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Development of a Traffic Light Control System using Programmable Logic Controller

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Abstract

Though practically elevators are controlled by PLC, still we employed it, because elevator is an appropriate system where we can explore a lot of feature of the PLC. As it is a mere model only, while shifting to practical elevator some module of our model need to be replaced, viz. DC motor drive need to be replaced by an induction motor drive, a weight counter-balancing technique should be employed. But as our target of doing this project is mainly PLC oriented, we mainly focused in PLC ladder logic and how to connect an external hardware/system with the PLC to control that hardware.

Keywords: *Programmable Logic Controller MASTER-K80s, Inductive Proximity Sensor, Pilot Lights, Conducting Wires.*

1. Introduction

1.1 Paper Objectives

This project is about develop a new practical traffic light control system which the system will solve the traffic congestion issue. To develop the project, there are two objectives that must be accomplished which are: -

A. Develop a new traffic light control system controlled by programmable logic controller (PLC).

B. Implement the system on a model of a traffic light.

1.2 Paper Scope

A. Construct a model of four-way junction of a traffic light model.

B. Programmed a ladder logic diagram to control the traffic light.

C. Combine the software part and the hardware part to simulate a traffic light system.

1.3 Paper Statement

The monitoring and control of city traffic light is becoming a major problem in many countries. The increasing number of vehicles and the lower phase of highways developments have led to traffic congestion problem especially in major cities such as Kuala Lumpur, Georgetown, Johor Bahru, and Ipoh. Travel time, environment quality, life quality, and road safety are all adversely affected as a result of traffic congestions. In addition, delays due to traffic congestions also indirectly affect productivity, efficiency, and energy losses. There are many factors that lead to traffic congestion such as the density of vehicles on the roads, human habits, social behavior, and traffic light system. One major factor is due to the traffic lights system that controls the traffic at junction. Traffic policeman are deployed at traffic intersection every day in order to overcome these congestion during peak hour, thus one of the roots of the problem is due to ineffective traffic lights controllers. With effective control the intersection, it is believed that the overall capacity and performance of urban traffic network could be resolve.

In the late sixties of the last century the American company general electric developed the programmable logic controllers (PLC) as an alternative to the complex relay control system in order to use it in its car production lines. These controllers showed very high efficiency in control systems and higher reliability in in protecting the components being controlled. In addition to this, the latter improved characteristics made PLCs the most control system used in production Processes The aim of this project is to illustrate the usage of PLC in automation of production lines and the utilization of its high capabilities to process input signals from several sensors. This is done by implementing a small model of the filling stage of a soft drinks production line as an application. Here several processes work in a sequential fashion, in this stage PLCs are used to maintain this sequence.

Programmable logic controllers, also called programmable controllers or *PLCs*, are **solid-state** members of the computer family, using integrated circuits instead of electromechanical devices to implement control functions.

They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation, and communication, to control industrial machines and processes.

Figure 1 illustrates a conceptual diagram of a PLC application:

