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SYNCHRONOUS MEASUREMENT OF ACCELERATION BY MEMS SENSORS OVER CAN BUS

SYNCHRONNÍ MĚŘENÍ ZRYCHLENÍ MEMS SENZORY POMOCÍ SBĚRNICE CAN

Abstract

This paper discusses possibility of synchronous measurements of acceleration by digital MEMs sensors with the use of the CAN bus. The CAN bus is not commonly used for the synchronous operations, so the main topic of the paper is focused at measurement of the reliability and accuracy of the whole measurement chain on a laboratory stand. We verified by measurements, that digital MEMs sensors can be synchronized over the CAN bus, with respect to theirs typical scanning frequency.

Abstrakt

V příspěvku je rozebrána možnost synchronizovaného měření zrychlení pomocí digitálních MEMs senzorů propojených sběrnicí CAN. Sběrnice CAN se obvykle k synchronním měřením nepoužívá, proto se v příspěvku zabýváme spolehlivostí a přesností takového měření celého měřicího řetězce na laboratorním testovacím zapojení. Měření potvrdila, že digitální MEMs senzory mohou být synchronizovány pomocí CAN sběrnice v rámci jejich běžné scanovací frekvence.

1 INTRODUCTION

Synchronous measurements of accelerations are typically used for different modal analysis of mechanical structures. We have developed a low cost measurement chain (see Fig.1) based on MEMs sensors and real time controller for low cost measurements in multi sensor configurations.

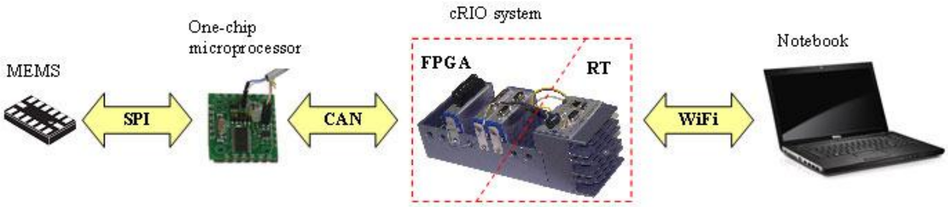

Fig. 1 Measurement chain with multiple communication busses.

In this paper we try to measure reliability and accuracy of new designed measurement chain on a laboratory stand. The components used in test are following.

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1.1 MEMS accelerometer Freescale MMA7456

MEMs (Micro-Electro-Mechanical Systems) accelerometers MMA7456 are miniature, low cost capacitive accelerometers, which can be used for different user regimes. The accelerometer is tree axis with selectable measurement range $\pm 2g, \pm 4g, \pm 8g$. The sensor is digital with communication possibility over the SPI or I2C bus.

The sensor has two selectable internal scanning frequencies, the 125Hz or 250Hz. The reading accuracy of sensor is 10bit – which means 1024 different values at the digital output. The principle of acceleration measurement is capacitive (see Fig 2).

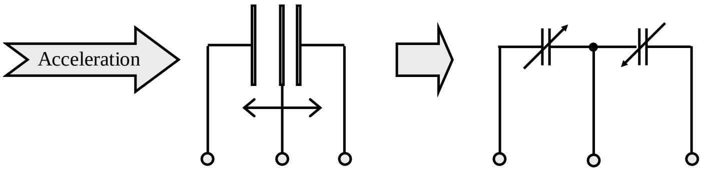

Fig. 2 Acceleration sensor principle.

For the communication with real time controller is used the CAN bus with microchip interface board. The whole acceleration sensor consists of a robust box, the microchip control [2] and a communication board and a sensor board (see the Fig 3).

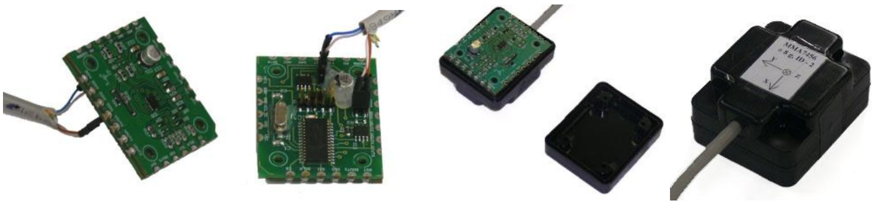

Fig. 3 Sensor board, microchip board, box with connected boards and connecting cable.

1.2 cRIO real time controller platform

For measurements in real time, we have to use the quick and robust real time controller cRIO 9014 extended by reconfigurable chassis cRIO 9104 based on FPGA (see Fig 4).

Fig. 4 Compact RIO real time and FPGA platform.

For communication with sensors we use the CAN board NI 9853, which has two high speed CAN interfaces. For connection with sensors we are using only one, so the second one can double the transmition speed and sensor count in future. The speed of NI 9853 CAN interface is 1 Mbit.

