DEVELOPMENT OF A TRAFFIC LIGHT CONTROL SYSTEM USING PROGRAMMABLE LOGIC CONTROLLER

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ABSTRACT

Development of a traffic light control system using PLC (Programmable Logic Controller) is the title of this project. This project is divided into two parts which are hardware and software. The hardware part for this project is a model of four way junction of a traffic light. Each lane has two limits switch (input) function as a sensor. Three indicator lamps with different colours (Red, Yellow and Green) are installed at each lane for represents as traffic light signal. This limit switches and indicator lamps are connected to Omron PLC CQM1H-CPU51. The PLC controls every signal which is coming from the inputs (Limit switch) to software and display to the outputs (Indicator lamps). The software part operates with Omron PLC is CX-Programmer. With using this software, the ladder logic diagram is programmed to control the traffic light base on the flow chart. At the end of this project, the traffic light successfully control by PLC.

CHAPTER 1

INTRODUCTION

1.1 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. In 1923 he patented an electric traffic light system using a pole with a cross section on which the words STOP and GO were illuminated.

These basic designs were soon improved. In 1926 the first automatic signals were installed in London; they depended on a timer to activate them. In the 1930s vehicle-activated lights were created in which cars rolled over half-buried rubber tubes. Air in the tubes was displaced by the weight of the car rolling over them, and the increased pressure operated an electric contact, activating the lights. But these tubes wore out quickly. A better idea was the inductive-loop device: a loop of wire was imbedded in the road itself and connected to a box controlling the lights; a current of electricity passed through the loop, and when the steel body of a car passed overhead, it produced a signal that activated the light.

Today, traffic is automatically routed onto limited access highways courtesy of a computer activated guidance system that determines traffic volume on the highway. Global positioning satellite systems (GPS) are installed in many cars. These systems connect with a satellite and inform drivers where they are and possible routes to their destination. Such systems will eventually enable a drive to determine the best route to a destination given prevailing traffic conditions.

1.2 Overview of Programmable logic controller (PLC)

A programmable logic controller (PLC) is an industrial computer used to control and automate complex systems. Programmable logic controllers are a relatively recent development in process control technology. It is designed for use in an industrial environment, which uses a programmable memory for the integral storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control through digital or analog inputs and outputs, various types of machines or processes.

Programmable logic controllers are used throughout industry to control and monitor a wide range of machines and other movable components and systems. PLC is used to monitor input signals from a variety of input points (input sensors) which report events and conditions occurring in a controlled process. Programmable logic controllers are typically found in factory type settings. PLCs are used to control robots, assembly lines and various other applications that require a large amount of data monitoring and control.

A typical programmable logic controller employs a backplane to serve as the communications bus for interconnecting the PLC processor with the array of individual input/output devices with which the processor interacts in terms of receiving input data for use in executing the control program and transmitting control data for use in controlling the targeted objects. A PLC includes a rack into which a plurality of input/output cards may be placed. A rack includes several slots into which these input/output cards are installed.

Each input/output card has a plurality of I/O points. The I/O modules are typically pluggable into respective slots located on a backplane board in the PLC. An I/O bus couples the cards in the slots back to the processor of the programmable logic controller. The slots are coupled together by a main bus which couples any I/O modules plugged into the slots to a central processing unit (CPU).

The CPU itself can be located on a card which is pluggable into a dedicated slot on the backplane of the PLC. The particular processor employed in a PLC together with the particular choice of input and output cards installed in the PLC rack are often referred to as the hardware configuration of the programmable logic controller. The hardware configuration also includes the particular addresses which the I/O cards. Each option module typically has a plurality of input/output points.

The option modules are coupled through an interface bus, for example via a backplane, to a main controller having a microprocessor executing a user program. Option modules may also include a microprocessor and a memory containing separate user programs and data directed to a particular operation of the PLC system. During the execution of a stored control program, the PLC's read inputs from the controlled process and, per the logic of the control program, provide outputs to the controlled process. The outputs typically provide analog or binary voltages or "contacts" implemented by solid state switching devices.

PLC's are normally constructed in modular fashion to allow them to be easily reconfigured to meet the demands of the particular process being controlled. The processor and I/O circuitry are normally constructed as separate modules that may be inserted in a chassis and connected together through a common backplane using permanent or releasable electrical connectors.

