Critical Design Review

MISCE project

Mechatronics for Improving and Standardizing Competences in Engineering

Competence: Programmable logic controller

Experimental platform: Factory I/O Simulations

Workgroup: Universidad de Castilla-La Mancha

Universitat Politècnica de València

This document is the Critical Design Review of the technical competence ‘Programmable Logic Controller’. It details the implementation of the virtual training platform for learning skills related to this competence.

Version: 1.0

Date: June 3th, 2024

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

Index of contents

Index of figures

Index of tables

1 Introduction

1.1 Scope

This document presents all the details for preparing the experimental framework for developing six practical lectures that cover the main basis of automation programs development. The technical competence to which this contributes is:

C13. Programmable Logic Controller

which related skills are (see Table I):

Table I. Skills of Programmable Logic Controller

S13.1.	To know the basics architecture of PLC
S13.2.	To know how to manage Digital IO
S13.3.	To know how to manage Analog IO
S13.4.	To know how to implement the complete functional behaviour of a system
S13.5.	To integrate PLC into an industrial network

1.2 Preliminary definition

The virtual system presented consists of learning the basic concepts of programming automation by solving six industrial processes simulated in the software Factory I/O. The programming is developed in a virtual Programmable Logic Controller (PLC) in CODESYS using Sequential Flow Charts (SFC). The software CODESYS is connected to the simulator Factory I/O using MODBUS TCP/IP, see Figure 1.

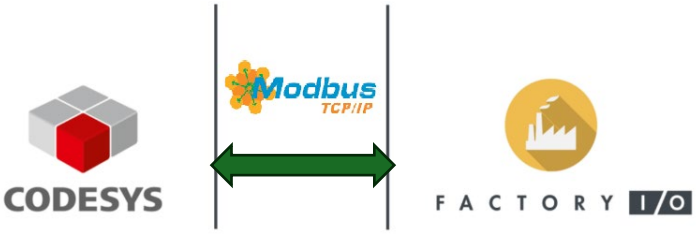

Figure 1. Overview of the Virtual system proposed.

These simulated industrial processes state basic concepts beginning with the automation of a basic sequence to continue with the learning of timers, counters, alternative and parallel sequences.

The work to be carried out by the students consists of making the initial design of the proposed automatic operation, later it would be implemented in CODESYS, and its correct operation would be verified using the developed simulations in Factory I/O. These steps are the usual ones to be carried out by any professional in a robot programming task.

1.3 Technical requirements

A computer with CODESYS V3.5 SP19 Patch 6 and Factory I/O v2.5.6 both properly installed.

2 Software design

2.1 Preliminaries

The software design of the virtual system proposed is general for the six simulated industrial processes. However, in this document, the software design is focused on the first industrial process defined as “simple sequence” to provide a detailed explanation of the proposed virtual system. There is needed to download the CODESYS template and the Factory I/O simulation (see Figure 2) available at https://misceproject.eu/programmable-logic-controller.

Figure 2. Required files to solve the simple sequence problem.

2.2 Automation program

The CODESYS template is a Standard project with the virtual device “CODESYS Control Win x64” (see Figure 3) composed by:

1. Global Variable List, named “FIO”.
2. Symbol configuration to communicate the FIO’s variables with Factory I/O simulation.
3. Sequential Flow Chart (SFC) script for the automation programming.
4. Ethernet adapter equipped with a Modbus TCP Slave device to control Factory I/O simulation.

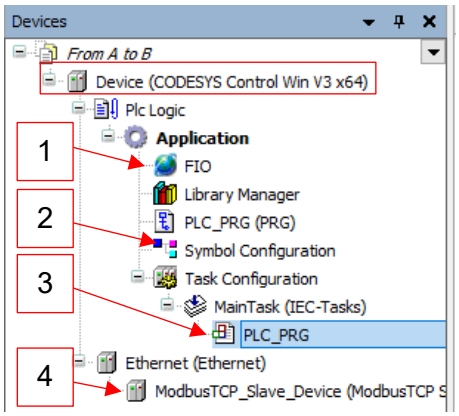

Figure 3. Project tree for CODESYS template for Simple sequence.

