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RAIN-WATER PLC BASED DETECTOR AND VALVE SWITCHER

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BORANG PENGESAHAN STATUS TESIS ¨

JUDUL: **RAIN-WATER PLC BASED DETECTOR AND VALVE SWITCHER**

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RAIN-WATER PLC BASED DETECTOR AND VALVE SWITCHER

MOHAMMAD HADI BIN ISMAIL

This thesis is submitted as partial fulfillment of the requirements for the award of
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"I hereby acknowledge that the scope and quality of this thesis is qualified for theaward of the
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Date : 6 May 2008

To my beloved parents....
who always pray for me and give me courage to finish this thesis.

Also, to those people who have guided and inspired me throughout my journey.

Thank you for the supports and advices that have been given…

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In the name of Allah S.W.T, the Most Gracious, the Ever Merciful. Praise is
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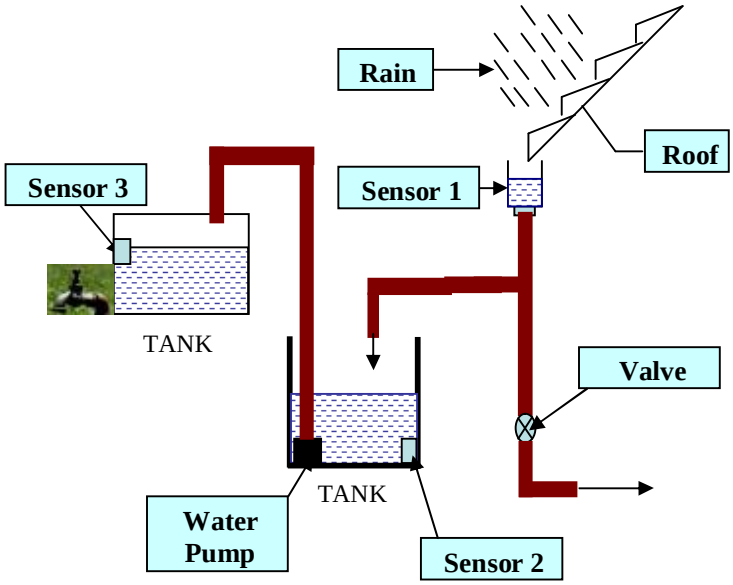
ABSTRACT

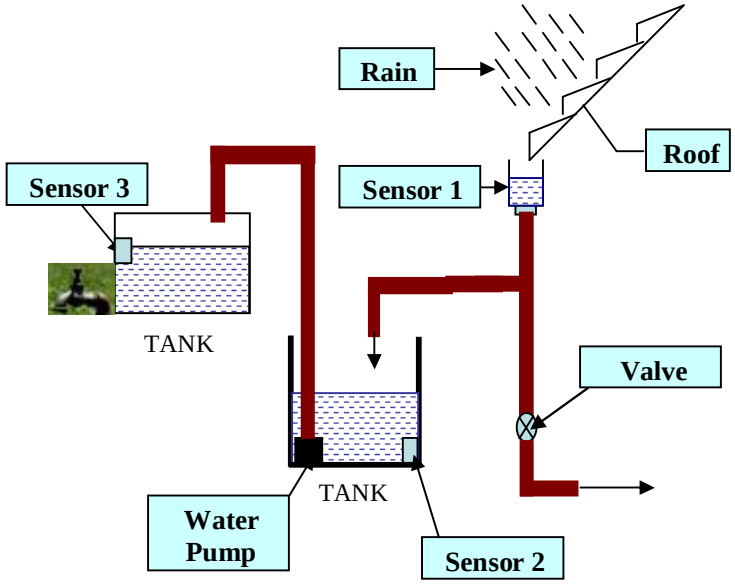
The main purpose of this project is to collect clean rain water automatically by using water sensor; solenoid valves, buzzer and water pump that controlled by Programmable Logic Controller (PLC). Below is modeling of the project.



When rain fall, sensor 1 will be detect water and make cause valve 1 will be open for 10 second. This is because; we need to flow out the dirty water from the roof firstly. After 10 second, the valve will be close and make cause the rain water will go to the tank A. If sensor 3 detect no water, water from tank A will be pump to the tank B, with condition, sensor 2 must be detect water in tank A firstly. Finally we can use rain water from Tank B for useful purpose like flushing toilets, washing machines, watering gardens, washing cars and etc.

ABSTRAK

Tujuan utama projek ini ada untuk mengumpul air hujan yang bersih secara automatik dengan menggunakan pengesan air, pili selonoid, penggera dan pam air yang dikawal oleh Pengawalan Logik Program (PLC). Rajah dibawah menunjukkan gambarajah projek tersebut:-



Apabila hujan turun, pengesan air 1 akan mengesan air hujan dan menyebabkan pili 1 akan terbuka untuk 10 saat. Ini adalah kerana air hujan yang kotor akan dikeluarkan terlebih dahulu. Selapas 10 saat, pili air akan ditutup dan menyebabkan air hujan tadi akan mengalir ke tangki A. Jika pengesan air 3 tidak mengesan air, air dari tangki A akan dipam ke Tangki B, dengan syarat, pengesan air 2 mesti mengesan air di Tangki A terlebih dahulu. Akhir sekali, air hujan yang telah dikumpul di Tangki B boleh digunakan untuk kegunaan harian seperti tangki air tandas, membasuh kain, pertanian, membasuh kereta dan lain-lain.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Project Background

Everyday we used mains water to supply all our water needs is needlessly wasteful, both financially and environmentally. Mains water is expensively purified to drinking water standards but much of the water is used for non-potable purposes, like flushing toilets, cleaning and gardening. Harvested rainwater can be substituted for mains water, saving money and contributing to the protection of a key natural resource. The idea of collecting rainwater has been around for thousands of years. Archaeologists have found that rainwater harvesting systems were being used in the Negev desert 4000 years ago. In Ancient Rome villas had their own individual cisterns and the rainwater was collected from paved courtyards which made them less reliant on the supply fed by the city's aqueducts. Today around the world rainwater harvesting is enjoying a renaissance and systems are being extensively installed for domestic, commercial and industrial use.

Rainwater is particularly useful to supply the large volume of water needed for flushing toilets. Each person on average uses almost 45 liters a day for this purpose. In an average household, this contaminates nearly 66,000 liters of drinking water a year. This is the main use of water in a household, closely followed by bathing and washing which uses 37 liters per person per day.

Rainwater is ideal for use in washing machines; on average people use 20 litres a day for washing clothes. The advantage is that the soft rainwater allows the use of natural soaps and biological washing powders, which are much more gentle on clothes than standard detergents.

Gardeners through the centuries have recognized the importance of a plentiful supply of water, and that plants prefer natural rainwater instead of heavily treated mains water. Rainwater can also be used for car washing and other general cleaning tasks around the home. The use of rainwater can really come into its own in business and industry. Not only is water extensively used in a wide range of tasks, but there are often large roof and hard standing areas to catch rainwater. This provides an incentive to invest in rainwater harvesting equipment as business use can offer a relatively short pay-back period. In large offices and public buildings, rainwater can be used for flushing toilets and urinals and for cleaning.

1.2 Problem Statement

Many people want to harvest rainwater to fill their tank. But they need to open the cap of tank to allow rainwater flow to the tank. So, rainwater PLC based water detector and valve switcher is a system to open and close valve automatically when rain is fall. Hence the user will not go to tank just want to open the cap.

1.3 Project Objectives

The Objectives of this project are:-

1.3.1 To develop the hardware and software by using PLC (Programmable Logic Controller) and as a main controller.

1.3.2 To open switcher valve when the sensor detect rainwater to allow dirty rainwater flow out firstly before fulfill Tank A.

1.3.3 To Control water level between Tank A and Tank B.

1.3.4 To develop rain water and water level sensor circuit.

1.4 Project Scope

The scope of this project is:-

1.4.1 PLC (Programmable Logic Controller) as main controller.

1.4.2 Constructing rainwater detection sensor circuit by using 555 timer IC.

1.4.3 Controlling Switcher Valve to flow out the dirty rainwater for 10 second.

1.4.4 Controlling Water level between Tank A and Tank B so that there were have same level water.

1.5 Methodology

There were some method was taken to make sure the flow of the project is smooth and can be done according to due date. There were two steps that must be taken to done this project. It is:-

1.5.1 do studies on hardware that needed in this project such as PLC, Water detection sensor and switcher valve.

1.5.2 Design a model to show the flow of the water.

1.5.3 Do studies on the available software that can be program on PLC to control the valve.

Figure 1.1 showed the methodology or work flow of the project that have been used as the guideline in order to do the project. In started with investigate the topic and objectives with supervisor. After doing literature review, equipment that needed was investigated like water detection sensor, PLC and valve. In the same time, programming was designed to control the system.

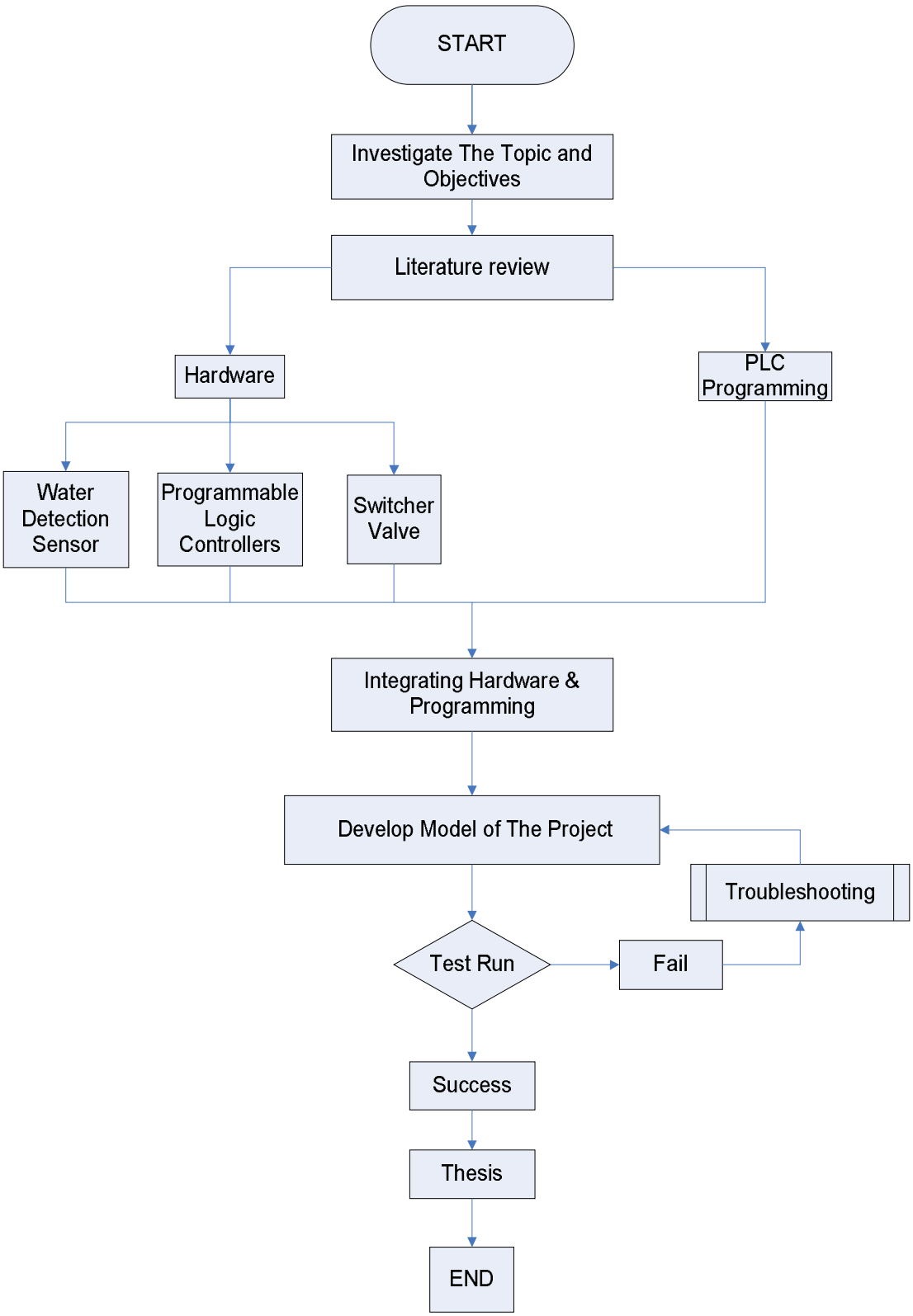


FIGURE 1.1 THE WORK FLOW OF THE PROJECT.

1.6 Review of Thesis Contents.

This thesis had six contents. Chapter 1 discusses about background of the project, problem statement, project objectives, scope of project and methodology.

Chapter 2 provides a literature review about water harvesting that many use by people in the world today. In this chapter, also discussing about characteristics of water detection sensor, PLC and switcher electronic valve that usually used in industry.

Chapter 3 focuses on the methods system architecture that is used for this project including all essential modules of the system. It also discusses on hardware and programming used for this project. For hardware, there were divided into several parts like hardware design module and programming development module.

Chapter 4 discusses all about the design system of the project. The explanation begin with applying the idea into action, using the hardware that has been choose, applying the programming that control the system and lastly combine all component into one perfect system.

Chapter 5 will be outcomes from the project which will be consist of figure of the hardware project and other related stuff.

Chapter 6 will be include the summary of the project where it will conclude overall of the project and recommendation for future development.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

On this chapter, some literature reviews have been done on several resources. The theories and description have taken as guidance in completing this project. So this chapter will present and overview the equipment that needed in this project.

2.2 RAINWATER HARVESTING SYSTEM OVERVIEW

2.2.1 ROOF

The existing roof is made use of to collect rainwater. Since rainwater is pure as it falls from the sky it is necessary that the roof be kept clean for it to remain pure when it is collected. This means the roof will need to be swept and cleaned daily during the rainy season in the district.

2.2.2 PVC GUTTERS

The gutters of PVC collect the rainwater from the roof and transfer it to the filter by controlled by valve to open and close. On sloping roofs, PVC gutters can pick up leaves, dust, small twigs and other organic matter. The gutters need to be cleaned regularly at least weekly once. During the rainy season the PVC gutters should be inspected and cleaned daily.

2.2.3 DOWNPIPES

PVC down pipes brings the water from the rainwater gutters or pipes vertically down. They should invariably be clamped firmly to the wall and should never be loosely fixed.

2.2.4 STORAGE TANK

The rainwater **storage tank** collects all the rainwater and keeps it for future use. The storage tank is made above the ground and on a platform. It can also be an underground sump in some cases.

2.2.5 OVERFLOW PIPE

The storage tank will have an overflow pipe from the top of the tank. In case of heavy rain, the overflow pipe will allow the excess rain water to be safely disposed of without causing any flooding.

2.3 PROGRAMMABLE LOGIC CONTROLLERS (PLC)

2.3.1 Introduction

A *programmable logic controller (PLC)* is a specialized computer used to control machines and processes. It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing, counting, sequencing, arithmetic, and data handling.

Initially the PLC was used to replace relay logic, but its ever-increasing range of functions means that it is found in many and more complex applications. Because the structure of a PLC is based on the same principles as those employed in computer architecture, it is capable not only of performing relay switching tasks but also of performing other applications such as counting, calculating, comparing, and the processing of analog signals.

2.3.2 Digital and analog signals

Digital or discrete signals behave as binary switches, yielding simply an On or Off signal (1 or 0, True or False, respectively). Pushbuttons, limit switches, and photoelectric sensors are examples of devices providing a discrete signal. Discrete signals are sent using either voltage or current, where a specific range is designated as *On* and another as *Off*.

For example, a PLC might use 24 V DC I/O, with values above 22 V DC representing *On*, values below 2VDC representing *Off*, and intermediate values undefined. Initially, PLCs had only discrete I/O.

Analog signals are like volume controls, with a range of values between zero and full-scale. These are typically interpreted as integer values (counts) by the PLC, with various ranges of accuracy depending on the device and the number of bits available to store the data. As PLCs typically use 16-bit signed binary processors, the integer values are limited between -32,768 and +32,767. Pressure, temperature, flow, and weight are often represented by analog signals. Analog signals can use voltage or current with a magnitude proportional to the value of the process signal. For example, an analog 4-20 mA or 0 - 10 V input would be converted into an integer value of 0 - 32767.

An analog output could send a 4 to 20 milliamp signal to a variable-speed drive. The drive will control the speed of a motor in proportion to analog signal received from the analog output module.

Figure below showed the valve position correlation to the module's output voltage.

ANALOG SIGNAL COMPARISON FOR SAMPLE ANALOG VALUE OUTPUT		
Valve Position	Voltage Ouput Signal	Decimal Valve Output to Output Section
FULL OPEN	10	32,767
80%	8	26,214
70%	7	22,937
60%	6	19,660
50%	5	16,384
40%	4	13,107
30%	3	9,830
20%	2	6,553
10%	1	3,276
Closed	0	0

Figure 2.1 Valve position correlation to the module's output voltage.

In addition to cost savings, PLCs provide much other benefit including:-

i) **Increased reliability**

Once a program has been written and tested, it can be easily downloaded to other PLCs. Since all the logic is contained in the PLC's memory, there is no chance of making a logic wiring error. PLC's also offer the reliability associated with solid-state components.

ii) **More Flexibility**

It is easier to create and change a program in a PLC than to wire and rewired a circuit. Originally equipment manufacturers can provide system updates by simply sending out a new program.

iii) **Lower Cost**

PLC were originally designed to replace relay control logic, and the cost savings have been so significant that relay control is becoming obsolete except for power application.

iv) **Communications Capability**

A PLC can communicate with other controllers or computer equipment to perform such functions as supervisory control, data gathering, monitoring devices and process parameters, and download and upload of programs.

v) **Faster Response Time**

PLCs are designed for high-speed and real-time applications. The programmable controller operates in real time, which means that an event taking place in the field will result in the execution of an operation or output.

vi) **Easier to troubleshoot**

PLCs have resident diagnostics and override functions that allow users to easily trace and correct software and hardware problems. [1] (Frank D. Petruzella, 2005)

Many types of PLC are available such as Omron, Mitsubishi, Siemen, Nais and many more. In this project, I am using Omron PLC which has 3 inputs and 2 outputs. This PLC is suitable to control the switching of valve and speed of motor pump.

2.4 SWITCHER VALVE

2.4.1 Introduction

A solenoid valve is a device that regulates the flow of substances (either gases, fluidized solids, slurries, or liquids) by opening, closing, or partially obstructing various passageways. Valves are technically pipe fittings, but usually are discussed separately.

Solenoid valves are used wherever fluid flow has to be controlled automatically. They are being used to an increasing degree in the most varied types of plants and equipment. The variety of different designs which are available enables a valve to be selected to specifically suit the application in question.

Valves are used in a variety of applications including industrial, military, commercial, residential, and transportation. Plumbing valves are the most obvious in everyday life, but many more are used.

2.4.2 Construction

Solenoid valves are control units which, when electrically energized or de-energized, either shut off or allow fluid flow. The actuator takes the form of an electromagnet. When energized, a magnetic field builds up which pulls a plunger or pivoted armature against the action of a spring. When de-energized, the plunger or pivoted armature is returned to its original position by the spring action.

2.4.3 Direct-Acting 2-Way Valves

Two-way valves are shut-off valves with one inlet port and one outlet port (Fig. 2.2). In the de-energized condition, the core spring, assisted by the fluid pressure, holds the valve seal on the valve seat to shut off the flow. When energized, the core and seal are pulled into the solenoid coil and the valve opens. The electro-magnetic force is greater than the combined spring force and the static and dynamic pressure forces of the medium.

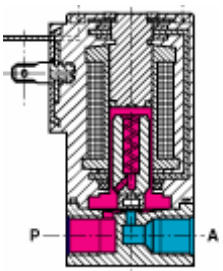


Figure 2.2

2.5 Water Pump

2.5.1 Introduction

Pump is a device used to move liquids or slurries. A pump moves liquids from lower pressure to higher pressure, and overcomes this difference in pressure by adding energy to the system (such as a water system). [Source: Wikipedia]

2.5.2 Water Pump System

Pumps fall into two major groups: rotodynamic pumps and positive displacement pumps. Their names describe the method for moving a fluid. Rotodynamic pumps are based on bladed impellers which rotate within the fluid to impart a tangential acceleration to the fluid and a consequent increase in the energy of the fluid. The purpose of the pump is to convert this energy into pressure energy of the fluid to be used in the associated piping system.[Source: Wikipedia]

2.6 Water Level & Rain Sensor

2.6.1 Introduction

Water Level Sensor is a sensor that detect water to control the output of the system. When the sensor detect water, it will trigger the output.

A **rain sensor** or *rain switch* is a switching device actuated by rainfall. [Wikipedia]

Level sensors are used to detect liquid level. The liquid to be measured can be inside a container or can be in its natural form (e.g. tank, a river and etc.). The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and are used to know the exact amount of liquid in a certain place and Point level sensors only measures a specific level, generally this is used to detect high level alarms or low level alarms.[Wikipedia]

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In order to make sure the flow of project is smoothly, this methodology is the one of important element to take the action. By referring methodology, we can make sure that the project goes according to the initial planning. It is a framework for a project.

By referring methodology, the progress of the project can be examined from time to time. We can found the mistake by referring the methodology.

The elements of the methodology of this project can be referred to the flow chart below.

