Computing the SEM Poles in the Frequency Domain and not from the Late Time Response

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The scattered electromagnetic field response from a general object can be modeled by its natural poles using the Singularity Expansion Method (SEM). The reason for choosing this topic for this special session is because this is the first presentation the first author heard given by Prof. Giorgio Uslenghi and Dr. Carl Baum in an evening session to popularize the SEM methodology. This was also the first APS/URSI meeting attended by the first author exactly 40 years ago in the year 1975!

The SEM poles are generally used to identify a target. Typically, these poles are computed from the late time response of an object, using the Matrix Pencil method. However, from a practical standpoint it is impossible to know a priori where the early time response ends and the late time response begins. This uncertainty has retarded the growth of the popularity of the SEM method. In this presentation, we describe a methodology for calculating the SEM poles directly in the frequency domain using the Cauchy method.

Numerical results will be presented to illustrate that the SEM poles can be computed accurately using the Cauchy method if special attention is paid in the computation using the Cauchy method. The trick here is to employ a QR decomposition of the data first so that the noise is not smeared to the elements of the matrix which are exact, before employing the Singular Value Decomposition to compute the polynomial coefficients of the rational function approximation to the given data. In linear algebra, a QR decomposition (also called a QR factorization) of a matrix is a decomposition of a matrix A into a product $A = QR$ of an orthogonal matrix Q and an upper triangular matrix R. QR decomposition is often used to solve the linear least squares problem, and is the basis for a particular eigenvalue algorithm, the QR algorithm. The Cauchy method thus provides a rational polynomial approximation of the given data. Once the coefficients of the denominator polynomial is known factorizing it yields the SEM poles. Numerical results will be provided to illustrate the application of this methodology.