NXP CUP 2017
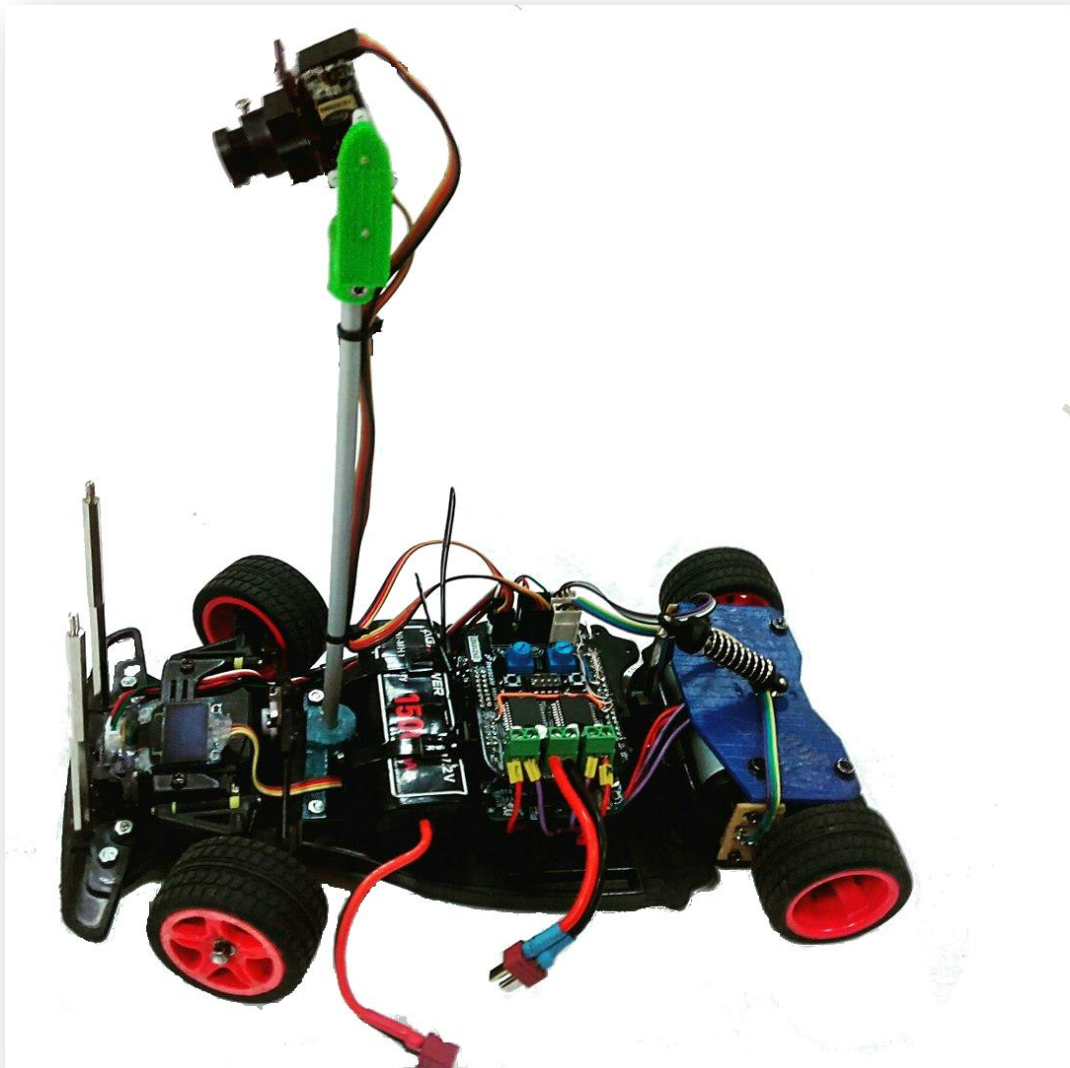
TECHNICAL REPORT

"Wonderbolts"

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1. INTRODUCTION

Authored by team Wonderbolts, this document is a complete technical report on a racecar model, engineered by the team based on the Freescale Cup kit (henceforth kit). We take part in this competition in the context of our semester's project.

Three students from Odessa National Polytechnic University compose our team, the Wonderbolts: Tymchenko Borys, Putilina Daria and Samodelok Vladislav.

This project is very exciting and we have a lot of pleasure working on it. We hope that we can go as far as possible in the competition!

2. MECHANICAL DESIGN

Servo

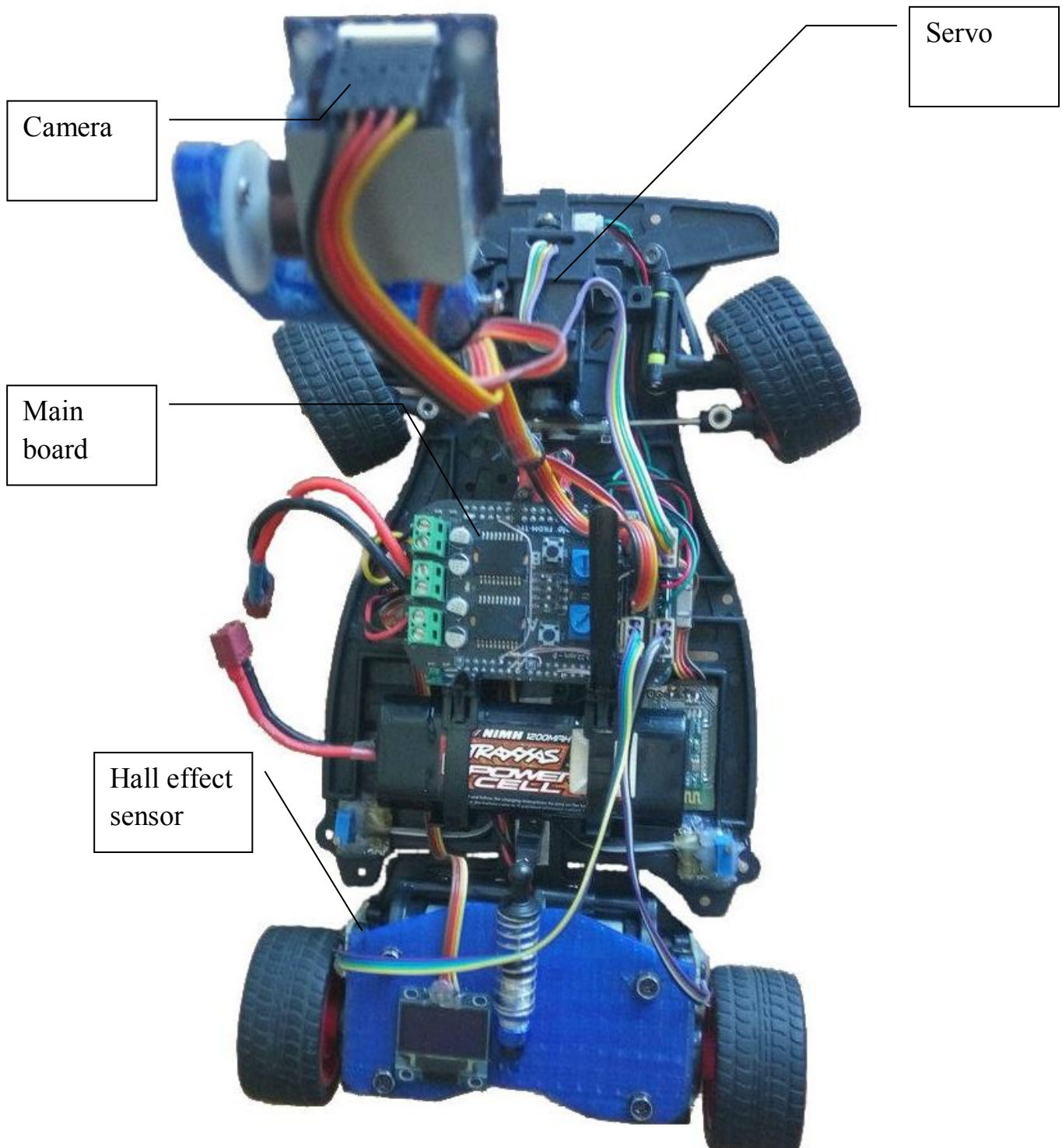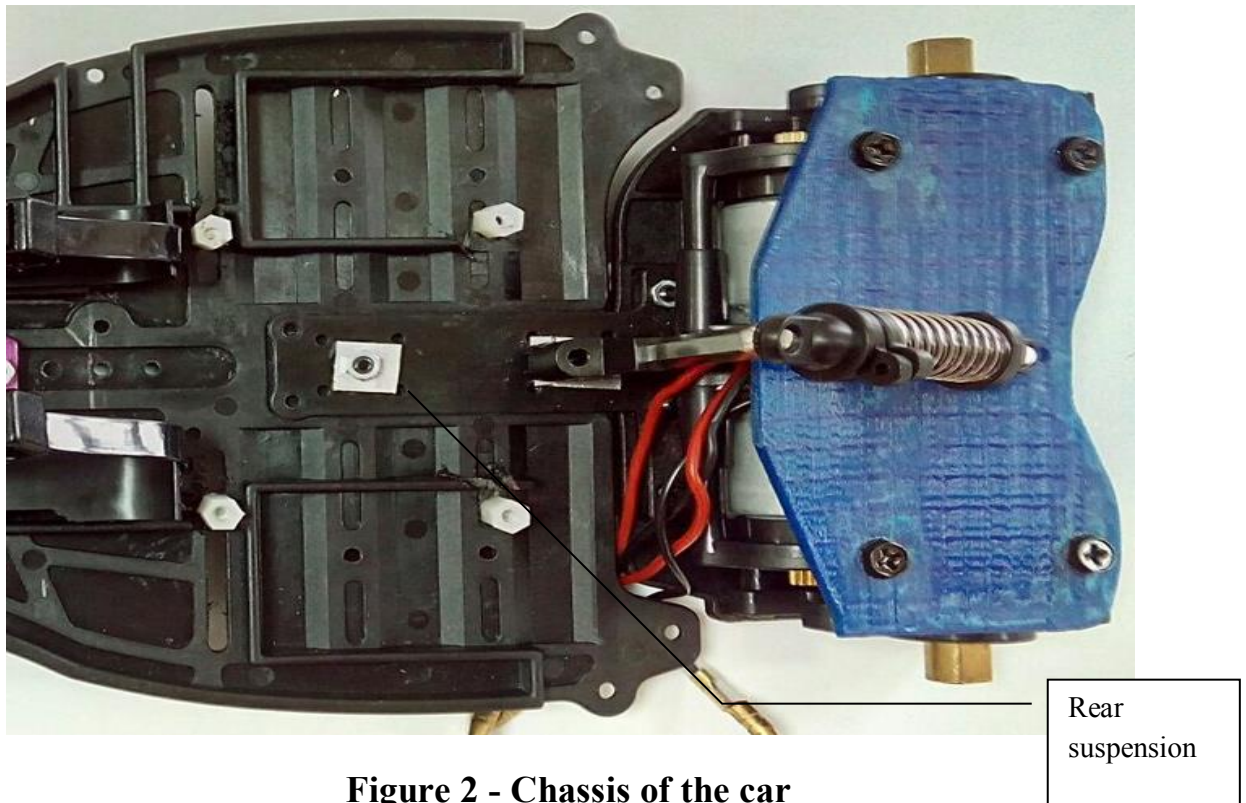Camera