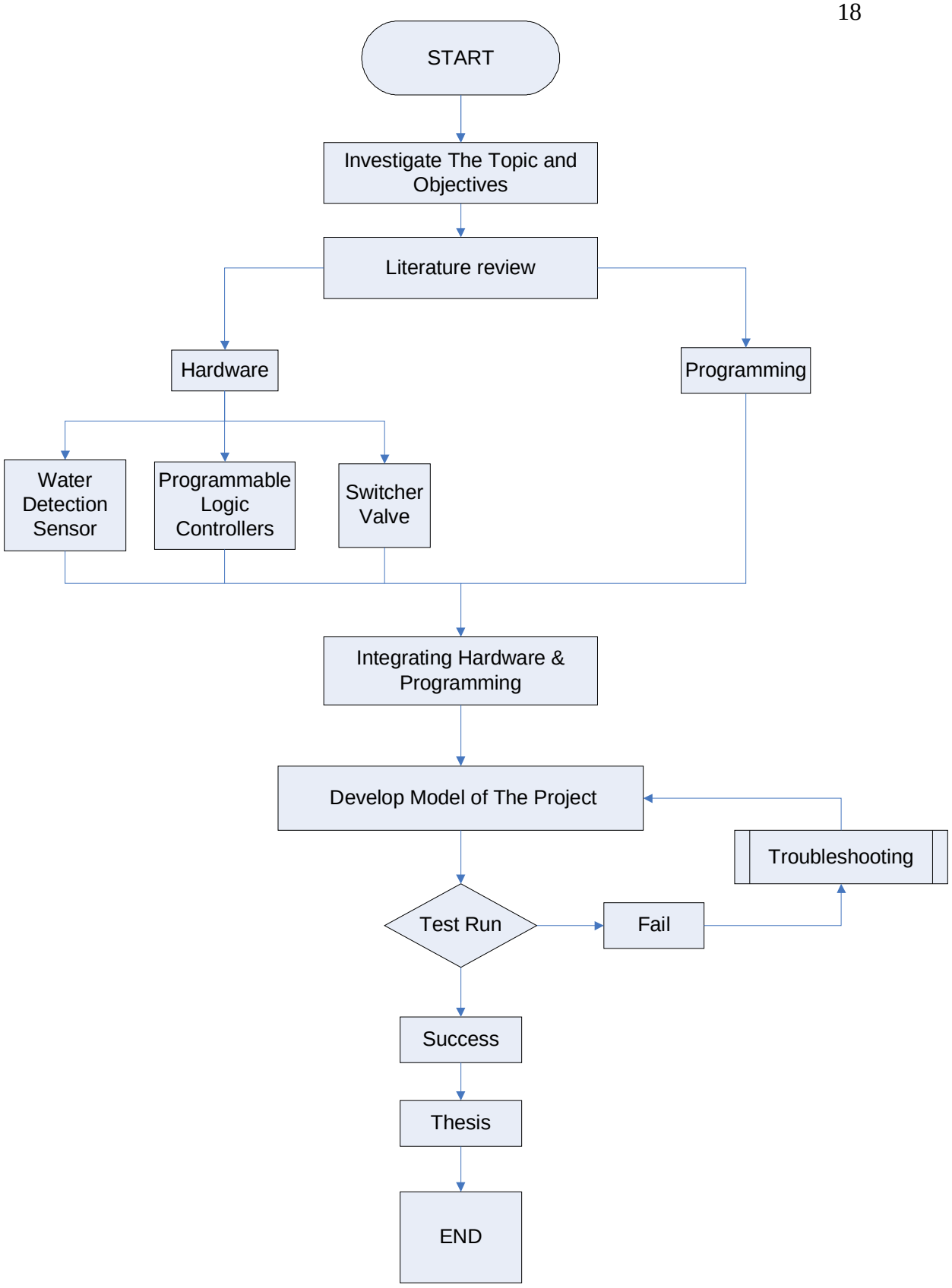


Figure 3 The flow chart of the methodology

3.2 LITERATURE REVIEW

The one important part on this project is finding literature review about PLC and water detector sensor. It is conclude doing research and getting more information about the previous method of the similar project and the component that use in this project. This research and information is very important to make us clear about the project scope and this is the ground level to get an idea for developing and designing the project. The literature review about this project was comes from book, internet, journals and discussion from experienced person. Otherwise, some entire books are from the UMP library and borrow from someone who is very familiar with PLC system.

3.3 ROOF

The existing roof is made use of to collect rainwater. Since rainwater is pure as it falls from the sky it is necessary that the roof be kept clean for it to remain pure when it is collected. This means the roof will need to be swept and cleaned daily during the rainy season in the district.

3.4 THEORETICAL DESIGN

After all the information is collected, the project was design and developed. It almost use water sensor detector circuit as input to PLC and water pump and switcher valve as the output. Also in this section, a model like house was design to place the sensor, water pump, PLC and switcher valve. The model also use to show the flow of water.

3.5 HARDWARE DEVELOPMENT

At this part, the project continues with the hardware development after the theoretical design was made. The hardware was developing based on the

design that is made before. In completing water sensor circuit part, electronic component was done on independent strip board and using wrapping wire to connect between component. For wiring PLC, it was done by referring manual PLC book. The last part is build a model to show the flow of water.

3.6 SOFTWARE DEVELOPMENT

Once all the hardware was developed, the last stage of methodology is programming development. The programming will transfer to OMRON PLC to control the switcher valve and water pump.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This Rain-Water PLC Based Detector and Valve Switcher project basically based on applying rain water sensor circuit, PLC, switcher valve and water pump to make a system; collecting rainwater automatically when rain fall.

This project also consist civil part which is to build a model to show the flow of rain water to fill the water in the tank.

These chapters will discussing about rain water sensor circuit, relays, PLC, switcher valve, flow chart of system, Programming design and water pump. This chapter also will be discussing about the result of the project. Otherwise, the costing and commercialized also will be discussing in this chapter.

4.2 RAINWATER AND WATER LEVEL SENSOR DETECTOR

As we know, water is as analog part. But PLC need digital signal to make it work. To achieve the project, rainwater and water level sensor is important part to sense rainwater and water level tank. The water sensor will be work as input to PLC. But the problem is, when the water sensor directly use to the PLC as an input, the PLC cannot work. This is because water has very high resistance. It cause the voltage will be drop with a large amount (from 24V to 10 V). Continuously, the PLC cannot work with 10V. This is because in ohm's law the equation can derive as followed:-

$$V=IR$$

V= Voltage
I = Current
R = Resistance

It shown that, value of voltage is dependent to current and resistance. If the value of resistor is high, the value of voltage also must be high. This will be cause the water sensor pad will be easy to damage.

To avoid this problem, a 555 timer was used to generate from analog signal to digital signal. It is a popular analog-digital integrated circuit. It is a simple circuit. The circuit is shown as below:-

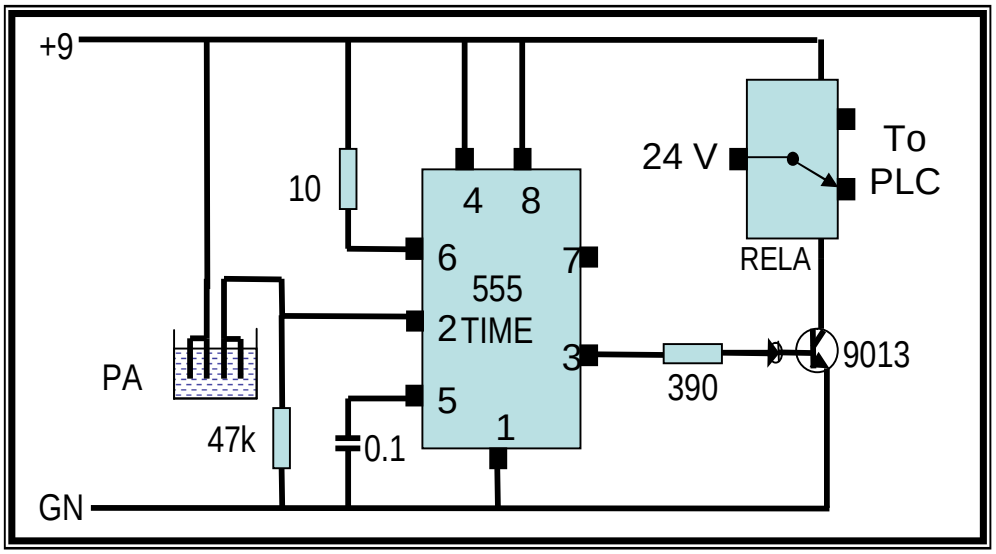


Figure 4.1 Water Sensor Detector Circuit

Figure 4.1 is a 555 timer circuit use astable multivibrator or clock circuit built using an external resistor and capacitor to set the timing interval of the output signal. When pad sense water, It will trigger 555 timer to pulse digital signal to transistor (9013). When Base at transistor get pulse, the current will be flow from Collector to Emitter of transistor. A relay was used as the output of the sensor to gives input (24V) to the PLC.

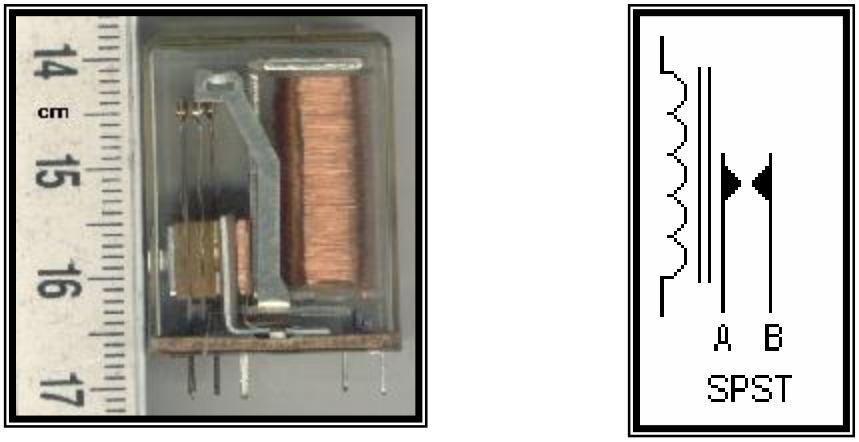


FIGURE 4.2 : RELAY

When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a fixed contact. When the current to the coil is switched off, the armature is returned by a force approximately half as strong as the magnetic force to its relaxed position. If the coil is energized with DC, a diode is frequently installed across the coil, to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a spike of voltage and might cause damage to circuit components

(a) **(b)**

FIGURE 4.3 : WATE R SENSOR PAD

Figure 4.3 (a) show for water level tank sensor and Figure 4.3 (b) show for rain water sensor pad. It almost like two probe. Basically, water is indicator and water sensor is two probe that will flow current when it touching with water.

4.3 THE CONCEPT OF THE WATER SENSOR CIRCUIT.

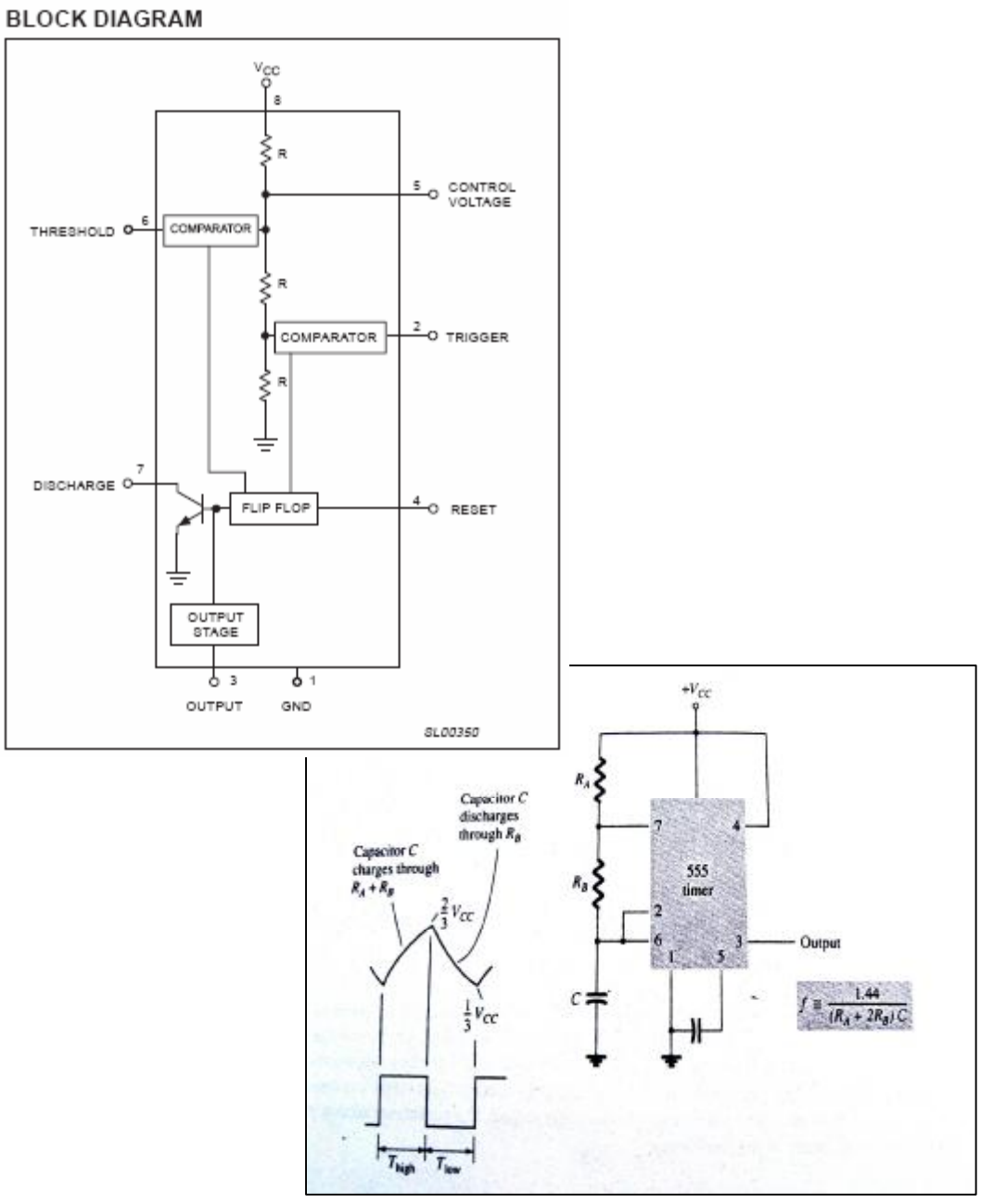


FIGURE 4.4 Details Of 555 timer and block diagram

Referring to Fig 4.4, we can see that the capacitor voltage rises until it goes above 2Vcc/3. This voltage is threshold voltage at pin 6, which drive comparator 1 to trigger the flip flop so that the output at pin 3 goes low. In addition, the discharge transistor is driven on, causing the output at pin 7 to discharging the capacitor through resistor R_B. The capacitor voltage then decreases until it drops below the trigger level (Vcc/3). The flip flop is triggered so that the output goes back high and the discharge transistor is turned off, so that the capacitor can again charge through resistor R_A and R_B toward Vcc.

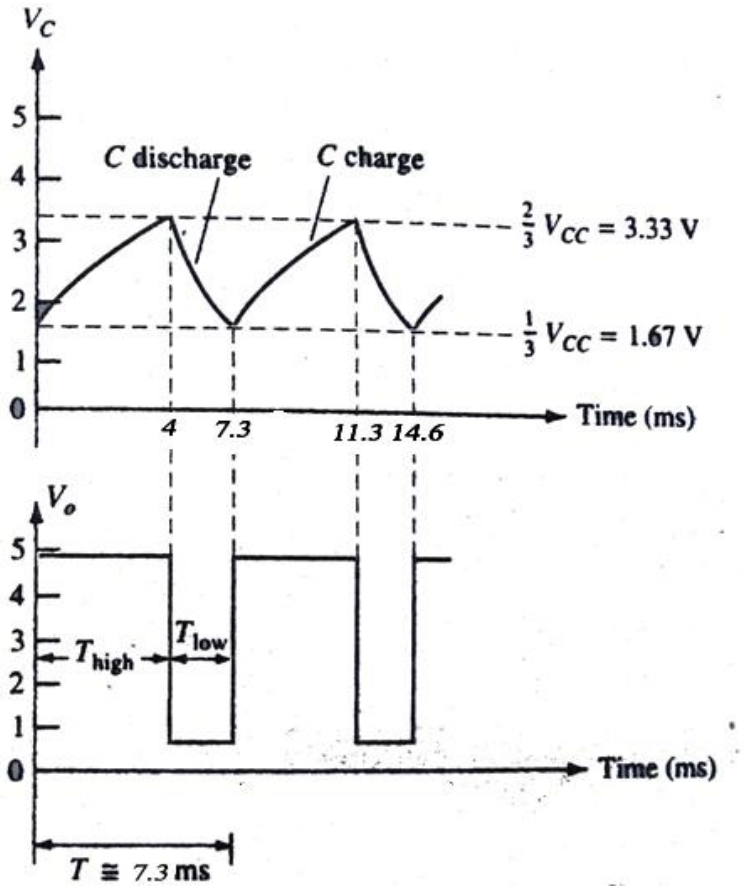


FIGURE 4.5: Output Waveform

Figure 4.5 shows the capacitor and output waveforms resulting from astable circuit. Calculation of the time intervals during which the output is high and low can be made using the relations

$$T_{high} \approx 0.7(R_A + R_B)C$$

$$= 0.7 (10k + 47k) 0.1\mu F$$
$$= 3.99ms$$
$$= 4ms$$

$$T_{low} \approx 0.7R_BC$$
$$= 0.7 \times 47k \times 0.1\ \mu F$$
$$= 3.3ms$$

The total period is

$$T = \text{period} = T_{high} + T_{low}$$

$$= 7.3\ ms$$

Frequency, fo

$$= \frac{1.44}{(R_A + 2R_B)\ C}$$

$$= \frac{1.44}{[\ 10k + 2(47k)]\ 0.1\ \mu F}$$

$$= 138.46\ Hz$$

Duty Cycle

$$= \frac{R_A + R_B}{R_A + 2R_B} \times 100$$

$$= \frac{10k + 47k}{10k + 2(47k)} \times 100$$

$$= 54.80\ \%$$

From the calculation we can conclude that 555 timer can use as analog-digital converter integrated circuit.

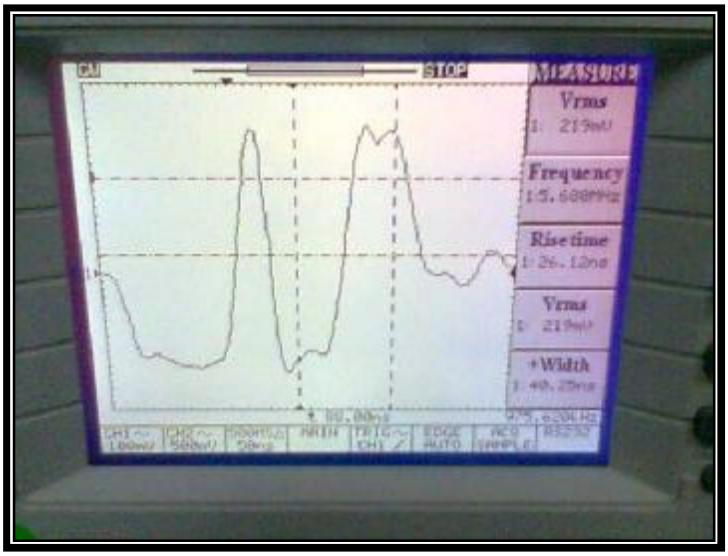


FIGURE 4.6 THE RESULT

From figure 4.6, it shown that the result at output of 555 timer when PAD is sense the water. It was proved that the digital signal can produced by using 555 timer.

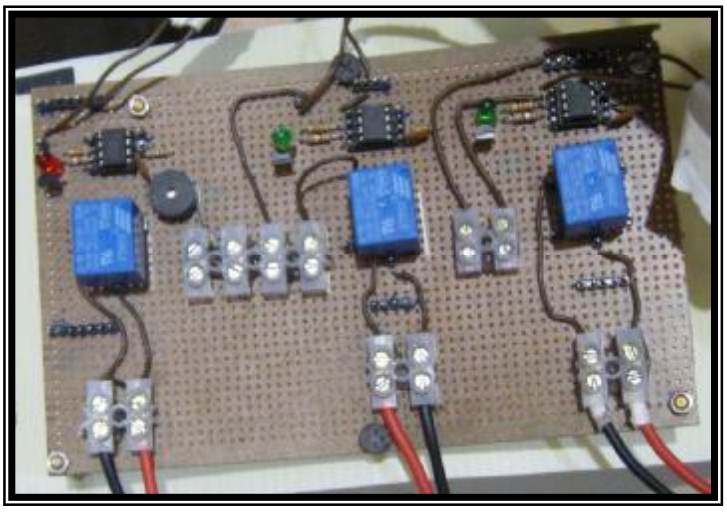


FIGURE 4.7 HARDWARE OF WATER SENSOR CIRCUIT

4.4 OMRON Programmable Logic Controllers

The PLC that use in this project is from brand OMRON type CQM1H which is a compact, high speed Programmable Logic Controller composed of a power supply unit, a CPU and I/O. CQM1H meant for advanced control system operation requiring 16 to 192 I/O points per PLC. The CPU is equipped with peripheral port to connect to programming Device and an RS-232C port for interfacing to serial device.

