Preparing centrally controlled system of sensors for autonomous yacht model

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Intermediate Project
under instructions of
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Abstract

Project concerns set of functional sensors, operated by one control unit. Each sensor responds to real physical signals. On main board is implemented communication with computer allowing results presentation and evaluation. Whole system or a single sensor can be implemented on model of a yacht

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1 Introduction

This project is a part of wider idea inspired by remote controlled yacht models. The future goal is to adjust such model for autonomous operation. Discussed project is a background from the side of electronic for developing autonomous vessel.

In order to decide what should be a entity of this project. It was necessary to determine which information are crucial to steer a yacht. Assumption has been made that at first yacht should be able to maintain work of sails in reactive manner.

Sails should be adjusted depending on wind direction and speed. The chosen strategy assumes sails would be adjusted optimally to a wind direction, and adjusted (loosen) if the yacht would start to tilt to much.

Another important aspect is that any electronic on the board has to be powered and it would be good to know how many power has left during the sail.

Those considerations allowed choosing three basic parts of this project:

- Wind direction sensor
- Tilt measuring
- Power board

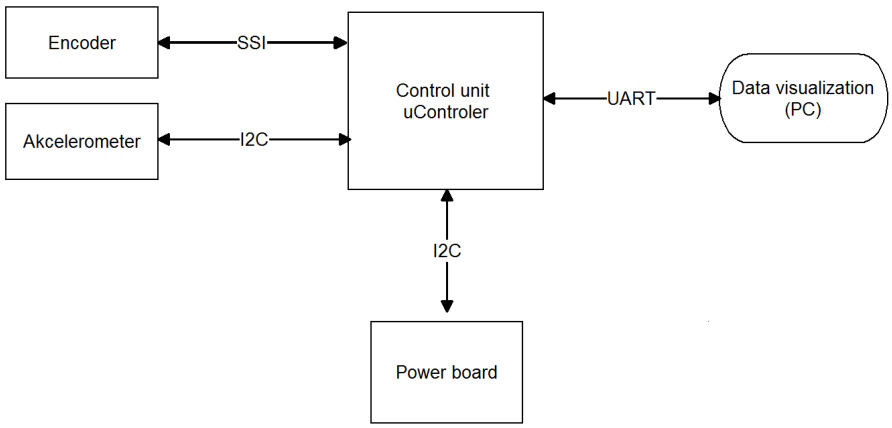

Figure 1: Communication schematic of the project

2 Implementation

2.1 Main board - control unit

FRDM-KL25Z development board for Kinetis microcontrolers was used as a main control unit. Used controller is KL25Z128VLK4–Cortex-M0+ MCU.

Figure 2: Used development board

Controller is collecting data processing it and sends it over to PC to visualise it.

2.2 Wind direction sensor

Wind direction sensor has been created basing on contactless magnetic rotary encoder AS5040 created by Austria microsystems. AS5040 is a system-on-chip using hall effect to determine position of two-pole magnet placed over a chip. Encoder provides instant indication of the magnet's angular position with a resolution of $0.35° = 1024$ positions per revolution.

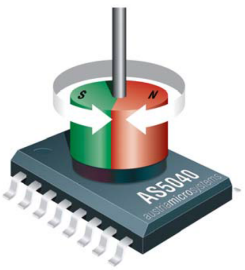

Figure 3: AS5040 basic principle

To use encoder preparing of a simple PCB was necessary. It was prepared using a thermal transfer and copper etching.