Main
board

Hall effect
sensor

Figure 1 - Top and side views of the car

2.2 CHASSIS

We received a basic chassis with mounted wheels.

We removed rear suspension bearings to add rigidity of our construction.

Rear suspension

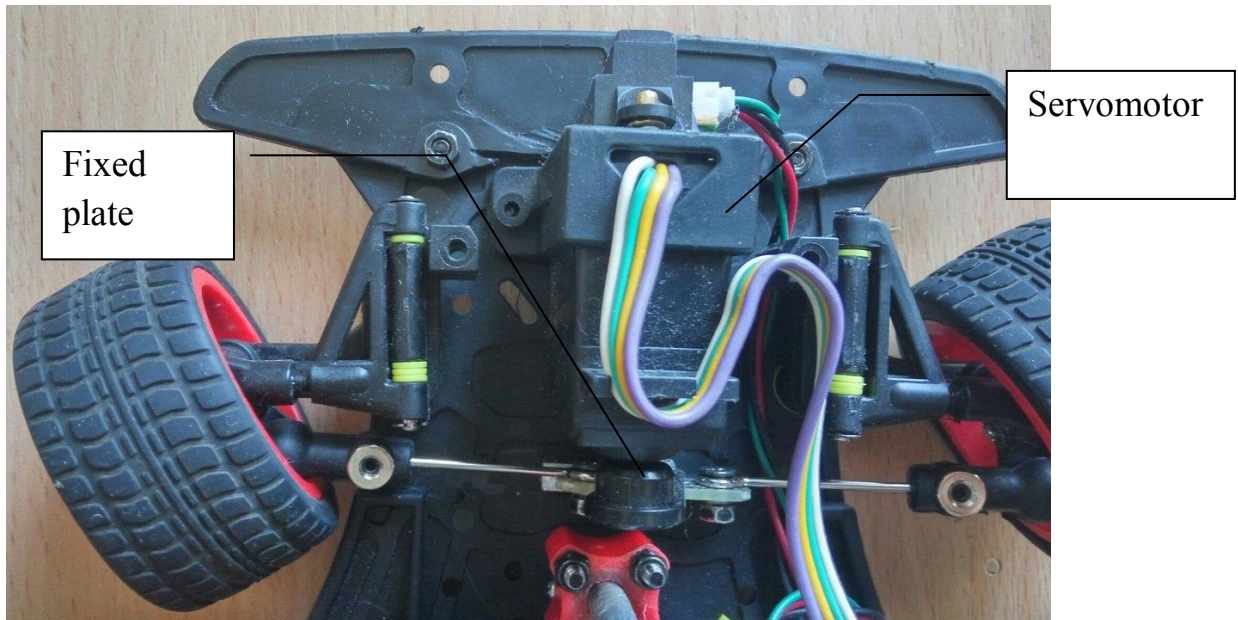**Figure 2 - Chassis of the car**
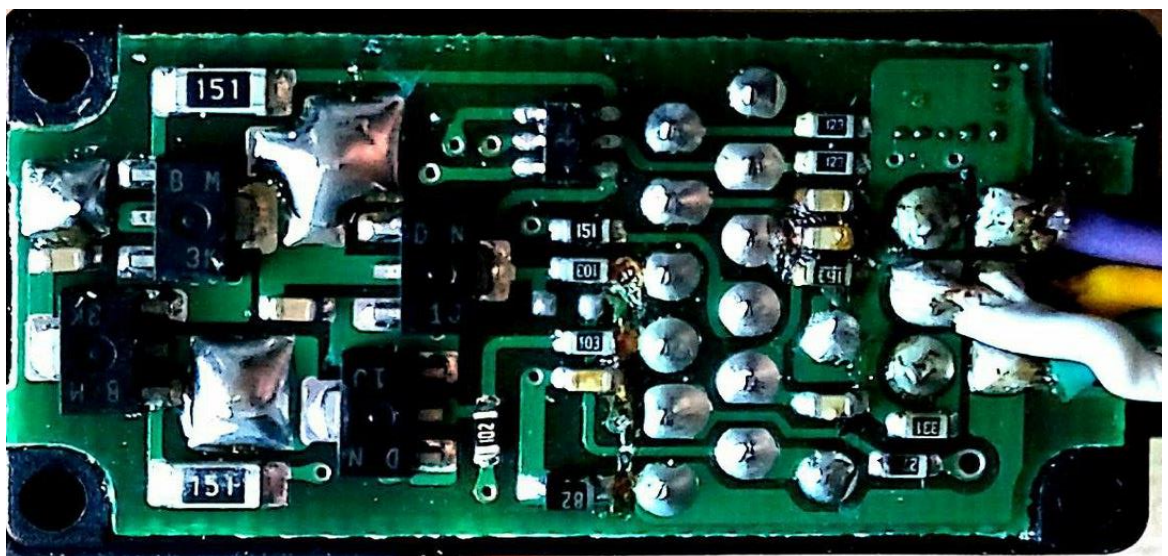
2.3 STEERING SYSTEM

The steering system is composed of controls arms connected to a Futaba S3010 (servomotor), which was imposed. We replaced servo keeper to the fixed plate for increased steering responsiveness