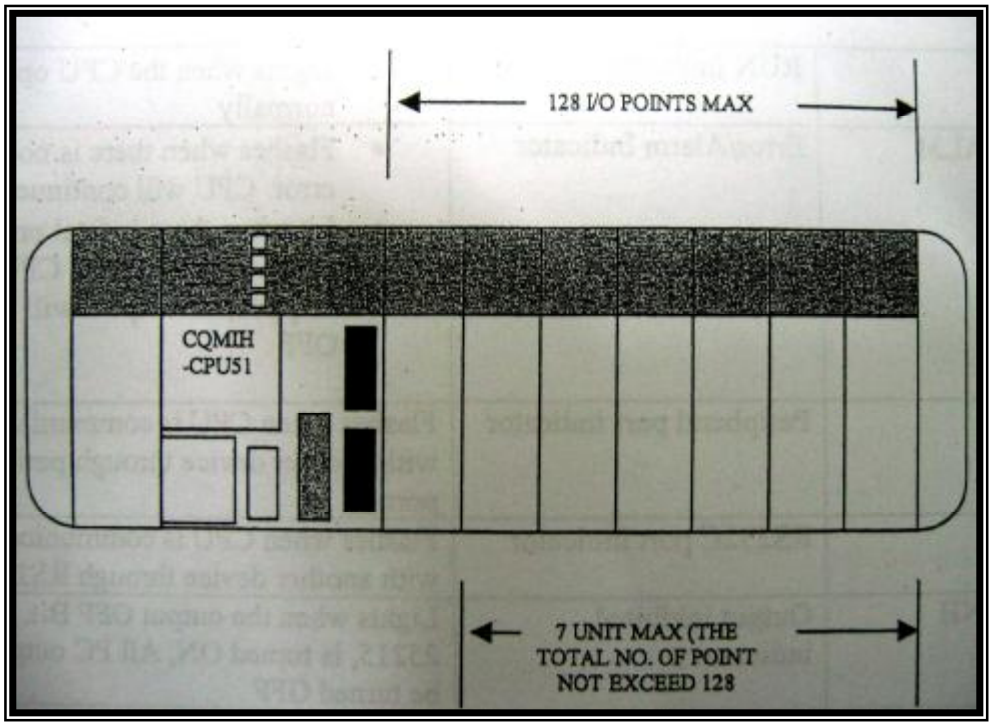


FIGURE 4.8 : Diagram Of PLC

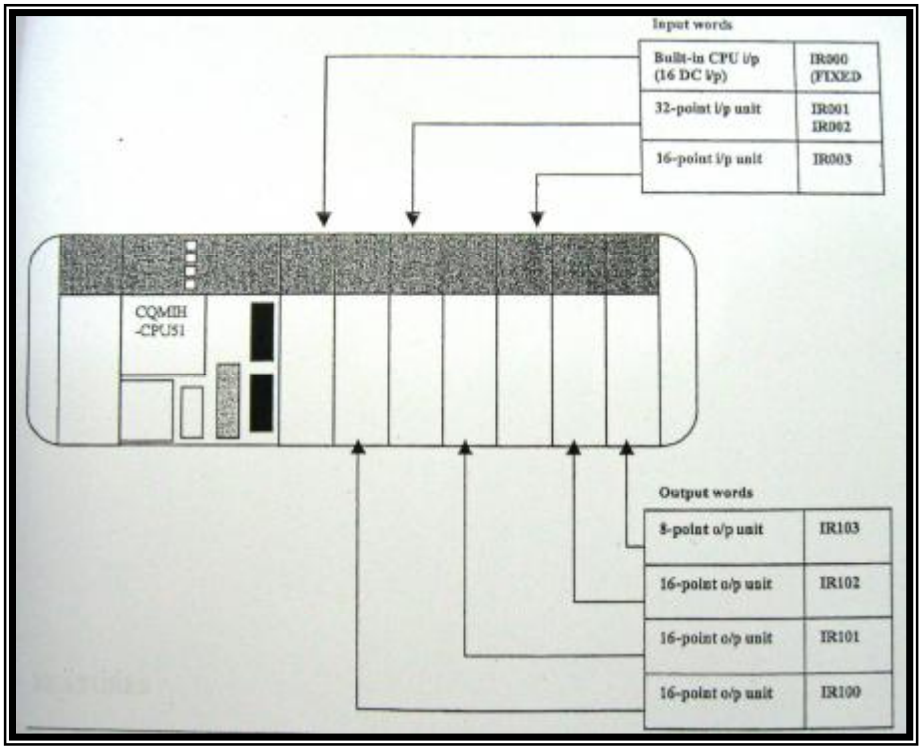


FIGURE 4.9: I/O Word Allocation

Figure 4.9 shows I/O word allocation. I/O words are allocated to I/O units according to their location on the PC.

1. The first i/p channel (IR000) is allocated to the CPU's 16 built in input points
2. The remaining i/p words (IR001 to IR007) for CPU51 are allocated to i/p units beginning with the unit closest to the CPU and continuing to the rightmost unit on the PLC.
3. One I/O word will be allocated to units that have 16 or fewer I/O points, and 2 words will be allocated to units that have 32 I/O points.

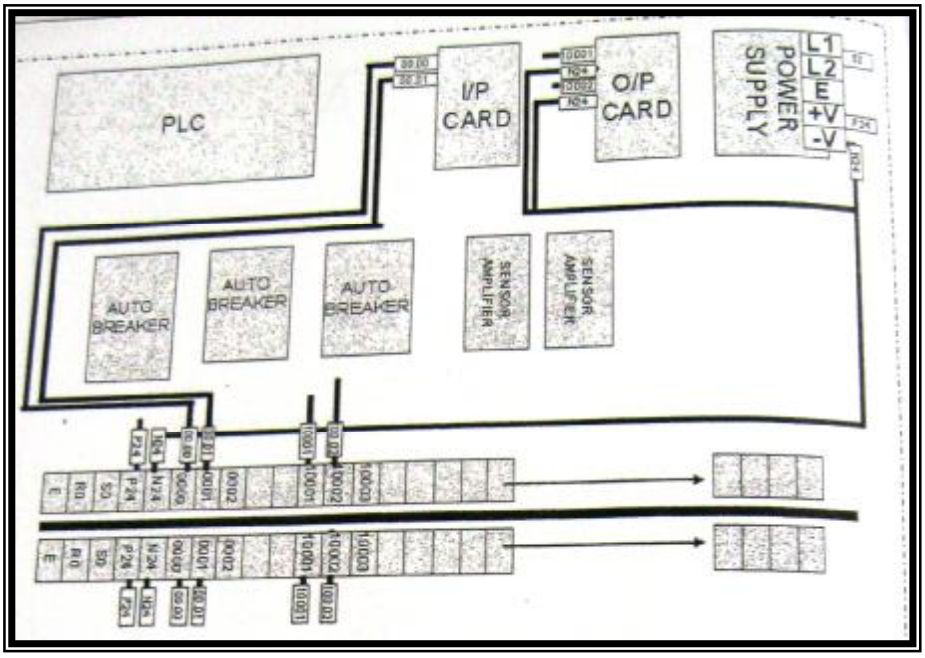


FIGURE 4.10: Wiring Schedule (I/P and N24 wiring)

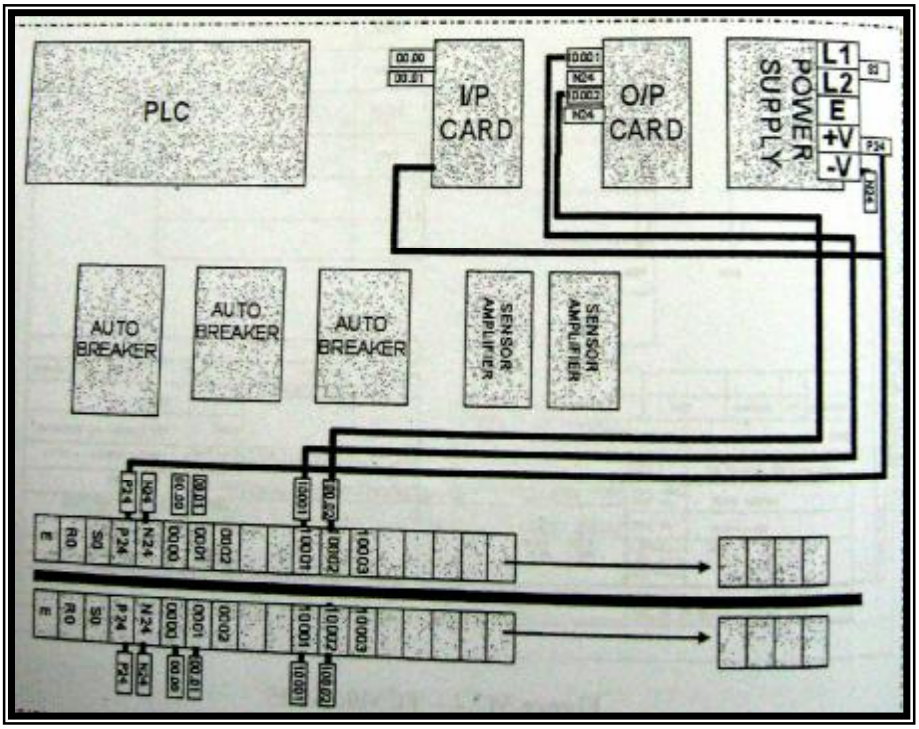


FIGURE 4.11 : Wiring Schedule (O/P and P24 wiring)

Figure 4.8 and 4.9 shows the wiring for I/O card.

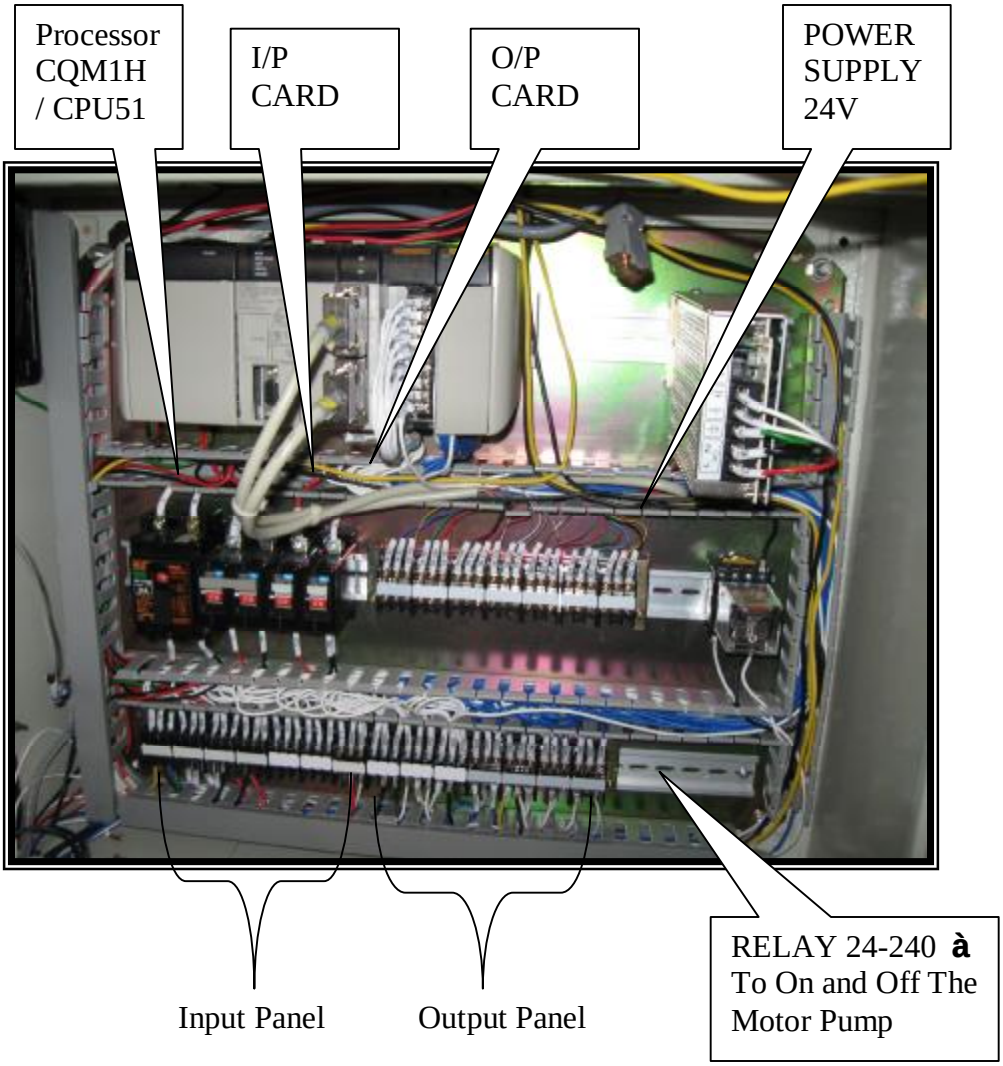


FIGURE 4.12 : Control Panel of PLC

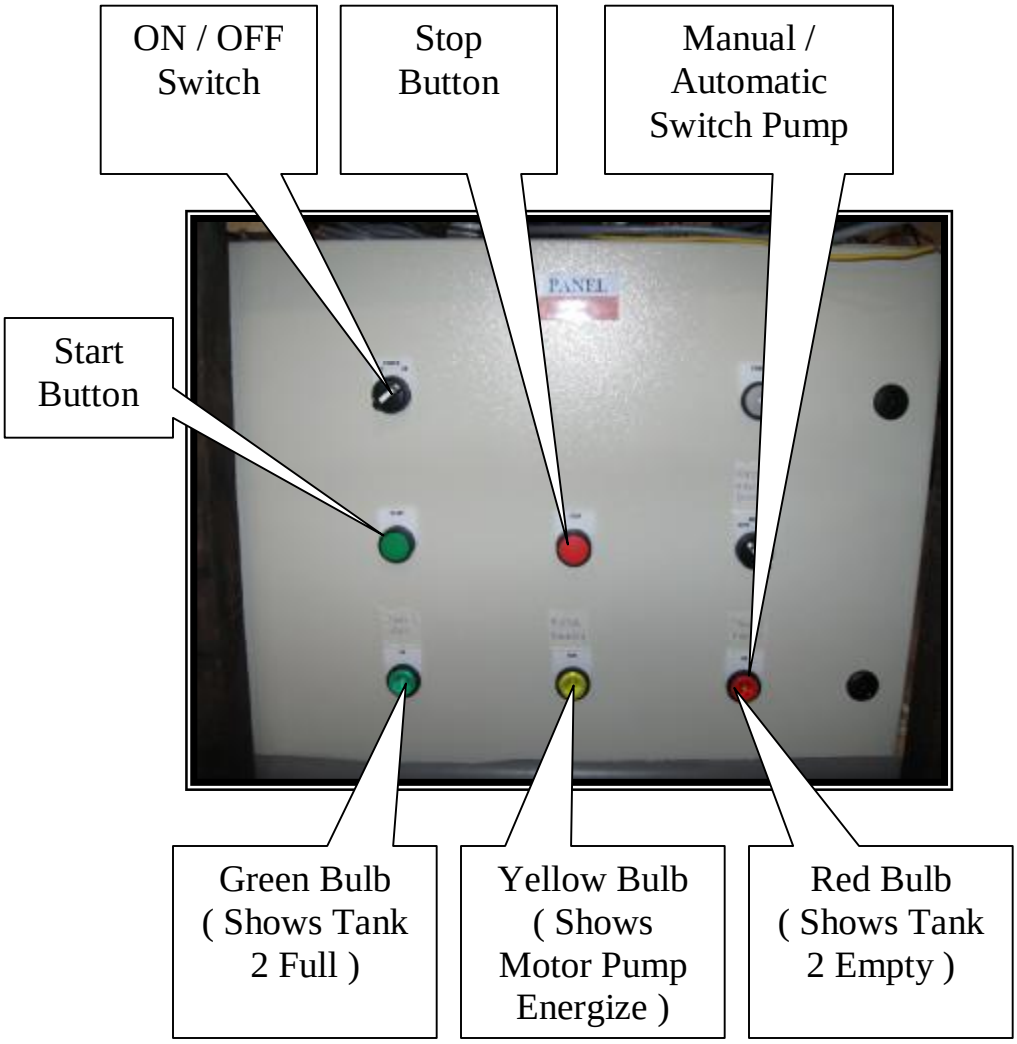


FIGURE 4.13 : Control Panel (Lamp and Button Switch)

4.5 VALVE

FIGURE 4.14 : Switcher Valve Before Installation

FIGURE 4.15 : Switcher Valve After Installation

Valve is a device that regulates the flow of substances (either gases, fluidized solids, slurries, or liquids) by opening, closing, or partially obstructing various passageways. Figure 4.14 show the valve before installation and figure 4.15 show switcher valve after installation. This is ON/OFF valve switcher. It use power supply 24VDC. The purpose installment of valve because we need to flow out the dirty water firstly. Then the valve will be close by gives the valve 0V. size of this valve is ½ inch and can ambient temperature between -10^{o}C to 60^{o}C. It also can use in AC 24V – 48V – 115V – 230V / 50Hz.

4.6 WATER PUMP

Water pump is a device used to move liquids or slurries. A pump moves liquids from lower pressure to higher pressure, and overcomes this difference in pressure by adding energy to the system (such as a water system). Pumps work by using mechanical forces to push the material, either by physically lifting, or by the force of compression.

FIGURE 4.16 : Water Pump

Figure 4.16 shows a motor pump after installment and ready to pump water from tank A to the Tank B. The pump can pump water between 5ft -10ft. It use 240VAC to functioning

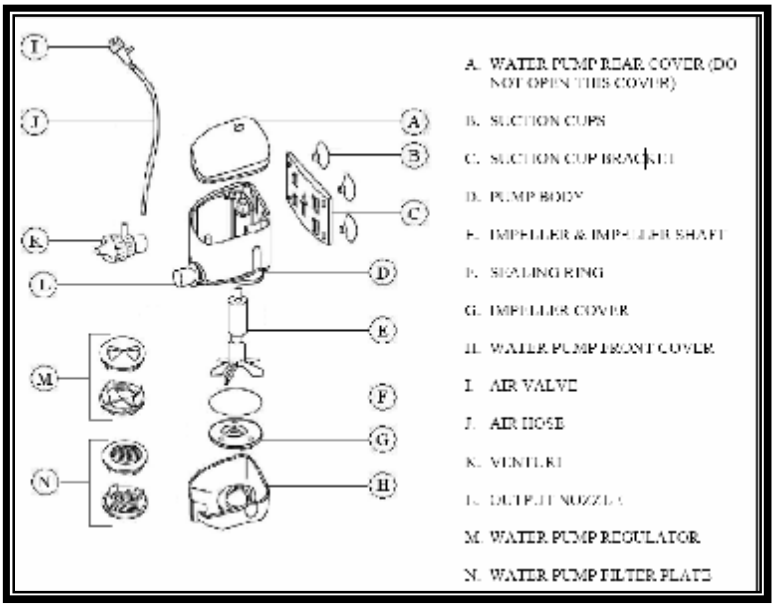


FIGURE 4.17 Water Pump Elements

Pump can separately into 14 elements component as shown in Figure 4.17. All this element of component is very important to make sure the pump can work smoothly.

4.7 PROGRAMMING DESIGN

To make sure the system of Rain-Water PLC Based Detector and Valve Switcher running smoothly, a PLC was used. In this project, OMRON PLC (CQM1H) was used to controlling the system. A software (CX-PRORAMMER) was used to programming the PLC.

Two flow chart was design to completing the program. The first flow chart known as System 1 and the second flow chart known as System 2.

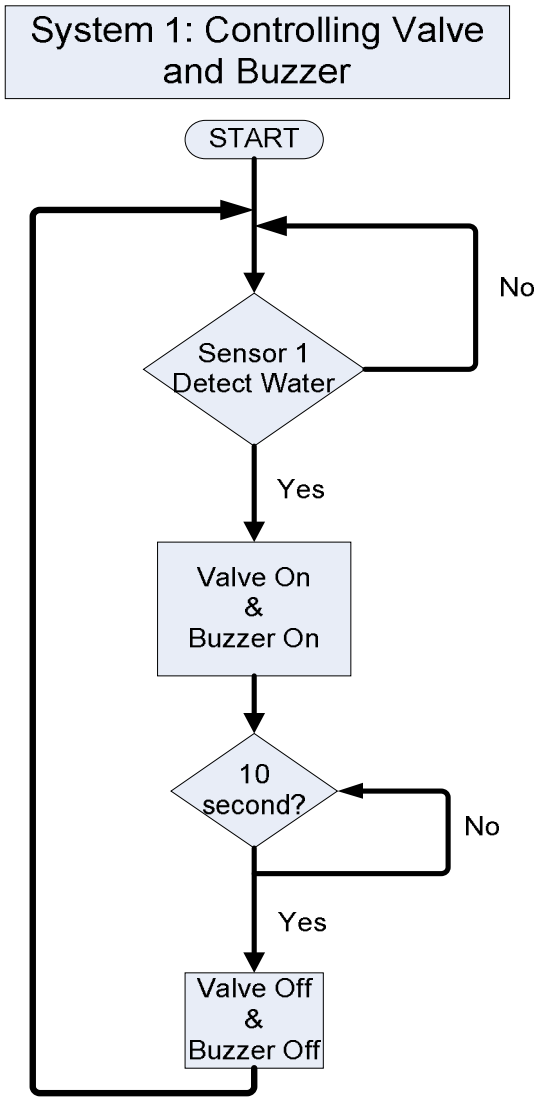


FIGURE 4.18: Flow Chart for System 1

From figure 4.18 shows flow chart for System 1. when sensor 1 detect rain water, PLC will give signal 'ON' to valve and buzzer for 10 second. If sensor 1 did not detect water, it will loop at the sensor 1. after 10 second, the valve and buzzer will be 'OFF' by PLC. After that, the system will be looping to initial condition which is detecting sensor 1 or not.

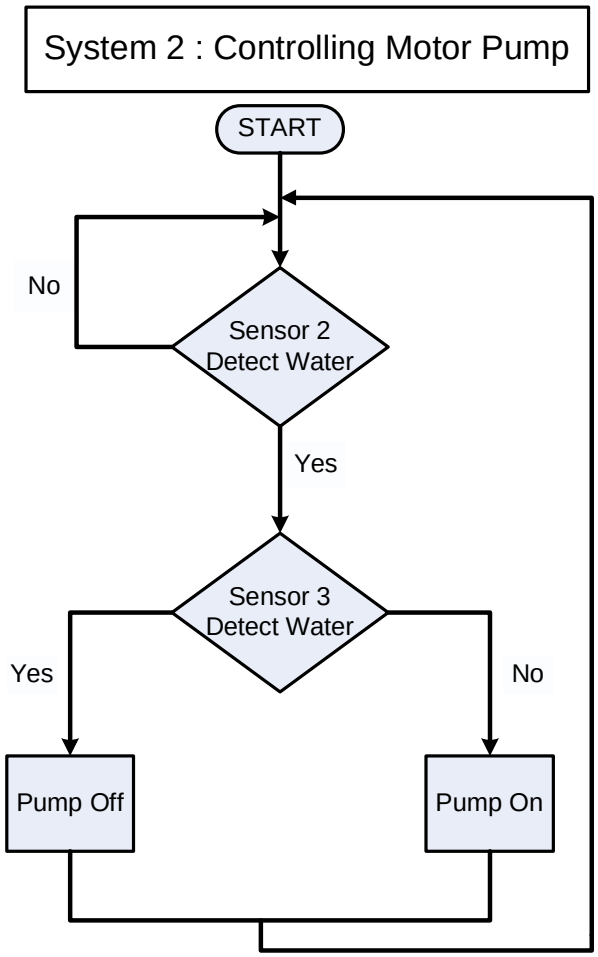


FIGURE 4.19 : Flow Chart for System 2

In this system, water Tank B must be fulfilling by using water pump when it is empty if Tank A have water. That mean, the pump will not energize if Tank A did not have water. Figure 4.19 show flow chart for System 2. When sensor 2 detect water, Sensor 3 will give signal to PLC whether it sense water or not. If sensor 3 did not sense water it's mean that Tank B is empty. So the water pump will be energizing. Thus water will be pump from Tank A to Tank B. If Sensor 3 sense water, the pump will be OFF. There was having two conditions if this happen whether Tank A is empty or Tank B is full. Lastly this system will loop to the initial condition.

