Using a PLC Trainer To Control a Utility Cart

Mohammad Fotouhi, Ali Eydgahi

University of Maryland Eastern Shore
Princess Anne, MD 21853

Abstract

This paper describes the details of an undergraduate project in electrical engineering technology program at UMES and experience gained by the student. The objective of this project was to incorporate the Allen Bradley commercial SLC 503 programmable logic controller (PLC) trainer to control and steer a utility cart. The utility cart was required to perform the maneuvering motions of going forward, going in reverse, turning right, and turning left, and stopping. All of these motions had to be controlled by PLC trainer.

Introduction

Design of a controller using a PLC to control a utility car was an undergraduate student project in our design technology course. The main objective of this project was to demonstrate the power of a programmable logic controller to control a utility cart that uses a dc motor and a stepper motor for turning. The student had seen different PLCs in-automated set up at work. However, he never had the opportunity to work or operate them. Thus, he was very interested in a project where he can design a control system with PLCs.

The flexible programmable logic controller trainer incorporated in this project was an undergraduate project, which was designed and fabricated by a student a year ago[1]. This trainer consists of an interface board that is connected to the inputs and outputs of the Allen-Bradley SLC500 PLC unit. This PLC system contains a processor that has 16k words of memory. The main component of the trainer is the SLC 503 processor with six replaceable modules in a rack. Two power supplies of 24 ^{V} DC and 5^{V} DC support circuitry. Multiple I/O modules with LED indicators are housed in a 19" rack mount enclosure, which allow flexible interfacing with visual feedback. The modules are digital input/output module, analog voltage/current input module, and an analog to digital conversion output module. The PLC trainer is shown in figure 1.

The PLC trainer is a digital controller that can be interfaced with all systems or processes that need to be controlled. The trainer has discrete ON/Off inputs that can accept various DC voltages and analog inputs that can accept voltage and current signals. Outputs are discrete ON/OFF DC and AC signals and ADC voltage levels.