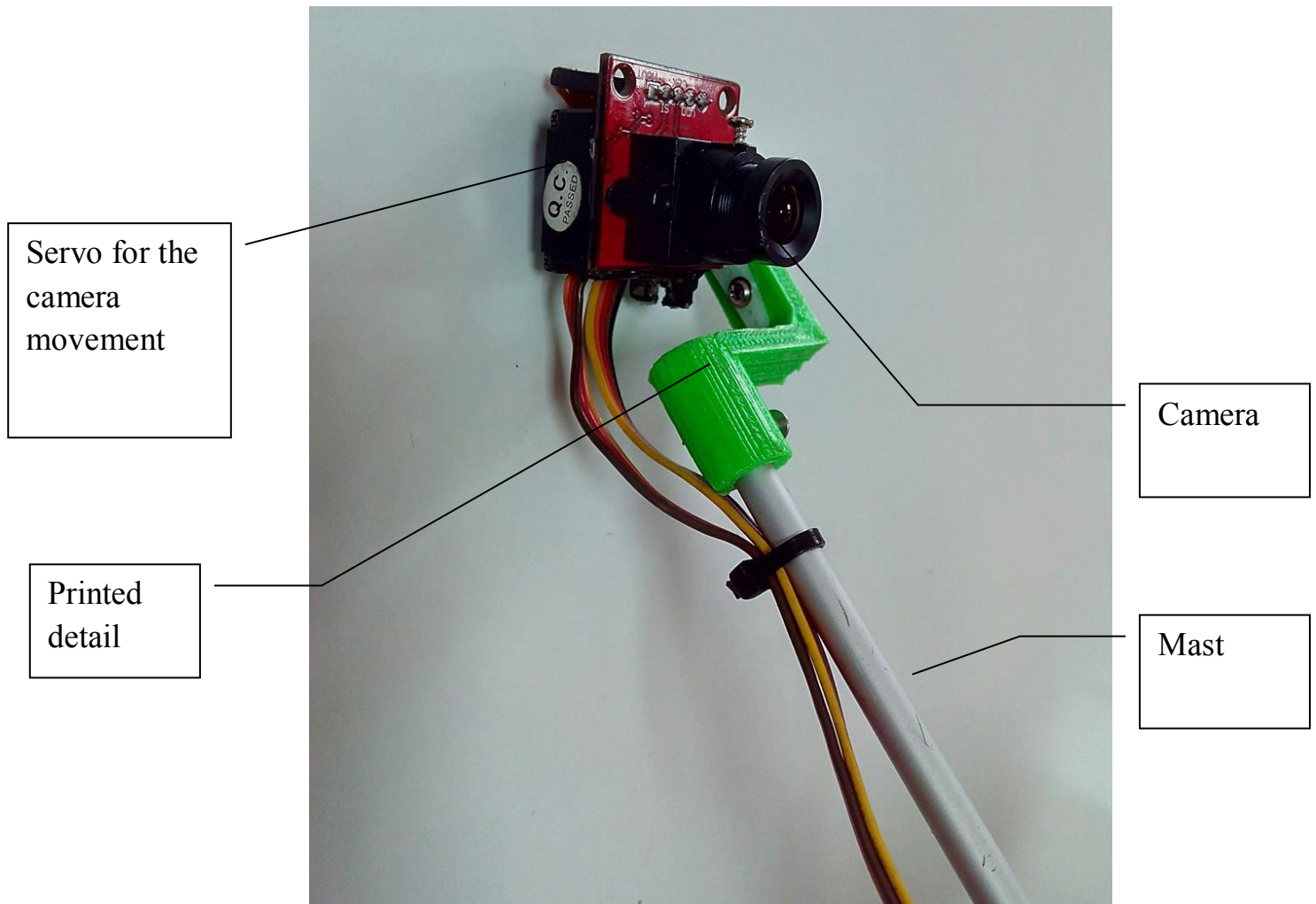**Figure 3 – Servomotor**

We added feedback position output for servo in order to know exact steering wheels position.

Figure 3.1 – Servomotor

2.4 CAMERA

A linear camera (1x128 pixels) scans the track's lines. The camera is mounted on a servo to automatically adjust distance of sight.

Servo for the camera movement

Printed detail

Camera

Mast

**Figure 4 - Camera with servo on the mast**

2.5 MAINBOARD, EXTENSION BOARD AND POWER SUPPLY

We use mainboard FRDM-K64F. The mainboard is placed at the center of the car between two DC motors and mast with the camera.

On top of it, we mounted TFC-SHILED from standard kit, which was modified in order to have pin compatibility with FRDM-K64F instead of FRDM-KL25.

Its position allows a direct access to the speed sensors and the DC motors. The extension board fixed on the mainboard. The power supply comes right after the mainboard. Its position is between mainboard and DC motors. As it is a heavy component, we found better to have it at the center of the car so that the weight of the car is well distributed.
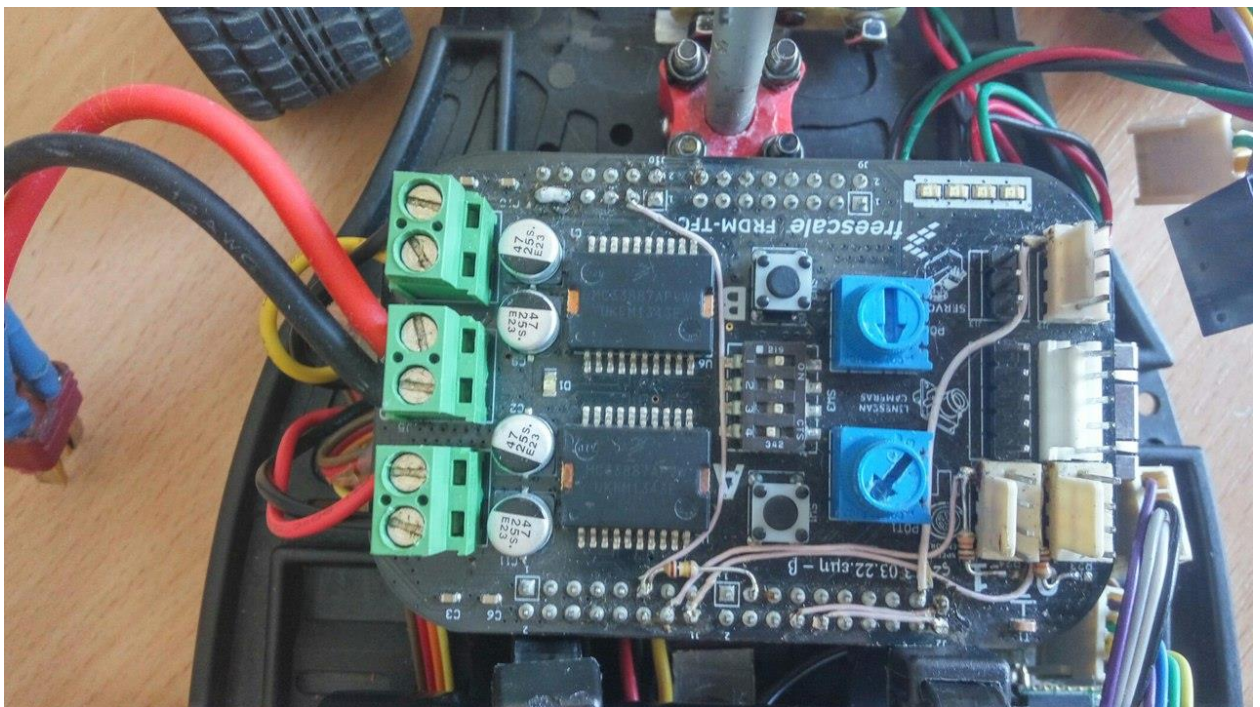
Figure 5 - Top view of the extension board with connected peripherals and power supply
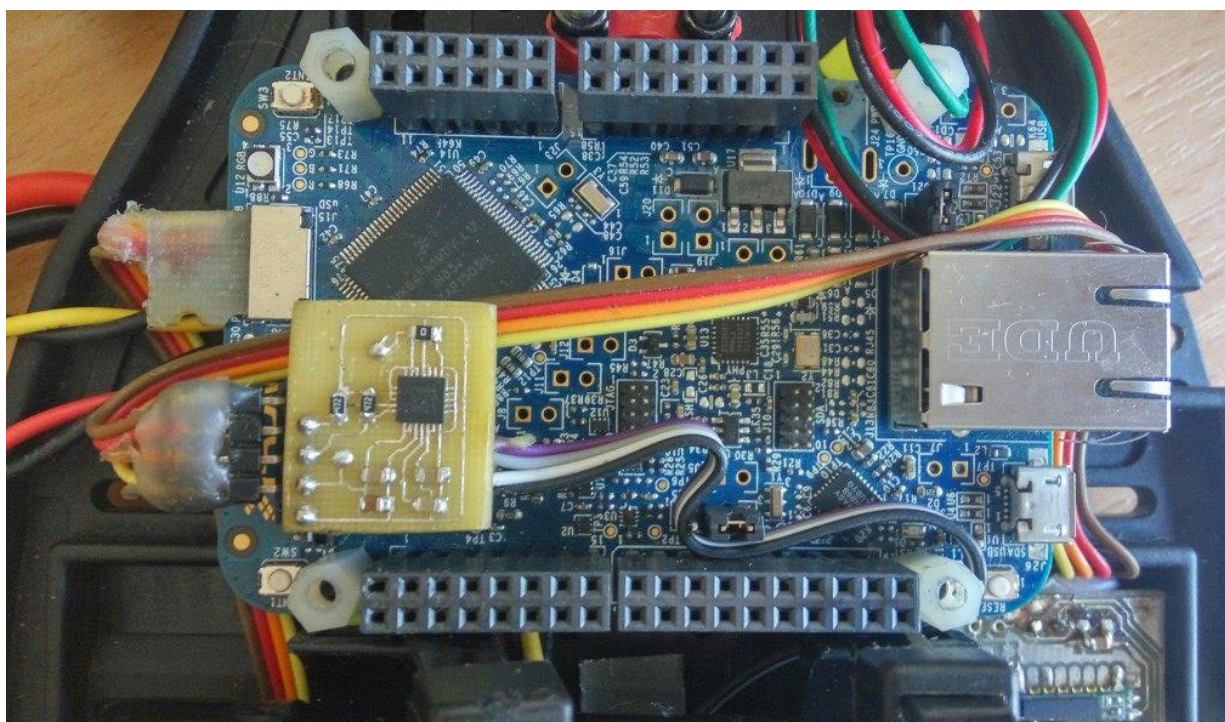
Figure 6 - Top view of the mainboard with gyroscope mounted

