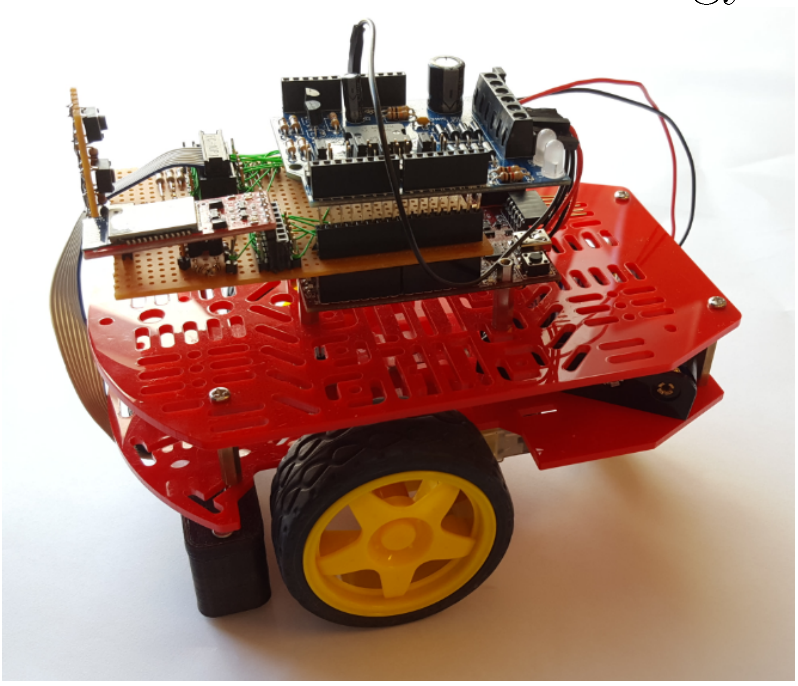
Fall Semester 2016

Autonomous Object Avoidance Robot

Group 2

3. Semester IT-Technology



Group members: Benjamin Nielsen - Henrik Jensen - Martin Nonboe - Nikolaj Bilgrau

Supervisor: Jesper Kristensen - Steffen Vutborg

IT-technology
Sofiendalsvej 60
9200 Aalborg SW
http://www.ucn.dk/

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Projectgroup:
Group 2

Group participants:
Benjamin Nielsen
Henrik Jensen
Martin Nonboe
Nikolaj Bilgrau

Supervisors:
Jesper Kristensen
Steffen Vutborg

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Preamble

This project was written by group 2, for the 3rd semester on the IT-electronics education at university college Nordjylland, Sofiendalsvej 60. The project goal is to make an autonomous robot that can navigate a course utilizing object avoidance and localization.

Benjamin Nielsen

Henrik Jensen

Martin Nonboe

Nikolaj Bilgrau

Table of Contents

1 Introduction **1**

2 Analysis **2**
2.1 Problem statement . . . 2
2.2 Problem analysis . . . 2

3 Requirements specification **3**

4 Hardware section **4**
4.1 Description of the hardware structure and functionality . . . 4
4.2 Hardware diagram . . . 4
4.3 Sensors and sensor concept . . . 5
4.4 Analog-to-digital converter . . . 7
4.5 The chipKIT Uno32 board . . . 7
4.6 The motor shield . . . 8
4.7 The Bluetooth tranceiver . . . 8
4.8 Part conclusion . . . 8

5 Software section **9**
5.1 Analog to digital conversion . . . 9
5.2 Pulse-width modulation . . . 9
5.3 Part conclusion . . . 9

6 Test **10**
6.1 Unit Testing . . . 10
6.2 Integration Testing . . . 13
6.3 System Testing . . . 13
6.4 Acceptance Testing . . . 13

