University
of Pardubice
Faculty
of Electrical Engineering
and Informatics

Low Cost MEMS-Based IMU Properties

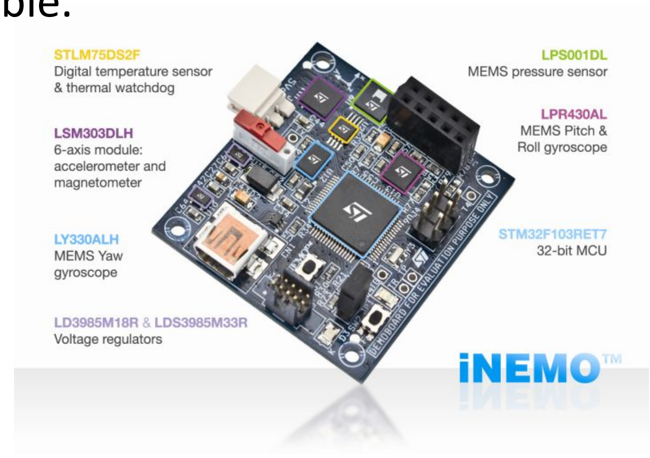
Ing. Luděk Zaplatílek

INTRODUCTION – rozepsat podrobněji

- Inertial measuring unit (IMU)
- Inertial navigation system (INS)
- Noise
- Improving the resolution
- Verification
- Results

IMU a INS

- Low cost MEMS IMU are consists from a number of inertial sensors, e.g. accelerometer, gyroscope, temperature sensor etc.
- IMU are often as a part of system with MCU and others position sensors e.g. magnetometer, pressure gauge and a GSM receiver all on single PCB (PCB INS).
- The area of PCB INS are only a few tens of square centimeter with high density of components.
- DPS INS was designed as small as possible.



Noise

- Two type noise of in accelerometer: electrostatic noise in the ASIC and mechanical noise from the MEMS g-cell.
- Thermo-mechanical noise (or Brownian noise)

$$ND_{thermo-mech} = \frac{\sqrt{\frac{4k_B T\omega}{mQ}}}{g}$$

K_b = Boltzmann‘s constant (1.38×10^{-23}J/K), ω = resonance frequency in Hz,
m = mass in kg, Q = damping, T = absolute temperature in K, g = acceleration

- The overall system noise is measured.

$$N_{RMS}^2 = \int_0^x PDS(f)df$$

$$N_{RMS} = \sqrt{PDS \times BW}$$

DPS Power Spectral Density, BW bandwidth

Improving the resolution

- The noise in the accelerometer is predominantly considered Gaussian white noise.
- Noise sources, while are uncorrelated, are combined in root-sum-square (RSS) fashion:

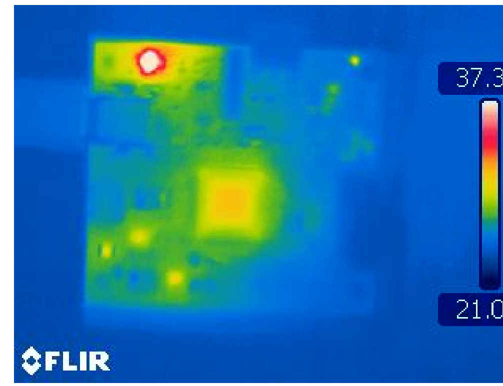
$$N_{RMS} = \sqrt{N_{1RMS}^2 + N_{2RMS}^2}$$

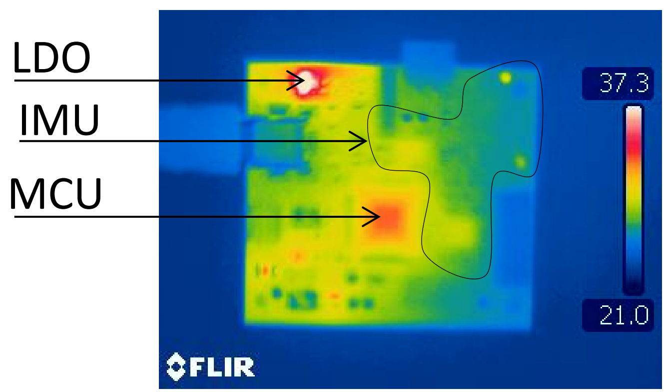
- they are two ways: oversampling, array sensors.

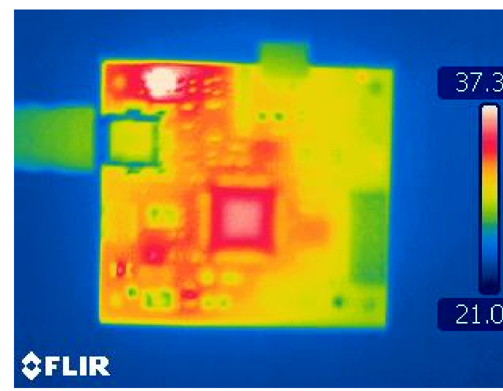
Oversampling Factor	SNR Improvement [dB]
2	3
4	6
16	15

Thermal bond of IC

- Layout with high density of components leads to increase of thermal bond among them, especially them with high temperature or components with variable surface temperature.
- Taken snaps illustrates heat spread accros the PCB in 1., 5. a 10. minute after power on.

