Critical Design Review

MISCE project

Mechatronics for Improving and Standardizing Competences in Engineering

Competence: Mechatronics

Experimental platform: Mechatronics Motion Platform

Workgroup: Universidade do Minho

This document is the Critical Design Review of the technical competence ‘Mechatronics’. Its details the complete design of the conveyor and rotating disk platform.

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

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1 Introduction

1.1 Scope

This document presents the Critical Design Review of the competence Motion Control in Industrial Automation Systems, following the laboratory activities previously planned and tested with the OMRON NJ controller and Sysmac Studio software. The final objective is to use the develop platform in the practical lectures of engineering degrees to contribute to the technical competence:

C9. Mechatronics

which related skills are (see Table I):

Table I. Skills of Control Engineering

S9.1.	Configure and integrate servo axes via EtherCAT in an industrial environment
S9.2.	Set up units, limits, and operational parameters for each axis
S9.3.	Perform movement tests (MC Test Run) and validate operation
S9.4.	Program basic motion commands (MC_Power, MC_Home, MC_Move)
S9.5.	Develop sequential automation logic for coordination of multiple axes

1.2 Preliminary definition

The training environment includes 1S servo drive controlling a conveyor (Axis1) and a rotating disk (Axis2). The exercises focus on real-time implementation of motion control programming, error detection, sensor interaction, and task coordination.

Figure 1. Training environment

1.3 Technical requirements

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

R1. **EtherCAT Configuration and Axis Detection:** The system must support automatic detection and configuration of servo drives (1S/G5) through EtherCAT Topology Scan. Proper axis naming, unit assignment, and encoder resolution must be set.

R2. **Axis Calibration and Unit Management:** Each axis must be configured with appropriate mechanical limits, gear ratios, and unit conversions (e.g., mm, deg). The motion range should be adjusted for safe operation.

R3. **Sensor Integration and Event Handling:** The controller must process virtual or physical sensor inputs to detect object presence and trigger appropriate actions. Logic must respond to timeouts and missing detections.

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R5. **Sequential Motion Logic:** A coordinated sequence must control Axis1 (conveyor) and Axis2 (labeling disk), ensuring synchronization and interlocked behaviour based on sensor feedback.

R6. **Error Detection and Safety Recovery:** The system must detect operational faults (e.g., object not detected in time) and respond with controlled halts. Recovery logic should allow resuming normal operation after correction.

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:

- 2 Servo Drive 1S (R88D-1SN02H-ECT) from the manufacture OMRON.

Figure 2. Servo Drive

- 2 Servo-motor R88M-1M20030H-BS2:

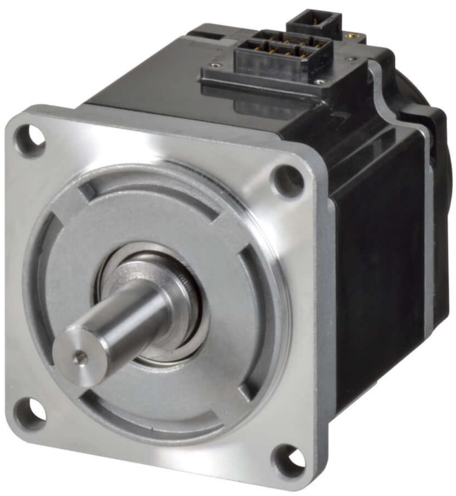

Figure 3. Sevomotor

- Power Supply 24V-5A:

Figure 4. DIN Power supply 24V (up to 5A)

- PLC with motion NX1P2-1140DT1 with 4 synchronized axes + 4 PTP axes:

Figure 5. PLC with Ethercat and Motion Contorl

- 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 6.

