Development Of Glycol Skid Unit Controller Using PLC

by

Mohd Nadirul Azwan Bin Abdul Manaf

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronics Engineering)

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CERTIFICATION OF APPROVAL

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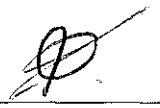
TRONOH, PERAK

SEPTEMBER 2011

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.



MOHD NADIRUL AZWAN BIN ABDUL MANAF

ACKNOWLEDGEMENT

At a very first, I would like to express my gratitude to God for giving me the strength to complete this project. Then, I would like to thanks to my parents and all my family members who give me support and advise when I am in problem.

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Last but not least, I offer my regards to those who support me especially all my friends and staff in Electrical and Electronic Engineering department for contributing their assistance and ideas for this project.

ABSTRACT

The purpose of this project was to introduce an activity of using the ladder diagrams on the learning of programmable logic controller (PLC). Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, and resistance to vibration and electrical noise. Programs to control machine operation are typically stored in non-volatile memory. PLC is a user friendly, microcontroller based, specialized computational device that can carry out many of control function such as distributed control system, process and motion. The advantages of PLC make it a brain of modern industrial control system and this reason, learning PLC operation is very important for modern industrial technologies. PLC can be employed to control processes or machine operations and they offer industrial control systems a very high flexibility of their application. Nowadays, they are becoming very popular among the field of industrial controls of various types. With varying in size and functions, this electronic device are becoming the standard controllers and rapidly replacing the available electronic and pneumatic controllers that still using the hardwire system.

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CHAPTER 1: INTRODUCTION

PROJECT BACKGROUND

Programmable logic controllers (PLC) were initially adopted by industrial automotive industry where hard-wired control panels replaced by designed software when production models changed. Before using the PLC, manufacturing company use a thousand of relay for controlling, sequencing and safety interlock logic. The process for maintenance and troubleshooting the relay logic is very time consuming and expensive. PLC was designed to solve all the problems cause by relay logic systems. These PLCs were programmed in ladder logic, which resembles a schematic diagram of relay logic.

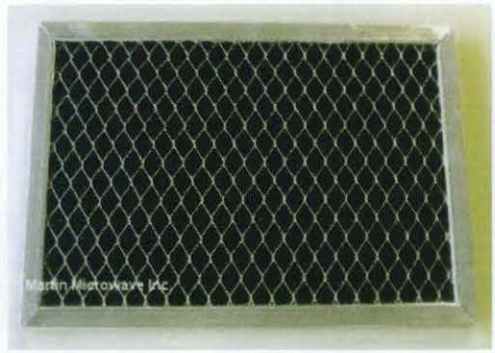
This project will focus on designing a controller of Glycol Skid unit using PLC to replace the existed controller which still using relay logic (hard-wired). For development of this controller, basic tool and equipments will be use such as ABB Programming Software for designing the ladder diagram and several switches as a sensor transmitter for Glycol Skid unit.

GLYCOL REGENERATION SKID PLANT

Glycol Regeneration Skid A5-0601 at GPPB uses to regenerate a glycol. The rich glycol in the plant flows to the Glycol Regeneration Skid where it is regenerated using high pressure stream. Then, the lean glycol from Glycol Regeneration Skid flows through the Glycol Cross Exchanger and is injected to the feed ethane stream (refer to APPENDIX I). There a few equipment use in this plant which are;

EQUIPMENT	DESCRIPTION
RICH/LEAN GLYCOL EXCHANGER  Figure 1:Rich/Lean glycol exchanger [1]	This heat exchanger adds more heat to the rich triethylene glycol (TEG) to increase the flash drum. Any foaming tendency can be reduce when the temperature of flash drum increasing. This exchanger also recovers heat from the lean TEG.
SURGE DRUM  Figure 2: Surge Drum [2]	Surge drums help reduce the effect of flow rate variations between interconnected process units. A low surge drum level can result in reduced capacity while a high level can cause liquid carryover. In an application characterized by alternating inertia and turbulence, stable level output is highly desirable.

