SURVEILLANCE SYSTEM FOR HIGHWAY MONITORING

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
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CERTIFICATION OF APPROVAL

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Approved:

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Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Yim Soon Yen

ABSTRACT

Surveillance System for Highway Monitoring is an intelligent system which can detect congestion in the highways and automatically alert the highway users. This project aims to design and build a system which is able to monitor traffic congestion on highways and automatically alert the users. This will help the road users in planning their journey by giving them the current situation of the highways. The system consists of mainly the Programmable Logic Controller (PLCs), sensors and alert devices. This system functions to give awareness to highway users and also help reduce highway congestion by monitoring the highways. The infrared sensors will detect the vehicles and the PLC will be programmed to count the frequency of vehicles that passes the sensor. If the frequency exceeds a certain limit, it will firstly warn the highway users at the entrance of the highway and along the highway so that they may use other road alternatives. If the frequency exceeds the second limit, then the system will warn the highway users that the high is jam and recommends another route to be taken.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

With rapid development in the automotive industries, vehicle numbers are shooting up the scales in many cities around the world thus causing more and more traffic congestions on the highway. Therefore highway traffic control is needed to overcome this rising problem in many cities.

As a result, highway surveillance systems are being implemented to monitor the traffic conditions for congestion and also for monitoring the road conditions for maintenance of the road. Such systems are normally implemented on manually in most countries where the traffic conditions on the highways are monitored by getting feedback from the road users on the highway. This method is not very efficient because it requires ample manpower and expense.

For example, some countries like in the United States or other developed country in the early days monitor traffic congestion by a helicopter flying above to monitor the congestion. These helicopters will patrol the highway looking for possible congestion or any road incidents where a probable congestion may occur from it and then report back to their base station. On the other hand, countries which are less developed monitor highway through 'patrol cars' where they have to patrol the highway through vehicles.

Therefore the control of urban traffic is an ever increasingly promising topic for research. As a result, automated surveillance systems for highway monitoring are implemented. This project implements an automated method to monitor highway congestion where it makes use of the Programmable Logic Controller (PLC) and several sensors.

1.2 Problem Statement

1.2.1 Problem Identification

Automated surveillance system for highway monitoring is not very popular in many countries. Most countries monitor their highways based on patrols along the highway which not only requires a lot of manpower, time and cost but in fact not very efficient. Particularly in Malaysia, there are only low-tech monitoring systems for highways. Therefore, it is not capable in forewarning the highway users on its current situation (whether it is congested or not). Thus this causes inconvenience for the road users due to the lack of proper highway monitoring devices in Malaysia.

1.2.2 Significance of The Project

This project helps in automatically monitoring highways. The system consists of sensors that will be able to detect congestion in stages. Then it will be able to inform the road users on the current road situation by forewarning the highway users and those about to enter the highway and also provide an alternative route. Thus it will be able to prevent / reduce traffic congestion. Besides, the sensors will also be able to detect speeds of the vehicle on the highway. If coupled with the RFID technology, it can be able to pinpoint the vehicles if they over speed thus making this system able to detect speeding vehicles.

1.3 Objectives

The project's main objective is to implement a surveillance system for highway monitoring via the use of the PLC and microcontrollers as the controller (build a prototype which is able to simulate a real life highway). This surveillance system should be able to automatically monitor traffic congestions and forewarn the road users on the current status of the highway. Also, it should be able to provide alternative routes incase of traffic congestion so that the road users can escape from being part of the congestion and further congest the highway.

1.3.1 The Relevancy of The Project

Due to the current situation where traffic congestion monitoring systems for highway in Malaysia is lacking, this project is relevant in providing a possible solution in helping to reduce the traffic congestion on the highway especially in Kuala Lumpur where highway congestions are very high. Besides, this project is easy to implement because it is cheap and reliable.

1.3.2 The Feasibility of The Project

The systems will integrate the microcontroller and PLC so that it can take preventive action to warn road users in case of traffic congestion on the highway. The system is similar to [1] and [2] and [3] which operates based on signals sent by the sensor, the signals are then sent to the microcontroller and PLC. This project is feasible given the time frame of 2 semesters to build. Furthermore, the cost of building the prototype is mostly absorbed by the University because most of the important and expensive equipments are already provided by the University. Therefore, this project is feasible.

1.4 Scope of Project

The main focus of this project is implementation of the PLC for controlling the surveillance system for highway monitoring. Therefore, this project requires building the ladder logic of the system and also C-Programming for the output display. Knowledge in integrating sensors to the PLC input is vital. Given that types of sensor planned to be used are easily available, the prototype of the project can be realized.

CHAPTER 2
LITERATURE REVIEW

2.1 Non-automated Highway Monitoring

2.1.1 Human Patrol

The most common system used for highway monitoring is the human patrol. Patrol vehicles are used to patrol the highways to and fro on intervals. Some highways companies whom have more finances will have helicopters to monitor the highways. Such system is for monitoring the highways for congestion and also to monitor the highway physical conditions. This system requires a lot of manpower and is less sufficient because it can only cover a part of the highway at a time. This system is commonly found in highways in Malaysia.

For monitoring traffic offences on highway for example a speeding vehicle, speed cameras are placed at strategic locations. But since the speed cameras in Malaysia are old technology and are not well maintained, and now no longer currently in use, authorities such as the Police has to set up spots and road blocks to capture speeding cars.

2.1.2 Cameras

In Malaysia, Lembaga Lebuhraya Malaysia (LLM) or known as Malaysia Highway Authority implemented the system called "Traffic Management Center" which incorporates the use of cameras placed in strategic locations where it will be monitored by human in the control room [4]. The traffic conditions (congestion) on the highway will then be disseminated to the public for the latest traffic conditions and travel advices via the web portal and to the radio stations or by Short Messaging Service (SMS).

2.2 Automated Highway Monitoring

2.2.1 Detector Coil System

Also in Malaysia and Singapore, according to [5] and [6] detector coils are buried under the ground. These types of sensors are accurate but expensive because it only covers a small area and maintenance is expensive. This system consists of a self-powered detector having a transmission coil which resonates at a certain frequency to provide a detection field and a detection coil which is tuned to the resonant frequency which is being responsive to entry and exit of an object within the detection field produced by the transmission coil. This system uses a computer to interpret the sensor in monitoring traffic congestion.

2.2.2 Infrared Detection System

In the United States of America, referring to [7] they have automated traffic monitoring systems which comprises infra-red monitoring units bolted to the sides of bridges or over the highway and emitting information as to traffic congestion at their locations, a control center which receives and transmits the information and paging units in respective vehicles and receiving and transmits the information and visually displaying the same upon diagrams of the network or zones thereof. This system also uses a computer to interpret the sensors in monitoring traffic congestion.

2.2.3 Two-axis Magnetometer

Also in the United States of America, referring to [5] there is a similar system which instead uses a two-axis magnetometer which is used for vehicle detection in place of an induction loop. The magnetometer is placed in the center of the highway the unit detecting the presence of a vehicle by measuring its magnetic field, and then transmitting vehicle presence information to a roadside control unit by way of a radio frequency telemetry link. The disadvantage of this system is firstly it will not detect a motor vehicle unless the motor vehicle comprises sufficient ferromagnetic material to create a noticeable perturbation in the inductance [8] and [9]. And because the trend is to fabricate motor vehicles with non-ferromagnetic alloys, plastics and composite materials, this system will not be able to detect the presence of motor vehicles.

2.2.4 Cameras with Image Processing Technology

The most current technology is by using image processing to detect congestion or accidents. This system uses the close circuit television (CCTV) to capture images of the situation and uses a Digital Signal Processing (DSP) microprocessor to compare each frame of images to detect the speed of the car referring to [10]. This system is capable of detecting congestion and also can monitor accidents. This system is very complicated and requires a powerful processor to interpret the frame rates.

2.2.5 Acoustic Highway Monitoring

This system is based on detecting the acoustic signals motor vehicles create and radiate during operation. The system comprises an array of electro-acoustic sensors for converting impinging acoustic wave fronts to analog electrical signals (referring to [10]. Therefore when a vehicle passes, it will be able to detect the vehicle through the reflection of its acoustic wave. Thus it is able to detect traffic congestion.

2.3 Programmable Logic Controller

2.3.1 Introduction to PLC

The PLC is the main controller for this project. It is a control component that is designed to replace the sophisticated and complex circuit of a sequential logic relay. But the PLC has several advantages which are smaller in size, easier to troubleshoot during a problem, easier to maintain and it is less hassle if the system is to control another system. The PLC is a family of computers that can be applied through out various kinds of industries for the use of controlling platforms, industries and factories.

The PLC is a control device which highly depend the input parameters. The signals that were received from the input will be processed by the PLC to determine the correct output states based on the PLC program. The PLC program consists of ladder logic which are based on Boolean logic but represented in a ladder diagram. The PLC consists of 3 main parts namely the input pins (sensors), the PLC processing unit (programming network) and the output pins.

2.3.2 History and Evolution of the PLC

Referring to [2], the PLC was first developed in 1986 by a group of engineers from the General Motors (GM). The PLC was firstly invented to replace the sequential logic relay. The reason for the replacement is because, GM wanted flexibility in their process control which the sequential logic relay isn't able to provide. The PLC sequence can be easily changed by just changing the program where else as for the sequential logic relays; it has to rewired and redesigned.

In the 1970's the AMD 2901 and AMD 2903 were one of the most popular PLCs. This is due to it ability to communicate with each other and other field devices. At that time, the Modicon's Modbus is used to achieve this capability. This gives the advantage of placing the PLC far from the machine that needs to be controlled.

In the 1980's, GM's Manufacturing Automation division started a protocol called Manufacturing Automation Protocol (MAP) which standardize the communication between control devices. This helped the evolution of the PLC into a much improved control system; the programming of the PLC became simpler.

2.4 Weather Effects

For this project, infrared are used for sensing moving vehicles on the highway. In Malaysia, rain is recorded to be present around the year, thus causing rain to be the main weather effect on the infrared sensors. Rain water droplets in the air will disrupt electro-optical transmissions thus causing it to be less reliable [11]. For example if a water droplet is in the way between the IR transmitter and receiver, then the transmitted IR wave can be reflected and refracted causing less of the IR beam to reach the receiver. If the IR beam is not intense enough or if the water droplet has refracted and reflected away most of the IR beam, then the IR receiver may not read it. Other weather effects such as fog, smoke also disrupts the signal transfer from the IR transmitter to the IR receiver. This is because, smoke and fog has particles which are not translucent and can block the pathway of the IR sensors. Thus, the IR receiver readings become erroneous.

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

The methodology of the course is shown in figure 1 where firstly the topic of the project is chosen together with the supervisor accompanying the topic. Once the topic is chosen, research and much thought are done to produce the problem identification. Then further research and literature review is done on the topic to realize the different methods and types of system pioneered that are related to the topic. Once the literature review is done, then the project is designed. The design of the project will incorporate reviewing the programming tools required, the circuit design of the system, the necessary calculations. After the designing process, it is then checked its feasibility and if it is feasible, the prototype of the project is then constructed. Figure 1 summarizes the whole procedure.

To further break down the project methodology, this project can be divided into several parts. The first part is identification of what needs to be monitored and what devices is needed. Then the second part is on the software and preparation of the PLC program and finally the last part is building a prototype of the working system.

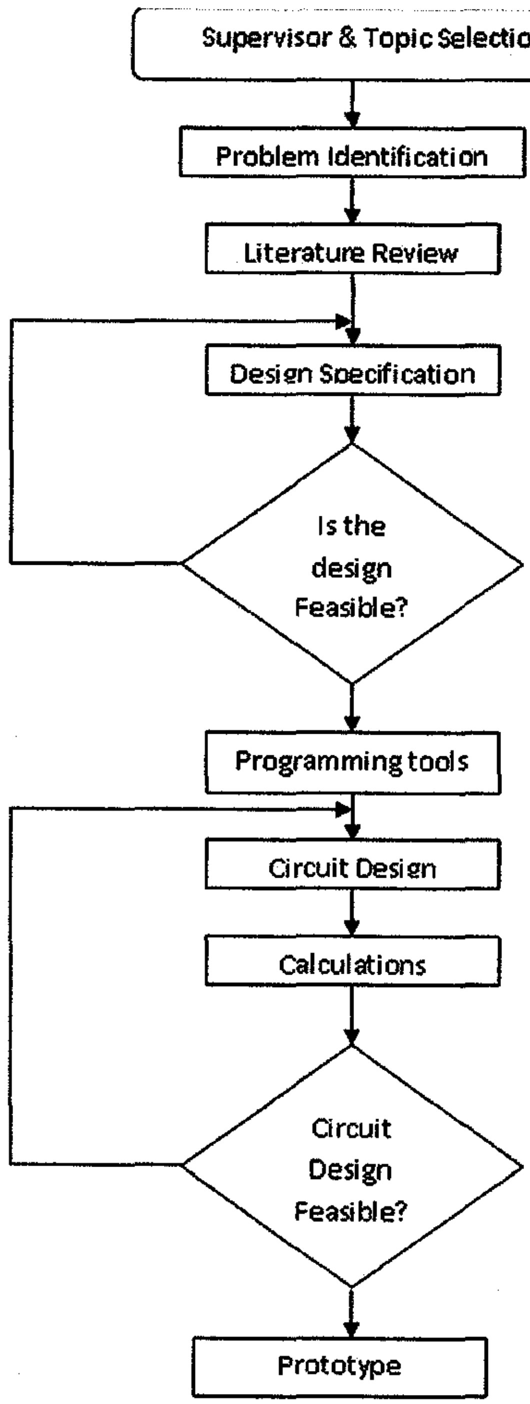

Figure 1: Flow chart of Procedure Identification

3.1.1 First Part

In this part, the design specification is mentioned. The project will consist of several sensors to detect traffic congestion on the highway (Lebuhraya Damansara Puchong, LDP) and sensors to be able to detect speeding vehicle on the highway. Then the PLC is chosen be used to process the input to be able to control the output. The output is designed to be able to inform / warn the road users on the highway and also those about to enter the highway. Besides it should be able to give alternative routes if traffic congestion occurs.

3.1.2 Second Part

In this part, the software for programming the PLC is obtained and learnt. The ladder logic is designed based on the design specifications of the project and the flow operation. Then by using the CX-Programmer software, the ladder diagram can be converted into mnemonic coding which is then keyed into a programming console attached to the PLC. Also C-programming is also used to program a microcontroller to control a LCD display as the output to indicate / warn the road user.

3.13 Third Part

In this part, the actual prototype in small scale of the project is constructed for simulation purposes. At this point, the components have to be found and then built based on the PLC wiring diagram design specification. Simulation of the prototype is done to determine its functionality and consistency.

