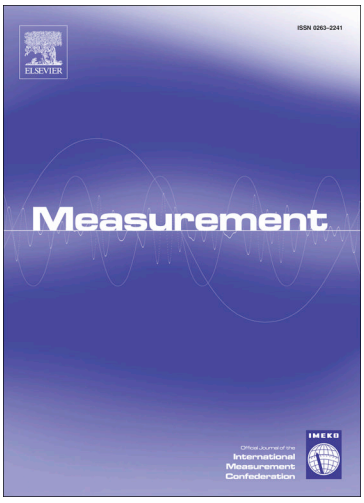

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A High Resolution Tilt Measurement System Based on Multi-accelerometers

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Abstract: In this paper, a wireless tilt measurement system of high resolution is proposed and demonstrated using multiple MEMS (Micro-electromechanical Systems) accelerometers. The measurement system is mainly composed of MEMS accelerometers as sensing unit, a MCU (Micro Controller Unit), wireless transceivers, battery and a PC terminal. Three MEMS accelerometers are purposely located with specific orientations and the system output is determined from the accelerometer that is most sensitive in the tilting range of the object under testing. The raw measured signal collected by the MCU is processed using Kalman Filter (KF) and the analyzed data is transmitted to the PC terminal by a wireless module. The effect of different KF parameters are analyzed using the Allan variance. After eliminating the accelerometers' installation errors, the measuring resolution of system is found to be 0.02° in the whole range from 0° to 360°. In the step test of tilting back and forth, it is found that the absolute measurement error is less than 0.004° for the step change of 0.05°.

Keywords: Accelerometer; Allan variance; Kalman filter; Tilt measurement

1. Introduction

Tilt is one of the important attitude parameters and its measurement is widely applied in a number of applications such as engineering machinery alignment, human body motion detection, game controllers like Sony's PlayStation, ground motion and land subsidence detection[1–4]. Hence, various tilt sensor and system have been developed accordingly. The main concept behind the tilt sensor is based on the measurement of physical response of a mass moving relative to the fixed casing due to the induced inertial force caused by gravity. The types of moving mass can be solid, liquid or gas and the response of the mass pendulum with respect to gravity can be sensed in various ways including capacitive, resistive, fiber optic, magnetic and thermal [5–12]. It is worthy of noticing from these reported research that the MEMS technology has revolutionized the sensors to enable them with a smaller size and lower