Development and Analysis of Programmable Logic Controller Program for Defect Detection Prototype by CX Programmer

Tatang Mulyana¹, Rasidi Ibrahim², Erween Abd Rahim²
¹School of Industrial and System Engineering, Universitas Telkom, Indonesia
²Premach, Faculty of Mechanical Engineering and Manufacturing, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia

Email: tatangmulyana@telkomuniversity.ac.id

Abstract. This paper presents a development of Programmable Logic Controller program for defect detection prototype by CX programmer. The PLC is a digital system that operates digitally, using programmable memory for user-oriented internal storage, to perform special functions such as logic, sequencing, timing, and arithmetic; to be controlled through input, both analogue and digital; various machines or processes. CX Programmer is software used to create Omron PLC ladder diagrams. It system scenario is done to analyse the system that has been created to fit the scenario. It is seen from the input and output system made in the ladder diagram on CX Programmer. For scenario design can be analysed by looking at indicator light on PLC when the program is running. Based on the tested results can be concluded that the development is successfully.

Keywords: PLC program; development; defect detection prototype; CX programmer

1. Introduction

Programmable Logic Controller (PLC) is the most commonly used controller in the industry. PLCs in the 1970s replaced relays, timers, counters, and other controllers. It is a microcomputer-based controller that is used to store instructions in the form of logic, sequence, timing, calculation, machine, and process. The advantage of the PLC compared to other controllers, among others are in programming is easier than doing wiring control panel of a relay, it can be re-programmed, it compared with smaller relay, so it does not take place, it are easier to maintain and have higher reliability, it can be connected to a computer more easily than a relay, it can execute more control variations than relays. Some use of PLC has been done in various studies, among others simulation of automation system [1], Supervisory Control and Data Acquisition System (SCADA) design [2, 3, 4, 5], monitoring and controlling [6], design on inspection system automation [7, 8, 9].

This paper presents a portion of the work of a large project of building a prototype tool of defect detection where data capture-based image processing and is analysed based on neural network and fuzzy logic methods. The construction of this prototype requires several kinds of design, including graphical user interface extract feature, graphical user interface identification, human machine interface, PLC program scenario. The MATLAB program is used for the inspection process using fuzzy logic [8] and artificial neural network methods [9]. Some studies of the use of MATLAB programs have been done by some such authors, digital control design [10, 11, 12], modelling and simulation [13, 14, 15, 16], design selection [17], data analysis [18, 19], nonparametric model [20], parametric model [21], NNARX
model structure [22], discrete time model [23, 24] ARX model [25], parametric and nonparametric identification [26], design and experiment analysis [27, 28, 29].

2. Defect Detection Prototype
In this prototype, the software and hardware such as the PLC, HMI, inverter, motor, webcam, and database of excel are already integrated. MATLAB software is used to process images taken from the capture process in real time for identification. The prototype block diagram can be seen in Figure 1. From this figure, it can be seen that there are three main parts consisting of: the upper frame part (a), the bottom frame part (b), and the bottom of the conveyer (c). In the upper frame there is a webcam and four fluorescent lamps, next to the bottom frame there is a button box and PLC, and the last inverter is placed under the conveyer. Figure 2 shows the actual prototype.

![Figure 1. The defect detection prototype block diagram](image)

![Figure 2. The actual prototype](image)

3. Design of PLC Program
PLC program used in this research is made in the form of ladder diagram using CX Programmer software, in accordance with PLC used which is Omron CP1E-N30DR-A PLC. The predetermined scenario is converted into ladder diagram, with input and output name tags as in Table 1. The PLC system scenario is performed to analyse the system that has been created to fit the scenario. It is seen
from the input and output system made in the ladder diagram on CX Programmer. For scenario design can be analysed by looking at indicator light on PLC when program is running. Scenario design for PLC input can be seen in Table 2. Table 3 shows scenario design for PLC output.

