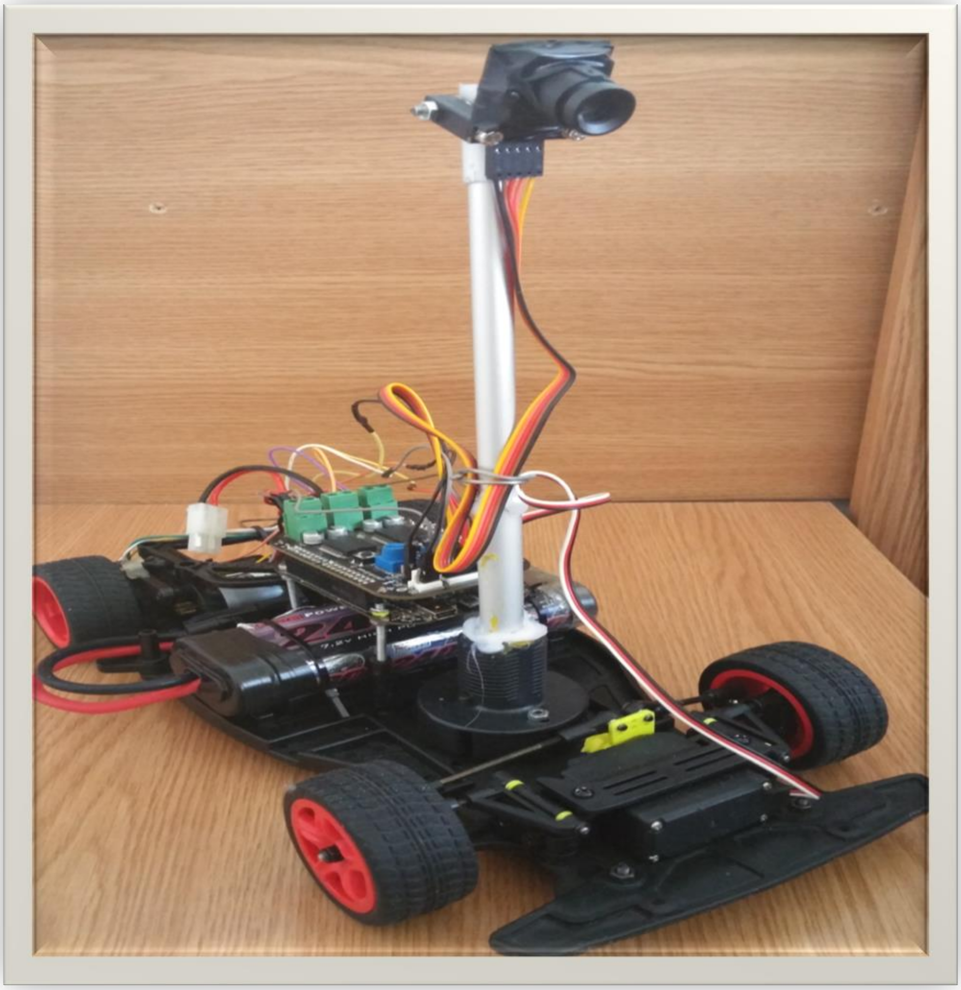
UNIVERSITY OF CRAIOVA

Romania



UCC team

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-2016-

Table of Contents

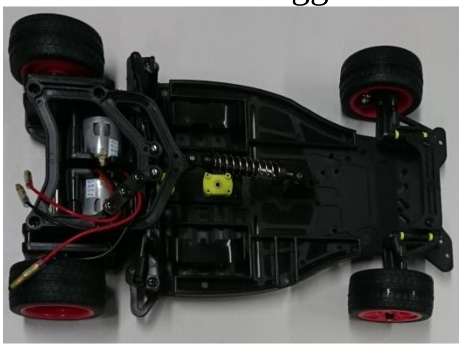
1. Description of mechanical design of car model

1.1 Mechanical components and tools

The goal was to build a self-guided car, able to follow the track in the shortest time.

Components used to build the car:

- Car Chassis: Rugged 1/18th scale car - includes frame and tires.



- 2 x Standard Motor “RN260 c” winding 18130

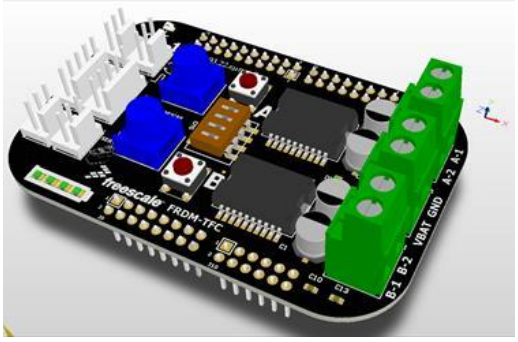
- Steering servo Futaba S3010

- Line Scan Camera-Texas Advanced Optical Solutions (TAOS) Linear Scan Sensor and Freescale Light sensor.