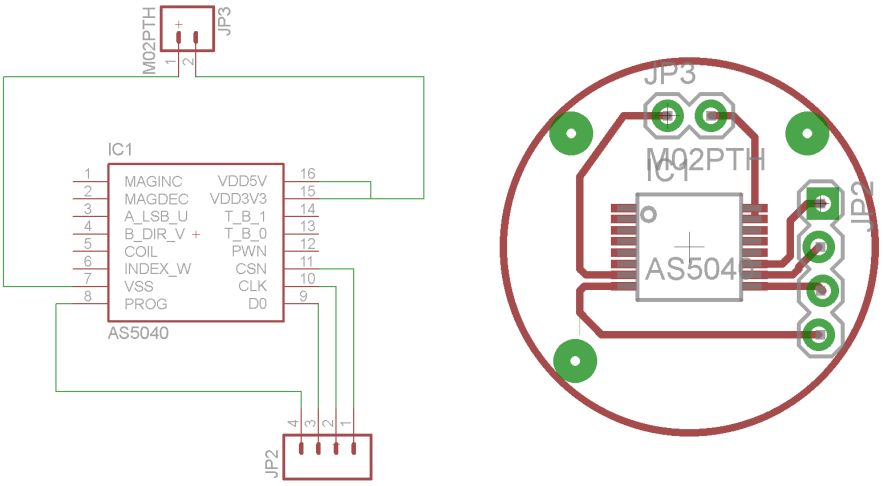

Figure 4: Schematic and layout of encoder board

To communicate with encoder Synchronous Serial Interface was used. Communication were operated by software with out hardware support. 16-bit data was acquainted from AS5040 in single pull. Were 10-bits consisted angular position and 6 information about validity of the data. More information about this communication protocol may be found in the chip documentation.

In order to test sensor performance simple test stand were created.

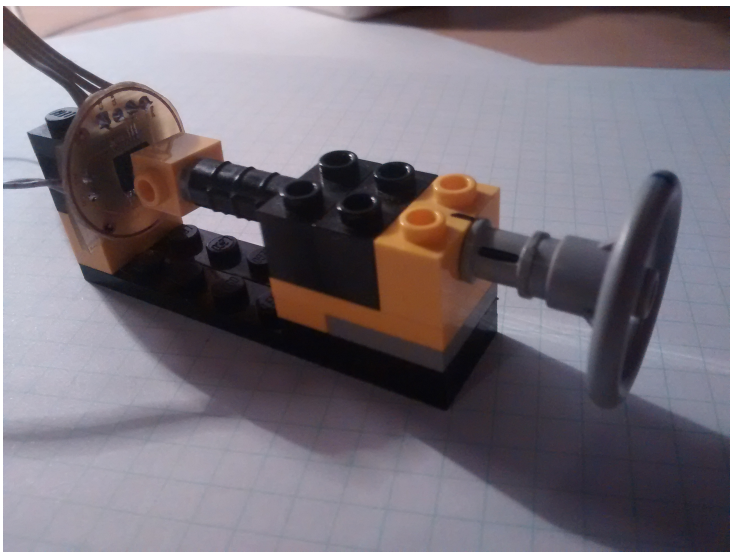

Figure 5: Test stand

Data obtained from sensor correspond to position of wheel.
Rapid unpredicted changes of sensor results are undesired. For providing more stable results, samples were averaged with circular buffer with order of two.
During multiple tests no problems with accuracy or hysteresis occurred. Acquainted data accurately represents position of the wheel. Results are stable and could be use to determine wind direction in the model of autonomous yacht.
Encoder it self and prepared code for handling communication, assures flexibility, user can define zero point of the encoder, data resolution, frequency of obtaining.

Control unit is gathering usefully results in less them 1ms which is more then enough for planned application.

2.3 Tilt measuring.

Tilt measuring is realised with use of accelerometer MMA8451Q. This is a smart, capacitive micro-machined accelerometer providing data with 14-bits of resolution. Communication with sensor is realised through I2C interface.

