

Enhancing a Programmable Logic Controller Course

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Enhancing a Programmable Logic Controller Course using Portable Trainers

Abstract

The current lab for a course on Programmable Logic Controllers (PLC) includes outdated, rack-mounted PLC equipment. While these provide the students with a procedural introduction to PLCs, it is the authors' belief that the current equipment do not allow for conceptual understanding or real world experience with PLCs. The focus of the present paper is on the steps taken to develop a new set of PLC trainers that will be used in teaching the course. The paper discusses the rationale for developing and building the trainers, and how the trainers will facilitate students learning.

Introduction

The curriculum of the Mechatronics Engineering Technology program, offered by the Department of Engineering Technology (ET) at Purdue University Northwest (PNW), includes a mandatory course on Programmable Logic Controllers (PLC). The course, which is also mandatory for all Electrical Engineering Technology, Mechanical Engineering Technology, and Mechatronics Engineering Technology students, includes hands-on activities that are necessary for engineering technology students to know, which requires working on a dedicated PLC trainer. However, due to limitations in terms of lab capacity and an increase in number of students taking the course, it is difficult to provide each student, or even groups of students, with an individual trainer. Portable PLC trainers, on the other hand, do not require a large lab space.

Historically, out-of-date, rack-mounted PLC equipment was used in the Department to support this class. While this provided the students with a procedural introduction to PLCs, it did not allow for conceptual understanding or real world experience with the equipment. The ET Program recently developed an updated set of PLC units utilizing the B&R controller that allowed an open platform for the laboratory components of the class while fostering a conceptual understanding of the topic. This paper presents an overview of the development cycle of the portable PLC training units to be used in the engineering technology curriculum. The paper also provides a summary of lab activities developed for the new trainers.

Motivation

The assembly and usage of these B&R trainers will be of immense help to students in the mechatronics program. Instructors are taught to instruct how to control circuits, using step rationale and organized content. Programming essentials such as variable revelation, code structure, programming hones, and programmable incitation will be taught to the students. Other important PLC topics such as inner clocks, outer sensors, CPU, and correspondence modules will be covered as well.

In addition, the new trainers will alleviate some major issues that have already been identified as follows: some of current trainers use power systems of 120 volts alternating current which can be very dangerous [1]. Parallax error and soft limitation can be seen as obtained by measurement. Perhaps, the most crippling disadvantage of the current equipment is the low number of usable PLCs.

By using the new trainers, visualization of topics is possible which helps students to better understand the topics. The trainers also give digital input and output and analog input and output. It is controlled manually by using motors and automatically by using sensors.

Problem Statement

The main problems associated with PLCs can be broken down into the following list:

- Getting new hardware (trainers) from vendors is very expensive
- Space issues
- Dedicated trainers for each student.
- Importance of hands on training
- Updated hardware is very important for students to fill the gap between university and real world applications
- Having individual trainers will help students to understand the material better

The B&R trainers can help to solve a majority of these problems by having the following characteristics:

- Training faculty who teach PLC's and industrial automation.
- Training technicians to help with maintaining, installing, and troubleshooting PLC's
- Introductory and advanced curriculum in the Mechatronics program.

The Requirements

The main requirement of the new proposed portable training PLC system is that it must support the sub-disciplines of software engineering, computer programming and panel wiring. While the basic system must support digital I/O, it should be expandable to support analogue handling and non-proprietary networking. The system should have capabilities to integrate with many components from different vendors. The authors require that the trainers should:

- Use only 24V DC
- Be portable to solve the problem of space (i.e., fit comfortably on a desk)
- Incorporate an industrial standard PLC with an interface to a PC
- Support Ladder Logic and at least two of the other IEC 6-1131 defined Languages
- Interface with common industrial electrical components
- Be low cost as continuing transportation will likely result in the need for frequent component replacement donated from B&R to the University
- Be expandable to facilitate analogue handling
- Be expandable to facilitate Ethernet networking

- Be compatible with other PLC vendors
- Be integrated to the other hardware such as robots, cameras vision systems, NI, and Labvolt

Conceptual Design and Assembly

Figure 1 shows the conceptual block diagram/schematic of the B&R trainer.

