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Direct calculation of modal parameters from matrix orthogonal polynomials

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ABSTRACT

The object of this paper is to introduce a new technique to derive the global modal parameter (i.e. system poles) directly from estimated matrix orthogonal polynomials. This contribution generalized the results given in Rolain et al. (1994) [5] and Rolain et al. (1995) [6] for scalar orthogonal polynomials to multivariable (matrix) orthogonal polynomials for multiple input multiple output (MIMO) system.

Using orthogonal polynomials improves the numerical properties of the estimation process. However, the derivation of the modal parameters from the orthogonal polynomials is in general ill-conditioned if not handled properly. The transformation of the coefficients from orthogonal polynomials basis to power polynomials basis is known to be an ill-conditioned transformation. In this paper a new approach is proposed to compute the system poles directly from the multivariable orthogonal polynomials. High order models can be used without any numerical problems.

The proposed method will be compared with existing methods (Van Der Auweraer and Leuridan (1987) [4] Chen and Xu (2003) [7]). For this comparative study, simulated as well as experimental data will be used.

1. Introduction

Experimental Modal Analysis (EMA) is currently one of the key technologies used in structural dynamics analysis such as for example cars, aircrafts, bridges, offshore platforms and industrial machinery [8–13]. Based on the fundamentals of system identification, it has evolved into a "standard" approach in mechanical product development. Modal analysis has, from the start, focused on solving specific problems related to the testing and modeling of large industrial structures. The merit of each new method or approach has always been evaluated for the added value it brought to help application engineers derive better models. During a modal test, both the applied forces and vibration responses of the structure are measured when excited in one or more locations. Based on this data, a modal model of the structure that essentially contains the same information as the original vibration data is derived by means of modal parameter estimation techniques.

The frequency-domain least squares estimators are widely used in modal parameters estimation. However, frequency-domain LS estimators are often known to suffer from numerical problems when identifying a continuous-time model specifically in case of boarder frequency bands and higher model orders. So, the use of orthogonal polynomials instead of ordinary power polynomials was proposed by several researchers in the literature to improve those numerical problems.

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