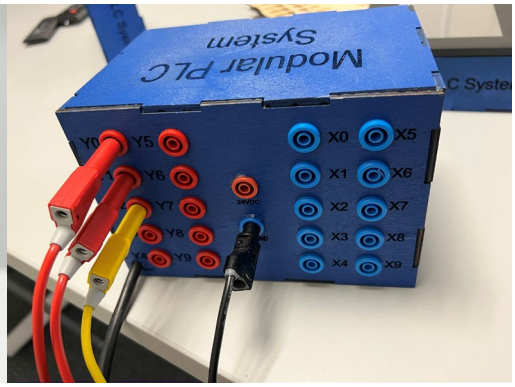
DIGITIZING PRODUCTS:
CREATING DEMONSTRATORS
FOR FUTURE EDUCATION

digi demo

The Modular PLC System

Demonstrator classification and documentation



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Dissemination level

Code	Access granted to
PU	Public
PP	Restricted to other programme participants (including the Commission Services)
CO	Confidential, only for members of the consortium (including the Commission Services)

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About the DigiDemo project

Environmental challenges and digital transformation are two of the main drivers changing the world and the way business will be is done in the future. Therefore, it is essential to enable future employees to address these drivers. The skills and competences needed to develop digitalized products and awareness of the environmental challenges are therefore crucial for the European workforce and industry to continue being competitive in a future green economy and to maintain jobs across Europe.

The DigiDemo project addresses these challenges by developing demonstrators especially for higher education allowing to improve mainly mechanical engineering studies by integrating skills and competences allowing them to understand, develop and commercialise connected products. The results will be publicly available and can be used by every institution interested in integrating this type of training in their cursus.

Content

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Abbreviations

ESTA	ESTA Belfort (France)
FHV	Fachhochschule Vorarlberg (Austria)
FIV	Fagskolen i Viken (Norway)
UCN	University College Nordjylland (Danmark)
UEMR	Universitatea "Eftimie Murgu" din Resita (Romania)
IoT	Internet of Things

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1 Elements of a Demonstrator

The purpose of this document is to describe the deliveries, scope, and responsibilities of developing the Modular PLC system. The document will also describe the technical, functional, and architectural requirements.

The goal is to develop and build a physical demonstrator. Any educational institute be it public schools, universities or industrial companies should consider using this type of demonstrator, due to the simple fact that it is safe, portable, and great for visualising your programing, The learning curve is from basic PLC programming to big sequential programming for example simple motor controls like star delta, traffic lights to elevator logic and automatic control of a silo, with programmable HMI. and it all fits on your desk. By adding or removing modules, you can get the education and training you need, and be very specific in what you want to achieve, it also gives room to play and explore without the fear of breaking equipment. the modular PLC system can be remote controlled using wireless network in the class room or teamviewer if your teaching or having a course through Teams,zoom or other video services, if you're at home, you can hook up the nights lesson turn on the cameras, and when the student want to test their code they can upload it directly to the PLC through teamviewer and watch if it works.

The set was designed for 9 modules, for the demonstrator I have focused on the traffic light.

1.1 Overview

The key properties of the focus project are:

Table 1: Specification of key properties of the focus project

Key Property	Value
EQF level	4 and 5 (Technician)
Year of study	2
Domain	Mechatronics
Objective	Hands-on
Workload	Depending on setup
Keywords	Internet of Things (IoT), C++/MCU programming, Microcontroller, WEB services

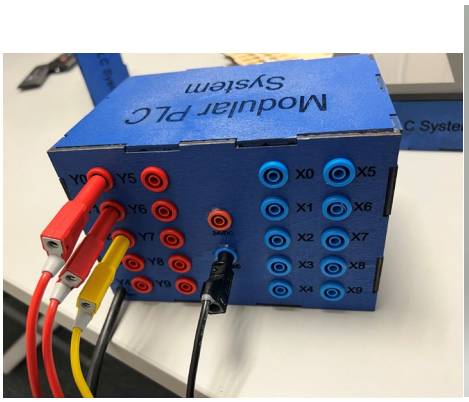
The demonstrator is suited for education on vocational college level. The demonstrator, shown below allows for teaching within the following subjects:

- IOT
- C++ programming
- PLC Programming
- Microcontrollers
- WEB services

The modular PLC system is a training system made for educational purposes such as schools or industrial training programs in a safe and easy manner. It can also be used to develop or test a new system. You can directly connect to it via Wi-Fi in classrooms or from TeamViewer if you are remote, you can control it from anywhere in the world. And you get to see the feedback through the monitoring system as well as watch live on the webcams.

Containing a main unit and a module, the module can be anything. From simple traffic light control to large factory production units. We have focused on module 5 which is the traffic lights.

- Safe and easy setup, banana plugs
- Fits on a regular desk
- No need for 400V, everything runs off 24VDC
- Training possibilities is endless and customizable, adding or removing modules such as an HMI display alongside your training module.
- PLC system got a mAP lite Router for setup with its own WIFI and network.