2.6 SPEED SENSORS

Four speed sensors, two for each rear wheel, are located on each DC motor. We need in that to know both the speed and direction of the wheels. A magnet is sticked on each motor's axis right after the transmission system. The speed sensor stand between the wheel and the motor, with its two Hall Effect sensors around the magnet.
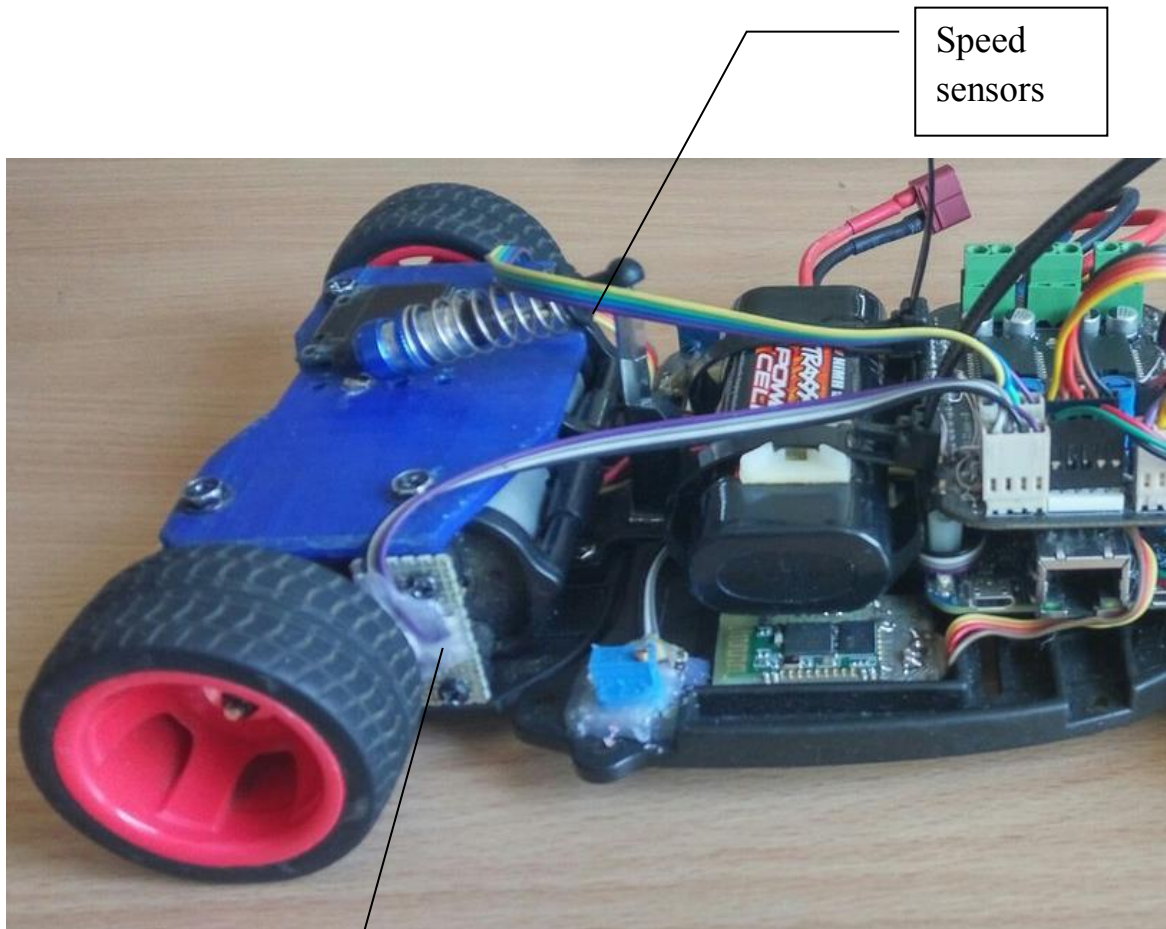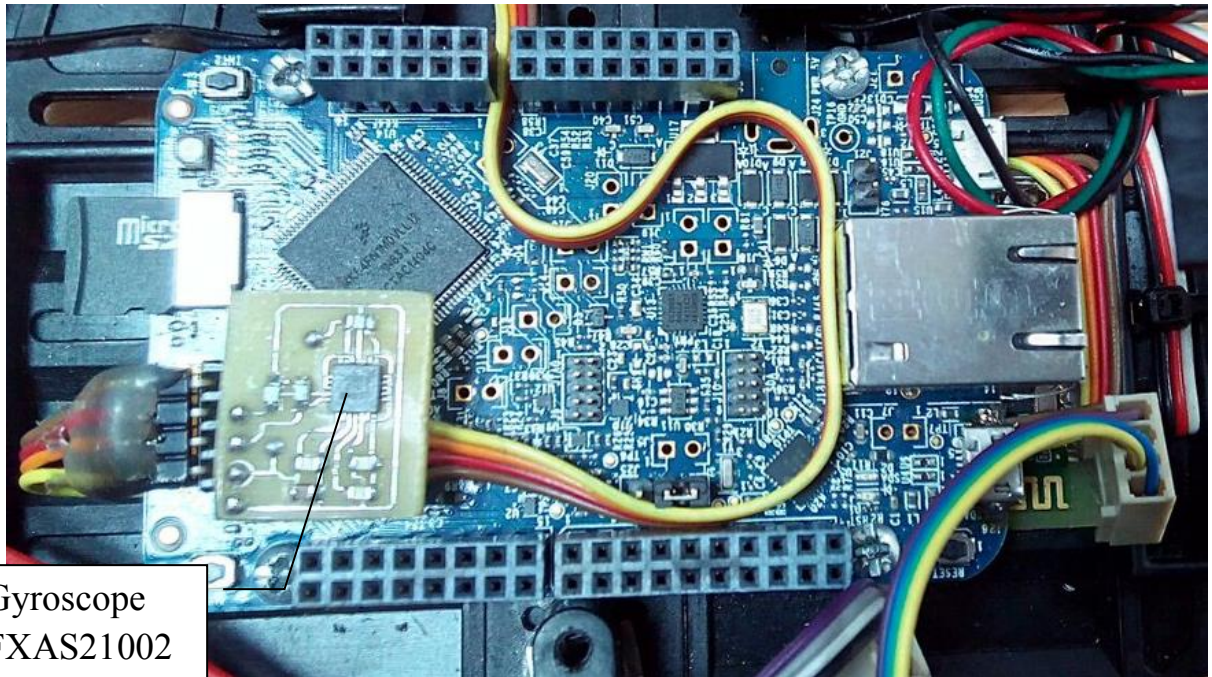
Speed sensors

Figure 7 - Speed sensors

Speed sensors

2.7 GYROSCOPE BOARD

We made custom PCB for FXAS21002 gyroscope and placed it into the FRDM extension port. This construction allows us to get gyroscope as close as possible to the center of mass.

