



**Los Persistentes**

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**Freescale Cup**

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# 1. Description of mechanical design of car model

The main parts of this design are the encoders and board stages. Up next we will describe each one.

## Encoders design

In order to measure the speed, we decided to put a sensor on the right wheel using an infrared technology, also the electronic circuit is able to support another sensor if we need it (left wheel). The toothed disc with 32 tooth is connected to the wheel by a plastic mold, when the wheel rotates the encoder will receive the speed by the toothed disc.

25 cm

16 cm

6 cm

Image 1. Back view of the wheels with the encoder

6 cm

2 cm

Image 2. Lateral view of the wheel with the encoder

## Boards design

The car has an acrylic table above the DC motors, because there is easy to connect the motors, battery and the speed sensor. This acrylic table has the microprocessor, the power shield and the speed sensor boards. In case we need to put another circuit we left enough space in the table.

25 cm

10 cm

Couple speed sensor

Encoder

5v regulator

Image 3. Lower level

Kinetis & power shield

25 cm

10 cm

Image 4. Upper level

# 2. Description of control circuit design

The main part of this design is the microcontroller, the encoder and the camera.

First we created a function that return the value of normalize current speed (from 0 to 1, where 0 the car is stop and 1 it has a maximum speed), using the infrared encoder. Now we have a simple closed loop, we have a function that set the desired speed and an automatic control function that is executed every 10ms. It uses a proportional control algorithm. In the future we are going to implement a more complex automatic control algorithm.

Microcontroller

DC Motors

PWM duty cycle

Speed sensor

K

Speed Ref

0-1kHz

Image 5. Block diagram of the speed control

With the position is almost the same, we use the linear camera to get the black line, then using a proportional control the microcontroller change the position of the servo to follow the black line.

Microcontroller

DC Motors

PWM duty cycle

Linear camera

K

Spin Ref

0-128

Image 6. Block Diagram of the servo motor

# 3. Description of electronic design

The main parts of this design are the power control, linear coupling for the camera and the speed sensor. Up next we will describe each one.

## Power control (DC motors and servo motor)

We control the DC motors and servo motor by PWM (pulse width modulation), we use the board provided by Freescale which has two MC33932 (5.0 A Throttle Control H-Bridge).

This board has some advantages, for example, all the control pines correspond directly to a port of the kinetis, and it has a lot of connectors two for servo motors, two for linear cameras, and two for speed sensors. It can measure the voltage level battery by a divider resistor that is implemented inside the board, and some peripherals like push buttons, potentiometers, and a dip switch.

## Linear coupling for the camera

Sometimes we had a problems with the noise; our servo motor was doing strange moves, after investigate we decided to design a circuit between the linear camera output and the microprocessor, and then the signal was more stable than before. We put two simple buffers in cascade configuration. Actually the noise is not as bad as the beginning and we decided to leave this board just in case the noise come back stronger.