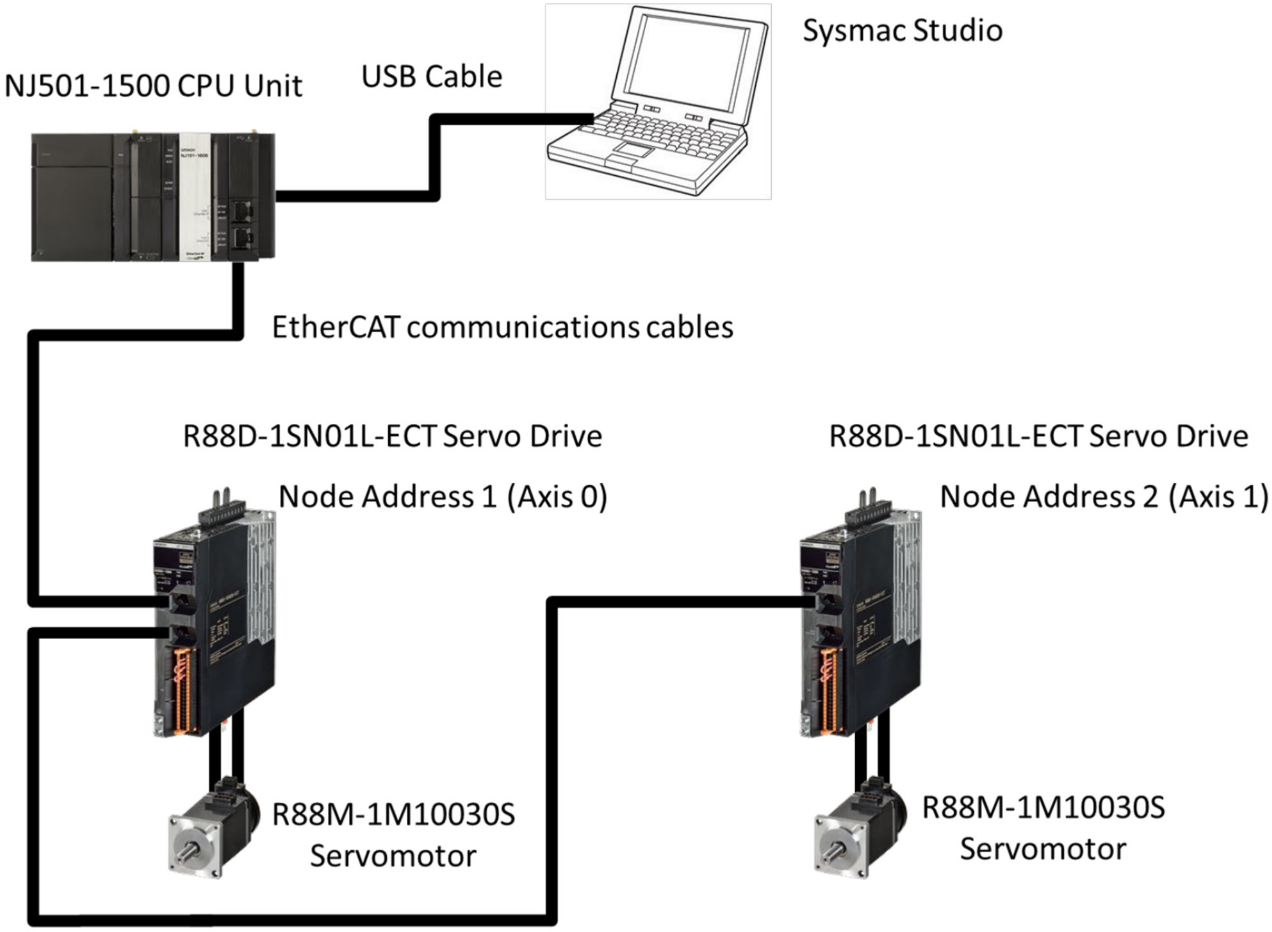

Figure 6. Hardware architecture of the experimental platform

2.2 Mechanical design

The system is built on a modular metallic frame, housing the conveyor and labeling disk. Mechanical alignment ensures that the object moves correctly from Axis1 to Axis2. Sensors are simulated to trigger motion transitions and fault detection routines (see Figure 7).

