# MBSD Lab #4 A.Y. 2023/24

## Purposes

- Integrate the one-pedal controller into a simulated Arduino Uno[1] microcontroller (μC), resorting to SimulIDE[2].
- Interact with the μC through its digital and analog interfaces.

## Instructions

For instructions on how to use SimulIDE and the Platform Support Packages, follow the instructions provided by Prof. Violante in the lectures.

The delivery shall contain:

- The controller Simulink model is used to generate the firmware binary file (plus all the accompanying files needed to make it possible to generate the code again, like .m files containing initializations)
- The firmware binary file to be loaded into the simulated Arduino in SimulIDE
- The SimulIDE project file.
- The PDF or Microsoft Word version of the report.

Is available an example based on a Tank level controller in the folder

The deliverable has to be provided as a . ZIP file up to **June 23rd at 23:59. It shall also contain a brief report explaining the** integration process using the following template. It is sufficient that only one of the group members uploads it.

[1] Arduino Uno Board Anatomy https://docs.arduino.cc/tutorials/uno-rev3/BoardAnatomy, last visited on 16/05/2022.
[2] SimulIDE, https://www.simulide.com/p/home.html, last visited on 16/05/2022.

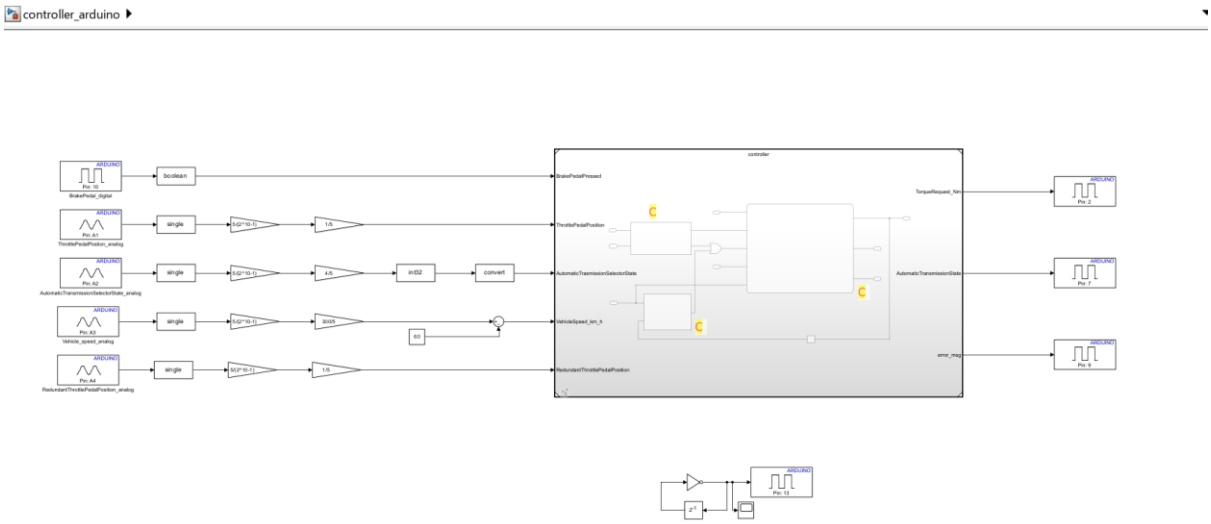
# Model-Based Software Design, A.Y. 2023/24

# Laboratory 4 Report

## Components of the working group (max 2 people)

- Luca Pili s331500, Riccardo Solazzo s331337

# I/O interfaces




| Name | Unit | Type[3] | Conversion formulas | Min[4] | Max |
|---|---|---|---|---|---|
| `BrakePedal_digital` | / | DI | / | 0 | 1 |
| `ThrottlePedalPosition_analog` | / | AI | $V_{in} = Raw_{in} \cdot \frac{5}{2^{10}-1} \cdot \frac{1}{5}$ | 0 | 1 |
| `AutomaticTransmissionSelectorState` | / | AI | $V_{in} = Raw_{in} \cdot \frac{5}{2^{10}-1} \cdot \frac{4}{5}$ | 0 | 4 |
| `Vehicle_speed_analog` | m/s | AI | $V_{in} = Raw_{in} \cdot \frac{5}{2^{10}-1} \cdot \frac{300}{5} - 60$ | -60 | 240 |

[3] Digital Input (DI), Digital Output (DO), Analog Input (AI).
For AIs, provide the conversion formula from input voltage to the measurement unit data (indicating also how to perform the conversion from the raw reading of the ADC).
[4] The Min/Max values that can be handled due to the conversion formula shall be expressed in the measurement unit specified in the Unit column.