1.3 Project 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:-

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

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

1.4 Project scope

i. Construct a model of four way junction of a traffic light model.

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

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

1.5 Problem 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 everyday 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.

There are several types of conventional methods of traffic light control; however they fail to deal effectively with complex and time varying traffic conditions. Currently, two types of traffic light control are commonly installed in Malaysia and many parts of the world: the preset cycle time (PCT) and vehicle-actuated (VA). Due the deployment of a large number of traffic police in the city during peak hours, it is evident that these types of traffic lights controllers are inadequate. There is a need to research on new types of highly effective practical traffic light controllers.

In this paper, the proposed of a new development of a traffic light control system controlled by PLC. This system will decreased the traffic congestion at traffic light by extend the time for the green signal if traffic density at that lane are high and give the priority to who first arrive at the junction to get a green signal.

1.6 Thesis outline

Chapter 1 is introduction to programmable logic controller and traffic light system. This chapter also explains about project objectives and scopes and discuss about problem statement.

Chapter 2 focuses on hardware development and configuration. This chapter explains every detail about PLC Omron CQM1H and traffic light model. The wiring diagram for this hardware also will be discussed in this chapter

Chapter 3 deals with the software development using software CX-Programmer. These chapters also discuss the flowchart and development program for traffic light system.

Chapter 4 presents all the results obtained and the configuration of doing simulation in the real world.

Chapter 5 discusses the conclusion of this project development traffic light control system using Programmable Logic Controller. This chapter also explains the problem and the recommendation for this project and for the future development or system modification.

CHAPTER 2

SYSTEM HARDWARE

2.1 Introduction

The hardware part of this project is Programmable logic controller (PLC) and a traffic light model. Omron CQM1H-CPU51 is the type of PLC used in this project as the processor to control the traffic light. This type of PLC was been chosen because the characteristic is fully necessary by the development of traffic light system.

The four 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 two limit 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 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.

2.2 Programmable Logic Controller

2.2.1 PLC configuration

i. Many PLC configurations are available, even from a single vendor. But each of these has common components and concepts. The most essential component is are:

ii. iPower supply – This can be built into the PLC or be an external unit. Common voltage levels required by the PLC are 24Vdc 120Vac 220Vac.

iii. CPU (central Processing Unit) – This is a computer where ladder logic is stored and processed.

iv. I/O (Input/output) – A number of input/output terminals must be provided so that the PLC can monitor the process and initiate actions. Inputs to, and outputs from, a PLC is necessary to monitor and control a process. Both inputs and outputs can be categorized into two basic types: logical or continuous. Consider the example of a light bulb. If it can only be turned on or off, it is logical control. If the light can be dimmed to different levels, it is continuous.

v. Indicator lights – These indicate the status of the PLC including power on, program running, and a fault. These are essential when diagnosing problems.

vi. Rack Type : A rack can often be as large as 18” by 30” by 10”

vii. Mini: These are similar in function to PLC racks, but about the half size. Dedicated Backplanes can be used to support the cards OR DIN rail mountable with incorporated I/O bus in module.

viii. Shoebox: A compact, all-in-one unit that has limited expansion capabilities. Lower cost and compactness make these ideal for small applications. DIN rail mountable.

ix. Micro: These units can be as small as a deck of cards. They tend to have fixed quantities of I/O and limited abilities, but costs will be lowest. DIN rail mountable

2.2.2 Basic PLC schema

The basic PLC schema include CPU, power supply, memory, Input block, output block, communication and expansion connections. Figure 2.1 shows the PLC system overview.