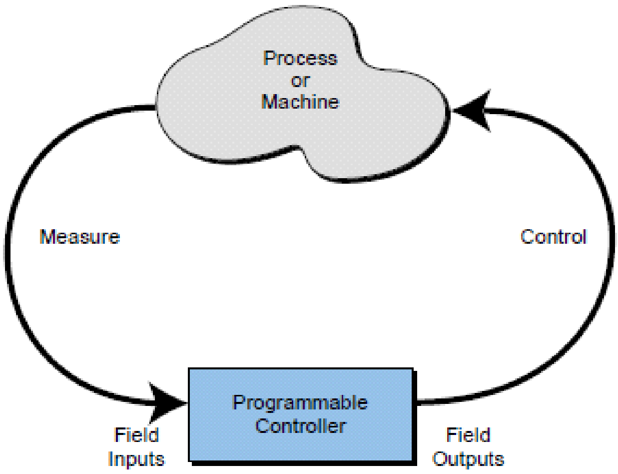

Figure 1: Illustrates a Conceptual Diagram of a PLC Application

2. Overview of Traffic Light System

Ever since Roman times, society has tried to control traffic. Even the fabled Roman road system created a conflict between pedestrian and equine travelers. However, a practical solution was not developed until the mid-nineteenth century, when J. P. Knight, a railway signaling engineer, created the first traffic signal, which was installed near Westminster Abbey in London, England in 1868. Unfortunately, the device exploded, killing a police officer, and its use was discontinued after being in operation for only a short time. The modern traffic light was invented in America. New York had a three-color system in 1918 that was operated manually from a tower in the middle of the street. Other cities soon adopted the idea of having someone on the scene to control the lights. Garrett Morgan, inventor of the gas mask, also developed traffic signaling devices. Having witnessed an accident between a car and a carriage, Morgan felt compelled to devise a system to prevent such collisions at street intersections.

3. Inductive Proximity Sensor

Proximity sensors indicate the presence and absence of an object without making any physical contact.

Inductive proximity sensor is a type of proximity sensor that detects the presence of metallic materials; figure 2 shows an inductive proximity sensor.

Figure 2: Inductive Proximity

When voltage is applied, an electromagnetic field is generated and extends out the face of the sensor.

When metal enters the sensing zone, an eddy current is induced in the metal. The change in eddy current is detected and the sensor's output is energized.

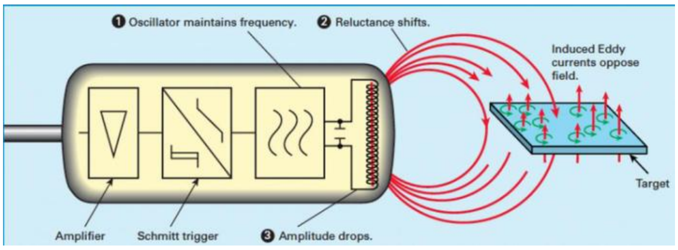

Figure 3: Block Diagram of Inductive Proximity Sensor

4. Principles of Operation

The Schmitt trigger responds to these amplitude changes, and adjusts sensor output. When the target finally moves from the sensor's range, the circuit begins to oscillate again, and the Schmitt trigger returns the sensor to its previous output.

If the sensor has a normally open configuration, its output is an**on** signal when the target enters the sensing zone. With *normally closed*, its output is an *off* signal with the target present. Output is then read by an external control unit (e.g. PLC, motion controller, smart drive) that converts the sensor on and off states into useable information. Inductive sensors are typically rated by frequency, or on/off cycles per second. Their speeds range from 10 to 20 Hz in ac, or 500 Hz to 5 kHz in dc.

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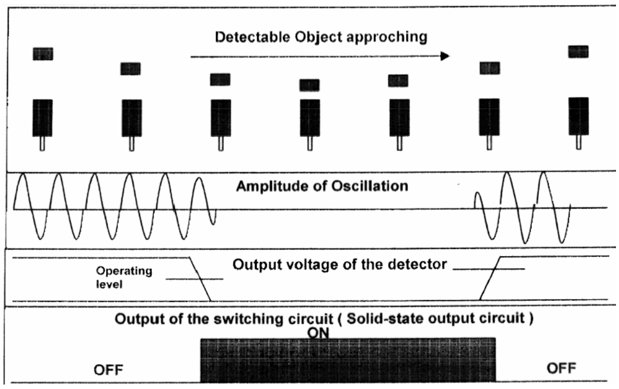

Figure 5: Principles of Inductive Proximity Sensor

5. System Hardware

The hardware part of this project is Programmable logic controller (PLC) and a traffic light model. LG 120s is the type of PLC used in this project as the processor to control the traffic light. This type of PLC was being chosen because the characteristic is fully necessary by the development of traffic light system.

The two ways traffic light model is constructed to display how this traffic light control system is running. This traffic light model has a complete set of traffic light signal which are red, yellow and green as a traffic signal for each lane. Each lane also has three switches represent as a sensor on the road. The first sensor placed in front of the lane to detect the presence of a car at the junction and the second sensor placed at certain length from first sensor to determine the volume of car at that lane, the third sensor placed at certain length from second sensor to determine the volume of car at that lane

The right connection between PLC and traffic light model is very important because it can avoid the problem or conflict when the program is transferred to PLC.