- Small components as: nuts, screws and plastic parts.

- Freescale Freedom development platform - FRDM-KL25Z

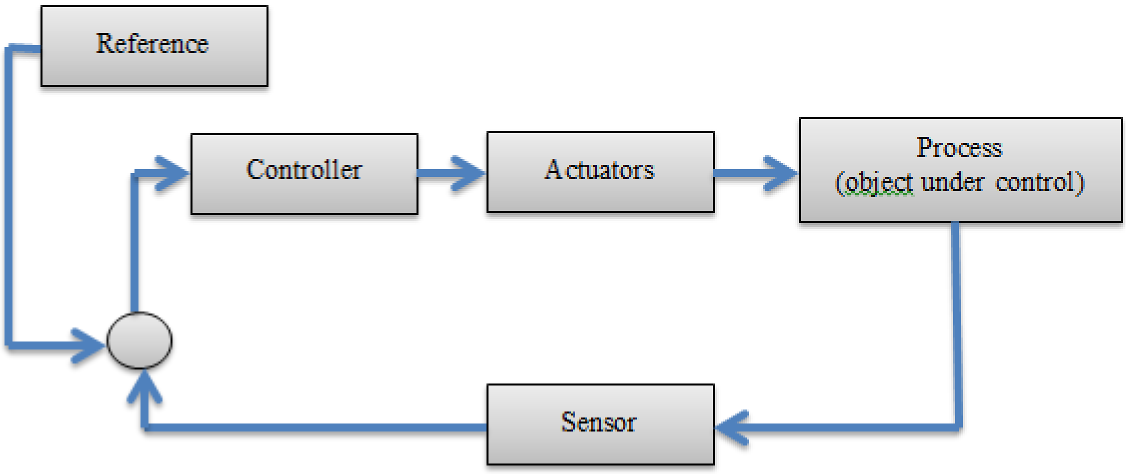
- FRDM-TFC Freescale Cup Shield

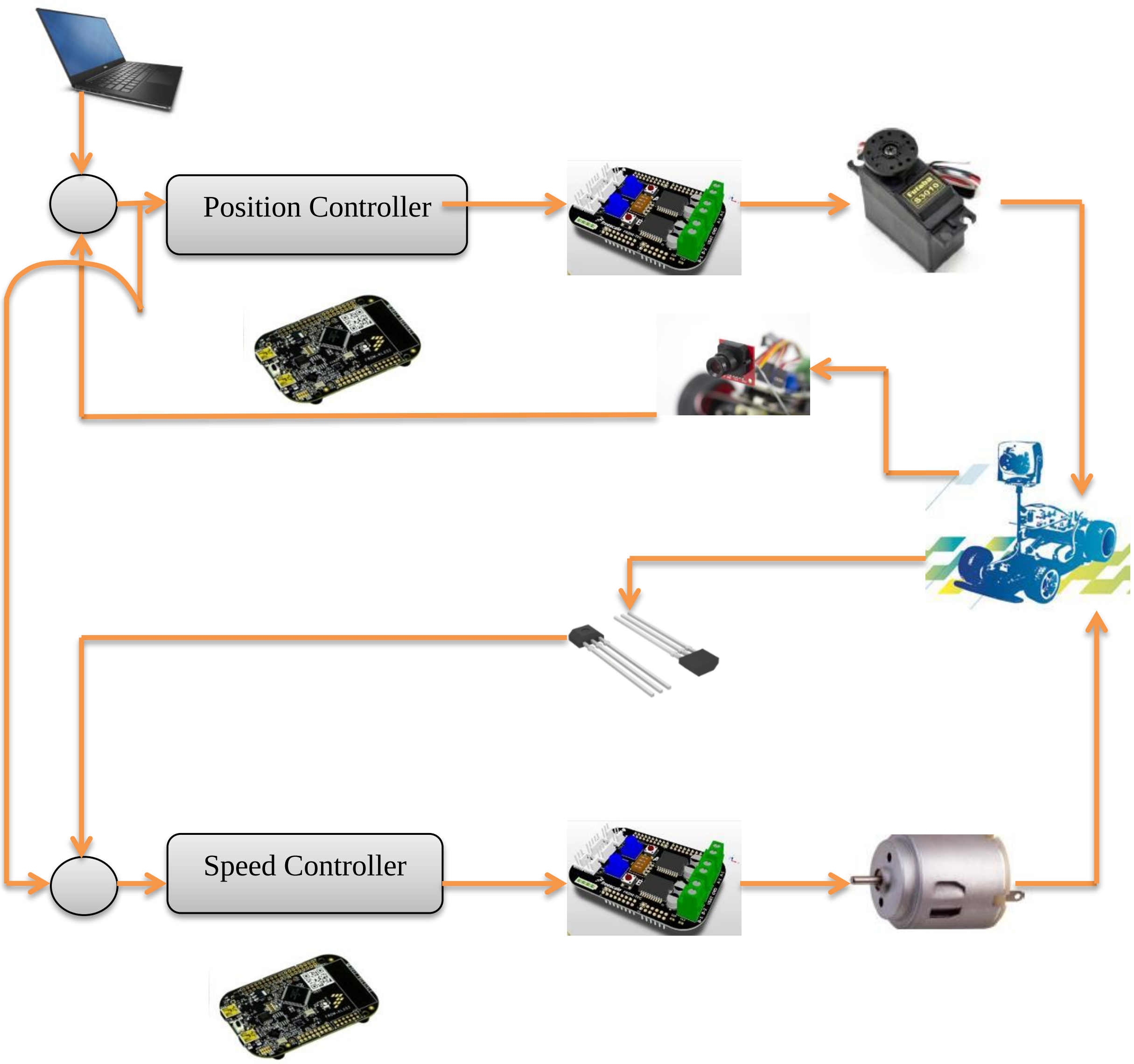


- 7.2V 2400mAh Ni-MH Battery Pack - UNI Plug by Venom Group International (VNR1531).

2. Description of control circuit design

Control circuit design is based on classical control loop:

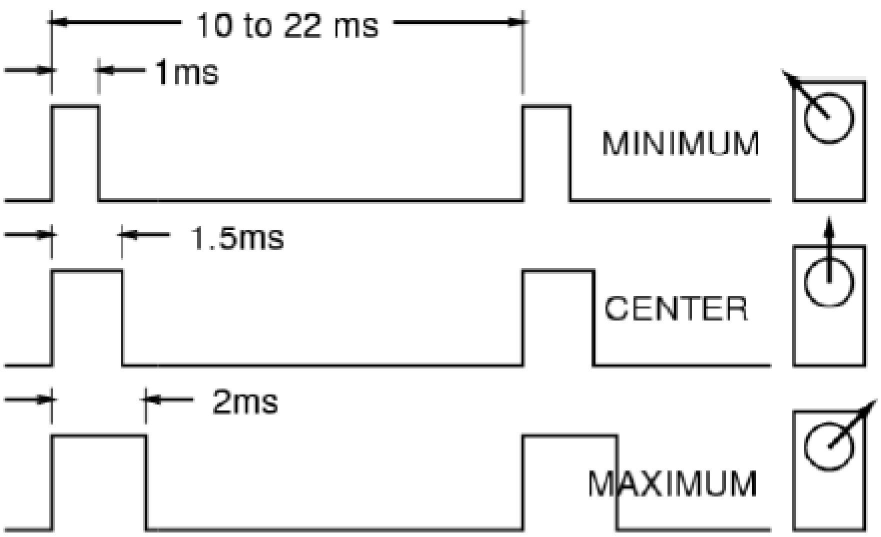