3.2 Tools Required

For this project, the main tools required can be broken down into 3 parts which is tools for the input of the PLC (sensors), the Programmable Logic Controller (PLC) itself and tools for the output of the PLC (alert/ alarm systems). Infra-red sensors are used to detect the speed of the car. Besides, CCTVs are used to monitor the highways to ensure safety. Then, alarms will be used to inform the road users and also the authorities running the highway. Besides, LCD displays will also be used to inform the road users of other alternative routes.

Table 1: List of Hardware and Software tools

Hardware tools	**Software tools**
Infra-red sensors	CX-Programmer
LEDs	PIC C Compiler
LCD display	PIC18 Simulator IDE
CCTVs	
Programmable Logic Controller (PLC)	
PIC 18x microcontroller	

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Design Specification

4.1.1 Prototype design

The project's design specification is listed in this section. This project will be based on the Lebuhraya Damansara Puchong (LDP) highway. The highway consists of a double lane dual carriageway. This system will incorporate infrared emitters placed on the top of the road and infrared sensors at the bottom. The overview of the system can be seen in Figure 2.

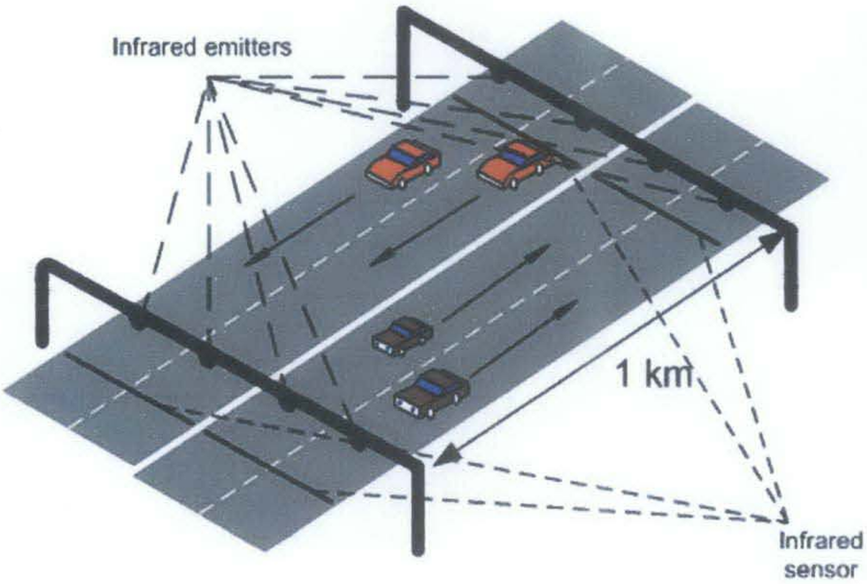

Figure 2: layout of infrared sensors on the highway

From Figure 2, the infrared sensors are designed to be placed at 1km intervals in order to save cost yet still reliable and efficient. The infrared sensors are placed in a vertical fashion in order to reduce the effects of refraction caused by rain (water droplets). Furthermore it is more convenient to place the sensors vertically because it does not obstruct traffic. The infrared emitters are designed to be placed on top where else the infrared sensors embedded on the highway is also to reduce the effects of refractions. Figure 3 explains the effects of the refraction of the water droplets in case of a rain fall.

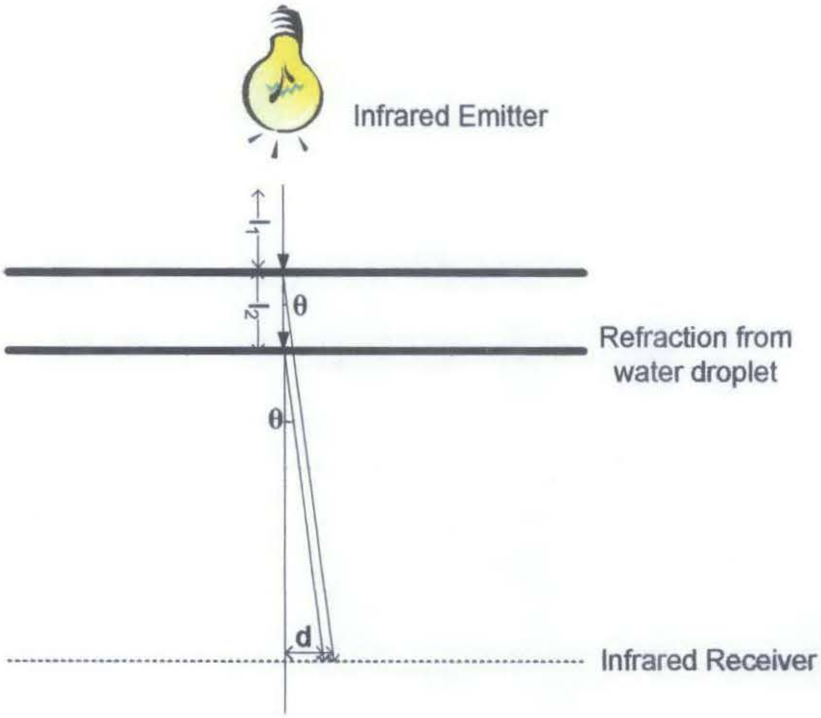

Figure 3: Effects of refraction

From Figure 3, given if the water droplet is in the path way of the infrared beam and the beam is refracted, the distance of the water droplet (length of l) will cause different refraction (error in distance, d). For example if the distance of the water droplet from the infrared emitter is l_1, the error caused by the refraction is much larger than of if the distance from the infrared emitter to the water droplet is l_2 provided that the refraction rate (θ) is the same. Therefore, in order to reduce the effects of refraction, the infrared emitter is placed on the top of the highway.

To further reduce the effects of refraction of the infrared beam caused by rain, the overhead pole which houses the infrared emitters are placed as low as possible (5 meters). As for the prototype, the height of the overhead pole is at 5cm.

The prototype of the system has been constructed based on a 2000:1 scale of a real highway. The highway built for simulating the real application only simulates a straight road for simplicity. Overhead poles stretching across all lanes of the highway is used to home the IR transmitters where else the IR receivers are buried onto the highway. The poles where the IR transmitters are situated are place 50cm apart in the scaled prototype. Figure 4 shows the constructed scaled prototype. The dimensions of the highways are shown in Table 2.

Figure 4: The constructed and scaled prototype (without the sensors module)

Table 2: Dimensions of the prototype

Full length	150cm aprox.
Width	28cm aprox.
Height of pole	5cm aprox.

4.1.2 Circuit Design

The signals produced from the infrared sensors will be amplified by an infrared circuit. This is to done because the input to the PLC requires 24 V. Figure 5 shows the design of the infrared circuit.

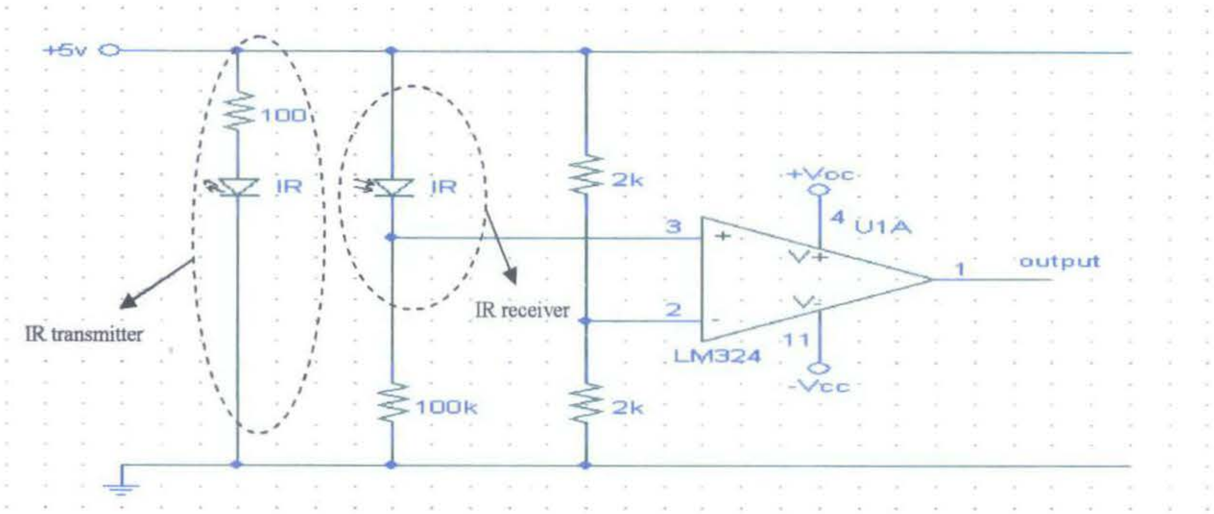

Figure 5: Circuit design for infrared circuit

As shown in Figure 5, the amplifier used is a comparator (LM324). The comparator is a type of an operational amplifier with characteristics of providing a digital output based on an analog input. Since the infrared signal is not a digital signal (not constant), it is better to amplify it as a digital signal because the input of the PLC requires a digital signal of 24V. If a transistor is used to amplify the signal of the sensors, then the amplified signal will still be a analog signal which varies and may cause inconsistency. Therefore, the comparator is used to design the circuit for the infrared. Figure 6 shows the expansion of Figure 5 where all 8 infrared sensors are used. Figure 7 show the actual circuit constructed.

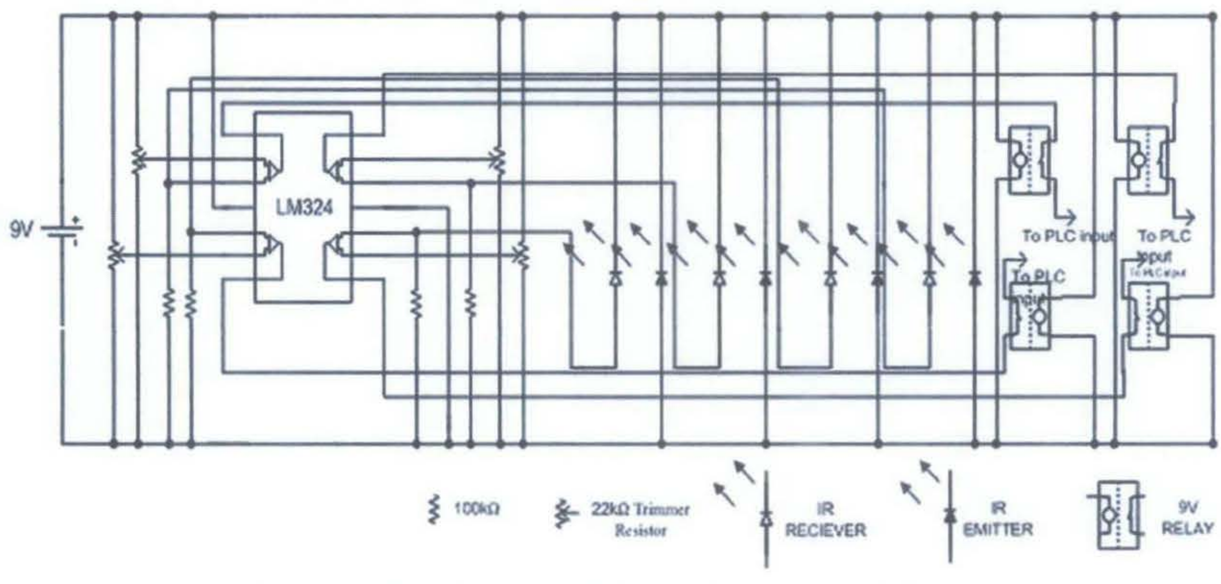

Figure 6: Complete circuit design for sensor module

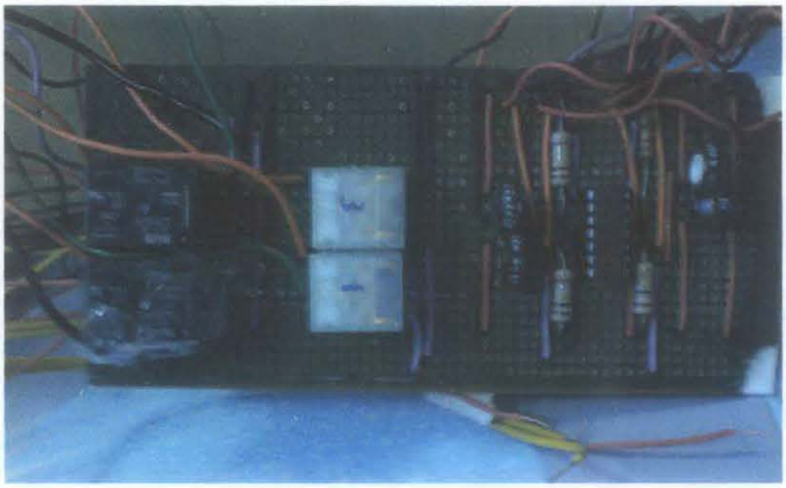

Figure 7: Constructed sensor circuit module

4.1.3 Design of LCD display

Figure 8 shows the actual constructed LCD system for displaying alternative route. The circuit connections for the LCD display alert system is shown in Figure 9. The PIC16F877A microcontroller is used for controlling the LCD display. The 16F family of microcontroller is used because it is cheaper and it has the sufficient in build functions for controlling the LCD. Besides that, the microcontroller is used because the PLC is not capable of controlling the LCD display. The pin connections from the LCD display to the microcontroller is shown in Figure 9.

