S7-1200 Siemens PLC based industrial automation educational platform

Robert Beloiu[1], Georgiana Deliu[1]

(1) University of Pitesti
1, Targu din Vale, 110040, ROMANIA
E-mail: robert.beloiu@upit.ro; robertbeloiu@gmail.com

Abstract

Industrial automation competences are in great demand by several industries worldwide. The 2020 academic year had its unique challenges that nobody in the community expected. The apparition and world wide spread of COVID-19 forced the educational institutions to adjust to conditions and requirements never encountered. In this context, the University of Pitesti developed an educational platform for industrial automation course. Even before COVID-19, industrial automation was a career in very high demand worldwide in general, and in Romania in particular. Now, with the implementation of robotic applications, companies active in a wide range of industrial activities demand this career more. This article presents a S7-1200 Siemens PLC based industrial automation educational station developed at the University of Pitesti for regular laboratories. By remotely accessing one PC, the platform can be use as support for remote laboratory applications.

Keywords: PLC, Tia Portal, electrical installations, industrial automation

1. Introduction

The 2020 academic year had its unique challenges that nobody in the community expected. The apparition and world wide spread of COVID-19 forced the educational institutions to adjust to conditions and requirements never encountered. In this context, the University of Pitesti developed an educational platform for industrial automation course.

Even before COVID-19, industrial automation was a career in very high demand worldwide in general, and in Romania in particular. Now, with the implementation of robotic applications, companies active in a wide range of industrial activities demand this career more.

In order to provide the specialists the industry demand, the universities around the world prepared different means to teach online or hands-on the required courses to equip students with the necessary competencies.

Thus, in (Garduno-Aparicio et al., 2018) the authors present a robot prototype for an undergraduate laboratory. The purpose of the prototype is to help students to learn basic concepts of robotics and apply them in practice applications. This application allows the students and teachers to modify the software and hardware units. The paper presents six practical applications. The authors present an analysis of student performance in digital systems that indicates sensible improvements during 2014 – 2016.

A different approach consists in using Power-Hardware-in-the-Loop system (PHIL) (Kotsampopoulos et al., 2017). This system allows the connection of a physical power component to a real-time simulated network. In the paper, the authors present the increased integration of distributed generation, voltage control with on load tap changer, short circuits with inverter-based distributed generation and microgrid operation. The beneficiaries of the system appreciated positively and appreciated real-time simulation. Another solution (Abichandani et al., 2019) of virtual laboratory was developed using Google Cloud Platform. This contained self-guided laboratory modules that covered the fundamentals of solar cells and parallel solar cell connections.

Automatic control laboratories could be offered as virtual or remote access as presented in (Saenz et al., 2015). The system is developed using low-cost solution for developing the laboratories based on Easy Java/Javascript Simulations. The laboratories are integrated in the Moodle system for maintenance and management. The authors make a distinction between virtual and remote laboratories. The virtual laboratories are the ones based on computer simulations that offers similar behavior with the real systems. The remote laboratories are the ones operated at distance. The remote laboratory (August et al., 2016) thematic is in the attention of the academic community since more than two decades ago and the continuous interest is proven by the publications in the field.

A new approach of laboratory development is to appeal to games and gamification. There are several publications (Abichandani et al., 2019), (Lopez-Pernas et al., 2019a) , (Lopez-Pernas et al., 2019b), (Morlovea et al., 2019) that present game related approaches for teaching important engineering concepts. After all, computer simulation of engineering installations or concepts are quite similar to present day computer games. Visual pick and place programs (Moreno-Leon and Robles, 2016), (Moros et al., 2020), (Kaučič and Asič, n.d.), etc. transforms the way of implementing complex algorithms.

2. Industrial automation platform

In this paper, we would like to present a S7-1200 Siemens PLC based industrial automation educational platform that helps the users to acquire basic competences required in the automation engineering. Various topics are covered by the use of the platform:

- Basic electrical installations (Beloiu, 2015a)
- Basic automation experiments cabled logic based (Beloiu, 2015b)
- Basic automation experiments programmed logic based (Beloiu, 2017)
- Remote connection to the platform (Saenz et al., 2015), (Hu et al., 2017)

Figure 8. Automation station

Figure 8 contains the picture of the implemented automation station. The main elements of the station are:

- Automation elements:
  - PLC: Siemens S7-1200
  - HMI: Siemens KTP-700
  - Profinet Switch: XB005
- Electrical elements:
  - Power supply

- Protection elements
- Buttons, lamps and numerical indicators
- Safety button

The station will be programmed and monitored with the Siemens developed programming software Tia Portal.