Gyroscope
FXAS21002
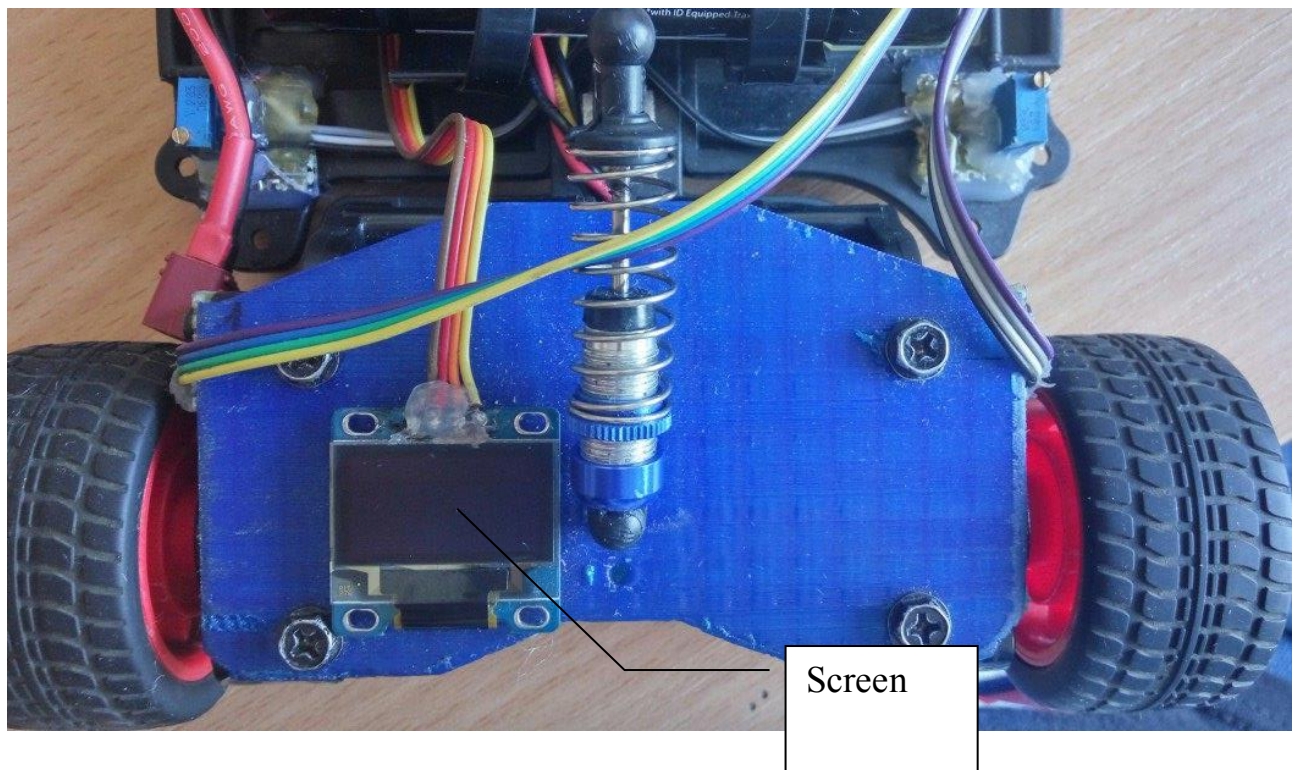
Figure 8 –Gyroscope mounted

3. OTHER CHANGES AND ADDITIONS

In addition, we use the SSD1306 OLED screen for debug purposes. Our team used exactly the SSD1306 OLED screen, which doesn't pertain to NXP Semiconductors as they do not produce such screens. We mounted it with hot glue on the printed platform of fixing the rear of the car.

Figure 9 - Screen

We changed the direction of the shock absorber for more effective anti-vibration. In addition, to add stiffness, we replaced the standard platform of fixing the rear of the car on the printed platform

Printed platform
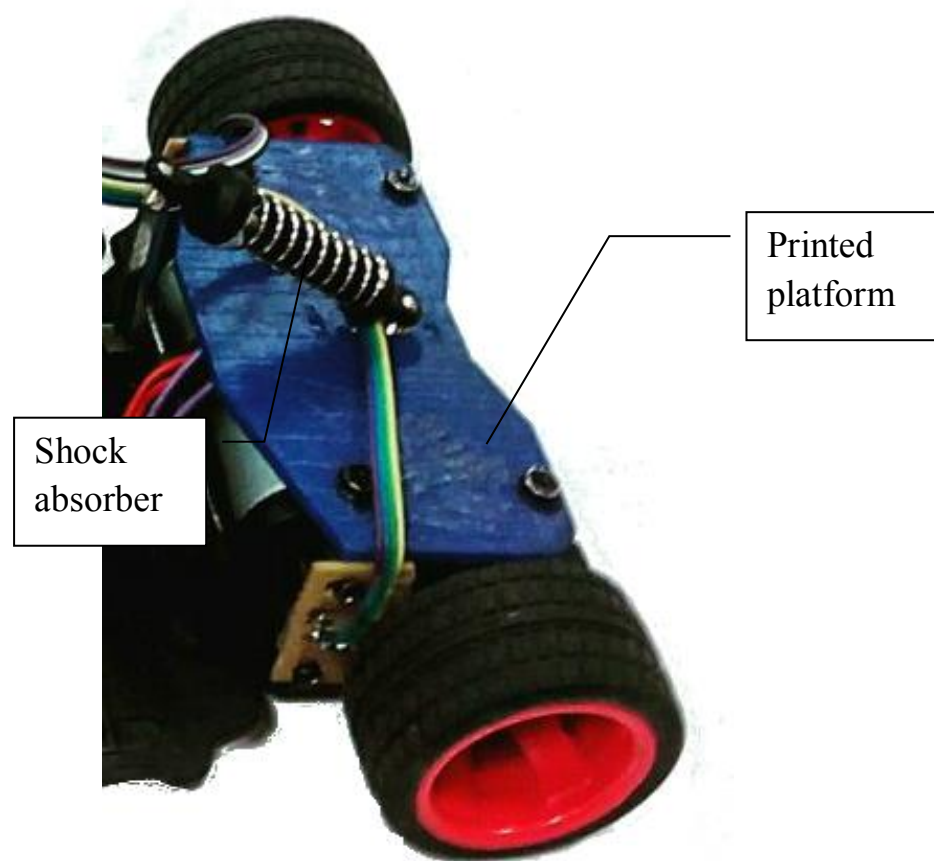
Shock absorber

Figure 10 - Shock absorber

To fix the mast with camera, we used a detail from the standard kit filled by ABS-plastic.

Detail from standard kit
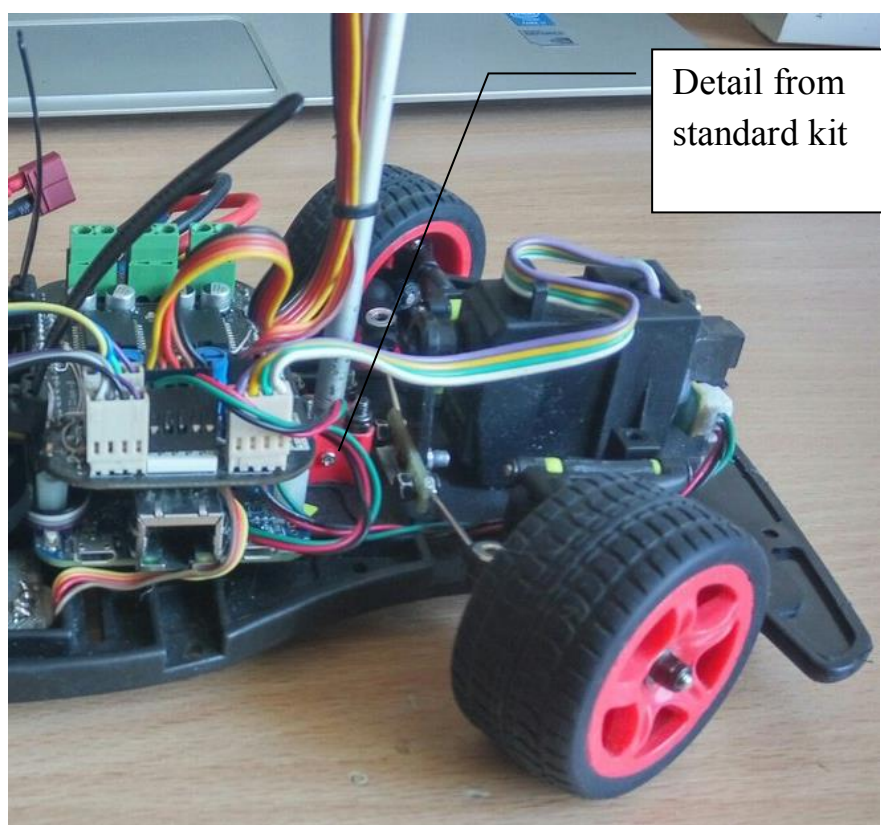
Figure 11 - Mount for the mast with camera

4. SENSORS

1. FREESCALE LINESCAN CAMERA. We use standard Freescale Linescan camera from car kit. The focal length can be adjusted manually by screwing the lens. Also we changed the standard lens to the lens with 70-90 degrees FOV.

2. HONEYWELL SS413A. Speed Sensor Honeywell SS413A digital Hall-effect sensor is operated by a permanent magnet. It responds to a magnetic South Pole by setting up a signal. We use a speed sensor board for each rear wheel and two SS413A sensors for each board, so that we can get both speed and direction of rotation for each wheel.   We use Hall effect sensors not from NXP Semiconductors because they have not Hall effect sensors with corresponding characteristics.

3. ACCELEROMETER. We use FXOS8700 accelerometer that is mounted on FRDM-K64F platform. We use it to calibrate the gyroscope before the start.