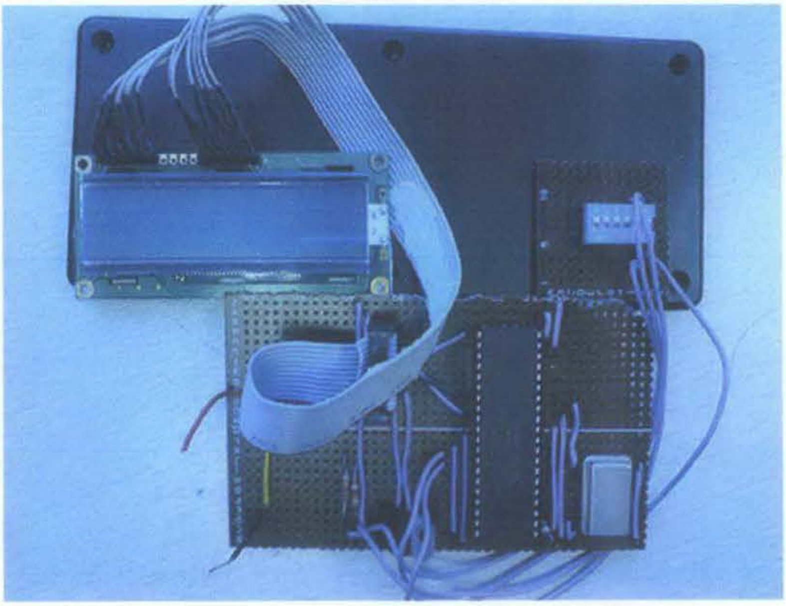

Figure 8: Actual circuit of the LCD display

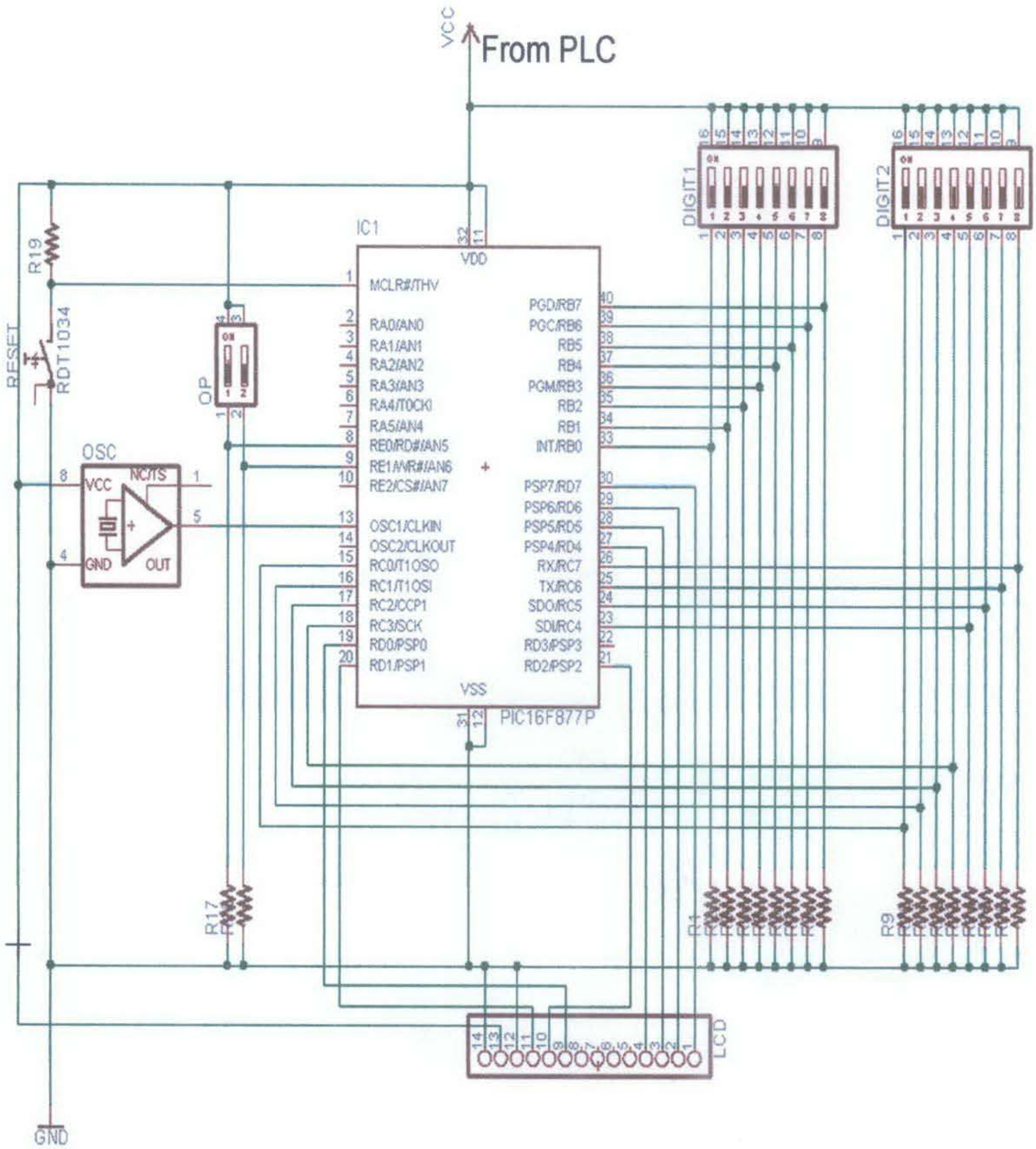

Figure 9: Schematic Diagram of the LCD system

4.2 Working Principle

The system works by having 2 sets of infrared sensors at different locations as shown in Figure 2. The first sensor will first detect the vehicle when it passes through it. Then the PLC will count the time it takes for the vehicle to pass the second sensor at 1 km apart. Therefore it can compute the speed of the vehicle within the 1 km of distance. With this design it can detect if the vehicle is moving fast or slow. If the cars are moving very slow (≤ 50 km/h) then it will detect as very congested and will alert the control room with a

Red LED ON. Also it will alert the highway users with the same Red LED ON at the entrance of the highway and a few kilometers away from the detected traffic congestion. A further illustration of the system is shown in Figure 10.

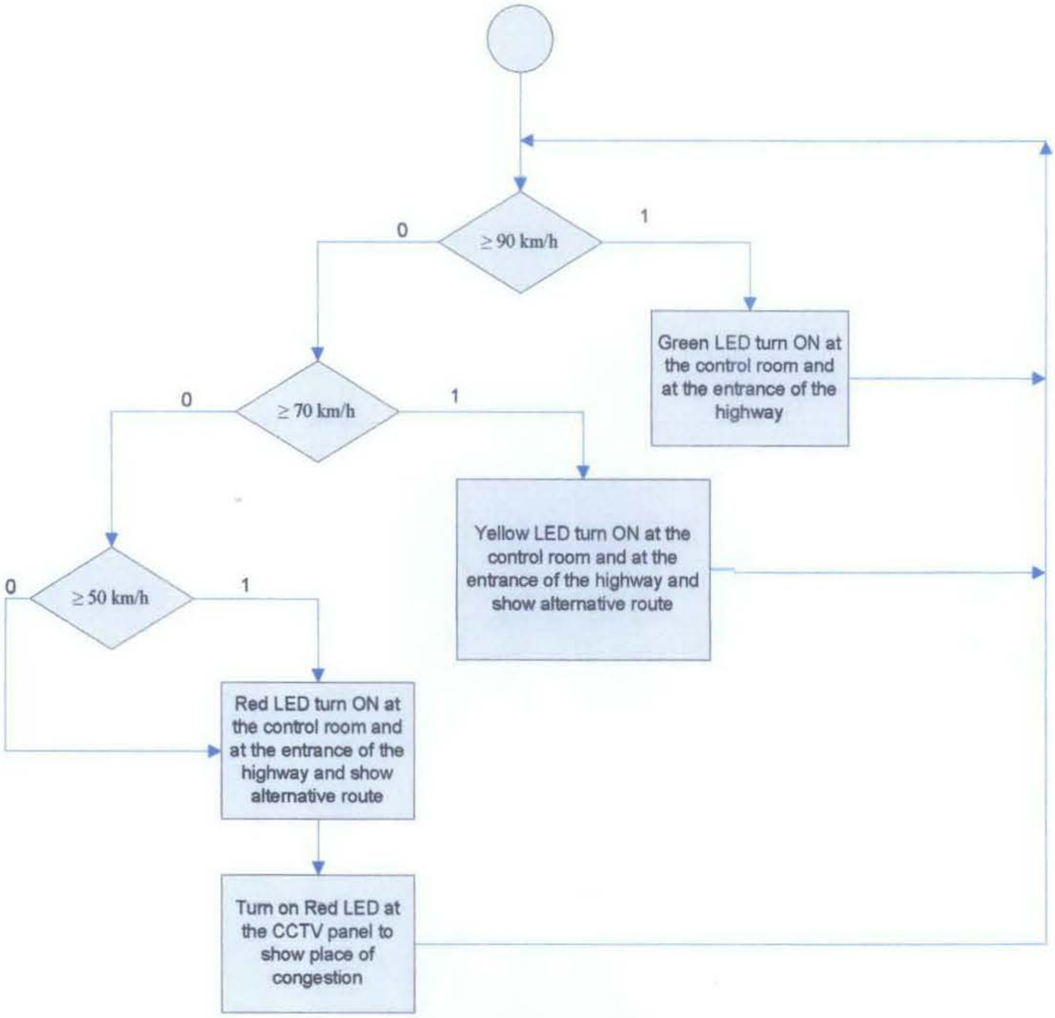

Figure 10: System Flow Chart

Also, this system will make use of the PLC to be a counter, which is able to count the number of vehicles that pass the sensor. It is able to detect traffic congestion by counting vehicles that pass from the first sensor to the second. Based on the law in Malaysia, it is good practice that each vehicle is to be driven at least 2 seconds apart of each other. Therefore this system is design to be based on the "2 seconds apart law". By doing so, it can compute the maximum number of vehicles between both sensors assuming that they all travel at the same speed. This is because given the distance from each sensor and if assuming that all vehicles are traveling at constant speed and that each car must be 2 seconds apart from each other, the system can compute the maximum vehicles that can be between the two sensors. Figure 11 shows the system flow chart using this method of calculation.

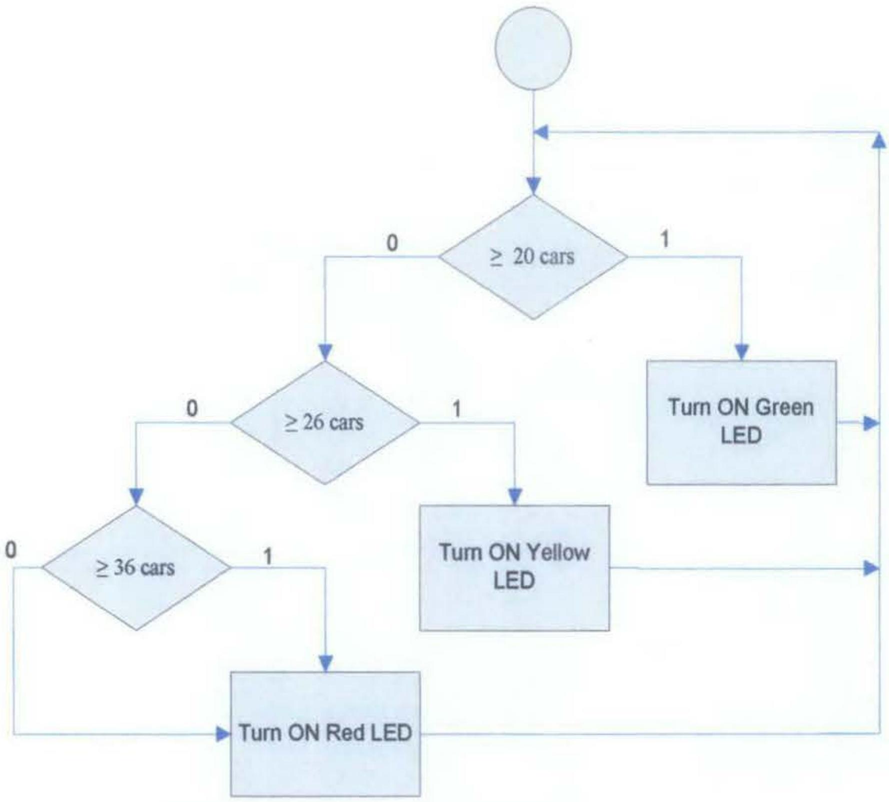

Figure 11: Flowchart for vehicle counting system

4.2.1 Working principle of infrared circuit

From Figure 5, the infrared receiver works as a switch where if it detects an infrared beam of light, then it will close the circuit and provide a voltage to the "+ve input" of the comparator. The comparator acts as an amplifier to the signal provided by the infrared sensor. The comparator takes the difference of the input voltages. For example if the "+ve input" voltage is higher than of the "-ve input" voltage, then the comparator's output will follow +Vcc. On the other hand, if the "-ve input" voltage is higher, than the comparator's output will follow –Vcc.

In the design of the circuit, resistors are used in the circuit to limit the voltages and current in the components used. The resistance value shown in Figure 5 is obtain through using the Ohm's Law formula V = I x R. The allowable current or voltages for each component is obtained from their datasheets.

4.2.2 Working principle of the LCD display system

The LCD display system is constructed to fulfill the objective of the project where an alternative route has to be provided incase of a traffic congestion. Therefore, the alternative route will be displayed on the LCD display. Based on Figure 10, when the RED LED is lit, this signal will then turn on the LCD display system. The LCD display will provide the alternative routes based on the operator from the control center. These LCD displays will be placed at the entrance of each highway (at the toll booths) so that the road users may instead reroute to another direction.

The program running the LCD and for displaying an alternative route for the LCD is shown in Appendix C. The function "#include <lcd.c>" is to call the function of the LCD from the compiler and the function "lcd_init()" is to initialize the LCD display. The program explains the two different alternatives provided from two possible logic states (PIN B0 and PIN B1). Since there are 2 pins used as an input, there are 4 logic states; 00 01 10 11. The program states that if both the input pins PIN B0 and PIN B1 of the microcontroller is of logic 00 (0V) or of logic 11, then the LCD display will display the words "drive safely". If both the pins provide a logic state of 01, then it will show the first alternative route; the LCD displays "alternative 1". If both the pins provide a logic state of 10, then it will show the first alternative route; the LCD displays "alternative 2".

The number of alternative routes is expandable; having more input pins will increase the possible logic states thus having more alternative routes.

4.2.3 Working principle of the PLC

Figure 12 shows the working principle of the system through ladder diagram for the PLC to understand.

