

Implementation of Programmable Logic Controller in multi machine operations with product sorting and packaging based on colour detection

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Abstract. Automation is widely used in various industries to increase the speed, accuracy and effectiveness of production and reduce the risk of hazards. In general, the manufacturing industry has a product packaging and sorting process based on size, weight, shape, height and color. Currently, the sorting process in the industry is still mostly done manually which causes human error problems, so the development of industrial automation that is low cost, easy to maintain, efficient, user friendly and more accurate needs to be done. Programmable Logic Controller (PLC) is one of the most widely used for automation equipment in the industry and can be programmed to control machine operations. In this paper, the Mitsubishi Melsec PLC with ladder diagram programming using GX work2 has been developed to control multi-machine operation by product sorting and packaging based on product color. Multi-machine operation consists of three DC motors used for conveyors, two single solenoids, proximity sensors, inductive sensors and limit switches. The proximity sensors are used to detect the products based on color. The system is equipped with an emergency button and alarm system to facilitate the implementation of troubleshooting. To facilitate communication with operators and user-friendly systems, the human machine interface (HMI) is used as an interface for system monitoring and controlling. HMI uses Pro-face from Schneider which is programmed using GP-Pro EX4.0. The ladder diagram has been implemented in the PLC and tested on hardware to simulate the system. Based on test results, MELSEC PLC can communicate with HMI and control multi-operation machines with product sorting and packaging. The machine can separate and package metal products by colour and the packaging system can be monitored and controlled remotely automatically with HMI.



1. Introduction

Automation is mostly used in various industry for increasing speed, accuracy and effectiveness of the production and also reduce risky hazards. Programmable Logic Controller (PLC) is one of the most widely used automation equipment in the industry and can be programmed to control the operation of a machine. PLC that used for automation and electromechanical process in many industries and machines serves to control some industrial processes and monitor the system. The use of PLC in the industry will be able to improve the efficiency of system and production so that a manpower who has the ability and expertise in PLC engineering is needed. Advantages of PLC are favoured this trend, instead of using custom-made controller systems: using a standard hardware assures rapid prototyping, quality parts at a reasonable cost, specialized maintenance support, availability of skilled programmers, and incremental upgrading to more powerful hardware that can increase the machine performance or add new capabilities such as internet connection, database logging of production data, or even flexible lines to follow closely changing production demands [1].

Compared to other computers, PLC has better robust to dust, moisture, heat and cold and has facilities for extensive input/output (I/O) settings. The PLC can be connected to sensors and actuators more easily [2]. In addition, its internal sequential operation is performed by tuning on/off the relay by connecting the normally open and normally close serially and parallel [3]. The configuration of MELSEC PLC is shown in Figure 1.

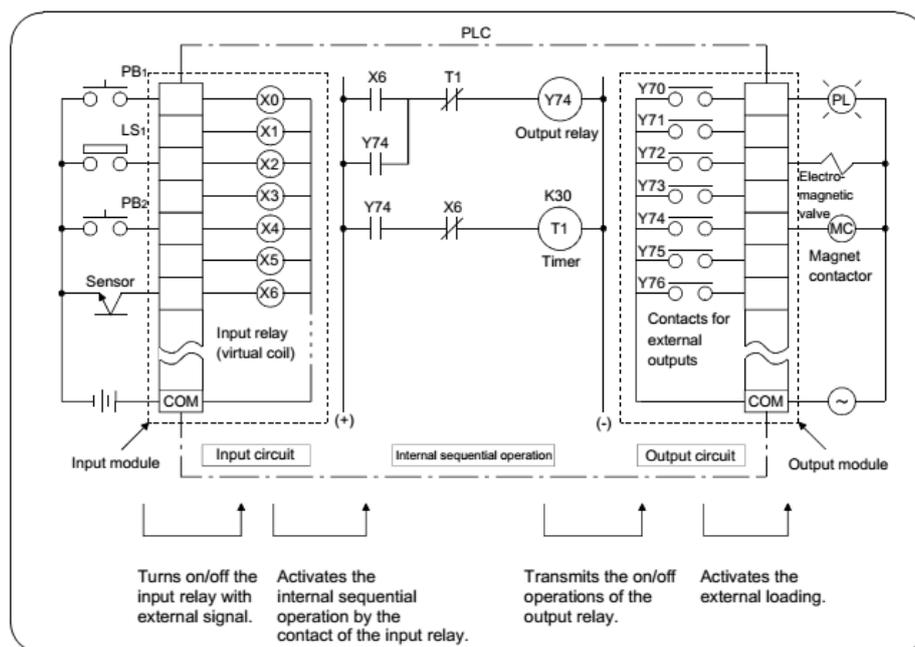


Figure 1. MELSEC PLC configuration.