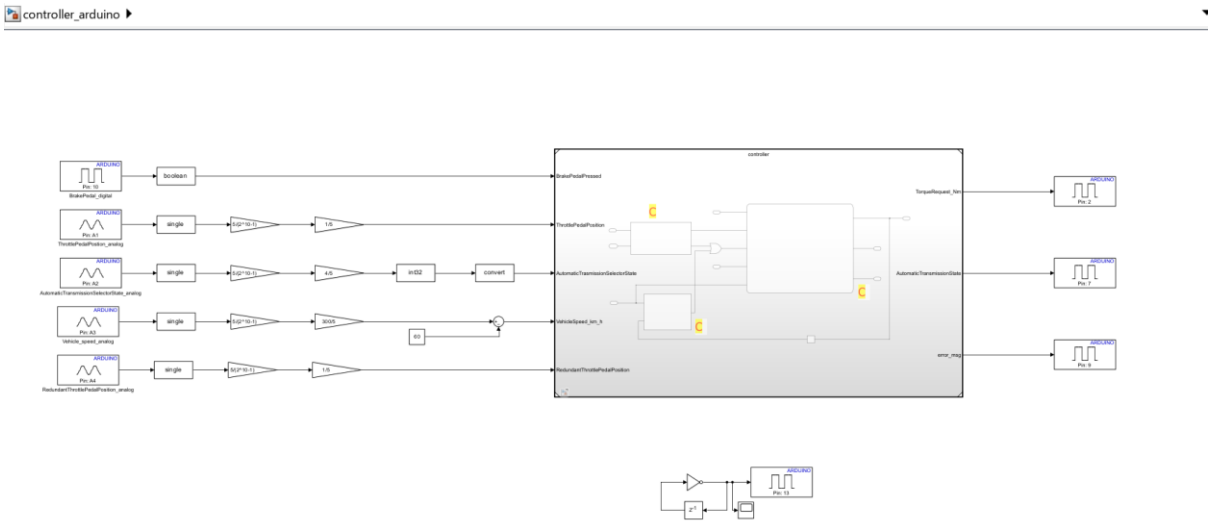
## Code generation for Arduino

First of all the Simulink model settings are modified as follows:

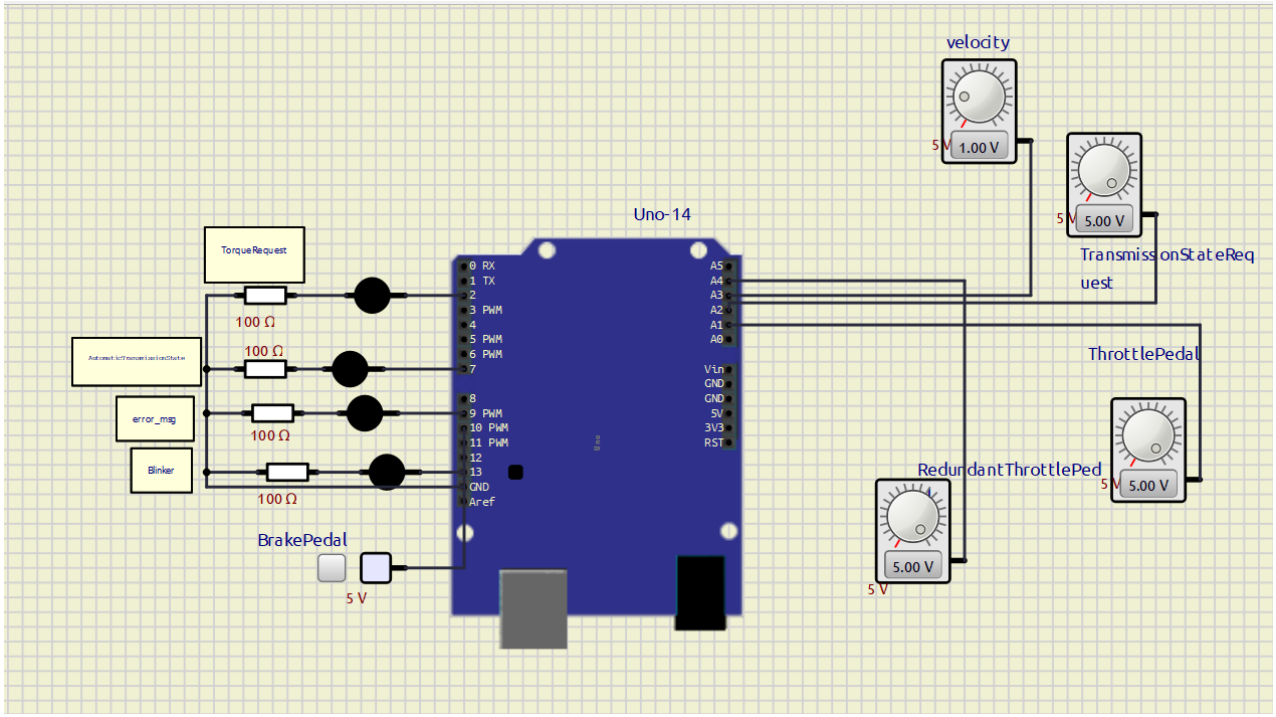
- the solver is set to fixed step with step = 1/10;
- the hardware board selected for code generation is set to “Arduino Uno”.

