DEVELOPMENT OF A PLC BASED EXPERIMENTAL SETUP FOR UNDERSTANDING CONTROL AND AUTOMATION APPLICATIONS

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Abstract
In accordance with industrialization of agriculture, PLCs (Programmable Logic Controllers) have been frequently employed in modern agricultural applications such as greenhouse automation, smart farms, autonomous tractors and harvesters, irrigation systems, animal automation systems, automatic transplanting machine. In this experimental and practical study, a test laboratory is designed with the aim of developing of teaching control and automation applications used not only in industry but also in agriculture, to students in the university. The developed control and automation system consists of PLC based control unit and HMI (Human Machine Interface) based monitoring unit. The physical signals are monitored in real time, through a local touch screen HMI. HMI screen also displays the downtime of the machine and the different process alarms occurred during the runtime. The communication mode between the PLC and HMI is supported by the Modbus RS485 protocol. Developed educational system allows students to learn programming, connecting, designing and understanding of the PLC/HMI based automation systems in industrial and agricultural application.

Keywords: PLC, HMI, agriculture, automation.

INTRODUCTION

Nowadays, many different processes like all manufacturing processes in industry, water treatment and distribution processes, electricity generation and distribution processes, agricultural process are automated. By Industry 4.0 revolution, technologies that facilitate the work of the producer by increasing productivity, profit and quality in agriculture have become smarter. With the developments in technology, it has become mandatory for our students to have knowledge about automation and control systems used not only in industry but also in agriculture. For this reason, in this study a test laboratory is developed to teach the students how to work with automatic control systems and how to implement them using the PLCs/HMIs. PLCs are the digital computers that makes machinery and systems work automatically. HMI is a device that connects a human to the controller in an automated system. HMIs provide a visual representation of the process parameters. They allow human operators to monitor and control machinery and the processes in real time.

PLCs are designed for multiple analogue and digital inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. The data handling, storage, processing power and communication capabilities of some modern PLCs are approximately equivalent to desktop computers. The main difference from other computers is that PLCs are armored for severe conditions (such as dust, moisture, heat, cold, vibration) and have the facility for extensive input/output (I/O) arrangements [1].

PLCs play vital role not only in process control plants but also in manufacturing industries where it is necessary to have proper control of the automated machine to yield accurate result and easy fault identification and fault location. This is achieved by using PLC and HMI the control and monitoring of the machine [2].

An application study is introduced for education of Electrical and Electronics students about programming, connecting, designing and understanding PLC/HMI based automation systems. Developed educational system allows students to learn processing of digital and analog signals about PLC unit and monitoring and controlling these signals via HMI. Developed education system is shown in Figure 1[3].

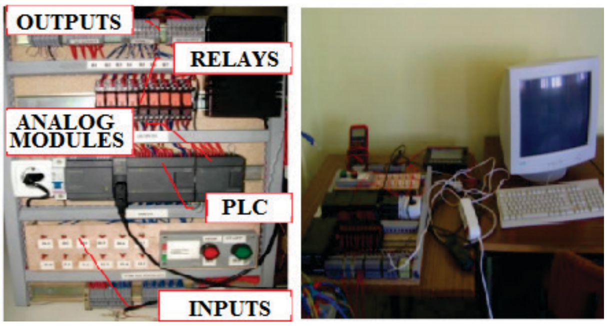

Fig. 1. *Developed experimental automation education system*

S7–200 PLC based automation laboratory is developed in Marmara University. It consists of PLCs and extension modules, operator panels, motors, lamps, control elements (switches, buttons, etc) and application sets. The control program for the PLC is written with MicroWin Software, and SCADA program is written with WinCC monitor configuration software [4].

A didactic kit, an intelligent house model is developed to teach control and automation to students. Several characteristics in the house (alarm intrusion, stair and internal illumination, main door and attic temperature) are controlled by using a PLC. The local and remote monitoring interface of the model is developed in LabVIEW. It also allowed the model visualization through a Webcam positioned in front of the house. Developed didactic kit is shown in Figure 3 [5].

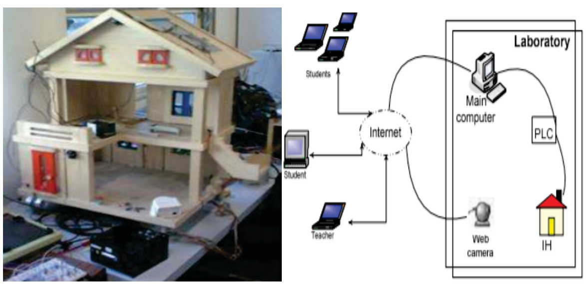

Fig. 3. *Didactic kit: intelligent house*

A hardware and software architecture that allows the students both to work with real PLCs through the simulation of real industrial plants and to develop appropriate SCADA systems is proposed. This system is based on LabVIEW, MODBUS, PLCs and SolidWorks. To illustrate the use of the proposed architecture, two semi-virtual laboratories based on a bottling plant and the automatic irrigation process of a greenhouse using PLCs have been developed. Figure 4 shows the hardware architecture of semi-virtual plants for the learning of automation [6].