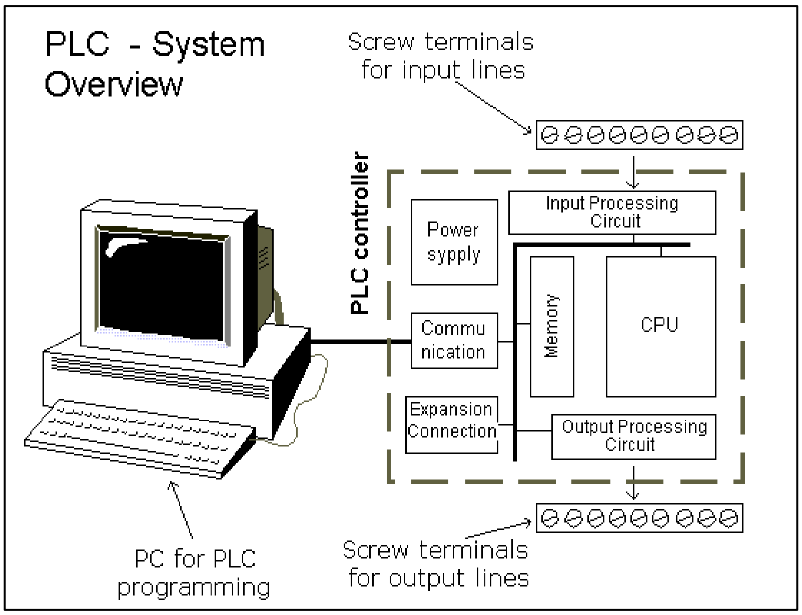

Figure 2.1 PLC system overview

CPU modules - The Central Processing Unit (CPU) Module is the brain of the PLC.Primary role to read inputs, execute the control program, update outputs. The CPU consists of the arithmetic logic unit (ALU), timing/control circuitry, accumulator, scratch pad memory, program counter, address stack and instruction register. A PLC works by continually scanning a program.

Memory - The memory includes pre-programmed ROM memory containing the PLC's operating system, driver programs and application programs and the RAM memory. PLC manufacturer offer various types of retentive memory to save user programs and data while power is removed, so that the PLC can resume execution of the user-written control program as soon as power is restored. Some types of memory used in a PLC include:

i. ROM (Read-Only Memory)

ii. RAM (Random Access Memory)

iii. PROM (Programmable Read-Only Memory)

iv. EPROM (Erasable Programmable Read-Only Memory)

v. EEPROM (Electronically Erasable Programmable Read-Only Memory)

vi. FLASH Memory

vii. Compact Flash – Can store complete program information, read & write text files

viii. I/O Modules - Input and output (I/O) modules connect the PLC to sensors and actuators. Provide isolation for the low-voltage, low-current signals that the PLC uses internally from the higher-power electrical circuits required by most sensors and actuators. Wide range of I/O modules available including: digital (logical) I/O modules and analogue (continuous) I/O modules.

2.2.3 PLC Operation

CHECK INPUT STATUS-First the PLC takes a look at each input to determine whether it is on or off condition.

EXECUTE PROGRAM-Next the PLC executes a program by one instruction at a time. If the first input is on then it should turn on the first output. Since it already knows then it will be able to decide whether the first output should be turned on based on the state of the first input. It will store the execution results for use later during the next step.

UPDATE OUTPUT STATUS-Finally the PLC updates the status of the outputs. It updates the outputs based on which inputs are on during the first step and the results of executing your program during the second step. Based on the example in step 2 it would now turn "ON" the first output because the first input is "ON" and your program said to turn "ON" the first output when this condition is true.

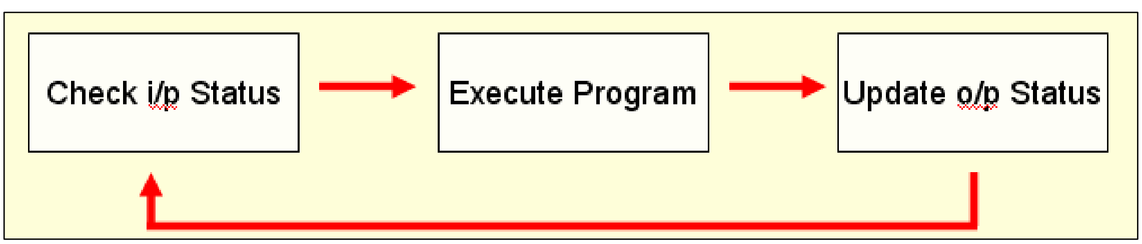

Figure 2.2 PLC operation block diagram

2.2.4 Internal PLC

INPUT RELAYS-(contacts) These are connected to the outside world. They physically exist and receive signals from switches, sensors, etc.

INTERNAL UTILITY RELAYS-(contacts) These do not receive signals from the outside world nor do they physically exist. They are simulated relays and are what enables a PLC to eliminate external relays.