Then, the I/O interface is managed exploiting the Arduino analog input, digital input and digital output blocks provided by the Support Packag; the analog inputs are converted into a proper digital input for the controller implemented in Simulink.

Finally, the code is generated and deployed both on the SimulIDE project and on the real HW board.

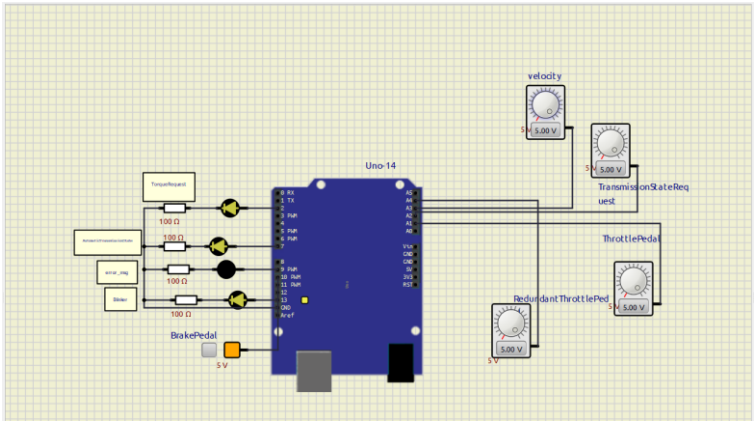


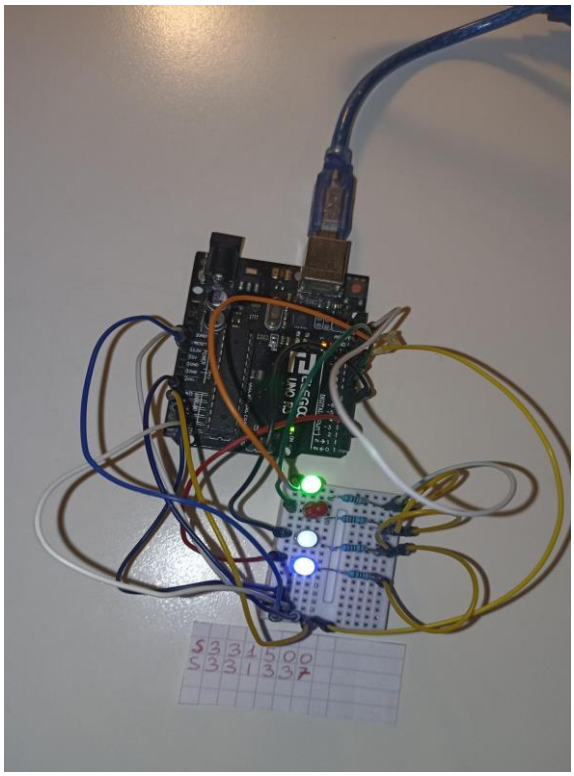

## Harness



## Test stimuli

In order to test the controller functionalities, suitable inputs are provided to simulate faultess and faulty scenarios.
In a faultess scenario, the provided inputs are consistent with each other: in this way the torque is correctly requested and the state transitions are correctly performed, as shown in the figures below.