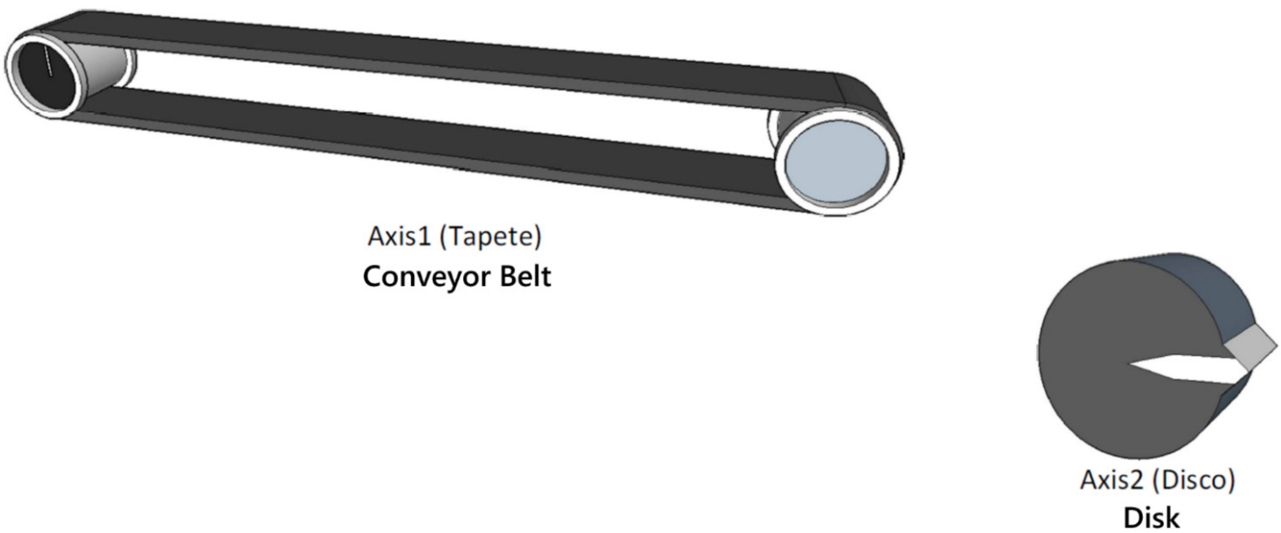

Figure 7. conveyor Belt (axis 1) and de Disk (Axis 2)

The final aspect of the experimental platform is shown in Figure 8.