4. MAGNETOMETER. This sensor is built-in with the accelerometer. Actually, we do not use this sensor.

5. GYRO FXAS21002C. We made the custom board for the gyro. We use gyro to get yaw rate on curves.
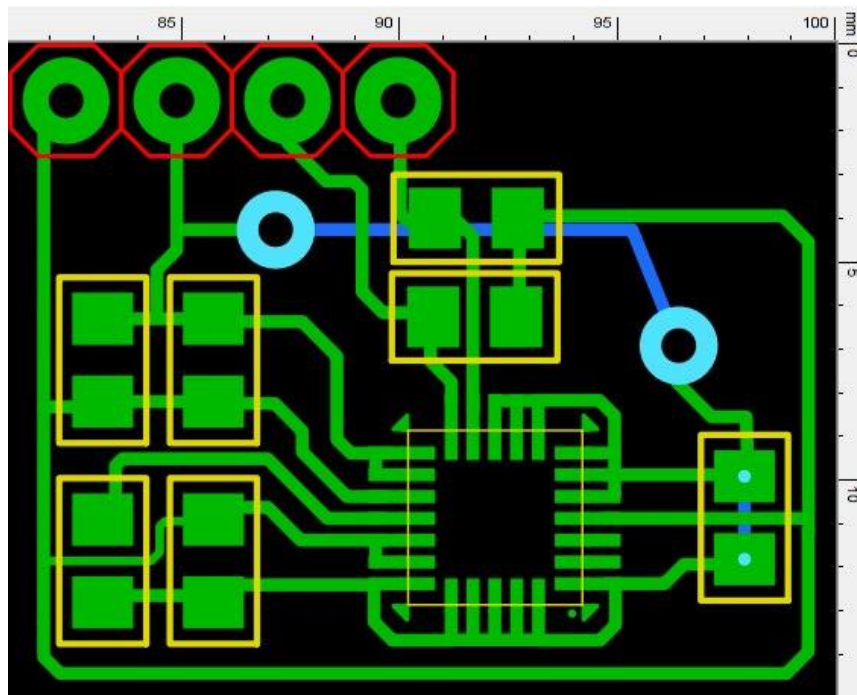
Figure 12 – Gyroscope PCB layout

6. OPTICAL PROXIMITY SENSOR. In our model, we use optical proximity sensor Sharp GP2Y0A21YK. We took this sensor not from NXP Semiconductors since they don't produce such type of the sensors. This sensor has an analog output that varies from 3.1V at 10 cm to 0.4V at 80 cm. It is used to detect hill in front of the car. We fixed it with hot glue in front of the car.
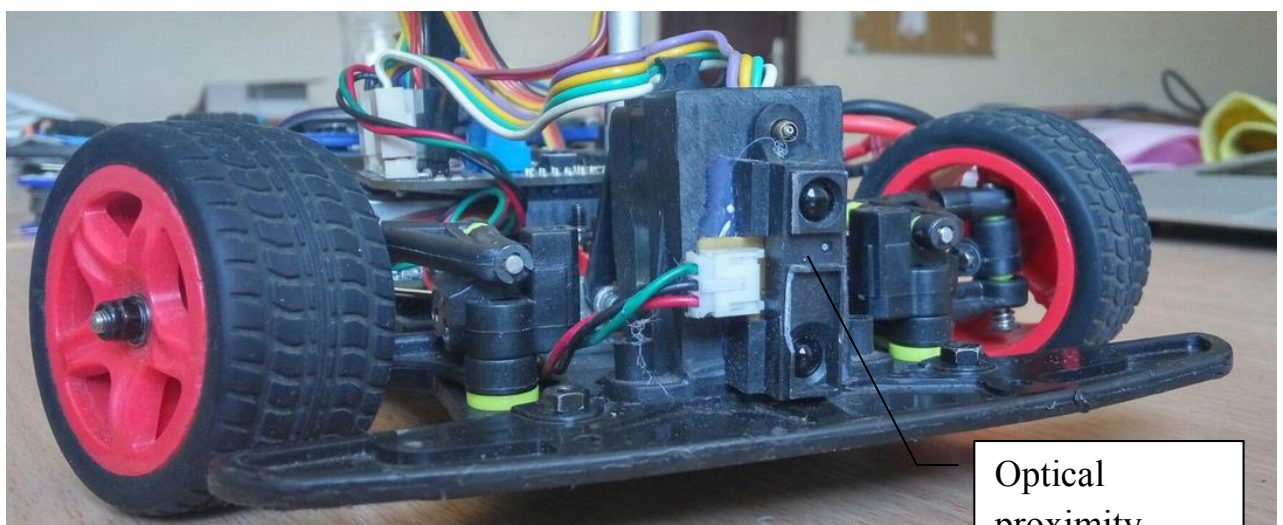

Optical proximity sensor

Figure 13 - Optical proximity sensor

7. Reflective Optical Sensor with Transistor Output TCRT5000.

Also we decided to use the optical sensor TCRT5000. The TCRT5000 is a reflective sensor which includes an infrared emitter and phototransistor in a leaded package which blocks visible light. The package includes two mounting clips. We took these sensor not from NXP Semiconductors since they don't produce such type of the sensors at all. We use this sensor for pinpointing finish lines. We use also trimming potentiometer 100 k, usual resister 303 ohm and insulation optron.

We decided to use 2 reflective optical sensors TCRT500 on our car because there are two separate finish lines on the race.

We fixed every sensor on the basic chassis on each side between the power supply and motors.

Figure 14 - Reflective Optical Sensor TCRT5000

5. COMMUNICATION DEVICE

Serial Port Bluetooth Module HC-05. This module allows us to send and receive data. The mainboard dialogues with this module using a RS232 communication. We use this module in test mode to send data in real-time from the car to the PC for monitoring purpose and to send start and stop signal from the PC to the car. This device is removed for the competition.

6. SCHEMATICS

All the alternations from standard TFC-SHIELD were made with jumper wires directly on the TFC-SHIELD PCB. This allowed us to reduce weight of the car compared to custom adapter board.

6.1 FRDM-K64F INTERFACE

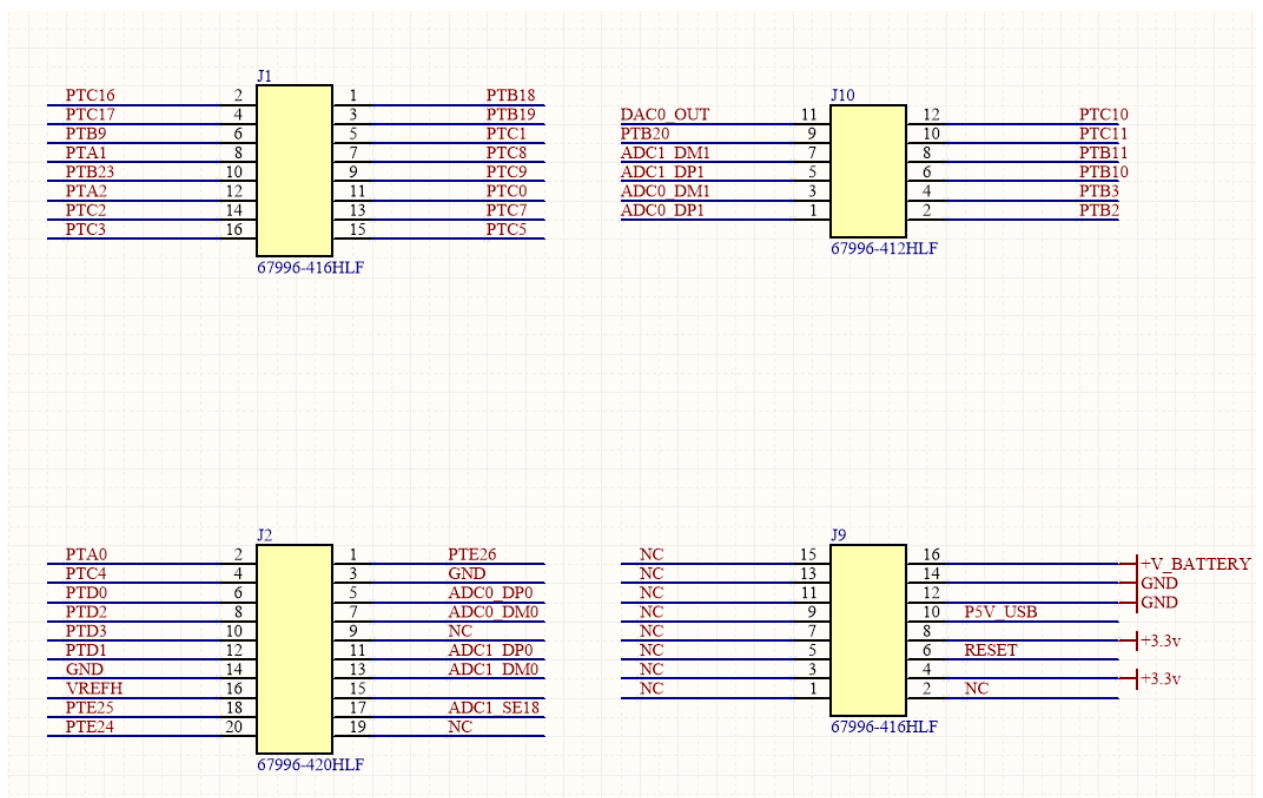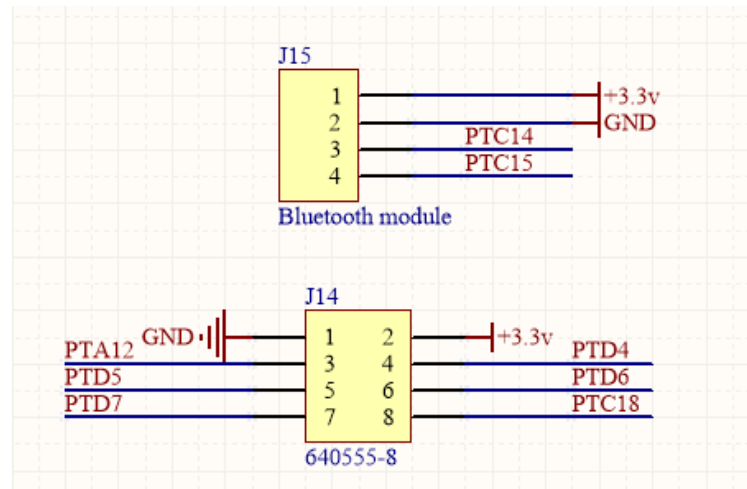Figure 15 – FRDM-K64F interface