2.1 Steering servo: Futaba S3010

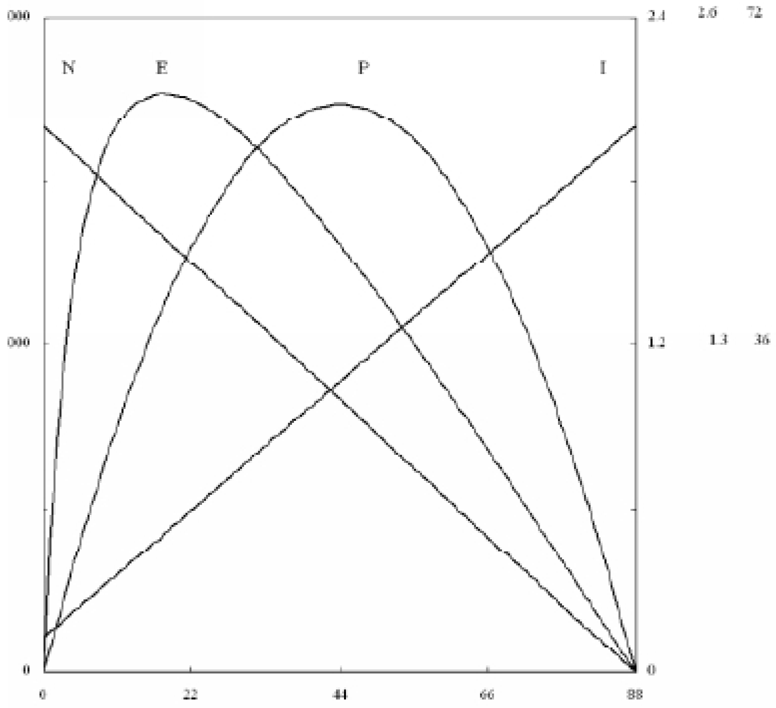
Basic Information

Modulation:	Analog
Torque:	**4.8V:** 72.0 oz-in (5.18 kg-cm) **6.0V:** 90.0 oz-in (6.48 kg-cm)
Speed:	**4.8V:** 0.20 sec/60° **6.0V:** 0.16 sec/60°
Weight:	1.45 oz (41.0 g)
Dimensions:	Length: 1.57 in (39.9 mm) Width: 0.79 in (20.1 mm) Height: 1.50 in (38.1 mm)
Motor Type:	3-pole
Gear Type:	Plastic
Rotation/Support:	Single Bearing



