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TESTING OF TOOLS FOR MEASUREMENT VIBRATION IN CAR

TESTOVÁNÍ NÁSTROJŮ PRO MĚŘENÍ VIBRACÍ V AUTOMOBILU

Abstract

This work is specialized on testing of several sensors for measurement vibration, that be applicable for measurement on vehicles also behind running. These sensors are connected to PC and universal mobile measuring system cRIO (National Instruments) with analog I/O module for measurement vibration, that is described in diploma work: [JURÁNEK 2008]. This system has upped mechanical and heat imunity, small proportions and is therefore acceptable also measurement behind ride vehicles. It compose from two head parts. First is measuring part, composite from instruments cRIO. First part is controlled and monitored by PDA there is connected of wireless (second part hereof system). To system cRIO is possible connect sensors by four BNC connector or after small software change is possible add sensor to other analog modul cRIO. Here will be test several different types of accelerometers (USB sensor company Phidgets, MEMS sensor company Freescale, piezoresistiv and Delta Tron accelerometers company Brüel&Kjær). These sensors is attach to stiff board, board is attach to vibrator and excite by proper signal. Testing will realized with reference to using for measurement in cars. Results will be compared with professional signal analyser LabShop pulse from company Brüel&Kjær.

Abstrakt

Tato práce je zaměřena na ověření několika snímačů pro měření vibrací, které jsou použitelné pro měření na vozidlech i za provozu. Tyto snímače jsou připojeny k přenosnému univerzálnímu měřicímu systému cRIO (National Instruments) s IO moduly pro měření vibrací, který je blíže popsán v diplomové práci:[JURÁNEK 2008]. Tento systém má zvýšenou mechanickou a tepelnou odolnost, malé rozměry a je proto vhodný i k měření za jízdy vozidla. Skládá se ze dvou hlavních částí. První je měřicí část, složena ze zařízení cRIO. Tato první část je ovládána a monitorována pomocí bezdrátově připojeného PDA, které tvoří druhou část tohoto systému. Je možné zde připojit snímače pomoci čtyř BNC konektorů nebo také po úpravě software lze připojit snímač k jinému analogovému modulu cRIO. Skupinu testovaných snímačů tvoří několik různých typů akcelerometrů (USB snímače značky Phidgets, MEMS snímače značky Freescale, piezoresistivní a Delta Tron akcelerometry značky Brüel&Kjær). Tyto snímače budou uchyceny na tuhé desce připevněné k vibrátoru a rozkmitány vhodným signálem. Testování bude prováděno s ohledem na použití pro měření v automobilech. Výsledky budou porovnány s profesionálním signálovým analyzátorem LabShop Pulse od firmy Brüel&Kjær.

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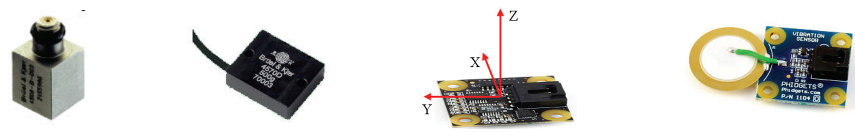
1 PROPERTIES USED DEVICES

1.1 Delta Tron accelerometers Brüel&Kjær (4507B a 4508B)

These sensors was been designed so as to be resistant to rugged environment automobile industry. There're small, light and have big sensitiveness. There're acceptable for metering body car, transmission force, modal analysis, etc. Accuracy of piezoelectric accelerometers are affected by variable surrounding temperature, high humidity or disturbance by HF electromagnetic field. These adverse effects of surrounding were in sensors 4508 and 4507 reduce thanks construction and option materials.



a) **b)** **c)** **d)**

Fig. 1 a) Accelerometer 4508B, **b)** Accelerometer 4574, **c)** 3axis accelerometer with signalizes positive orientation of axis, **d)** Vibration sensor.

