tions "done very quickly"? Can it be that the authors have managed to do away with the old faithful quadratic form and found a simpler alternative sign-check? This certainly would be a significant advance in the state of the art. However, short of this miraculous cure, the proposed matrix method is impossible in any finite mechanism. Although Tarnai's ring (a space truss with bars arranged along the edges of Archimedes' antiprism) indeed possesses an interesting symmetry, this has no relation to its inability to hold a self-stress. In the authors' notation (Reference), both of the systems are characterized identically: \( s = m = 1 \), where \( s \) is the degree of statical indeterminacy and \( m \) is the number of mechanisms. Since both systems are finite mechanisms, neither can be prestressed.

3 The absence of symmetry is exactly the point: even the two spans in the "equivalent" system were made unequal. This has been done in order to demonstrate that symmetry is not a factor in Maxwell's conceptualization, and that prestress is impossible in any finite mechanism. Although Tarnai's ring (a space truss with bars arranged along the edges of Archimedes' antiprism) indeed possesses an interesting symmetry, this has no relation to its inability to hold a self-stress. In the authors' notation (Reference), both of the systems are characterized identically: \( s = m = 1 \), where \( s \) is the degree of statical indeterminacy and \( m \) is the number of mechanisms. Since both systems are finite mechanisms, neither can be prestressed.

An Alternating Frequency/Time Domain Method for Calculating the Steady-State Response of Nonlinear Dynamic Systems

F. H. Ling. Periodic response of nonlinear dynamic systems are calculated by expanding the response into the Fourier series and using the Fast Fourier Transform (FFT) technique in this paper. This paper is written in an easily understood manner and contains some useful material towards engineering applications. As the authors of the paper pointed out, there are fundamental similarities in the concepts underlying their method (AFT) and the Fast Galerkin method (FG) described in an earlier work of ours (Ling and Wu, 1987). Moreover, the authors listed three differences between these two methods, two of which will be discussed as follows.

The first difference concerns the form of the equations to be solved. It is emphasized that the AFT permits the equations to be of any order, but the FG does not. In fact, there are two subsections (4.4 Treatment of a Second-Order Equation and 4.7 Equations in Implicit Form) in Ling and Wu (1987), in which the possibilities of treating higher-order equations not only in explicit form but also in implicit form are discussed.

The second point is about the form of nonlinearities handled. Although we did not give an example containing a nonanalytical nonlinearity, there is no problem in treating it. Since the nonlinear function \( f(x(t), t) \) in our notation is calculated numerically at discrete nodes \( t_i, i = 1, 2, \ldots, 2m \), so the nonanalytical nonlinearity can be equally handled.

Besides, a comparison with the Runge-Kutta method and two-point boundary value formulation are touched in this paper. Two remarks will be made as follows. First, a fixed steplength Runge-Kutta method mentioned in the paper is now usually replaced by an adaptive steplength one, especially if there is an abrupt change or even a discontinuity in the nonlinearities (cf., Stoer and Bulirsch, 1982 and also the IMSL subroutine IVPRK and DIVPRK). Second, there are intensive studies on using the shooting method to solve two-point boundary value problems with the aim of calculating periodic solutions (cf., e.g., Ling, 1981, 1982, 1983). To quote from Ling and Wu (1987), "The advantages of the Fast Galerkin Method are the completeness in the theory, the clearness in physical meaning and the directness in error estimation. Especially for simpler problems or problems requiring only low accuracy, the amount of computation by the Fast Galerkin method is less than that of the direct numerical method." Since AFT and FG are in essence the same, so this conclusion may also be applied to AFT.

References


Authors' Closure

We thank Professor Ling for his thoughtful and instructive comments on our paper. We especially appreciate the note from his own research that the Fast Galerkin (FG) method offers computational and theoretical advantages over shooting methods in many instances, and that this would also apply to our Alternating Frequency/Time (AFT) domain method.

Several of Professor Ling's comments are replies to our discussion of his work (Ling and Wu, 1987). We agree that the FG and AFT methods are fundamentally similar in balancing multiple harmonic terms in an equation, and using a fast Fourier transform (FFT) to obtain the harmonic content of the nonlinear terms. Consequently, the comments here and in our paper focus on how to view and implement the solution of a nonlinear dynamics problem, rather than on theoretical differences.

Professor Ling is correct in stating that Ling and Wu do mention the possibility of treating higher than first-order equations. However, since they formulate the FG method for systems of first-order ODE's, and do not show how higher-order equations are handled, the reader can be left with the impression that higher-order equations should be decomposed into first-order equations involving the state variables. The point we made is that this adds unnecessary computation since the velocity function is derivable from the displacement function and need not be calculated independently.

Professor Ling is also correct in stating that there is nothing to prevent the FG method from handling nonanalytic nonlinearities. Our work with a discontinuous nonlinearity (Coulomb friction) should be seen as an extension applicable to FG as well as AFT, and not as a limitation in the FG method.

The principal advantage in the AFT implementation is this: The unknowns are the complex components of the discrete Fourier transform of the dependent function, rather than the real coefficients of its Fourier series, as in FG. This simple difference in perspective—for periodic functions they are mathematically equivalent—can provide substantial computational advantages. The advantage is not immediately ap-