After designing flow chart, it will be applied to the programming. Here, CX-PROGRAMMER was used to programming OMRON PLC. There were some knowledge about the software must be know. The manual of software can refer in Appendix B. Below the programming that was designed by using CX-PROGRAMMER.

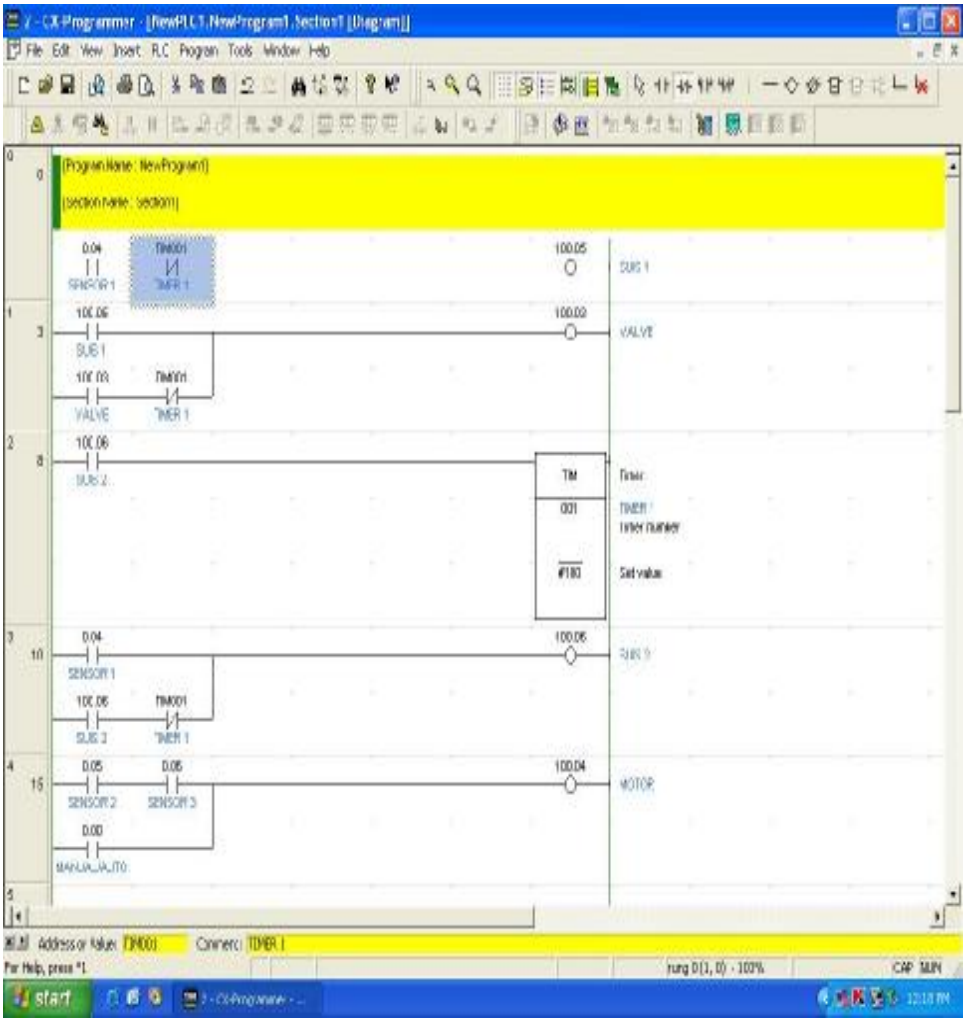


FIGURE 4.20 : Programming Using CX-PROGRAMMER

Figure 4.20 show the programming using CX-PROGRAMMER. Paragraph 1 to 4 in CX-PROGRAMMER shows program for system 1. The Input for sensor 1 was used for normally open contact at address 004.

SUIS 1 was used OUTPUT COIL at address 100.05. When sensor 1 detects water, OUTPUT COIL 100.05 will be ON. It make cause OUTPUT COIL 100.03 also will be ON, continuously Timer will be timing for 10 second and switcher valve will be open. After 10 second, TIMER will be open NORMALLY CLOSE TIMER 1. This will cause the Valve will be OFF.

Paragraph 5 in CX-PROGRAMMER shows program for system 2. When input NORMALLY OPEN CONTACT 0.05 (Sensor 2) detect water and NORMALLY CLOSE CONTACT 0.06 (Sensor 3) detect no water, OUTPUT COIL 100.04 (Water Pump Motor) will be energize.

4.8 COSTING AND COMMERCIALIZED

In completing the project, many components is come from FKEE laboratory. However, it still need spend own money to completing the project because the item did not available at FKEE laboratory. Table below shown the costing of the project.

NO	COMPONENT	QUANTITY	PRICE
1	½ inch ASCO Switcher Valve	1	RM 125
2	Water Pump 1 Phase	1	RM 13
3	Wood 2x2 inch	1	RM40
4	Zink	1	RM 5
5	Pvc Pipe	5m	RM 6
6	Sensor PAD	3	RM 7
7	Fitiing PVC Pipe	20	RM15
8	Roller	4	RM 20
		TOTAL	RM231

This project can be commercialized by doing more R & D about this project. It's including improving the water sensor and using smaller controller like PIC or 68H11 Microcontroller. User can use PLC as the controller, but it is very expensive and need more space and money. This project can be as prototype to Universiti Malaysia Pahang as alternatives method to solves water problem supply where always happen at campus. It also can apply to new hometown that always faced with water problem supply.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This project is achieved 100% the objectives. Basically, this project many applying knowledge about hardware and programming. The software CX-PROGRAMMER was used to programming OMRON PLC to make sure the flow of system will work smoothly. Rain water and water level sensor circuit also was developing by using 555 timer as input to OMRON PLC. Finally switcher valve as an output was used to allow dirty rain water flow out firstly before fulfill Tank A and water level between Tank A and Tank B can be controlled by using OMRON PLC as controller.

5.2 FUTURE RECOMMENDATION

During the project, there were disadvantages of the equipment and system. One of them is the water sensor PAD. The pad sensor was too sensivity and not stable when sense water. So using capacitive sensor is more reliability and consistent. The flow of two tanks also can be control by using analog valve. Analog valve can be control the flow of water by giving a different value of volts. Finally, I hope this project can be implementing in the Campus of UMP as alternatives method to solve water problem supply.

REFERENCE

1. John W.Webb, Ronald A. Reis (1999) “Programmable Logic Controller, Principles and Applications”
2. http://en.wikipedia.org/wiki/Programmable_logic_controller
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7. Katsuhiko Ogata “Modern Control Engineering”, Prentice Hall 2002.

APPENDIX A

DATASHEET OF 555 TIMER

FAIRCHILD
SEMICONDUCTOR®

www.fairchildsemi.com

LM555/NE555/SA555

Single Timer

Features

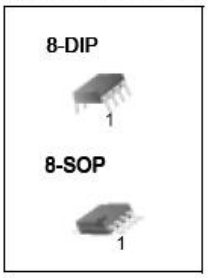
- High Current Drive Capability (200mA)
- Adjustable Duty Cycle
- Temperature Stability of 0.005%/°C
- Timing From μSec to Hours
- Turn off Time Less Than 2μSec

Applications

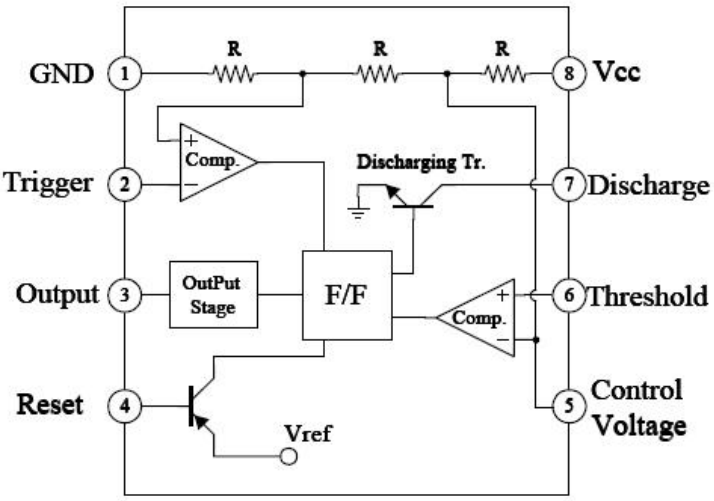
- Precision Timing
- Pulse Generation
- Time Delay Generation
- Sequential Timing

Description

The LM555/NE555/SA555 is a highly stable controller capable of producing accurate timing pulses. With a monostable operation, the time delay is controlled by one external resistor and one capacitor. With an astable operation, the frequency and duty cycle are accurately controlled by two external resistors and one capacitor.



Internal Block Diagram



Absolute Maximum Ratings (T_A = 25°C)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	16	V
Lead Temperature (Soldering 10sec)	T_{LEAD}	300	°C
Power Dissipation	P_D	600	mW
Operating Temperature Range LM555/NE555 SA555	T_{OPR}	 0 ~ +70 -40 ~ +85	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Electrical Characteristics

(T_A = 25°C, V_{CC} = 5 ~ 15V, unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	V_{CC}	-	4.5	-	16	V
Supply Current (Low Stable) (Note1)	I_{CC}	V_{CC} = 5V, R_L = ∞	-	3	6	mA
		V_{CC} = 15V, R_L = ∞	-	7.5	15	mA
Timing Error (Monostable) Initial Accuracy (Note2) Drift with Temperature (Note4) Drift with Supply Voltage (Note4)	ACCUR Δt/ΔT Δt/ΔV_{CC}	R_A = 1kΩ to100kΩ C = 0.1μF	-	1.0 50 0.1	3.0 0.5	% ppm/°C %/V
Timing Error (Astable) Intial Accuracy (Note2) Drift with Temperature (Note4) Drift with Supply Voltage (Note4)	ACCUR Δt/ΔT Δt/ΔV_{CC}	R_A = 1kΩ to 100kΩ C = 0.1μF	-	2.25 150 0.3	-	% ppm/°C %/V
Control Voltage	V_C	V_{CC} = 15V	9.0	10.0	11.0	V
		V_{CC} = 5V	2.6	3.33	4.0	V
Threshold Voltage	V_{TH}	V_{CC} = 15V	-	10.0	-	V
		V_{CC} = 5V	-	3.33	-	V
Threshold Current (Note3)	I_{TH}	-	-	0.1	0.25	μA
Trigger Voltage	V_{TR}	V_{CC} = 5V	1.1	1.67	2.2	V
		V_{CC} = 15V	4.5	5	5.6	V
Trigger Current	I_{TR}	V_{TR} = 0V		0.01	2.0	μA
Reset Voltage	V_{RST}	-	0.4	0.7	1.0	V
Reset Current	I_{RST}	-		0.1	0.4	mA
Low Output Voltage	V_{OL}	V_{CC} = 15V I_{SINK} = 10mA I_{SINK} = 50mA	-	0.06 0.3	0.25 0.75	V V
		V_{CC} = 5V I_{SINK} = 5mA	-	0.05	0.35	V
High Output Voltage	V_{OH}	V_{CC} = 15V I_{SOURCE} = 200mA I_{SOURCE} = 100mA	 12.75	12.5 13.3	-	V V
		V_{CC} = 5V I_{SOURCE} = 100mA	2.75	3.3	-	V
Rise Time of Output (Note4)	t_R	-	-	100	-	ns
Fall Time of Output (Note4)	t_F	-	-	100	-	ns
Discharge Leakage Current	I_{LKG}	-	-	20	100	nA

Notes:

1. When the output is high, the supply current is typically 1mA less than at V_{CC} = 5V.
2. Tested at V_{CC} = 5.0V and V_{CC} = 15V.
3. This will determine the maximum value of R_A + R_B for 15V operation, the max. total R = 20MΩ, and for 5V operation, the max. total R = 6.7MΩ.
4. These parameters, although guaranteed, are not 100% tested in production.

2. Astable Operation

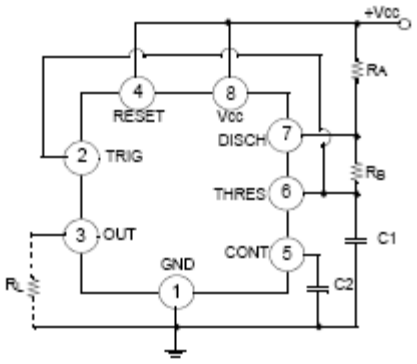


Figure 5. Astable Circuit

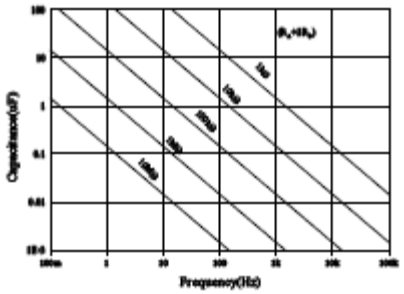
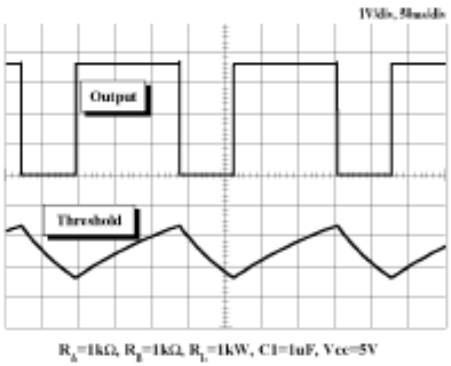


Figure 6. Capacitance and Resistance vs. Frequency



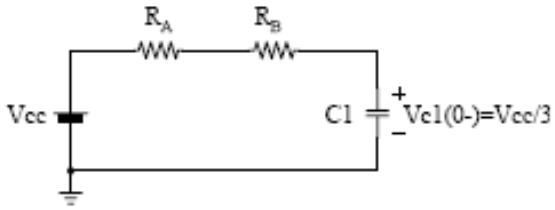
R_A=1kΩ, R_B=1kΩ, R_L=1kW, C1=1uF, Vcc=5V

Figure 7. Waveforms of Astable Operation

An astable timer operation is achieved by adding resistor RB to Figure 1 and configuring as shown on Figure 5. In the astable operation, the trigger terminal and the threshold terminal are connected so that a self-trigger is formed, operating as a multi vibrator. When the timer output is high, its internal discharging Tr. turns off and the VC1 increases by exponential function with the time constant (RA+RB)*C.

When the VC1, or the threshold voltage, reaches 2Vcc/3, the comparator output on the trigger terminal becomes high, resetting the F/F and causing the timer output to become low. This in turn turns on the discharging Tr. and the C1 discharges through the discharging channel formed by RB and the discharging Tr. When the VC1 falls below Vcc/3, the comparator output on the trigger terminal becomes high and the timer output becomes high again. The discharging Tr. turns off and the VC1 rises again.

In the above process, the section where the timer output is high is the time it takes for the VC1 to rise from Vcc/3 to 2Vcc/3, and the section where the timer output is low is the time it takes for the VC1 to drop from 2Vcc/3 to Vcc/3. When timer output is high, the equivalent circuit for charging capacitor C1 is as follows:



$$C_1\frac{dv_{c1}}{dt} = \frac{V_{cc} - V(0\text{-})}{R_A + R_B} \qquad (1)$$

$$V_{C1}(0+) = V_{CC}/3 \qquad (2)$$

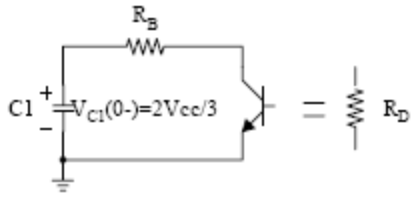
$$V_{C1}(t) = V_{CC}\left(1 - \frac{2}{3}e^{-\left(\frac{t}{(R_A+R_B)C1}\right)}\right) \qquad (3)$$

Since the duration of the timer output high state(t_H) is the amount of time it takes for the VC1(t) to reach 2Vcc/3,

$$V_{C1}(t) = \frac{2}{3}V_{CC} = V_{CC}\left(1-\frac{2}{3}e^{-\left(\frac{t_H}{(R_A+R_B)C1}\right)}\right) \quad (4)$$

$$t_H = C_1(R_A+R_B)\ln 2 = 0.693(R_A+R_B)C_1 \quad (5)$$

The equivalent circuit for discharging capacitor C1, when timer output is low is, as follows:



$$C_1\frac{dv_{C1}}{dt} + \frac{1}{R_A+R_B}V_{C1} = 0 \quad (6)$$

$$V_{C1}(t) = \frac{2}{3}V_{CC}e^{-\frac{t}{(R_A+R_D)C1}} \quad (7)$$

Since the duration of the timer output low state(t_L) is the amount of time it takes for the $V_{C1}(t)$ to reach Vcc/3,

$$\frac{1}{3}V_{CC} = \frac{2}{3}V_{CC}e^{-\frac{t_L}{(R_A+R_D)C1}} \quad (8)$$

$$t_L = C_1(R_B+R_D)\ln 2 = 0.693(R_B+R_D)C_1 \quad (9)$$

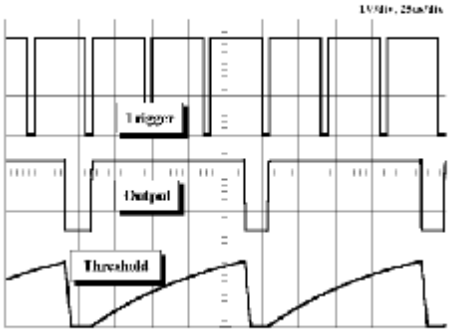
Since R_D is normally $R_B >> R_D$ although related to the size of discharging Tr.,
$t_L = 0.693R_BC_1$ (10)

Consequently, if the timer operates in astable, the period is the same with
'$T=t_H+t_L=0.693(R_A+R_B)C_1+0.693R_BC_1=0.693(R_A+2R_B)C_1$' because the period is the sum of the charge time and discharge time. And since frequency is the reciprocal of the period, the following applies.

$$\text{frequency,} \quad f = \frac{1}{T} = \frac{1.44}{(R_A+2R_B)C_1} \quad (11)$$

3. Frequency divider

By adjusting the length of the timing cycle, the basic circuit of Figure 1 can be made to operate as a frequency divider. Figure 8. illustrates a divide-by-three circuit that makes use of the fact that retriggering cannot occur during the timing cycle.



R_A=9.1kΩ, R_L=1kΩ, C1=0.01uF, Vcc=5V

Figure 8. Waveforms of Frequency Divider Operation

4. Pulse Width Modulation

The timer output waveform may be changed by modulating the control voltage applied to the timer's pin 5 and changing the reference of the timer's internal comparators. Figure 9 illustrates the pulse width modulation circuit.
When the continuous trigger pulse train is applied in the monostable mode, the timer output width is modulated according to the signal applied to the control terminal. Sine wave as well as other waveforms may be applied as a signal to the control terminal. Figure 10 shows the example of pulse width modulation waveform.

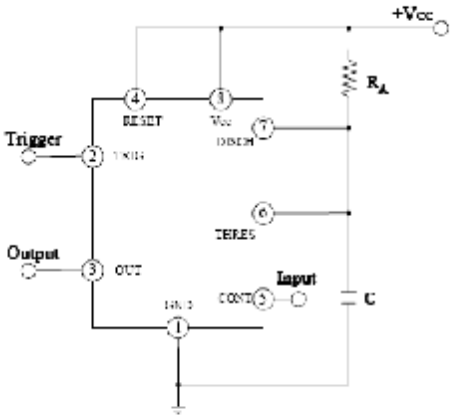
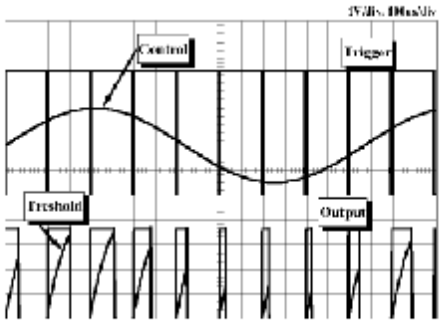


Figure 9. Circuit for Pulse Width Modulation



R_A=9.1kΩ, R_L=1kΩ, C1=0.01uF, Vcc=5V

Figure 10. Waveforms of Pulse Width Modulation

5. Pulse Position Modulation

If the modulating signal is applied to the control terminal while the timer is connected for the astable operation as in Figure 11, the timer becomes a pulse position modulator.
In the pulse position modulator, the reference of the timer's internal comparators is modulated which in turn modulates the timer output according to the modulation signal applied to the control terminal.
Figure 12 illustrates a sine wave for modulation signal and the resulting output pulse position modulation : however, any wave shape could be used.

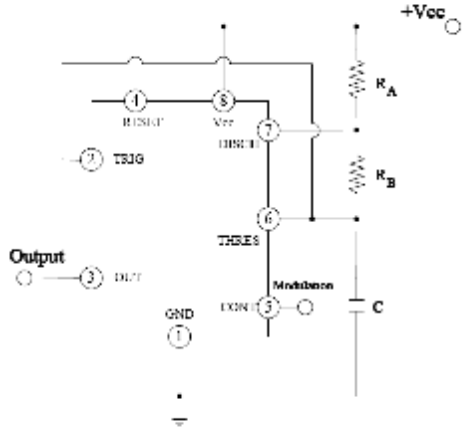


Figure 11. Circuit for Pulse Position Modulation

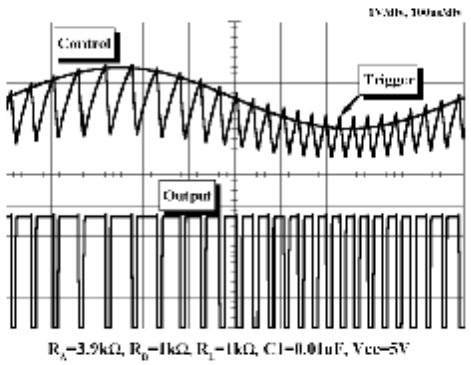


Figure 12. Waveforms of pulse position modulation

6. Linear Ramp

When the pull-up resistor RA in the monostable circuit shown in Figure 1 is replaced with constant current source, the V_{C1} increases linearly, generating a linear ramp. Figure 13 shows the linear ramp generating circuit and Figure 14 illustrates the generated linear ramp waveforms.

