# Critical Design Review

## MISCE project

Mechatronics for Improving and Standardizing Competences in Engineering

Competence: Control Engineering

Experimental platform: DC-motor Control

Workgroup: Universidad de Castilla-La Mancha

Universitat Politècnica de València

This document is the Critical Design Review of the technical competence ‘Control Engineering’. Its details the complete design of the DC-motor control platform.

Version: 1.0

Date: November 13th, 2023

Visit https://misceproject.eu/ for more information.

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# 1 Introduction

## 1.1 Scope

This document presents the detailed design of the DC-motor control platform developed in the framework of MISCE project.

The final objective is to use the develop platform in the practical lectures of engineering degrees to contribute to the technical competence:

| **C1. Control Engineering** |
|---|

which related skills are (see Table I):

Table I. Skills of Control Engineering

| | |
|---|---|
| S1.1. | Understanding the static and dynamic responses of a system |
| S1.2. | Proficiency in implementing/utilizing PID-type controllers |
| S1.3. | Tuning various controller parameters |
| S1.4. | Identifying unknown systems |
| S1.5. | Enhancing the dynamic responses of controlled systems |

## 1.2 Preliminary definition

This experimental platform has been widely analysed for teaching purposes (e.g. [1-3]). It consists on a DC motor/gearbox set, with a coupled encoder to measure its angular position and a marker to visually note the angular pose of physical axis of the gearbox (see Figure 1).

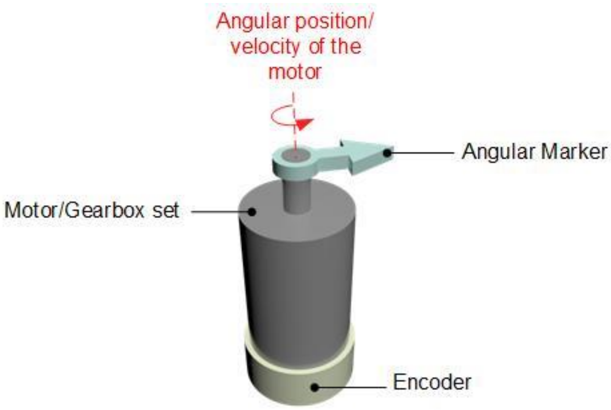


Figure 1. DC motor platform

This proposal requires of the electronics and control devices that allows to control the angular position or velocity of the motor, which is the main goal.

The main advantage of this experimental platform is that is widely used in different academic activities. In addition, the dynamics of the motor is well-know and easy to be controlled and offers a very illustrative way to introduce in all the skills of control engineering competence.

On the contrary, the main drawback is that some important dynamics (as time delays or unstable plants) do not appear on it.

## 1.3 Technical requirements

The technical requirements to efficiently contribute to the achievement of skills of Table I are:

R1. The device shall allow to warm up the motor by exciting it with a high-level control signal during a customizable time.

R2. The DC-motor gear box set shall be excited by step input signals with customizable amplitude and outputs the angular position and/or velocity of the output shaft. This requirement is aligned to the motor identification procedure.

R3. The device shall be able to control the velocity of the output shaft by means of:

a. A PID type controller with customizable parameters: $K_p$, $K_i$ and $K_d$:

$$R(s) = K_p + K_i \cdot \frac{1}{s} + K_d \cdot s$$

b. A poles/zeros defined controller following this expression:

$$R(s) = k \cdot \frac{s + c}{s + p} \cdot \frac{s + c_i}{s + p_i}$$

R4. The device shall be able to control the angular position of the output shaft by means of:

a. A PID type controller with customizable parameters: $K_p$, $K_i$ and $K_d$:

$$R(s) = K_p + K_i \cdot \frac{1}{s} + K_d \cdot s$$

b. A poles/zeros defined controller following this expression:

$$R(s) = k \cdot \frac{s + c}{s + p} \cdot \frac{s + c_i}{s + p_i}$$

R5. For all experiments, the device shall allow the user to save the experimental results in terms of time, input reference, output and control signal.