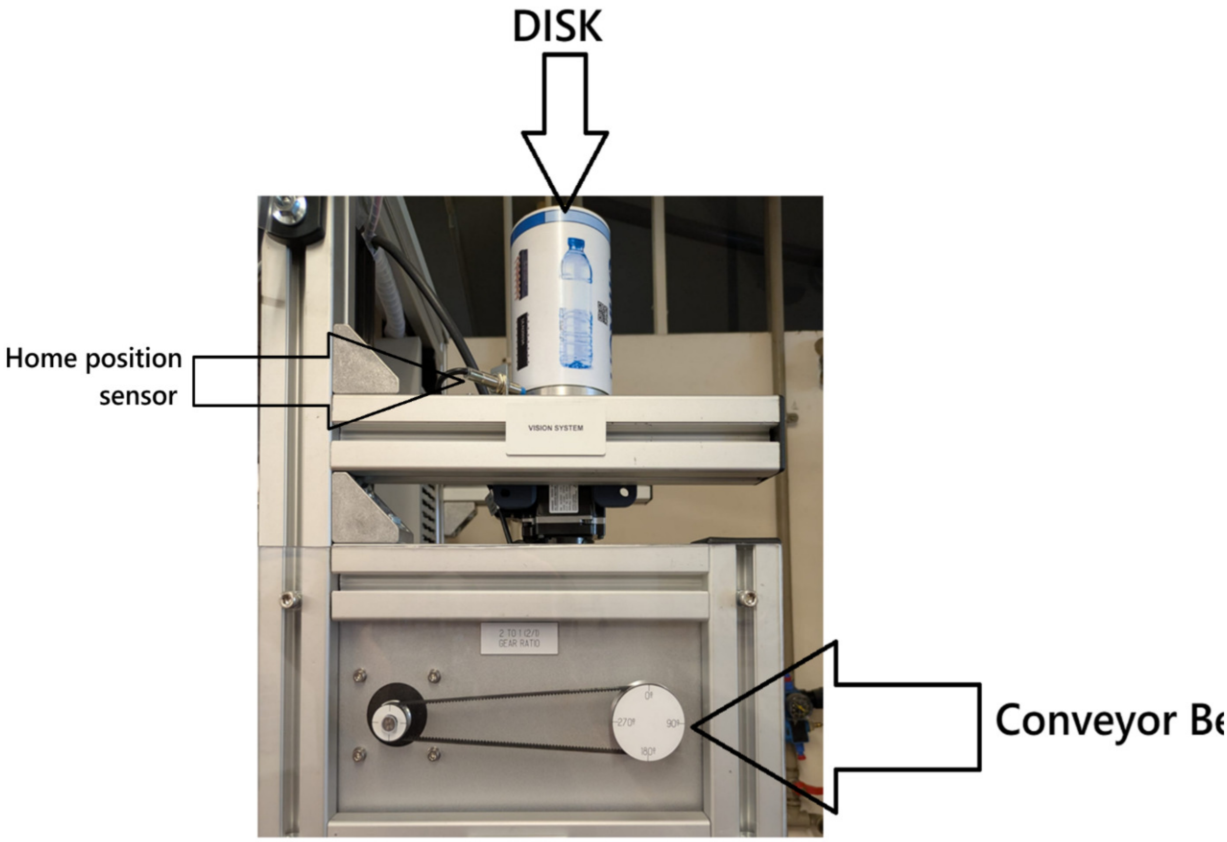

Figure 8. Experimental platform overview

3 Software design

3.1 Preliminaries

All motion commands were implemented in Ladder Diagram, with variables properly managed via the Variable Manager. Task scheduling was ensured by assigning programs to the primary task using Task Settings (see Figure 9).