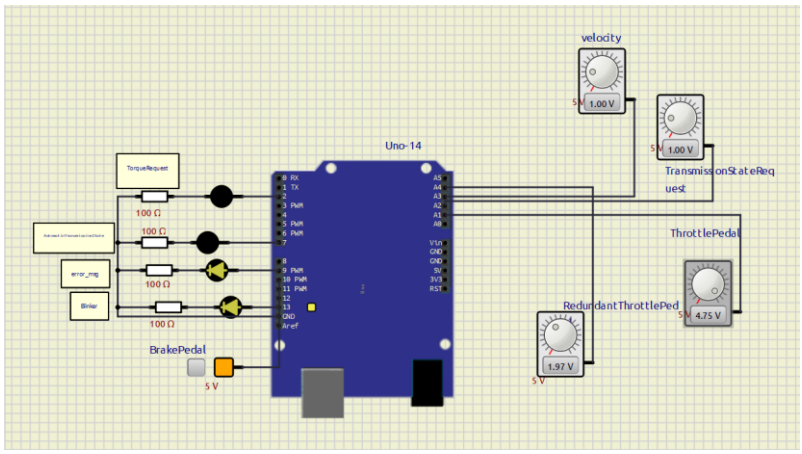


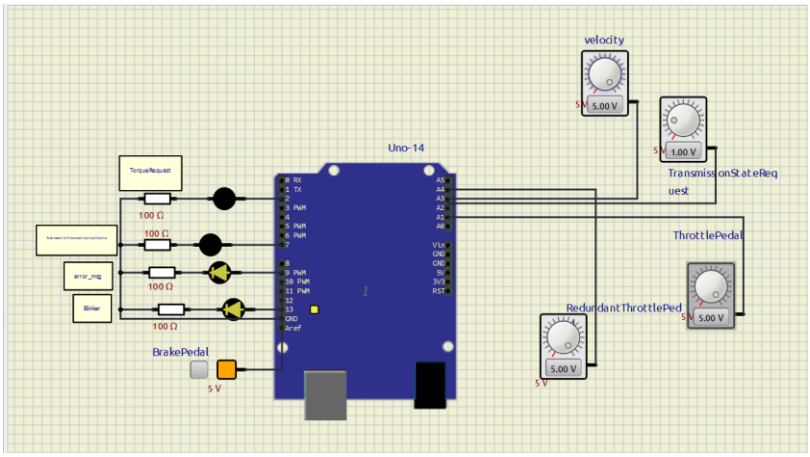



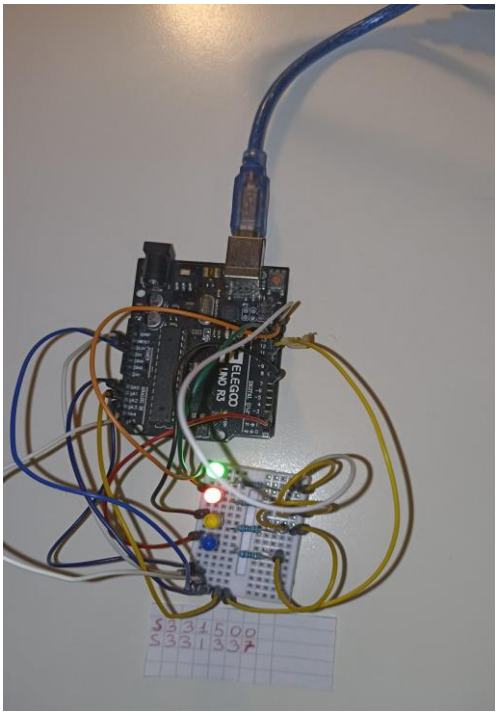
Then, the safety functions are tested by fault injection, in particular the following faulty scenarios are simulated:

- discrepancy between the two throttle inputs greater than 5%;
- vehicle speed not consistent with the current transmission state.

As shown in the pictures below, in both cases an error led turns on.


velocity
1.00 V
1.00 V
TransmissionStateReq
uest
Uno-14
TorqueRequest
100 Ω
100 Ω
error_msg
100 Ω
Blinker
100 Ω
BrakePedal
5 V
ThrottlePedal
4.75 V
RedundantThrottlePed
1.97 V
5 V


velocity
5.00 V
1.00 V
TransmissionStateReq
uest
Uno-14
TorqueRequest
100 Ω
100 Ω
error_msg
100 Ω
Blinker
100 Ω
BrakePedal
5 V
ThrottlePedal
5.00 V
RedundantThrottlePed
5.00 V
5 V


ELEGOO
UNO R3