7 Conclusion **14**

8 Appendices **15**
8.1 Group collaboration agreement . . . 15

9 List of references **16**

List of Figures **17**

List of Tables **18**

10 Hardware appendix **19**
10.1 Hardware Schematics . . . 19

11 Software appendix **23**
11.1 C code . . . 23
11.2 C# code - interface . . . 25

Bibliography **26**

Glossary

3D print 3-Dimensional printing

ADC Analog-digital conversion

GUI Graphical User Interface

IDE Integrated Development Environment

MCU Microcontroller Unit

PCB Printed Circuit Board

PID Proportional-integral-derivative

PWM Pulse-width modulation

THT Through-hole-technology

UART Universal Asynchronous Receiver/Transmitter

Introduction 1

In countries with high wages and where manual labour is expensive, the industrial production is often organized as an automated process. To make the whole industry smarter and more customizable, new automated robots and reliabilities are needed. The many new forms of robots rely on sensors to face the many different challenges. Automation of movement and avoidance enables even robotic space exploration, as seen in the many rovers visiting the different nearby planets.

There are different sensors in play when needing to avoid obstacles or collision. To mention a few, ultrasound, infra-red and laser sensors comes to mind, all of which are viable picks when building a robot with object avoidance.

In the project at hand, we will be focusing mainly on the ultrasound sensor for building an object avoiding robot. The objective of this project is to design and implement an automotive robot capable of autonomous object manoeuvring, specially a collision avoiding robot employing light detecting sensing and ultrasound sensing.

The project was handed to the group at the start of third semester and is to be handed in at the 9th of January, 2017.

Analysis 2

This section will be focused on analysing any problems the group may face, how to approach them, and how they should be handled.

2.1 Problem statement

The problem presented to the group is how to make a robot move from point A to point B, with the help of different sensors, including ultrasound and infrared, and to make use of autonomous algorithms to avoid obstacles.

Problem statement:

- Bot should be able to move from A to B
- Should be able to stop at a predetermined point
- Manoeuvre around obstacles

2.2 Problem analysis

2.2.1 Mobility from A to B

The robot receives a coordinate to reach, and will use its own starting point to determine a direction to drive towards the given coordinate. The robot will need a way to control its movement and direct current to function optimal.
The robot needs a way to effectively regulate speed and also steer itself autonomously. To dictate how quickly the robot moves, the robot will need some system that allows it to move around on a flat surface, the robot needs to be able to move around from point A to point B. .

2.2.2 Predetermined end point

After starting, the robot needs to know when to stop. The pre-determined end-point consists of a series of circles which the robot needs to detect.

2.2.3 Obstacles avoidance

As part of its functionality, the robot needs to be able to see objects that are in front of it and avoid them.

Requirements specification 3

This section specifies the requirements. The requirements have been found through the analysis.
[2]

- The robot needs line following capabilities
- The robot needs object avoidance
- The robot should make use of an H-bridge
- The robot should make use of Motors
- The robot needs a way to implement motor control
- The robot should make use of a micro-controller unit
- The robot should make use of the Magician chassis

Hardware section 4

4.1 Description of the hardware structure and functionality

In this section the different components of the hardware will be listed, described and explained.