Human machine interface (HMI) is an interface system that connects between human and PLC or machine, so that the interaction between operator and machine will increase through the touchscreen or computer screen. HMI is functioned to monitor real conditions in the plant by providing visualization of the system in real time and alarms as warning signs if any problem happened in the system. HMI in the manufacturing is performed by Graphic User Interface (GUI) display that will be monitored by the machine operator and user who need machine data [4].

The Packaging system is one of important part in the industrial system to make product safe and good condition. Kanimozhi has used PLC to control food packaging machine based on the weight of an object that was measured by the load cell [5]. The interaction between user and machine uses Human Machine Interface (HMI) through DOP soft. The basic purpose of an HMI is to allow an easy graphical

interface with a process. Bano et al compares three brands of PLC; Siemens, Schneider Electric and ABB to control packaging machinery using any IEC 61131-3 programming language that stored as an XML file using the PLC open XML schema [6]. Automatic translators are used to write the specific code required by any PLC brand, without any user intervention. Saracin et al used Schneider Twido PLC to control metal packaging waste according to optical and hall sensor and automotive electric windows mechanism with ladder diagram programming that is installed in PLC [1]. The PLC to control the collecting and packaging of metal waste without HMI because it has a high maintenance cost. PLC also has been applied on the elevator control with a good performance [7].

This paper will discuss on designing of automation of packaging system using MELSEC PLC from Mitsubishi and Human Machine Interface (HMI) using Pro-Face to remotely monitoring and controlling the system. In this system, two different metal products will be selected by the sensor and then will be packaged in different boxes where each box contains three products. This packaging system uses three conveyors to move the product, an inductive sensor to detect the product, two proximity sensors to differentiate the product and two single solenoids to move the product into the box.

2. Design of automatic packaging machine

PLC is a microprocessor-based system that uses programmable memory to store instructions and implement functions such as logic, sequencing, timing, counting, and arithmetic in order to control machines and processes. Unlike general purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. A PLC has many "input" terminals, through which it interprets "high" and "low" logical states from sensors and switches. It also has many output terminals, through which it outputs "high" and "low" signals to power lights, solenoids, contactors, small motors, and other devices lending themselves to on/off control. Figure 2 shows block diagram of automation packaging system Pro-Face remote HMI based on PLC.

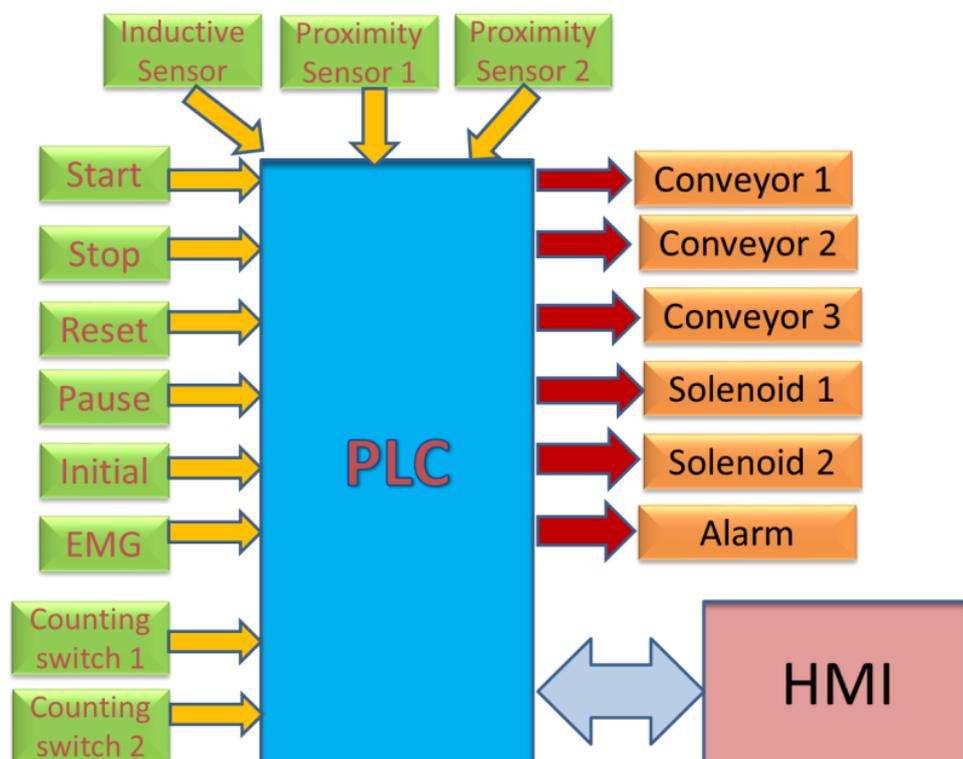


Figure 2. Block diagram of automation packaging system pro-face remote HMI [8].

