales.

Numerical evaluation of the pulsed field produced by a focused aperture with a transient excitation will be used to demonstrate the new concepts. It will be shown that time and space localization of the emerging PBs fields facilitates numerically efficient field computations in free space and complex environment such as radomes.

[1] A. Shlivinski, E. Heyman, A. Boag and C. Letrou, "A frame based beam summation algorithm for wideband radiation," *This Session* .