4.2 Hardware diagram

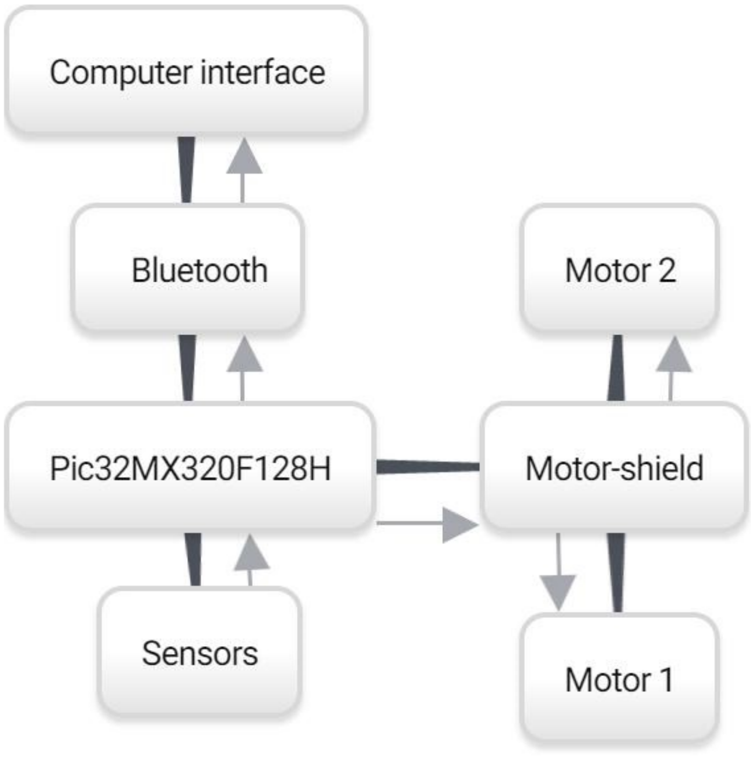

Figure 4.1: Hardware diagram with arrows

The micro controller is connected to the motor-shield. The motor-shield is then connected to the two motors, called motor 1 and motor 2 and is powering both motors. The micro controller is receiving data from the 3 sensor sets; the ultrasound sensors, infrared light-sensors and the tachometer sensor. The micro controller then receives the data from the sensors and sends it further to the Bluetooth transceiver and then the Bluetooth transceiver will send it to the interface.

4.3 Sensors and sensor concept

TBD: Find out why this doesn't show up in build...
The robot will utilize two sets on sensors - one set of QRE1113 sensors, which will be used for line-following capabilities, they are fastened towards the end of the robot, and will give the robot a way to detect what surface it is about to enter.
The second is a hybrid set of ultrasound and infrared sensors. These will be working together to make the robot able to navigate open spaces more precisely, since infrared and ultrasound sensors work the best under different circumstances. This will end up as a product which is more optimized for usage in situations that would not be ideal for one of the other, since the hybrid design will leverage shortcomings of a given sensor method.

4.3.1 Ultrasound sensor - HC-SR04

When a robot should be able avoid obstacles it will need a device to inform the robot where it's position is compared to the obstacle. This is where an ultrasound sensor plays an important role. For this task the HC sr04 has been picked.

The way the ultrasound sensor works is by emitting acoustic waves and then waits for the waves to reflect back to the sensor. The waves are often at about 40 kHz and humans are unable to detect the sounds because of the frequencies being above the human audible range.
What is causing the device to make ultrasonic sound is a piezoelectric crystal. The crystal is receiving a rapid oscillating electrical signal, this causes the crystal to expand and contract and thereby creating a sound wave. The sound waves will then after being reflected return to a piezoelectric receiver which can then convert the waves into voltage by using the same method as explained above.

There are several popular ways to process the information gathered from the ultrasound sensor.

- Time of flight

- Doppler shift
- Amplitude attenuation

In the scope of the project, the robot will be using "Time of flight" for sensing the distance between itself and the obstacle.
When working with the term time of flight, it means the ultrasound sensor only generates pulses of sound instead of an continuous streak of sound waves. to avoid confusion. In high speed situations this will mean there is waiting time limits.

The calculation for using the ultrasound sensor is:

t = time
r = distance travelled
c = speed of light

r= c*t

With this the robot can calculate the time of flight. TBD SR04 Ultrasound:

Considerations:

When using the ultrasound as a sensing tool, there are some factors that must be taken into consideration.
Temperature and humidity can affect the speed of sound, just as air currents have been known to be able to create invisible boundaries that can reflect ultrasonic waves.
Ultrasound sensors have something called a dead zone, this occours when an object is infront of the sensors and the receiver can't keep up.
Some materials are very absorbent, which will result in less reflected ultrasound to be detected by the receiver.

