Modal dynamics of structures with bladed isotropic rotors and its complexity for 2-bladed rotors

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The modal dynamics of structures with bladed isotropic rotors is analyzed using Hill’s method. First, analytical derivation of the periodic system matrix shows that isotropic rotors with more than two blades can be represented by an exact Fourier series with 3/rev as the highest order. For 2-bladed rotors, the inverse mass matrix has an infinite Fourier series with harmonic components of decreasing norm, thus the system matrix can be approximated by a truncated Fourier series of predictable accuracy. Second, a novel method for automatically identifying the principal solutions of Hill’s eigenvalue problem is introduced. The corresponding periodic eigenvectors can be used to compute symmetric and anti-symmetric components of the 2-bladed rotor motion, and the additional forward and backward whirling components for rotors with more than two blades. Finally, the generic methods are used on a simple wind turbine model consisting of three degrees of freedom for each blade and seven degrees of freedom for the nacelle and drivetrain. The modal dynamics of a 3-bladed 10MW turbine from previous studies is recaptured. Removing one blade, the larger and higher harmonic terms in the system matrix lead to resonant modal couplings for the 2-bladed turbine that do not exist for the 3-bladed turbine, and that excitation of a single mode of a 2-bladed turbine leads to responses at several frequencies in both the ground-fixed and rotating blade frames of reference which complicates the interpretation of simulated or measured turbine responses.

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