1.2 Description of fulfilment of keywords/characteristics

Table 2: Description of fulfilment of demonstrator characteristics for the focus project

Characteristic	Description
Teaching improvement	The PLS system demonstrator will improve teaching, due to the safety aspects. Everything runs of 24VDC and there is no need for 400V to run the PLS modular system. The learning curve is from basic PLC programming to big sequential programming for example a meat packing plant, or a tool manufacturing plant. The demonstrator gives room to play and explore without the fear of safety issues or breaking equipment.
Sustainability awareness	In this project the sustainability awareness is seen in a broader context, relating to World goal 4, Quality education.
Replicability	The demonstrator will be replicable, as most of the hardware will be based on readily available modules, and further instructions on system fitting will be provided.
Industry needs	The modular PLS system can be used to develop or test a new system
Interdisciplinarity	The demonstrator will be interdisciplinary, covering the following fields: • IoT architecture • PLC FBD/LD • Microcontroller GSM 1400 board • Antenna • SIM card with a data plan • Lidar-lite v3 • Battery

1.3 Classification according to the dimensions

Table 3: Classification of the focus project according to the dimensions

Dimension	Property	Value
Value chain	development	☑
	production	☑
	sales	☐
	after-sales-support	☐
	end-of-life	☐

Dimension	Property	Value
Chain of technology	mechanical structure	☑
	sensors	☑
	electronic circuits	☑
	edge device	☑
	data transmission	☑
	cloud	☑
Sustainability	energy reduction	☑
	material reduction	☐
	better materials	☐
	better production	☐
	reparability	☐
	recycling	☐
Physicality	physical setup	☑
	simulation	☐
Degree of student freedom	demonstrated	☐
	guided	☑
	coached	☑
	autonomous	☑
Transportability	fixed	☐
	transportable	☐
	portable	☑
Costs (implementation)	EUR	300 – 400
Costs (operation)	EUR	NA
Workload (implementation)	Hours	5-15
Workload (operation)	Hours	10-20
Size	m	< 1
Weight	kg	0,5-2
Special requests	no/yes, if yes: which	no

1.4 Educational information

Course content

Intended Learning Outcomes

The demonstrator is thought to be used over several teaching sessions with exercises. These sessions consist of 9 modules of 45 to 90 minutes each. But for this demonstrator we will focus on the traffic lights which is a module lasting 45 to 90 minutes, depending on how many of the lessons within the module you're teaching. It is expected that the student after the demonstrator session, can control the full logic of most common traffic lights, with pedestrian crossing including aided sound for those with visual impairments. Each module comes with several assignments which progresses from basic to advanced.

PL S-Modules overview

1. Module 1: Introduction to PLCs. We will connect pressure switches and lights.
2. Module 2 and/or Functions with block or buttons and we will connect switches and lights.
3. Module 3 Timer and sensors we will use limit switches and timers to turn on and off lamps.
4. Module 4 Motor controls, we will hook up motors and relays and control a star Delta sequence.
5. Module 5 Traffic lights, we will connect and program the logic of several traffic lights.
6. Module 6 Sequential programming, we will use limit switches and motors to make a machine that crushes cans.
7. Module 7 Elevator. We will program and hook up the model with a 4-floor elevator logic.
8. Module 8 HMI and level regulator, we will learn about HMI as well as hook up sensors and program a grain silo where we will look at quantity of grain, temperature control, as well as rotation of grain.
9. Module 9 HMI we will program the HMI display and simulate a small factory.

Intended Learning outcome.

- Get the fundamentals of how a PLC works.
- Learning basic Ladder/block diagram programming using Mitsubishi or Siemens/Allan Bradley.
- How the Inputs/Outputs work and how to connect them.
- Basic signal handling.
- Learn about different types of sensors and when to use them.
- Learn about relay controls and different motors and pumps.
- Learn about monitoring systems and reading its data.
- Learn how to program HMI displays.
- Learn how to debug and search for the solutions when something is not working right, using the inbuilt wireless network to monitor all the inputs and outputs of the module.
- Learn how to sequential program a machine.

Starting the session we pick a module, they range from level one to level 9 in difficulty, each module comes with its own kit, including the instructions and models needed for the module. Here you get your I/O list and how you should program your inputs and outputs.

Before we start on the modules themselves, we need to get a better understanding of what a PLC is and how it works.

After the fundamentals on how a PLC works, we proceed to the first module. And slowly progress forward over the course of several weeks.

Keep in mind that this can all be done from home or anywhere in the world using mAP lite and TeamViewer, then the student can upload their project and watch it unfolds on the demonstrator. Using webcams, they can visually see what happens, as well as monitor the PLC. And In this case we will look further into the traffic light module number 5.

First Assignment: Getting two traffic light to work on a timer.