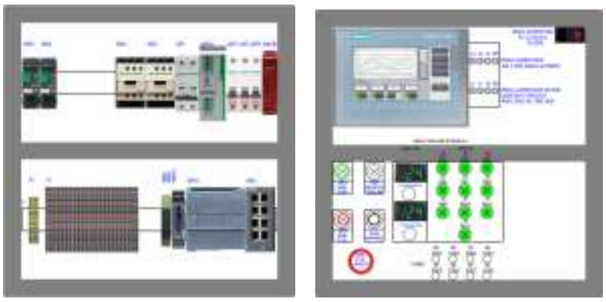

Figure 9. Automation station distribution

Figure 9 displays the distribution of the elements of the automation station in the electric panel.

2.1. Basic electrical installations

Figure 10 displays the input-output PLC electrical connections. Analyzing these schematics the students can accomplish two very important practical tasks:

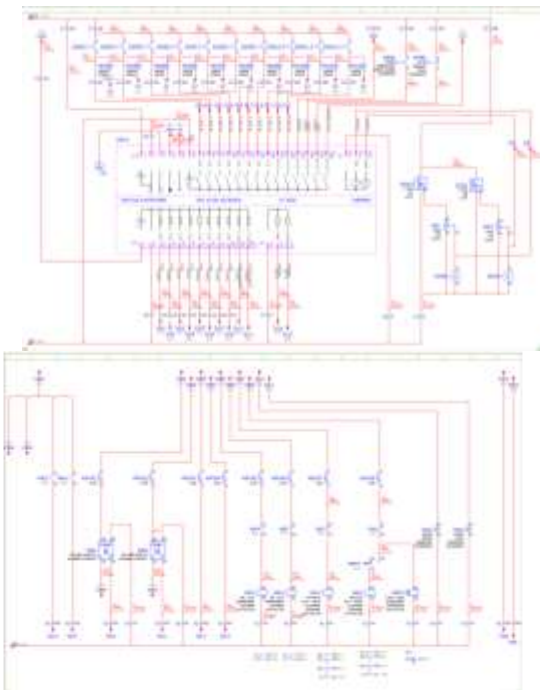

Figure 10. Input-output PLC electrical connections

- Identify the electrical elements that needs to be connected to both inputs and outputs of the PLC
- Identify the electrical connections between the PLC and the rest of the electrical elements: relays, lamps, buttons, etc.
- Understand how electrical schematics have to be made
- Failures can be induced as part of the educational process and students have to diagnose and fix them using the schematics
- Learn how to read a real electrical schematic

2.2. Basic automation experiments cabled logic based

Using the automation station (Figure 8) the implementation of cabled logic based applications is up to the user imagination. There are practical limitless possibilities of exercises that can be simulated.

For exemplification reasons, we chose to implement a conveyor application. Conveyors are used in industry on a very large scale to move products from one place to another. Many industries use conveyors to move a wide variety of products from one point to another in order to be sorted, processed, packed, etc.

A conveyor consists of an electric motor, start and stop buttons and limit starting and ending sensors, as indicated in Figure 11.

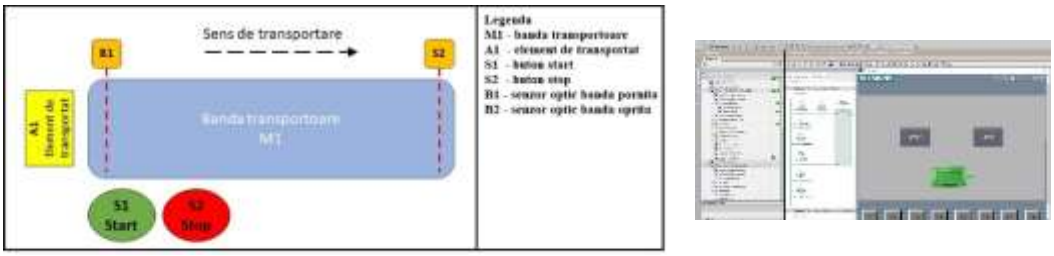

Figure 11. Conveyor application simulation

For this application, the process starts with the push of the S1-start button and stops with the push of S2-stop button. The S1 and S2 sensors send information to the PLC to be processed: to start and stop the moving process. In this application, the motor simply starts and stops according the commands received from the PLC. The most common configuration of the commanding schematics of the motor is either direct or wye-star connection (Beloiu, 2015a). The analysis of these schematics is not the purpose of this article.

