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电力系统运行与规划

采用周期轨Poincaré映射的非线性电力电子系统小干扰稳定性分析

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摘要： 拓扑结构切换、占空比控制方法和非线性元件均可使电力电子系统具有非线性特性，因此其小干扰稳定问题属于微分方程周期轨的稳定问题。由于状态空间平均法误差较大、难以预测分叉，而数值仿真法物理概念不清晰，因此，提出了基于梯形积分法的非线性电力电子系统周期轨稳定性分析方法。利用梯形积分法描述系统占空比方程和每阶段的非线性状态方程，由隐函数求导法和链式求导法计算周期轨Poincaré映射的雅可比(Jacobian)矩阵，提出了系统稳定裕度指标，建立了基于周期轨Poincaré映射的非线性电力电子系统小干扰稳定性分析方法。该方法能够克服小干扰稳定传统分析方法的困难，揭示非线性电力电子系统失稳的动力系统机制。仿真分析验证了算法的有效性。

关键词： 非线性电力电子系统 小干扰稳定性 周期轨 Poincaré映射

Small Signal Stability Analysis of Nonlinear Power Electronic Systems Based on Poincaré Mapping of the Periodic Orbit

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Abstract: Topological structure switching, duty ratio control method and nonlinear components can all make power electronics systems have nonlinear characteristics, so small signal stability of nonlinear power electronic systems belongs to stability of periodic orbit of differential equations. State space averaging method has difficulty to predict bifurcation or the prediction has lower accuracy, while numerical integration method has not clear physical concept, so this paper presents an analysis method of periodic orbit stability based on trapezoidal integration method. Trapezoidal integration method was applied to describe the duty ratio equation and nonlinear state space equation of each stage. Jacobian matrix of the Poincaré mapping was calculated by implicit function derivative method and chain derivative method, and the stability margin was presented. Thus the analysis method of small signal stability for nonlinear power electronic systems was established based on Poincaré mapping of periodic orbit. The presented method can overcome the difficulty of traditional analysis method of small signal stability and reveal the instability mechanism of dynamical system for nonlinear power electronic systems. Simulation analysis verified the validity of the algorithm.

Keywords: nonlinear power electronic systems small signal stability periodic orbit Poincaré mapping

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