Delta Tron is mark of accelerometers and products of Brüel&Kjær company for modification signals. These accelerometers need permanent supply current and output signal is modulated on supply voltage. It enabled using low cost cables.

Low output impedance enabled connection accelerometer to measurement equipment through the use of long cable.

1.2 Piezoresistiv accelerometer Brüel&Kjær (4574)

This sensor is designed for measure vibration and static acceleration (gravitation of earth). It has high temperature stability (from -55 °C to 121°C), low consumption and is resistant to impact (to 10 000 g).

Tab. 1 Properties of accelerometers Brüel&Kjær

	unit	**4507B**	**4508 B**	**4574**
Sensitivity	mV /ms^{-2}	10	1	20
Measure range	ms^{-2}	700	7000	± 100
Frequency range 10%	Hz	0,3 – 6 k	0,1 – 8 k	0 až 500
Inside noise	µV	< 35	< 8	500
Nois (DC to f10%)	µV RMS	-	-	350
Nois (0,5 to 100 Hz)	µV RMS	-	-	150

1.3 USB accelerometers Phidgets (2 a 3 axis)

These sensors of acceleration can measure static and dynamic acceleration in two or three axes. Sensor is internally calibrated, output is in unit G – multiple acceleration of gravity (1 G = 9,82 m / s^2). Sensor is possible use for measure tilt, low frequency, vibration and detection movement. Connect to PC is realize across USB. These accelerometers use as same Phidgets library. If you won't connect 2 axis and 3 axis accelerometer together, you must use their identification parameters (type of sensor, serial number).

Tab. 2 Parameters of accelerometers Phidgets

	3 axis	2 axis
Update rate	60 samples / second	60 samples / second
Measurement range (XYZ axis)	± 3G (29,4 m / s2)	± 5G (49,05 m / s2)
Band width (XYZ axis)	30 Hz	30 Hz
Noise level axis 0 (X)	1.9 mG standard deviation	1.9 mG standard deviation
Noise level axis 2 (Y)	1.9 mG standard deviation	1.9 mG standard deviation
Noise level axis 3 (Z)	2.9 mG standard deviation	-

1.4 Analog vibration sensor

This analog sensor is connecting to PC help to Phidgets interface. Phidgets interface is to PC connect across USB. This sensor use piezoelectric effect. Variable *Sensor Value* may be from 0 to 1000, value 500 matches acceleration 0 g. During testing this senor I supposed that it have range from several Hz to approximately 50 Hz and sensor can be mounting by the help of holes in printed circuit.

1.5 PC (application from measure with USB accelerometers)

This application is intended for connect 2 Phidget accelerometers (2 and 3 axis) and one analog sensor Phidget (vibration sensor). Application can display measured signal, and make FFT analysis (frequency spectrum). In application is also tool to measured tilt for 3 axis accelerometer.

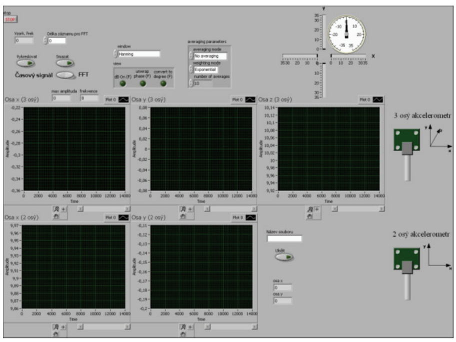


Fig. 2 Front panel application for connect accelerometers

Both accelerometers use same library, therefore I must have created instrument for identify these sensors. Both accelerometers have self serial number and information about type of sensor. Application can work with since one for three sensors. Applications identify connected sensors automatically. It possible set sampled frequency, but sampling isn’t precise.

1.6 cRIO system (National Instrument)

System cRIO is group devices intended for measure vibration through accelerometers. Accelerometers are connecting through module cRIO-9233 (BNC connectors). System cRIO is consisting of Real–Time Embedded Controllers, ReconFig.urable Chassis and analog and digital I/O modules.