6.2 FRDM-K64F Extension Slots

Figure 16 - FRDM-K64F Extension Slots

6.3 Power supply
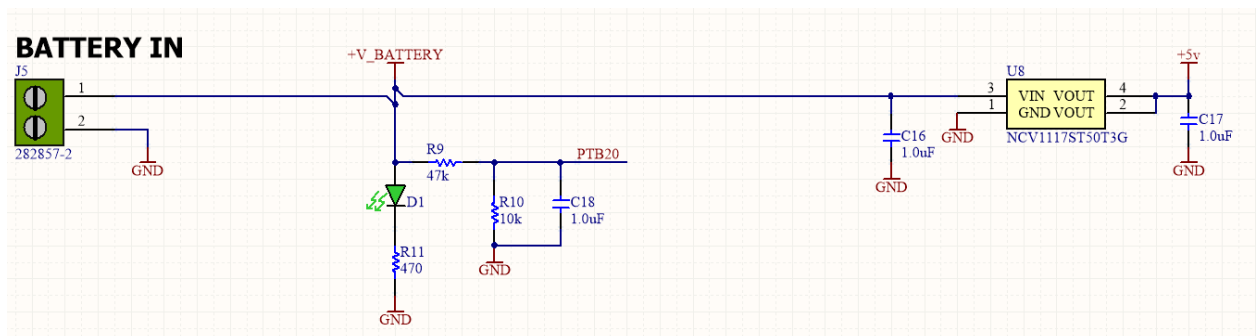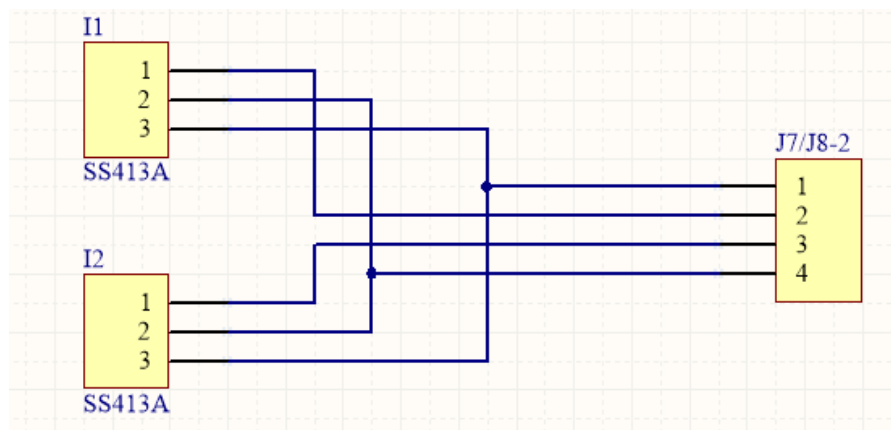

Figure 17 – Power supply

6.4 Speed sensors
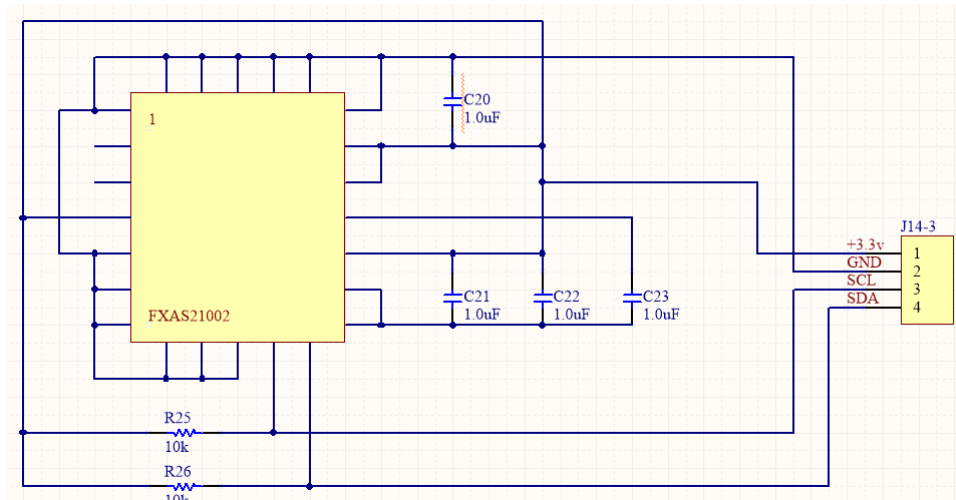

Figure 18 – Speed sensors

6.5 Gyroscope board

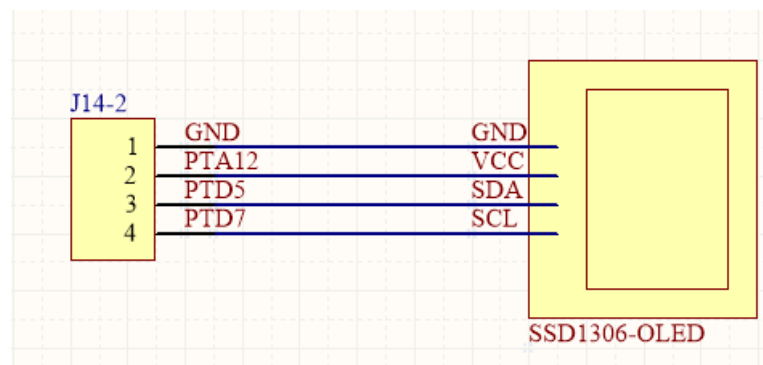Figure 19 – Gyroscope board

6.6 OLED Display

Figure 20 – OLED Display connection
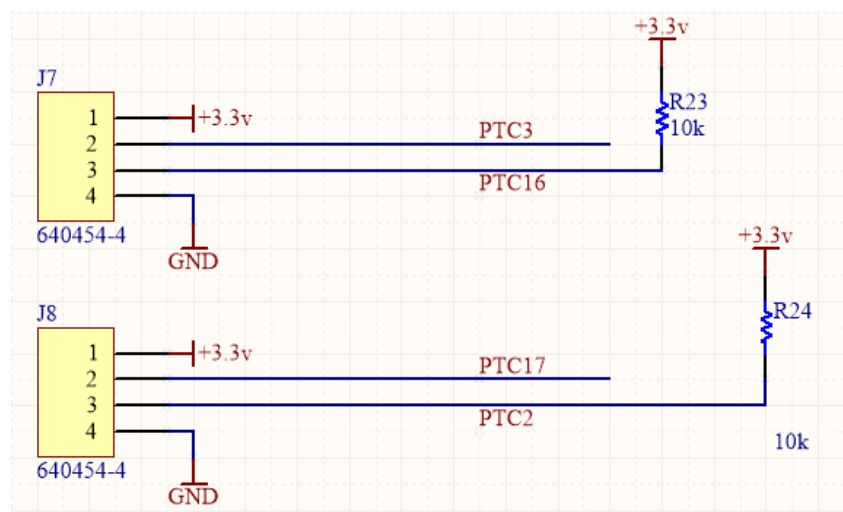
6.7 Speed sensors inputs

