Designing & manufacturing of a smart Programmable logic controller work station

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ABSTRACT:

The Programmable Logic Controller (PLC) is an important component for industrial automatic engineering operation. Hence, the need to comprehend its basis of operation becomes an inevitable task. Some of the problems is industrial PLC is an expensive, pre-built hardware kit, acquisition of programming software and its requisite programming competence is a challenge. Thus, this document presents the design steps for a desktop PLC trainer workstation for industrial automation. Although researchers have proposed and reported several PLC trainers but they fail to discuss the hardware connection of the input/output components and PLC input output interface. These are the areas discussed in this document to train participant on PLC programming knowledge by maximizing learning effect. The develop PLC workstation consist of push buttons switches, sensors for input signals and for output signals are buzzer, indicator lights and motor, pneumatic cylinder. The control aspect comprises the PLC, timer and relay. The PLC controller are the Siemens Logo 8, Siemens S7 1200, and the programming software is the Siemens Logo Soft Comfort, Siemens TIA Portal. A 6-inch color HMI is used as a process visualization. Performing close control theory, two step temperature control and for PID control a pressure sensor along with a compressor is used to teach the close loop control technology. In this document two automatic control application scenarios to train participants and evaluate how the trainer is applicable to real-world situation. We conducted a survey after training to measure the impact of our approach for PLC programming knowledge for participants and result show enhanced knowledge within a shorter period of time.

Introduction:

The PLC replaced the antique relay control logic in the late 1970s in the control of machines and processes that has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, machines, robotic devices, or any activity that requires high reliability, ease of programming, and process fault diagnosis. Some of the benefits of the PLC over the relay control logic are flexibility, higher reliability, communication possibilities, faster response time, and easier troubleshooting. Hence, it has become a vital component in the industry for engineering operation control. The PLC is a microprocessor-based controller; it receives analogue and digital signal input from input component such as switches and sensors and apply instructions stored in its programmable memory to control outputs to output components such as motors, pneumatic devices and status indicator. Its implement's functions such as logic and sequence. The rapid pace of technological development with new model and innovation of PLC technology and its flexibility has encouraged its application beyond industrial control spectrum. Therefore, the development of competence through training programming of PLC and its application become imperative for student and person with interest in the field of industrial automation. Nevertheless, some of the problems is that industrial PLC is an expensive, prebuilt hardware kit also to acquire programming software and its requisite programming competence is a challenge.

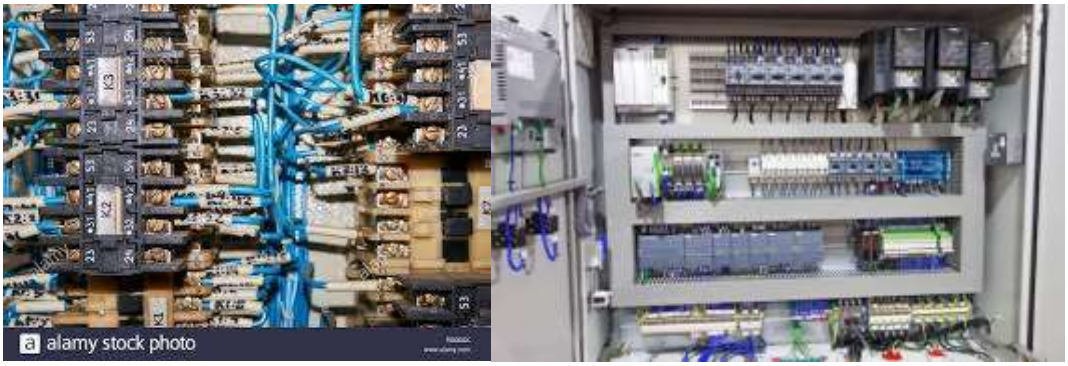

Fig. 01: Conventional & PLC Based control panel.

The programming languages defined by IEC 6-1131 for PLC is the Ladder Logic (LL), Structure Text (ST), Function Block (FB) and Instruction List (IL). The PLC programming device can be a handheld device or the personal computer (PC). However, the PC is commonly used for PLC

programming because it is readily available and portable. The LL is the most used programming language because it is simple to comprehend and implement. In this document SIEMENS S7-1200 and logo 8.2 are used as a main PLC controller due their flexibility and user-friendly architecture. Siemen S7-1200 offers both liner and structured programming option for the trainees which enable configure 500 inputs out required for mid-range industry.

R & D and design step: Programmable logic controller are readily available in Bangladesh as an Industrial automation components. Input and output are connected to different types of switches, sensors and actuator. Program is required to download for a specific application and control. This is very hard for a beginner to learn this skill from the industrial environment. Therefore, an inexpensive compact PLC training kit is required for learning on industrial automation practice which can reduce inefficient time during the training to maximize learning effect. To overcome those problem BITAC had taken an initiative to developed PLC training workstation for our own training. BITAC has developed a PLC work-station in 2017 to minimize skill by reducing inefficient time during training period.