Figure 6: LG PLC MASTER-K80s Configuration

The main body of this PLC is power supply unit, Central processor unit and input/output slot. The power supply unit receive the required PLC voltage is 240Vac. For safety the voltage to PLC must connect to automatic circuit breaker before connect to the PLC because to protect the PLC from overload. The CPU covered by Analog input/output slot, RS232 port, and processor.

The inputs/outputs slot uses for system are using digital input and digital output. There are not limited slot for input and output port and can use for multiple inputs/outputs card.

Figure 6 Master K80s.

6. Traffic Light Model

The two ways junction is developed to display the simulation the development of the new traffic light control system. Figure 7 and 8 show the design of traffic light model. Every lane and traffic light signals have been labeled with alphabet A and B to separate each lane and traffic light. Each traffic light lane has their set of traffic light signal “Red, Yellow, and Green”. This traffic light signal operates similar like common traffic light signal. It changes from red to green and then yellow and after that back to red signal. Each lane also has three inductive sensors represent as a sensor on the road. The suitable sensor for design a real traffic light system is type of inductive sensor. The first sensor placed a side of lane to detect the presence car at the junction and the second sensor placed at certain length from first sensor to determine the volume of the car at that lane, the third sensor placed at certain length from second sensor to determine the volume of the car at that lane. From this combination of sensor, we will know the expected time for green signal on when each lane changes to the green signal.

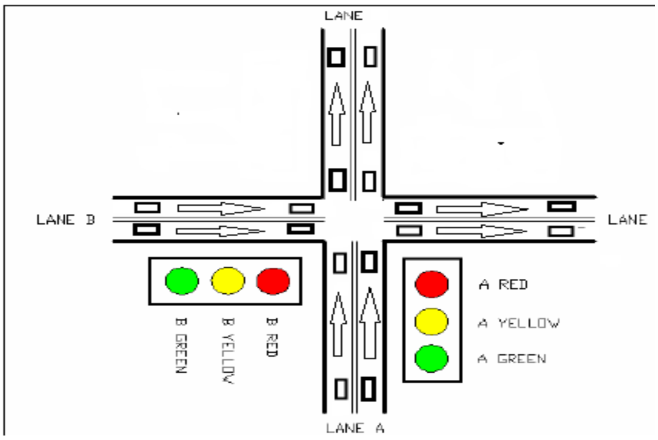

Figure 7: Traffic Light Model

Figure 8: Hardware Design

7. Hardware Wiring Diagram

Once hardware is designed ladder diagrams are constructed to document the wiring. For this project, existed PLC cabinet box are use and connect with the traffic light model. A basic wiring diagram is as shown in figure 9. The PLC would be supplied with AC power 240V and then I/O card supplied with DC power 12V to 24V. The common for input card is 24Vdc and for output card is 0Vdc. A fuse is used after disconnect to limit the maximum current drawn by the system.

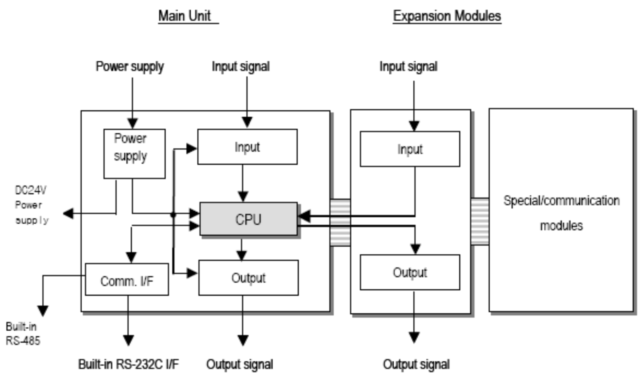

Figure 9: PLC Cabinet Box Wiring Diagram

The PLC input wiring address start with number 0.00 to 0.06 for every input card. When the other input card is install to the PLC socket the address for this input card will start with number 1.00 to 1.06 and so on. Figure 10 shows the wiring diagram for input card which this input card connects to sensor at traffic light model.