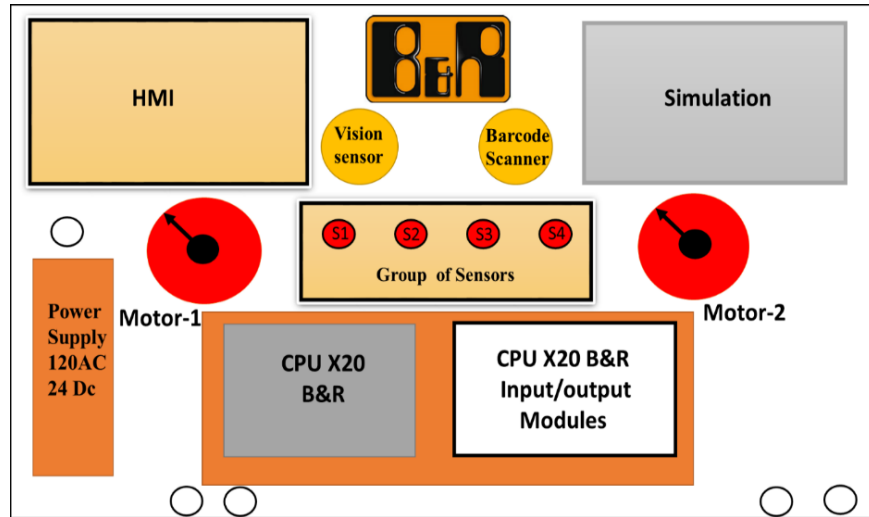


Figure1. The schematic of the trainer

The goal is to build 22 trainers, on which a group of two students can work. The dimensions of each trainer are 22 by 15 inches. A prototype is already completed and operational as shown in Figure 2. The frame was built in-house using 1/8-inch aluminum sheet. Figures 3 show the complete trainer in the lab.

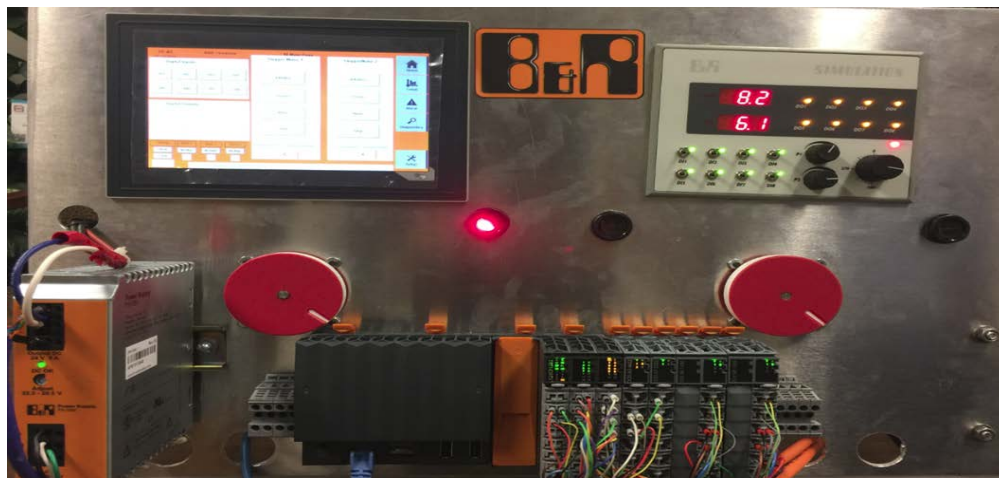


Figure 2. The complete trainer.

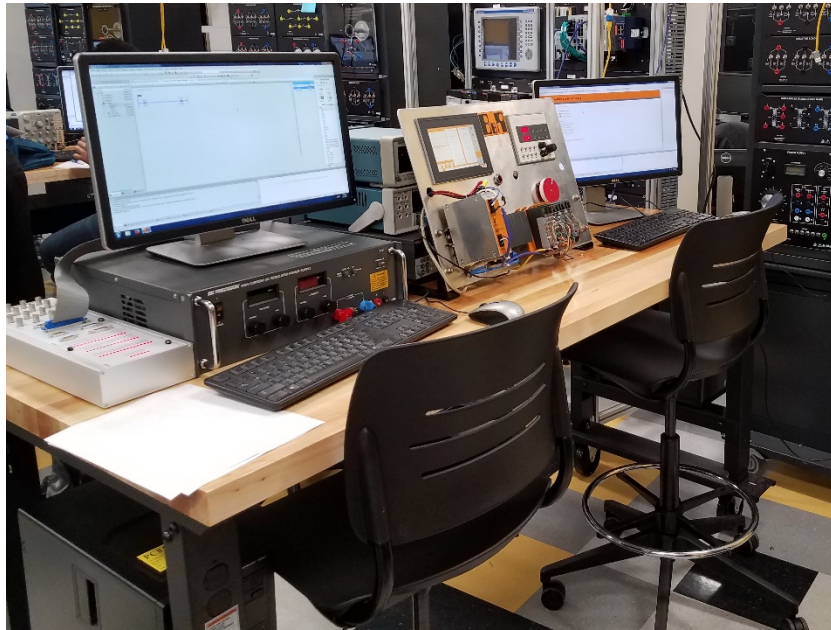


Figure 3. The working trainer in the lab.