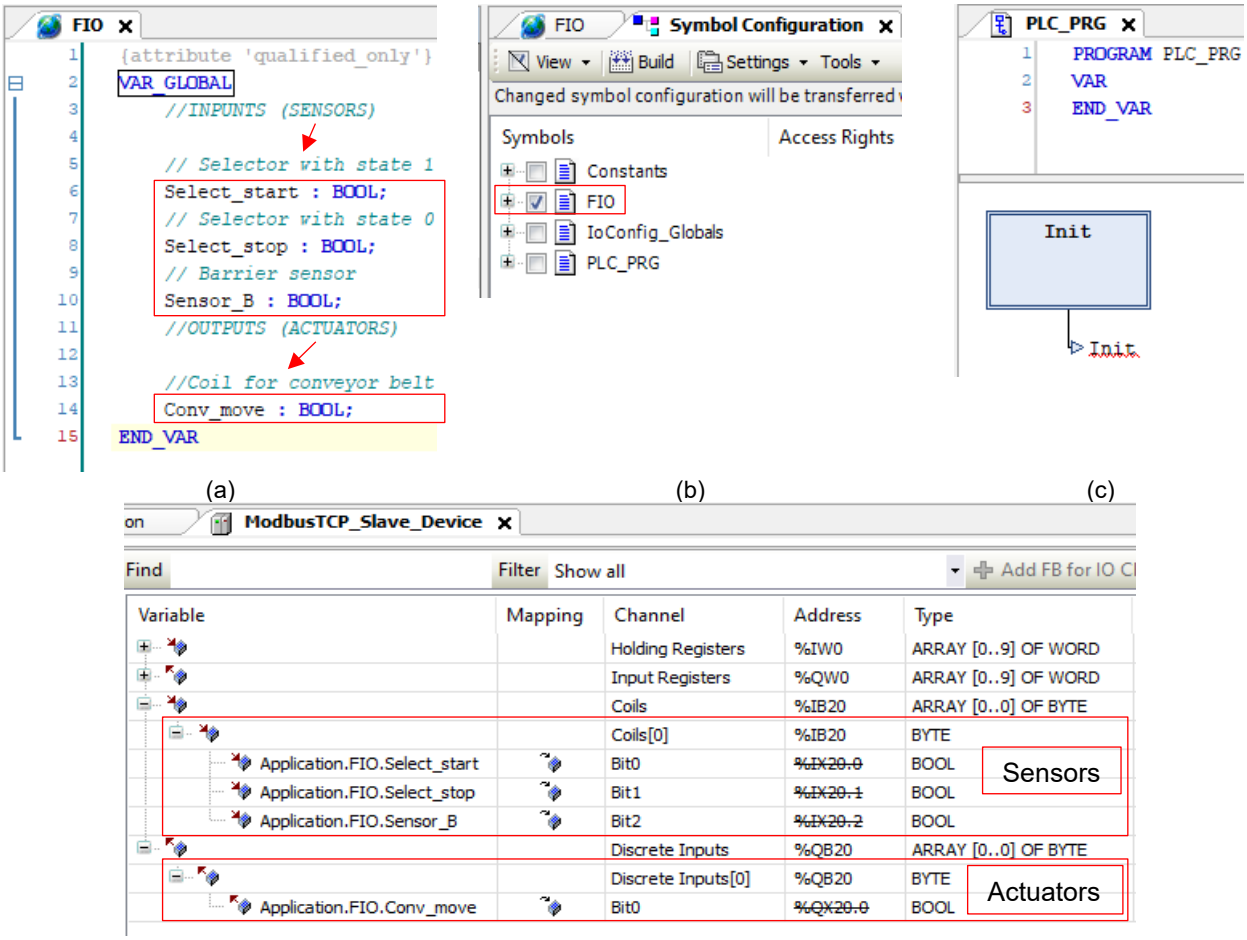

Figure 4. CODESYS template for Simple sequence (a) Global variables for communication with Factory I/O, (b) Symbol configuration for communication with Factory I/O, (c) SFC script to develop the automation solution and (d) Modbus TCP Slave device for communication with Factory I/O.