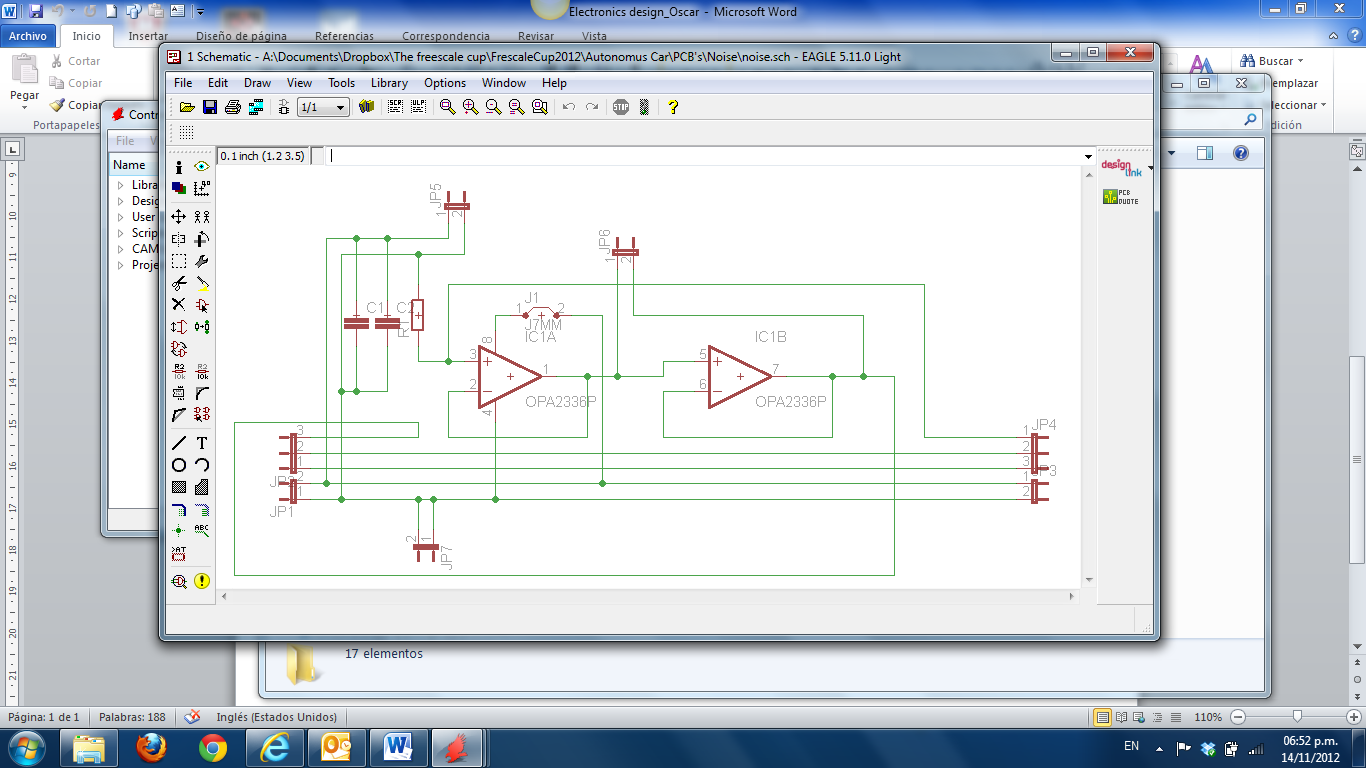


Image 7. Electric diagram of the linear coupling for the camera

## Speed sensor

We are using an encoder in order to measure the speed of the car, the encoder deliver a square signal, we implement a buffer and a smith trigger I.C. to clean the signal. After that the clean square signal goes to the kinetis in an input capture pin.