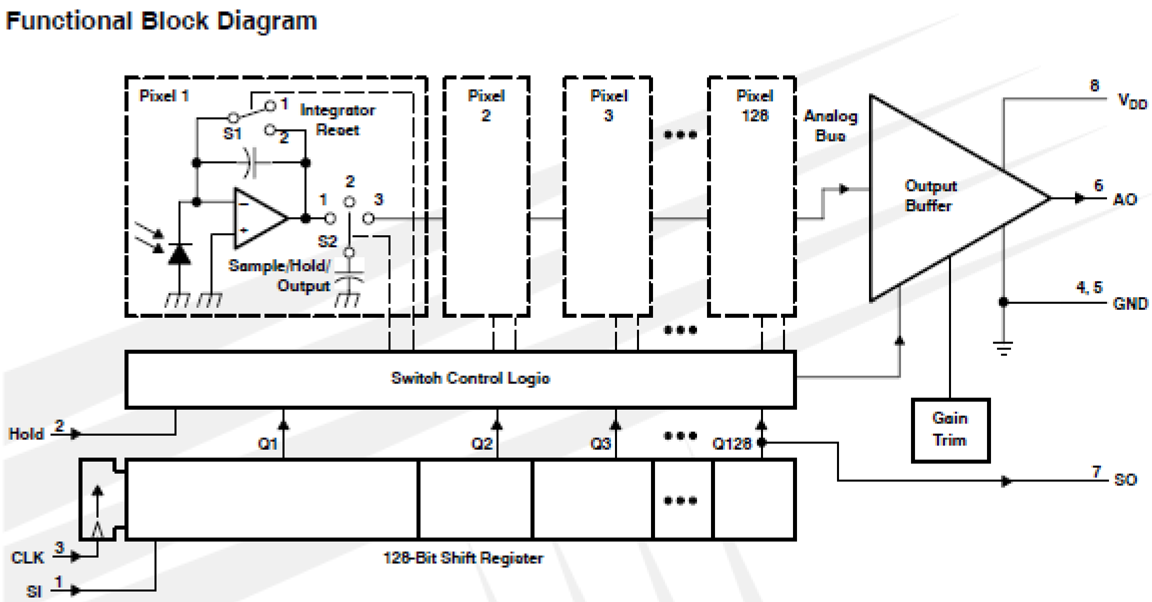
PWM command

2.2 Data sheet: Standard Motor "RN260 c" winding 18130



PWM commands to the traction DC motors have no specific limitations.

2.3 Line Scan Camera: TSL1401CL



The sensor consists of 128 photodiodes arranged in a linear array. Light energy impinging on a photodiode generates photocurrent, which is integrated by the active integration circuitry associated with that pixel. During the integration period, a sampling capacitor connects to the output of the integrator through an analog switch. The amount of charge accumulated at each pixel is directly proportional to the light intensity and the integration time."

Integration Time: T

T = (1 / Fmax)*(n-18) pixels + 20us, where n is the number of pixels

Minimum integration time: 33.75us

Maximum integration time: capacitors will saturate if exceeding 100ms.

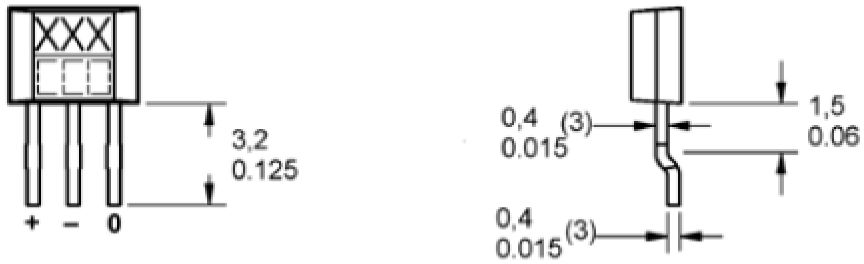
2.4. Speed sensors. Unipolar Hall-Effect Digital Position sensor, SS449a