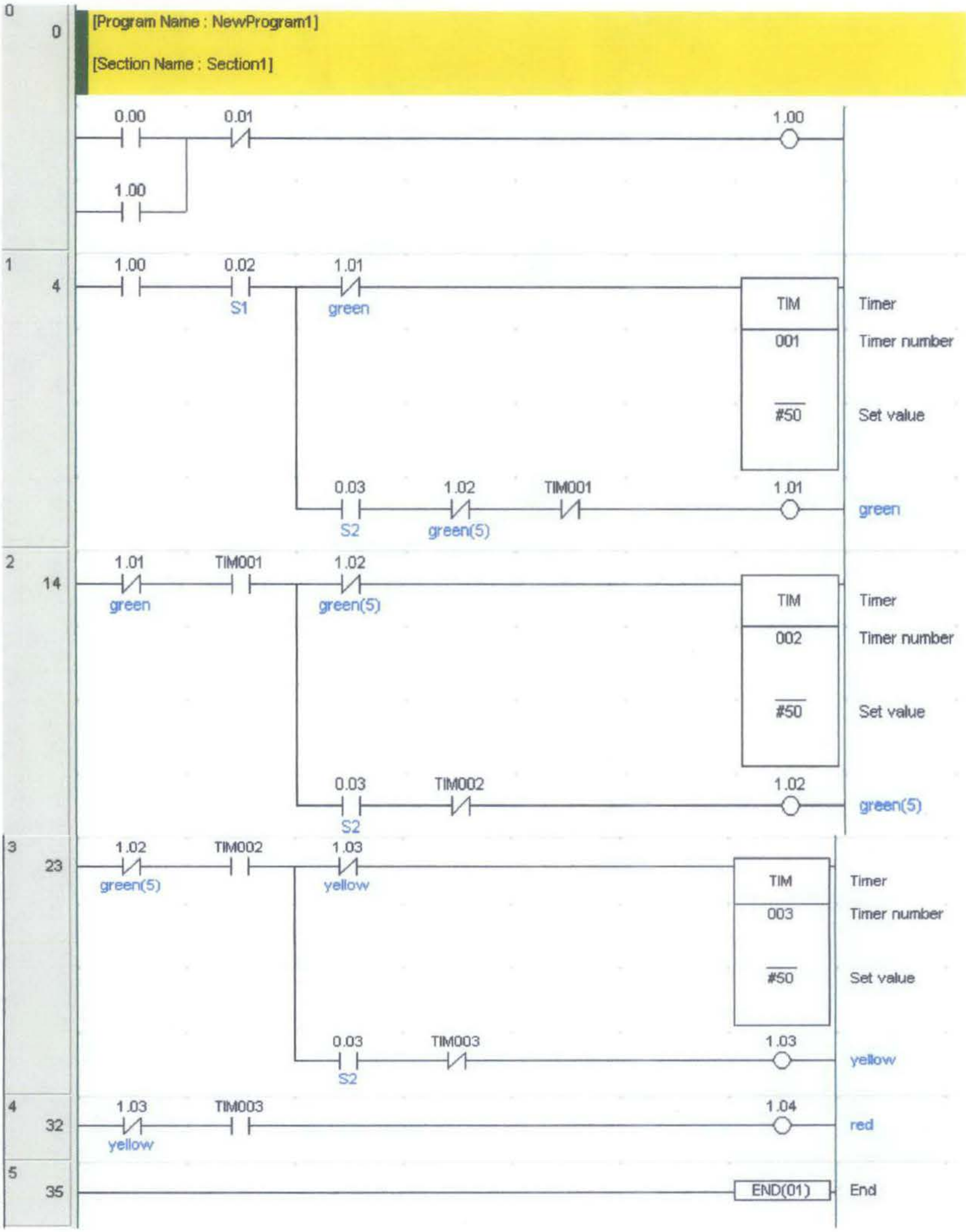

Figure 12: Ladder diagram for traffic congestion sensing system

From Figure 12, the first rung explains the start and reset of the system. In the second rung the normally open contact (NO) with the S1 comment represents the infrared sensor. When the sensor detects a passing vehicle, it will close its contact and starts the timer (TIM01). If the second sensor (NO contact 0.003) detects a passing vehicle before the timer finishes counting, then it will output a green light to indicate smooth traffic. In the second rung, also a normally closed (NC) contact is used to reset the timer if the second sensor S2 detects a passing vehicle before the timer finishes counting.

The third rung illustrates if the second sensor does not detect a moving vehicle within the timer count indicating the vehicle is traveling at a slower speed then another timer (TIM02) turned ON. If the second sensor S2 detects a passing vehicle within the second timer count, then the green light will be ON. Based on the system, it still output a green light because the vehicle may be traveling at speeds which would not cause congestion. Similar with the rung before, a NC contact will be used to reset the second timer if sensor S2 detects a passing vehicle within TIM02's count.If S2 still has not detected the vehicle after TIM02 finishes count, then it will output a yellow light to indicate mild congestion. If still the sensor S2 has not detected a vehicle after the third timer TIM03, then a red light will be ON to indicate traffic congestion.

4.3 Discussion

4.3.1 Design consideration

Sensors

In this project, infrared emitters and detectors are used as the vehicle detecting sensor instead of using CCTVs or cameras. This is due to the length of highways which normally stretch a long distance. Using CCTVs or cameras coupled with image processing to detect vehicles will incur a higher cost. Furthermore, infrared detectors are easy to maintain and fairly simple sensors where else CCTVs or cameras are complicated circuits in which maintenance will definitely cost more.

Instead, cameras are placed only at strategic locations where higher probability of occurrence of incidents. The camera will be used as a manual tool for the user at the control room to monitor.

Processor

The PLC and the microcontroller is being used in this project to process the sensors output and provide an output based on the processors instructions. The PLC is chosen instead of other hardware processing systems because the PLC is proven to be reliable (has very low downtime) and is sequential based which fits the project. Unlike the computer which has many bugs that will eventually stall or cause it to freeze, the PLC has little of it or none. A microcontroller is also used. This is because the PLC cannot directly be connected to a LCD display or a keypad. Therefore the microcontroller is used to interpret the LCD display coupled with the keypad and is connected to the PLCs input.

Indicators

Indicators are used as an output device for alert. In this project, several types of indicators will be used to alert both the highway users and also the staff in the control room. LEDs will be used as a representative of pilot lights to indicate warning for the prototype. Different color LEDs represents different stages of congestion as mention above. The LEDs will be placed along the highway to assist the road users on the traffic conditions. Besides LEDs will also be placed at the entrances of highways to notify road users on the traffic condition on the highway before they enter the highway. This is to prevent further congestion. Coupled with the LEDs, an LCD display will be placed at every entrance (tolls) along the highway to provide an alternative route only if the highway is badly congested. The alternative route is designed to be keyed in by the personnel in the control room and he is to do it manually.

4.2.3 Cost consideration

This project is designed to be able to provide effective congestion sensing at highways with low cost incurred. An estimation of the cost of this project will be shown in Table 3 and Table 4.

Table 3: Estimated cost of the prototype (for 1km long)

Items	Quantity	Estimated Cost
OMRON PLC	1	RM 1500
PIC16F877A Microcontroller	1	RM 30
Infrared sensors	6	RM 24
LCD display	1	RM 80
Pilot lights (indicators)	6	RM 18
Miscellaneous	-	RM 50

Total: RM 1702

Table 4: Estimated cost for the real system (for 1km long)

Items	Quantity	Estimated Cost
OMRON PLC	1	RM 3000
PIC16F877A Microcontroller	1	RM 30
Infrared sensors	6	RM 180
LED display	1	RM 2600
Indicator lights	6	RM 120
Miscellaneous	-	RM 2000

Total: RM 7900

4.2.4 Calculations

The infrared sensor circuit shown in Figure 5 is feed with a +5V supply. This is done by using a 9V – 5V voltage regulator (VR7805). This is to ensure the infrared sensors do not overheat and burn. To ensure that the battery won't be short-circuited at the transmitter (because the infrared transmitter has extremely low resistance) side a 100Ω resistor is placed to absorb partial of the current and reduce the voltage entering the infrared transmitter. The simulation done in P-SPICE is shown in Figure 11. The calculations done to produce the current and voltages as shown in Figure 11 is based on ohm's Law where it states:

$$V = I \times R$$

The current at each junction can be calculated by using nodal analysis or mesh analysis. From Figure 9, the resistance of the infrared emitter is very small that is can be negligible and the infrared receiver is represented as a 42K Ω resistor. And the voltages entering the comparator (LM324) will be 3.521V and 2.5V. All the details are shown in Figure 12.

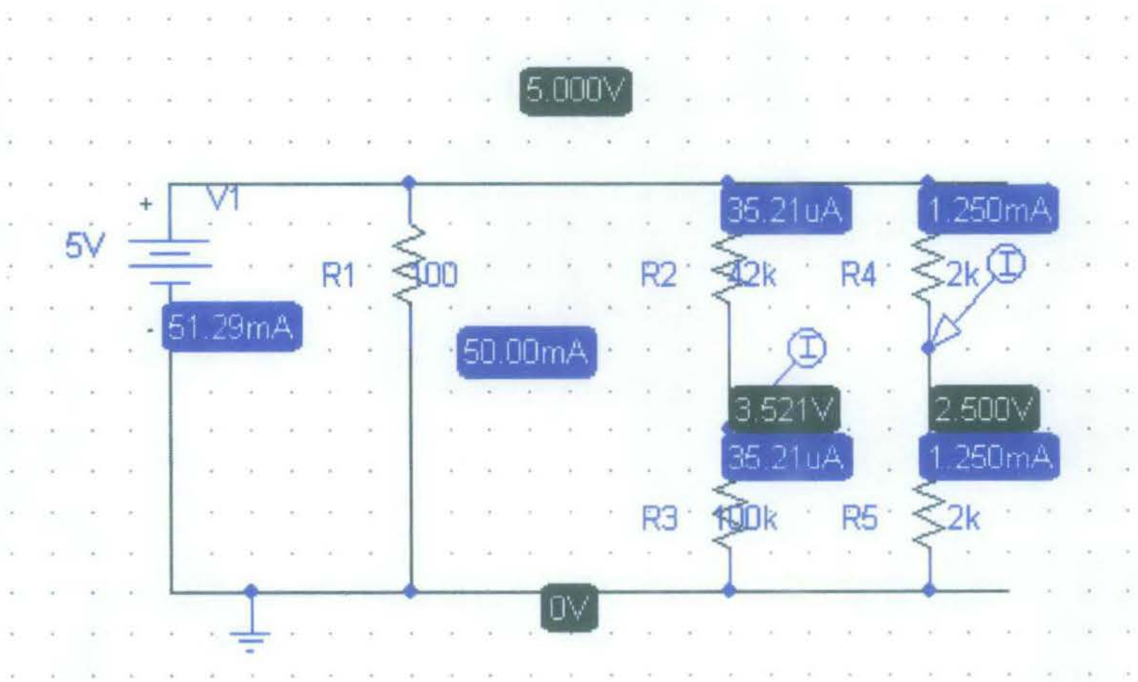

Figure 13: Simulation of infrared circuit

This system can detect traffic congestion by calculating the speed of the vehicle that passes the two sensors. Given situation:

1. Vehicle travel at $\geq$ 90 km/h, therefore for every 60 minutes, it travels 90 km.
   Let vehicle travel 1 km, therefore:

   90 km = 60 min

   1 km = x min

   Therefore, $x = 60 / 90$

   $x \leq 0.67$ min

2. Vehicle travel at $\geq$ 70 km/h, therefore for every 60 minutes, it travels 70 km
   Let vehicle travel at 1 km, therefore:

   70 km = 60 min

   1 km = x min

   Therefore, $x = 60 / 70$

   $x \leq 0.86$ min

3. Vehicle travel at $\geq$ 50 km/h, therefore for every 60 minutes, it travels 50 km
   Let vehicle travel at 1 km, therefore:

   50 km = 60 min

   1 km = x min

   Therefore, $x = 60 / 50$

   $x \leq 1.2$ min

Therefore, this system will detect traffic congestion by taking into consideration 3 stages of congestion. This system will detect the time taken for the vehicle to travel from the 1st sensor to the 2nd sensor and categorize its time taken into the 3 different stages of congestion. The 1st stage is considered as not congested, the 2nd mild congestion / getting congested and the 3rd is congested.

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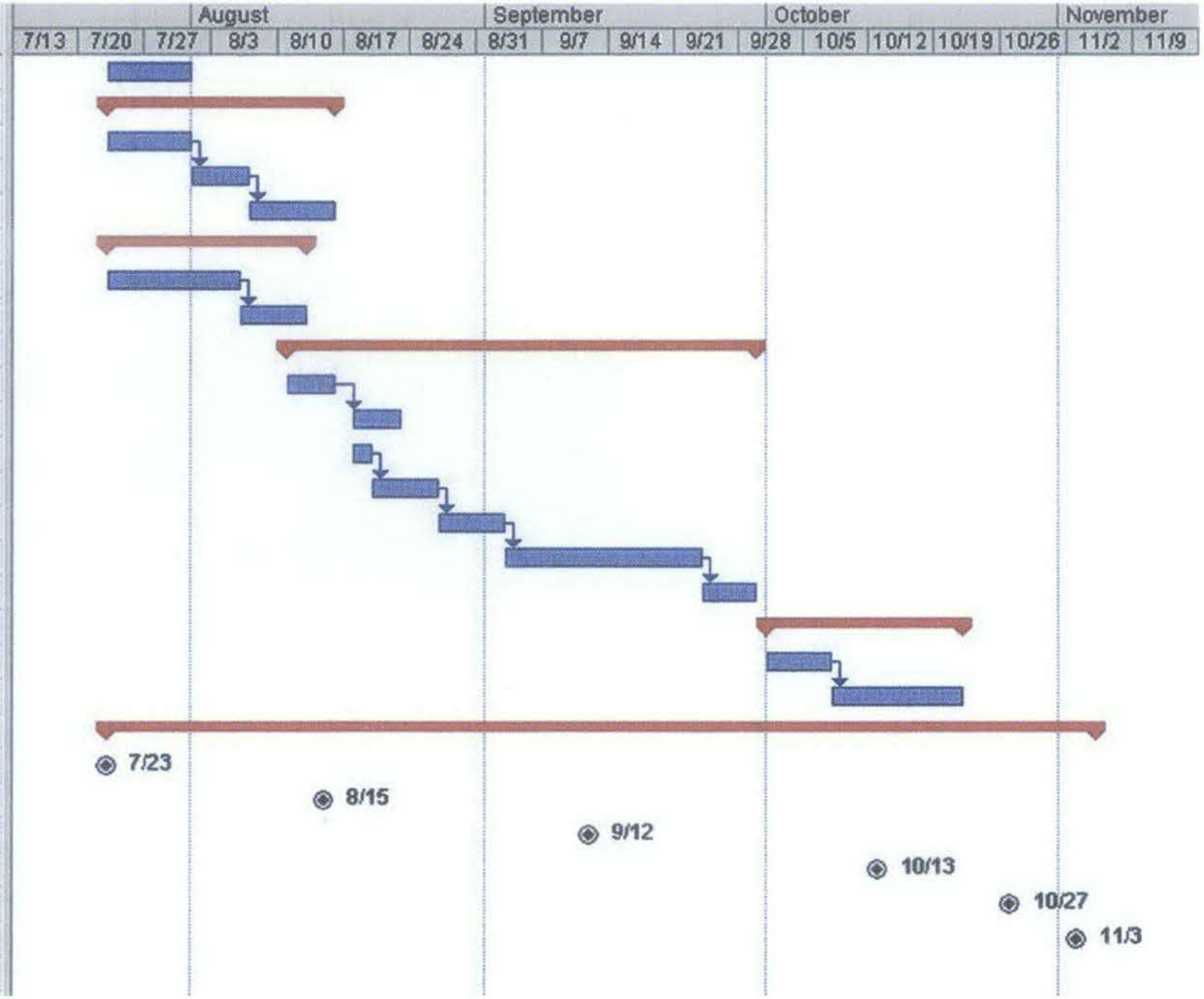
APPENDICES