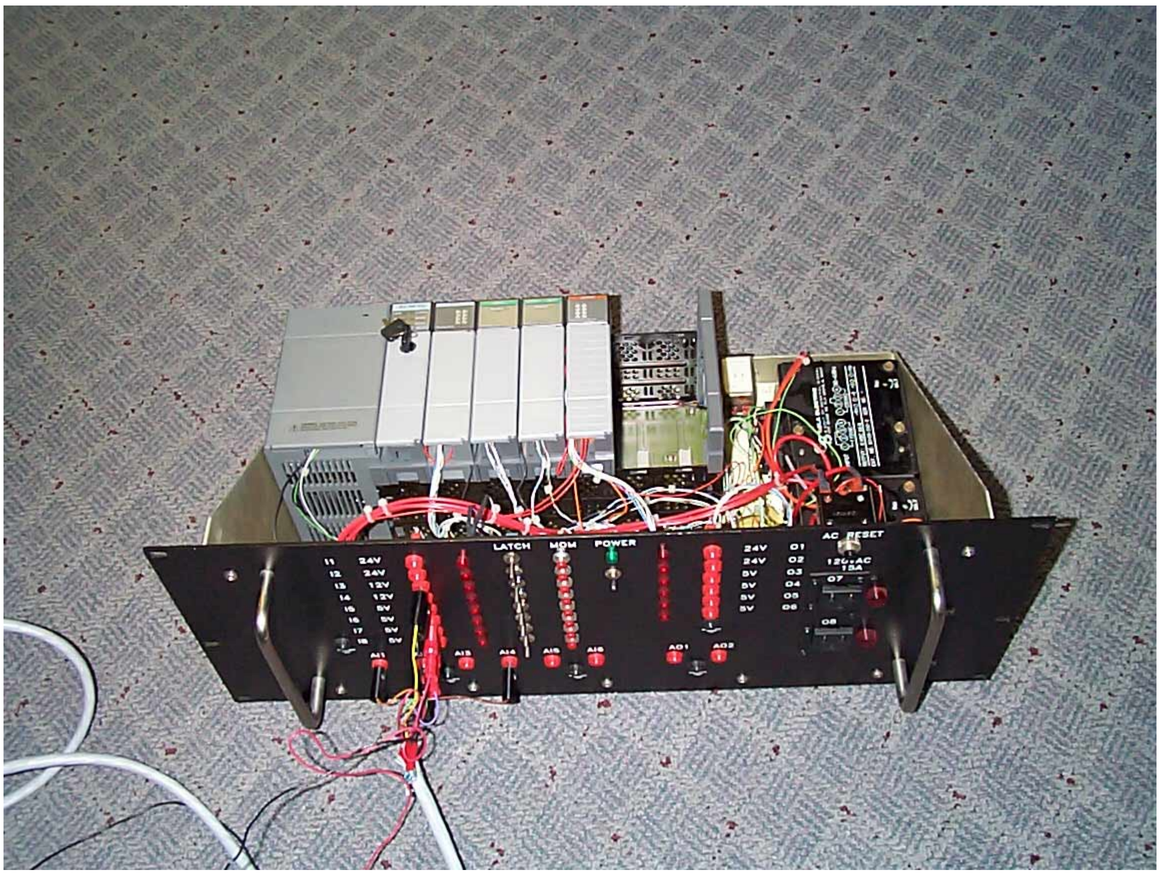

Figure 1: The PLC Trainer

Programming the PLC requires Wintelligent Linx and RSLogix 500 software packages. The Wintelligent Linx is the communication software. It sets up the mode of communication between the computer and the PLC. The RSLogix 500 is software where the development of programming projects is conducted. This software allows user-friendly visual writing of the control programs. The program uses ladder logic[2-3] as its structure. The ladder logic has evolved from relay logic that was widely used to control processes until the PLC was developed. The program takes the data from the various inputs and uses that data to compute the corresponding outputs. The outputs are generated to control external circuitry or equipment.

This process of accepting data and providing outputs can be observed on the computer as well as on the PLC modules. If a PLC is located away from the programming computer. The PLC can send near real time data to PC and allow remote monitoring of the PLC. This situation can be simulated using the software and the interfacing RS232 cable.

The Design Project

The project requirements were:

- Design and construction of a mechanical frame.
- Construction of a drive mechanism using an electrical DC motor to move the cart and a stepper motor to steer it.
- Design and construction of an electronic circuit for interfacing the cart with PLC.
- Programming the PLC using ladder logic for controlling the cart.

Mechanical Drive Mechanism

The body of utility car platform is made of ¼ inch aluminum. It is shaped as a triangle with three wheels. The front wheel is coupled with stepper motor passing through a yoke for ease of steering. The rear axle is coupled with 12^V DC motor with high torque that could move the cart forward and backward. The steering is done using an Airpax stepper motor. The stepper motor also required 12^V DC to operate. This particular motor rotates 15^o per step. Each of the four coils in this unipolar motor had a resistance of 36 ohms.

Design of Electronic circuit interfaced with PLC

A 30ft eight-conductors cable is used to connect the PLC to the Cart. The controller for the stepper motor consists of four 2N6796 transistors that are used to activate the stepper motor coils. The stepper motor coils were hooked to the drain on the transistors. The source was hooked to ground, and the gate was hooked to one of the four 5^V outputs from the PLC. All four coils were energized in the same way. In order to run the DC and stepper motors, a 12^V external power supply is used. To be able to control the DC motor by the PLC, the 24^{V} outputs from the PLC is used to turn a relay that is between the 12^{V} supply and the motor, on and off. The electronic circuit was constructed on a prototype board so that it could be easily modified. Figures 2 and 3 show the designed cart.

Familiarization with programming the SLC 503

The student did not know much about the PLC and its software. His first objective was to familiarize himself with the SLC500 software. The ladder logic program is exactly what it sounds like, a series of ladder rungs that tell the PLC what to do in a certain order to control the stepper motor by PLC. Once that was accomplished, he made a ladder logic program. After the drivers were configured properly, he downloaded the program to the PLC processor.