PLC module for educational purpose to enhance the learner's theoretical comprehension and hands-on skill especially for programming, cabling, circuit design and problem solving is presented in their module consists of I/O devices such as push buttons NO, NC, limit switch, digital and analog sensor, DC motor (24V), DC relay (24V), DC solenoid piston cylinder (24V) and DC light (24V) capable of interfacing with PLC controller produced by Allen Bradly, Omron, Siemens. FANUC etc. Survey report from the trainees show that 95.70 % attest to the enhancement in their theoretical comprehension and hands-on skill competence in their learning process. However, the programming aspect of the PLC is not discussed in this document.

Size of the work-station:

PLC Work-station training board compact and portable for learning on industrial automation practice is for the hardware for Siemens S7-1200 and Siemens LOGO and the size is 2m × 800 mm × 2 m.

Objective:

The objective of this documents is to present design steps for a desktop PLC trainer workstation for industrial automatic engineering operation with emphasis on hardware connection of the input/output components. We present basic PLC automatic operation such as latching and component symbols with description. In order to train students and persons with interest in the field of automatic control for industrial automation. The design and implementation comprise the cabling, programming of PLC using ladder logic with the PC, downloading and uploading the program to the PLC through Ethernet cable and testing on the workstation with the I/O device.

Main component:

The materials for the development of the proposed PLC training workstation are: Siemens Logo 8, Siemens S7 1200 PLC, and programming software; Siemens Logo Soft Comfort, Siemens TIA Portal, Power Supply Unit, Ethernet cable, switches, push buttons, blower, relay and buzzer, RTD sensor, thermocouple, Pressure sensor, stepper motor, three phase induction motor, Variable frequency drive, multi-turn potentiometer, panel volt meter, PID simulator and safety laboratory cable.

Siemens Logo 8 & Siemens S7 1200 PLC:

Siemens Logo 8 is an intelligent logic module meant for small automation projects in industrial (control of compressors, conveyer belts, door control, etc.), office/commercial and home settings (lighting control, pool-related control tasks, access control, etc.). It is deployed worldwide and can be controlled remotely. It is considered as most powerful control at very low price.

Siemens Logo 8.2 is new version of mini logic module capable to connect cloud. The Logo! Soft Comfort engineering software is getting a functional update to enable configuration of the new devices. With this Version Logo 8.3, it is possible to activate and configure the cloud connection and use the new free Logo! Web editor to create user-defined website and dashboards in the cloud. Users can also design their automation projects and operate them from the cloud via smartphone, tablet or PC. The webserver can be directly hosted in the cloud, enabling individual visualization and centralized control of switching and automation solutions

in building management systems, and in the construction of control cabinets, machines and apparatus – comfortably, regardless of the location. Users can use network feature with more options for simple networking. The encrypted connection from the cloud to Logo! 8.3 via the TLS protocol, a secure data transfer is carried out in both directions, i.e., read and write.

The cloud connectivity of the new logic modules represents a paradigm shift. Whereas previously the Logo! had to be interrupted for data handling or acquisition purposes, real-time access in the cloud makes it possible to access all data during operation. At the first level, Logo! 8.2 enables Amazon Web Services (AWS) to be connected to the cloud. But in future more connections, such as to Mind-Sphere, the Siemens cloud-based, open IoT operating system, and Alibaba will be also available. Logo! 8.2 can also be used as a cloud gateway for existing systems. This enables data to be exported to the cloud, for example, because memory space in the controller is limited. In this way, the entire data of smaller automation projects is available in the cloud for further processing and analysis, resulting in new possibilities for the automation engineer to record and evaluate energy data, carry out predictive maintenance or implement flexible service concepts.

Fig. 02: Siemens LOGO 8.0 with Cloud connectivity for Industry 4.0

Fig. 03: Siemens Logo Logic Module

On the other hand, SIMATIC S7-1200 controllers are the intelligent choice for compact automation solutions with integrated IOs, communication and technology functions for automation tasks in the low to medium performance range. They are available in standard and fail-safe versions. This version of PLC uses TIA portal automation software that enable control & visualization in single platform.

Fig. 04: SIEMENS S7-1200 logic Module

Supporting components list

Quantity	List of supporting components	Quantity	List of supporting components
12	 Momentary push switch	1	 Pressure switch & sensor
10	 Indicator	1	 Pt1000
1	 Buzzer	4	 Multi turn potentio -meter
1	 Three phase induction motor	4	 Digital volt and current meter
1	 Variable frequency drive	1	 HMI
2		50	 Safety laboratory cable

2		100	 Safety laboratory female connector
4		500	 Connector

Programming Language:

The LL defined by IEC 6-1131 is the programming language used in this workstation. The Ladder logic programming structure is similar to ladder with horizontal rails and vertical rungs. In the LL structure; power flows from left horizontal rail to right horizontal rail through the connecting vertical rung. Circuit components are shown on the vertical rung in their normal condition. Every rung must specify a control operation with at least one input and output component on each rung. Input component is shown on the left and output component on the right of the rung. Same component can appear multiple time on a LL. I/O component are addressed as specified by the PLC manufacturer. The PLC reads the LL left to right, top to bottom with the last rung specified as END or RET.