Mounting

4.3.2 Infrared sensor - QRE1113

The robot will make use of infrared sensors in symbiosis with the aforementioned ultrasound sensors.
This will allow it to take readings on a wider array of surfaces, as infrared sensors are better suited for less even surfaces.
They work by emitting infrared light onto a surface, and then taking a reading based on the amount of light that gets reflected. A light surface will reflect more light back than a dark one.
The sensor will then output a feedback signal made of a certain amount of voltage, ranging from 1% to 100%, based on how much light was reflected back. Based on this output voltage, it is possible to use an ADC to convert these signals into digital signals, which can be monitored more conveniently.
Functionally, the robot is left with a way of knowing which surface the sensors are above - and in the case of a track with a black line to follow, this allows it to detect

where the line it needs to follow is.

Due to past experiences, the QRE1113 sensor has been chosen to be utilized on the robot to enable its line-following properties and positioning

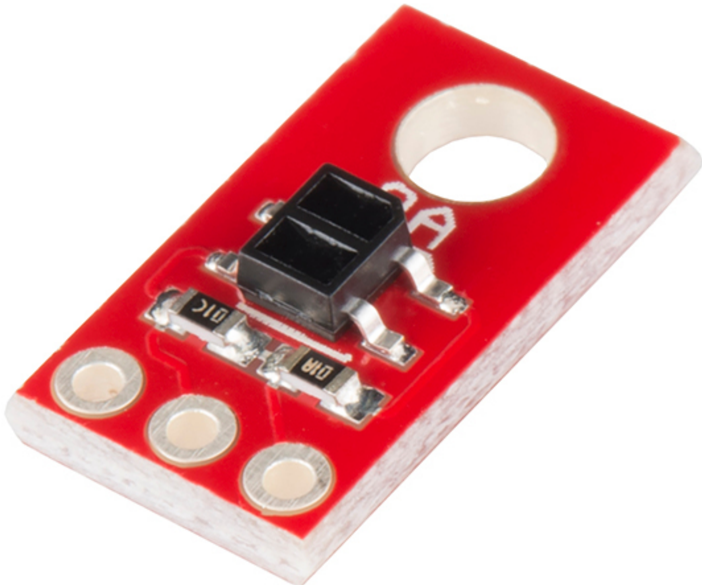

Figure 4.2: Mounted QRE1113 sensor

4.4 Analog-to-digital converter

The usage of ADC

TBD (skal vi overhovedet forklare det igen? B: Vi skal nok forklare hvordan, og til hvad, vi udnytter det i projektet)

4.5 The chipKIT Uno32 board

The robot will utilize the chipKIT Uno 32 board to execute code. The board was chosen both due to past experiences, but also because the robot would need line-following properties, and we had already written a functional line-following robot previously, which also included some important features, including PID control and pulse-width modulation patterns.
This enabled a lot of recycled code, which was a strong point in the Uno 32's favor due to time constraints.

The board is also compatible with Arduino shields, and as such designing the H-bridge for it becomes more straightforward. It's fast enough to execute the code, and works well within the input power the robot will utilize.

4.6 The motor shield

The motor shield is containing the H-bridge and will be the board for ensuring control of the different components and motors. TBD (hvad er der helt præcist på boarded?)

4.6.1 The H bridge

The robot will make use of an H-bridge. An H-bridge is a circuit made for controlling the motor of the robot, by making sure the motor will never try to do forward and backward motion and cause errors or short circuits. The point of using an H-bridge is to ensure motor safety and functionality.

4.6.2 The motors - Pololu

4.7 The Bluetooth tranceiver

The robot will utilize the BlueSmiRF Silver bluetooth tranceiver. The transceiver is made by Sparkfun, it is utilized to make use of an GUI, by sending data from the MCU to the computer (GUI) by the use of bluetooth.
The bluetooth tranceiver makes it possible to monitor both the inputs and the logic behind the steering. The baudrate is between 2400-115200 bps and the tranceiver can be powered from 3.3v up to 6v.