The variables in “FIO” are defined to control the sensors and actuators in the Factory I/O simulation. Figure 4a shows the FIO’s variable for simple sequence problem.

The symbol configuration enables the FIO’s variables to communicate with Factory I/O simulation through Ethernet protocol, see Figure 4b.

The sequential Flow Chart (SFC) script provide the draft for programming the automation solution required, see Figure 4c. The programming language could be change according to the user, however, the SFC language is more suitable for people that is new in automation programming.

The Modbus TCP Slave device connect the sensors and actuators variable in FIO with the correspondent Coils and Discrete Inputs to control the Factory I/O simulation, see Figure 4d.

2.3 Industrial process (Plant) simulation

The six Industrial processes have a tridimensional virtual simulation in Factory I/O. Figure 5 shows the simulation for the Industrial process defined as “simple sequence“ with its correspondent sensor and actuators.

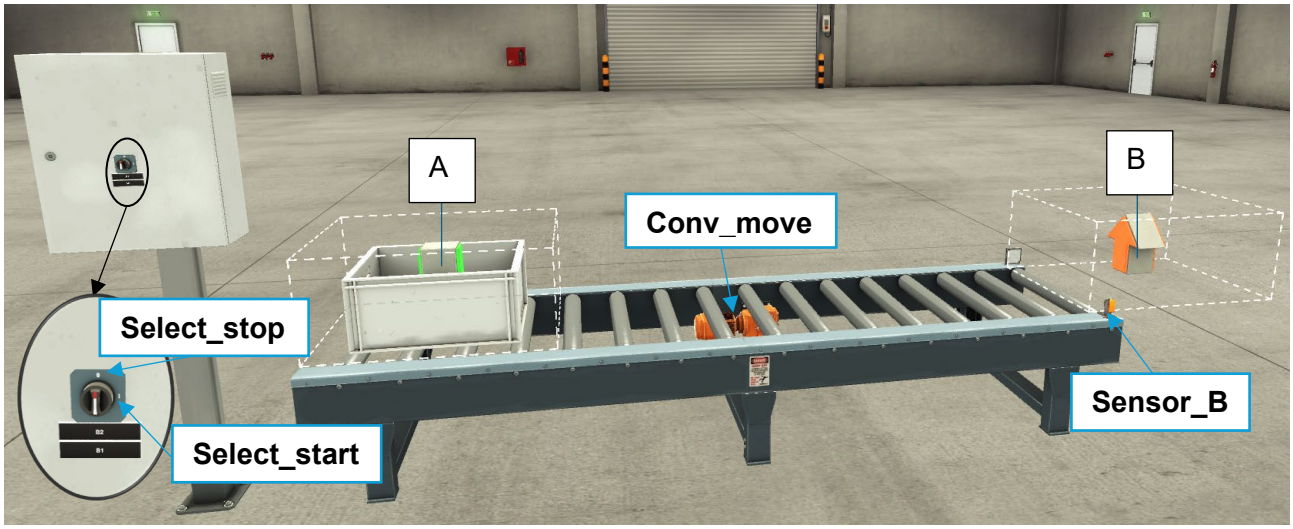

Figure 5. Overview of the Virtual simulation of simple sequence in Factory I/O.

The communication of the sensor and actuators in the Factory I/O simulation are defined in the Drivers section in FILE menu, see Figure 6. This figure shows the configuration of the sensors and actuators in Factory I/O to communicate with the global variables FIO in CODESYS.

Figure 6. Factory I/O Modbus setting to communicate with CODESYS.

2.4 Commissioning of the entire system

All six proposed automation problems follow the same process for executing. Taking “simple sequence” as example, the steps for executing the virtual automation system are:

STEP 1 Open the CODESYS Project “From A to B.project”, see Figure 2.