R6. For all closed loop experiments, the device shall show a figure with the input reference and the output.

# 2 Hardware design

## 2.1 Functional parts

The hardware design includes some functional parts that shall be easy to find and to acquire by the teaching professionals. In this case, the following functional elements have been selected:

- DC Motor/gearbox set 12V and gearbox ratio between 10 and 100 with 64 CPR hall encoder.

Figure 2. DC-motor/gearbox set

- Microcontroller Arduino Mega rev 3:


Figure 3. Arduino Mega rev 3

- Driver module L298N:

Figure 4. Driver module L298N

- Converter module FT232 usb c:


Figure 5. Converter module FT232 usb c

- External Power Supply 12V-5A:

Figure 6. Generic external power supply 12V (up to 5A)

- Additional elements: This item includes cables, connectors, screws, … see Mounting Instruction document for more details.

With these functional elements the hardware architecture of the device is shown in Figure 7.

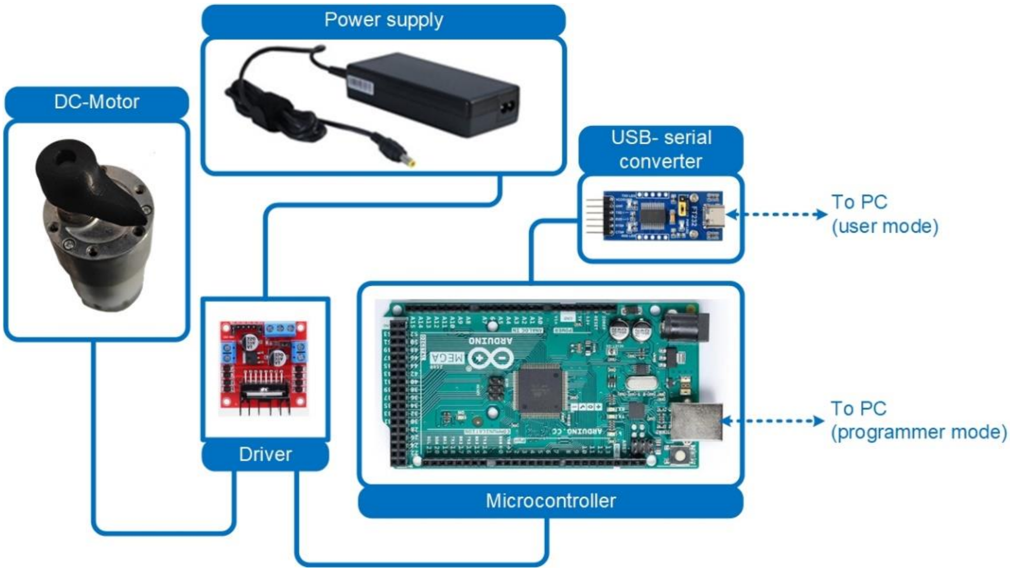


Figure 7. Hardware architecture of the experimental platform

## 2.2 Mechanical design

The mechanical design of the device has been carried out to be built by a conventional 3D printer. The 'box' contains' all the aforementioned functional elements making the device a compact experimental platform. Figure 8 shows some renders illustrating the designed experimental platform. The .STL files to print the different parts can be downloaded at: www.misceproject.com.