4.8 Part conclusion

After initial H-bridge problems, the rest of the process of building the robot went according to plan, and there were no future issues. The robot utillize a range of components which have been used for previous projects, which made the project much more simple to work with. This eliminated some of the learning curve that the previous robot presented, and made it possible to plan out and assemble the robot very rapidly, even though a lot of time was spent waiting for components for the motor shield, and the faulty components. This way, a lot more time could be used on programming and other software solutions.

5 Software section

Beskriv Software section

5.0.1 Software diagram

5.1 Analog to digital conversion

TBD ?

5.2 Pulse-width modulation

Pulse Width Modulation is a very effective and straightforward way to control the speed of the robot rapidly. It works by limiting how long the of a given period the power is ‘on’ compared to ‘off’.

5.2.1 Why utilize pulse-width modulation

Pulse-width modulation, or PWM, is a way to regulate power distribution within a system. It is a software solution that manages when a device receives power, and for how long at a time it does this. This is called a duty cycle. The robot utilizes PWM for its motors, to regulate how quickly it moves. PWM can be compared to turning a switch on and off extremely quickly - much more quickly than what will affect the performance of the motors. Effectively, this means that the robot's programming will now be able to regulate speed autonomously.

5.2.2 Duty cycles

The duty cycle is used to describe how long the power is 'on' compared to 'off'. A higher duty cycle will yield more energy than a low one. The programming uses a frequency of 1000Hz, which makes it straightforward to calculate to real time, if this is needed - it also provides enough precision to make the motors responsive quickly.

5.3 Part conclusion

Software problemer og løsninger

Test 6

TBD Beskriv hvad der skal ske i afsnittet

6.1 Unit Testing

6.1.1 Infrared TBD: Find navn på sensor

Equipment

- Hameg HM8040-2 Triple Power Supply
- Agilent MSO-X 3024A Oscilloscope

Setup

Power to the sensor is supplied by the power supply and the output is read on the oscilloscope.

Results

30mm: 2.29V
50mm: 3.07V
100mm: 2.34V
200mm: 1.31V
500mm: 515mV

As is evident in the results above, this sensor does not work at low distances, which is also described in the datasheet.

6.1.2 Ultralyd TBD: Find navn på sensor

Equipment

- Arduino UNO
- Agilent MSO-X 3024A Oscilloscope

Setup

A small program for the Arduino has been written which allows the MCU to trigger the sensor and waits a pre-specified amount of time before triggering again, to allow for the return of the ultrasound wave.

Results

30mm: 152 us
50mm: 285 us
100mm: 600 us
200mm: 1.23 ms
500mm: 2.32 ms

6.1.3 QRE1113

Equipment

- Hameg HM8040-2 Triple Power Supply

Setup

Power to the motors is supplied by the power supply, which also measures the current.

Results

Measured current on both engines is between 70 and 80 mA when running freely.

6.1.4 DC Motors

Equipment

- Hameg HM8040-2 Triple Power Supply
- Fluke 45 Multimeter

Setup

Results

6.1.5 H-Bridge

Equipment

- Elcanic Power Supply
- Fluke 45 Multimeter

Setup

Power to the H-bridge is supplied by the power supply. Current and voltage will be measured by the multimeter. All of the Mosfet transistors were removed before doing the test. It was done to avoid powering the engines.

Results

There was a suspicion concerning the H-bridge, it had been measured that there was an error or a damaged component. The affected suspected part was the H-bridge for the left motor.

All of the transistors were tested on the part of the H-bridge in question. Since there was a 0 in value on the base, it is suspected that a resistor which sat on the board just before the transistor. This and the other resistor values were measured and found to be identical, based on the measures it could be concluded that it was most likely a failed transistor.

It was concluded that the damaged transistor was the: Q14 [1] (TBD link til schematics).

The results were as following:
Normal NPN transistors: base 0.854V, collector 0.073V
Faulty NPN transistor. base 0V, collector 0V.