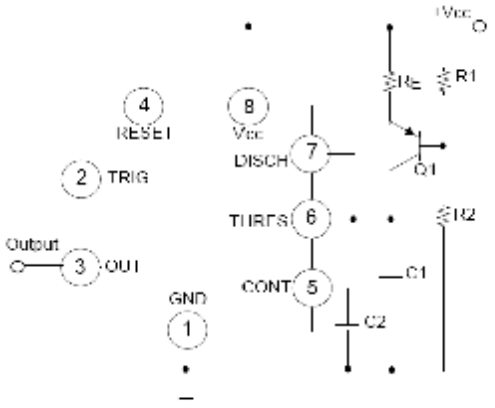


Figure 13. Circuit for Linear Ramp

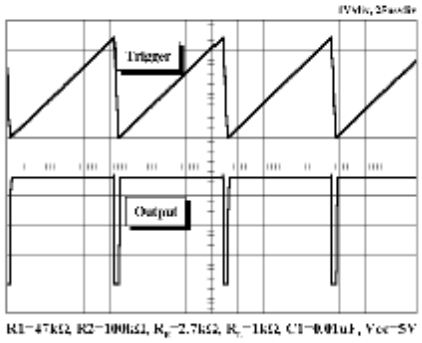


Figure 14. Waveforms of Linear Ramp

In Figure 13, current source is created by PNP transistor Q1 and resistor R1, R2, and R_E.

$$I_C = \frac{V_{CC} - V_E}{R_E} \qquad (12)$$

Here, V_E is

$$V_E = V_{BE} + \frac{R_2}{R_1 + R_2} V_{CC} \qquad (13)$$

For example, if Vcc 15V, R_E 20kΩ, R1 5kW, R2 10kΩ, and V_{BE} 0.7V,
V_E=0.7V+10V=10.7V
Ic=(15-10.7)/20k=0.215mA

When the trigger starts in a timer configured as shown in Figure 13, the current flowing through capacitor C1 becomes a constant current generated by PNP transistor and resistors.
Hence, the VC is a linear ramp function as shown in Figure 14. The gradient S of the linear ramp function is defined as follows:

$$S = \frac{V_{p-p}}{T} \qquad (14)$$

Here the Vp-p is the peak-to-peak voltage.
If the electric charge amount accumulated in the capacitor is divided by the capacitance, the VC comes out as follows:

$$V=Q/C \qquad (15)$$

The above equation divided on both sides by T gives us

$$\frac{V}{T} = \frac{Q/T}{C} \qquad (16)$$

and may be simplified into the following equation.

$$S=I/C \qquad (17)$$

In other words, the gradient of the linear ramp function appearing across the capacitor can be obtained by using the constant current flowing through the capacitor.
If the constant current flow through the capacitor is 0.215mA and the capacitance is 0.02μC, the gradient of the ramp function at both ends of the capacitor is S = 0.215m/0.022μ = 9.77V/ms.

APPENDIX B

PLC

1-2 System Configuration

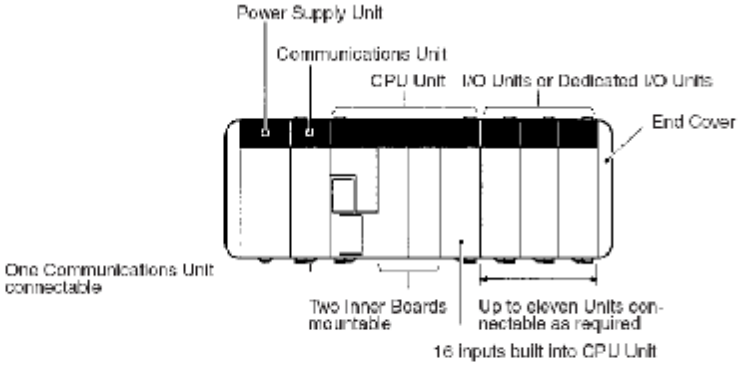
1-2-1 Basic Configuration

The PC configuration depends on the model of CPU Unit being used and on whether or not an Expansion I/O Block is connected. Examples are shown below.

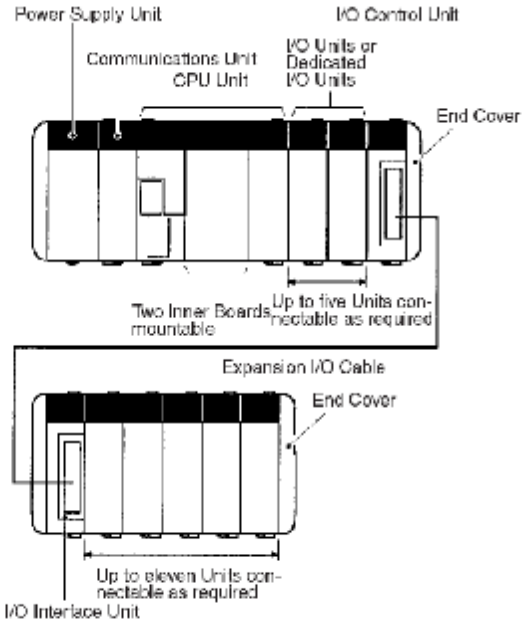
CQM1H-CPU51/61

Up to two Inner Boards can be mounted and one Communications Unit can be connected with the CQM1H-CPU51 or CQM1H-CPU61 CPU Unit. The configuration is shown below.

CPU Block Only



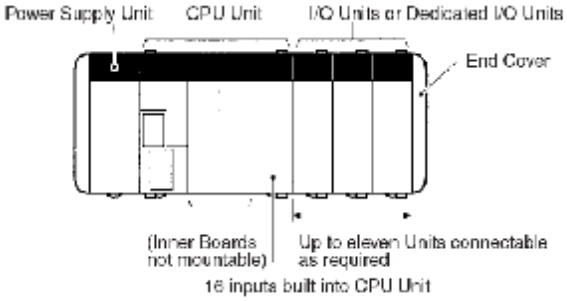
CPU Block and Expansion I/O Block



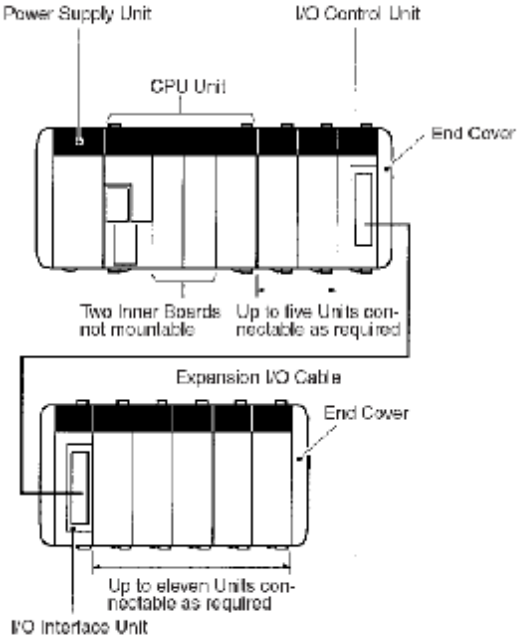
CQM1H-CPU11/21

The CQM1H-CPU11 and CQM1H-CPU21 CPU Units do not support Inner Boards or Communications Units. The configuration is shown below.

CPU Block Only



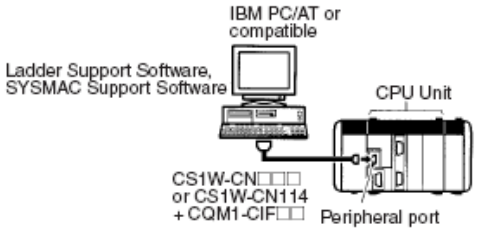
CPU Block and Expansion I/O Block



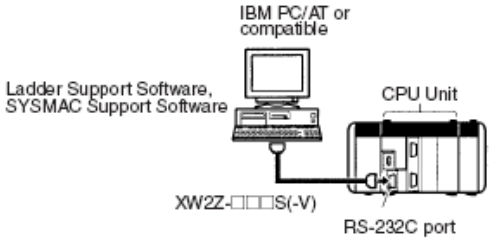
1-2-2 Connections to Programming Devices

Connections to personal computers running Support Software and connections to Programming Consoles are shown below.

Personal Computer Connecting to CPU Unit's Peripheral Port

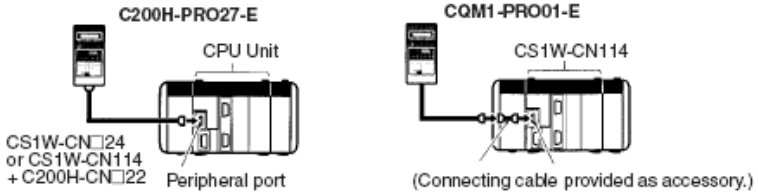


Connecting to CPU Unit's RS-232C Port



Note You can also connect to the RS-232C port on a Serial Communications Board.

Programming Console



1-2-3 CPU Units

Basic Specifications

Model	Number of I/O points (see note)	Program capacity (words)	CPU Unit external input points	DM capacity (words)	EM capacity (words)	Built-in serial communications ports		Inner Boards	Communications Units
						Peripheral port	RS-232C port		
CQM1H-CPU61	512	15.2 K	DC: 16	6 K	6 K	With	With	Supported	Supported
CQM1H-CPU51		7.2 K		6 K	None				
CQM1H-CPU21	256	3.2 K		3 K				Not supported	Not supported
CQM1H-CPU11							Without		

Note Number of I/O points = Number of input points (≤ 256) + Number of output points (≤ 256).

Maximum Number of Units

CPU Block Only

CPU Unit	Maximum number of Units connectable			
	Communications Units	Inner Boards	I/O Units	Dedicated I/O Units
CQM1H-CPU61	1	2	11	
CQM1H-CPU51				
CQM1H-CPU21	None	None		
CQM1H-CPU11				

CPU Block and Expansion I/O Block

CPU Unit	Maximum number of Units connectable			
	Communications Units	Inner Boards	I/O Units	Dedicated I/O Units
CQM1H-CPU61	1	2	5 on CPU Block 11 on Expansion I/O Block	
CQM1H-CPU51				
CQM1H-CPU21	None	None		
CQM1H-CPU11				

Note

1. An Analog Power Supply Unit is counted as one Unit, the same as I/O Units and Dedicated I/O Units.
2. The Units that can be connected to the CPU Block and Expansion I/O Block are also limited by power supply capacity, as shown in the following table.

Block	Max. current consumption	
CPU Block	3.0 A (See note 2.)	5.0 A total (see note 1)
Expansion I/O Block	2.0 A (See note 3.)	

Note

1. If the CQM1-PA203 Power Supply Unit is used, the maximum current consumption total is 3.6 A.
2. Includes current consumed by the CPU Unit, Communications Unit, and Inner Boards.
3. Includes current consumed by the I/O Control Unit.

1-2-4 Inner Boards

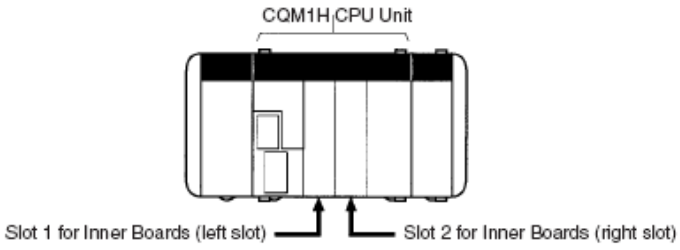
Name	Specifications	Model number
High-speed Counter Board	Pulse inputs (high-speed counter): 4 points (single-phase: 50 kHz/500 kHz switchable; phase difference: 1x/2x/4x multiplication ratio, 25 kHz/250 kHz switchable) External outputs: 4 points	CQM1H-CTB41
Pulse I/O Board	Pulse inputs (high-speed counter): 2 points (single-phase: 50 kHz, phase difference: 25 kHz) Pulse outputs: 2 points (50 kHz) (fixed duty factor and variable duty factor supported)	CQM1H-PLB21
Absolute Encoder Interface Board	Absolute encoder (gray code binary) inputs: 2 points (4 kHz)	CQM1H-ABB21
Analog Setting Board	Analog settings: 4 points	CQM1H-AVB41

Name	Specifications	Model number
Analog I/O Board	Analog inputs of 0 to 5 V, 0 to 20 mA, −10 to +10 V: 4 points Analog outputs of 0 to 20 mA, −10 to +10 V: 2 points	CQM1H-MAB42
Serial Communications Board	One RS-232C port and one RS-422A/485 port	CQM1H-SCB41

Mounting Combinations

CPU Unit and slot		Inner Board					
		High-speed Counter Board	Pulse I/O Board	Absolute Encoder Interface Board	Analog Setting Board	Analog I/O Board	Serial Communications Board
		CQM1H-CTB41	CQM1H-PLB21	CQM1H-ABB21	CQM1H-AVB41	CQM1H-MAB42	CQM1H-SCB41
CQM1H-CPU61/51	Slot 1 (left slot)	OK	Not possible	Not possible	OK	Not possible	OK
	Slot 2 (right slot)	OK	OK	OK	OK	OK	Not possible
CQM1H-CPU21/11		Not possible	Not possible	Not possible	Not possible	Not possible	Not possible

Note
1. High-speed Counter Boards can be mounted in both slots of the CQM1H-CPU51/61 simultaneously.
2. Analog Setting Boards cannot be mounted in both slots of the CQM1H-CPU51/61 simultaneously.



1-2-5 Communications Units

Name	Specifications	Model
Controller Link Unit (wired)	Data link (Maximum number of words per node: 8,000) Message communications (SEND/RECV/CMND instructions)	CQM1H-CLK21

Note A Communications Unit is connected between the Power Supply Unit and the CPU Unit. Communications Units cannot be connected to Expansion I/O Blocks.

1-2-6 Memory Cassettes

Model number	Memory	Capacity	Clock (see note)	Saveable data (saved together)			Reading/ writing
				User programs	Data memory (read-only areas, PC Setup)	Expansion instruction information	
CQM1H-ME16K	Flash memory	16 Kwords	No	Yes	Yes	Yes	AR area: Memory Cassette ↔ CPU (comparison available) Automatic transfer at power ON: Memory Cassette → CPU
CQM1H-ME16R			Yes				
CQM1H-ME08K	EEPROM	8 Kwords	No				
CQM1H-ME08R			Yes				
CQM1H-ME04K		4 Kwords	No				
CQM1H-ME04R			Yes				
CQM1H-MP08K	EPROM	8K/16 Kwords (According to switch setting)	No	Yes	Yes	Yes	Read only: Memory Cassette → CPU
CQM1H-MP08R			Yes				

Note The accuracy of the clock is affected by the ambient temperature, as shown in the following table.

Ambient temperature	Accuracy by month
55°C	–3 to 0 min
25°C	±1 min
0°C	–2 to 0 min

1-2-7 Power Supply Units

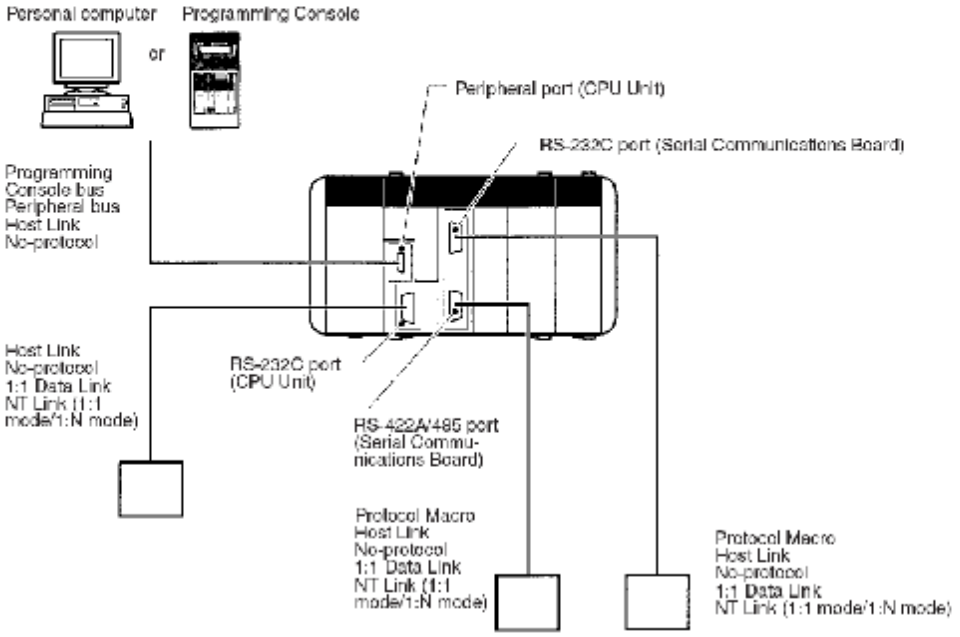
Name	Specifications				Model number
	Supply voltage	Operating voltage range	Output capacity	Service power supply	
AC Power Supply Units	100 to 240 V AC, 50/60 Hz (wide range)	85 to 265 V AC	5 V DC: 3.6 A (18 W)	None	CQM1-PA203
			5 V DC: 6 A 24 V DC: 0.5 A (30 W total)	24 V DC: 0.5 A	CQM1-PA206
	100 or 230 V AC (selectable), 50/60 Hz		5 V DC: 6 A 24 V DC: 0.5 A (30 W total)		CQM1-PA216
DC Power Supply Units	24 V DC	20 to 28 V DC	30 W 5 V DC: 6 A	None	CQM1-PD026

1-3 Expanded System Configuration

1-3-1 Serial Communications System

The CQM1H system configuration can be expanded by using the following serial communications ports.

- CPU Unit built-in ports, 2 ports: Peripheral port and RS-232C port
- Serial Communications Board ports, 2 ports: RS-232C port and RS-422/485 port (CQM1H-CPU51/61 only)



Communications Ports and Serial Communications Modes (Protocols)

Serial communications protocol	Application	CPU Unit		CQM1H-SCB41 Serial Communications Board	
		Peripheral port	RS-232C port (Not on CQM1H-CPU11)	RS-232C port (port 1)	RS-422A/485 port (port 2)
Programming Console bus	Communications with Programming Consoles	YES	No	No	No
Peripheral bus	Communications with Programming Devices	YES	No	No	No
Host Link (SYSMAC WAY)	Communications with a host computer or PT	YES	YES	YES	YES
Protocol macro	Sending and receiving messages according to the communications specifications of external devices	No	No	YES	YES
No-protocol	No-protocol communications with general-purpose devices	YES	YES	YES	YES
1:1 Data Link	Data links with other CPU Units	No	YES	YES	YES
NT Link (1:1 mode)	One-to-one communications with PT	No	YES (See note.)	YES	YES
NT Link (1:N mode)	One-to-one or one-to-many communications with PTs	No	No	YES	YES

Note Programming Console functions are possible with a PT. They are, however, not possible when pin 7 on the DIP switch on the front of the CPU Unit is OFF.

Protocols

The serial communications port protocol can be switched in the CPU Unit's PC Setup. Depending on the protocol selected, the following systems can be configured to support serial communications.

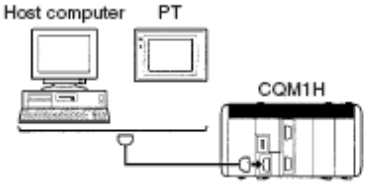
Protocol	Main connection	Application	Applicable commands, communications instructions
Programming Console bus	Programming Console	Communications between Programming Console and PC	None
Peripheral bus (see note)	Programming Devices, e.g., CX-Programmer	Communications between Programming Devices and the PC from the computer	None
Host Link	Personal computer OMRON Programmable Terminals	Communications between the host computer and the PC Commands can be sent to a computer from the PC.	Host Link commands/ FINS commands Commands can be sent to a computer from the PC.
Protocol macro	General-purpose external devices	Sending and receiving messages (communications frames) according to the communications specifications of external devices SYSMAC-PST is used to create protocols by setting various parameters.	PMCR(—) instruction
No-protocol communications	General-purpose external devices	No-protocol communications with general-purpose devices	TXD(—) and RXD(—) instructions
1:1 Data Link	C-series PCs	Shared link words between PCs	None
NT Link (1:1)	OMRON Programmable Terminals	High-speed one-to-one communications with a Programmable Terminal using direct access	None
NT Link (1: N)	OMRON Programmable Terminals	High-speed one-to-one or one-to-many communications with Programmable Terminals using direct access	None

Note The peripheral bus mode is used for Programming Devices other than Programming Consoles (e.g., CX-Programmer).

Host Link System (SYSMAC WAY Mode, 1:N)

The Host Link System allows the I/O memory of the PC to be read/written, and the operating mode to be changed from a host computer (personal computer or Programmable Terminal) by executing Host Link commands. Other Programming Devices can also be connected via a computer using this mode. Alternatively, it is also possible to send data from the CPU Unit of the CQM1H to the host computer using TXD(—) instructions to initiate communications from the PC. This mode is supported by the peripheral port and the RS-232C

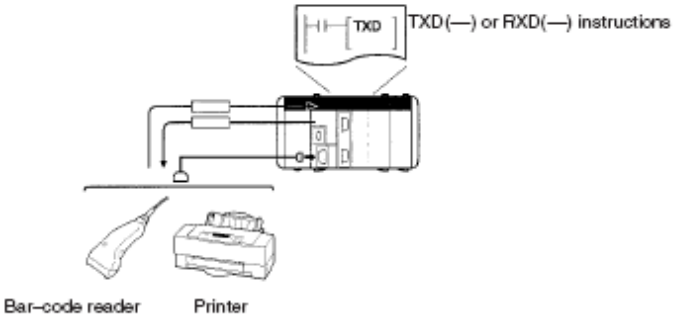
port on the CPU Unit, as well as the RS-232C port and RS-422A/485 port on the Serial Communications Board.



For details on cables required to connect the host computer to the CQM1H in Host Link Mode, refer to *3-6 Programming Devices*.