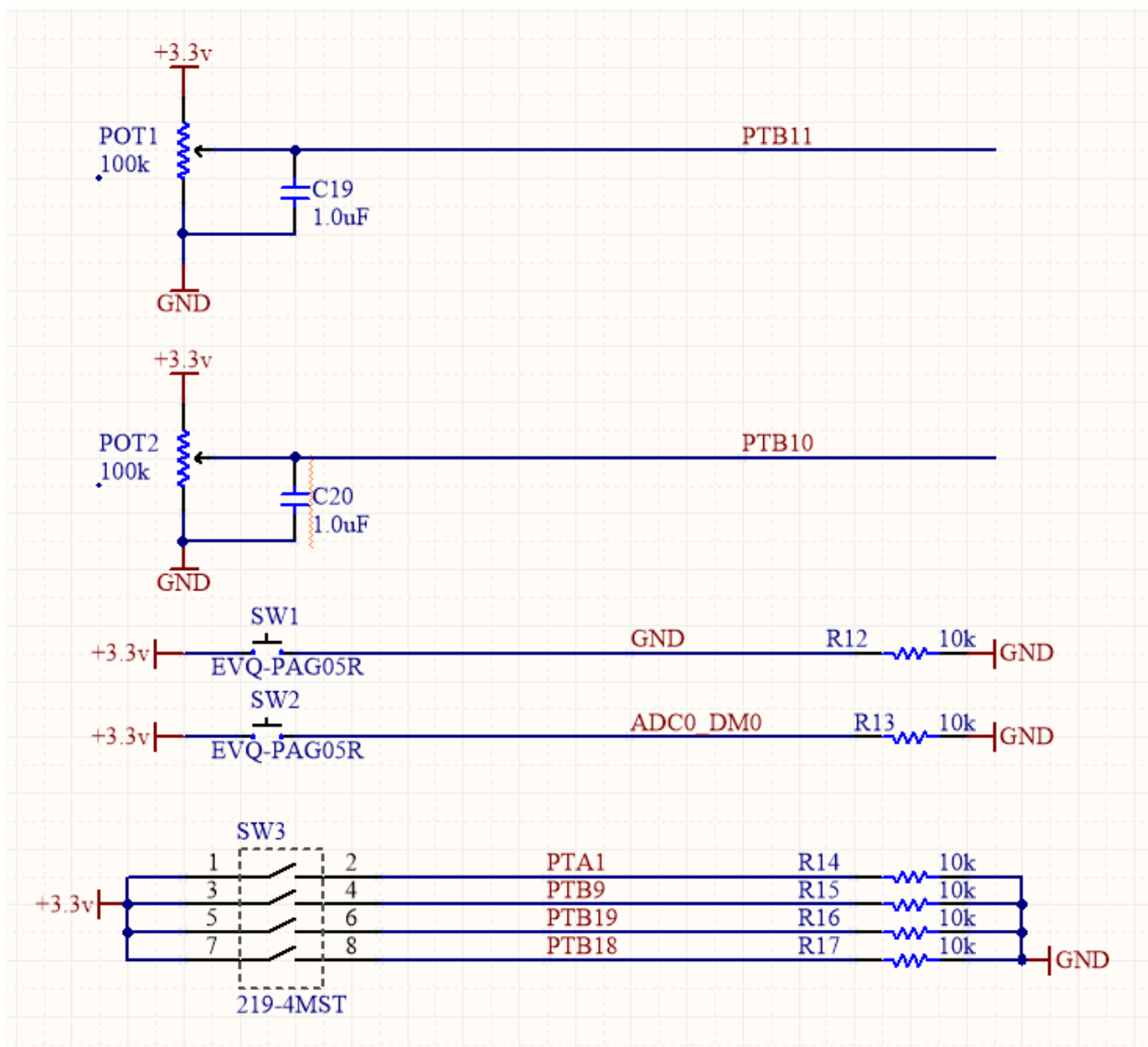Figure 21 – Speed sensors inputs

6.8 Input devices

Figure 22 – Input devices

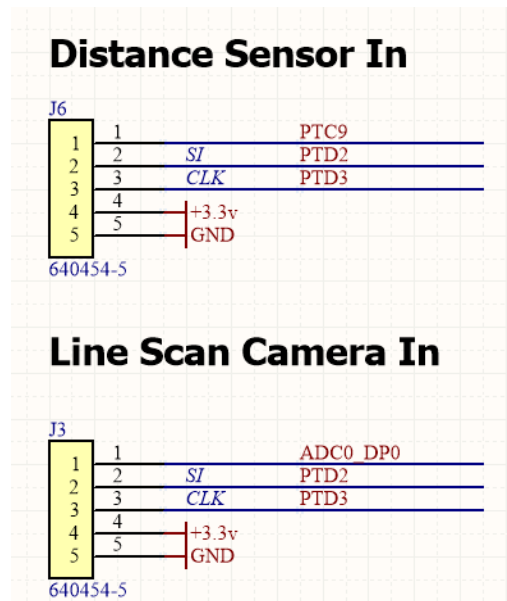## 6.9 Linescan camera and distance sensor inputs

Figure 23 - Linescan camera and distance sensor inputs
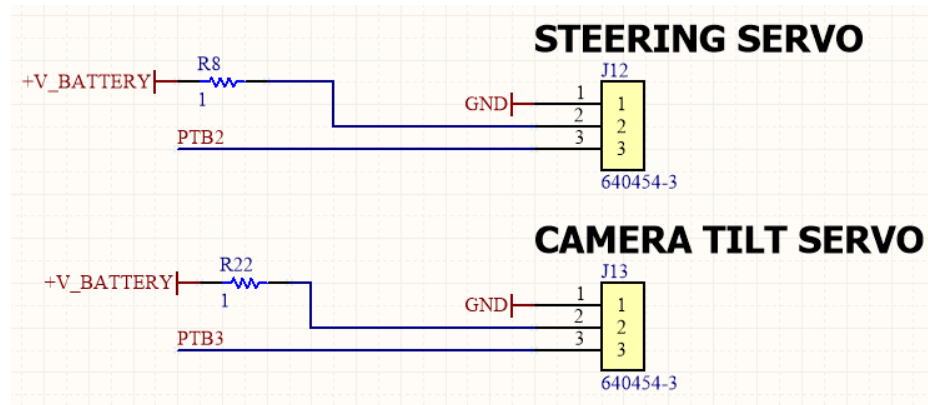
6.10 Servos

Figure 24 – Servo interfaces
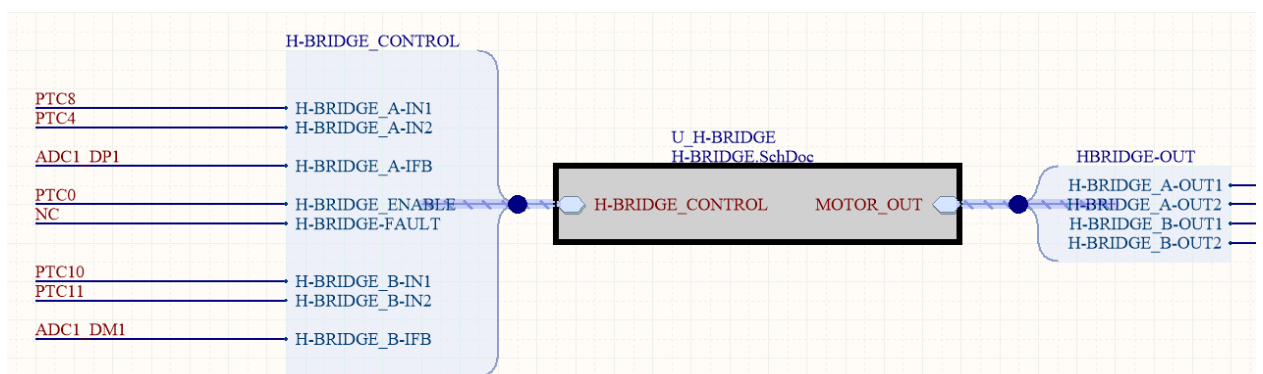
6.11 Motor control

Figure 25 – H-bridge control

7. CHARACTERISTICS OF THE CAR

7.1 DIMENSIONS AND WEIGHT

Length: 293 mm

Height: 275 mm

Width: 165 mm

Weight with battery: 825 grams

7.2 Power consumption

Name	Current	Power
Mainboard idle	98 mA	0.7 W
Operating mode, motors off	520 mA	3.75 W
Operating mode, motors stalled	7.3 A	52.56 W

8. BILL OF MATERIALS

Not including resistors, capacitors, etc.

Name	Description	Quantity	Price
Corona CS-929	Camera tilt servo	1	$4.52
Sharp GP2Y0A21YK	Optical proximity sensor	1	$4.80
SSD1306	OLED Display	1	$7.75
NXP FXAS21002	Gyroscope	1	$2.57
HC-05	Bluetooth module	1	$2.80
Molex 22-27-2041	4 pin header	2	$0.52
Honeywell SS413A	Hall effect sensor	4	$3.58
AGAPOWER 1500mAh 7.2V	Battery	1	$15.20
Battery T-Connector		2	$0.80
TCRT5000	Reflective Optical Sensor with Transistor Output	2	$0.72
Total			$42.54