光学 精密工程
OPTICS AND PRECISION ENGINEERING
Ei 核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国仪器仪表学会
主编：曹健林

光学精密工程 2013, 21(6) 1561-1567 ISSN: 1004-924X CN: 22-1198/TH

微纳技术与精密机械

微隧道式加速度计的最优控制

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摘要： 为了扩大隧道式加速度计（MTA）的动态测量范围并通过降低系统中的主要噪声来提高器件的性能，本文为隧道式加速度计（MTA）设计了线性二次高斯（LQG）控制器。推导了微隧道式加速度计的线性化状态-空间方程；依据分离定理，设计了卡尔曼滤波器和最优状态反馈控制器；最后，在Matlab/Simulink中构建了由卡尔曼滤波器和最优状态控制器串联的LQG仿真系统并进行了动态和静态测试。仿真结果表明，LQG最优控制系统能够将微隧道式加速度计的带宽从2×103 rad/s扩大到3×106 rad/s。通过LQG最优控制，静态测试结果显示其静态隧道电流的波动从1 nA~2.95 nA降到0.73 nA~1.14 nA；动态实验数据表明其在方波加速度信号的作用下能够将隧道间隙维持在1 nm。

关键词： 闭环微系统 隧道式加速度计 控制器的设计 LQG控制

Optimal Control for Microchined Tunneling Accelerator

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Abstract: To enlarge the dynamic measurement range of a Micromachined Tunneling Accelerator(MTA) and to improve its performance by reducing the influence of main noise operated in a closed-loop mode，a Linear Quadratic Gaussian (LQG) optimal controller was designed for our MTA to maintain a constant tunneling gap. The linear state space equation for the MTA was deduced, and an Kalman filter and an optimized sate feedback controller were designed. Finally, a simulation system was constructed by combining the Kalman filter and the optimized sate feedback controller in series, and simulation tests were performed. Obtained results show that the bandwidth of the MTA has been increased from 2×103 rad/s to 3×106 rad/s by the optimal control system. Moreover, the fluctuation of the static tunneling current is decreased from 1-2.95 nA to 0.73-1.14 nA from a static test and the distance from the proof mass to the tunneling electrode is effectively regulated to its nominal value of 1 nm under the dynamic square-wave accelerator.

Keywords: Closed-loop microsystems Tunneling accelerator Controller design Linear Quadratic Gaussian(LQG) cotroller

收稿日期 2013-01-08 修回日期 2013-03-05 网络版发布日期 2013-06-20

基金项目:

国家自然科学基金项目（基于可交换clifford代数的彩色图像矩不变量研究）;青年科学基金项目;中央高校基本科研业务费专项资金资助

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