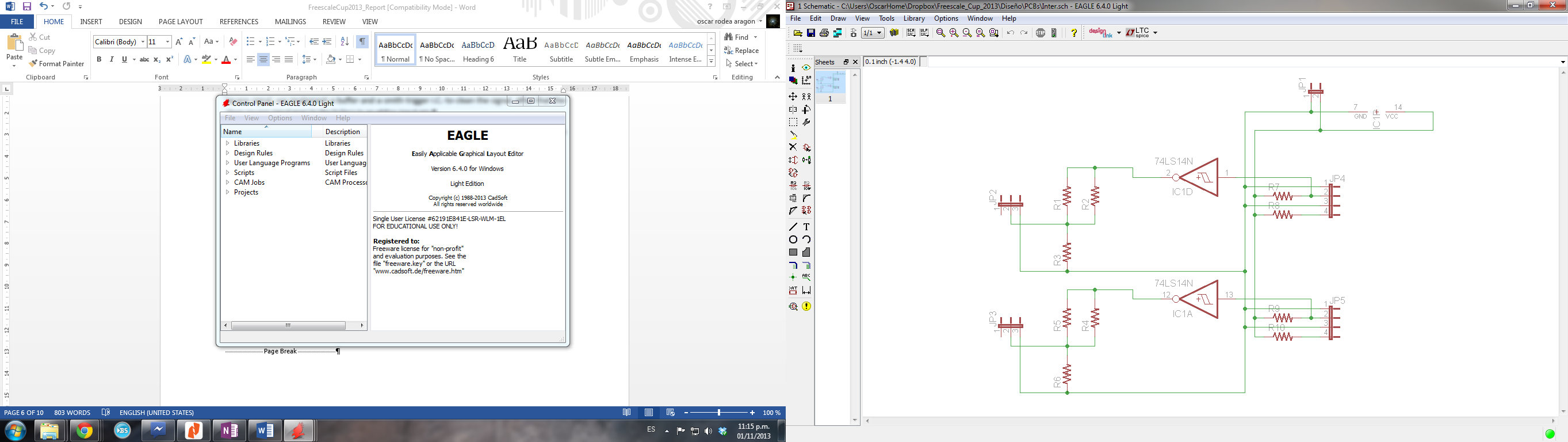


Image 8. Electric diagram speed sensor

**4.- Description of control software design**

**a. SW architecture and module interaction block diagram.**

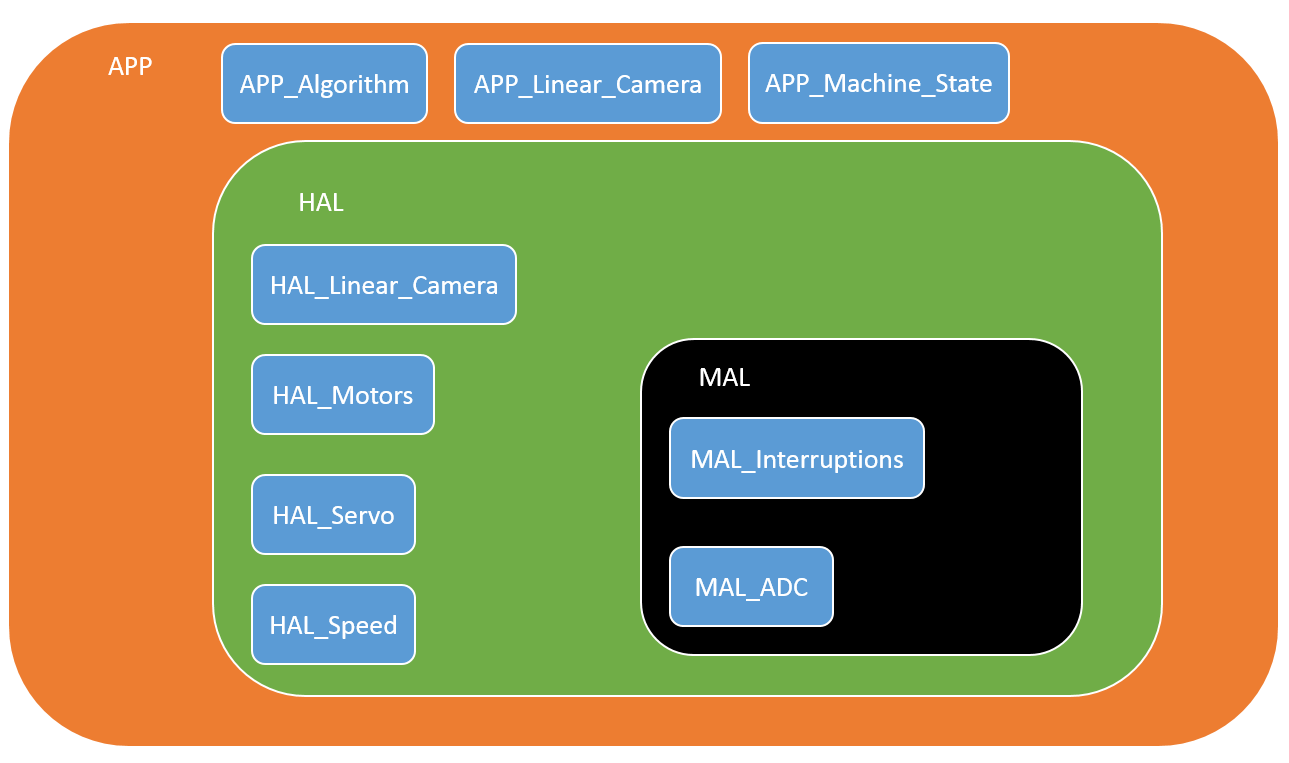
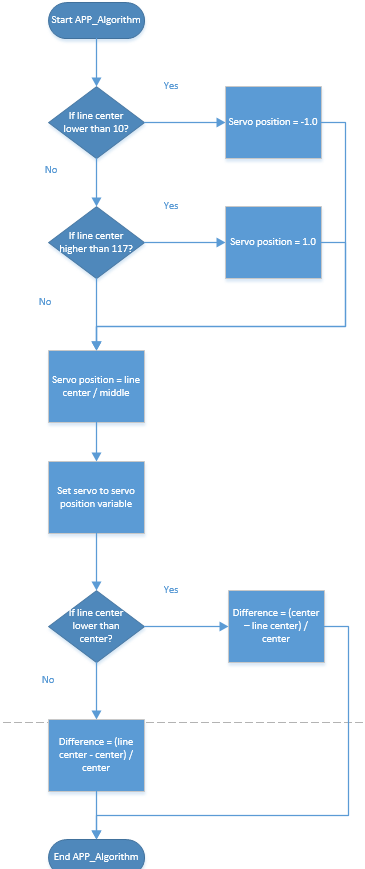