No-protocol Communications

The TXD(—) and RXD(—) instructions in the ladder program can be used with no communications protocol or conversion to transfer data with a general-purpose external device equipped with an RS-232C port. It is possible to attach a start code to the beginning and an end code to the end of data (or specify the amount of data) when sending/receiving. Unlike protocol macro, it is not possible to construct a communications frame (message) according to the communications specifications of the communications partner. Also, there are no procedures for retry processing, data format conversion processing or branch processing for receiving data. This communications mode is thus used for simple data transmissions, such as inputting bar code data and outputting printer data. This mode is supported by the peripheral port and the RS-232C port on the CPU Unit, as well as the RS-232C port and RS-422A/485 port on the Serial Communications Board.



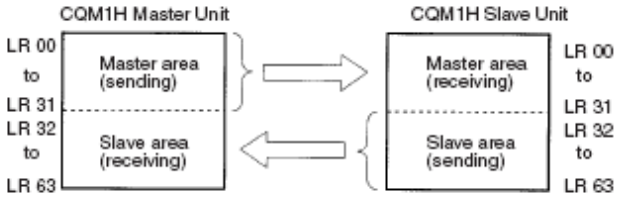
1:1 Data Link System

If two PCs are linked one-to-one by connecting them together through their RS-232C ports, they can share up to 64 words of LR area. One of the PCs will serve as the master and the other as the slave.

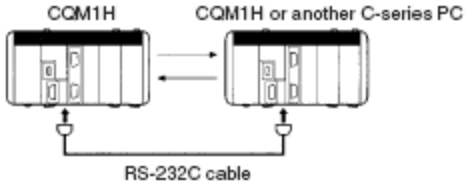
One of the following three ranges of words can be set to be linked:
LR 00 to LR 63, LR 00 to LR 31, or LR 00 to LR 15

A 1:1 Data Link communications system can be created between the CQM1H and another CQM1H, or between the CQM1H and the CQM1, C200HX/HG/HE, C200HS, CPM1, CPM1A, CPM2A, CPM2C, or SRM1(-V2).

Note The link area will always be LR 00 to LR 15 (16 words) for 1:1 Data Link communications with the CPM1, CPM1A, CPM2A, CPM2C, or SRM1(-V2).



This mode is supported by the RS-232C port on the CPU Unit, as well as the RS-232C port and RS-422A/485 port on the Serial Communications Board.



Wiring

Connect the Units with the cables wired as shown below.

CQM1H		CQM1H or another C–series PC	
Signal Abb.	Pin No.	Pin No.	Signal Abb.
FG	Hood	Hood	FG
SD	2	2	SD
RD	3	3	RD
RTS	4	4	RTS
CTS	5	5	CTS
–	6	6	–
–	7	7	–
–	8	8	–
SG	9	9	SG

Recommended Cables

UL2464 AWG28x5P IFS-RVV-SB (UL-approved, Fujikura Ltd.)
AWG28x5P IFVV-SB (not UL standard) (not UL-approved, Fujikura Ltd.)

UL2464-SB (MA) 5Px28AWG (7/0.127) (UL-approved, Hitachi Cable, Ltd.)
CO-MA-VV-SB 5Px28AWG (7/0.127) not UL-approved, Hitachi Cable, Ltd.)

Applicable Connectors (Standard Accessories for CQM1H)

Socket: XM2A-0901 (OMRON); Hood: XM2S-0911-E (OMRON)

NT Link System

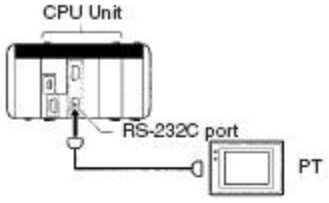
If a PC and Programmable Terminal (PT) are connected together using RS-232C or RS-422A/485, the allocations for the PT's status control area, status notify area, and objects (such as touch switches, indicators, and memory maps) can be allocated in the I/O memory of the PC. The NT Link System allows the PT to be controlled by the PC, and the PT can periodically read data from the status control area of the PC to perform necessary operations if there are any changes in the area. The PT can communicate with the PC by writing data to the status notify area or the I/O memory of the PC from the PT. The NT Link system allows the PT status to be controlled and monitored without using the PC's ladder program.

There are two NT Link modes: One is for communications between one PC and one PT (1:1 mode), and the other is for communications between one PC, and one or many PTs (1:N mode). These modes support completely different communications.

NT Link: 1:1 Mode

This mode is used for communications between one PC and one PT. This mode is supported by the RS-232C port on the CPU Unit, as well as the RS-232C port and RS-422A/485 port on the Serial Communications Board. The

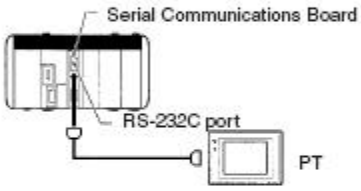
1:1 NT Link mode is supported for communications between only one PC and one PT. Set the PT communications settings for a 1:1 NT Link.



Link Mode: 1:N Mode

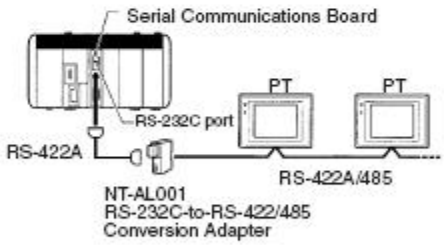
This mode is used for communications between one PC and n (8≥n≥1) PTs. This mode is supported by the RS-232C port on the CPU Unit, as well as the RS-232C port and RS-422A/485 port on the Serial Communications Board. The 1:N NT Link mode is supported for communications between one PC and one or more PTs. Set the PT communications settings for a 1:N NT Link.

NT Link: 1:1 Mode

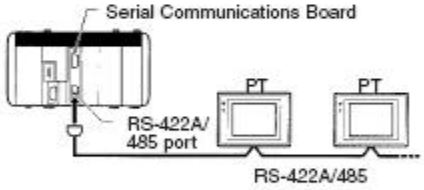


NT Link: 1:N Mode

Connection to RS-232C port of Serial Communications Board



Connection to RS-422A/485 port of Serial Communications Board



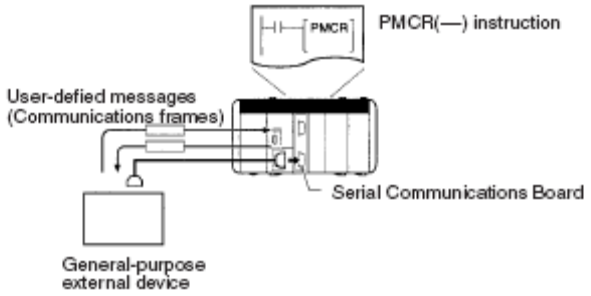
Note The 1:1 NT Link mode and 1:N NT Link mode use different types of serial communications and there is no data compatibility between them.

Protocol Macros

The CX-Protocol is used to create sets of data transmission procedures called protocols for general-purpose external devices according to the communications specifications of the general-purpose external devices. Communications must be half-duplex and must use start-stop synchronization. The protocols that have been created are recorded in a Serial Communications Board, enabling data to be sent to and received from the external devices by simply executing the PMCR(—) instruction in the CPU Unit. Protocols for data communications with OMRON devices, such as Temperature Controllers, Intelligent Signal Processors, Bar Code Readers, and Modems, are supported as standard protocols (see note 1). These protocols can be changed to suit user needs. Protocol macros are supported by the RS-232C port and RS-422A/485 port on the Serial Communications Board (see note 2).

Note

1. The standard protocols are provided as standard features with the CX-Protocol and Serial Communications Boards.
2. Protocol macros not supported by the CPU Unit's built-in ports.



Note **CompoWay/F (Host Function)**
A CQM1H CPU Unit can operate as a host to send CompoWay/F commands to OMRON components connected in the system. CompoWay/F commands are executed by using the CompoWay/F send/receive sequences in one of the standard protocols provided in the protocol macros.

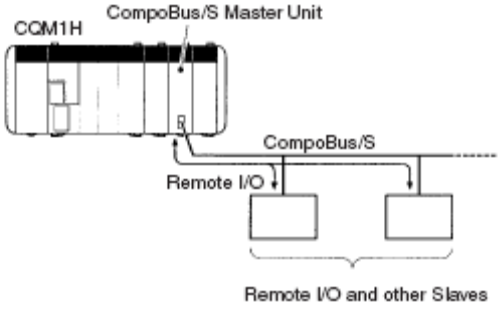
1-3-2 Communications Networks

With the CQM1H CPU Unit, networks can be created using the following Communications Units:

- CompoBus/S Master Unit
- Controller Link Unit (CQM1H-CPU51/61 only)

CompoBus/S Network

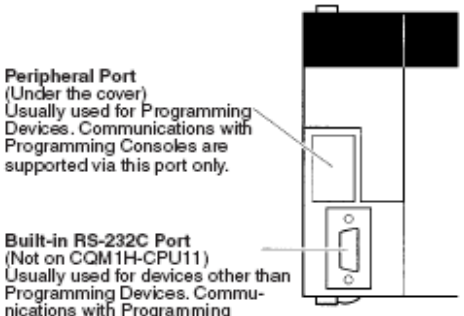
CompoBus/S is a high-speed ON/OFF bus for remote I/O communications. Connecting a CQM1-SRM21-V1 CompoBus/S Master Unit (a Dedicated I/O Unit) to the network allows remote I/O communications, without programming in the CPU Unit, between the PC and Slaves. High-speed communications are performed with 256 points in a cycle time of 1 ms max. With the CQM1H-SRM21-V1, a long-distance communications mode is also available in addition to the previous high-speed communications mode, enabling communications on a trunk line of up to 500 m.



Controller Link Network

The Controller Link Network is the basic network of the OMRON PC FA Networks. When using a CQM1H-CPU51/61 CPU Unit, the CQM1H can be connected to the network using a Controller Link Unit. This enables the flexible and simple transfer of large amounts of data with other OMRON PCs (e.g., CQM1H, CS-series, C200HX/HG/HE, CVM1, and CV-series PCs) or with personal computers. Data links can be created between PCs so that data can be shared without programming and FINS message communications can be per-

3-1-6 Serial Communications Ports



Serial Communications Modes and Ports

Device and mode	Peripheral port	Built-in RS-232C port
Programming Console in Programming Console Bus Mode	Yes (Pin 7: OFF)	No
Programming Device running on personal computer in Peripheral Bus Mode	Yes (Pin 7: ON)	No
Host computer or PT in Host Link Mode	Yes (Pin 7: ON)	Yes
General-purpose external device in No-protocol Mode	Yes (Pin 7: ON)	Yes

Device and mode	Peripheral port	Built-in RS-232C port
C-series PC in 1:1 Data Link Mode	No	Yes
PT in 1:1 NT Link Mode	No	Yes

3-1-7 Peripheral Port

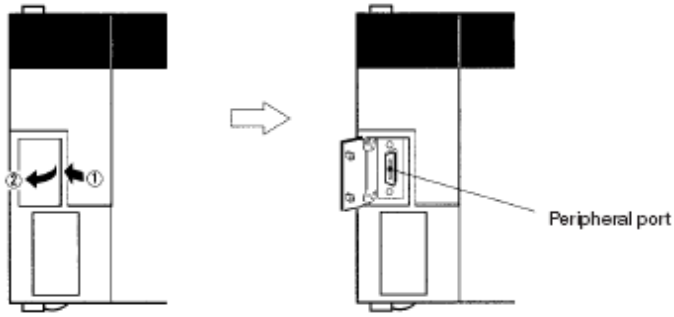
The peripheral port is mainly used for connecting Programming Devices, such as Programming Consoles and personal computers running Support Software. Programming Consoles can be connected only to this port. Host Link and no-protocol communications are also supported for this port.

Note

1. When connecting a Programming Console to the peripheral port, turn OFF pin 7 on the DIP switch on the front of the CPU Unit.
2. When connecting a device to the peripheral port other than a Programming Console, such as a personal computer running Support Software, be sure to turn ON pin 7 on the DIP switch on the front of the CPU Unit. When connecting to a peripheral bus, it is also necessary to set the communications mode in the PC Setup to Host Link mode.

Opening the Peripheral Port Cover

Insert your fingertip or a small screwdriver in the gap on the right of the cover and pull to the left to open, as shown on the left in the following illustration.

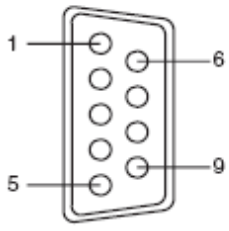


3-1-8 Built-in RS-232C Port

The RS-232C port built into the CPU Unit is mainly used for connecting devices other than Programming Devices. It is not possible to perform communications with a Programming Console or any other Programming Device via a peripheral bus using this port. The following communications modes are supported: Host Link, no-protocol, 1:1 Data Link, and 1:1-mode NT link.

Connector Pin Assignments

Pin assignments for the RS-232C port are given in the following table.



Pin	Abbreviation	Name	Direction
1	FG	Field ground	---
2	SD (TXD)	Send data	Output
3	RD (RXD)	Receive data	Input
4	RS (RTS)	Request to send	Output
5	CS (CTS)	Clear to send	Input
6	+5V (see note)	Power supply	---
7	---	Not used.	---
8	---	Not used.	---

Pin	Abbreviation	Name	Direction
9	SG	Signal ground	---
Connector fitting	FG	Field ground	---

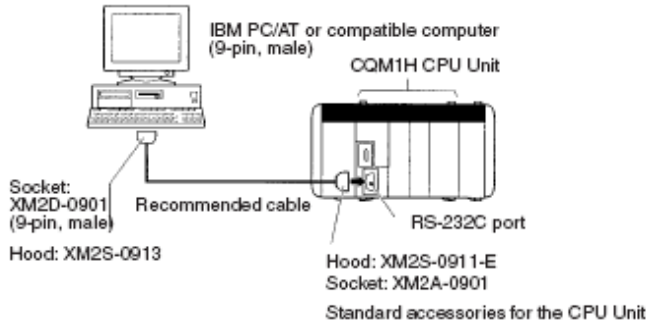
Note The 5-V power supply connected via pin 6 is only for the NT-AL001 RS-232C/RS-422S Converting Link Adapter.

Port Specifications

Item	Specification
Communications method	Half duplex
Sync	Start-stop
Baud rate	1,200, 2,400, 4,800, 9,600, or 19,200 bps
Transmission method	Point to point
Transmission distance	15 m max.
Interface	EIA RS-232C

Connecting to a Computer

The CPU Unit can be connected to an IBM PC/AT or compatible computer via the RS-232C port as shown below.



Recommended Cables

UL2464 AWG28 × 5P IFS-RVV-SB (UL standard) (Fujikura Ltd.)
AWG28 × 5P IFVV-SB (not UL standard) (Fujikura Ltd.)
UL2464-SB (MA) 5P × 28AWG (7/0.127) (UL standard) (Hitachi Cable Ltd.)
CO-MA-VV-SB 5P × 28AWG (7/0.127) (not UL standard) (Hitachi Cable Ltd.)

3-6-2 Support Software

The different types of Support Software that can be used with the CQM1H are shown in the following table.

Name	Model number	Format	Computer	OS	Serial communications mode	Model	Functional limitations
CX-Programmer V1.2 or higher	WS02-CXP□□-E	CD-ROM	IBM PC/AT or compatible	Microsoft Windows 95 or 98	Peripheral bus or Host Link	CQM1H	No
SYSMAC-CPT	WS01-CPTB1-E	3.5-inch floppy disks (1.44 MB) and CD-ROM		Microsoft Windows V 3.1	Host Link	CQM1-CPU43	Yes (see note)
SYSMAC Support Software (SSS)	C500-ZL3AT1-E	3.5-inch floppy disks		Microsoft DOS V 3.2 or higher	Peripheral bus or Host Link	CQM1	

Note Functional limitations are shown in the following table.

Serial Communications Mode Characteristics

The two following serial communications modes are supported for connecting Support Software to the PC.

Serial Communications Mode	Features
Peripheral bus	High-speed communications are possible. Usually, this mode should be used when connecting with CX-Programmer. Only 1:1 connection is supported.
Host Link (SYSMAC WAY)	Basic protocol for communications with a host computer. Communications speed lower than peripheral bus. One-to-one or one-to-many communications are possible. Connections to a modem or Optical Link Adapter are possible.

DIP Switch and PC Setup Settings

Peripheral Bus Connection

Make the following settings when connecting Support Software to the peripheral port via the peripheral bus protocol. The serial communications mode must be set to Host Link.

DIP switch pin 5	DIP switch pin 7	PC Setup: DM 6650
OFF	ON	0000 Hex (standard settings) or 0001 Hex (custom settings)
ON	ON	Ignored (standard settings)

Note Always turn ON pin 7 on the DIP switch when connecting Support Software running on a computer using the peripheral bus. You will not be able to connect if pin 7 is OFF.

Host Link Connection

Make the following settings when connecting Support Software via the Host Link protocol.

Peripheral Port

Use the following settings for the standard communications settings in the PC Setup:

DIP switch pin 5	DIP switch pin 7	PC Setup: DM 6650
OFF	ON	0000 Hex (standard settings)

Use the following settings to make custom communications settings in the PC Setup:

DIP switch pin 5	DIP switch pin 7	PC Setup: DM 6650
OFF	ON	0001 Hex (Custom settings: Set the baud rate, data length, etc., in DM 6651)

Use the following settings for communications according to pin 5 default settings:

DIP switch pin 5	DIP switch pin 7	PC Setup: DM 6650
ON	ON	Ignored (standard settings)

Note Always turn ON pin 7 on the DIP switch when connecting Support Software running on a computer using a Host Link connection. You will not be able to connect if pin 7 is OFF.

RS-232C Port

Use the following settings for the standard communications settings in the PC Setup:

DIP switch pin 5	DIP switch pin 7	PC Setup: DM 6645
OFF	Ignored	0000 Hex (Standard settings)

Use the following settings to make custom communications settings in the PC Setup:

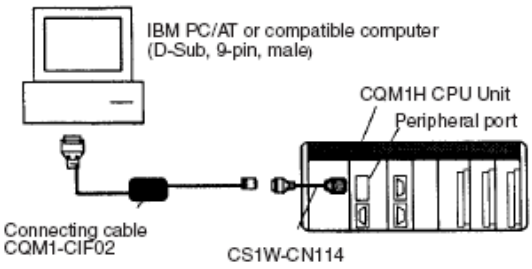
DIP switch pin 5	DIP switch pin 7	PC Setup: DM 6645
OFF	Ignored	0001 Hex (Custom settings: Set the baud rate, data length, etc., in DM 6646)

Use the following settings for communications according to pin 5 default settings:

DIP switch pin 5	DIP switch pin 7	PC Setup: DM 6645
ON	Ignored	Ignored (standard settings)

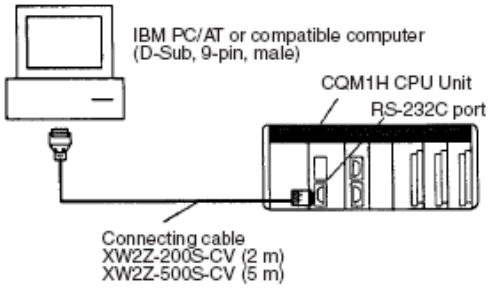
Connecting Cables

Connecting to Peripheral Port



Note
1. Connecting cables CS1W-CN225/625/227/627 cannot be used with the CQM1H.
2. The FIT 10/20 connecting cable CQM1-CIF-11 cannot be used with the CQM1H.

Connecting to RS-232C Port (on CPU Unit or Serial Communications Board)



One-to-one Communications

Use the following cables for one-to-one communications between the personal computer and the PC.

Unit/Board	Port	Serial communications mode	Model number	Length	Comments	Startup Mode (see note)
CPU Unit	Peripheral port	Peripheral bus or Host Link (SYSMAC WAY)	CS1W-CN114 + CQM1-CIF02	0.05 m + 3.3 m	--	PROGRAM mode
	RS-232C port (D-Sub, 9-pin, male)	Host Link (SYSMAC WAY)	XW2Z-200S-CV	2 m	Use a connector for which ESD countermeasures have been taken.	Ignored
			XW2Z-500S-CV	5 m		
Serial Communications Board	RS-232C port (D-Sub, 9-pin, female)	Host Link (SYSMAC WAY)	XW2Z-200S-CV	2 m	Use a connector for which ESD countermeasures have been taken.	
			XW2Z-500S-CV	5 m		

Note The Startup Modes in the above table are for when DM 6600 in the PC Setup is set to the default settings. The Startup Mode depends on the type of cable used. For details refer to *5-2-3 Startup Mode*.

Direct Connection to Peripheral Port

It is possible to connect the personal computer directly to the peripheral port using the CS1W-CN226/626 Connecting Cable (dedicated cable for IBM PC/AT or compatible computers). If this cable is used, the Startup Mode (when

DM 6600 in the PC Setup is set to the default settings), will be RUN mode as shown in the following table.

Unit	Port	Serial communications mode	Model number	Length	Startup Mode (see note)
CPU Unit	Peripheral port	Peripheral bus or Host Link (SYSMAC WAY)	CS1W-CN226 or CS1W-CN626	2 m or 6 m	RUN mode

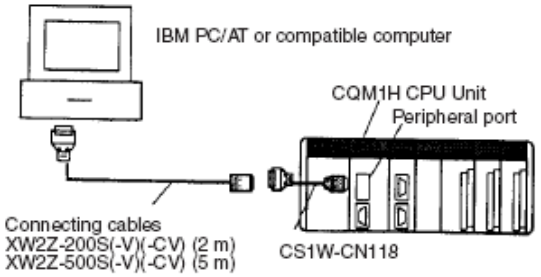
Note The Startup Mode in the above table is for when DM 6600 in the PC Setup is set to the default settings. The Startup Mode depends on the type of cable used. For details refer to *5-2-3 Startup Mode*.

Connecting to Peripheral Port using RS-232C Cable

When connecting an RS-232C cable to the peripheral port, use the CS1W-CN118 Connecting Cable as indicated below. When the XW2Z-200S-CV/500S-CV is connected, the Startup Mode (when DM 6600 in the PC Setup is set to the default settings) will be RUN mode.

Unit	Port	Serial communications mode	Model number	Length	Comments	Startup Mode (see note)
CPU Unit	Peripheral port	Peripheral bus or Host Link (SYSMAC WAY)	CS1W-CN118 + XW2Z-200S-CV/500S-CV	0.1 m + (2 m or 5 m)	Use a connector for which ESD countermeasures have been taken with the XW2Z-□□□S-CV.	RUN mode
			CS1W-CN118 + XW2Z-200S-V/500S-V		---	PROGRAM mode

Note The Startup Modes in the above table are for when DM 6600 in the PC Setup is set to the default settings. The Startup Mode depends on the type of connecting cable used. For details refer to *5-2-3 Startup Mode*.