OUTPUT RELAYS-(coils) These are connected to the outside world. They physically exist and send on/off signals to solenoids, lights, etc.

DATA STORAGE -Typically there are registers assigned to simply store data. They are usually used as temporary storage for math or data manipulation. They can also typically be used to store data when power is removed from the PLC.

2.3 CQM1H configuration

Figure 2.3 shows the Omron PLC CQM1H 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.

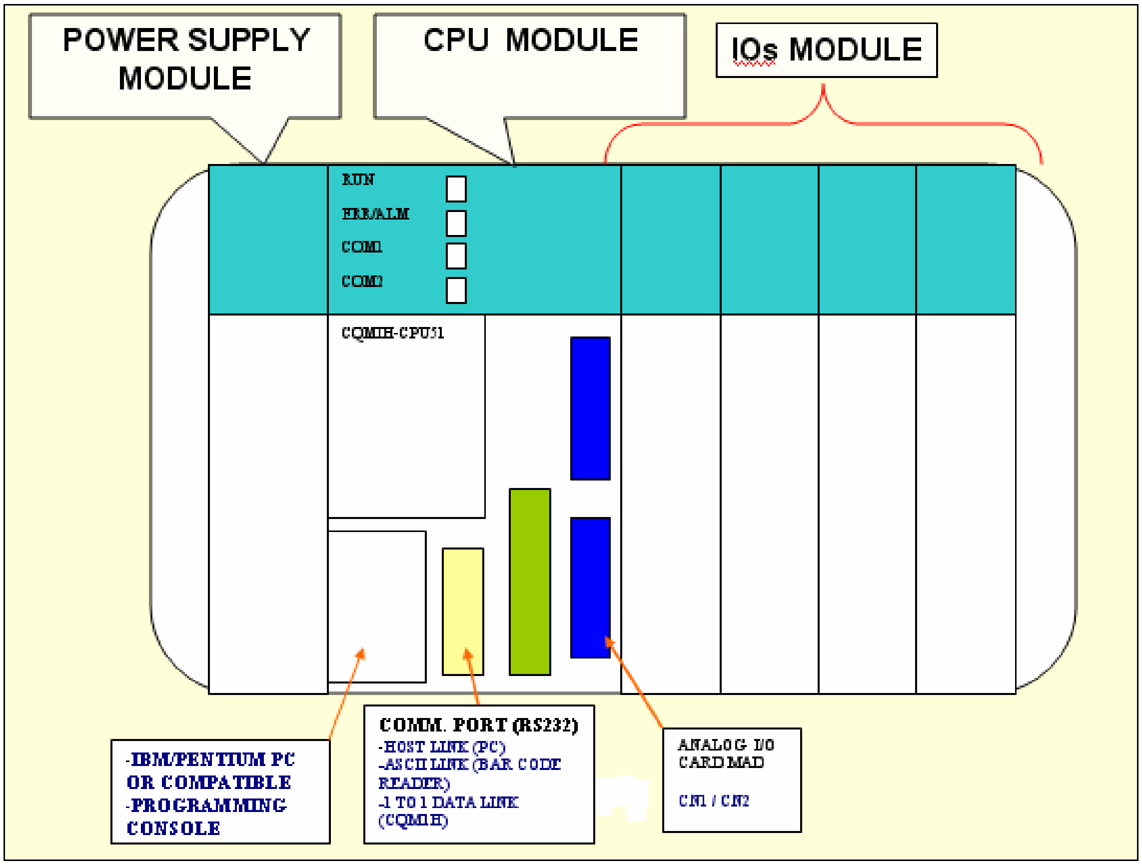

Figure 2.3 CQM1H configuration

2.4 Traffic light model

The four ways junction is developed to display the simulation the development of the new traffic light control system. Figure 2.4 and 2.5 show the design of traffic light model. Every lane and traffic light signals have been labeled with alphabet A, B, C and D 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 two limit switches represent as a sensor on the road. The suitable sensor for design a real traffic light system is type of linear sensor or electromagnetic sensor. The first sensor placed in front 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. From this combination of sensor, we will know the expected time for green signal on when each lane change to the green signal.