All these devices are products by National Instruments. System cRIO is connected to PDA by wifi. PDA is used to control measurement, display and analysis measured data. For these devices was made several applications for measurement of vibration.

Fig. 3 System cRIO

Thanks to gate array from ReconFig.urable Chassis (FPGA) is possible measurement four channels with precise sampled frequency to 3,8 kHz.

1.7 Signal analyzer LabShop Pulse (Brüel&Kjær)

This device has 9 input and 2 output channels. Frequency range is to 25,6 kHz. It is mobile device. It need for run PC or notebook. It communicates with PC by TCP/IP.

During testing accelerometers, this device I consider as etalon and I compare rest device with it. I use Pulse to generate signal too.

1.8 Shaker Tira

This device is being done for transformation of electrical signal onto movement (in one axis). On picture (Fig. 4) is on shaker mounted stiff aluminum board. Phidgets sensors are mounted to this board by screws, sensors Brüel&Kjær are stuck.

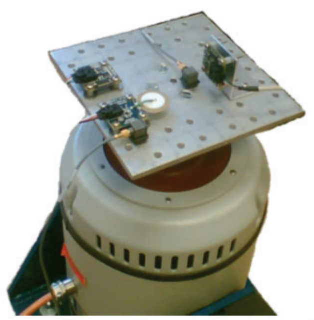


Fig. 4 Shaker Tira with mounted sensors

This construction is enough stiff for measure low frequency (to 50 Hz). Frequency range by shaker is from 2 Hz to 7 kHz.

2 MADE MEASUREMENT

Measurement of vibration on shaker was made on all described devices simultaneously. On all devices was adjusted same sampling frequency (128 Hz).

On first I was testing reaction of sensors on excitation by broken white noise. Noise was broken periodically. In time behavior was seen reaction of sensors on excitation. This test was successful for all sensors except Phidgets piezoelectric vibration sensor, therefore data from this sensor isn't used in next analysis. For using this sensor isn't adequate mounting by screws to excitation board. On picture (Fig. 5) is seen that all sensors oscillate around zero (DC accelerometers too). It was evoked by conversion measured data (zero displacement). I discovered noise level of sensors from place of record without excitation. Results are in one graph. Next I tested linear dependence output on input of record with excitation by white noise. For this analyze I used function Coherence. Results this test are in one graph (Fig. 6 - b). For this test I not use sensors Phidgets, because it don't be precise sampled.

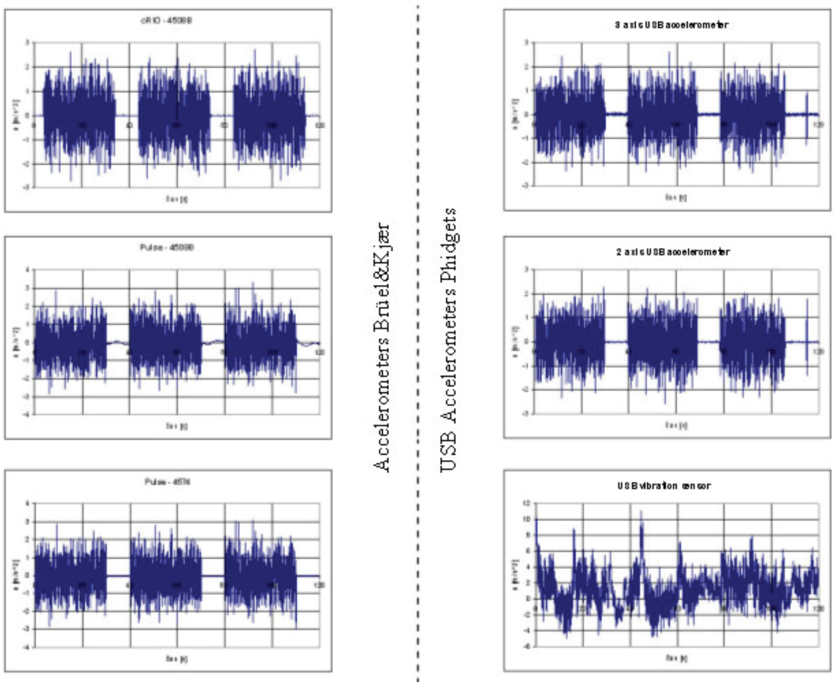
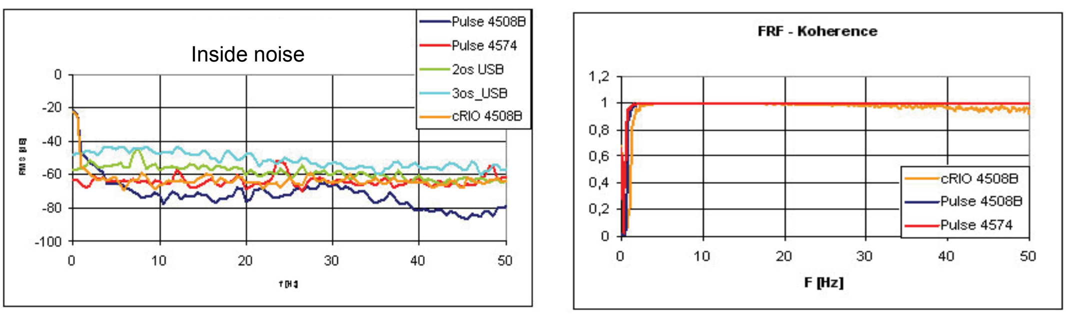


