ABSTRACT

The frequency domain finite element method (FEM) results in matrix equations that have polynomial dependence (or transcendental dependence which can be written as a polynomial via a Taylor series) on the frequency of excitation. For a wide-band fast frequency sweep technique based on a moment-matching model order reduction (MORe) process, researchers generally take one of two approaches. The first is to linearize the polynomial dependence (which will either limit the bandwidth of accuracy or require the introduction of extra degrees of freedom) and then use a well-conditioned Krylov subspace technique such as the projection via Arnoldi (PVA) or the Padé via Lanczos (PVL) processes. The second approach is to work directly with the polynomial matrix equation and use one of the available, but ill-conditioned, asymptotic waveform evaluation (AWE) methods. For large-scale FEM simulations, introducing extra degrees of freedom, and therefore increasing the length of the MORe vectors and the amount of memory required, is not desirable; therefore, the first approach is not alluring. On the other hand, an ill-conditioned AWE process is unattractive. This dissertation presents two MORe techniques for polynomial matrix equations. The first, an automated multipoint Galerkin AWE (MGAWE) process, is capable of producing a reduced order model (ROM) with a relatively small subspace. The second novel process presented, well-conditioned AWE (WCAWE), is capable of producing an accurate, robust, wide-band simulation with just one expansion point.

These novel processes are able to circumvent the problematic issues that arise from the traditional PVA, PVL or AWE techniques. First, these novel processes do not require any additional unknowns and can operate directly on the polynomial matrix equation. Second, these processes are wide-band, and in the case of WCAWE, very well-conditioned even for a large approximation order. Along with the presentation of these algorithms, numerical examples modeled using the FEM are given throughout the work to illustrate their accuracy, efficiency and robustness. Finally, this dissertation closes with a detailed description of many possible areas of further research including an extension of the methods to a block and/or multivariable versions, and applications of the methods to problems in which the system matrix has exponential variations in the ROM varying parameter.