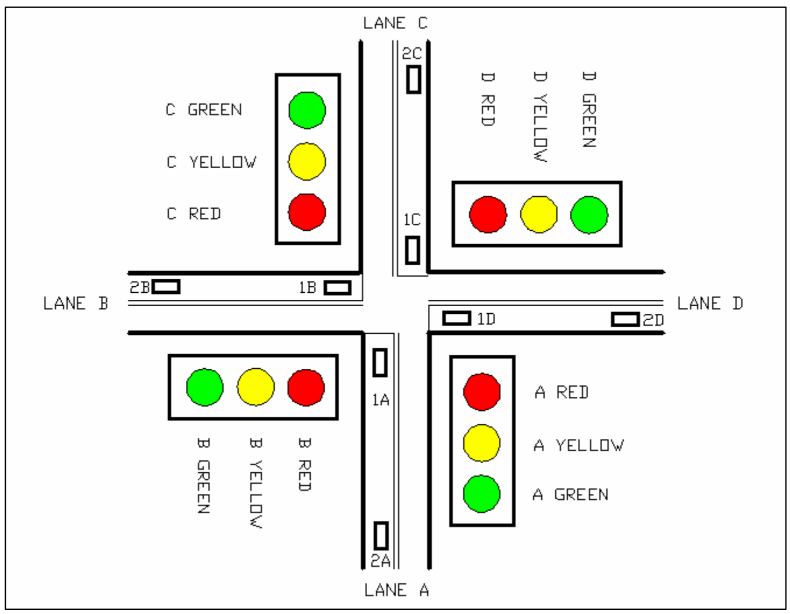

Figure 2.4 Traffic light model

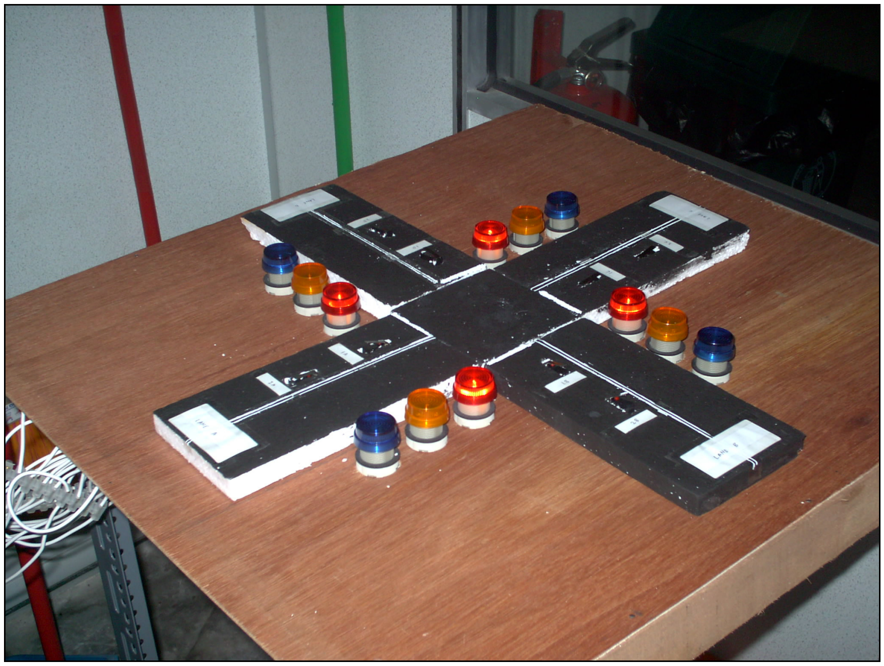

Figure 2.5 Traffic light hardware

2.5 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 2.6. 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.

