A Review of the Existing Techniques for Complex Natural Resonance Extraction

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***Abstract*—** We present in this paper a comparative review of the methods for calculating the Complex Natural Resonance extraction of backscattering signals. Existing techniques are characterized in terms of computational cost, noise sensibility and early time sensibility.

***Keywords*—**Singularity Expansion Method, Cauchy's Method, complex natural resonance, matrix pencil method, Laplace transformation, radar, Half Fourier Transform.

I. INTRODUCTION

The Singularity Expansion Method (SEM), proposed by Carl Baum in 1971[1], is a technique used to characterize the response of an object to electromagnetic stimuli using its Complex Natural Resonance (CNR). This response, unique for each object is aspect independent and can be used for object identification.

This method has been applied to several domains and applications, especially Automatic Target Recognition (ATR). Several techniques are used to extract the CNR of the signal, among them we have: the Matrix Pencil Method, the TLS-Prony's Method and the Cauchy's Method.

With the aim of implementing an FPGA version of SEM, for operation time application, we performed a comparative analysis of the existing techniques for CNR extraction.

II. CNR EXTRACTION METHODS COMPARISON

The results of the analysis are presented in Table 1. The analysis characterizes each method in three aspects: Early Time (ET) -Late Time (LT) incorporation, Computational cost and Noise influence. The analysis was performed from both, theoretical point of view and using simulation results of canonical geometries.
As a conclusion, the most feasible method to be implemented in a portable, real time processing unit is the method based in the Half Fourier Transform.

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TABLE I. METHODS COMPARISON FOR SEM CNR EXTRACTION

Method/performance	Date	SNR	Computational Cost	Domain of operation	Early time response incorporation	Overall FPGA implementation suitability
Matrix Pencil	1990	High	Moderate	Time	Moderate	High
Cauchy	2007	Low	High	Frequency	High	Moderate
TLS-Prony	1987	Moderate	Moderate	Time	Low	High
HFT	1980	N/A	High	Frequency	High	Moderate