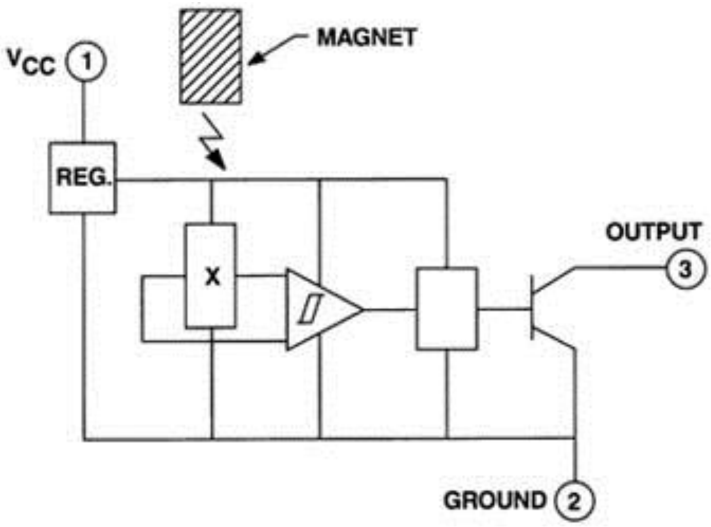
SS400 Series position sensors have a thermally balanced integrated circuit over full temperature range. The negative compensation slope is optimized to match the negative temperature coefficient of lower cost magnets.

Features:

- Digital current sinking output
- Quad-Hall design virtually eliminates mechanical stress effects
- Temperature compensated magnetics
- Operate/release points can be customized
- High output current capability
- Operate/release points symmetrical around zero gauss (bipolar/latch)
- Package material: Plaskon 3300H
- Surface mount version available: SS400-S (with cut and formed leads).

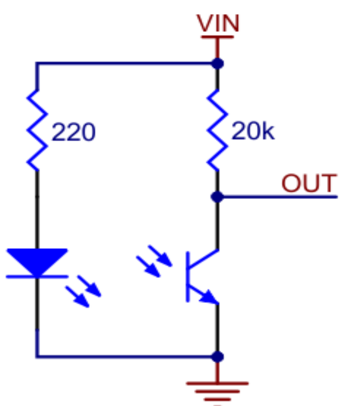
SURFACE MOUNT STYLE (-S)





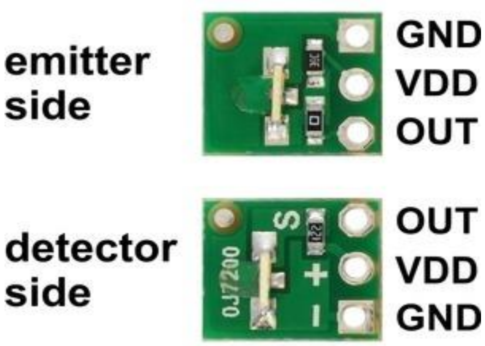
2.5. QTR-L-1A reflectance sensors

The Pololu QTR-L-1A reflectance sensor carries a right-angle infrared LED and a right-angle phototransistor, both pointing toward the front edge of the board. The phototransistor is connected to a pull-up resistor to form a voltage divider that produces an analog voltage output between 0 V and VIN (which is typically 5 V) as a function of the reflected IR. Lower output voltage is an indication of greater reflection.