STILL COLUM/ REFLUX CONDENSER  Figure 3:Still Colum/Reflux Condenser [3]	This is an area that has resulted in annoying TEG losses. The typical reflux condenser is a coiled tube. The tube can crack/fail and then rich TEG is sprayed into the outlet still column gas stream.
TEG CIRCULATION PUMP  Figure 4:TEG Circulation Pump [4]	Additional energy is needed to overcome friction losses within the pump and connecting piping in order to circulate the glycol. This additional energy is supplied by the TEG circulation pump.
FLASH TANK  Figure 5: Flash Tank [5]	The function of a flash tank is to reduced pressure steam nad allow high-pressure condensate to flash. This reduced pressure steam is then used to supply heat to a "low" pressure supply main. It can also used to reduce and cool to low-pressure steam before re-introducing it to the boiler or condensate receiver.

TEG CARTRIDGE FILTER  Figure 6: TEG Cartridge Filter [6]	The rich stream flows through a cartridge filter to remove solid particles coming from corrosion or TEG degradation.
CHARCOAL FILTER  Figure 7: Charcoal Filter [7]	Charcoal filter is a method of filtering that uses a piece of carbon to remove contaminants and impurities, utilizing chemical adsorption. In general, charcoal filters are more effective at removing a larger number of contaminants.

GYLCOL SKID PUMPS PROCEDURES

These are the procedures for glycol skid unit for the procedures to start up the pump (during Glycol skid unit shutdown), the procedures during normal running (PAL-1014 appeared) and the procedures to manually stop the pump during normal running.

Start up (Glycol Skid Shutdown)

- All pumps not running
- If any of these alarms appeared pump will not running:-
  a) PSH-1014
  b) LSLL-1007
  c) LSHH-1007
  d) LSLL-1033
  e) LSHH-1033
  f) LSLL-1035
- To start pump select pump to run via pump selector switch.
- if PAL-1014 alarm indication appeared :-
  -in 3 minutes, PAL-1014 shall cleared or else pump running will trip.
  -after PAL-1014 cleared, after 30 seconds select pump not running in standby via pump selector To stop pump standby if running, select previous running pump via pump selector switch and push stop button for the standby pump.

During normal running and actual PAL -1014 triggered

- Selected pump running
- If any of these alarm indication appeared pump running will trip :-

  a) PSH-1014
  b) LSLL-1007
  c) LSHH-1007
  d) LSLL-1033
  e) LSHH-1033
  f) LSLL-1035

- If PAL-1014 alarm indication appeared:-
  -in 3 minutes:
    - Standby pump will kick in with current pump running (both pumps running).
    - Standby pump try to normalize PT-1014.
    - If within 3 minutes, PT-1014 normalized then after 30 seconds (if within 30 second, both pump will run) standby pump can be stop(manually by pushing stop button).
    - Or else, both pumps will trip.

During normal running and manually stop the pump

- Press the stop button to stop the running pump.
- If PAL-1014 triggered, refer start up guideline.
- If PAL-1014 not trigger, to start up just presses start button for either of pumps (select pump not running in standby via pump selector switch).

PROBLEM STATEMENT

Currently, the controller for Glycol Skid unit (refer to appendix 1) at GPPB, Petronas Gas Berhad in Kerteh, Terengganu are using relay logic (hard-wired) to control the unit. Relay logic is a method controlling industrial electronic circuit using relay and contact. In some cases, the relay might be easier to install and less expensive but required high maintenance and difficult to troubleshooting. To control a more complex system of the controller need timing, counting and other mathematical calculation and in this case PLC is a better choice because of its flexibility, less cost for complex process and space efficient. This project will look into development of PLC controller to replace the hard-wired controller system.

OBJECTIVE

The objectives of this project are:

- To develop a controller for Glycol Skid unit using PLC
- Design a ladder logic using ABB PLC Programming software to simplify the existed hard-wired control system.

SCOPE OF STUDY

These are the scope of study for Final Year Project 1:

- Learning how to use Allen Bradley Programming Software and its features
- Study of ladder diagram and its symbols that will be implemented in this project.
- Develop flowchart for Glycol Skid project.
- Develop timing diagram for Glycol Skid project.
- Develop the ladder diagram and test it to ABB PLC AC500 to test if meet the requirement of the plant procedures.