Fig. 5 Time behavior on excitation by white noise



a) **b)**

Fig. 6 – **a)** Noise level of sensors, **b)** Check dependence output on input

In picture (Fig. 6 - b) is seen frequency with full linear dependence (Coherence = 1) and frequency with none linear dependence (coherence = 0). Low coherence here was incurred by shaker (work from 2 Hz). I used function frequency response for testing cRIO (sensor Brüel&Kjćr 4508B).

As ethanol was used sensor Brüel&Kjćr 4574 and Pulse. Result was nearly straight line in zero. It means that results from both measurement devices were almost same.

I tried capability sensors measure only one harmonic frequency (10 Hz). Sampling frequency was set same on all devices (128 Hz). Amplitude of signal was amplified on 3 m.s^{-2}. I place frequency spectrums of all sensors to one 3D graph.

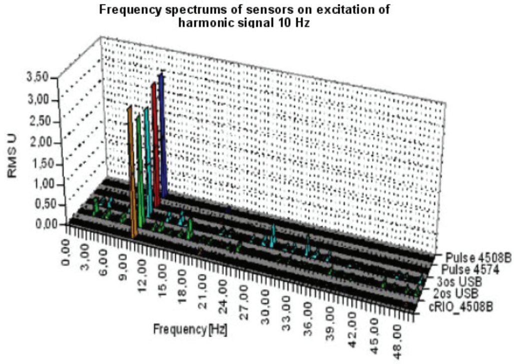


Fig. 7 Frequency spectrums on measurement harmonic signal 10 Hz

On picture (Fig. 7) is seen, that every sensors except USB sensors have only one peak in frequency spectrum (10 Hz). It matches excitation signal. USB sensors have in spectrum more smaller peaks. It was incurred mostly by inconstant sampling from PC.

3 CONCLUSION

I tested functionality of cRIO and USB sensors. Devices were tested by several measurements and analysis. cRIO have almost same results like signal analyzer Pulse (with same type of sensor). I tested 3 USB sensors destined for measure acceleration. Two and three axis accelerometers is possible use to measurement mostly static acceleration, tilt and vibration with low frequency. Disadvantage USB sensors is inconstant sampling frequency of measured application. Inside noise of all tested accelerometers corresponding with parameters from producer. Piezoelectric vibration sensor Phidgets isn't possible use without next adjustment, data from sensor not corresponding excitation signal.

ACKNOWLEDGEMENT

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