6.1.6 PWM

Equipment

Setup

Results

6.1.7 ADC

Equipment

Setup

Results

6.2 Integration Testing

6.2.1 PWM motor control

Equipment

Setup

Results

6.2.2 Robot to Interface communication

Equipment

Setup

Results

6.3 System Testing

Equipment

Setup

Results

6.4 Acceptance Testing

Equipment

Setup

Results

7 Conclusion

TBD Skriv en fucking Conclusion!!

Appendices 8

8.1 Group collaboration agreement

8.1.1 Contact Information

Table 8.1: Contacts

Benjamin Nielsen	Tlf: 30427645	@: yipiyuk5@gmail.com
Henrik Jensen	Tlf: 28568934	@: henrik_kort@hotmail.com
Martin Nonboe	Tlf: 23827566	@: nonsens_4@hotmail.com
Nikolaj Bilgrau	Tlf: 29802715	@: nikolajbilgrau@gmail.com

8.1.2 Workflow

8.1.3 Deadline

8.1.4 Milestones and goals

Gerne en kalender der viser dage arbejdet!

List of references 9

List of Figures

4.1 Hardware diagram with arrows 4
4.2 Mounted QRE1113 sensor 7

Page

10.1 H-bridge 1 Schematics 19
10.2 H-bridge 2 Schematics 20
10.3 Schematics of the CPLD 20
10.4 Power supply 21
10.5 Full board Schematics 22