CHAPTER 2: LITERATURE REVIEW

PLC has been in existence since the 1969. Initially, they were developed for the automotive industry to replace hard-wired relay control logic that required modification every year. PLC is a special type of controller that use programmable memory to implement function and to store instruction in order to control machines and process [1].It is designed to be operated by engineers with maybe a limited knowledge about the computer and its computing language. Programmable controllers are much like personal computers in that the user can be overwhelmed by the vast array of options and configurations available. Therefore, when it comes to selecting a PLC for an application, experience is the best teacher [2].

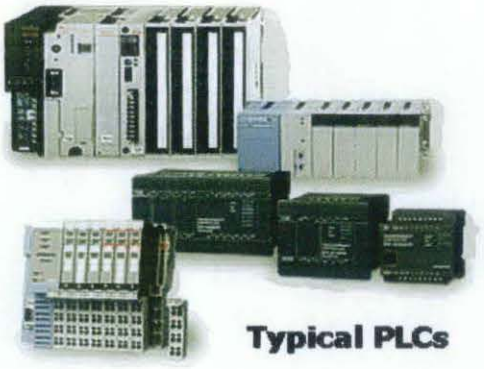


Figure 8: Typical PLC [8]

ADVANTAGES OF AUTOMATION

The PLC is the tool that provides the control for an automated process. Automation will help a manufacturing facility to [3]:

- Gain complete control of the manufacturing process
- Achieve consistency in manufacturing
- Improve quality and accuracy
- Work in difficult or hazardous environments
- Increase productivity

PLC BASIC OPERATION

PLC designed for discrete process. They use a unique programming language called ladder logic [4]. Ladder logic has been developed to resemble relay logic and the decision to use ladder diagram was very strategic. An easy way to interprete ladder diagram is to think the left rail as a positive electrical terminal and right rail as ground. Each rung only has one output. The input are logically 'closed' (slash) or 'open' (no slash) and can be arranged in series (logical AND) or parallel (logical OR). If then the microcomputer scan the inputs, rung' logic is true, then the output is activated; otherwise it is not activated [5].

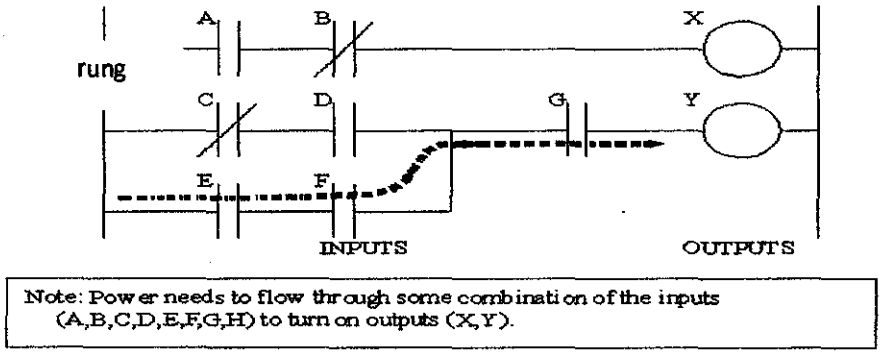
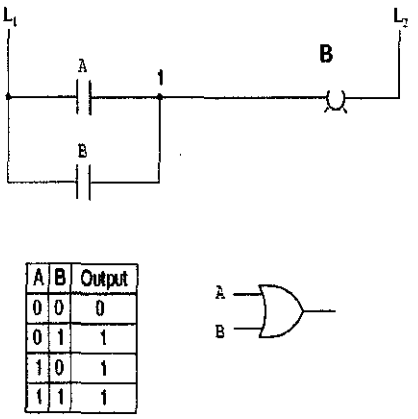
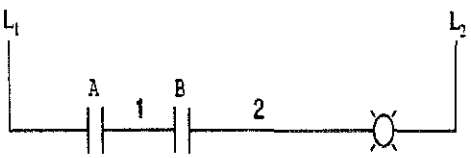


Figure 9: The way to read ladder logic [9]



A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

Figure 10 :Logical OR gate[9]



A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

figure 11: Logical AND gate [9]

For figure 10, when A is pushed, the output B will turn on and the input B will also turn on and keep B permanently(until the power is removed). For figure 11, when A is pushed the output will turn on if input B will also been pushed. A ladder diagram can contain multiple rungs, inputs may be used more than once and output can be making interlock situation possible.