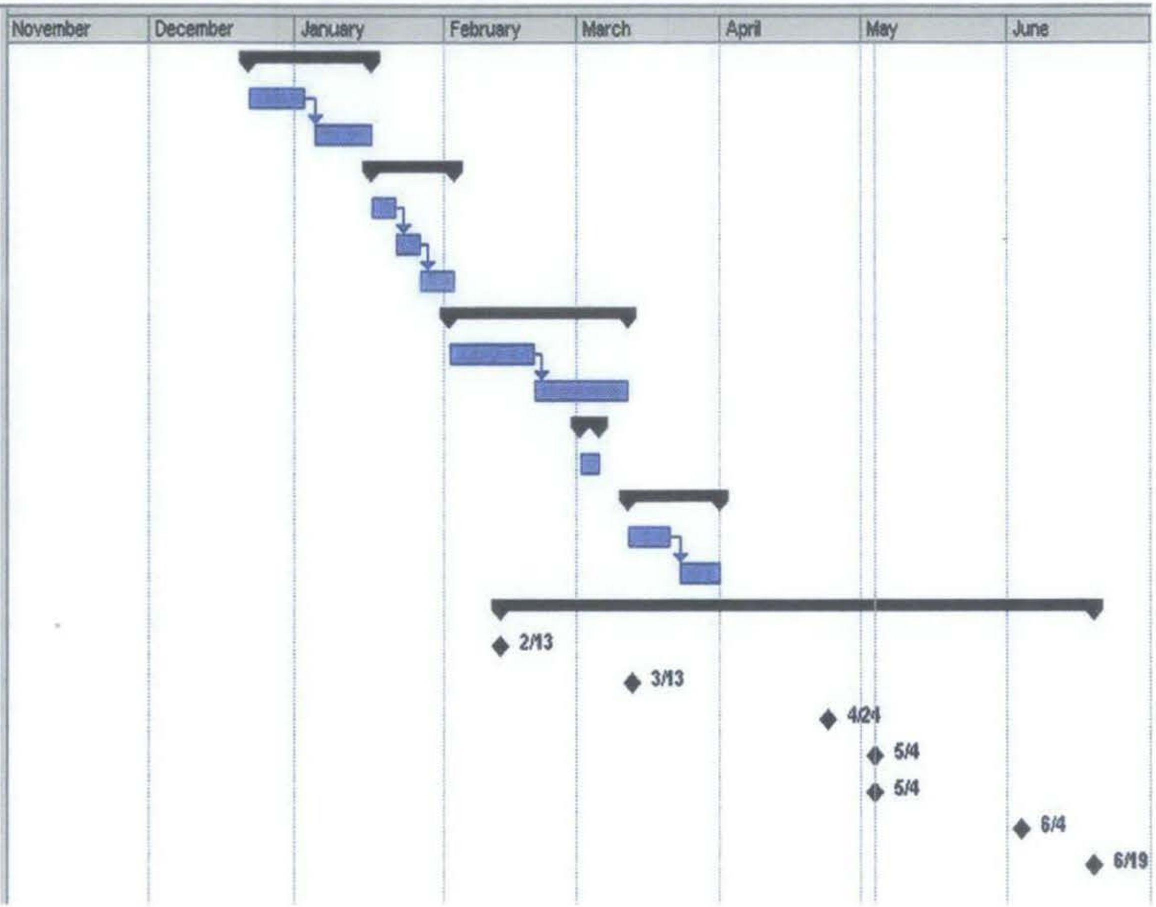
APPENDIX A – Gantt Chart FYP 1

	Task Name	Duration
1	Selection of Project Topic	7 days
2	**Preliminary Design Stage**	**18 days**
3	Problem Identification	7 days
4	Objectives and Scope of Work	4 days
5	Project Planning	7 days
6	**Literature Review and Research**	**15 days**
7	Product Survey	2 wks
8	Design Concept	1 wk
9	**Design of System**	**36 days**
10	Design Criteria	1 wk
11	Design Specifications	5 days
12	Design Constraints	2 days
13	Schematic Diagram	1 wk
14	Circuit Design	1 wk
15	Programming	3 wks
16	Calculation	4 days
17	**Testing and Simulation**	**15 days**
18	Project Simulation	1 wk
19	Simulation and Testing Analysi	2 wks
20	**Project Documentation**	**75 days**
21	Topic Selection	1 day
22	Preliminary Report	1 day
23	Progress Report	1 day
24	Draft Report	1 day
25	Interim Report	1 day
26	Oral Presentation	2 days



APPENDIX B – Gantt Chart FYP 2

	Task Name	Duration	Start	Finish
1	**Design Work**	**20 days**	**Mon 12/22/08**	**Fri 1/16/09**
2	Design Specifications	10 days	Mon 12/22/08	Fri 1/2/09
3	Design Details	10 days	Mon 1/5/09	Fri 1/16/09
4	**Hardware construction**	**13 days**	**Sat 1/17/09**	**Mon 2/2/09**
5	Planning	5 days	Sat 1/17/09	Wed 1/21/09
6	Purchase material	3 days	Thu 1/22/09	Mon 1/26/09
7	Assembly	5 days	Tue 1/27/09	Mon 2/2/09
8	**Programming**	**28 days**	**Mon 2/2/09**	**Wed 3/11/09**
9	PLC	14 days	Mon 2/2/09	Thu 2/19/09
10	PIC	14 days	Fri 2/20/09	Wed 3/11/09
11	**Circuit contrruction**	**4 days**	**Mon 3/2/09**	**Thu 3/5/09**
12	Infrared sensors	4 days	Mon 3/2/09	Thu 3/5/09
13	**Prototype**	**14 days**	**Thu 3/12/09**	**Tue 3/31/09**
14	Assembly	7 days	Thu 3/12/09	Fri 3/20/09
15	Testing	7 days	Mon 3/23/09	Tue 3/31/09
16	**Project Documentation**	**91 days**	**Fri 2/13/09**	**Fri 6/19/09**
17	Progress Report I	0 days	Fri 2/13/09	Fri 2/13/09
18	Progress Report II	0 days	Fri 3/13/09	Fri 3/13/09
19	Draft Report	0 days	Fri 4/24/09	Fri 4/24/09
20	Final Report (soft cove	0 days	Mon 5/4/09	Mon 5/4/09
21	Technical Report	0 days	Mon 5/4/09	Mon 5/4/09
22	Oral Presentation	0 days	Thu 6/4/09	Thu 6/4/09
23	Final Report (hard cove	0 days	Fri 6/19/09	Fri 6/19/09



APPENDIX C – C Programming for alternative route

```
#include <16F877a.h>
#fuses HS,NOPROTECT,NOBROWNOUT,NOWDT,NOPUT,NOLVP
#use delay(clock=20000000)
#include <lcd.c>
void main ()
{
   while (1)
   {
   lcd_init();
   if (input(PIN_B0)==0 && input(PIN_B1)==0)
   {lcd_putc("drive sa");
   lcd_putc("\n");
   lcd_putc("vely");
   delay_ms(200);
   }
   else if (input(PIN_B0)==1 && input(PIN_B1)==0)
   {
   lcd_gotoxy(1,1);
   lcd_putc("alternat");
   lcd_putc("\n");
   lcd_putc("ive 1");
   delay_ms(200);
   }
   else if(input(PIN_B0)==0 && input(PIN_B1)==1)
   {
   lcd_gotoxy(1,1);
   lcd_putc("alternat");
   lcd_putc("\n");
   lcd_putc("ive 2");
   delay_ms(200);
   }
   else if (input(PIN_B0)==1 && input(PIN_B1)==1)
   {
   lcd_putc("drive sa");
   lcd_putc("\n");
   lcd_putc("vely");
   delay_ms(200);
   }
   else
   {
   lcd_putc("drive sa");
   lcd_putc("\n");
   lcd_putc("vely");
   delay_ms(200);
   }
   }
}
```

APPENDIX D – Pictures of the prototype

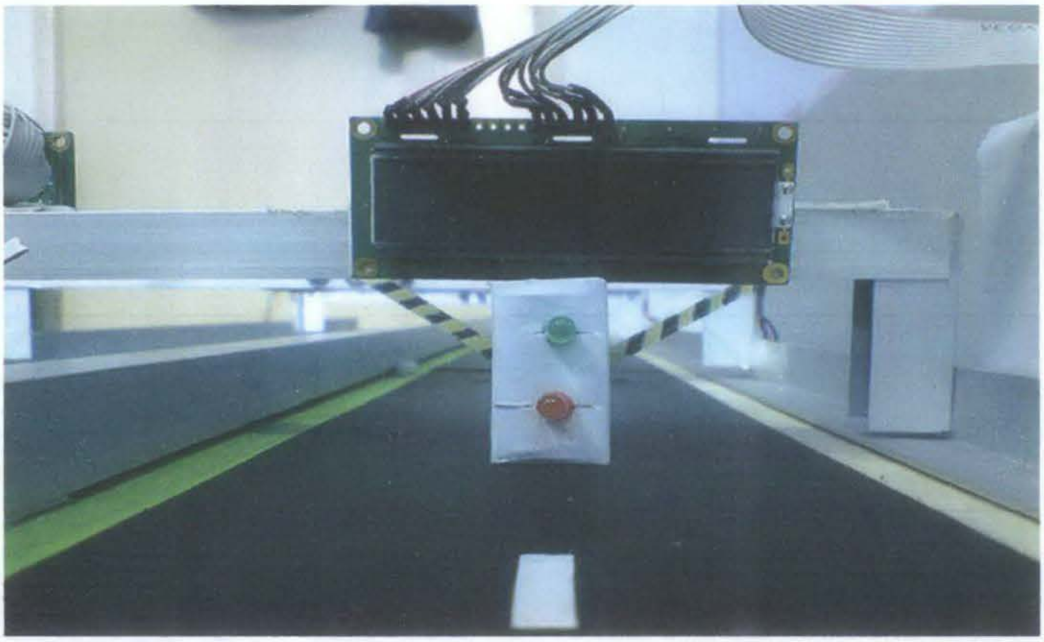


Figure 1: LCD display to display alternative route at tool booth / entrance of the highway

Figure 2: Overview of the final constructed prototype (1)

