Turn-on Bias Behavior Prediction for Micromachined Coriolis Vibratory Gyroscopes

Qiang Shen, Honglong Chang, Yixuan Wu, Jianbing Xie, Senior Member IEEE,

PII: S0263-2241(18)30838-8
DOI: https://doi.org/10.1016/j.measurement.2018.09.010
Reference: MEASUR 5868

To appear in: *Measurement*

Received Date: 10 May 2018
Revised Date: 3 September 2018
Accepted Date: 4 September 2018

Please cite this article as: Q. Shen, H. Chang, Y. Wu, J. Xie, Senior Member IEEE, Turn-on Bias Behavior Prediction for Micromachined Coriolis Vibratory Gyroscopes, *Measurement* (2018), doi: https://doi.org/10.1016/j.measurement.2018.09.010

Turn-on Bias Behavior Prediction for Micromachined Coriolis Vibratory Gyroscopes

Qiang Shen[a, b], Honglong Chang[b], *Senior Member, IEEE*, Yixuan Wu[a, b], Jianbing Xie[a, b]

[a] Research & Development Institute of Northwestern Polytechnical University in Shenzhen, China.
Email: shenq@nwpu.edu.cn
[b] MOE Key Laboratory of Micro and Nano Systems for Aerospace, Northwestern Polytechnical University, Xi'an, 710072, China.
Corresponding author: changhl@nwpu.edu.cn

Abstract

The turn-on bias behaviour of a Coriolis vibratory gyroscope (MCVG) is theoretically modelled, numerically simulated and experimentally verified in this paper. First, the bias-temperature relationship during the thermal start-up process is analytically established. Second, the bias-time characteristic is modelled by analyses of different transient responses via different pathways in the heat transfer process. Finally, an experimental verification method is proposed to verify the established turn-on bias model. The comparison proves the established model can predict the turn-on bias behaviour of MCVGs with an acceptable error of 9%.

Keywords: Bias, Coriolis vibratory gyroscope, turn-on

1. Introduction

Microelectromechanical system (MEMS) technologies have successfully enabled the miniaturization and cost reduction of inertial sensors. However, the comparatively low accuracy of MEMS inertial sensors severely limits the application range. The comparatively large bias drift of the sensors is one major motivation to lower the accuracy. Bias drift of most micromachined Coriolis vibratory gyroscopes (MCVGs) mainly sources from their inherent sensitivity to temperature variations [1-2]. When the power supply is turned on, the bias drift of the MCVG suffers severely from the temperature rising caused by variation of the package temperature [3-4], which will lead to packaging stress at the contact adhesion surface between the MCVG device and the package because of coefficient mismatches of the thermal expansion of these two materials [5-6]. For the MCVG, the uncompensated bias sensitivity is typically on the order of a few tens to hundreds of degrees per hour [7]. After the thermal start-up, bias drift can reach a relatively stable state. Therefore, it is very important to understand the turn-on bias behaviour of the start-up process and shorten the thermal start-up time for MCVGs to meet the rapid response requirement.

Recently, researchers began to take advantage of the linear temperature dependence of the drive-mode resonant frequency to self-compensate temperature-induced output drifts. Using this method, during a thermal start-up time of 900 s, bias drift is improved from 2000 °/hr to 5 °/hr [8]. Output drift of the gyroscope within the temperature range from room temperature to -20℃ decreases from 3.01 °/hr to 0.58 °/hr [9]. In these studies, the temperature dependence of the drive-mode resonant frequency in the