**Table 1. Input and output name tags of the PLC program**

| No. | Input   | Address  | Lamp       | Address  |
|-----|---------|----------|------------|----------|
| 1   | System ON | 10.05    | System ON  | Q100.01  |
| 2   | START   | 10.09    | START      | Q101.02  |
| 3   | STOP    | 10.06    | STOP       | Q100.04  |
| 4   | EMERGENCY | 10.03  | EMERGENCY  | Q100.05  |
| 5   | MANUAL  | 10.04    | MANUAL     | Q100.06  |
| 6   | CONVEYOR FORWARD | 10.10 | CONVEYOR FORWARD | Q101.01 |
| 7   | CONVEYOR BACKWARD | 10.08 | CONVEYOR BACKWARD | Q101.09 |
| 8   | CAPTURE | 10.07    | CAPTURE    | Q100.02  |
| 9   | -       | -        | -          | Q100.07  |
| 10  | -       | -        | -          | Q100.03  |

**Table 2. Scenario design of the PLC input**

| No. | Input     | Enter Pushbutton | Indicator Lamp | Result                     |
|-----|-----------|------------------|----------------|---------------------------|
| 1   | System ON | 10.05            | I0.05 ON       | System Run               |
| 2   | START     | 10.09            | I0.09 ON       | Conveyor Run             |
| 3   | STOP      | 10.06            | I0.06 ON       | Conveyor Stop            |
| 4   | EMERGENCY | 10.03            | I0.03 ON       | System Off               |
| 5   | MANUAL    | 10.04            | I0.04 ON       | Manual System Run        |
| 6   | CONVEYOR FORWARD | 10.10 | I0.10 ON       | Conveyor move to forward |
| 7   | CONVEYOR BACKWARD | 10.08 | I0.08 ON       | Conveyor move to backward|
| 8   | CAPTURE   | 10.07            | I0.07 ON       | Camera take picture      |
Table 3. Scenario design of the PLC output

| No. | Output                  | Enter Pushbutton | Indicator Lamp       | Result               |
|-----|-------------------------|------------------|----------------------|----------------------|
| 1   | System ON               | System ON        | Q100.01 ON           | System Run           |
| 2   | START                   | START            | Q101.02 ON           | Conveyor Run         |
| 3   | STOP                    | STOP             | Q100.04 ON           | Conveyor Stop        |
| 4   | EMERGENCY               | EMERGENCY        | Q100.05 ON           | System Off           |
| 5   | MANUAL                  | MANUAL           | Q100.06 ON           | Manual System Run    |
| 6   | CONVEYOR FORWARD (AUTO) | START            | Q100.02 ON           | Conveyor move to forward |
| 7   | CONVEYOR BACKWARD       | CONVEYOR BACKWARD| Q100.07 ON           | Conveyor move to backward |
| 8   | CSV READ                | START ON         | Q100.03 ON           | Motor Stop 2 seconds |

The PLC program is transferred to Omron CP1E PLC to run scenarios in these tables that have been created in CX Programmer software. This program should be flexible, user friendly and understandable so it will be easier to do maintenance and trouble shooting. Some of the programs that have been created consist of programs to activate systems, programs to stop the system, emergency programs, manual programs, and programs to read CSV files. These programs are shown in Figure 3 consist of (a) program to activate the system, (b) program to run the conveyor and capture, (c) program to reset the process, (d) program to shut the system, (e) program for emergency, (f) program for manual system, and (g) program to read CSV file.

PLC is a digital system that operates digitally, using programmable memory for user-oriented internal storage, to perform special functions such as logic, sequencing, timing, and arithmetic; to be controlled through input, both analogue and digital; various machines or processes. CX programmer is software used to create ladder diagram of Omron PLC. In this study CX programmer used to create the program. CX Programmer used in this study is version 9.1. In the active system program when pressing the system button on. The input address of the system on button is 0.05, and when the button is pressed the indicator lights will turn on. The PLC program to activate the system can be seen in Figure 3(a). Next after the system is active, when the start button with input address 0.09 is pressed, the conveyor will turn on and move forward for 2 seconds, and stop for 2 seconds. The PLC program for this scenario can be seen in Figure 3(b).

After the capture process, the system will return to the initial process and repeated continuously until the process is stopped. The program for this reset can be seen in Figure 3(c). On the ladder there is a stop button. This stop button serves to dismiss or temporarily turn off the inspection process. The input address of the stop button is 0.06. When the stop button is pressed the indicator light will light up. The indicator lights here function as outputs with address Q.100.04. The PLC program for disabling this system can be seen in Figure 3(d). Emergency function in this scenario serves to dismiss the system as a whole in case of errors in the system is running. This emergency button has an input address of 0.03. When the emergency button is pressed, feeding the emergency indicator light with the Q.100.05 output address will light up. The PLC program for this emergency function can be seen in Figure 3(e).