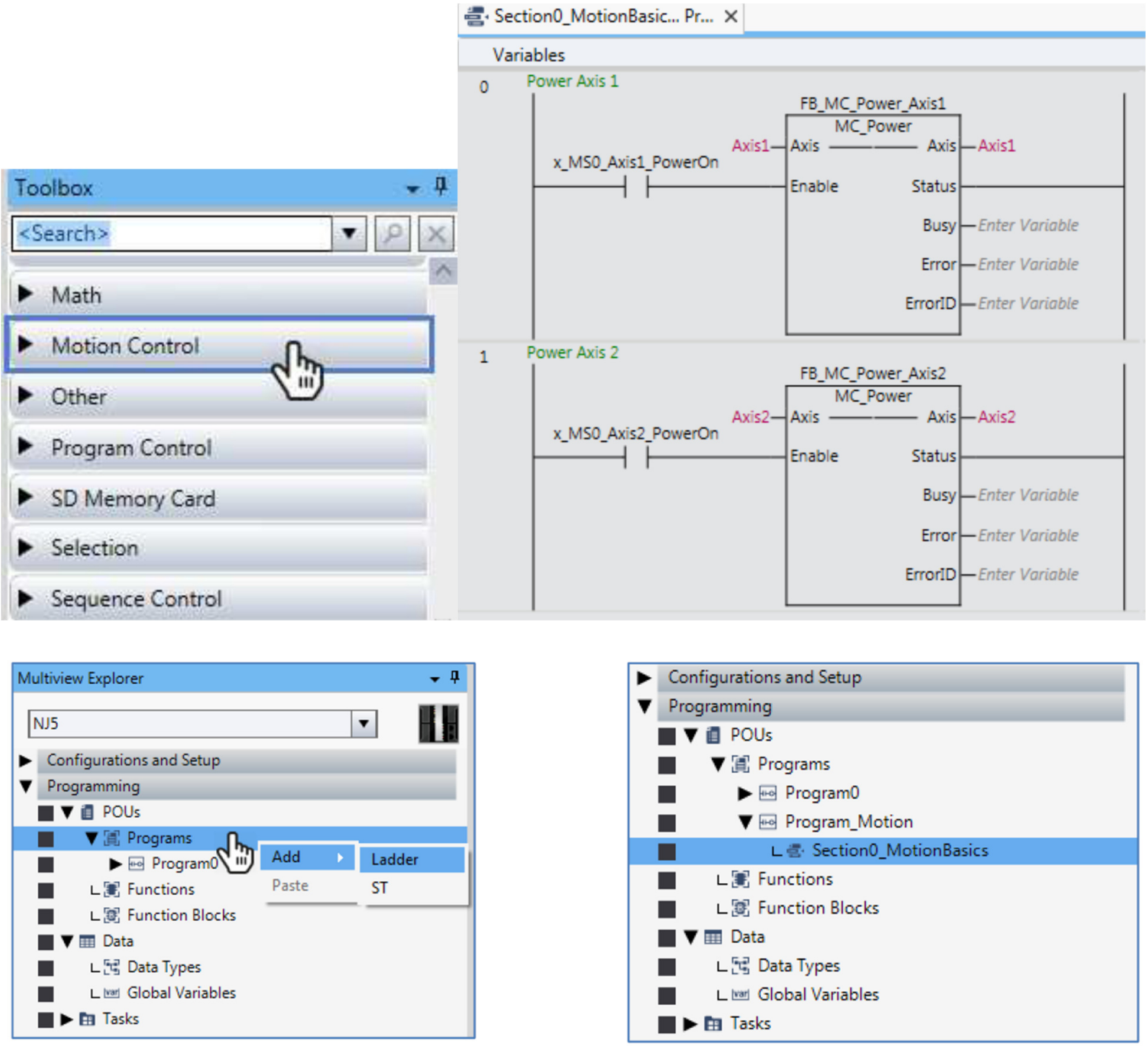

Figure 9. Sysmac Studio interface showing project configuration, EtherCAT axes, and task/variable definitions for motion control development.

3.2 Motion Control Programming

The implementation was validated through the following steps:

- **Axis Configuration**: EtherCAT communication established, axis parameters set (gear ratio, unit conversion).
- **Basic Motion Execution**: Programs executed MC_Power, MC_Home, and MC_MoveVelocity. Servo motors responded as expected.

- **Sensor Interaction**: Simulation of sensors (e.g., x_Box1_Detection) allowed real-time object flow control.
- **Sequential Control**: Logic was developed to stop the conveyor if a sensor mismatch occurred (indicating a stuck item), or to activate the rotating disk upon detection of the labeling position.
- **Safety and Fault Handling**: Implemented delay-based checks (5s window between sensor 1 and 2) and logic to resume normal operation after label placement.

3.3 Functional Motion Logic

Figure 2 shows the logic developed in the final exercise:

- Conveyor moves a box detected by virtual sensors.
- If box does not reach the second sensor in 5 seconds, the system halts.
- If the labeling mark is detected, the conveyor stops and the rotating disk performs label application.
- After a 3-second delay, Axis2 returns to origin and Axis1 resumes motion.

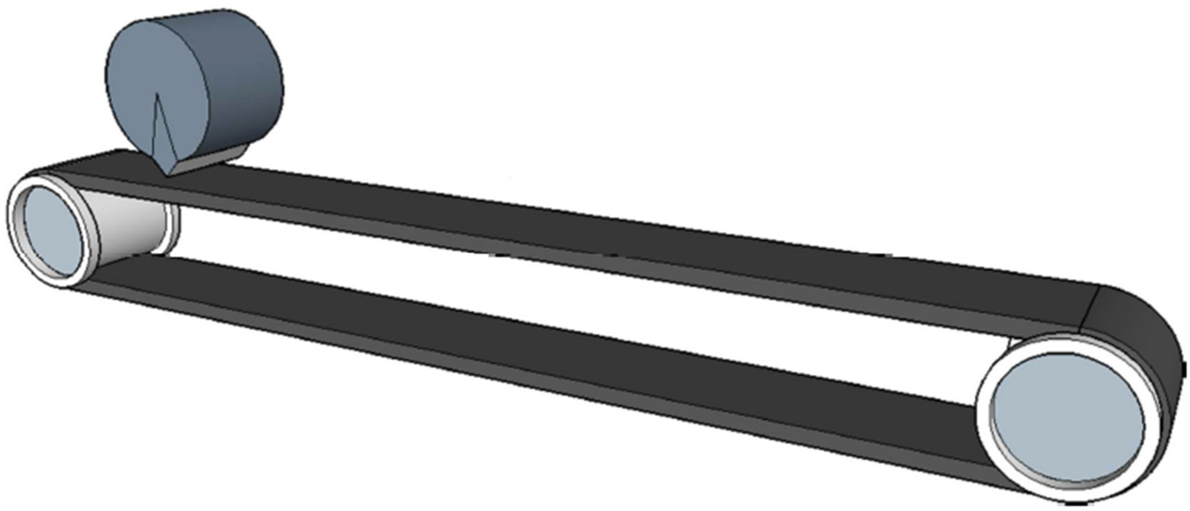

Figure 10. Functional logic diagram showing coordinated motion sequence between Axis1 (conveyor) and Axis2 (rotating disk), with integrated sensor logic and fault recovery.

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