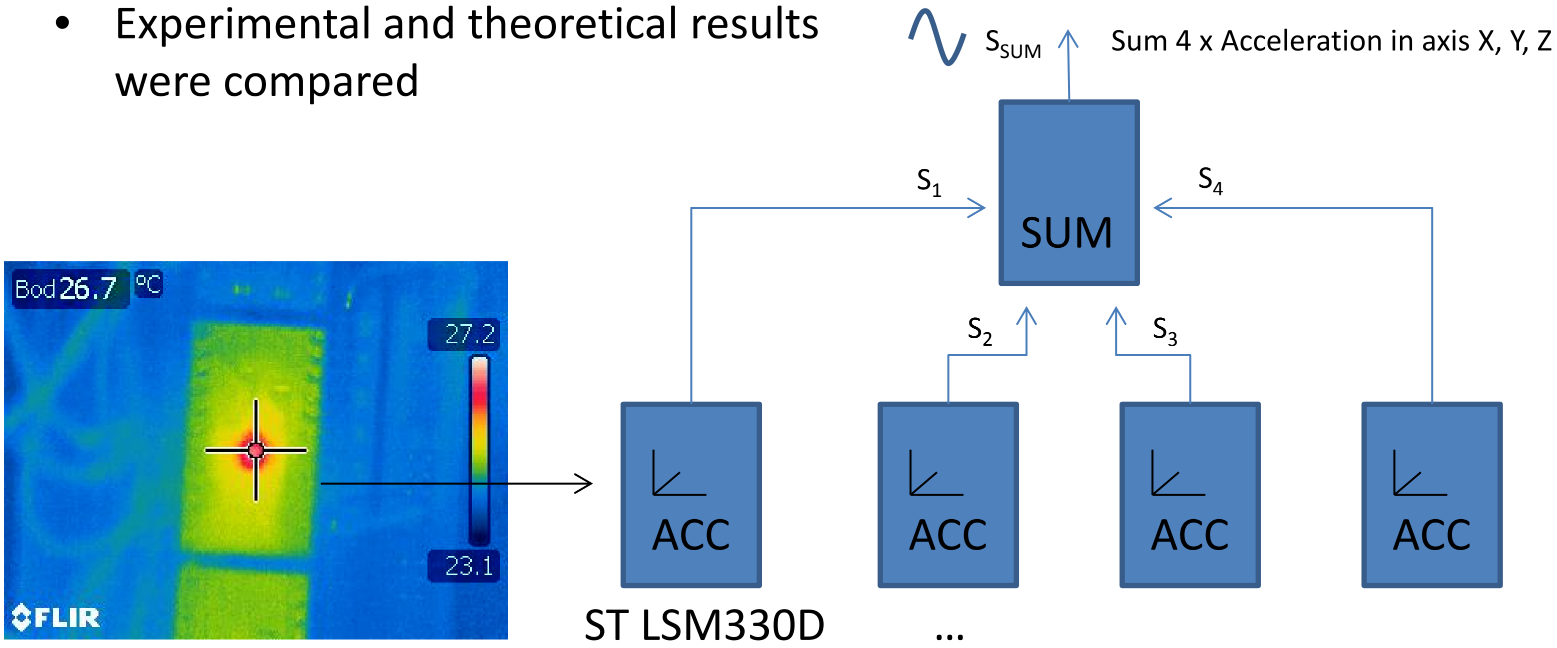






Verification

- experiment with 4 x ST LSM330D
- accelerometers kept away from any movement and vibration to obtain noise only.
- Calculated the standard deviation from individual accelerometer data and sum of data.
- Experimental and theoretical results were compared



Verification

- Calculated standard deviation: vzorce vynechat nebo omezit

$$S_{SUM} = S_1 + S_2 + S_4 + S_4$$

$$STD(S_1) = STD(S_2) = STD(S_3) = STD(S_4)$$

$$STD(S_{SUM}) = \frac{STD(S_{SUM})}{\sqrt{4}} = \frac{STD(S_{SUM})}{2}$$

- Results based on measured data:

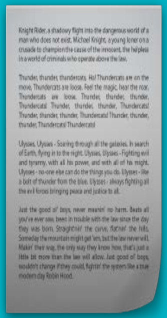
$$STD(S_{SUM}) = \frac{STD(S_1)}{2} = \frac{3{,}44}{2} = 1{,}72$$

Signal name	STD
S_1	3,44
S_2	3,99
S_3	3,12
S_4	3,39
S_{SUM}	1,7

RESULTS

- The work deals with two ways how to improve accuracy of resolution.
- The error in the MEMS g-cell is possible to minimize by good design principles.
- It is good to avoid placing the sensors near components that may have high temperature variations, or that are constantly very hot as this will affect the offset stability of the sensor.

ACKNOWLEDGEMENT & CONTACT



Ing. Josef Marek, CSc.
Josef.Marek@upce.cz
Ing. Luděk Zaplatílek
ludek.zaplatilek@student.upce.cz
Department of Electrical Engineering

Faculty of Electrical Engineering and Informatics
University of Pardubice
Czech Republic

http://www.upce.cz/en/fei/ke.html

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