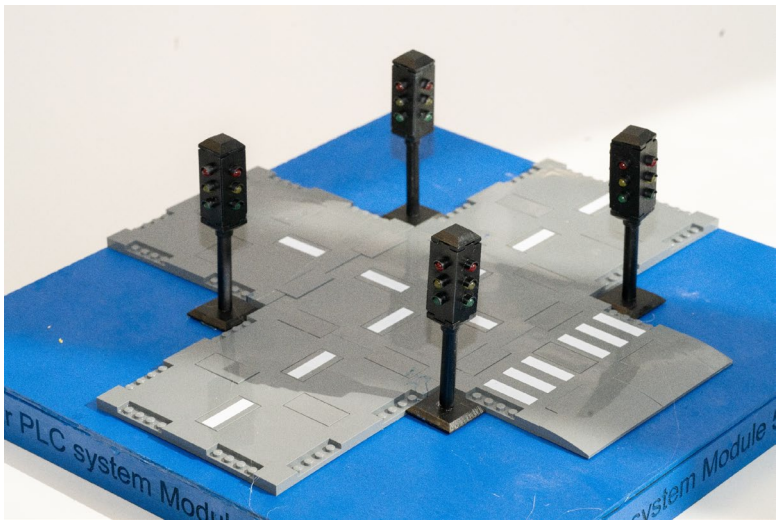
As we all are familiar with sometimes, we come to a road where there is being done some maintenance and they have set up two traffic lights to control the flow of traffic that is exactly what we intend to do in this first assignment, by pulling out our traffic lights module. Each module comes with a list of I/O (inputs/outputs) and by following the step-by-step guide in the modular plc compendium lesson 5 the students will start by opening their software (GX works 3), and follow the step-by-step guide,

Second Assignment: Getting Two traffic lights to work together using an infrared sensor and a timer.

This second assignment adds an extra input to the programming part, by adding a infrared sensor we can control the logic of which light turns red and green, and the wait time based on a timer, who set and reset the light sequence. Depending on the que with cars.

Third Assignment: Getting four traffic lights to work together, with a board walk.

Here another input will be added, here the student needs to add a button that activates a timer and a buzzer, making the sound for those with visual impairments. As well as controlling a new axis with the lights.



1.5 Organizational information

The following requirements apply

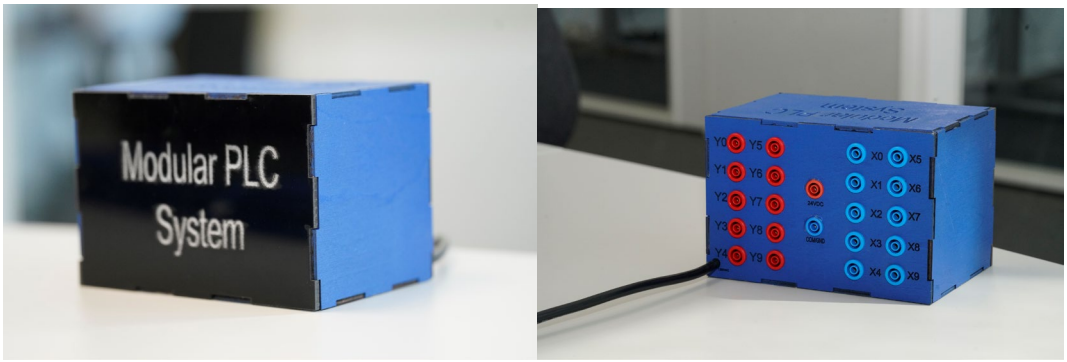
- Project duration. *The optimal time frame (for instance in weeks) for the project shall be estimated.*
  15 to 20 Weeks depending on student level.
- Team size. *The number of student team members is useful.*
  There is really no limit to how many students can use these demonstrators, only limitations is a bit of waiting time, but since there is a difference between how fast each student is I think 30 persons can do it easily.
- Preparatory and follow-up activities. *If this type of activities is needed prior to the use of the demonstrator, or after the project has been finished, these shall be listed.*
  Teacher needs to test system and prep the webcam if doing it on the web, in a classroom need to check uplink to the wireless network.

1.6 Description of the technology and the setup

The following describes the hardware and software needed to configure and run the Modular PLC system with Module number 5 only. All the other modules are not finished and will not be listed.

Hardware

Main PLC unit



This PLC unit is a prewired Mitsubishi FX5 and is used to drive the modules, take note of the Banana plugs which allows for very easy wiring and control. Inside the glass you will find the Fx5cpu with the mAP lite and its network cable with POE

Module Of a Traffic light

Control traffic logic to your heart's desire.

This module contains 4 resin made traffic lights, with 12 LEDs each. 1 push button, infrared sensor, and a small speaker for the cross walks.

Bill of Materials

The following table will outline the materials needed to produce the demonstrator. Note this is the equipment for one group of SW developers and must be multiplied with the number of groups.

This demonstrator uses the following hardware:

Components	Quantity
Green LED	16
Yellow LED	16
Red LED	16
Red female banana plug	20
Blue female banana plug	20
Mitsubishi HMI display	1
Mitsubishi Fx5cpu PLC	1
Meter Cable 0,25mm2	5 meter
Mini speaker 2w 8Ohm	1
Cat6A cable for POE	20 Cm
RJ45 contact	2
1.1K Ohm 440mW	48
3d filament	500 grams
*optional Resin for resin printer	1 liter
3mm planks for making the boxes and foundaition for the modules	
mAP lite router for wireless connections	1
Proximity sensor with infrared emitter	1

2 References