2.1. Designing automatic packaging system based on PLC

The designed packaging system will differentiate two product packages based on its colour. If a product is coming and exist in conveyor 1, immediately an inductive sensor (IS) will detect metal of the product and the conveyor 1 will start to move. Proximity sensors (PR1 and PR2) will determine the products and drive one of two single solenoids to push the product into the tank according to its colour.

The conveyors 2 and 3 will start to move the tank to the end line after the counter counts three products in the tank.

2.2. Operation of the system

The designed packaging system will differentiate two product packages based on its colour. Based on Figure 3, if a product is coming and exist in conveyor 1, immediately an inductive sensor (IS) will detect metal of the product and the conveyor 1 will start to move. Proximity sensors (PR1 & PR2) will determine the products and drive one of two single solenoids to push the product into the tank according to its colour. The conveyor 2 & 3 will start to move the tank to the end line after the counter counts three products in the tank. Flow chart of the designed packaging system that describes operation of the system is shown in Figure 4.

2.3. Wiring diagram of the system

Wiring diagram and simulation of the automatic packaging system have been conducted using software fluidSim as shown in Figure 3. This software will simulate behaviour of the system before designing ladder programming.

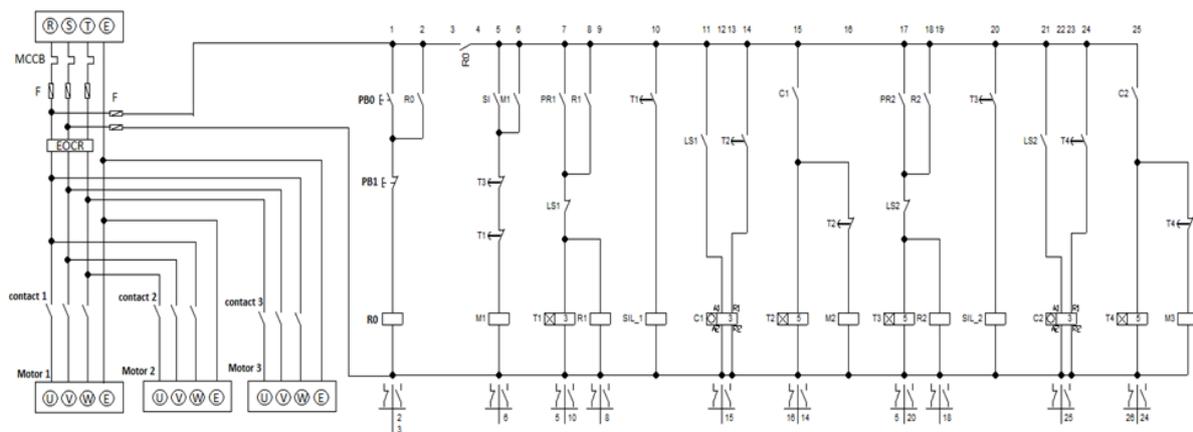


Figure 3. Wiring diagram of the designed automation packaging system.

