Home-made PLC laboratory training set for limited budget vocational education institution

Sunomo¹ and A Asmara²

¹,²Department of Electrical Engineering Education, Yogyakarta State University, Yogyakarta, Indonesia

E-mail: sunomo@uny.ac.id

Abstract. The objective of this study is to build a low voltage three phase 24/41-volt programmable logic controller (PLC) lab. experiment training set for vocational education institution with limited budget. The training set is very cheap, durable and safe from electric shock hazard due to no other and no higher voltage used for running it. The 12 I-O PLC unit using ATMEGA 16 processor, programmed by LD micro ladder diagram software on the laptop connected to the PLC module. The loads are: two units three phase motor modified from washing machine motor with specific designed, three phase electronic magnetic contactor, three modified motorcycle bulb lamp and one buzzer. The training set equipped with two version protection; electronic phase failure for the three phase source and electronic fuse destroyer in every unit module. The 24/41 volt three phase source will be blackout one second after one of the 8 ampere three phase fuse become off by overload condition or destroy due to a wrong connection of the individual module from phase to neutral (24 volt) become phase to phase(41volt). The evaluation result from the three internal department of PLC programmer expert and five vocational secondary school (SMK) teachers in Yogyakarta shows that the unit works well as it intended.

1. Introduction

Programmable Logic Controller (PLC) is a commonly used for lab experiment course in vocational education due to application of automation system in modern industry. PLCs are covered in many undergraduate automation and control-related courses, such as; Computer-Aided Manufacturing, Computer-Integrated Manufacturing, Industrial Control and Networking, Sensors and Instrumentation, Manufacturing Automation and Robotics [1]. For education, Rana proposed a Universal Simplest possible PLC using Personal Computer, The PLC unit has been produced by industries eg; ABB, Siemens, Omron, Mitsubishi, Hitachi, GE, Fanuc, Schneider, Zelio etc, and standardized for industries applications [2]. For educational purposes, PLC Training set can be ordered from Festo didactic, Allen-Bradley, Shandong Xinke China, SCE Siemens and others. But if the price is a problem due to limited budget, a vocational education institution can make a PLC training set module with electric load to be controlled, for example; very low voltage three phase motor, buzzer (alarm), lamp, led module traffic light arranged. With LDmicro, the PLC itself can be built by ordinary microcontroller and programmed using LDmicro free software prepared by Jonathan Westhues Portland, Oregon [3].
In this study, PLC training set build with 12 input-output ATMEGA 16 processor, and with electric loads to be controlled is; two very low voltages three phase motor 24/41 volts via electronic magnetic contactor, buzzer, and bulb lamp. The motor itself made by modification of secondhand washing machine capacitor motor, the bulb lamp constructed from double filament 12 volts’ motorbike lamp, in series with 12.5 ohm 40 watt to reduce the light intensity and its current. The buzzer is DC 6-24volt specification, series connected with a diode and resistor 220 ohm to make it fed with 24-volt ac. With the whole system operated in the same voltage 24-volt ac for input and output terminal, the price will be low and ideal for institutions which have a limited budget. No different voltage sources are needed to perform the experiment on board like the module proposed by [4]. Optocoupler is used to bridge the different voltage inside the circuits of microcontroller.

2. Method

The method using in this study is R & D, by designing the physical form and testing its performance. All of the performance tested running in within four hours. The evaluation of its appropriateness done with open sistem questionnaire to three people PLC programmer in the department and five people from vocational high school (SMK) is; SMKN2 Yogyakarta, SMKN3 Yogyakarta, SMKN 1 Sedayu Bantul, SMKN1 Pundong, SMK YAPPI Wonosari.