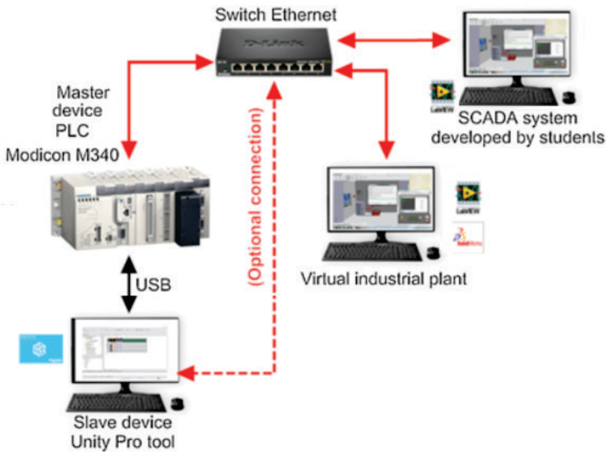

Fig. 4. *Hardware architecture of semi-virtual plants for the learning of automation*

A PLC and SCADA (Supervisory Control and Data Acquisition) based smart village was developed for monitoring and controlling water distribution, energy maintenance and cold storage for cultivated product. The block diagram of the system is shown in Figure 5 [7].

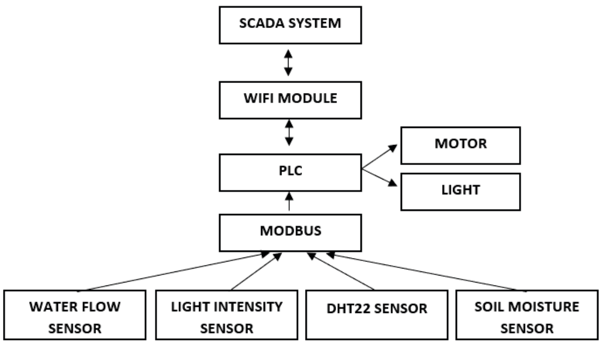

Fig. 5. *Block diagram of the smart village*

A PLC-based control and telemetry system for self-propelled pruning residue mulcher prototype was developed. The developed machine is the first self-propelled agricultural mulcher machine developed in Turkey. This system provides the flexibility for control of the different agricultural machines, meets industry 4.0 requirements such as changeability, reconfiguration and autonomy. The system is shown in Figure 6 [8].

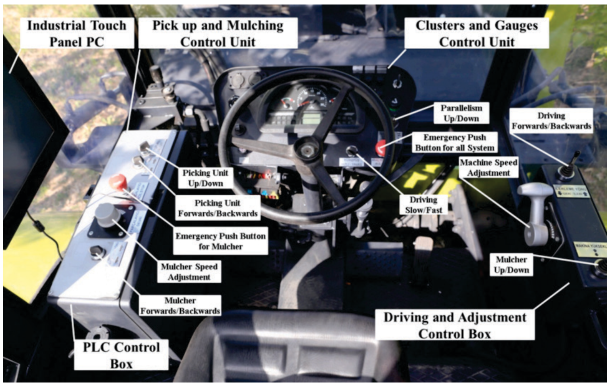

Fig. 6. *The interior view of the pruning mulcher machine cabin*

It has been observed that studies on the development of applications related to control and automation systems have been carried out in the industrial sector for many years and have started to take place in other sectors like agriculture, home automation, power plants. Some of the technological applications used in agriculture are smart farms [9], agricultural robots [10], irrigation automations [11], automatic animal milking/feeding systems [12], greenhouse automations [13] etc.

The developed system in this study consists of real control and automation hardware and software components used in industrial enterprises.

EXPOSITION

The developed experimental setup consists of an Enda ELC-386RT model PLC, an Enda EOP 41-70ETE model HMI, a Higen servo motor and its driver, a pneumatic cylinder, a sliding table linear motion system, and buttons. The overall system components are shown in Figure 5.

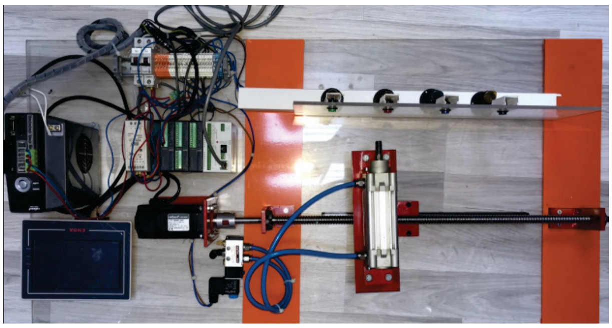

Fig. 5. *Components of experimental setup*

In this system, position, velocity and acceleration of the servo motor were controlled by PLC.

The position information of the button which have to be pressed is entered on HMI screen by users. According to entered information, PLC send commands to servo motor system to let the pneumatic cylinder to take position. The cylinder mounted on the sliding table is moved horizontally forwards and backwards on the ball screw during servo motor runs. After taking the desired position, and the piston is moved, the chosen button is pressed.

The user interface in HMI allows users to interact with the automation system. The users can monitor system variables, send and receive control commands to and from PLC via HMI. The used HMI is directly connected to PC through Ethernet port in order to download/upload programs and for on-line simulation. It has serial communication ports that support RS232/RS485/RS422 protocols.

PLC program of the system was written in EndaSoft PLC ladder editor. After the preparation of automation scenario the program was downloaded to PLC device via Ethernet port.

The visual program for HMI was developed in ENDA.EOP_V1.6_Enu editor software.

CONCLUSION

In this study, an experimental automation setup has been designed and practically tested. It has been seen that in the setup PLC, HMI, servo system, pneumatic system and linear motion system have been worked smoothly and compatible each other.

It was observed that the position information entered from the HMI screen by the user was correctly executed by PLC controlled servo system and that the pneumatic cylinder was able to push on the knobs at the defined points.

After entering the position information on the HMI, it has been seen that PLC controlled the servo system correctly and that the pneumatic cylinder pressed the desired button.

The control system is extensible because it is modular. By using the digital and analog channels on the PLC, system provides more flexibility for the students performing the different applications.

This setup proposes a hardware and software architecture that allows the university students to work with real PLCs. They improve their skills on PLC-based automation systems widely used in industrial applications, intelligent buildings, agricultural automation, electrical power generation, transmission and distribution systems etc...

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