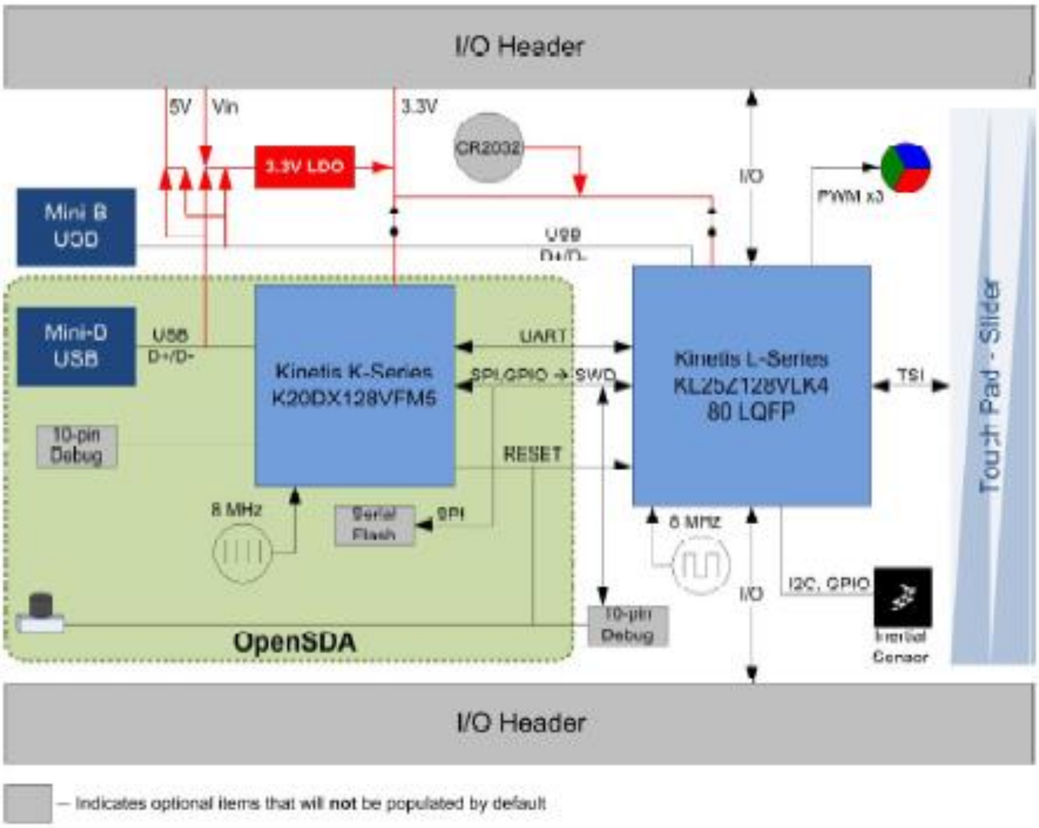
Specifications

- Dimensions: 0.3″ × 0.35″ × 0.12″ (without optional header pins installed)
- Operating voltage: 5.0 V
- Supply current: 17 mA
- Output format: analog voltage
- Output voltage range: 0 to supplied voltage (dependent on operating environment)
- Optimal sensing distance: 0.125″ to 0.25″ (3 mm to 6 mm)
- Maximum recommended sensing distance: 1″ (25 mm)
- Weight without header pins: 0.006 oz (0.2 g)

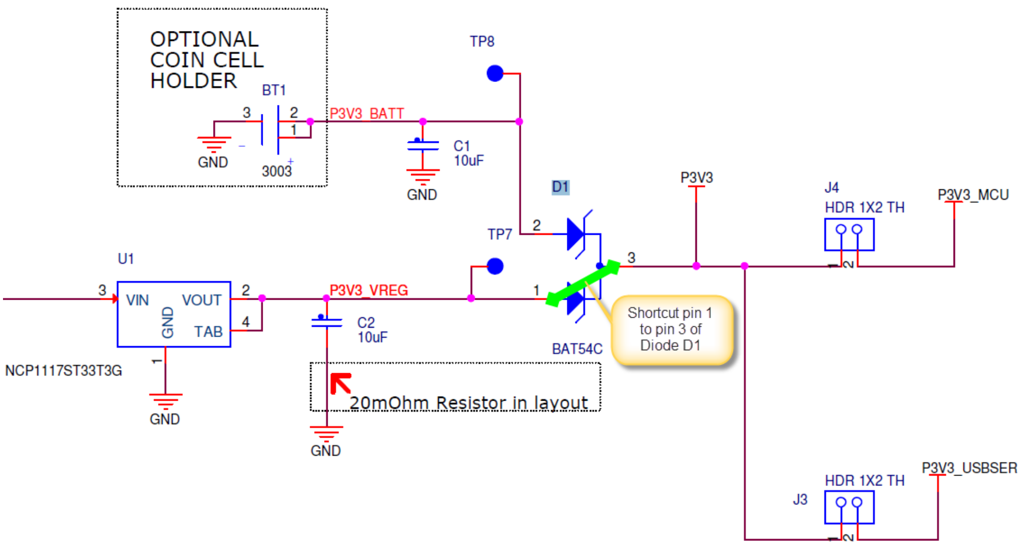


3. Description of the electronics design

3.1. FRDM-KL25Z schematics



3.2. FRDM-KL25Z power supply schematics



4. Description of control software design

4.1. Drivers

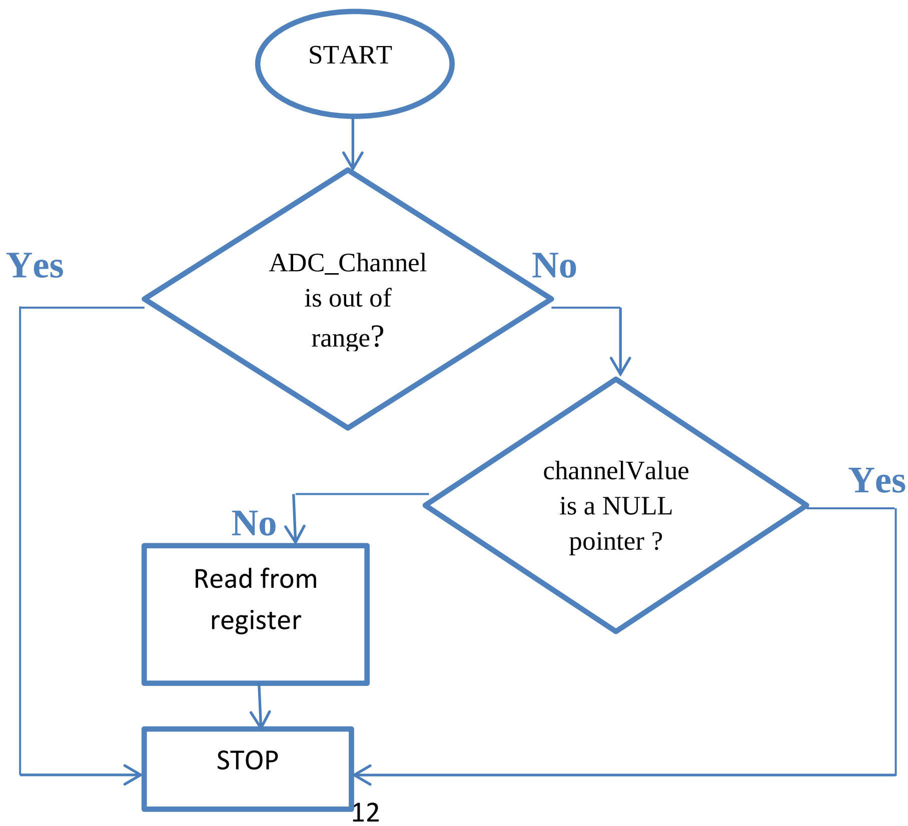
- ✓ **MCU driver -** provides services for the MCU system clock and prescaler settings.
- ✓ **DIO driver -** provides functions used to manage the digital inputs and outputs.
- ✓ **ADC driver -** implements the logic needed to drive the analog to digital hardware convertor integrated into the microcontroller. It includes also the information for **CAMERA driver** (provides the signals for camera functionality and implements function that read the value of the 128 pixels).
- ✓ **PWM driver -** used to control the generation of the PWM signal for actuators**.**
- ✓ **GPT driver -** initialization and operation for the hardware timers. It includes also the information for **ENCODER driver** (complex driver needed to read the position of the DC motor).