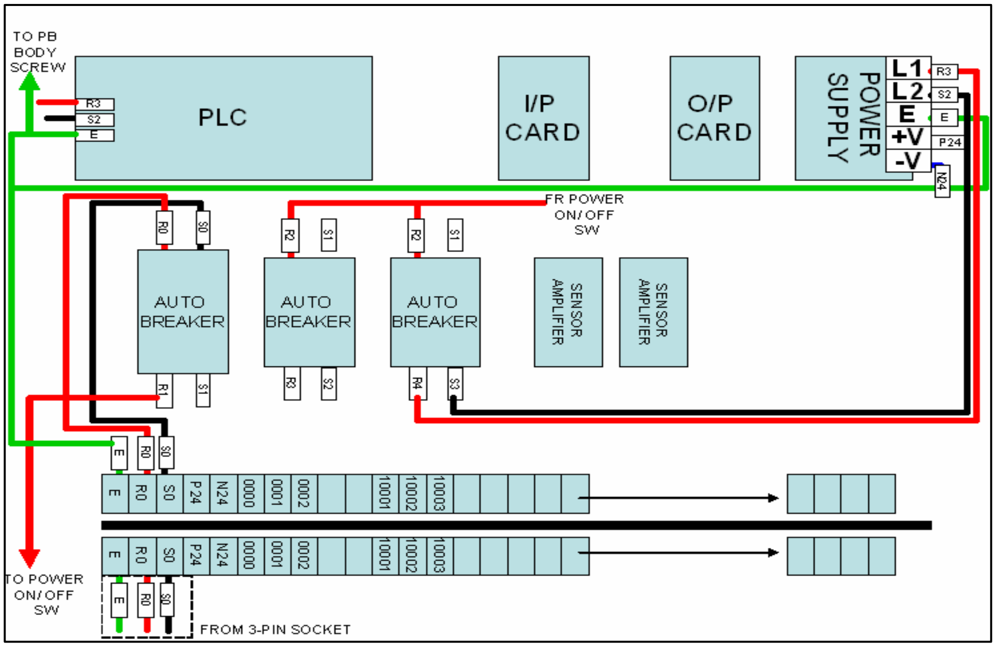

Figure 2.6 PLC cabinet box wiring diagram

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The PLC input wiring address start with number 0.00 to 0.15 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 1.15 and so on. Figure 2.7 shows the wiring diagram for input card which this input card connects to sensor (limit switch) at traffic light model.

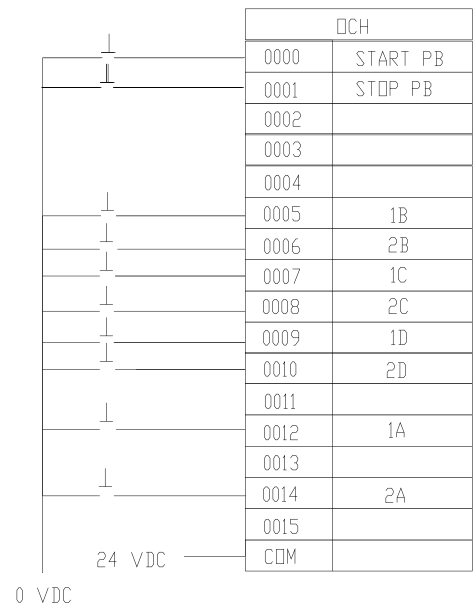

Figure 2.7 Input wiring diagram

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. The figure 2.8 show the wiring diagram for output card which output card connect to sensor (limit switch) at traffic light model.