PLC CONNECTION

When a plant process controlled by PLC, the input of the plant which is the sensor will make a decision and the update output use to change the position of the actuator. The actuator will drive the system to a new state based on the sensor. This mean that the controller limited by the sensor and if the sensor is unavailable, there is no ways the controller can detect the condition of the plant.

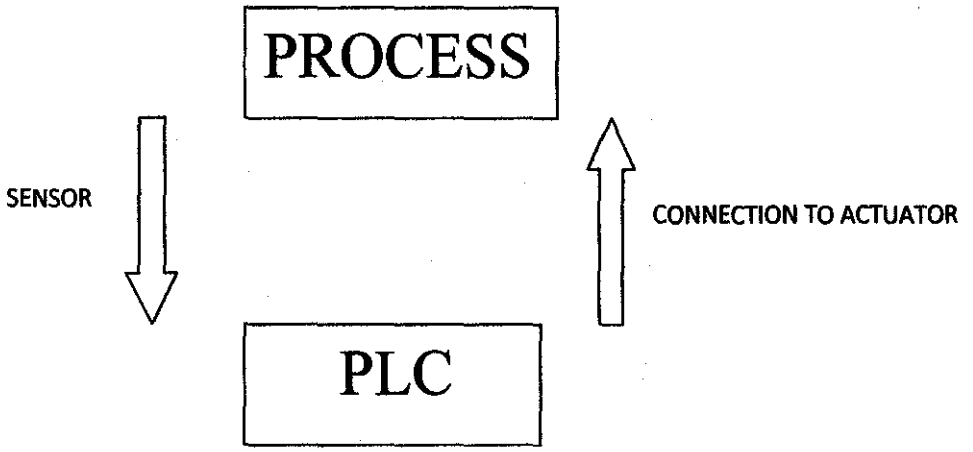


Figure 12: The Separation Of Controller and Process

The control loop in the PLC will continue to cycle, reading the input, solve the ladder diagram and finally changing the output. When the power is on, the PLC have to make sure the hardware is working properly. If the problem occurred, the PLC will indicate there is an error. For example, if the battery power of PLC is low, the memory will be corrupted and this will result in fault.

ADVANTAGES OF PLC

There are some particular advantages of PLC over digital circuits for the factory [6]:

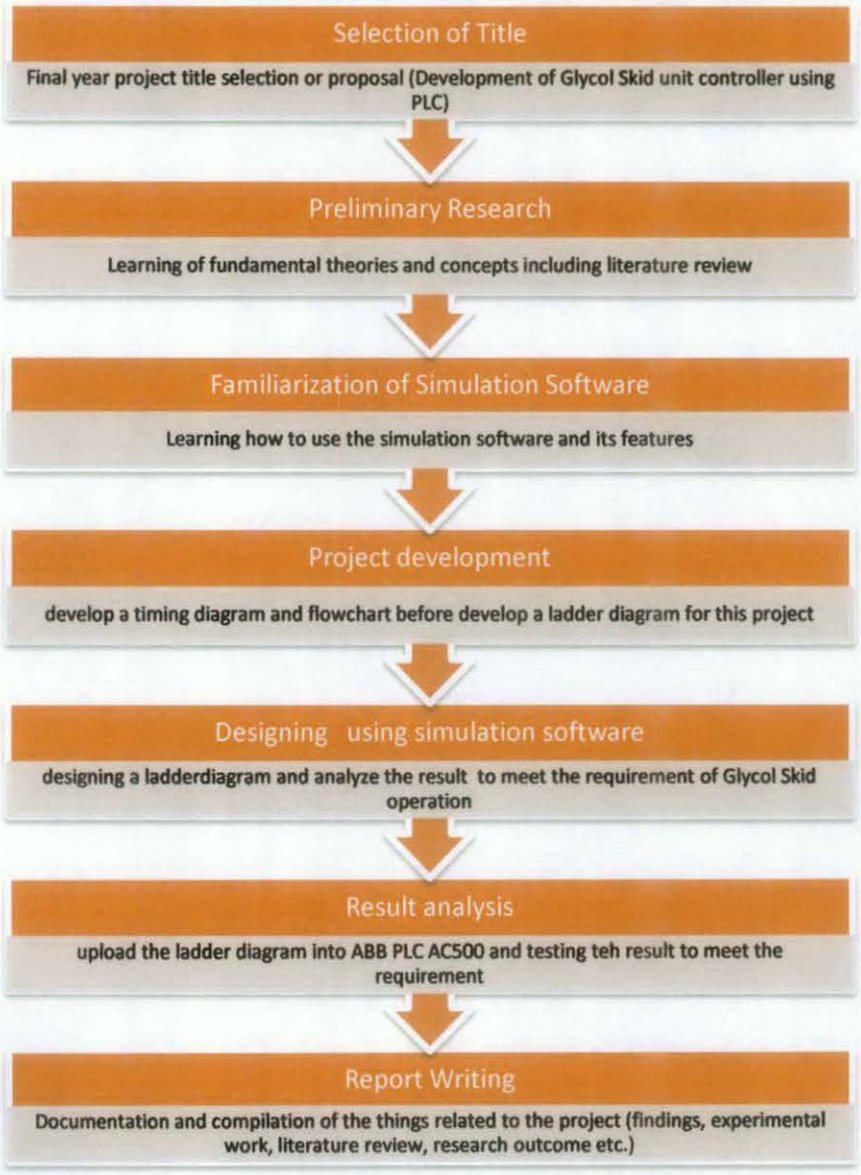
- The PLC will be more rugged
- The program can change easily
- Less skill is needed to maintain the equipment