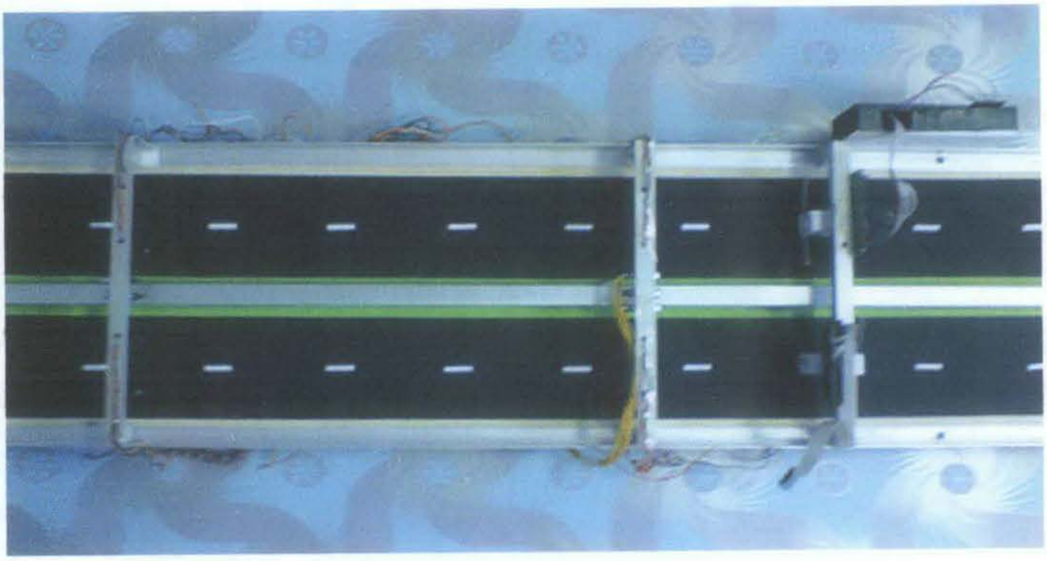
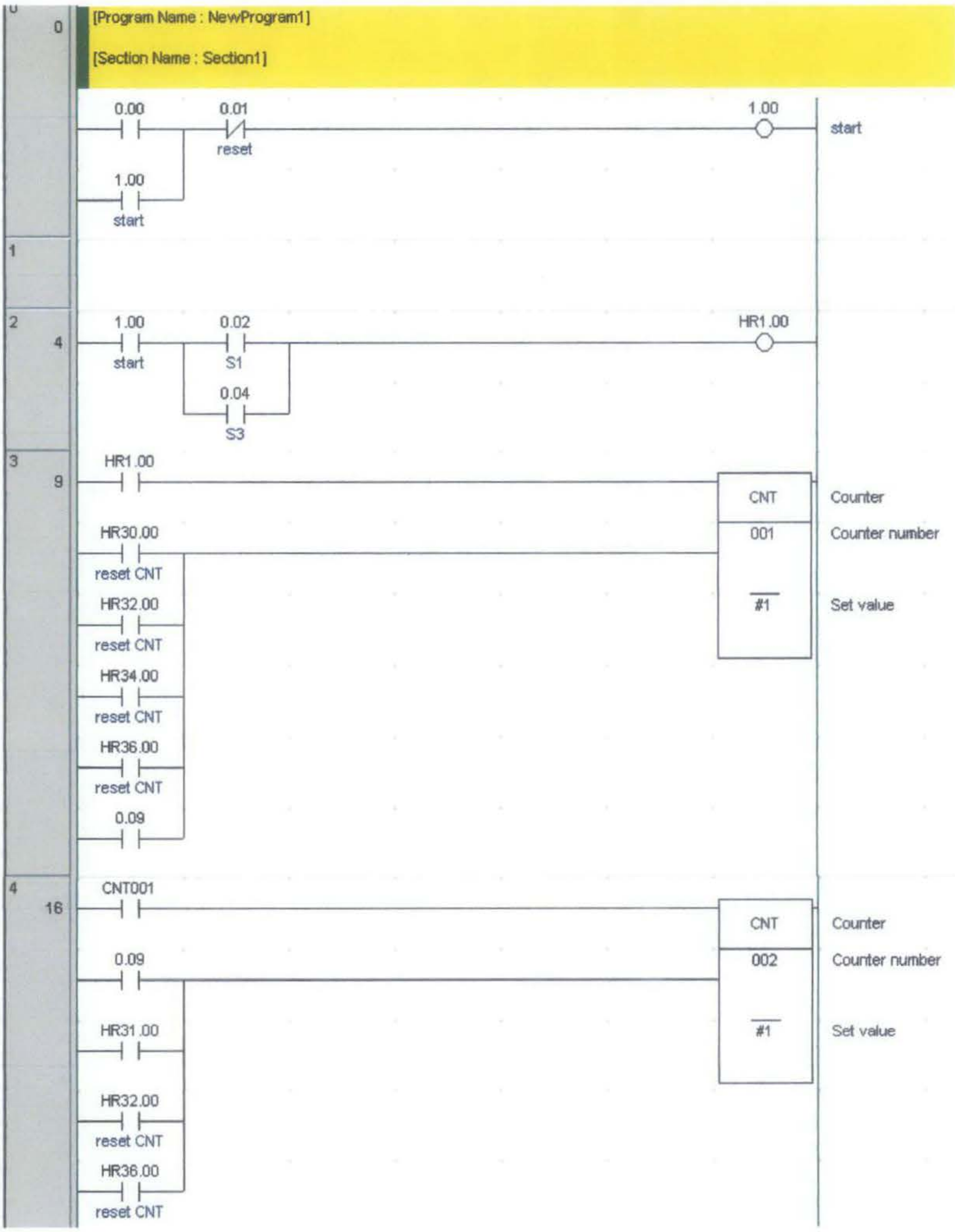
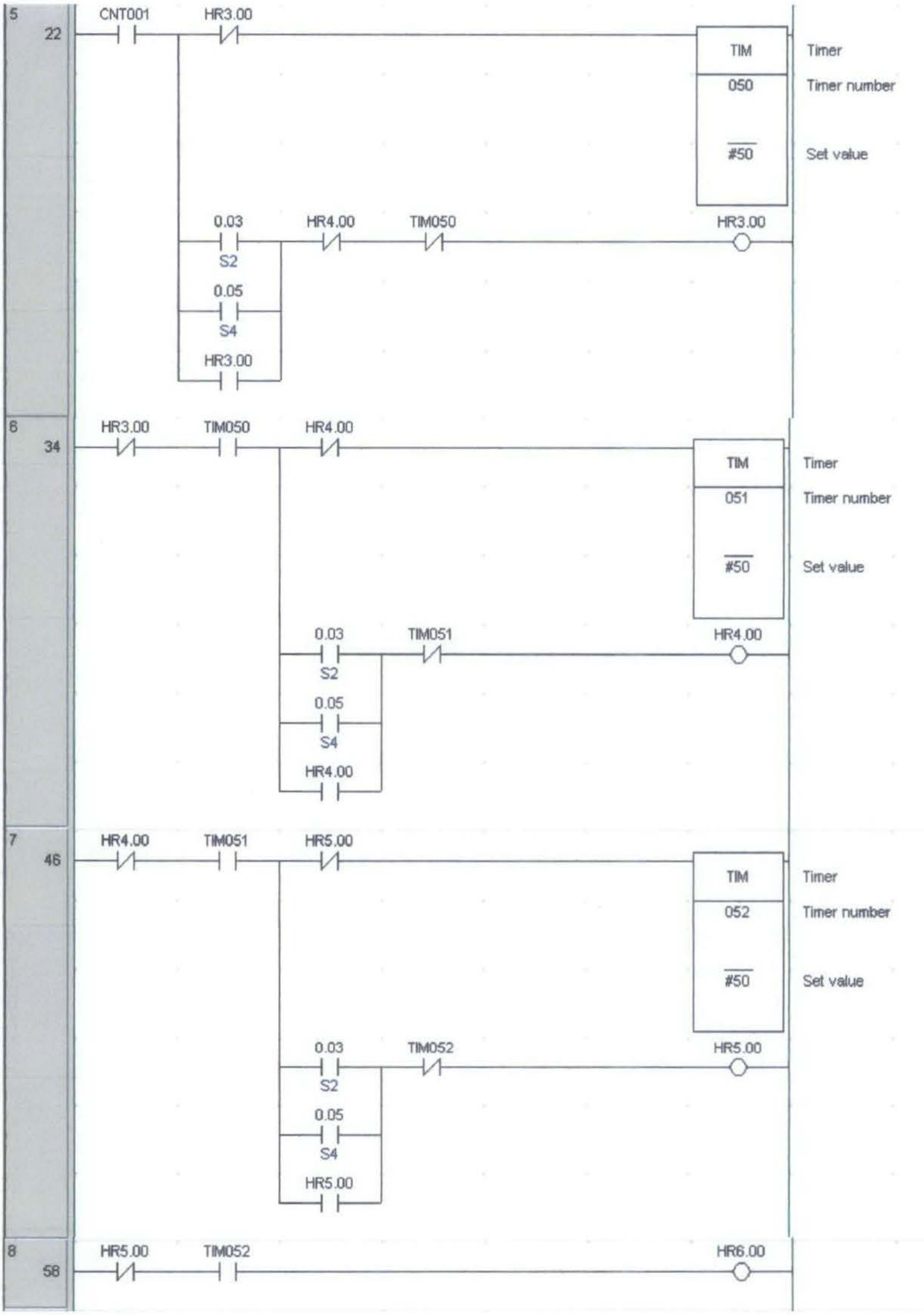
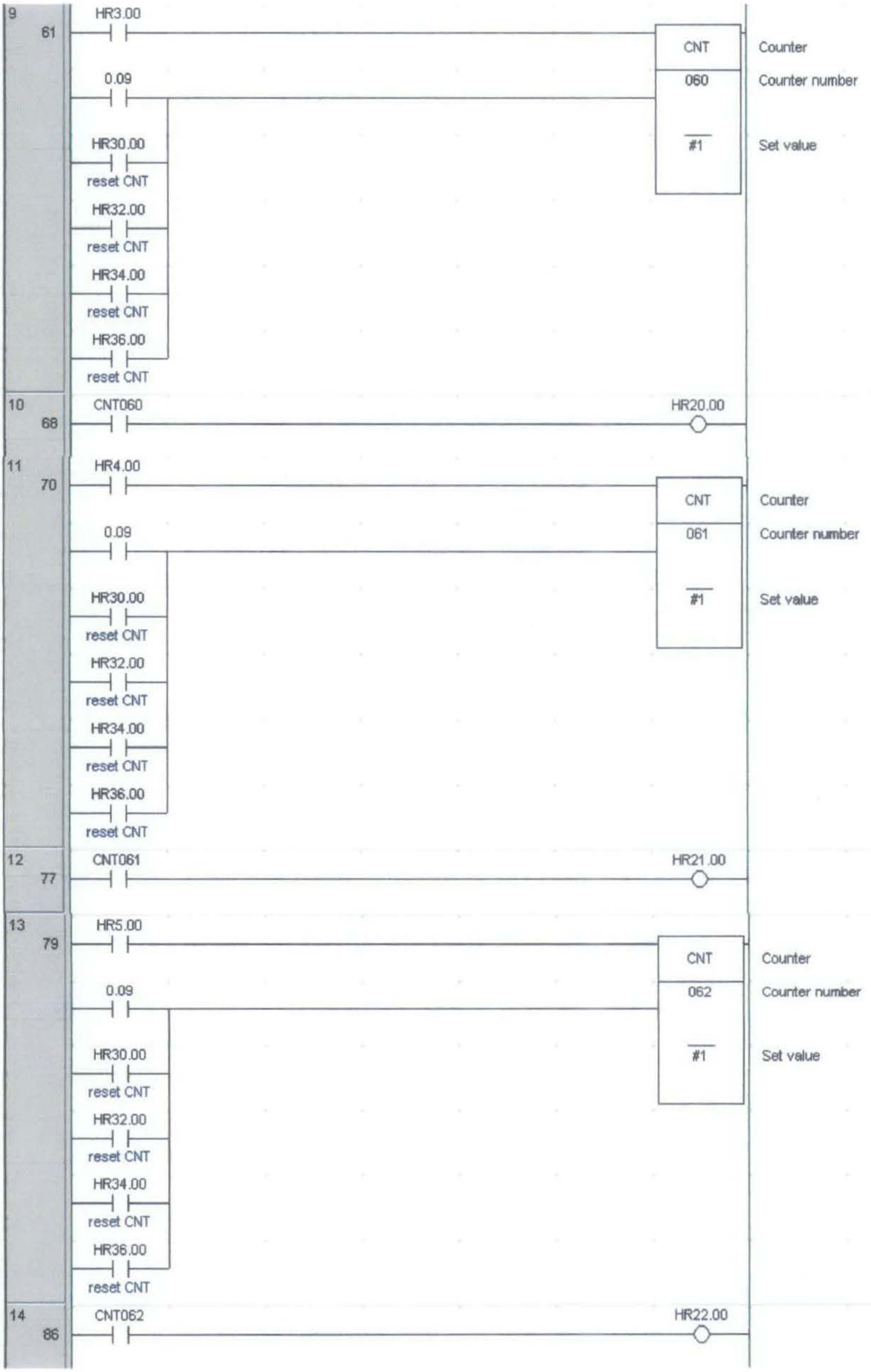


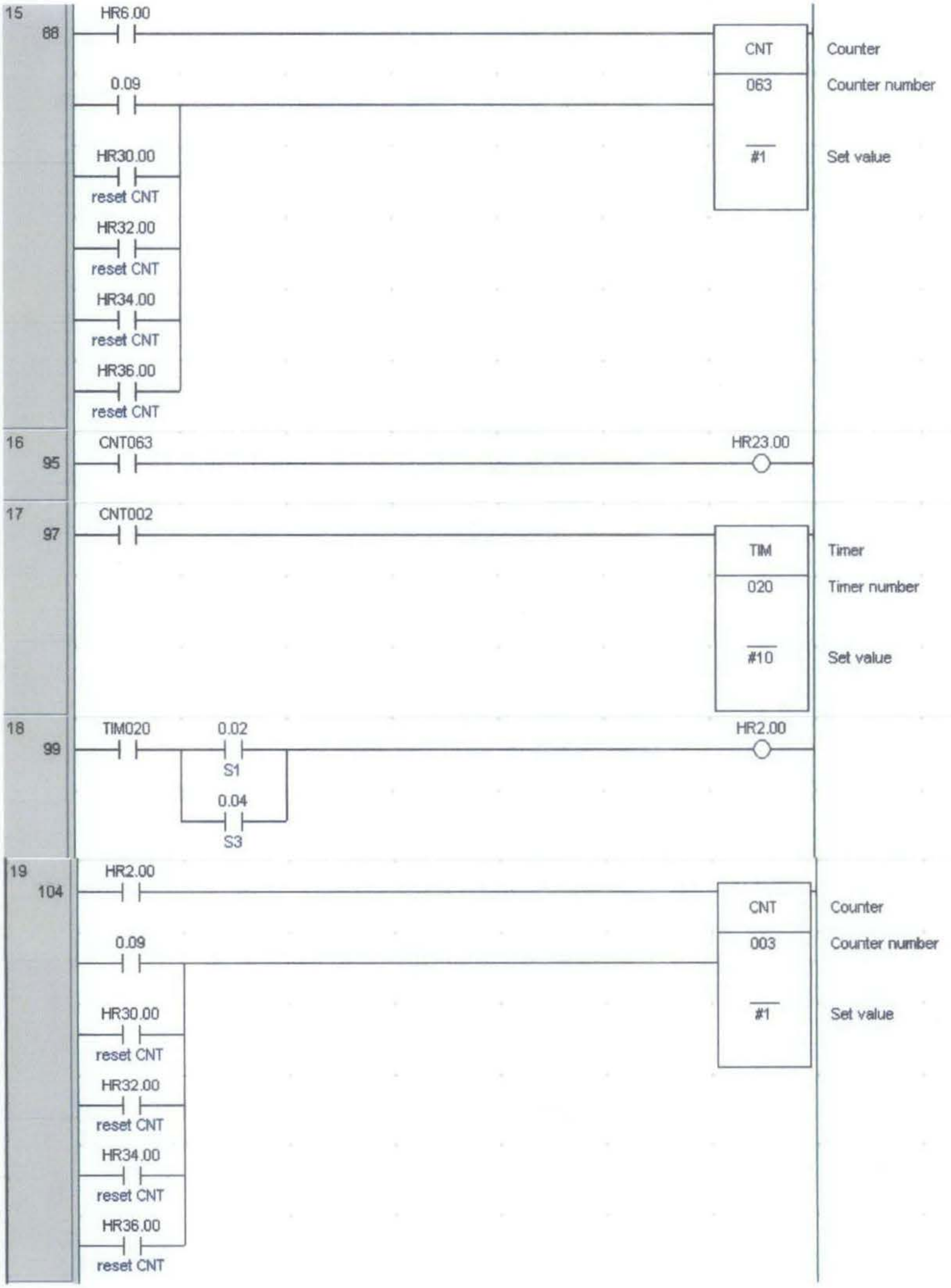
Figure 3: Overview of the final constructed prototype (2)

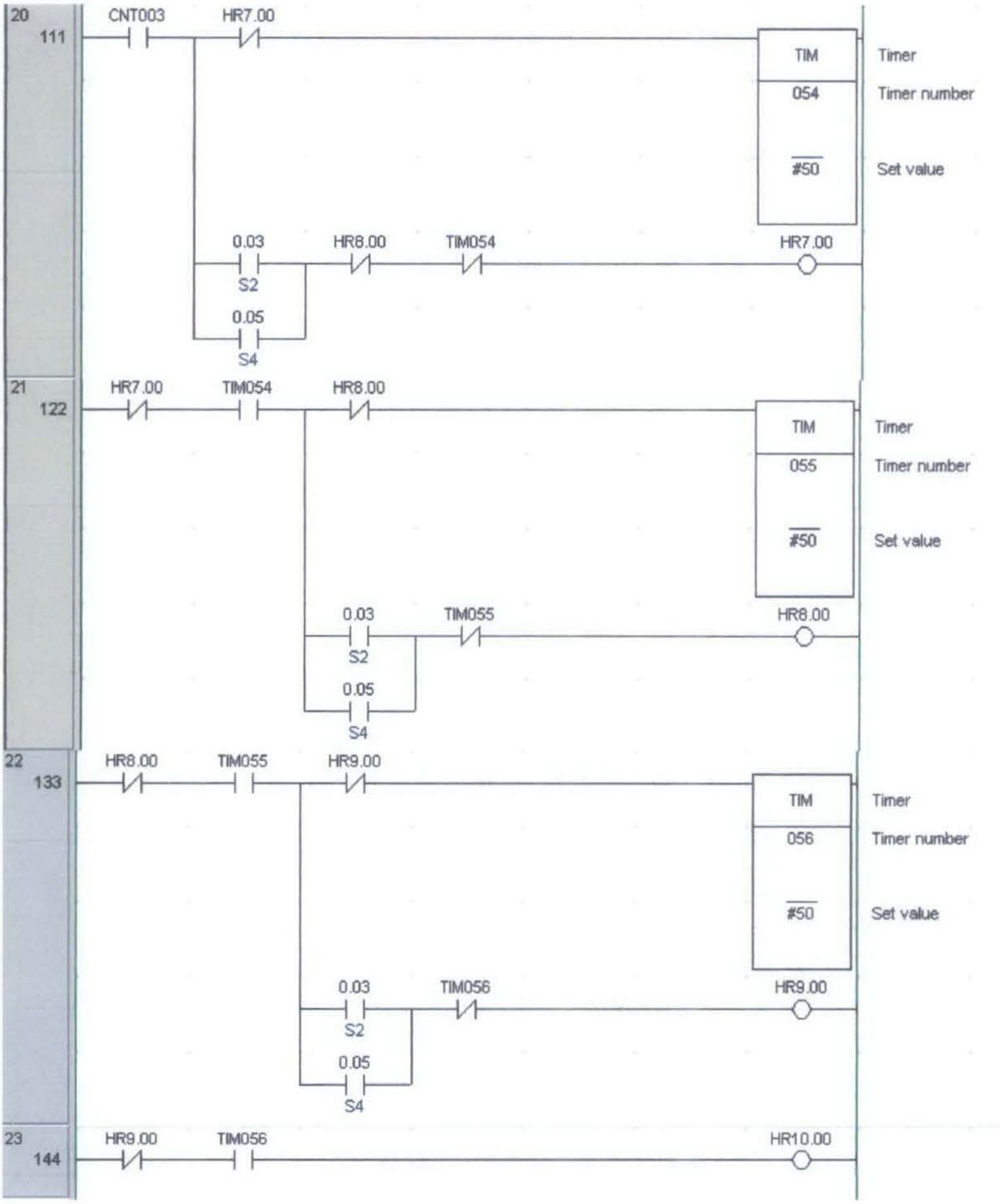
APPENDIX E – Ladder logic for PLC programming