2.3. Basic automation experiments programmed logic based

As far as programmed logic based application, we meant applications that use electronic converters to control the electric motor. In this case we focused on a Siemens PM240-2 FSA-IP20 U400V 0,75 kW converter. The programming environment Tia Portal allows the configuration of both control and power module of the converter.

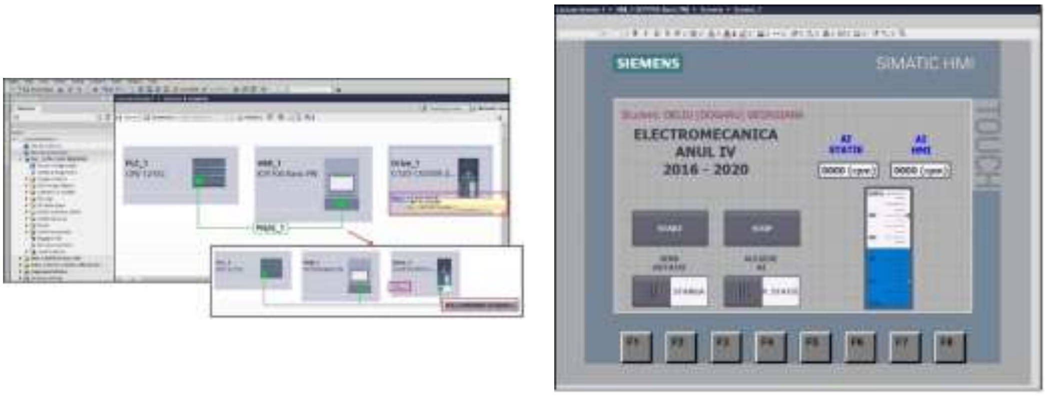

Figure 12. Basic programming logic based application

These converters are widely used in different industries. The configuration of the converter is not an easy task. Therefore, by using this platform and the associated programs, the students can get used with the implementation, configuration and monitoring complex applications.

2.4. Remote laboratory configuration

Another advantage of the developed platform is that in can be remotely accessed. The platform is connected to a regular computer via network port.

All the elements of the platform communicate between them using Profinet protocol. Thus, the platform contains a very simple industrial network switch. In this switch is connected the controlling and programming PC. A free port of the switch is connected to the Internet connection of the laboratory.

Using any kind of remote access application the main computer can be accessed from distance. During the setup of the platform we obtained very good results using Google application: Chrome Remote Desktop. In order to use this application, the user has to configure both the accessing PC as well as the accessed PC in the same network via a single google user account. By using this possibility, this complex laboratory can be done remotely, which proves to be very advantageous in the COVID-19 context.

At the same time, using this configuration, the physical resources can be shared with other laboratories. Thus, it is encouraged communication and collaboration between laboratories from different universities both national as international.

3. Conclusions

In this article, we presented the implementation of a S7-1200 Siemens PLC based industrial automation educational platfrom. The implementation of the station follows industrial specifications for these applications.

Industrial automation competencies were, are and will be required by many industries. Therefore, the University of Pitesti, as being concerned of the necessity, developed a practical laboratory application.

Using this implementation, we identified several advantages for the students that uses it:

- Learn about electrical connection of industrial equipment
- Reading and understanding an electrical schematic

- Programming PLCs
- Diagnosis of industrial electrical panel
- Profinet configuration

The platform can be used directly in the laboratory in classical application industrial automation classes. At the same time, due to the present day condition, the platform can be used remotely using remote access computer applications. Once the programming PC could be accessed remotely, the automation platform can be used too.

Acknowledgements

We would like to thank Intech Integration Technologies for sponsoring the Industrial automation and robotics laboratory from the University of Pitesti for developing the presented S7-1200 Siemens PLC based industrial automation educational platform.

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