2.1 The Whole Module

The physical form of the whole module shown in Figure 1a-1b. With laptop connected to the PLC module via USB to make a program via ladder diagram (Fig.1a) and running the program with laptop connection released from the PLC module (Fig.1b). The bottom side of the module (main module on Fig.1a) is 3 phase 24/41 volts source with three 220V/24 volt 5 ampere transformers connected in star to convert 220/380 volts source to 24/41 volt, protected with MCB in the primer and switched on and off by magnetic contactor. In the secondary circuit (24/41 volt), protection done by 5 ampere fuse on each phase and electronic three phase failure relay. If one of the 5 ampere fuse is off, it takes one second for the 24/41-volt source will be blackout. The physical modules of the PLC and the magnetic contactor seen from rear side shows in fig.2a and 2b, Fig 3a is the three phase motor modules seen from the rear side, laid on the upper side of the main 24/41 three phase source box, connected via sockets to the acrylic motor symbol terminal. Fig.3b is the circuit module of phase failure protector (left) and over voltage fuse destroyer (right). No screw used for every individual module, just insert and play on the main slot power modul with the motor laid on the upper side plywood box where the three power transformer 10 ampere 220volt/24 volt installed in the box (see Fig 1a and Fig 3a).
Figure 1. The PLC training set module; (a) programming via laptop (b) running condition

Figure 2. The physical module seen from the rear side; (a) The PLC (b) The Contactor magnetic

Figure 3. The physical module seen from the rear side; (a) 24/41 three phase motors, (b) Phase failure and over voltage electronic protector units
2.2 Current measurement for the loads
The measurement result of current draws by the loads are: 1.03 amperes for motor in star connection and 0.97 – 1.05 amperes for the bulb lamps, 0.30 amperes for electronic magnetic contactor, and 0.0346 amperes for buzzer. Due to the easy circuit

2.3 Outlines of loads and protection design
For good skills of vocational education teacher or lecturer in basic electronics and electrical machines, home-made loads described in this paper is easy to implemented. To convert the motor from one phase to four pole in three phase mode, taking the data about number of slots, diameter of wire and turn per coil of the main winding coil in 220volt, then converted to turn per coil in linear comparison for 24 volt, and use the ordinary rewinding formula available for the phase mode. In this study, single layer winding was applied. For the electronic magnetic contactors, use the ordinary 12 volt dc relays with its contact poles arranged as ordinary three phase contactors. To energized from 24 volt ac, use the ac to dc simple power supply that acts as magnetic coils in three phase contactor. To avoid wrong connection from phase to neutral 24Vac) become phase to phase (41Vac) done by anyone who operate the unit, use the TRIAC fuse destroyer with peak back-to back zanier diode sensor setting at little more of 24 volt ac peak voltage. This will be save the filter capacitor and series pass transistor breakdown in the dc power supply in the electronic magnetic contactor. Electronic phase failure relay 24/41 volt connected in series with stop push button of the main magnetic contactor in the main module that convert the 220/380volts ac main source to 24/41 volt via 3x 1 phase 5A or 10 amperes transformer.

3. Conclusion
The evaluation results from the eight evaluators shows that the whole PLC lab experiment training set work properly as it intended, recommendation or suggestion only in the standardization of the electrical schematic, whether it will follow totally to the ANSI, IEC or PUll (Indonesia) standard.

4. References
[1] Sheng-Jen (Tony) Hsieh 2003 Animations and Intelligent Tutoring Systems for Programmable Logic Controller Education (Department of Engineering Technology and Industrial Distribution, Texas A&M University) Int. J. Engng Ed. Vol. 19, No. 2, pp. 282±296
[2] B.K.Rana Universal Simplest possible PLC using Personal Computer Electrical Engg (India: VSSUT)
[3] Westhues, Jonathan 2017 LDmicro: Ladder Logic for PIC and AVR (http://cq.cx/ladder.pl access March 14, 2017).
[4] Erdal Yilmaz , Sevan Katrancioglu 2003 Designing Programmable Logic Controller (PLC) Experiment Set with Internal Experiment Blocks (Great Britain: Elsevier Ltd) ; Procedia - Social and WCETR 2011Behavioral Sciences 28 (2011) 494 – 498 1877-0428