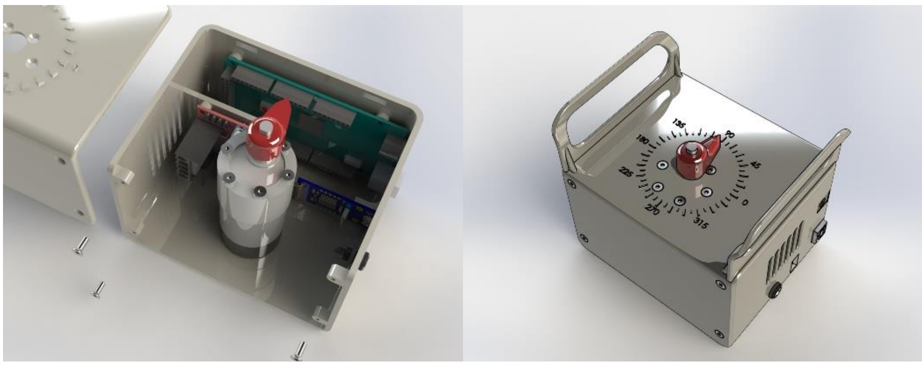

Figure 8. Ball and beam platform

The final aspect of the experimental platform is shown in Figure 9.

Figure 9. Experimental platform overview

# 3 Software design

## 3.1 Preliminaries

The software has been designed to be usable by any user (professors/students) without any licensable software requirements. In this way, the microcontroller Arduino Mega rev 3 has been programmed using its IDE (https://www.arduino.cc/en/software) and a front application has been designed using App Designer of Matlab® https://es.mathworks.com/products/matlab/app-designer.html).

Both applications are communicated by means of a USB port, usually available in any desktop or laptop computer. Figure 10 illustrates the software architecture.

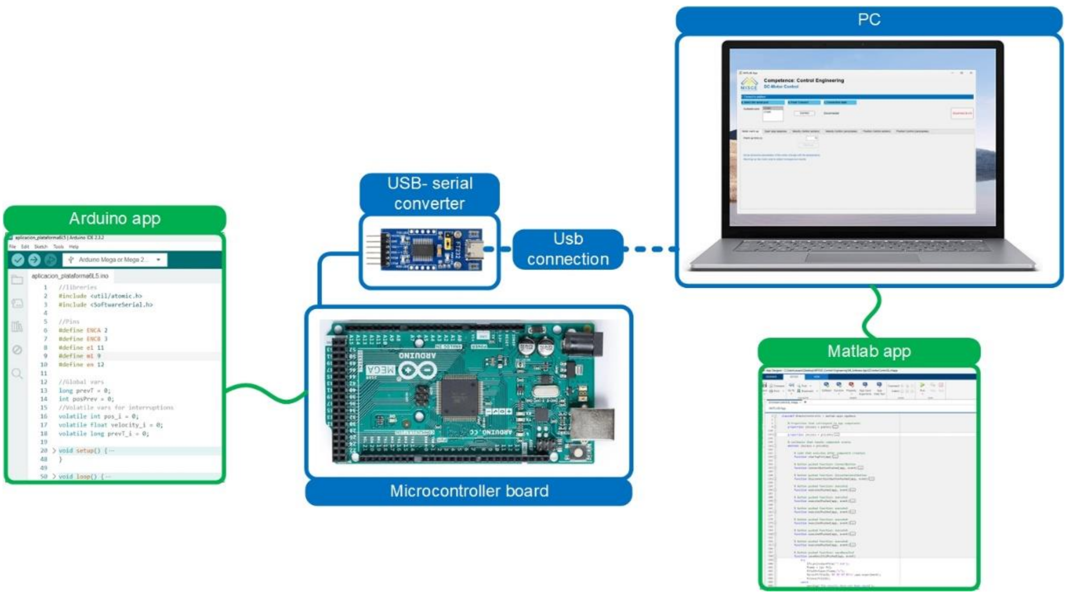


Figure 10. Software architecture of the experimental platform

The end-user of the device only has to download the Arduino Program from MISCE project webpage and upload it into Arduino board and to install the Matlab designed app.

## 3.2 App design (Matlab®)

The code of the Matlab® app and its corresponding installer file are available, under demand, in MISCE project webpage.

## 3.3 Software design (Arduino®)

The Arduino code is also available, under demand, in MISCE project webpage.