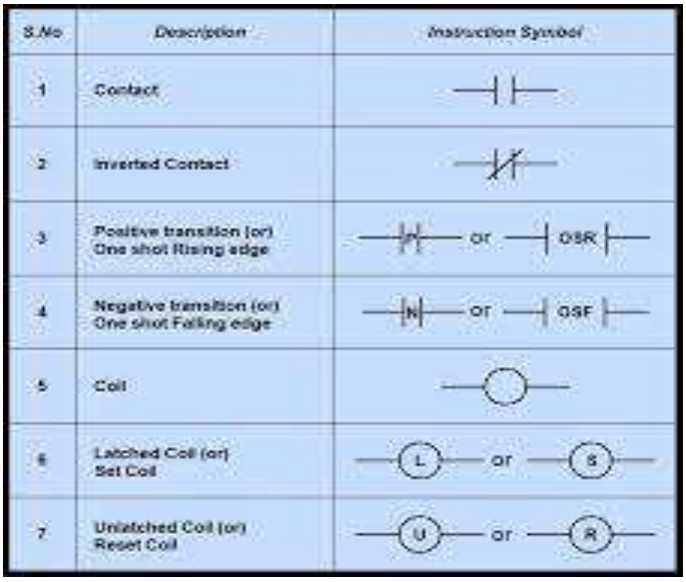

Fig. 05: Ladder Symbols

Outcome:

Participants are given a specific task that includes planning of the project, preparation electrical drawing, electrical wiring between PLC input output and the sensor & actuator. Then programs are developed for the specific task, testing & commissioning of the task. through the step-by-step wring of the PLC trainer workstation and LL programming discussed above. Under instructor supervision participant hardwired the PLC trainer work station shown in figure 4 & 5. To train participant on automatic control they are taken through LL programming for PLC with LL symbols with description explained above. Participant are trained on writing LL program for automatic control and are given assignment on latching procedure to develop their PLC programming skill. The participants are required to write and program at least 25 different applications. The 25 project is carried out in ten days. Before designing this work-station only ten projected was implemented by the student. As because students making project, the learning effect became doubled.

Fig. 06: PLC Advanced work station

Fig. 07: PLC Advanced work station

To measure the impact of the trainer on PLC knowledge of participants a survey was conducted after training. It has been observed that learning effect become doubled and time saved 3 time than previous method by using this work-station.

Results and discussion:

The summary of the workstation-based training filled by the 23-participant taking the course; Automation and PLC in 2018 and the participants agreed that the PLC trainer workstation enhance their knowledge on design step module and LL programming module significantly. However, about 70 % of participant did show confidence writing LL program for automatic control. This can be enhanced with further practice with Human Machine Interface (HMI) for real-time control visualization.

This document presents the design steps for a trainer workstation for industrial automation & control. By adding the IoT platform this trainer can be easily converted industry 4.0 trainer board. To convert the work-station only sight modification required & IIoT device need to be concocted.

Acknowledgement:

Authors like to acknowledge the staff and student of BITAC, Dhaka for their support during this work.

Further information:

Please contact at BITAC Dhaka if any further information is required.

References:

[1] M. O. Arowolo, A. A. Adekunle, M. O. Opeyemi, “Design & Implementation of a PLC Trainer Workstation” in Advances in Science, Technology and Engineering Systems Journal, Federal University Oye, Nigeria, 2020.

[2] M. Barrett, "The Design of a Portable Programmable Logic Controller (PLC) Training System for Use Outside of the Automation Laboratory" in 2008 International Symposium for Engineering Education, Dublin City University, Ireland, 2008.

[3] K. Bhise, S. S. Amte, "Embedded PLC Trainer Kit with Industry Application" Int. J. Eng. Sci. Innovative Tech (IJESIT), **4**(3), 1-9, 2015.

[4] C. D. Johnson, Process Control Instrumentation Technology (8th ed.), Upper Saddle River, New Jersey, Prentice Hall, 2006.

[5] W. Bolton, Programmable Logic Controllers, (4th ed.), UK, ELSEVIER, 2006.

[6] D. H. Gawali, V. K. Sharma, "FPGA Based Micro-PLC design Approach" Advances in Computing, Control, and Telecommunication Technologies" in 2009 International Conference on Communication, Computing and Electronics Systems, 2009.https://doi.org/10.1109/ACT.2009.167

[7] M. Mahadi, N. A. Mohd Amin, M. Ab-Rahim, M. S. Abdul Majid, "PLC Trainer Kit Simulator: An Improvement for Automation Study in Polimas" Appl. Mechanics and Mater., **786**, 367-371, 2015. https://doi.org/10.4028/www.scientific.net/AMM.786.367

[8] B. Ibrahim, A. A. Ahmad, T. Saharuddin, "Multiple Input/Outputs Programmable Logic Controller (PLC) Module for Educational Applications" in 2015 Innovation & Commercialization of Medical Electronic Technology Conference (ICMET), Shah Ala, Malaysia, 2015.https://doi.org/10.1109/ICMETC.2015.7449570