Components

The trainers have several features such as 2 analog outputs (0 - 10V), Over temperature display, 1 Ethernet port 10/100 Base-T, to name a few. Appendix A includes a list of all the features. As mentioned before, the software installed on the trainers are B&R, which is an open-source software. Figure 4 shows step-by-step instruction to assemble the trainer. All the electronic components were provided by B&R [1]. The authors are planning to complete all the 22 trainers in near future.

Lab Activity Outline

The trainers will be used in Programmable Logic Controller course (ECET 26200), as well as in Control and Instrumentation for Automation (MET 38200). The former is the backbone of the Mechatronics program which includes such topics as PLC hardware components, Input/output modules, programming using timers and counters, programming using Math instructions, Human Machine Interface, PID control, etc. The objectives of the course are as follows:

The students will be able to:

1. Write basic PLC's ladder programs from a given description of the logical and I/O operations
2. Manipulate data using PLC instruction sets.
3. Write motion control programs using Function Block Diagram (FBD) and Structured Text (ST)

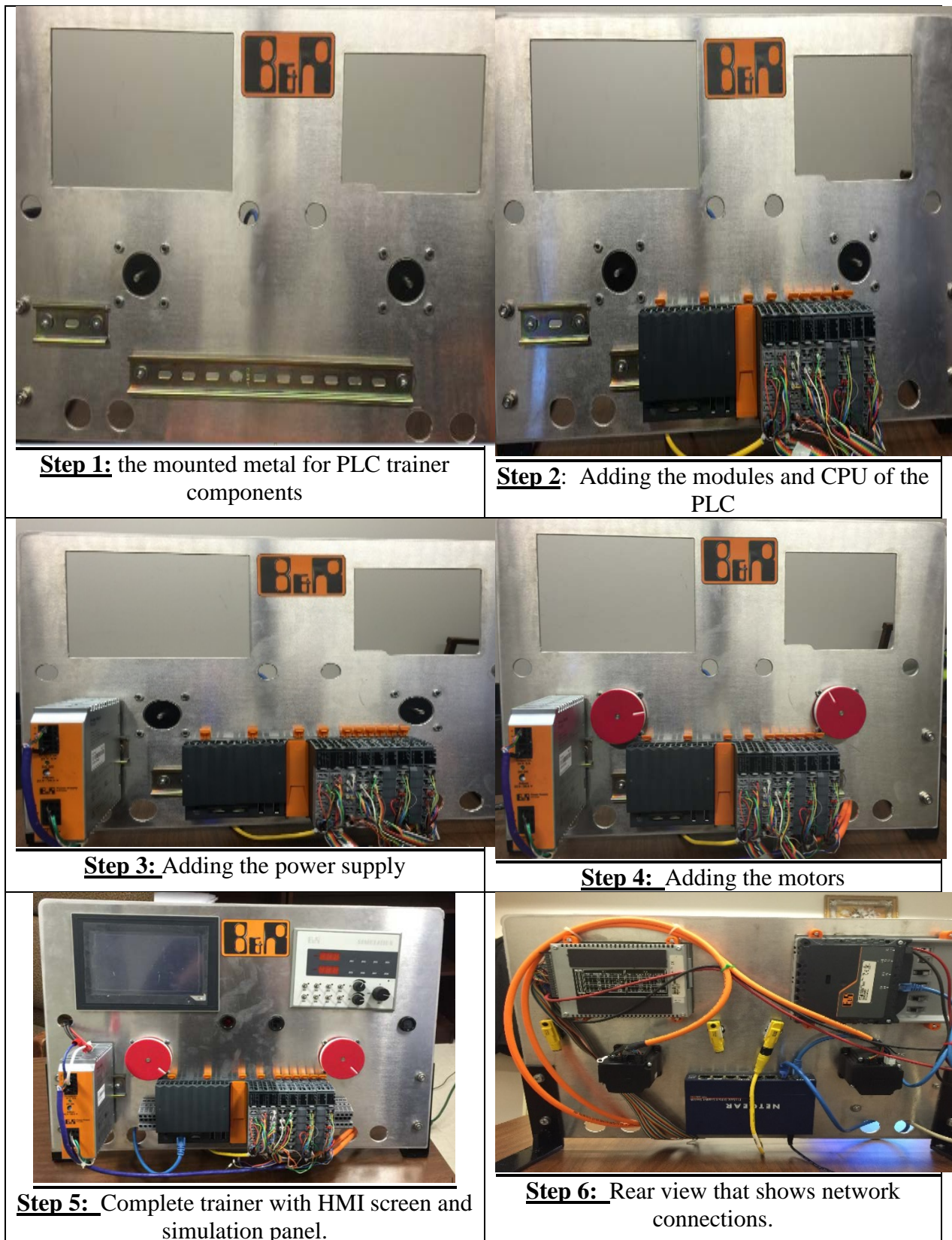


Figure 4. Detailed assembly steps

4. Write advanced motion control programs using Function Block Diagram (FBD) and Structured Text (ST)
5. Design and Configure graphical screens for HMI (Human Machine Interface) units

The lab portion of the PLC course follows the outlines shown in the table below:

- Lab #1: Introduction to PLC Lab and Automation Studio AS4.2
- Lab #2: Connect to PLC -download and transfer basic program into PLC
- Lab #3: Number systems (Decimal-Binary-Octal-Hexadecimal-BCD-Gray Code)
- Lab #4: Timer Programming Part #1
- Lab #5: Timer Programming Part #2
- Lab #6: Counter Programming Part #1
- Lab #7: Programming using Sensors (Digital\Analog)
- Lab #8: Timer and Counter Programming
- Lab #9: Math instructions
- Lab #10: Digital Logic Instructions
- Lab #11: Advanced Math Instruction
- Lab #12: HMI using Digital Input/output
- Lab #13: HMI using Analog Input/output
- Lab #14: HMI using Digital /Analog / Motor controlLab #15: PID Controller and advanced PLC Instruction/MAPP

Conclusion