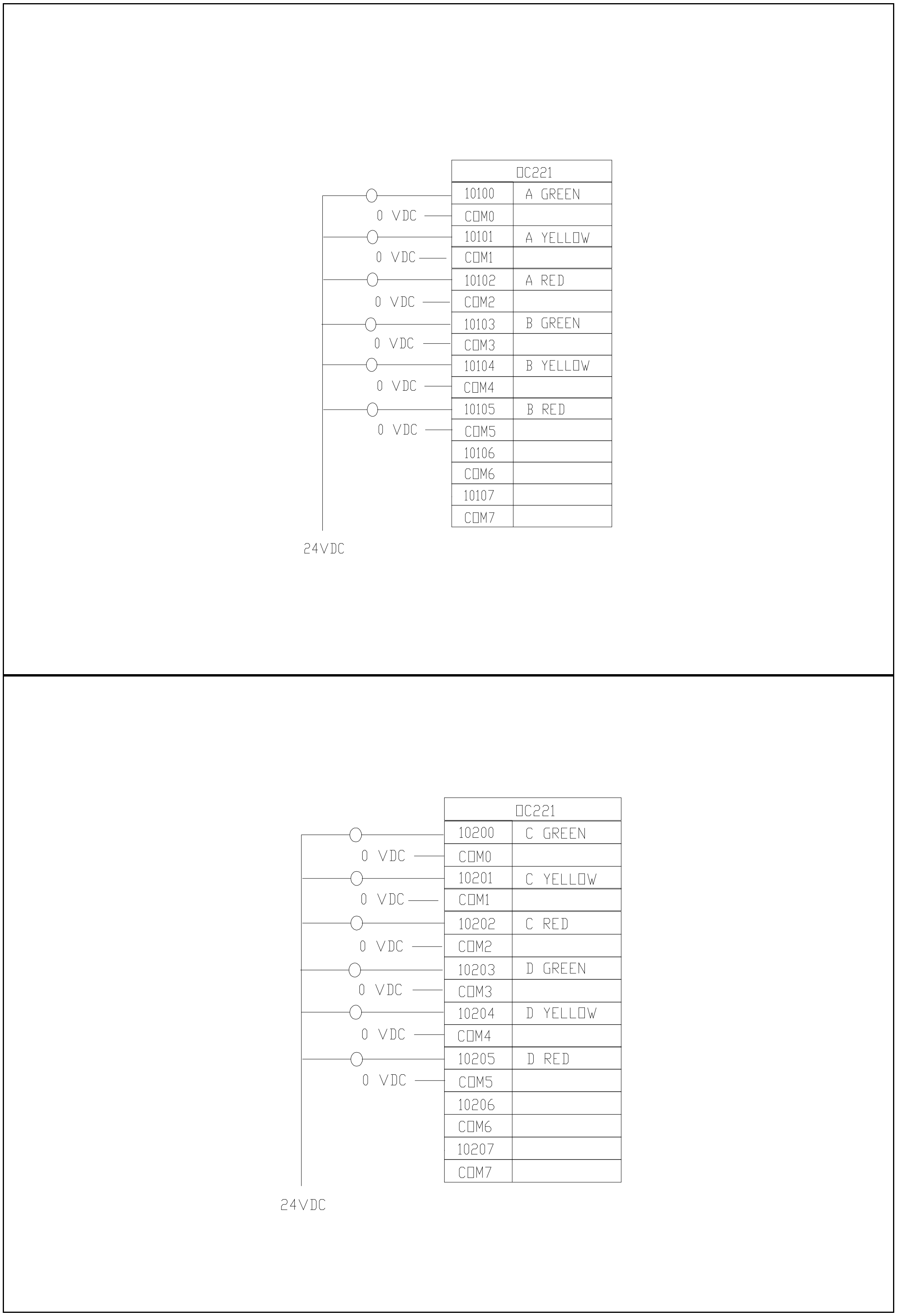

Figure 2.8 Output wiring diagram

CHAPTER 3

SYSTEM SOFTWARE

3.1 Introduction to CX-Programmer software

CX-Programmer is a PLC programming tool for the creation, testing and maintenance of programs associated with Omron CSI-series PLCs, CV-series PLCs and C-series PLCs. It provides facilities for support of PLC device and address information and for communications with OMRON PLCs and their supported network

CX-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 CX-Programmer project consists of ladder programs, operands, required PLC memory content, I/O table, expansion instructions (if applicable) and symbols. Each CX-Programmer project file is separate and is a single document.

CX-Programmer can only open a single project at a time. However, it is possible to deal with many project files by using CX-Programmer at once. A CX-Programmer project has a CXP or CXT file extension (normally the CXP file is used and is a compressed version of the CXT file).

3.2 Diagram workspace

The diagram workspace can display a ladder program, the symbol table of that program or the Mnemonic view. The details displayed depend upon the selection made in the project workspace.

When a new project is created or a new PLC added to a project, an empty ladder is automatically displayed on the right-hand side to the project workspace. The symbol table and Mnemonics view must be explicitly selected to be displayed. All views can be opened at the same time and can selected via option associated with the window menu.

PLC program instruction can be entered as a graphical representation in ladder form. Programs can be created, edited, and monitored in this view. The 3.1 shows the diagram workspace appearance.

