University of Liege

faculty of applied sciences

INFO0064 Embedded Systems project

Development of an autonomous car

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Contents

1 Introduction

This project aims to create an autonomous car that will be able to avoid obstacles by changing its direction.

2 Hardware

ATTENTION : Note that transmitter for infra sensors are sold by 5. We just need **TWO** of them!

Here comes the different components we will use in order to do our project.

- **2** Servo motors

⇒ Lien : https://www.farnell.com datasheets/3708794.pdf

⇒ Justification :

1) The first servo motor is needed in order to control the direction of the car by adjusting the angle of the steering to which the front wheels are attached.

2) The second one is used for the handbrake.

- **2** Motors DC 12 V (1 A)

⇒ Lien : https://www.farnell.com/datasheets/3708794.pdf

⇒ Justification :

1) One idea is to attach the motors to the front wheels.

2) Alternatively, they could be attached on the back wheels, allowing the car to go straight while the servo motors could handle the steering.

- **1** Complete Bridge Motor Controller

⇒ Lien : https://www.farnell.com/datasheets/1693054.pdf

⇒ Justification :

1) This device is used for this implementation and was chosen based on compatibility with their specifications and power requirements.

- **2** Sensors Ultra & **2** Sensors Infra

⇒ Lien : https://www.farnell.com/datasheets/3422740.pdf_gl=1*b8dzj*_gcl_aw*R0NMLjE3MzM0MzQ3OTUuQ2owS0NRaUF1OFc2QmhDLUFSSXNBQ0VRb0RCajJkM1JjczR2R201WUNvV3ZZLTVoSVE3T1FkQmxjNHNTSG5qbk9XSzFNY18teXVRSjNPc2FBdmFHRUFMd193Y0I.*_gcl_au*MTYwMzk0MTg0Mi4xNzMzNDI2MjIz

⇒ Justification :

1) We chose to use ultra sensors to detect obstacles either in front of or behind the car.

2) We chose to use infra sensors to detect obstacles on both sides. Besides, the infra are faster than the ultra and better to evaluate distance.

- **2** Transmitter Infra

⇒ Lien : https://www.farnell.com/datasheets/2049868.pdf

⇒ Justification :

1) Use to transmit infra sensors.

- **1** Receiver Infra

⇒ Lien : https://www.farnell.com/datasheets/2049841.pdf

⇒ Justification :

1) Use to receive infra sensors.

- **4** Battery (1,5 V)

⇒ Lien : https://www.farnell.comdatasheets/3743834.pdf_gl=1*1pscblf*_gcl_aw*R0NMLjE3MzM0MzQ3OTUuQ2owS0NRaUF1OFc2QmhDLUFSSXNBQ0VRb0RCajJkM1JjczR2R201WUNvV3ZZLTVoSVE3T1FkQmxjNHNTSG5qbk9XSzFNY18teXVRSjNPc2FBdmFHRUFMd193Y0I.*_gcl_au*MTYwMzk0MTg0Mi4xNzMzNDI2MjIz

⇒ Justification :

1) This package of four cells (total of 6V) was chosen to supply our project and to match the load requirement of the motors.

- **1** Support Battery

⇒ Lien : https://www.farnell.com/datasheets/2629289.pdf

⇒ Justification :

1) Use to support the battery.

- **1** Linear Tension Regulator

⇒ Lien : https://4donline.ihs.com/images/VipMasterIC/IC/MCRL/MCRLS04241/MCRLS04241-1.pdf?hkey=6D3A4C79FDBF58556ACFDE234799DDF0

⇒ Justification :

1) Since the sensors and micro-controllers operate on a 5 V supply and our battery delivers 6 V, a voltage regulator is necessary. It provide the required voltage to all components while preventing damage from over-voltage.

- **1** PIC16F1789

⇒ Justification :

1) It is used to contain and execute the program of the project through the necessary peripheral.