The Drivers for the microcontroller were made in the likeness of AUTOSAR standard, greatly simplified.

Example: ADC driver

void ADC_GetChannelValue(ADC_ChannelId_Type ADC_Channel, ADC_ValueType* channelValue);

This function will read the result of the ADC conversion on the channel specified by the ADC_Channel.



4.2. Control algorithm

- **Input**
  Data read from Line Scan Camera and data processing regarding the position and speed reference.
- **Controller**
  Implementation of two controllers: one for position control and the other one for speed control, on the same microcontroller device.
- **Output**
  PWM command: one for servomotor (position control) and one for DC motors (speed and position control).

The controller is represented by PID control algorithm, always a good choice in finding a control solution.

Continuous PID control:

$$H_C(s) = K_P + K_I \frac{1}{s} + \frac{K_D s}{T_g s + 1}$$

To implement PID control algorithm, the continuous form must be discretized, using one of the following methods:

a. *Tustin substitution*: $H_d(z) = H_c(s)\Big|_{s = \frac{2}{T_s} \cdot \frac{1-z^{-1}}{1+z^{-1}}}$

b. *Forward Rectangular*: $H_d(z) = H_c(s)\Big|_{s = \frac{1}{T_s} \cdot (z-1)}$

c. *Backward Rectangular* : $H_d(z) = H_c(s)\Big|_{s = \frac{1}{T_s} \cdot \frac{z-1}{z}}$

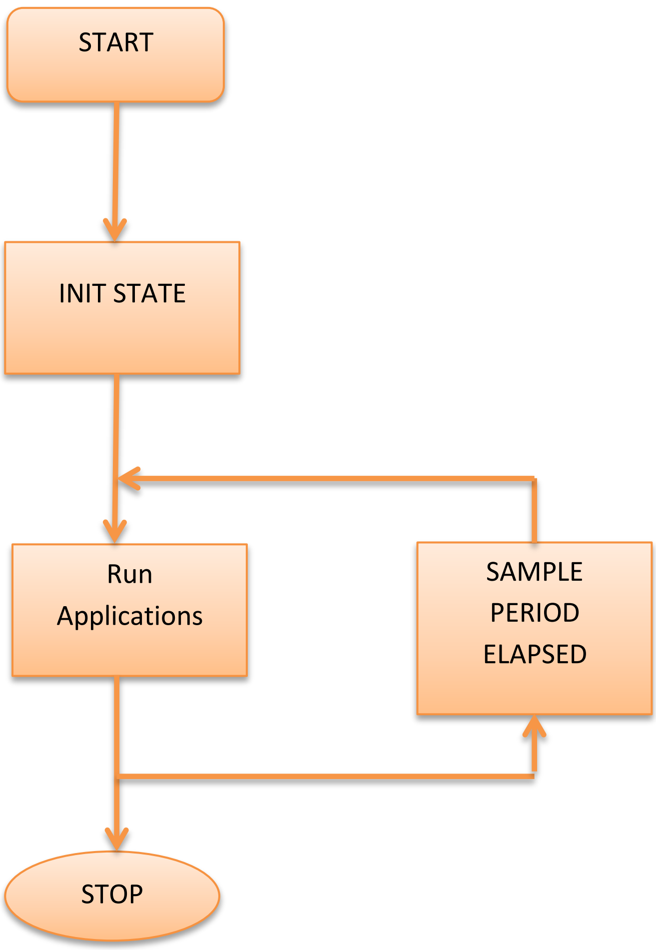
Where Ts represents the sampling period.