STEP 2 In CODESYS, open the SFC script “PLC_PRG” in the device tree, see Figure 7. In this script the student develops the solution for the Industrial process under analysis using the global variables in FIO list to control the sensors and actuators in the Factory I/O simulation. **The variables within the FIO list should remain unaltered and unchanged**. The student is free to declare another variable within the “PLC_PRG” file.

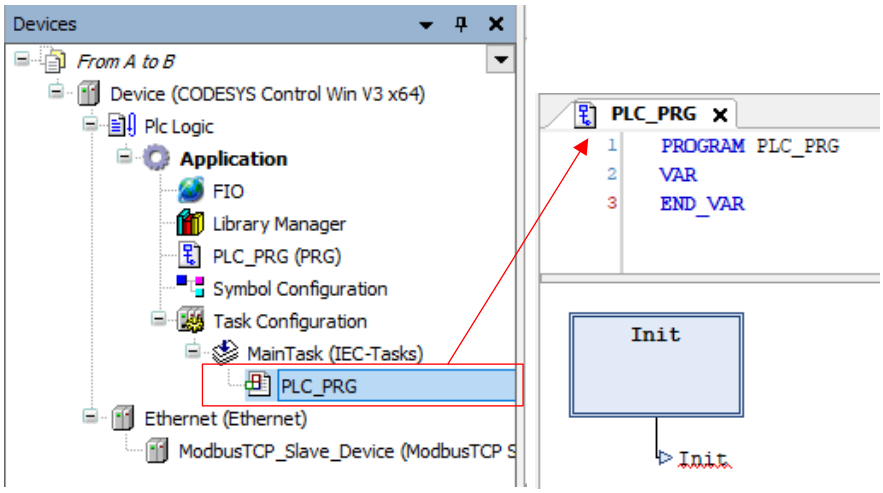

Figure 7. SFC script for developing the automation solution in CODESYS.

STEP 3 In Notification Area, run the Simulated PLC “CODESYS Control Win V3 X64”. (1) Right click on CODESYS Control Win SysTray, (2) Click on Start PLC, (3) Accept the warming message, see Figure 8.

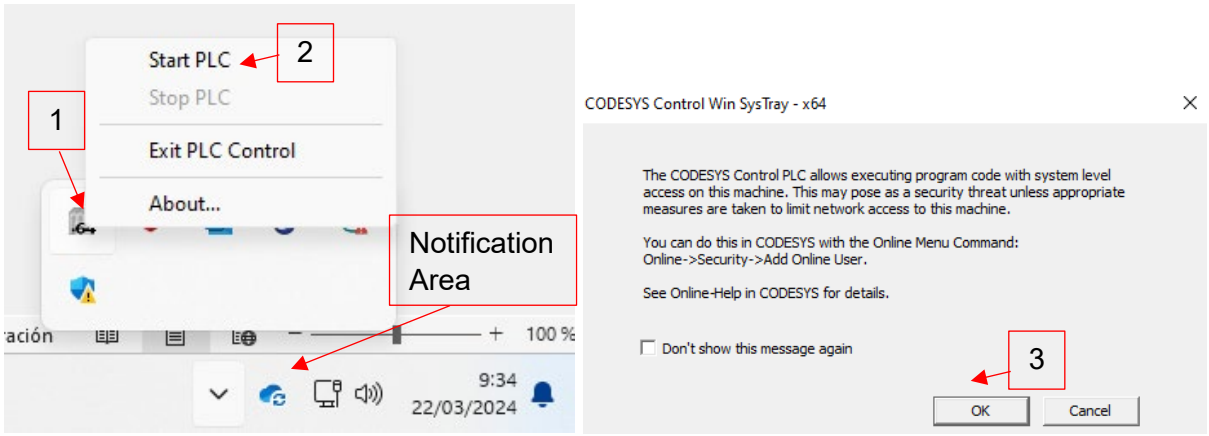

Figure 8. Run CODESYS Control Win V3 X64.

STEP 4 In CODESYS, load the automation solution in the simulated PLC. (1) Login to the PLC (2) Accept the warming message (3) Start the SFC program, see Figure 9.

