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Analysis of Nonlinear Dynamic Systems Excited by Combined Colored and White Noise Excitations

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Abstract : In this paper, single-degree-of-freedom (SDOF) systems to white noise and colored noise excitations are investigated. By expressing colored noise excitation as a second-order filtered white noise process and introducing colored noise as an additional state variable, the equation of motion for SDOF system under colored noise is then transferred artificially to multi-degree-of-freedom (MDOF) system under white noise excitations. As a consequence, corresponding Fokker-Planck-Kolmogorov (FPK) equation governing the joint probabilistic density function (PDF) of state variables increases to 4-dimension (4-D). Solution procedure and computer programme become much more sophisticated. The exponential-polynomial closure (EPC) method, widely applied for cases of SDOF systems under white noise excitations, is developed and improved for cases of systems under colored noise excitations and for solving the complex 4-D FPK equation. On the other hand, Monte Carlo simulation (MCS) method is performed to test the approximate EPC solutions. Two examples associated with Gaussian and non-Gaussian colored noise excitations are considered. Corresponding band-limited power spectral densities (PSDs) for colored noise excitations are separately given. Numerical studies show that the developed EPC method provides relatively accurate estimates of the stationary probabilistic solutions. Moreover, statistical parameter of mean-up crossing rate (MCR) is taken into account, which is important for reliability and failure analysis.

Keywords : filtered noise, narrow-banded noise, nonlinear dynamic, random vibration
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