Image 9. Software architecture

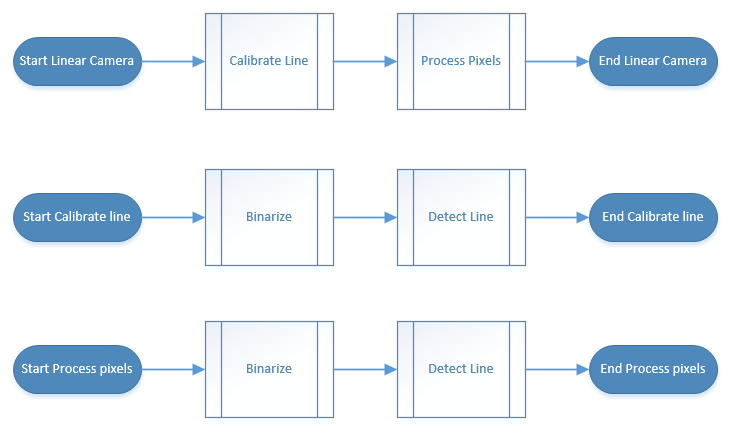
**b. Software design per module.**

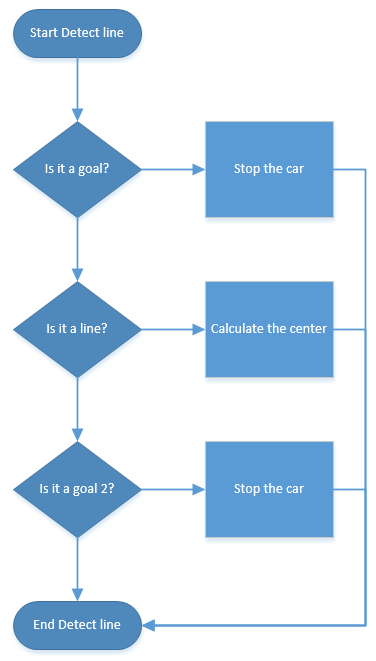
* **Aplication layer**

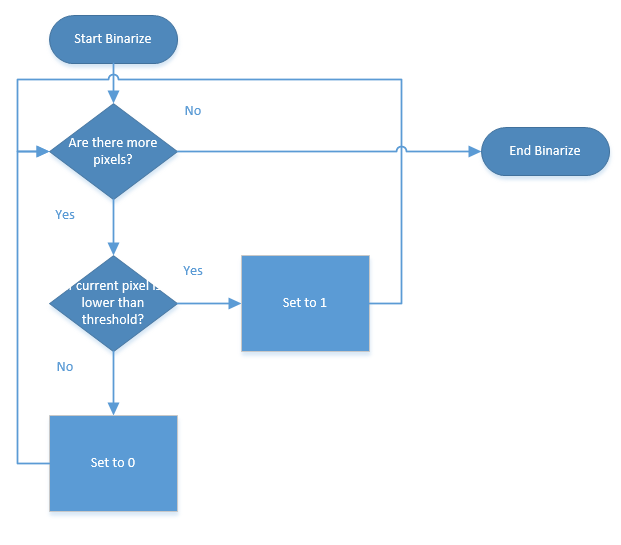