1.3 Laboratory stand with vibrator of the TIRA type and PULSE the BK signal analyzer

For the accuracy and reliability tests we use the testing stand with vibrator and signal generator PULSE from B&K (see Fig. 6). On experimental stand is mounted robust aluminum plate on vibrator core. On the mentioned plate are attached eight sensors by screws. The signal for controlling the vibrator was generated by signal analyzer PULSE [1], or in some cases also manually. The measured data from sensors are transmitted by CAN bus, over the tree topology and standard ethernet cables. After reading out and storing into memory of real time controller, the data are transmitted over WIFI into laptop (see Fig.1 and Fig. 6)

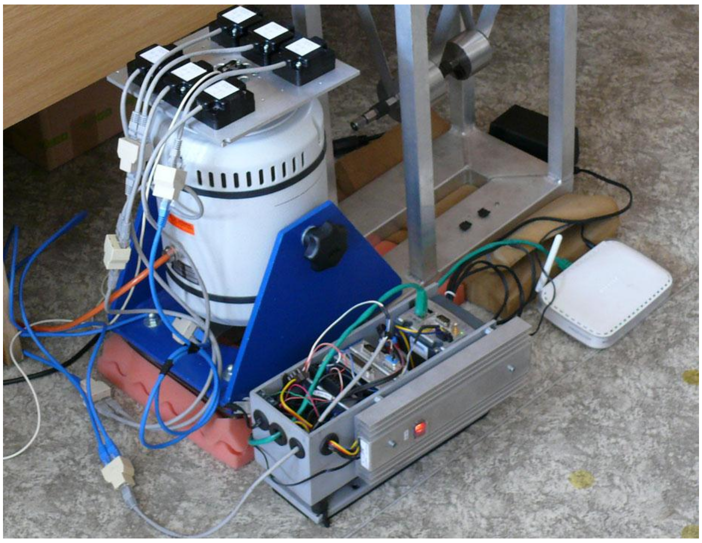

Fig. 5 Testing stand with vibrator and mounted sensors, cRIO controller and WIFI.

2 EXPERIMENTS AND MEASURED DATA

The first test is measurement of generated periodic sinus signal from the vibrator by eight sensors on aluminum plate (see Fig 6). The second test is a response to the pulse signal generated manually on the same test stand. After analysis of measured data, we recognize random time shift in measured data [3]. The time shift was in the range of 0 to 1/250 s. The random time shift was independent on sampling frequency, the bandwidth of CAN bus and order of sensors. The hypothesis is, that time shift is caused by different time of MEMs sensors power up. The sensors are powered, connected to CAN network and started in different time – that results in different internal MEMS sensors timers shift.

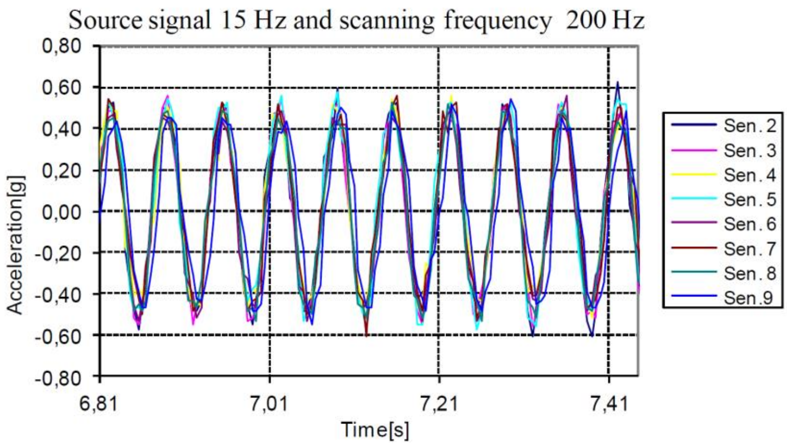

Fig. 6 Measurement of periodic signal.

For reduction of time shift error we change the measure algorithm in such a way, that all MEMs on CAN network are switched into sleep mode before starting measurements and then wake up by one synchronization CAN packet. In this way we improve the time shift error for the whole frequency range (see Fig.7 blue curve designates the synchronized time shift). The data on Fig.7 are computed from long periodical measurement.

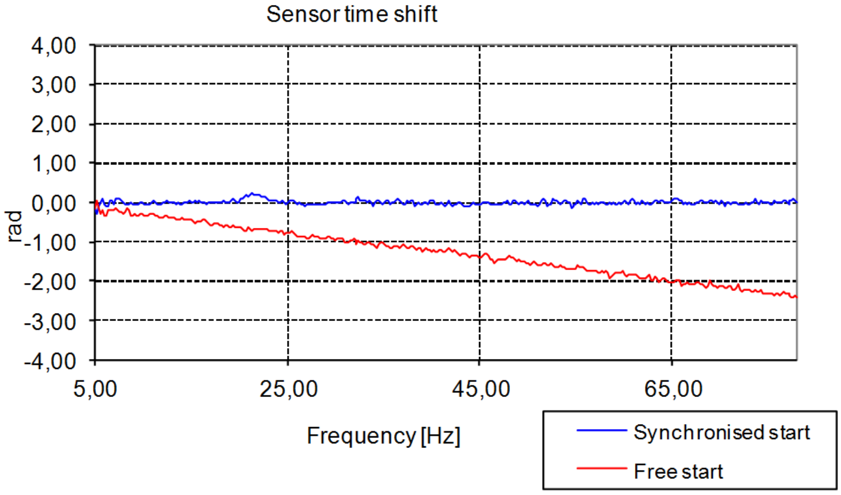

Fig. 7 Time shift of sensors with synchronized and free power up.

3 CONCLUSIONS

Based on our measurements we can confirm that data measured by MEMs sensors are time synchronized. The measured small time shift was caused by different start time of MEMs. After improvement of the algorithm the phase shift was less than 10 times smaller than scanning frequency, which is enough for typical measurements. We are satisfied with results of these eight sensors reading data at synchronous way with low cost of measurement chain. Next, we prepare new accelerometric modules with new MEMs sensors, with better resolution and scanning frequency.

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