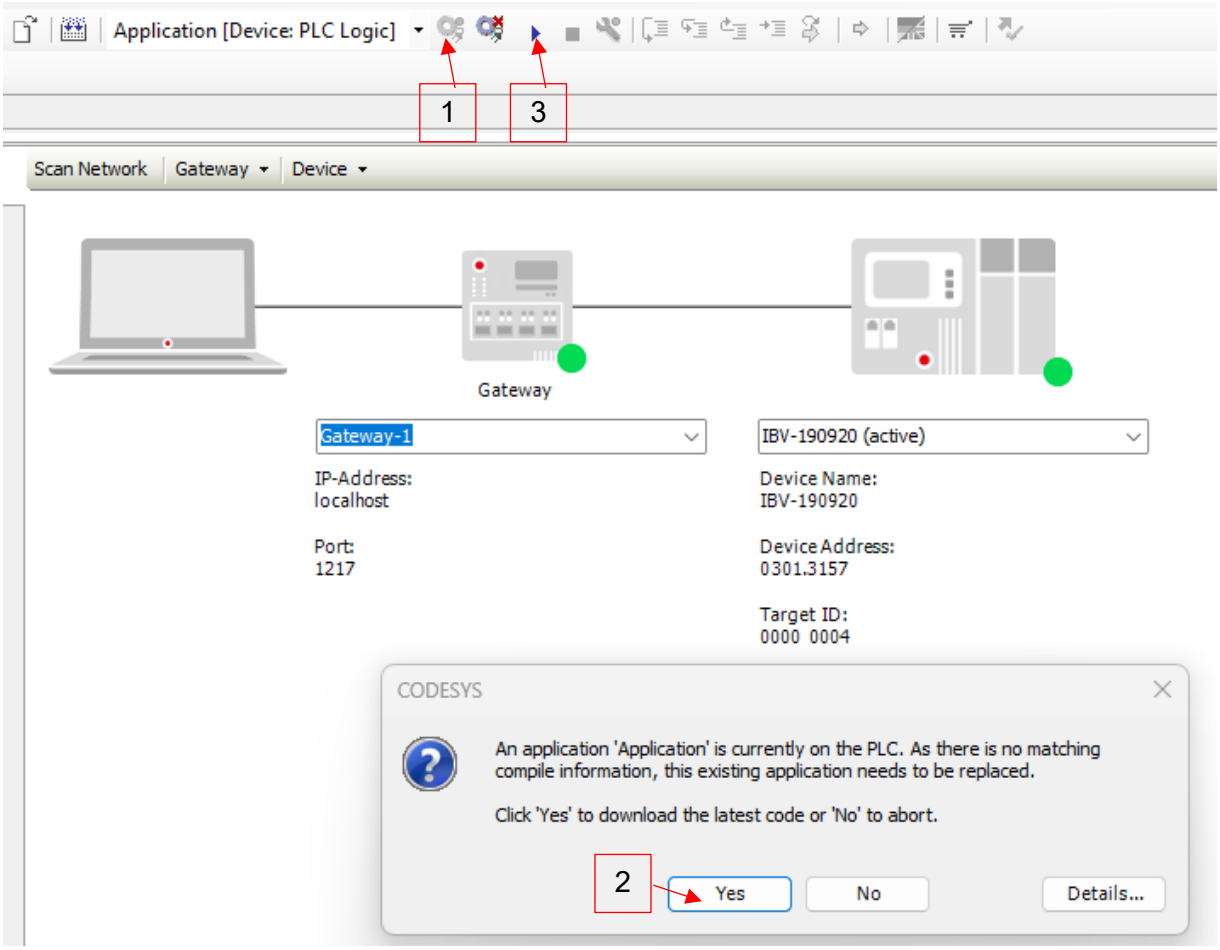

Figure 9. Connection to the simulated PLC Control Win V3 X64.

STEP 5 Open the 3D simulation in Factory I/O, in this case the file “From A to B.factoryio”, see Figure 2.