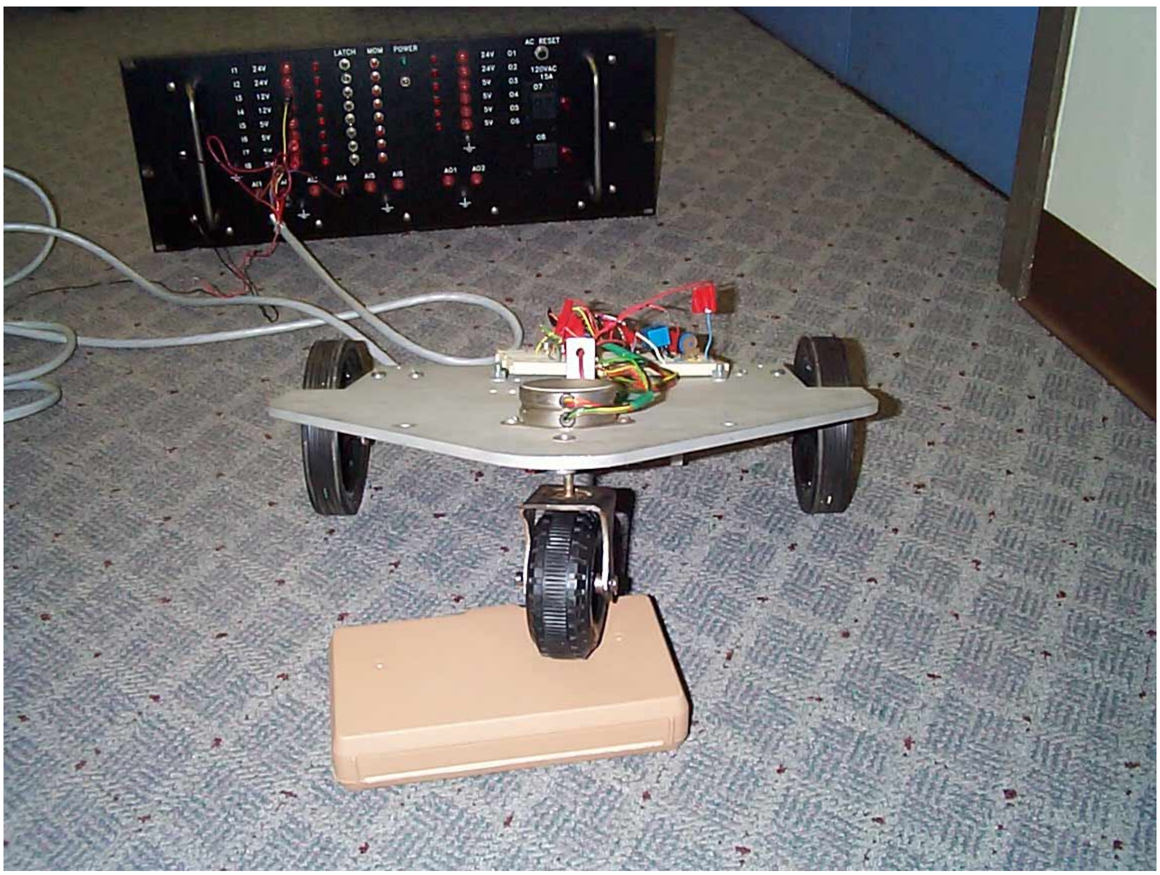

Figure 2: The Designed Utility Cart

Once the program was properly downloaded to the PLC, and all wires were connected properly, the controlling of the cart was carried out. Unfortunately, the stepper motor was not powerful enough to turn the heavy platform. Other than that, it did control the stepper motor when the weight was reduced by slightly holding it upward. The controlling was done through a series of timers that latched and unlatched the proper 5^V outputs and activated the next timer for the next step. The DC motor was able to move the cart forward and backward; and performed the maneuvering.