4.3. Main file

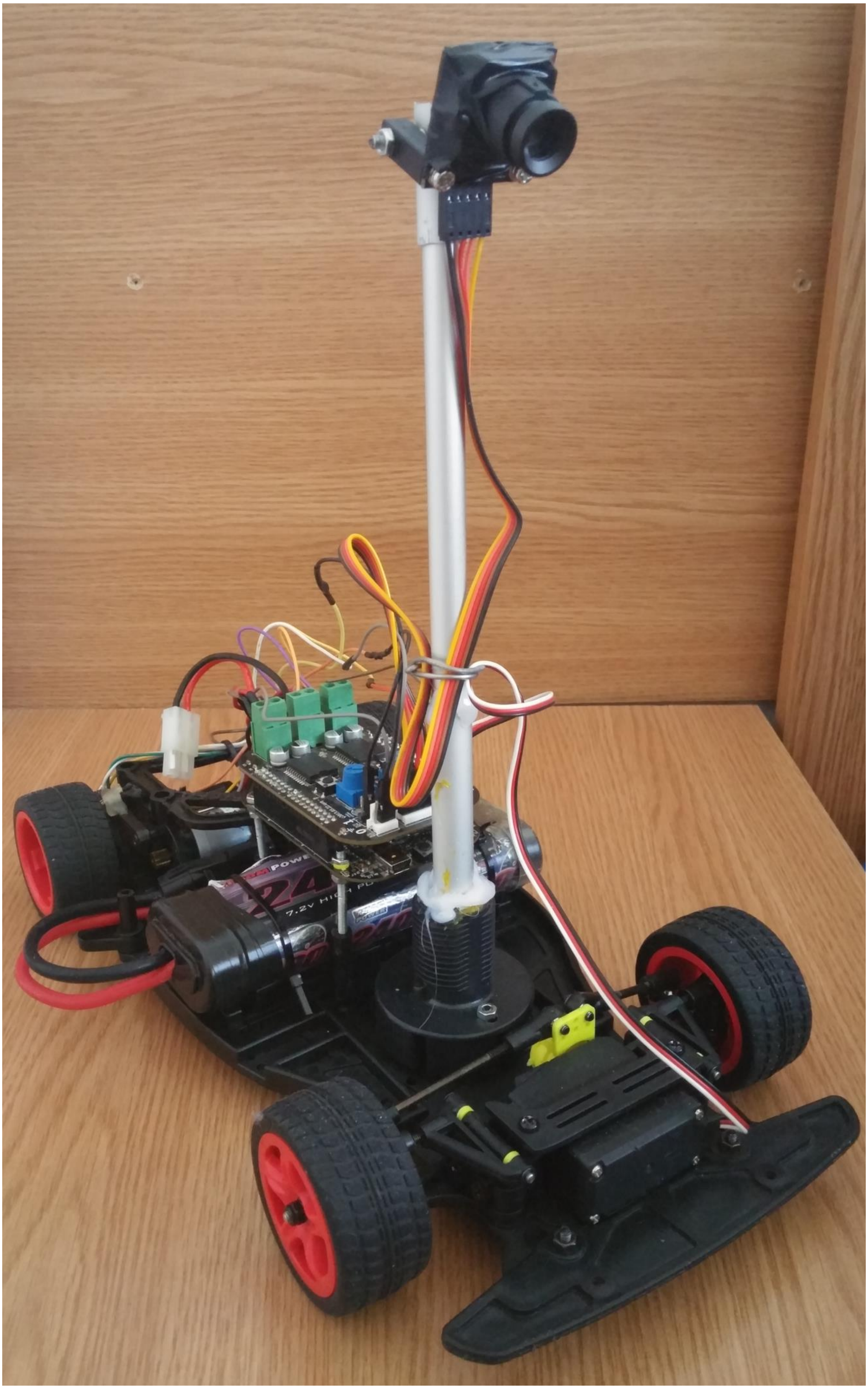
This file contains the *main function* that works such an operating system. Its role is to initialize all drivers and to schedule the correct run of the applications.

Firstly, all drivers and applications are initialized before they are being used. Then, the applications are called in the correct order.

Sensors → Controllers → Actuators



NXP CUP
INTELLIGENT
CAR RACING



Bibliography

[1] FasTech_UCV team (University of Craiova) technical report– Freescale Cup 2016

[2] MEM_team (University of Craiova) technical report – Freescale Cup 2015

[3] FRDM-KL25Z User's manual

[4] Futaba (http://www.futabarc.com)

[5] https://www.pololu.com/product/2454

[6] Servo motor tutorial (http://www.seattlerobotics.org)

[7] Standard Motors (http://www.standardmotor.net/)

[8] SS449a-1 Datasheet

[9] Taos, *TSL1401CL 128x1 linear sensor array with hold*, July 2011

[10] https://community.freescale.com/community/uvp