Light Science & Applications

Research Progress on Capacitive Sensing Circuits of Inertial Sensors

Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, China

Yanlin Sui
Email: yanlinsui@gmail.com

In the space gravitational wave detection mission, the inertial sensor serves as the core load. The sensitive structure and capacitive sensing circuit are the core components of the inertial sensor. The sensitive structure includes the test mass and electrode cage. Capacitive sensing circuits measure capacitance changes caused by movement of the test mass in sensitive structures, and their measurement accuracy has a direct impact on the sensor's resolution. , its acceleration noise needs to reach $3 \times 10^{-15} ms^{-2}/\sqrt{Hz}$ at a frequency of $0.1mHz$, corresponding to the capacitive sensing noise on the sensitive axis of the capacitive sensing system needs to reach $1aF/\sqrt{Hz}$, unlike traditional circuit noise evaluation, the noise in the mHz frequency band is dominated by thermal noise and $1/f$ noise of the device, which is a challenging technical goal. This report introduces the use of a low-frequency and high-precision resonant capacitor bridge method based on a planar transformer. The developed planar transformer has the advantages of low temperature drift and low $1/f$ noise compared with the traditional wire-wound transformer, and further analyzes a method using discrete JFET to Methods to reduce op amp current noise and analyze how feedback resistors and capacitors in TIA circuits affect overall circuit noise. The converted capacitive sensing noise can reach $0.84aF/\sqrt{Hz}$ in the frequency band of $10mHz - 1Hz$, laying the foundation for precise measurement of capacitive (displacement) sensors in inertial sensor systems.

Short Bio:

Yanlin Sui received his PhD degree in Mechatronic Engineering from University of Chinese Academy of Sciences, China. He is an assistant professor of Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, China.