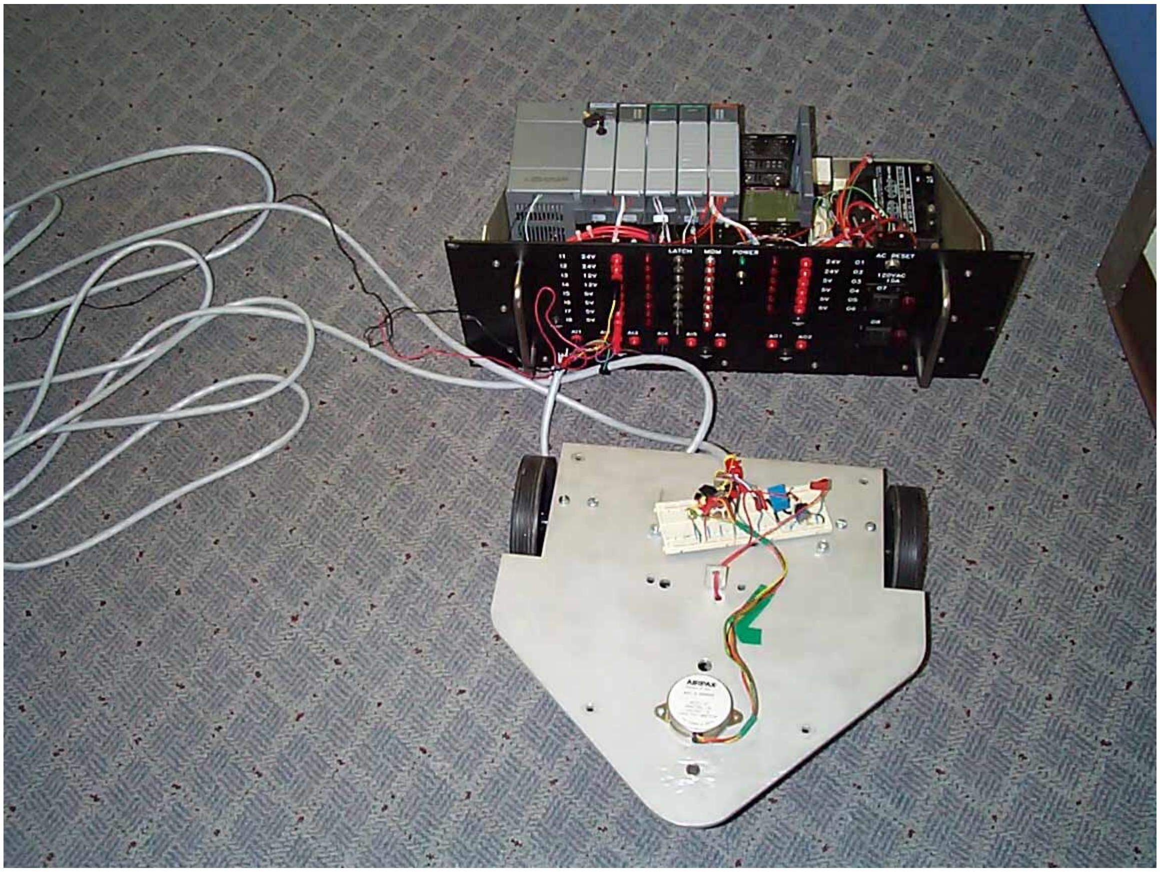

Figure 3: Another View of the Designed Utility Cart

Conclusion

The enormous power of PLCs in industry automation can not be emphasized enough. The possibilities are nearly endless as to what can be controlled with these devices. Students can gain valuable experience through projects that use PLCs to operate and control different types of motors. This project could be integrated into the beginning of an automation control assembly line project.

Bibliographies

1. Fotouhi, M., Eydgahi, A., and Cavey, W., Design of a Programmable Logic Controller Trainer, Computers in Education Journal, pp. 17-20, Vol. X, No. 1, Jan/March 2000.
2. Webb, J.; Programmable Logic Controller: principals and Application, 4Th edition, Prentice Hall, 1998.
3. Simpson, C.; Programmable Logic Controller, Prentice Hall, 1994.

MOHAMMAD FOTOUHI

Dr. Fotouhi is a Professor of electrical engineering technology at University of Maryland Eastern Shore. He received his Ph.D. in power System Engineering from University of Missouri-Rolla, M.S. from Oklahoma State University, and B.S. from Tehran Polytechnic College. He has been conducting a practical research on the growth and characterization of the dilute magnetic semiconductor since 1985. He is a member of Eta Kappa Nu Honor Society. He was Chairman of Student and Industry Relation and Host Committee member of IEEE Conference on Power Systems Computer Application in 1991. He also was chairman of Student Relation and Host Committee member of the IEEE Power Society Winter Meeting in 1996.

ALI EYDGAHI

Dr. Eydgahi is a Professor of electrical engineering at University of Maryland Eastern Shore. He received his Ph.D. and M.S. in Electrical and Computer Engineering from Wayne State University. Since 1986 and prior to joining University of Maryland Eastern Shore he has been with the State University of New York, University of Tehran, Wayne County Community College, and Oakland University. Dr. Eydgahi is recipient of the Dow Outstanding Young Faculty Award from American Society for Engineering Education in 1990, and the Silver Medal for outstanding contribution from International Conference on Automation in 1995. He is the ASEE Campus Representative at UMES and has served as a regional and chapter chairman of IEEE and SME in New York. He also has served as a session chair and a member of scientific, and international committees for many international conferences. He has published more than seventy papers in refereed international and national journals and conference proceedings.