Manual function in this program, done to run the system manually. Manual process is done by pressing the button one by one. When the manual button is pressed then the manual indicator light will turn on. The address of the manual input button is 0.04 and the output address of the inductor lamp is Q.100.06. After the next indicator light lights up is pressing the conveyor button with input address 0.10 to make the conveyor move forward, while to make the conveyor move backward by pressing the input button 0.08. The PLC program for this manual system can be seen in Figure 3(f). CSV file is a communication process between CX Programmer, Wonderware InTouch, and MATLAB. This program is used to...
instruct Wonderware InTouch to change the value in the CSV file when the motor is stopped or on the capture process. When the motor stops, the timer counts for 2 seconds to capture the image and process the image. Then the picture is taken starting the identification process. The program is shown in Figure 3(g).

![Figure 3](image)

**Figure 3.** PLC program of the defect detection prototype

4. Result and Discussion

Based on the PLC program that has been created, the next step is to test the program to ensure the program runs according to the existing scenario. Test results can be seen from the input and output indicator lights contained in the PLC. Test results from PLC input program can be seen in Figure 4 and for the output can be seen in Figure 5. The PLC input program consist of:

(a) Test result of PLC SYSTEM ON input, and if the I0.05 button on PLC is pressed then the indicator lamp on I0.05 address turns on and the system is active,

(b) Test result of PLC START input, and if the I0.09 button on PLC is pressed then the indicator lamp on I0.09 address turns on and the conveyor moves,

(c) Test result of PLC STOP input, and if the I0.06 button on PLC is pressed then the indicator lamp on I0.06 address turns on and the conveyor stop,

(d) Test result of PLC MANUAL input, and if the I0.04 button on PLC is pressed then the indicator lamp on I0.04 address turns on and the manual system is active,

(e) Test result of PLC CONVEYOR FORWARD input, and if the I0.10 button on PLC is pressed then the indicator lamp on I0.10 address turns on and conveyor is moving forward,

(f) Test result of PLC CONVEYOR BACKWARD input, and if the I0.08 button on PLC is pressed then the indicator lamp on I0.08 address turns on and conveyor is moving backward,
(g) Test result of PLC CAPTURE input, and if the I0.07 button on PLC is pressed then the indicator lamp on I0.07 address turns on and the camera is capture the image, and

(h) Test result of PLC EMERGENCY input, and if the I0.03 button on PLC is pressed then the indicator lamp on I0.03 address turns on and the system stopped.

![Figure 4. Test results from PLC input program](image)

The PLC output program consist of:

(a) Test result of PLC SYSTEM ON output, and if the system ON button on PLC is pressed then the indicator lamp on Q100.01 address turns on and the system turns on,

(b) Test result of PLC START ON lamp output, and if the START button on PLC is pressed then the indicator lamp on Q101.02 address turns on and the system start,

(c) Test result of PLC STOP ON lamp output, and if the STOP button on PLC is pressed then the indicator lamp on Q100.04 address turns on and the system stopped,

(d) Test result of PLC CONVEYOR FORWARD (AUTO) output, and if the START ON button on PLC is pressed then the indicator lamp on Q100.02 address turns on and the conveyor moves forward,

(e) Test result of PLC CDV READ output, and if the START button turns on and the motor stop then the indicator lamp on Q100.03 address turns on,

(f) Test result of PLC MOTOR CONVEYOR BACKWARD output, and if the CONVEYOR BACKWARD button is pressed then the indicator lamp on Q100.07 address turns on,

(g) Test result of PLC MANUAL LAMP ON output, and if the MANUAL button on panel is pressed then the indicator lamp on Q100.06 address turns on,

(h) Test result of PLC CONVEYOR BACKWARD LAMP ON output, and if the CONVEYOR BACKWARD ON button on panel is pressed then the indicator lamp on Q101.00 address turns on, and

(i) Test result of PLC EMERGENCY LAMP output, and if the EMERGENCY button on panel is pressed then the indicator lamp on Q100.05 address turns on.
5. Conclusion
In this paper we have presented the development of PLC program for defect detection prototype by CX programmer. It system scenario is done to analyse the system that has been created to fit the scenario. It is seen from the input and output system made in the ladder diagram on CX Programmer. For scenario design can be analysed by looking at indicator light on PLC when the program is running. Based on the tested results can be concluded that the development is successfully. The input / output unit or often abbreviated as Unit I/O is the most important PLC component. This component serves to provide the interface that connects the system with the outside world. This makes it possible to establish connections between input devices, such as sensors, with output devices, such as motors and solenoids, through the available panels. Similarly, through the input / output unit, programs are inserted from the program panel. Each input / output point has a specific address that the CPU can use to access it.