Connecting to RS-232C Port using RS-232C Cable

When connecting an IBM PC/AT or compatible computer to the RS-232C port (built-in or on the Serial Communications Board) using an RS-232C cable, the following connection methods are possible.

Unit/Board	Port	Serial communications mode	Model number	Length	Comments	Startup Mode (see note)
CPU Unit	Built-in RS-232C port (D-Sub, 9-pin, female)	Host Link (SYSMAC WAY)	XW2Z-200S-V	2 m	---	Ignored
			XW2Z-500S-V	5 m		
Serial Communications Board	RS-232C port (D-Sub, 9-pin, female)		XW2Z-200S-V	2 m		
			XW2Z-500S-V	5 m		

Note The Startup Mode in the above table is for when DM 6600 in the PC Setup is set to the default setting. The Startup Mode depends on the type of connecting cable used. For details refer to *5-2-3 Startup Mode*.

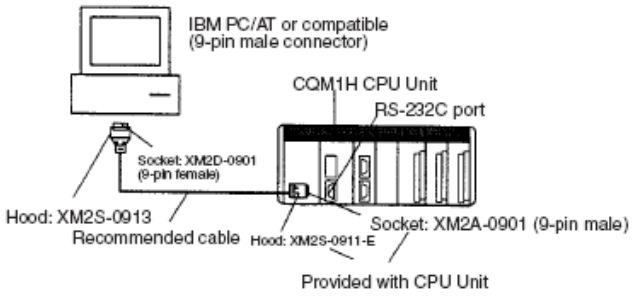
Applicable Connectors

CPU Unit Connector

Item	Model number	Specifications	
Socket	XM2A-0901	9-pin male	Used together (One of each provided with CPU Unit.)
Hood	XM2S-0911-E	9-pin, millimeter screws	

Personal Computer Connector

Item	Model number	Specifications	
Socket	XM2D-0901	9-pin female	Used together
Hood	XM2S-0913	9-pin, inch screws	



Recommended Cables

Fujikura Ltd.: UL2464 AWG28 × 5P IFS-RVV-SB (UL product)
AWG 28 × 5P IFVV-SB (non-UL product)

Hitachi Cable, Ltd.: UL2464-SB(MA) 5P × 28AWG (7/0.127) (UL product)
CO-MA-VV-SB 5P × 28AWG (7/0.127) (non-UL product)

OMRON

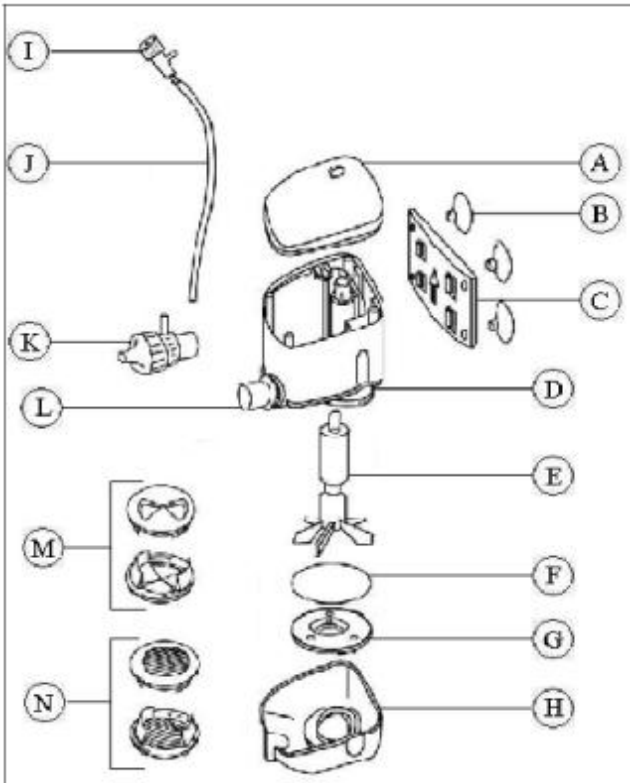
Authorized Distributor:

Cat. No. W363-E1-07 Note: Specifications subject to change without notice. Printed in Japan

APPENDIX C

MOTOR PUMP

LAC AQUARIUM WATER PUMP AP2000



VOLTAGE: 230V WATT: 26W OUTPUT: 1000 L/H

A. WATER PUMP REAR COVER (DO NOT OPEN THIS COVER)
B. SUCTION CUPS
C. SUCTION CUP BRACKET
D. PUMP BODY
E. IMPELLER & IMPELLER SHAFT
F. SEALING RING
G. IMPELLER COVER
H. WATER PUMP FRONT COVER
I. AIR VALVE
J. AIR HOSE
K. VENTURI
L. OUTPUT NOZZLE
M. WATER PUMP REGULATOR
N. WATER PUMP FILTER PLATE

INSTALLATION

CAUTION:

DISCONNECT THE POWER SUPPLY OF ALL THE APPLIANCES INSIDE THE AQUARIUM BEFORE PLACING HANDS INTO THE WATER.

THE AP2000 MUST NOT RUN DRY.

INSERT THE FOUR SUCTION CUPS (B) ONTO THE SUCTION CUP BRACKET (C) THEN SLOT ONTO THE BACK OF THE WATER PUMP BODY (D)

THE OPENNING OF THE OUTPUT NOZZLE (L) SHOULD BE PLACED AT LEAST 2 CM BELOW THE WATER SURFACE TO MAINTAIN GOOD SURFACE MOVEMENT AND OPTIMUM WATER CIRCULATION (REFER TO DIAGRAM 2)

THE OUTPUT OF THE AP2000 CAN BE REGULATED BY INSTALLING THE REGULATOR (M) INSTEAD OF THE FILTER PLATE (N)
PLUG THE POWER CORD INTO A SUITABLE ELECTRICAL OUTLET THAT IS LOCATED NEAR THE AQUARIUM

THE AP2000 CAN ALSO BE USED TO AERATE THE AQUARIUM BY ATTACHING THE AIR HOSE (J) TO THE TOP OF THE VENTURI (K), THEN ATTACHING THE VENTURI TO THE OUTPUT NOZZLE (L). THE AIR VALVE (I) MUST BE POSITIONED ABOVE THE WATER SURFACE (REFER TO DIAGRAM 2)

THE AP2000 CAN BE USED AS A FOUNTAIN PUMP BY CONNECTING A FOUNTAIN KIT (FH01) (FH01 NOT INCLUDED), AS SHOWN IN DIAGRAM 1.

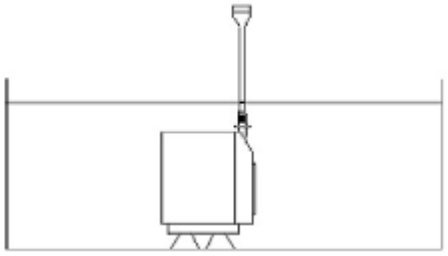


DIAGRAM 1:

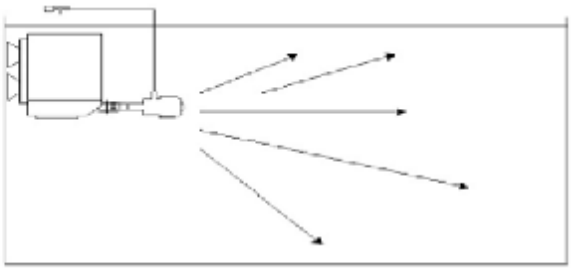


DIAGRAM 2:

MAINTENANCE:

CAUTION:

DISCONNECT THE MAINS PLUG FROM THE ELECTRICAL SUPPLY BEFORE CARRYING OUT ANY MAINTENANCE.

THE MOTOR UNIT OF THE AP2000 IS SEALED AND THEREFORE REQUIRE NO LUBRICATION OR OTHER MAINTENANCE. REGULAR MAINTENANCE OF THE IMPELLER & IMPELLER CAVITY IS REQUIRED. REMOVE THE FRONT COVER (H), THEN THE IMPELLER COVER (G) & IMPELLER (E) AND CLEAN THESE PARTS WITH A BRUSH TO REMOVE ACCUMULATED SLIME, DIRT OR DEBRIS.

AFTER CLEANING, REASSEMBLE THE PARTS IN REVERSE ORDER AS TO HOW THEY WERE REMOVED, AS MENTIONED IN THE ABOVE STEPS. (ALSO REFER TO MAIN DIAGRAM)

WATER PUMP AP2000 SPARE PARTS:

AP2000 IMPELLER: AP2000_I

AP2000 SUCTION CUPS: AP2000_C

ACCESSORY

FOUNTAIN KIT FOR AP2000: FH01

SAFETY INSTRUCTIONS

1. **DANGER** – To avoid possible electric shock, special care should be taken since water is employed in the use of aquarium equipment. For each of the following situations, do not attempt repairs by yourself; return the appliance to an authorized service facility for service or discard the appliance.

   1.1. If the appliance falls into the water, **DON'T** reach for it! First unplug it and then retrieve it. If electrical components of the appliance get wet, unplug the appliance immediately. (Non-immersible equipment only)

   1.2. If the appliance shows any sign of abnormal water leakage, immediately unplug it from the power source. (Non-immersible equipment only)

   1.3. Carefully examine the appliance after installation. It should not be plugged in if there is water on parts not intended to be wet.

   1.4. Do not operate any appliance if it has a damaged cord or plug, or it is malfunctioning or has been dropped or damaged in any manner.

   1.5. To avoid the possibility of the appliance plug or receptacle getting wet, position aquarium stand and tank to one side of a wall-mounted receptacle to prevent water from dripping onto the or plug.

   A "drip-loop", should be arranged by the user for each cord connecting an aquarium appliance to a receptacle. The "drip-loop" is that part of the cord below the level of the receptacle, or the connector if an extension cord is used, to prevent water travelling along the cord and coming in contact with the receptacle.

   If the plug or socket does get wet, **DON'T** unplug the cord. Disconnect the fuse or circuit breaker that supplies power to the appliance. Then unplug and examine for presence of water in the receptacle.

2. Close supervision is necessary when any appliance is used by or near children.

3. To avoid injury, do not contact moving parts or hot parts such as heaters, reflectors, lamp bulbs, and the like.

4. Always unplug an appliance from an outlet when not in use, before putting on or taking off parts, and before cleaning. Never yank cord to pull plug from outlet. Grasp the plug and pull to disconnect.

5. Do not use an appliance for other than intended use. The use of attachments not recommended or sold by the appliance manufacturer may cause an unsafe condition.

6. Do not install or store the appliances where it will be exposed to the weather or to temperatures below freezing.

7. Make sure an appliance mounted on a tank is securely installed before operating it.

8. Read and observe all the important notices on the appliance.

9. If an extension cord is necessary, a cord with a proper rating should be used. A cord rated for less amperes or watts than the appliance rating may overheat. Care should be taken to arrange the cord so that it will not be tripped over or pulled.

APPENDIX D

DATASHEET OF RELAY

OMRON

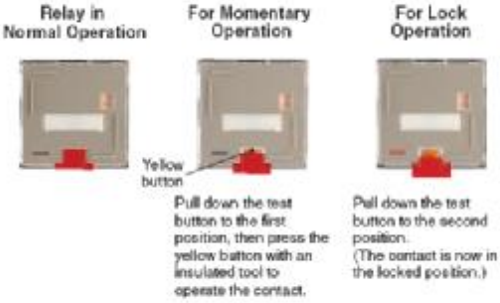
General-purpose Relays
MK-S New Model

General-purpose Relays Featuring Mechanical Indicator and Lockable Test Button

- Built-in operation indicator (mechanical and LED), and new models with lockable test button.
- Nameplate provided on models with lockable test button.
- RoHS Compliant.
- UL approval for most models. (UL approval pending for models with built-in LED indicators.)

Features

Two-way Action Test Button



Model Number Structure

■ Model Number Legend

MKS□□□□□-□-□
1 2 3 4 5 6 7

1. Contact Form
   2: DPDT
   3: 3PDT
2. Terminals
   P: Plug-in
3. Mechanical Indicator/Test Button
   Blank: Mechanical indicator
   I: Mechanical indicator and lockable test button
4. LED Indicator
   Blank: Standard
   N: LED indicator
5. Coil Polarity
   Blank: Standard
   1: Reverse polarity (DC coil only)
6. Surge Absorption
   Blank: Standard
   D: Surge absorber diode (DC coil only)
   V: Surge absorber varistor (AC coil only)
7. Internal Connections
   Blank: Standard
   2 or 6: Non-standard connections (Refer to *"Terminal Arrangement/Internal Connection"*.)
8. Rated Voltage
   (Refer to *"Coil Ratings"*.)

OMRON

Ordering Information

■ List of Models

Type	Terminals	Contact form	Internal connections (See note 3.)	With mechanical indicator	With mechanical indicator and lockable test button	Coil ratings
Standard Models	Plug-in	DPDT	Standard	MKS2P	MKS2PI	AC/DC
			Non-standard	MKS2P-2	MKS2PI-2	
		3PDT	Standard	MKS3P	MKS3PI	
			Non-Standard	MKS3P-2	MKS3PI-2	
				MKS3P-5	MKS3PI-5	
Models with LED Indicator (See note 2.)		DPDT	Standard	MKS2PN(1)	MKS2PIN(1)	AC/DC
			Non-standard	MKS2PN(1)-2	MKS2PIN(1)-2	
		3PDT	Standard	MKS3PN(1)	MKS3PIN(1)	
			Non-Standard	MKS3PN(1)-2	MKS3PIN(1)-2	
				MKS3PN(1)-5	MKS3PIN(1)-5	
Models with Diode (See note 2.)		DPDT	Standard	MKS2P(1)-D	MKS2PI(1)-D	DC
			Non-standard	MKS2P(1)-D-2	MKS2PI(1)-D-2	
		3PDT	Standard	MKS3P(1)-D	MKS3PI(1)-D	
			Non-Standard	MKS3P(1)-D-2	MKS3PI(1)-D-2	
				MKS3P(1)-D-5	MKS3PI(1)-D-5	
Models with LED Indicator and Diode		DPDT	Standard	MKS2PN-D	MKS2PIN-D	DC
			Non-standard	MKS2PN-D-2	MKS2PIN-D-2	
		3PDT	Standard	MKS3PN-D	MKS3PIN-D	
			Non-Standard	MKS3PN-D-2	MKS3PIN-D-2	
				MKS3PN-D-5	MKS3PIN-D-5	
Models with Varistor		DPDT	Standard	MKS2P-V	MKS2PI-V	AC
			Non-standard	MKS2P-V-2	MKS2PI-V-2	
		3PDT	Standard	MKS3P-V	MKS3PI-V	
			Non-Standard	MKS3P-V-2	MKS3PI-V-2	
				MKS3P-V-5	MKS3PI-V-5	
Models with LED Indicator and Varistor		DPDT	Standard	MKS2PN-V	MKS2PIN-V	AC
			Non-standard	MKS2PN-V-2	MKS2PIN-V-2	
		3PDT	Standard	MKS3PN-V	MKS3PIN-V	
			Non-Standard	MKS3PN-V-2	MKS3PIN-V-2	
				MKS3PN-V-5	MKS3PIN-V-5	

Note: 1. When ordering, add the rated voltage to the model number. Rated voltages are given in the coil ratings table in the specifications.

Example: MKS3P 24 VDC

Rated voltage

2. The DC coil comes in two types: standard coil polarity and reverse coil polarity. Refer to *Terminal Arrangement and Internal Connections*.

Example: MKS2PIN-2 24 VDC

Reverse coil polarity

3. Refer to *Terminal Arrangement and Internal Connections* for non-standard internal connections.

■ List of Models (Order Separately)

Item	Type	Model
Track-mounted Socket	8-pin	PF083A-E
	11-pin	PF113A-E
	8-pin	PF083A-D
	11-pin	PF113A-D
Hold-down Clip (for PF083A-E and PF113A-E)		PFC-A1

OMRON

Specifications

■ Ratings

Coil Ratings

Rated voltage		Rated current		Coil resistance	Must operate voltage	Must release voltage	Max. voltage	Power consumption
		50 Hz	60 Hz					
AC	6 V	443 mA	355 mA	3.1 Ω	80% max. of rated voltage	30% min. of rated voltage at 60 Hz 25% min. of rated voltage at 50 Hz	110% of rated voltage	Approx. 2.3 VA at 60 Hz Approx. 2.7 VA at 50 Hz
	12 V	221 mA	199 mA	13.7 Ω				
	24 V	110 mA	95.3 mA	48.4 Ω				
	100 V	26.6 mA	23.1 mA	780 Ω				
	110 V	24.2 mA	21.0 mA	932 Ω				
	200 V	13.3 mA	11.6 mA	3,160 Ω				
	220 V	12.1 mA	10.5 mA	3,550 Ω				
	230 V	10.0 mA	11.5 mA	4,250 Ω				
	240 V	11.0 mA	9.6 mA	4,450 Ω				
DC	5 V	224 mA		25.7 Ω		15% min. of rated voltage		Approx. 1.4 W
	12 V	112 mA		107 Ω				
	24 V	55.8 mA		430 Ω				
	48 V	28.1 mA		1,710 Ω				
	100 V	13.5 mA		7,390 Ω				
	110 V	12.3 mA		8,960 Ω				

Note: 1. The rated current and coil resistance are measured at a coil temperature of 23°C with tolerances of +15%/−20% for AC rated current and ±15% for DC coil resistance.
2. Performance characteristic data are measured at a coil temperature of 23°C.
3. The maximum voltage is one that is applicable instantaneously to the Relay coil at 23°C and not continuously.
4. For DC-operated Relays with the LED indicator built-in, add an LED current of approx. 5 mA to the rated current.

Contact Ratings

Load		Resistive load (cosφ = 1)	Inductive load (cosφ = 0.4)
Contact mechanism		Single	
Contact material		AgSnIn	
Rated load	NO	10 A, 250 VAC 10A, 30 VDC	7 A, 250 VAC
	NC	5 A, 250 VAC 5 A, 30 VDC	
Rated carry current		10 A	
Max. switching voltage		250 VAC, 250 VDC	
Max. switching current		10 A	
Max. switching power	NO	2,500 VA/300 W	
	NC	1,250 VA/150 W	

OMRON

■ Characteristics

Contact resistance	100 mΩ max.
Operate time	AC: 20 ms max. DC: 30 ms max.
Release time	20 ms max.(40 ms max. for built-in Diode Relays)
Max. operating frequency	Mechanical: 18,000 operations/h Electrical: 1,800 operations/h (under rated load)
Insulation resistance	100 MΩ min. (at 500 VDC)
Dielectric strength	2,500 VAC 50/60 Hz for 1 min between coil and contacts 1,000 VAC 50/60 Hz for 1 min between contacts of same polarity and terminals of the same polarity 2,500 VAC 50/60 Hz for 1 min between current-carrying parts, non-current-carrying parts, and opposite polarity
Insulation method	Basic insulation
Impulse withstand voltage	4.5 kV between coil and contacts (with 1.2 × 50 μs impulse wave) 3.0 kV between contacts of different polarity (with 1.2 × 50 μs impulse wave)
Pollution degree	3
Rated insulation voltage	250 V
Vibration resistance	Destruction: 10 to 55 to 10 Hz, 0.75-mm single amplitude (1.5-mm double amplitude) Malfunction: 10 to 55 to 10 Hz, 0.5-mm single amplitude (1.0-mm double amplitude)
Shock resistance	Destruction: 1,000 m/s² (approx. 100 G) Malfunction: 100 m/s² (approx. 10 G)
Endurance	Mechanical: 5,000,000 operations min. (at 18,000 operations/h under rated load) Electrical: 100,000 operations h. (at 1,800 operations/h under rated load)
Failure rate P level (reference value)	10 mA at 1 VDC
Ambient temperature	Operating: –40 to 60°C (with no icing or condensation)
Ambient humidity	Operating: 5% to 85%
Weight	Approx. 90 g

Note: 1. The values given above are initial values.
2. P level: $\lambda_{60} = 0.1 \times 10^{-6}$/operation
3. Ambient temperature of models with LED indicator is –25 to 60°C.

■ Approved Standards

UL508 (File No. E41515)

Coil ratings	Contact ratings		Operations
6 to 110 VDC 6 to 240 VAC	N.O. contact	10 A, 250 V AC 50/60 Hz (Resistive) 10 A, 30 V DC (Resistive) 7 A, 250 V AC 50/60 Hz (General Use)	6,000
	N.C. contact	5 A, 250 V AC 50/60 Hz (Resistive) 5 A, 30 V DC (Resistive) 7 A, 250 V AC 50/60 Hz (General Use)	6,000

CSA Standard: CSA Certification by c UL us: CSA C22.2 No. 14

Note: Applications have been submitted for UL and CSA certification for models with built-in LED indicators.

IEC Standard/TUV Certification: IEC61810-1 (Certification No. R50104853)

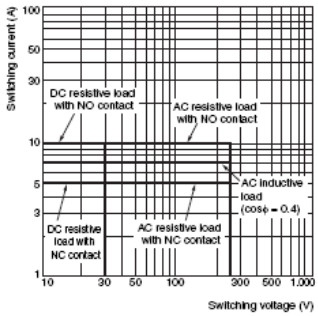
Coil ratings	Contact ratings		Operations
6, 12, 24, 48, 100, 110 VDC 6, 12, 24, 100, 110, 200, 220, 240 VAC	N.O. contact	10 A, 250 V AC 50/60 Hz (Resistive) 10 A, 30 V DC (Resistive) 7 A, 250 V AC 50/60 Hz (General Use)	100,000
	N.C. contact	5 A, 250 V AC 50/60 Hz (Resistive) 5 A, 30 V DC (Resistive) 7 A, 250 V AC 50/60 Hz (General Use)	100,000

Note: When Relays are mounted on the PF083A-E or PF113A-E, the maximum carrying current is 9 A.