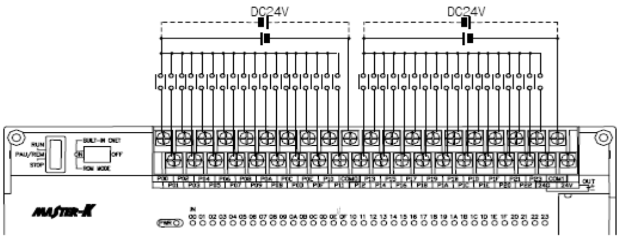

Figure 10: LG Input Wiring Diagram

The PLC outputs wiring address start with number 100.00 to 100.07 for every output card. When the other output card is install to the PLC socket the address for this output card will start with number 101.00 to 101.07 and so on. Figure 10 shows LG input wiring diagram.

The PLC outputs wiring address start with number 100.00 to 100.07 for every output card. When the other output card is install to the PLC socket the address for this output card will start with number 101.00 to 101.07 and so on.

8. System Software

KGLWIN-Programmer is a PLC programming tool for the creation, testing and maintenance of programs associated with LG PLCs. It provides facilities for support of PLC device and address information and for communications with LG PLCs and their supported network KGLWIN-Programmer operates on IBM compatible personal computers with Pentium or better central processors, including Pentium II. It run in a Microsoft windows environment. The information within a KGLWIN-Programmer project consists of ladder programs, operands, required PLC memory content, I/O table, expansion instructions (if applicable) and symbols. Each KGLWIN-Programmer project file is separate and is a single document. However, it is possible to deal with many project files by using KGL-Programmer at once.