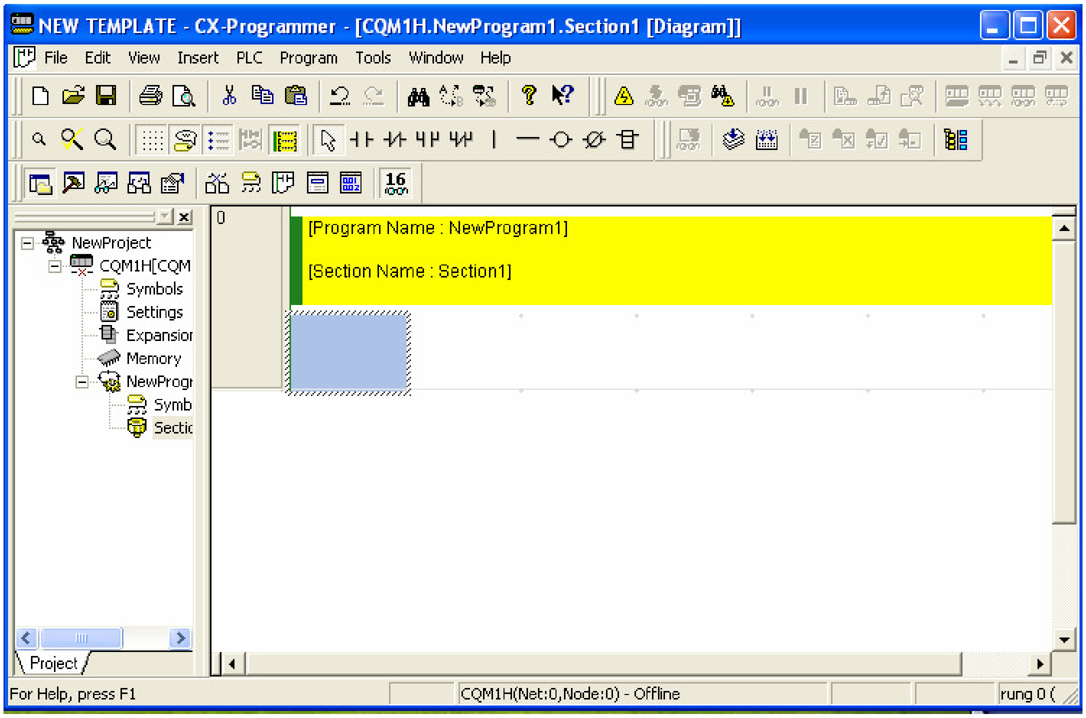

Figure 3.1 Programming section

3.3 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.

A flowchart in figure 3.2 shows about how the lane changes to the other lane for a green signal. 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 give the priority to the lane which have a car and followed by the other..

This traffic light control system operate similar to intelligent traffic light system which it only give 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.

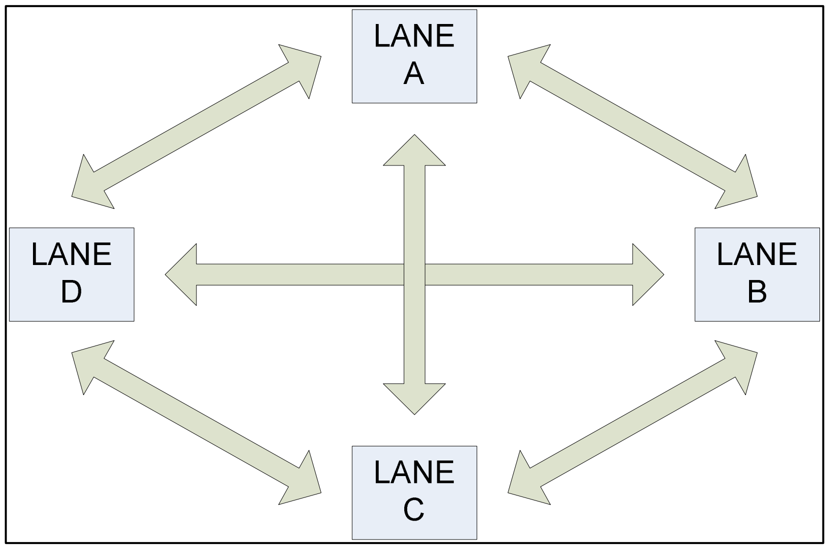

Figure 3.2 Traffic phase flowchart

Figure 3.3 shows a sample ladder logic diagram that has been constructed for the flowchart is shown in figure for the lane A. The ladder diagram for the other lanes is similar with this ladder diagram but the memories for the contacts are different.