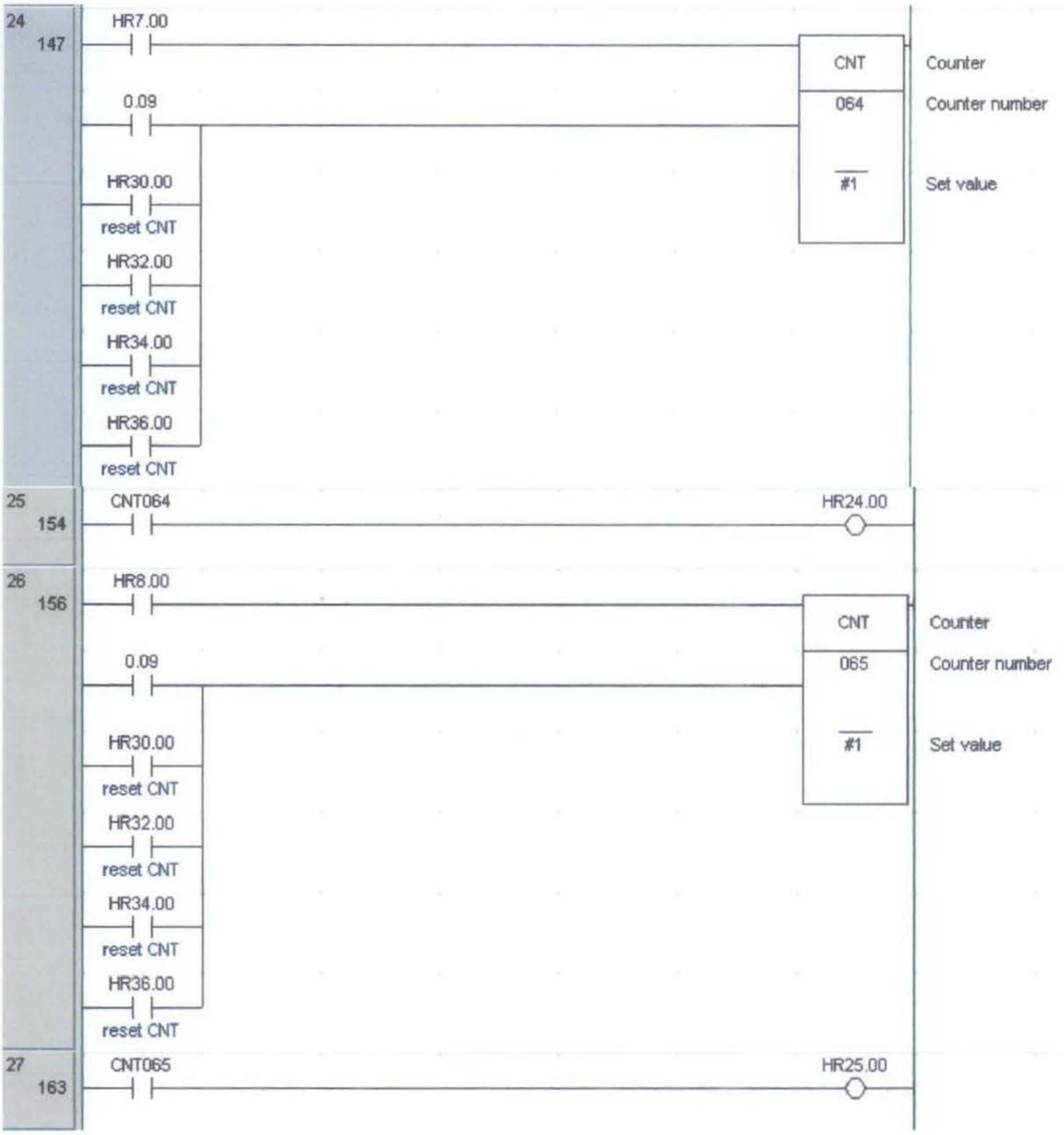


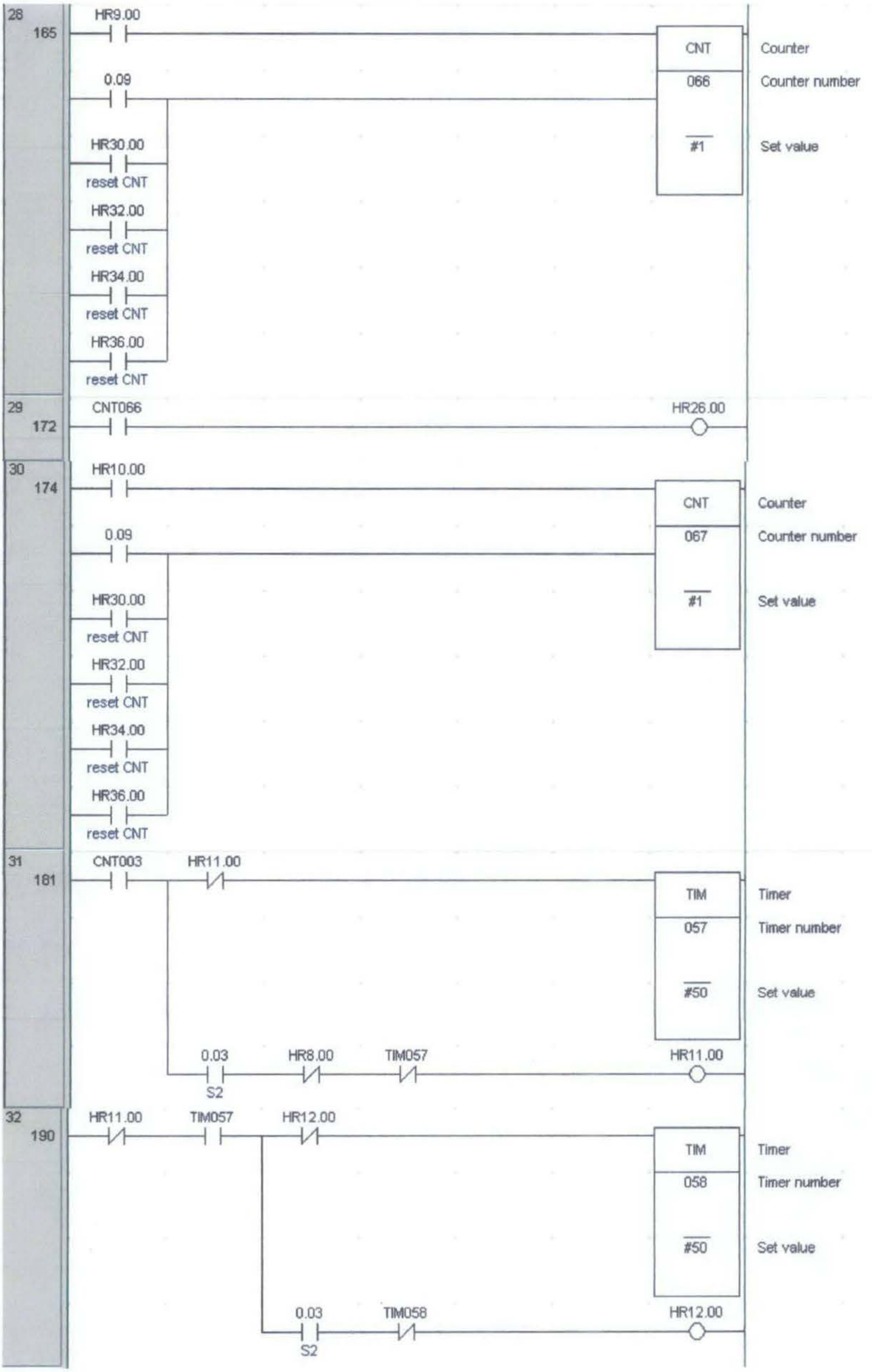

5
22
CNT001
HR3.00
TIM
Timer
050
Timer number
#50
Set value
0.03
S2
HR4.00
TIM050
HR3.00
0.05
S4
HR3.00
6
34
HR3.00
TIM050
HR4.00
TIM
Timer
051
Timer number
#50
Set value
0.03
S2
TIM051
HR4.00
0.05
S4
HR4.00
7
46
HR4.00
TIM051
HR5.00
TIM
Timer
052
Timer number
#50
Set value
0.03
S2
TIM052
HR5.00
0.05
S4
HR5.00
8
58
HR5.00
TIM052
HR6.00

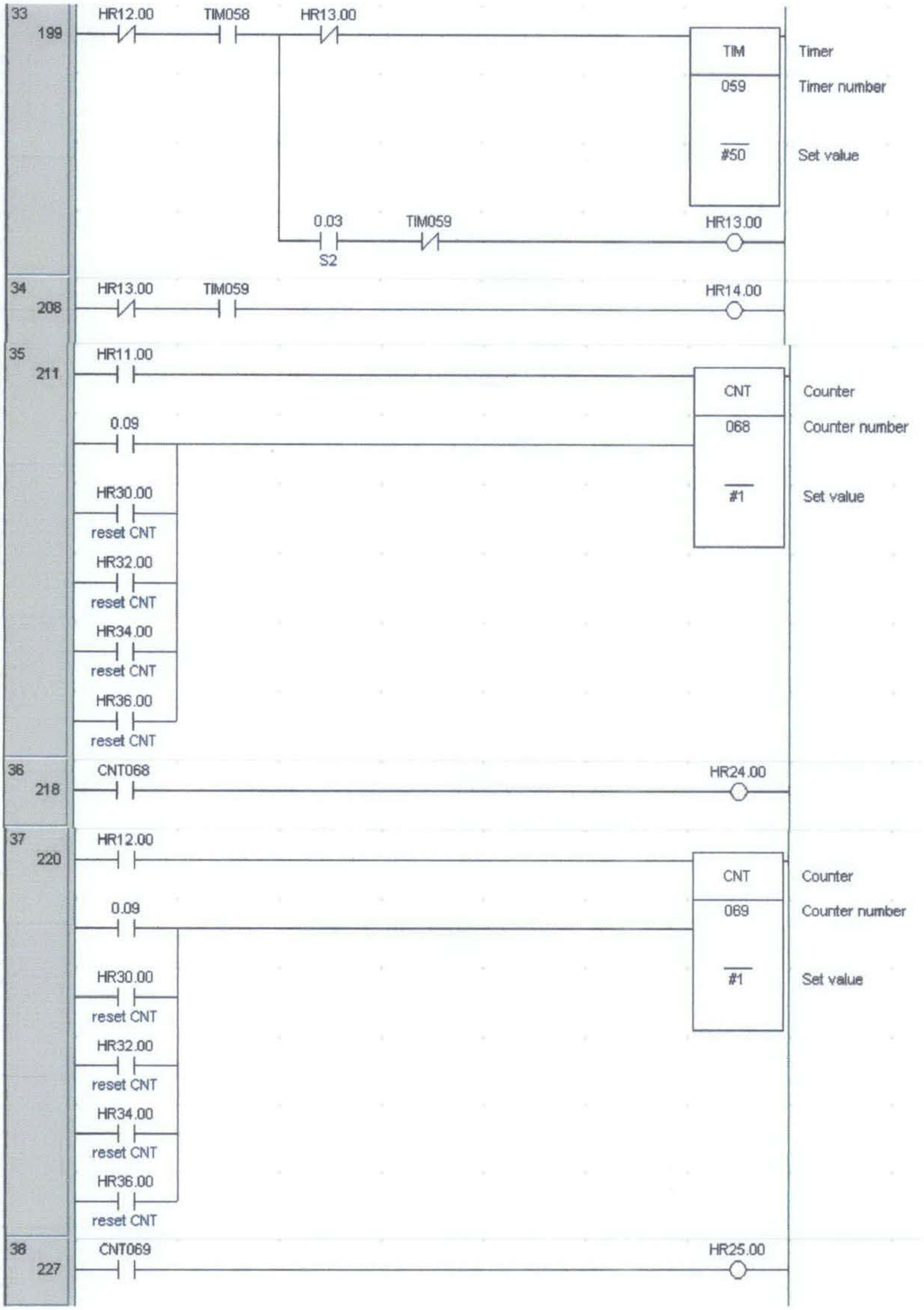

9
61
HR3.00
CNT
Counter
0.09
060
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
10
68
CNT060
HR20.00
11
70
HR4.00
CNT
Counter
0.09
061
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
12
77
CNT061
HR21.00
13
79
HR5.00
CNT
Counter
0.09
062
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
14
86
CNT062
HR22.00