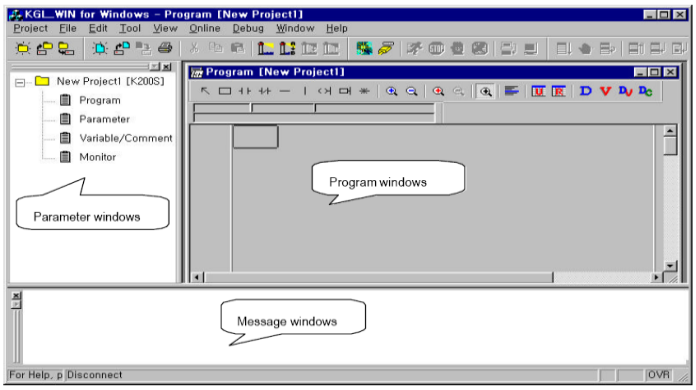

Figure 11: KGL Software

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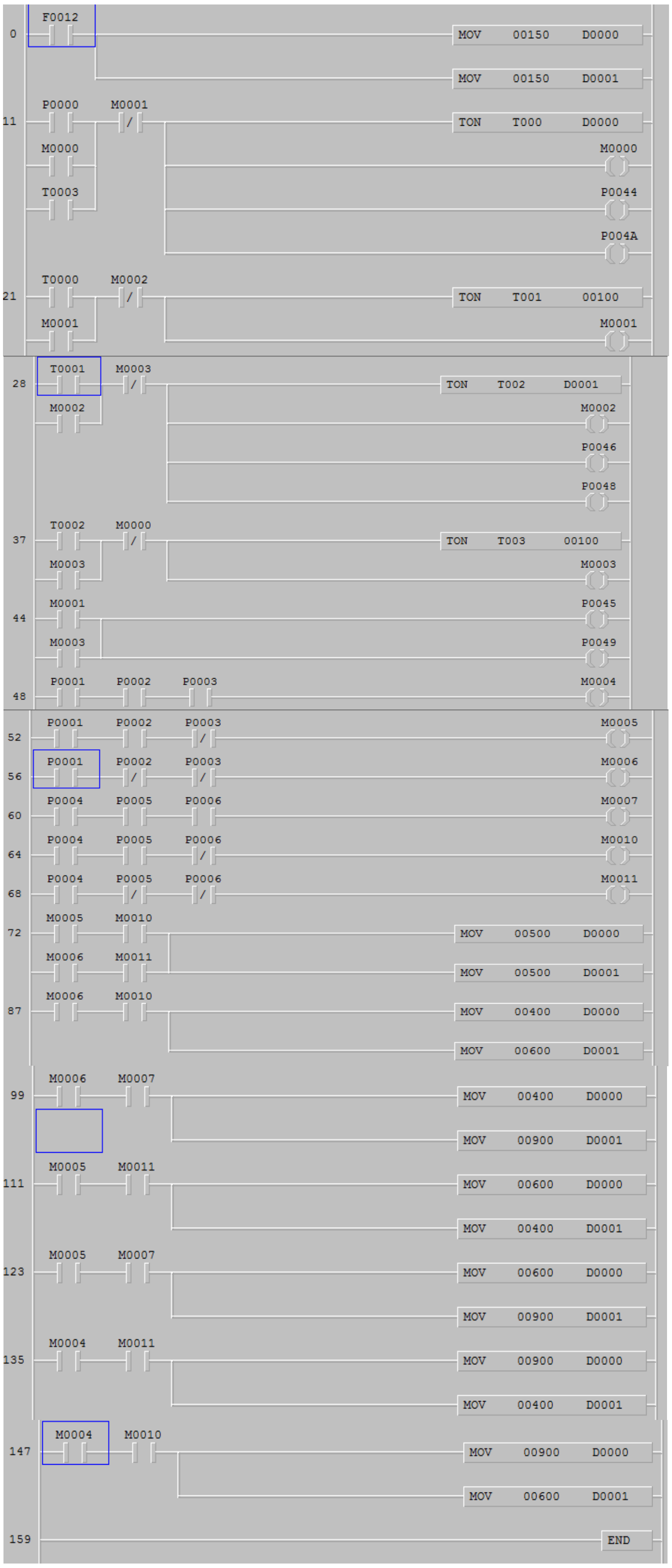

Figure 12: Ladder Program for the Traffic Light System using KGL Software Program

9. Program Development

Before construct a ladder logic diagram, program flowchart is ideal for a process that has sequential process steps. The steps will be executed in a simple order that may change as the result of some simple decisions. The block symbol is connected using arrow to indicate the sequence of the steps and different types of program actions. The other functions may be used but are not necessary for most PLC applications. This traffic light system is working independently to change from one lane to the other lane based on which lane can activate sensor 1 fast. This traffic light system gives the priority to the lane which has a car and followed by the other. This traffic light control system operates similar to intelligent traffic light system which it only gives a green signal to the lane which have a vehicles and not like a common traffic light control system which have a fix rotation for each lane.

10. Conclusion

Dealing with logical controlled it can be easily connecting and programming without need of to changing the connections, both in input or output, and therefore the result of a system can be flexible, it can be used in the functions than can changing nature of control, it also takes the advantage of the basic functions of the logical controller in applications that are more complex that make them more visible and easy to control, although of its multiple inputs and outputs. It can also ensure the implementation of the program before installing a logical controller equipment application traffic signal. It is also easy to correct errors and to locate faults and accurately and therefore can be procedure in the program to continue the performance of the traffic signal until it reforms the faults. An intelligent traffic light system had successfully been designed and developed. The sensors were interfaced with Lab PLC Module. This interface is synchronized with the whole process of the traffic system. This prototype can easily be implemented in real life situations. Increasing the number of sensors to detect the presence of vehicles can further enhance the design of the traffic light system. Another room of improvement is to have the infrared sensors replaced with an imaging system/camera system so that it has a wide range of detection capabilities, which can be enhanced and ventured into a perfect traffic system.

11. Recommendations

It also takes the advantage of the basic functions of the logical controller in various industrial fields. When selecting an application, you must know the easiest kinds and best suited to the performance of the timer or counter. The possibility of knowing to the connecting the timer or counter when processing the control circuits. The possibility of connecting two timers or more than for the use of applications that needs longer time. You can use more sensors in the application of the traffic signal to obtain high accuracy in processing. You can also replace sensors to vision sensors using a camera that address the overcrowding of vehicles, you can also use a weight sensor under the road. It can also interface the traffic signal system with a traffic network management to monitor the line of vehicles for the reasons of safety and security.

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