List of Tables

8.1 Contacts 15

Page

Hardware appendix 10

10.1 Hardware Schematics

10.1.1 H-bridge 1

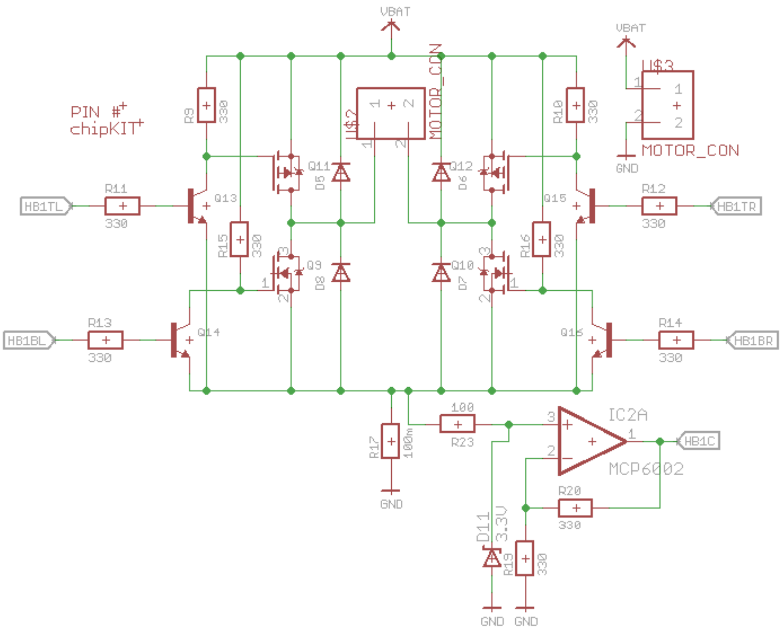

Figure 10.1: H-bridge 1 Schematics

10.1.2 H-bridge 2

10.1.3 CPLD

10.1.4 Power

10.1.5 Board schematics

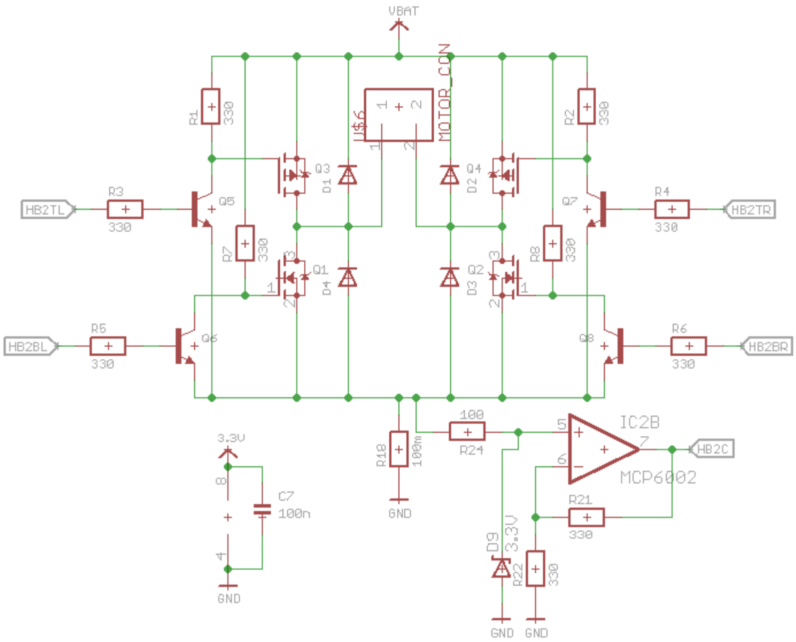

Figure 10.2: H-bridge 2 Schematics

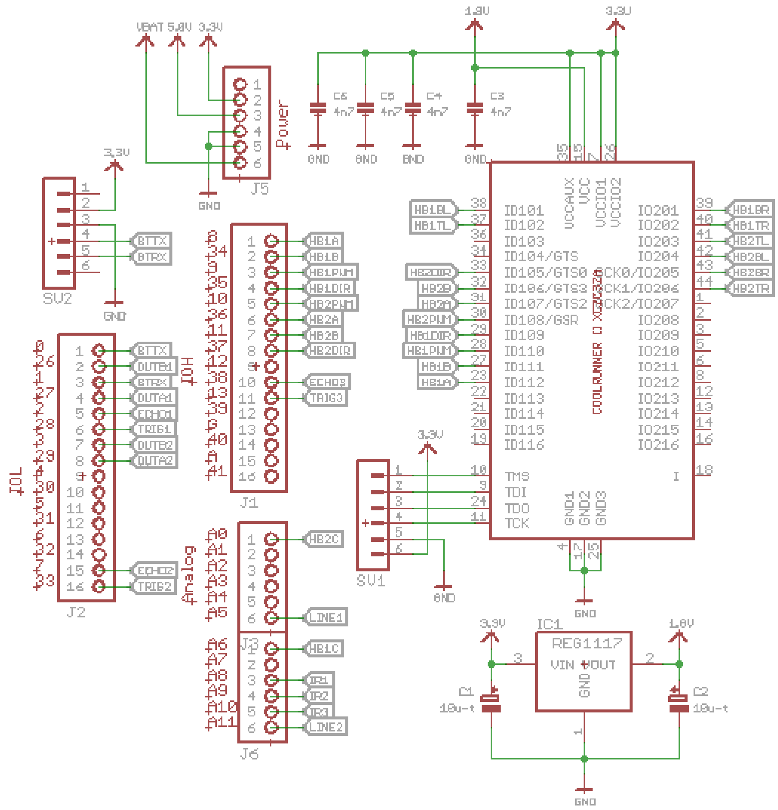

Figure 10.3: Schematics of the CPLD