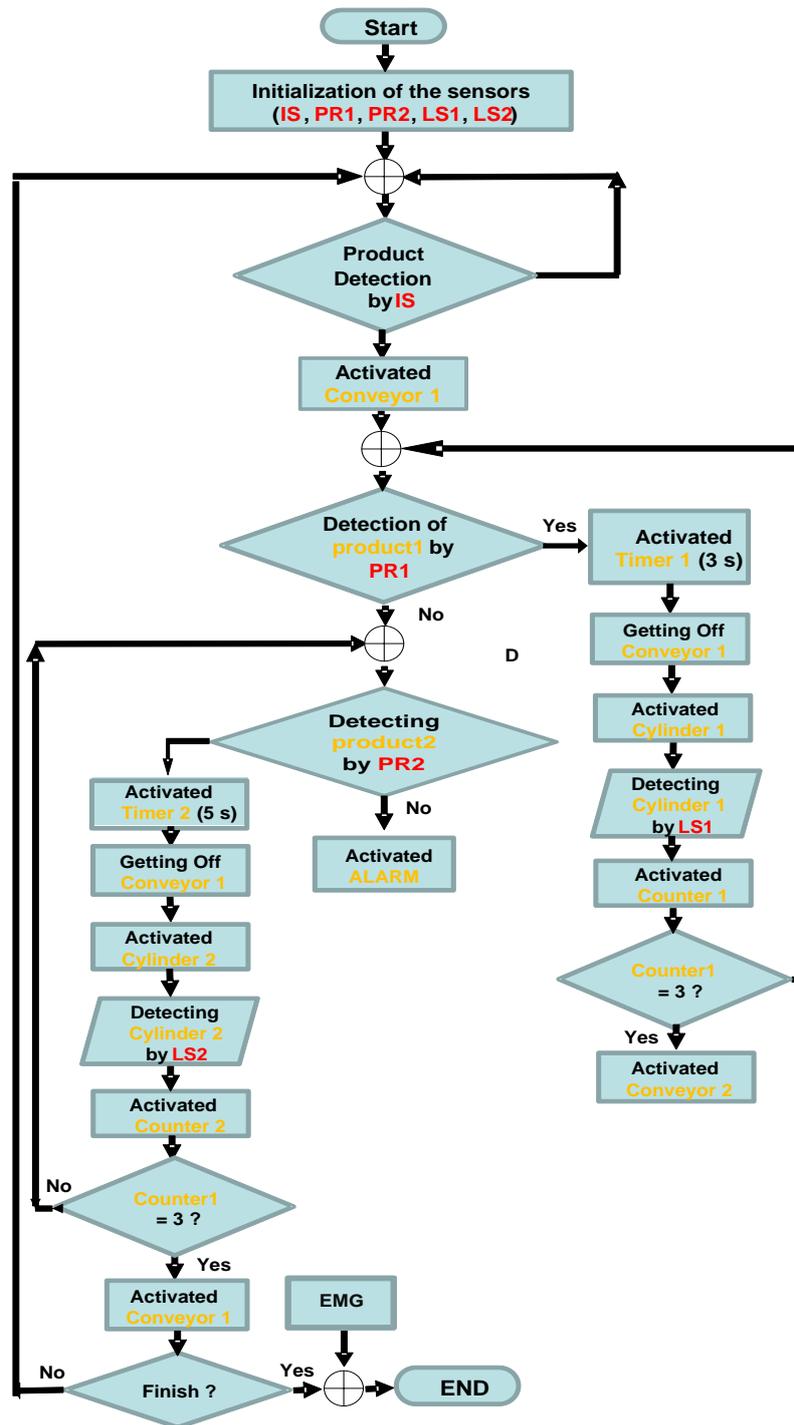


Figure 4. Flow chart of the automation packaging system's operation.

2.4. Ladder diagram implementation

In an effort to make PLCs easy to program, their programming language was designed to resemble ladder logic diagrams. Thus, an industrial electrician or electrical engineer accustomed to reading ladder logic schematics would feel comfortable programming a PLC to perform the same control functions. Ladder diagram of the system has been implemented using GX work2 with I/O addressing shown in Table 1.

Table 1. I/O addressing of the designed system.

Input			Output	
No.	Add	Name	Add	Name
1	X0	Start	Y20	Conveyor 1
2	X1	Stop	Y21	Conveyor 2
3	X2	Inductive Sensor	Y22	Conveyor 3
4	X3	Reset	Y23	Single Solenoid 1
5	X4	Pause	Y24	Single Solenoid 2
6	X5	Initial	Y25	Alarm Lamp
7	X6	Emergency		
8	X7	Counting Switch 1		
9	X8	Counting Switch 2		
10	X9	Proximity Sensor 1		
11	XA	Proximity Sensor 2		

2.5. Human Machine Interface design

HMI is functioned to monitor real conditions in the plant by visualization of the system in real time. HMI also provides alarms as warning signs if any problem happened in the plant. Ports used by HMI include com port, USB port, RS232 port, and serial port. In this project uses Pro-face HMI to monitor automatic packaging system. Pro-face Remote HMI Server is an application that shares the computer screen with smart devices such as a smartphone or tablet. It can be installed on a Pro-face industrial computer (IPC Series), SP5000 Series Open Box, or PC/AT compatible machine [8], as shown in Figure 5.

**Figure 5.** Pro-face remote HMI [8].

3. Implementation and results

The designed automatic packaging system comprises of MELSEC PLC with Q2H CPU Series, two proximity sensors, inductive sensors, three motor conveyors, and 2 single solenoid. Ladder programming has been successfully uploaded into the PLC system and tested using HMI for controlling and monitoring the plant. The machine (PLC system) can separate and package metal products by colour, and the packaging system can be monitored and controlled remotely with HMI.

Figure 6 shows the designed HMI for monitoring and controlling the system.



Figure 6. HMI design and implementation the automatic packaging system.

4. Conclusions

The ladder diagram has been successfully implemented in the Melsec PLC and tested on hardware to simulate the system. Based on test results, the system can communicate with HMI and control multi-operation machines with product sorting and packaging. The machine can separate and package metal products by colour and the packaging system can be monitored and controlled remotely automatically with HMI.

Acknowledgments

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