STEP 6 In Factory I/O, connect the Modbus TCP/IP client to the server in CODESYS. (1) Click on File->Drivers (2) Connect to the server (3) verify the connection (4) return to Factory I/O simulation, see Figure 10.

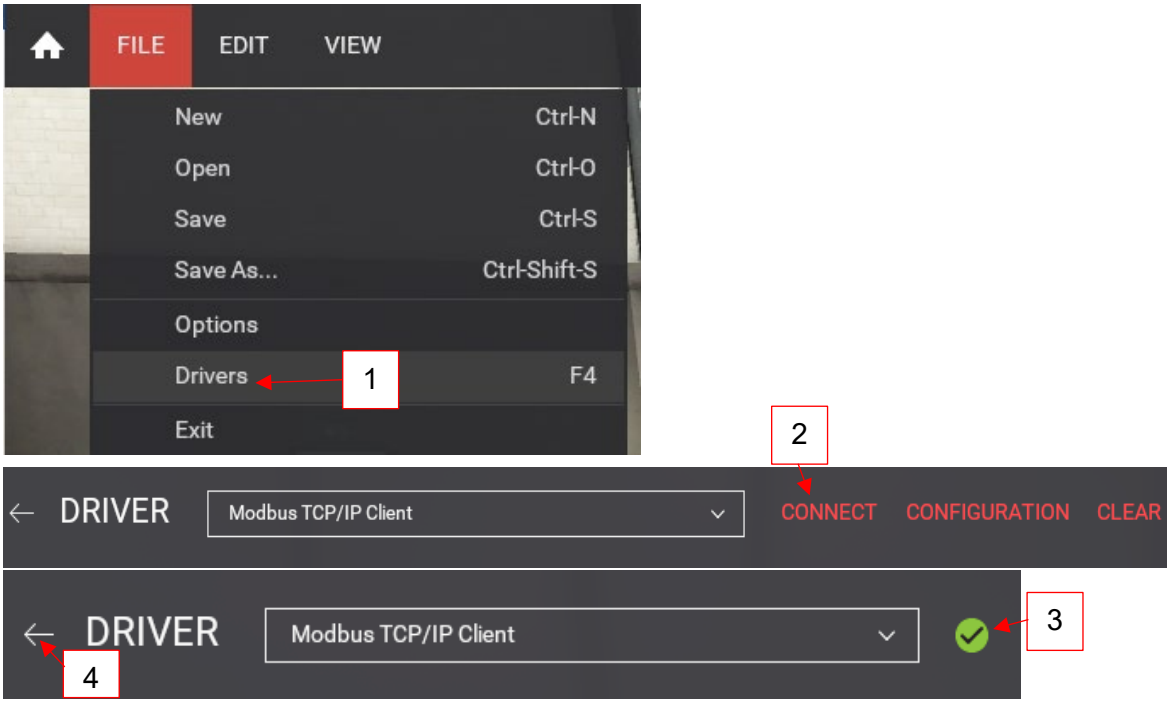

Figure 10. Connection to the CODESYS Modbus server from Factory I/O.

STEP 7 Run the simulation on Factory I/O (1) and execute the sequence using the control panel (2), see Figure 11.

Figure 11. Run the 3D simulation in Factory I/O.

This execution procedure is described at "03_FactoryIO_Simulation_Execution instructions.pdf" available at https://www.dropbox.com/scl/fi/g7owcz5lxqp0j3jvomqxi/03_FactoryIO_Simulation_Execution-instructions.pdf?rlkey=f10q2wvmpg6b7xgkxzpqgsjm5&st=2o57j8ms&dl=0 .

Moreover, the document "04_FactoryIO_Simulation_Codesys Troubleshooting.pdf" available at https://www.dropbox.com/scl/fi/rl2yxm2esheb5mjghrrr6/04_FactoryIO_Simulation_Codesys-Troubleshooting.pdf?rlkey=pex5k6e89ovjdvevkm39tm8mn&st=498ksz1b&dl=0 cope the most general problems that the student could have in executing the proposed virtual platform for solving automation problems.