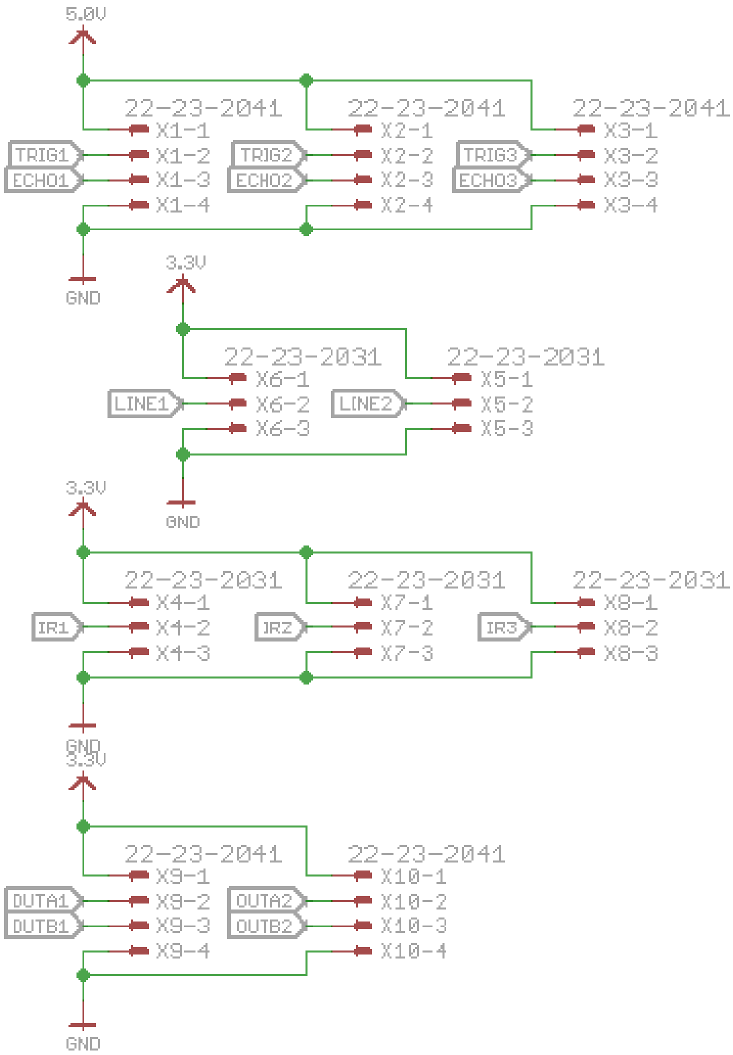

Figure 10.4: Power supply

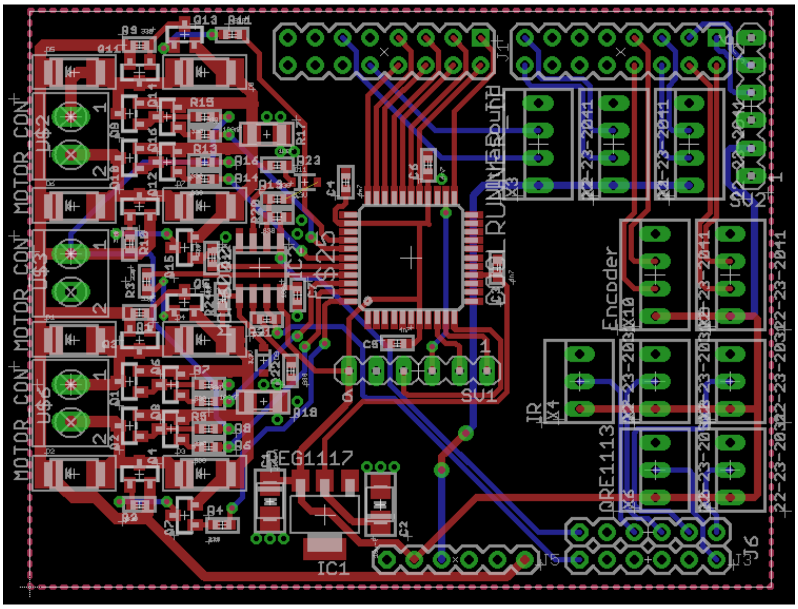

Figure 10.5: Full board Schematics

Software appendix 11

11.1 C code

main.c:

ADC.c:

11.2 C# code - interface

Bibliography

[1] UCN Group 2. "Third semester report". Chapter 10, board schematics. 2016.

[2] placeholderAuthor. *placeholderTitle*. 2016. URL: `http://www.ucn.dk`.