2.1 Electronic schematic

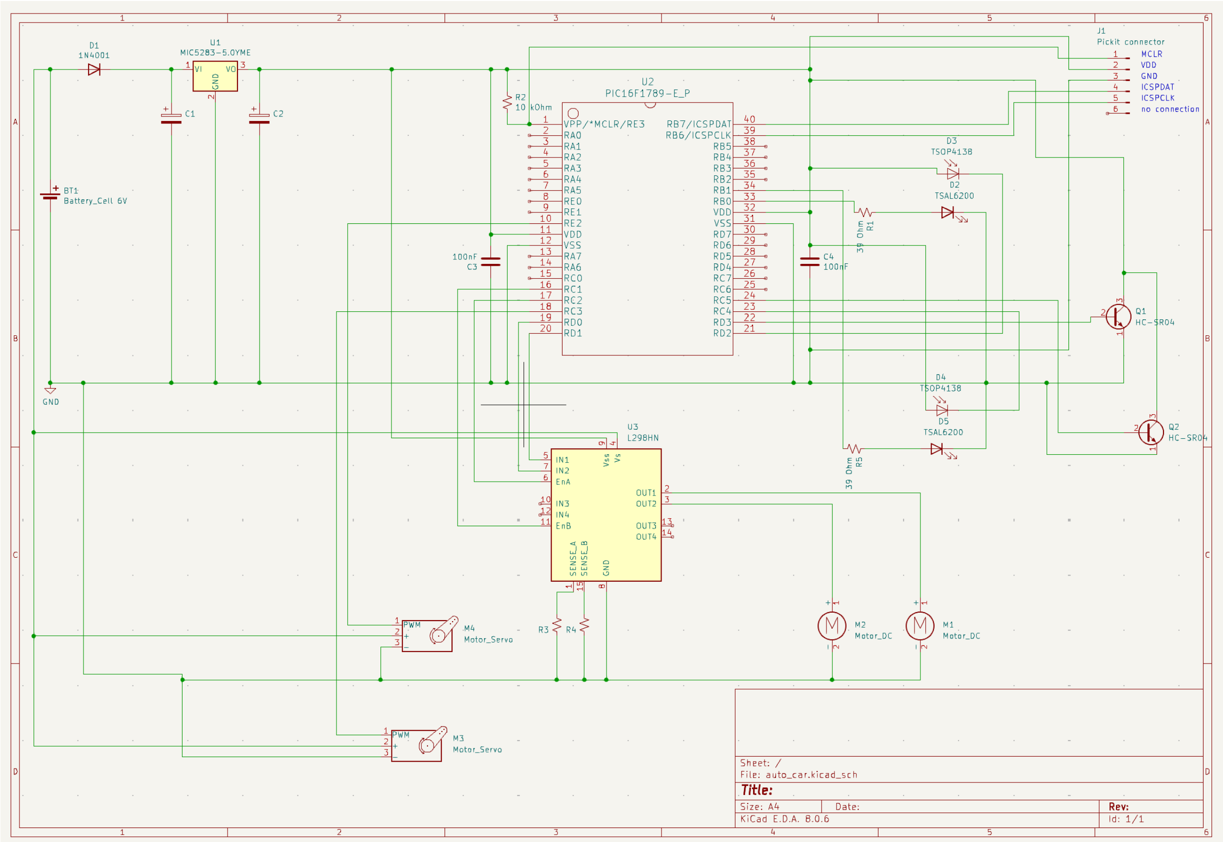

Figure 1: Schematic

This schematic is not final or complete; it still needs further work and adjustments. We had to use pre-made component schematics from the KiCad library. For instance, the infrared sensor is represented by a LED, and the ultrasonic sensor is shown with a transistor. Some resistors and capacitors are missing, and their values have not been specified.

3 Software

3.1 List of tasks

- τ_1: Motors control
- τ_2: Sensors data acquisition
- τ_3: Servo motors control
- τ_4: Motors data acquisition

3.2 Tasks description

- τ_1:
  This task consists of controlling the DC motors of the car, which enables the car to move. Controlling the motors also means changing the direction of the wheels. Indeed, by controlling the motors, the car is able to turn, which is necessary to avoid obstacles. The motors are controlled through the PWM peripheral.

- τ_2:
  `1) Ultrasound :`
  This task consists of detecting obstacles either in front of or behind the car using ultrasound sensors. They periodically send a signal that generates 8 instances of sound waves. When the sensor detects a reflected signal (an echo), it triggers a response on the echo pin. This signal is then used to calculate the distance to an obstacle by measuring the time it took for the sound waves to travel to the obstacle and back. The test distance is calculated by doing : ((high level time) * (velocity of sound))/2. We suggest to use over 60 ms measurement cycle in order to prevent the echo signal from being triggered.

  `2) Infrared :`
  In the same way, this task focus on detecting obstacles from both sides using infrared sensors. Those latter are also used as distance calculators to compute the difference in distances between the "nearest wall" and the "parking place wall" to check if the car can be parked in the parking place. If the distance is large enough, the parallel parking can be done using the sensors to avoid hitting any walls.

- τ_3:
  This task focus on controlling the servo motors to enable the car to turn. Indeed, they are responsible for adjusting the angle of the front wheels, allowing the car to steer to the left or right. The steering of the autonomous car is controlled through a mechanical part, specifically the steering rod. The steering adjustments are made based on the navigation instructions provided by the car's sensors or the control module, ensuring that the vehicle follows its intended path. The servo motors operate by receiving a continuous signal, which is converted into a PWM (Pulse Width Modulation) signal. The angle of the wheels is adjusted according to the duration of the event period within each PWM cycle, ensuring precise and responsive steering control for the car.

- τ_4 :
  This task consists of acquiring data from the motors such as the velocity, the distance traveled by the car. The signals acquired from the motors are analog and require an ADC to convert them into a digital representation of the motor's actual angle relative to a reference point, which will be used as feedback to control motors.

3.3 Task priorities

$P(\tau_1) > P(\tau_2) > P(\tau_3) > P(\tau_4)$

3.4 Use of the interrupt routines

Interrupts are used to handle critical events (e.g., detecting an obstacle) that require immediate attention.

In this project, one interrupt routine is used for the sensor data acquisition. The interrupt is used to temporarily suspend the program execution in order to execute the interrupt routine which in this case is the sensor data acquisition. By doing so, this task is being prioritized.

3.5 Preemption need

Preemption is used to prioritize a task over another task and defines a more precise order of priority. The sensor data acquisition task is prioritized over the motor control task. Therefore, the obstacle detection is a priority in our project.

3.6 Software architecture

For this project, we use the architecture RTOS (= Real-Time Operating System) for several reasons. The main one being that it can manage real-time tasks which ensures a determined precised period. For instance, the sensors have to be regularly read to avoid any delay. Moreover, this software architecture enables the use of priority tasks such as preemption.