* + **APP\_Algorithm**



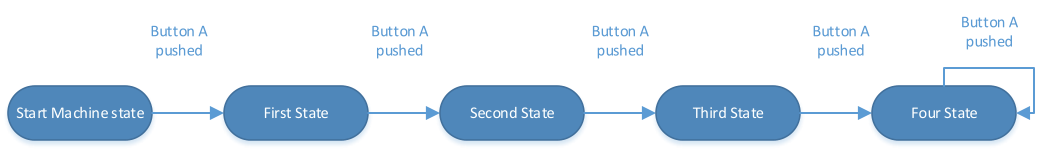
* + **APP\_Linear\_Camera**

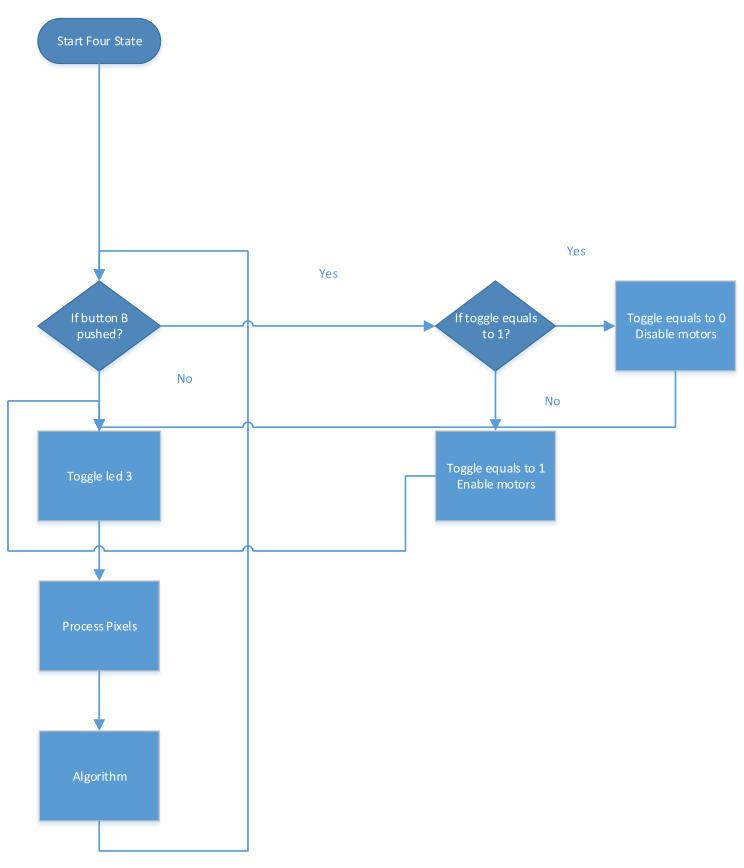
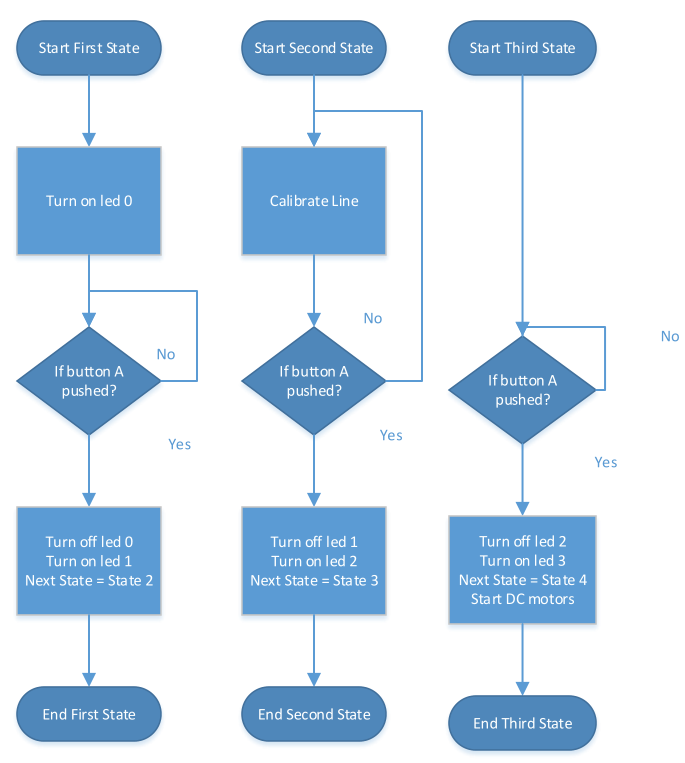