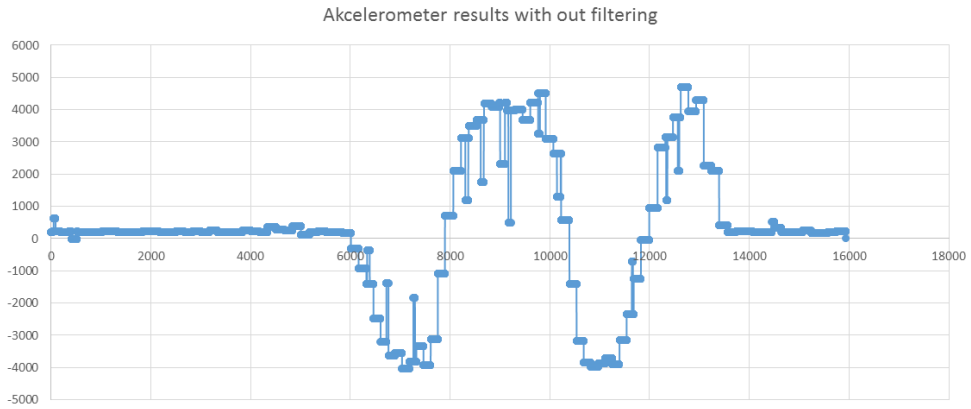

Figure 6: Results

As it can be seen in above picture data obtained was unstable, every rapid movement resulted with peaks in the readings. In order to reduce influence of the noise, and impact of sudden changes. Data has been filtered with low-pass filter with order 32, and averaged.

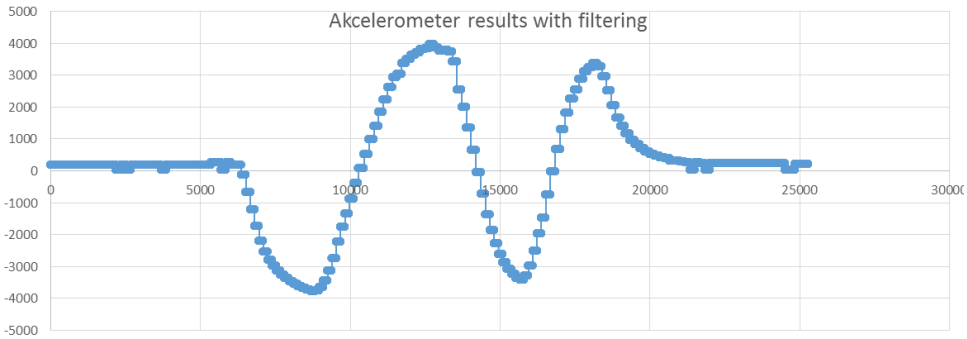

Figure 7: Results

2.4 Power board

Whole device is powered by battery with output of 7,4V. To adjust this voltage DC-DC converter LT1765 were used in power board. Measurements of voltage, current and power used by devices has been assured with rail-to-rail system monitor LT2945. Which is really power full and flexible system-on-chip.

Most important features of LT2945:

- Rail-to-Rail Input Range: 0V to 80V
- Wide Input Supply Range: 2.7V to 80V
- ADC with less than 0.75% Total Unadjusted Error
- 12-Bit Resolution for Current and Voltages
- Internal Multiplier Calculates 24-Bit Power Value
- Stores Minimum and Maximum Values
- Alerts When Limits Exceeded
- Continuous Scan and Snapshot Modes