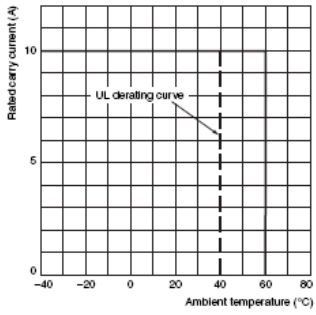
Engineering Data

■ Reference Data

Maximum Switching Power



Rated Carry Current vs. Ambient Rated Temperature



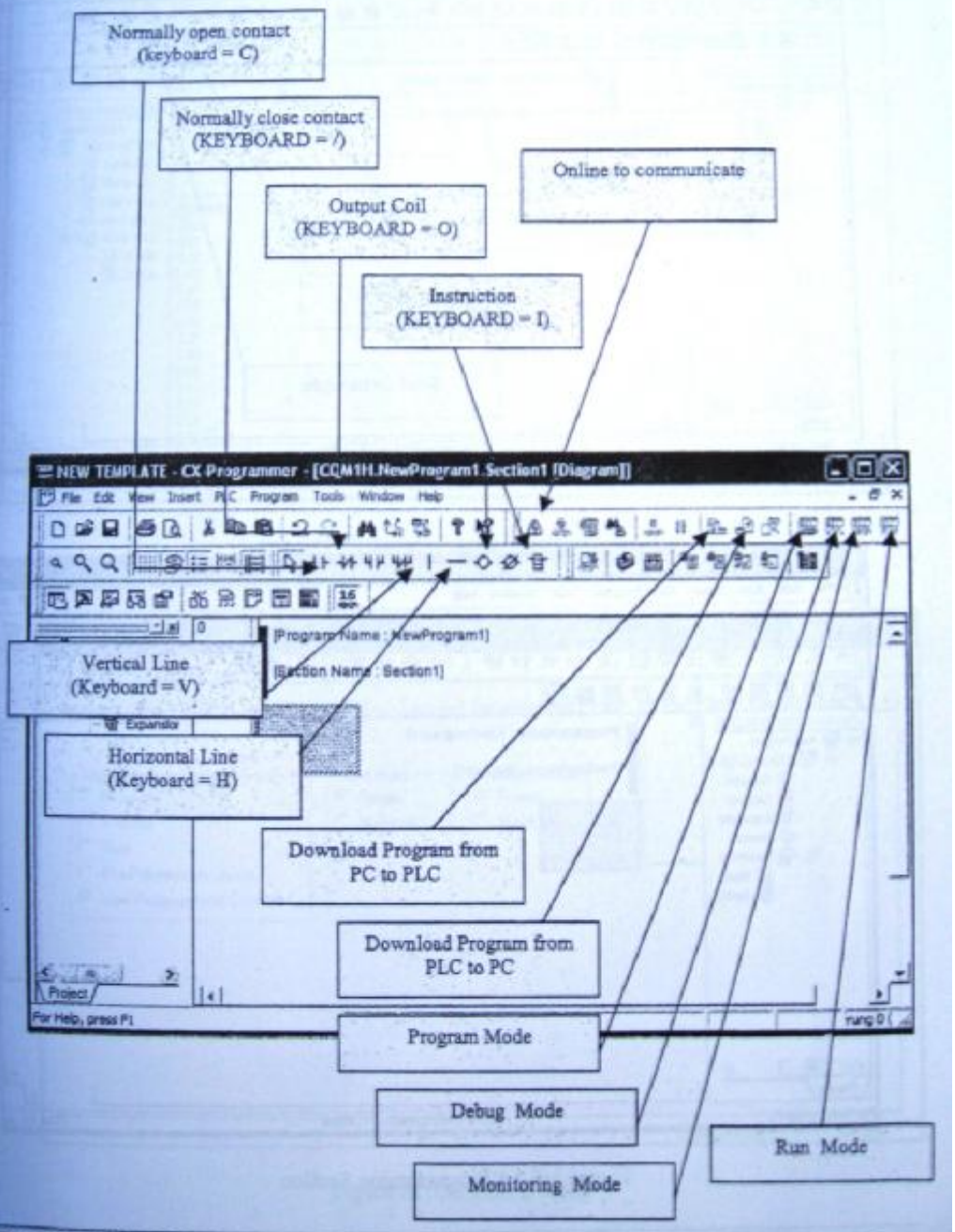
Note: The lower limit of the ambient operating temperature for models with built-in operation indicators is –25°C.

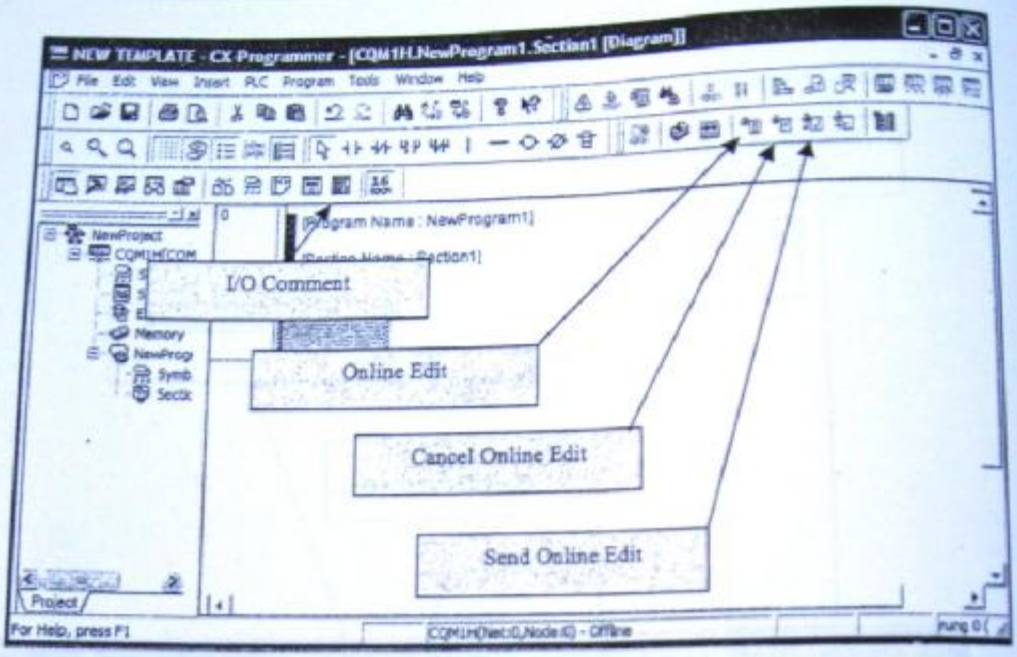
APPENDIX E

CX PROGRAMMER

CX-PROGRAMMER

1. Menu Overview





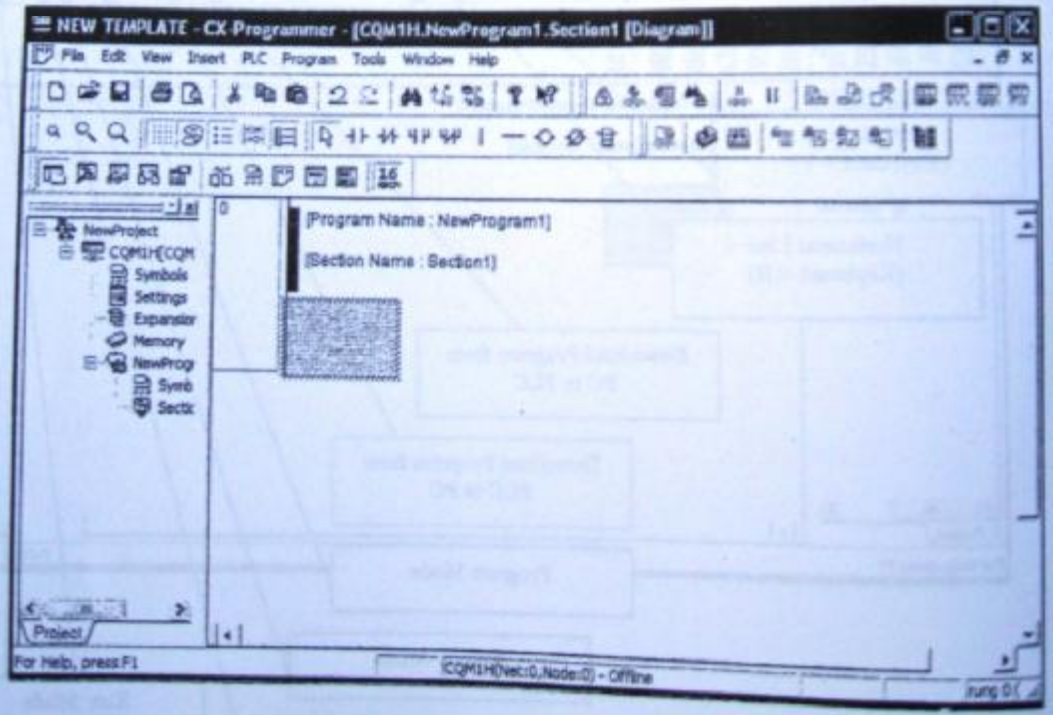


Figure M10.1 Programming Section

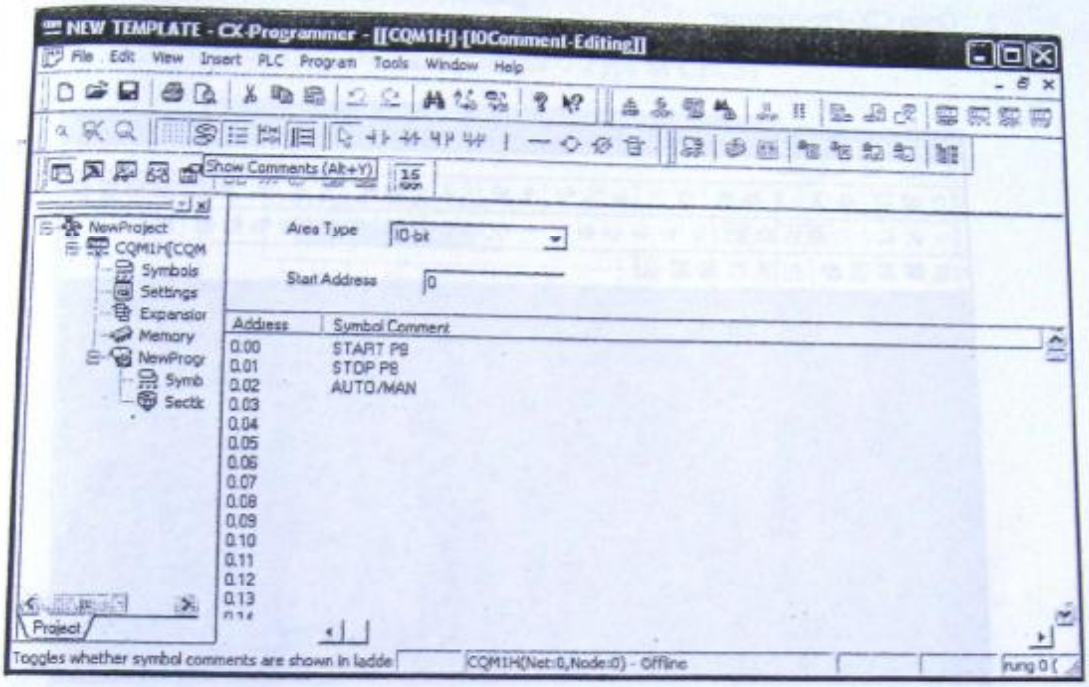


Figure M10.2 Input Output Comment Section

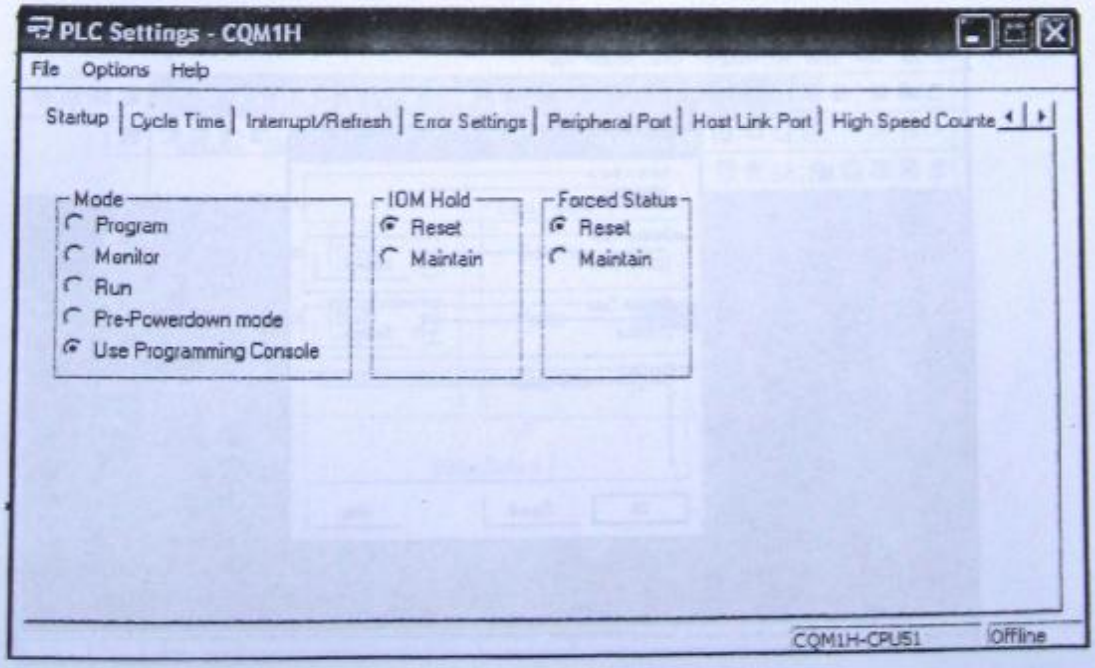


Figure M10.3 PLC Setting

2. Open CX-Programmer
   - Create new file

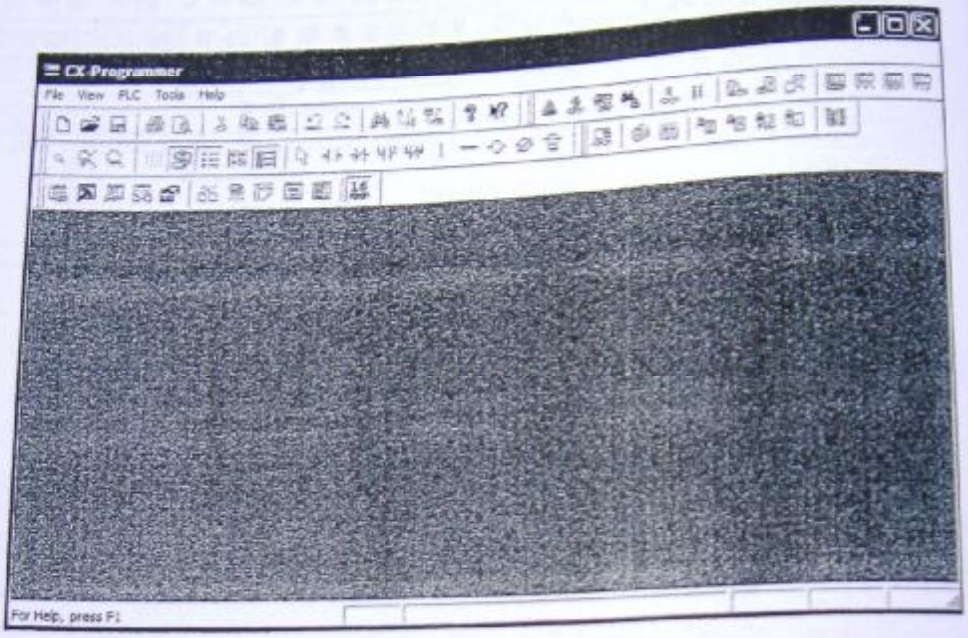


Figure M10.4 Opening New File

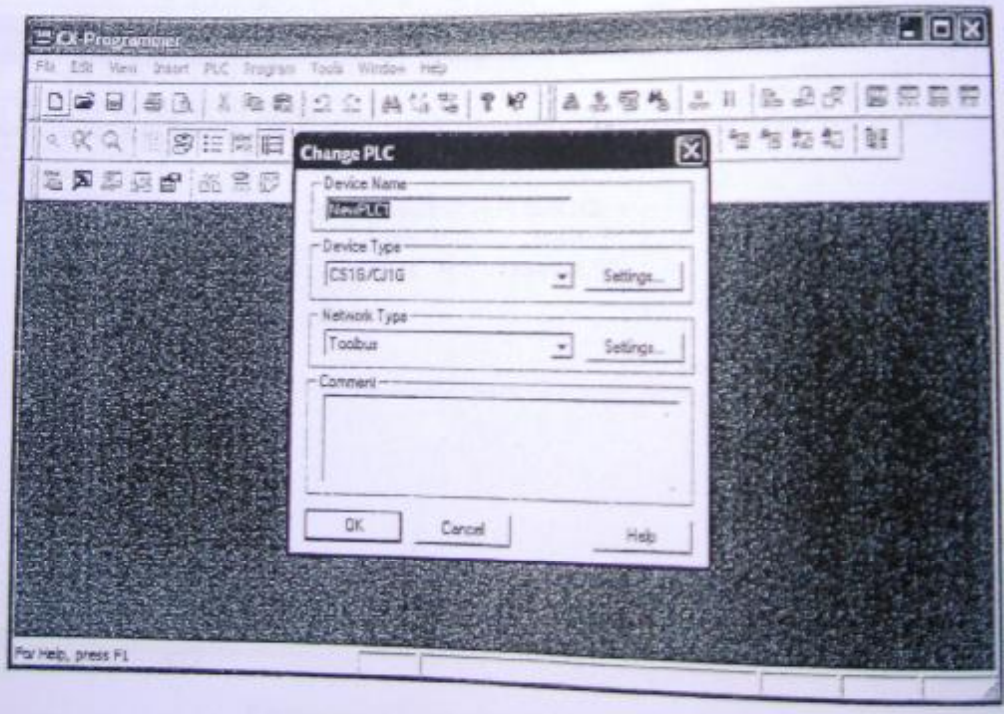


Figure M10.5 Configure PLC Device

- Set Device name as **PLC_Training**
- Device type as **CQM1H**
- Click Device Type Setting and Set CPU Type as **CPU51**

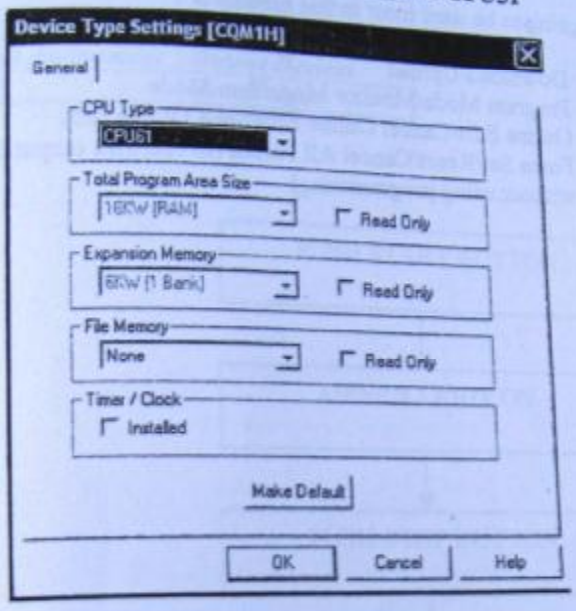


Figure M10.6 Setting CPU Type

- Click Network Type > Modem and Make Default

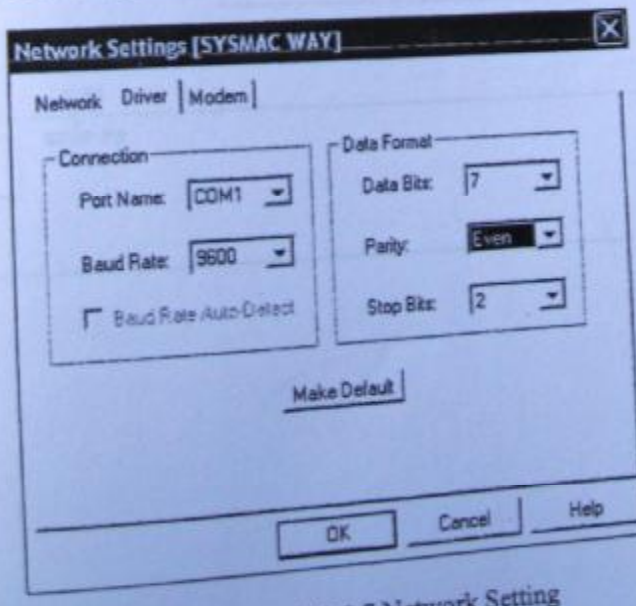


Figure M10.7 Network Setting

- Change to I/O comment to label addresses.
- Change again to programming mode to start programming

Below functions are going to be used most in this module :-

i. Download/Upload
ii. Program Mode/Monitor Mode/Run Mode
iii. Online Edit/Cancel Online Edit/Send Online Edit
iv. Force Set/Reset/Cancel All Forces (to energize output device without using programming)

APPENDIX F

WORK PROGRESS & PRESENTATION

FIGURE E-1: Completing The Project By Doing Measurement and Constructing.

FIGURE E-2: The equipments that use during the project

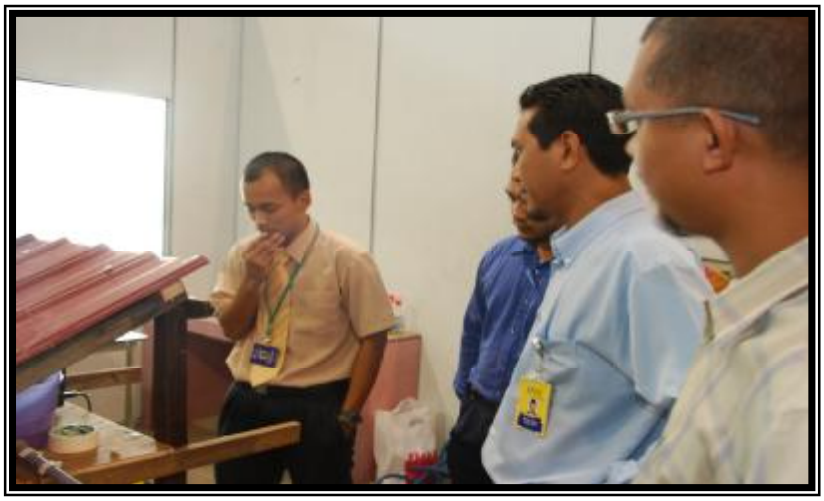


FIGURE E-3: Presentation And Demonstration of the Project.