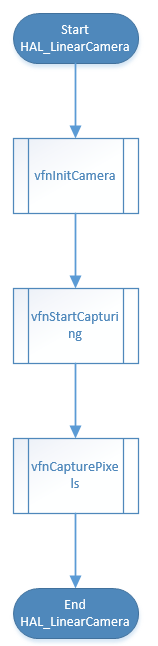
* + **APP\_Machine\_State**





* **Hardware layer**

* + **HAL\_Linear\_Camera**



* + **HAL\_Motors**



* + **HAL\_Servo**

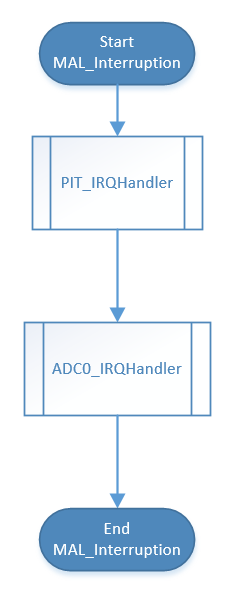


* + **HAL\_Speed**

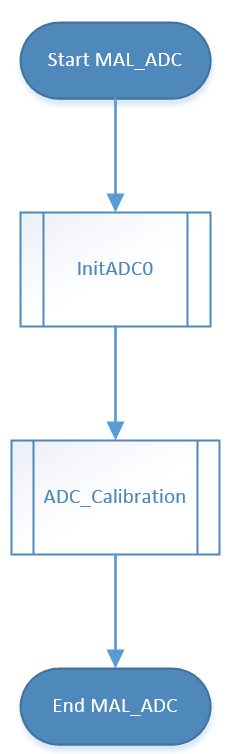


* **Microntroller layer**

* + **MAL\_Interruptions**



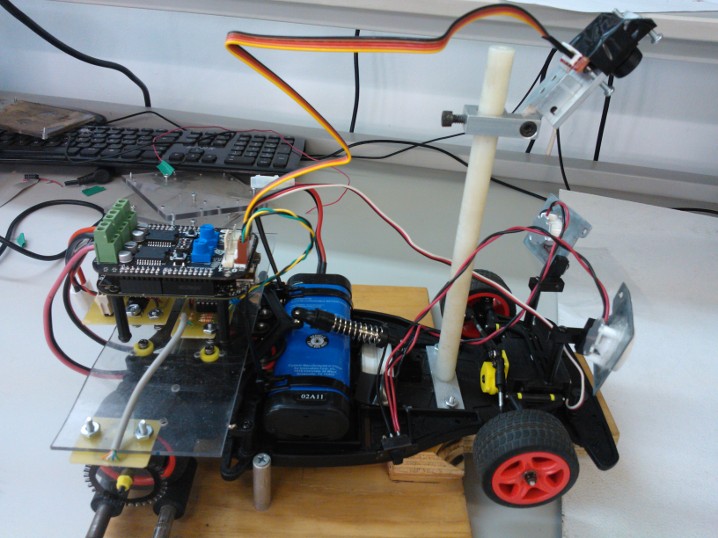
* + **MAL\_ADC**

  
  
**c. All code source files and project files.**

**Link to Google code repository**

http://code.google.com/p/elementxyz/source/browse/

**5. Total weight and dimensions of the reengineered car**



26 cm

28 cm

Weight 1.2Kg

# 6. Power consumption

The consumption is different; it depends of the speed of the motors, if we take as a reference that the speed is the highest the power consumption is:

The consumption at sleep mode is:

# 7. Count and type of sensors used

The sensor that we are using is a linear camera

# 8. Number of servo motors

We don’t use any extra servo motor besides the existing ones.

**9. Bibliography**

<http://www.ams.com/eng/LinearSensorArray>

<https://community.freescale.com/groups/tfc-mexico>

<http://www.stefanv.com/rcstuff/qf200005.html>

<http://www.ntsc-tv.com/>

Wang Xiuquan; Shen Xiaoliu; Chang Xiaoming; Chai Ying, "Route Identification and Direction Control of Smart Car Based on CMOS Image Sensor," *Computing, Communication, Control, and Management, 2008. CCCM '08. ISECS International Colloquium on* , vol.2, no., pp.176,179, 3-4 Aug. 2008

Ming-Shun Wang; Mou-Quan Shen, "Intelligent car control based on switching control," *Control and Decision Conference, 2008. CCDC 2008. Chinese* , vol., no., pp.3196,3199, 2-4 July 2008