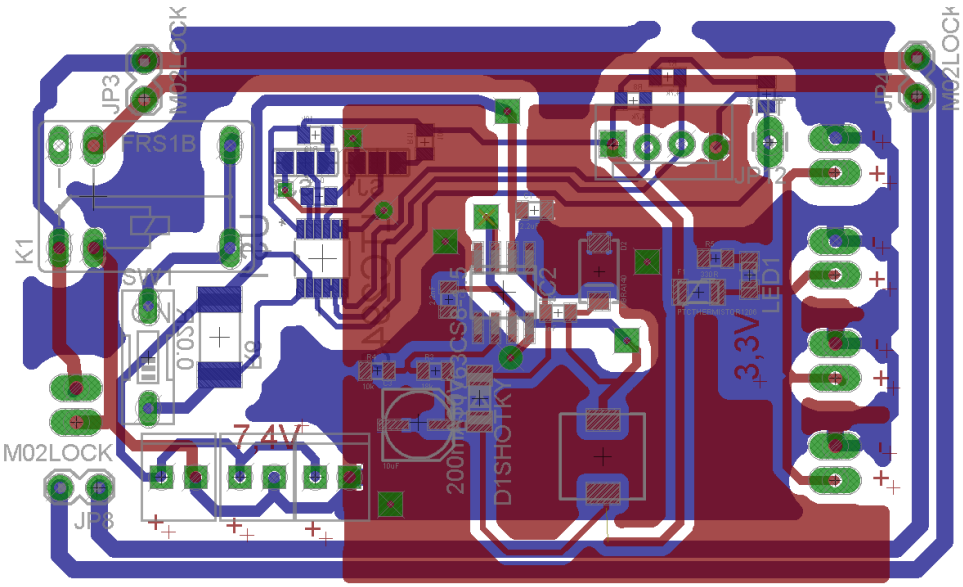

Figure 8: Power board layout

Unfortunately during the realization of the project, LT2945 has not been evaluated so the power board was used only to adjust the voltage.

Figure 9: Power board

2.5 Data visualization

Next realized feature was simple GUI to help present data obtained from sensor. GUI was the Lab-View vi, which read data form a serial port parsed it and presented on plots changing in real time. This helped to understand results and make it easier to improve them.

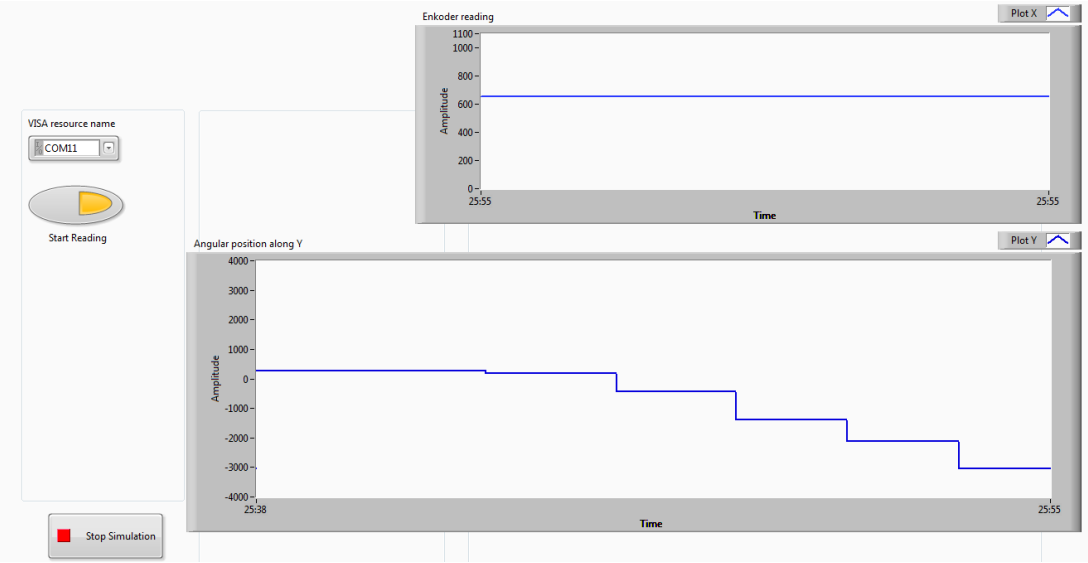

Figure 10: GUI

3 Summary

Prepared system could be implemented in a model of the autonomous yacht. The prototype of wind direction sensor has been tested, obtained data are valid. Preparing final version of such sensor would be reduced to mechanic aspects. Tilt data obtained from a accelerometer should be sufficient to determine if the yacht is tilting to much and sails should be loosen. Power board could be used to power electronics on board, but data about power source has not been provided.