Exploiting Noisy Transient Response Using the Fractional Fourier Transform

Seongman Jang, *Tapan K. Sarkar

Department of Electrical Engineering and Computer Science
Syracuse University, 121 Link Hall, Syracuse, NY 13244
Email: sejang@mailbox.syr.edu; tksarkar@mailbox.syr.edu

The goal of this paper is to obtain the electrical properties of the target from the received transient noisy time domain waveforms. Because of their aspect independence, complex resonant frequencies of a conducting object are used as a signature of the object to discriminate it from others for the purpose of target identification. The singularity expansion method (SEM) proposed by Baum [1] has been applied to express electromagnetic response in an expansion of complex resonances of the system. It has been shown that the dominant complex natural resonances of a system are a minimal set of parameters that define the overall physical properties of the system. So, a transient scattering response is analyzed in terms of the damped oscillations corresponding to the complex resonant frequency of the scatterer or target. Since the resonance describe global wave fields that encompass the scattering object as a whole, the SEM series representation encounters convergence difficulties at early times when portions of the objects are not yet excited. Early time response is strongly dependent on the nature of the source, the location of the source, and the location of the observer. Usually the early time response shows impulse-like characteristics. Because of this difficulty, most previous techniques such as Prony's method and Matrix pencil method (MPM) used just late time signals only. It is necessary to include 'entire function' to represent early time impulse-like components. The 'entire function' is subset of the analytic function but it doesn't have any singularities.

In this paper, the transient noisy electromagnetic response is considered in the time domain and in the fractional Fourier transform (FrFT) domain. The whole time domain data set is used to test. Fractional Fourier transform (FrFT) is a generalized Fourier transform. Using the FrFT it is possible to discriminate an impulse-like component from the other components of the signals. Because of this property, impulse-like early time components can be separated from the damped exponentials. To describe the early time response a Gaussian pulse is selected. Gaussian pulse is an entire function and is quite adequate to describe pulse-like components in early time. Complex exponentials are used to describe the late time signals. The concept of a 'Turn-on time' is utilized to consider a time when the fully excited resonance can be used, formally. The results for wire scattering element and finite closed cylinder with various SNR show that if SNR is greater than 30dB it is possible to get meaningful parameters using proposed techniques.