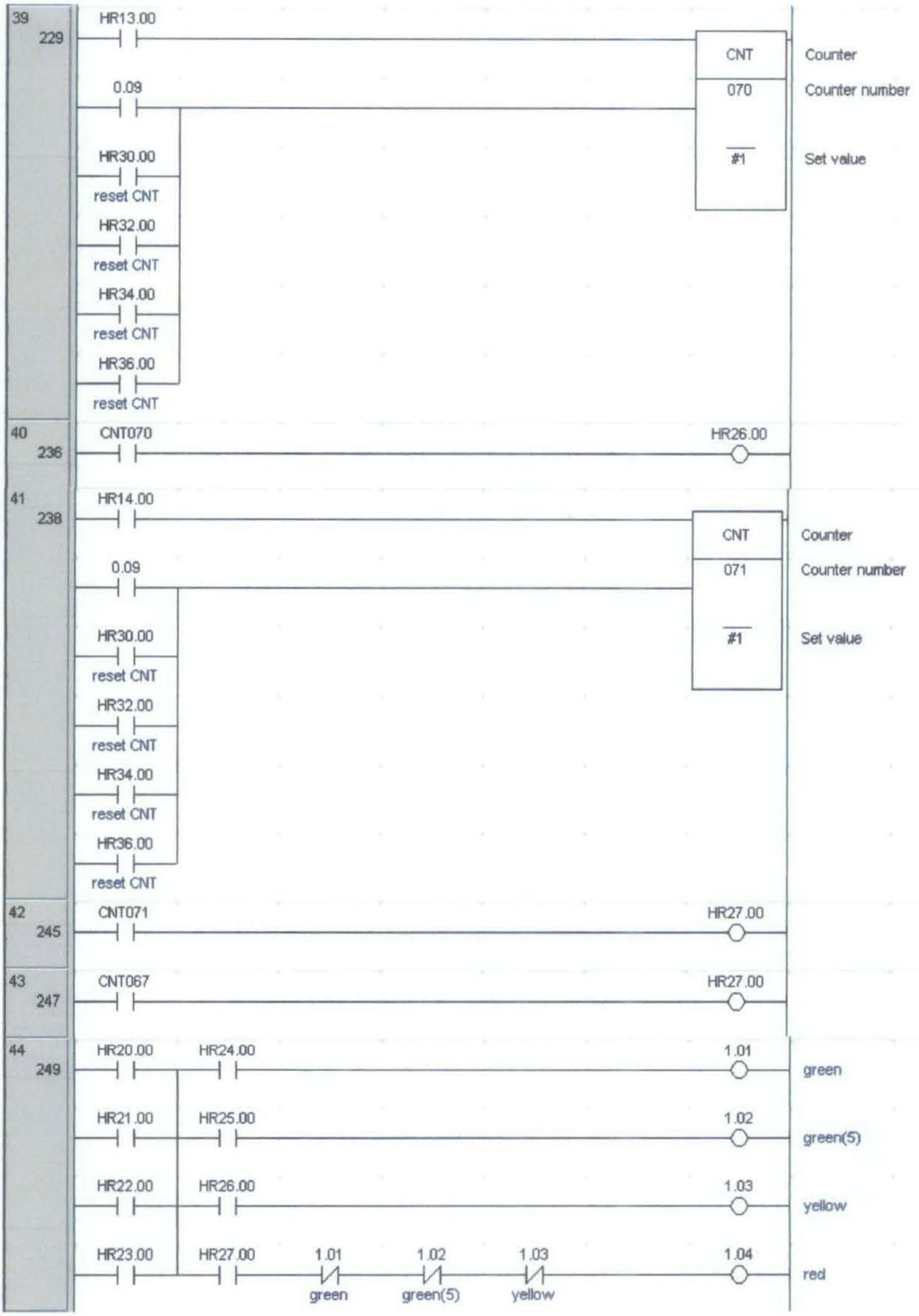

15
88
HR6.00
CNT
Counter
0.09
063
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
16
95
CNT063
HR23.00
17
97
CNT002
TIM
Timer
020
Timer number
#10
Set value
18
99
TIM020
0.02
HR2.00
S1
0.04
S3
19
104
HR2.00
CNT
Counter
0.09
003
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT


20
111
CNT003
HR7.00
TIM
054
#50
Timer
Timer number
Set value
0.03
S2
0.05
S4
HR8.00
TIM054
HR7.00
21
122
HR7.00
TIM054
HR8.00
TIM
055
#50
Timer
Timer number
Set value
0.03
S2
0.05
S4
TIM055
HR8.00
22
133
HR8.00
TIM055
HR9.00
TIM
056
#50
Timer
Timer number
Set value
0.03
S2
0.05
S4
TIM056
HR9.00
23
144
HR9.00
TIM056
HR10.00

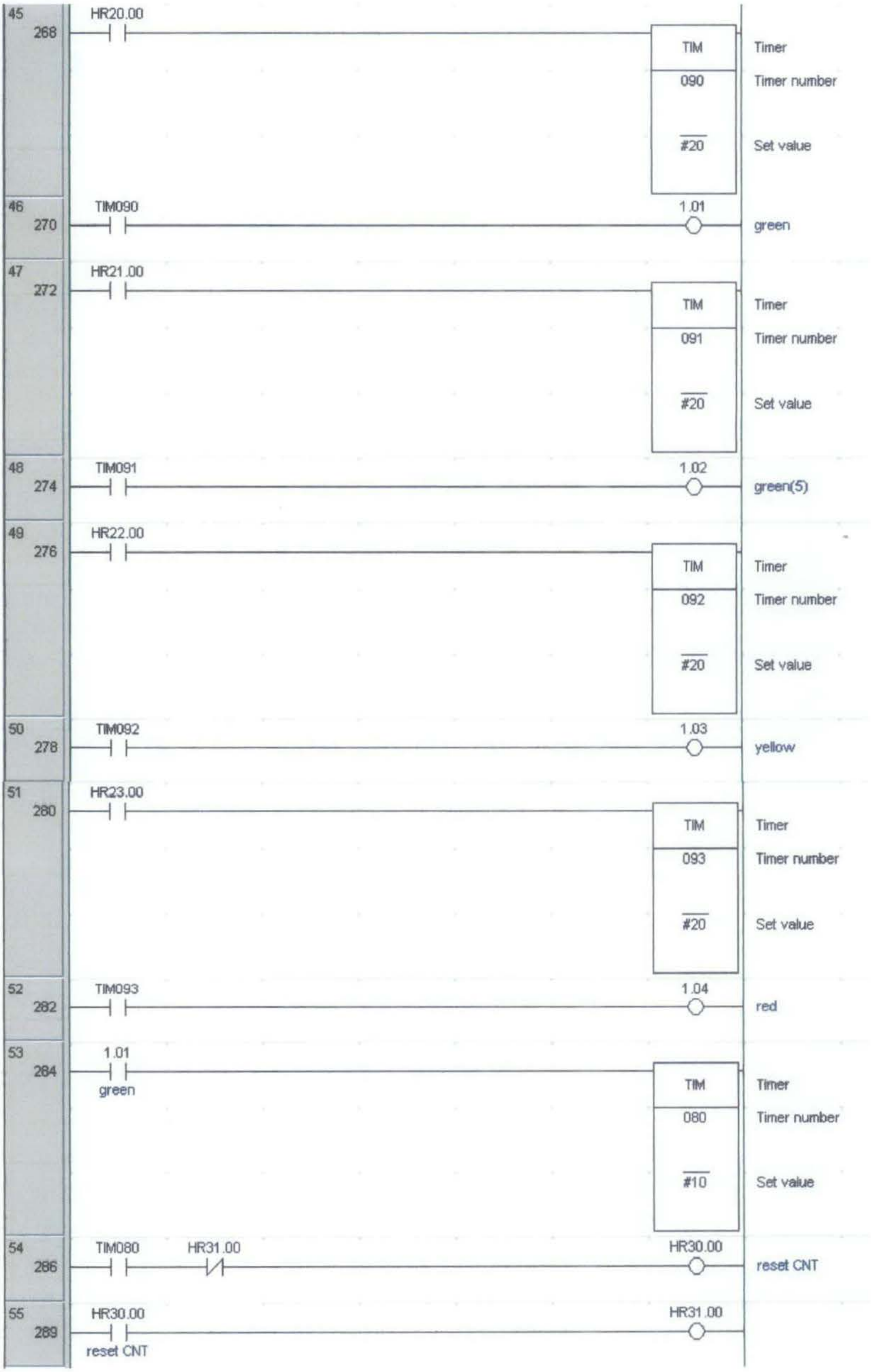

24
147
HR7.00
CNT
Counter
0.09
064
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
25
154
CNT064
HR24.00
26
156
HR8.00
CNT
Counter
0.09
065
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
27
163
CNT065
HR25.00

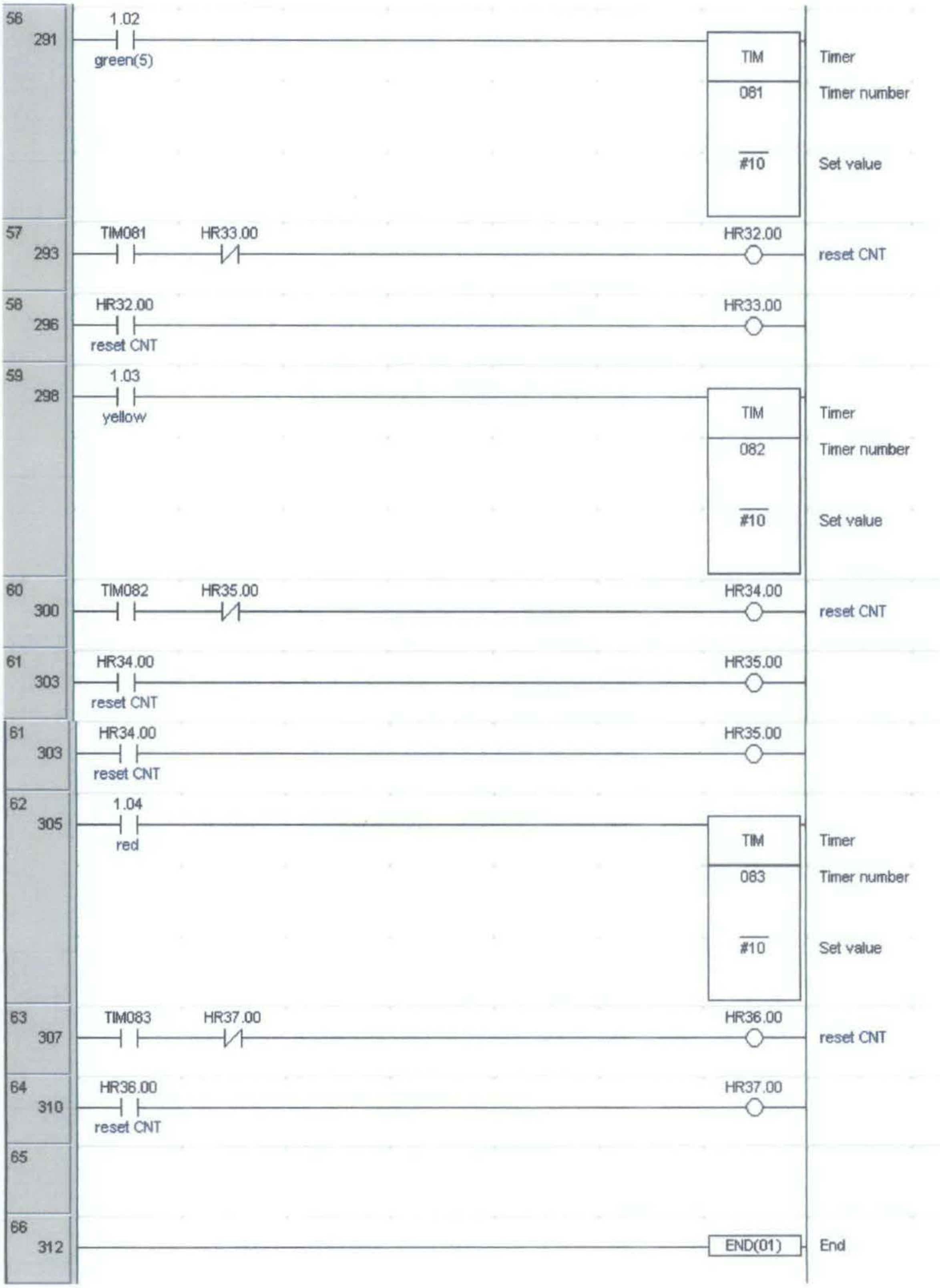

28
165
HR9.00
CNT
Counter
0.09
066
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
29
172
CNT066
HR26.00
30
174
HR10.00
CNT
Counter
0.09
067
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
31
181
CNT003
HR11.00
TIM
Timer
057
Timer number
#50
Set value
0.03
HR8.00
TIM057
HR11.00
S2
32
190
HR11.00
TIM057
HR12.00
TIM
Timer
058
Timer number
#50
Set value
0.03
TIM058
HR12.00
S2


33
199
HR12.00
TIM058
HR13.00
TIM
Timer
059
Timer number
#50
Set value
0.03
TIM059
HR13.00
S2
34
208
HR13.00
TIM059
HR14.00
35
211
HR11.00
CNT
Counter
0.09
068
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
36
218
CNT068
HR24.00
37
220
HR12.00
CNT
Counter
0.09
069
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
38
227
CNT069
HR25.00



39
229
HR13.00
CNT
Counter
0.09
070
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
40
236
CNT070
HR26.00
41
238
HR14.00
CNT
Counter
0.09
071
Counter number
HR30.00
#1
Set value
reset CNT
HR32.00
reset CNT
HR34.00
reset CNT
HR36.00
reset CNT
42
245
CNT071
HR27.00
43
247
CNT067
HR27.00
44
249
HR20.00
HR24.00
1.01
green
HR21.00
HR25.00
1.02
green(5)
HR22.00
HR26.00
1.03
yellow
HR23.00
HR27.00
1.01
1.02
1.03
1.04
red
green
green(5)
yellow


45
268
HR20.00
TIM
090
#20
Timer
Timer number
Set value
46
270
TIM090
1.01
green
47
272
HR21.00
TIM
091
#20
Timer
Timer number
Set value
48
274
TIM091
1.02
green(5)
49
276
HR22.00
TIM
092
#20
Timer
Timer number
Set value
50
278
TIM092
1.03
yellow
51
280
HR23.00
TIM
093
#20
Timer
Timer number
Set value
52
282
TIM093
1.04
red
53
284
1.01
green
TIM
080
#10
Timer
Timer number
Set value
54
286
TIM080
HR31.00
HR30.00
reset CNT
55
289
HR30.00
reset CNT
HR31.00


56
291
1.02
green(5)
TIM
Timer
081
Timer number
#10
Set value
57
293
TIM081
HR33.00
HR32.00
reset CNT
58
296
HR32.00
reset CNT
HR33.00
59
298
1.03
yellow
TIM
Timer
082
Timer number
#10
Set value
60
300
TIM082
HR35.00
HR34.00
reset CNT
61
303
HR34.00
reset CNT
HR35.00
61
303
HR34.00
reset CNT
HR35.00
62
305
1.04
red
TIM
Timer
083
Timer number
#10
Set value
63
307
TIM083
HR37.00
HR36.00
reset CNT
64
310
HR36.00
reset CNT
HR37.00
65
66
312
END(01)
End