In PLC, input devices are usually used for digital and analogue devices, such as mechanical switches, potentiometers, thermistors, strain gauges, and thermocouples. Some of these enhancements act as sensors, which will produce a digital output (discrete), which is ‘ON (1)’ / ‘OFF (2)’, and can be easily connected to PLC input ports. Sensors that produce analogue signals must first be converted into digital signals before they are connected to PLC ports. The ports on the output of a PLC can be either a relay type or an optical-optic type with a transistor or triac type, depending on the device connected to it, which will be controlled. Generally, a digital signal from one of the output channels of a PLC is used to control an actuator which in turn controls a process. The term actuator itself is used for devices that can convert electrical signals into mechanical movements to control the process.

Acknowledgments
The results of the study presented in this paper are part of a study funded by a research grant from SISPROMASI Laboratory of Telkom University.
6. References

[1] T. Mulyana, L.A. Hakim, M.N. Amanullah, R.A. Yulinasari, R.S. Latifani, “Simulasi Sistem Otomasi Pencucian Mobil Menggunakan PLC Omron CP1E,” ELEKTRA, Vol.2, No.1, Januari 2017, 22 – 31

[2] H. Rachmat, T. Mulyana, “Website Design of EMS-SCADA for AC Usage on a Building,” 3rd International Conference on Information and Communication Technology (ICoICT), 2015, 17-22

[3] H. Rachmat, R.A. Anugraha, T. Mulyana, “EMS-SCADA Design of AC Usage on a Building,” Proceeding 8th International Seminar on Industrial Engineering and Management (ISIEM), 2015, PS45-49

[4] H. Wicaksono, “SCADA Software dengan Wonderware InTouch,” Yogyakarta Graha Ilmu, 2012

[5] F.D.M. Fauzi, T. Mulyana, Z.I. Rizman, M.T. Miskon, W.A.K.W. Chek, M.H. Jusoh, “Supervisory Fertigation System Using Interactive Graphical Supervisory Control and Data Acquisition System,” International Journal on Advanced Science Engineering Information Technology, Vol. 6, No. 4, 2016, 493-494

[6] R.A. Anugraha, T. Mulyana, “Monitoring and Controlling of EMS-SCADA via SMS Gateway,” 3rd International Conference on Information and Communication Technology (ICoICT), 2015, 616-619

[7] M Mirsyah, T Mulyana, “Design on inspection system automation of curtain woven fabrics by image processing and the taguchi approach method at PT. Buana Intan Gemilang,” IOP Conference Series: Materials Science and Engineering 277 (1) 2017, 012057

[8] Shadika, T Mulyana, M Rendra, “Optimizing Woven Curtain Fabric Defect Classification using Image Processing with Artificial Neural Network Method at PT Buana Intan Gemilang,” MATEC Web of Conferences 135, 00052 (2017) ICME’17

[9] R. Safitri, T. Mulyana, “Optimizing Woven Fabric Defect Detection Using Image Processing and Fuzzy Logic Method at PT. Buana Intan Gemilang,” 1st International Conference on Industrial, Enterprise, and System Engineering (ICoIESE) 2017

[10] T. Mulyana, M.N.M. Than, D. Hanafi, and A. Ali, “Digital Control Design for the Boiler Drum,” UTHM FKEE Compilation of Papers 2009

[11] T. Mulyana, M.N.M. Than, D. Hanafi, A. Ali, “Digital control design for the boiler drum BDT921,” Proceeding of Conf. on Industrial and Appl. Math., Indonesia 2010, 257-260

[12] T. Mulyana, M.N.M. Than, D. Hanafi and A. Ali, “Digital Control Design for the Boiler Drum BDT921,” Journal of Mechanics Engineering and Automation 1 (2011) 392-397

[13] T. Mulyana and H. Azhar, “Modeling and Simulation of Temperature Control PID Single Loop of a Heat Exchanger Process Control Training System QAD Model BDT921,” UTHM FKEE Compilation of Papers 2009, 227-236

[14] T. Mulyana, M.N.M. Than, D. Hanafi, M. Ismoen, “Simulation of Various PI Controllers Setting for Boiler Drums T11 QAD MODEL BDT 921,” IndoMS International Conference on Mathematics and Its Applications, UGM, Yogyakarta - Indonesia, Oct 12-13, 2009 034/Mulyana/IICMA/2009

