Abstract

The stationary responses of some stochastic nonlinear oscillators in the presence of Poisson white noise excitations are studied in this thesis using the exponential-polynomial closure (EPC) method. The EPC solution procedure is formulated and presented for the case of Poisson white noise excitations.

The probability density function (PDF) of the response of nonlinear stochastic systems is governed by the generalized Fokker-Planck-Kolmogorov (FPK) or Kolmogorov-Feller equation when the oscillators are excited by Poisson white noises. In this thesis, the EPC method which was proposed and investigated by G. K. Er and V. P. Iu in 1990s to solve the FPK equation and fulfill the task of obtaining the approximate PDF when the system excitation is Gaussian white noise is further extended to obtain the approximate PDF in the presence of Poisson white noise excitations by solving the generalized FPK equation. The solution procedure for the approximate solution of the generalized FPK equation is presented. The PDF of the response is assumed to be an exponential function of polynomials in state variables. Special measure is taken such that the generalized FPK equation is satisfied in the average sense of integration with the assume PDF. The problem of determining the unknown parameters of the approximate PDF finally results in solving simultaneous nonlinear algebraic equations. The solution procedure is extensively applied to different types of nonlinear oscillators with Poisson excitations, including Duffing oscillators, oscillators with nonlinear damping and the nonlinear oscillators with external excitations and parametric excitations. The numerical analysis shows that the results obtained with the EPC method are equal or close to those from equivalent linearization method when the polynomial order equals 2, which presents a Gaussian PDF. It further shows that the result from EPC ($n = 2$) (Gaussian PDF) differs significantly from the result from Monte Carlo simulation, particularly in the tail regions of the PDF. When the polynomial order (n) increases to 4 or 6, good agreement is observed in the results between the EPC method and Monte Carlo simulation. Especially the EPC method can provide good estimation in the tail regions of the PDF, which is of significance in the analysis of structural reliability.

In addition to the above, the PDF solutions of several types of nonlinear stochastic systems are investigated, including the oscillators governing the ship roll motion, the oscillators excited by both Gaussian and Poisson white noises and the systems excited by the Poisson white noises which impulse amplitude is Gaussian or non-Gaussian. The hardening hysteretic systems excited by Gaussian white noise excitations are also analyzed with the EPC method.