In this paper provided a background of the current issues with PLC trainers that are used to teach Programmable Logic Controller course (ECET 26200). The authors presented the rationale to develop new PLC trainers and to explain steps to build them. In addition, various advantages and features of the new PLC trainers were explained. The courses in which the trainers will be used were mentioned with more emphasis on ECET 26200. For this course, the lab activities were also outlined. The authors believe that these PLCs enhance students learning and improve the lab's safety. Yet, examining the impact of these trainers on students learning is the subject of a future study.

For future, the authors are planning to conduct a survey to learn about students' feedback on what they think about the new trainers in terms of the design, features, etc. The authors will conduct the study in next fall when the course and the lab will be offered.

Acknowledgement

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Reference

[1] Neil, O, 2003. [Online]. Available: <http://www.impomag.com/article/2003/11/consider-24v-dc-control-voltage-safety-reliability-by/>. Accessed: March22. 6, 2017.

[2] "B&R," 2009. [Online]. Available: <https://www.br-automation.com/en-us/perfection-in-automation/>. Accessed: Feb. 6, 2017.

Appendix A: The features of the trainers

- 24 VDC supply voltage
- Options for simulation: 8 digital inputs
- 8 digital outputs (using lock-or-toggle switches)
- Options for simulation: 2 analog inputs that display a voltage of +/- 10V on the status display
- 2 analog outputs (0 - 10V)
- Rotary pulse encoder with button function (A, B signal)
- Temperature controller system:
- Fan control
- Heat transistor control
- Thermal over temperature protection
- Over temperature display
- PT1000 probe sensor
- Fastened using retaining clips and magnetic strips
- Everything included in delivery
- Compact construction
- 1 RS232 interface
- 1 CAN bus interface,
- 1 POWERLINK interface,
- 1 Ethernet port 10/100 Base-T,
- 14 digital inputs, 24 VDC, sink,
- 4 digital inputs, 2 μ s, 24 VDC, sink,
- 4 digital outputs, 24 VDC, 0.5 A, source,
- 4 digital outputs, 2 μ s, 24 VDC, 0.2 A,
- 4 digital in-/outputs, 24 VDC, 0.5 A,
- 2 analog inputs \pm 10 V or
- 0 to 20 mA / 4 to 20 mA,
- 1 PT1000 instead of 1 analog input, incl. power supply module,
- 3x X20TB1F terminal block, slot cover and X20 locking plate (right) X20AC0SR1 included