[15] D. Hanafi, M.N.M. Than, A.A.A. Emhemed, T. Mulyana, A.M. Zaidi and A.H. Johari, “Heat Exchanger’s Shell and Tube Modelling for Intelligent Control Design,” 2011 International Conference on Computer and Communication Devices (ICCCD 2011), V2-37-41

[16] T. Mulyana, M.N.M. Than, D. Hanafi, H. Azhar, “Modeling and Simulation of Temperature Control PID Single Loop of a Heat Exchanger Process Control Training System QAD Model BDT921,” International Conference Electrical Energy and Industrial Electronic Systems (EEIES), Park Royal Penang, Malaysia 7-8 December, 2009 Re: 73-85976

[17] H. Rachmat, T. Mulyana, S.H. Hasan, M.R. Ibrahim, “Design Selection of In-UVAT Using MATLAB Fuzzy Logic Toolbox,” International Conference on Soft Computing and Data Mining (SCDM), 2016, 538-545

[18] T. Mulyana, J. Ahliman, E. Kurniawan, “Data Analysis using System Identification Toolbox of Heat Exchanger Process Control Training System,” Fourth International Conference on Information and Communication Technologies (ICoICT), 2016, 466-471
[19] E. Kurniawan, B. Rahmat, T. Mulyana, J. Alhilman, “Data Analysis of Li-Ion and Lead Acid Batteries Discharge Parameters with Simulink-MATLAB,” Fourth International Conference on Information and Communication Technologies (ICoICT), 2016, 472-476

[20] T. Mulyana, “A Nonparametric System Identification Based on Transient Analysis with Plant Process of Heat Exchanger as Study Case,” International Journal of Innovation in Mechanical Engineering & Advanced Materials (IJIMEAM), Vol.1 (No.1), 2015, 19-26

[21] T. Mulyana, M.N.M. Than, D. Hanafi, “Parametric Model of Laboratory Heat Exchanger,” Keynote Speaker: International Conference on Vocational Education and Electrical Engineering (ICVLEE) 2015, 25-37

[22] T. Mulyana, “NNARX Model Structure for the Purposes of Controller Design and Optimization of Heat Exchanger Process Control Training System Operation,” AIP Conference Proceedings 1831, 020040 (2017)

[23] T. Mulyana, M.N.M. Than, D. Hanafi, “A Discrete Time Model of Boiler Drum and Heat Exchanger QAD Model BDT 921,” International Conference on Instrumentation, Control & Automation ICA2009 Bandung, Indonesia, October 20-22, 2009, 154-159

[24] T. Mulyana, M.N.M. Than, D. Hanafi, “A Discrete Time Model of Four Heat Exchanger Types HE 158C,” 7th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT2010), 19-21 July 2010 Antalya, Turkey

[25] T. Mulyana, F.N. Suhaime, D. Hanafi, M.N.M. Than, “ARX Model of Four Types Heat Exchanger Identification,” MUiCET 2011

[26] T. Mulyana, “Parametric and Nonparametric Identification of Shell and Tube Heat Exchanger Mathematical Model,” A Thesis submitted in Fulfilment of the requirement for the award of the degree of Philosophy of Doctoral in Electrical Engineering, Faculty of Electrical and Electronic Engineering Universiti Tun Hussein Onn Malaysia, August 2014

[27] H. Rachmat, M.R. Ibrahim, S.B. Hasan, S. B. “Design Selection of an Innovated Tool Holder for Ultrasonic Vibration Assisted Turning (IN-UVAT) using Finite Element Analysis Simulation”, AIP Conference Proceeding, Volume 1831, 7th International Conference on Mechanical and Manufacturing Engineering, Sustainable Energy towards Global Synergy, (ICME2016), 3 August 2016.

[28] M.R. Ibrahim, E.A. Rahim, M.I. Ghazali, M.H. Chai, Z.O. Goh, “Experimental Analysis on Ultrasonic Assisted Turning (UAT) based on Innovated Tool Holder in the scope of Dry & Wet Machining.” Applied Mechanics and Materials, Volume 660, 2014, 5th International Conference on Mechanical and Manufacturing Engineering 2014, (ICME2014) Bandung Indonesia. 104-108.

[29] M.R. Ibrahim, N.H. Rafai, E.A. Rahim, K. Cheng, H. Ding, “A Performance of 2 Dimensional Ultrasonic Vibration Assisted Milling in Cutting force Reduction, on Aluminium AL6061”. ARPN Journal of Engineering and Applied Sciences, Volume 11, Issue 18, 2016. 11124-11128