PLC APPLICATIONS

For many years, manufacturing and process industries have used PLCs for the industrial ruggedness and flexible computing abilities. Because of reliability and industrial substation level, it is common for PLCs to be used in turbine control schemes, secondary selective residual bus transfer schemes, load shedding and motor re-acceleration schemes. Modern PLCs are small, versatile and well adapted to industrial application [7].

CHAPTER 3: METHODOLOGY

The objective of this project is to design a controller for Glycol Skid unit using PLC. For FYP1, my supervisor instructs me to develop a timing diagram, flowchart for development of ladder diagram. Below is the methodology and general flow of this project:



PROJECT GANTT CHART WITH KEY MILESTONES FOR FYP1 & FYP2

No	Task Name	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic							MID SEM BREAK							
2	Preliminary Research Work														
3	Submission extended proposal														
4	Proposal defence														
5	Software Learning and preparation for the project														
6	Draft Interim Report Submission														
7	Interim Report Submission														

FYP 1

No	Task Name	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Submission of progress report							MID SEM BREAK								
2	Finalize simulation															
3	Testing ladder diagram into PLC															
4	FYP poster presentation															
5	Submission of dissertation report															
6	FYP final presentation															

FYP2

Figure 13: Project Gantt chart with Key Milestones for FYP1 & FYP2

TOOLS REQUIREMENT

The tools and equipment which are required in this Final Year Project are a Windows based PC together with the programs such as Microsoft Office and ABB Programming Software which is used in designing the ladder diagram for PLC controller. TimeGen 3.3.1 software will be use to drawing the ladder diagram for the project and the type of PLC that will be use in this project is ABB PLC AC500.

ABB PLC AC500-eCo

After finalizing the ladder diagram and testing using simulation software for 3 conditions of pump in the Glycol Skid plant, the program need to be testing with PLC. The type of PLC that will be use for testing the program is ABB PLC AC500 – eCo starter kit which is recommended by my supervisor.

Short Description of AC500-eCo

- AC500 –eCo CPU PM554-T (8 digital inputs 24Vdc / 6 transistor outputs) ;
    1. 128kB program memory
    2. Expansion by up to 7 I/O modules via the I/O-Bus
    3. Up to 2 serial ports for programming and communication
    4. Integrated CMO1(D-Sub 9,serial RS-485 interface)
    5. Optional COM2 (5 pole terminal, serial RS-485 interface)
    6. 8 configurable onboard digital inputs, 24 V DC
    7. 4 interrupt inputs
    8. 2 fast counter inputs
    9. 6 configurable onboard transistor outputs, 24V DC, 0.5A
    10. 2 PWM outputs

11. Integrated RUN/STOP switch
12. Optional SD adapter
13. 24 DC power supply

- CP-E 24/0.75 external power supply module (24V DC)
- TK503 USB programming cable

Operating, Display and connection elements of PM554-T

- Green PWR LED. On = CPU power on
- Green RUN LED, On = CPU in run mode
- Red ERR LED. On = Error indicated
- 14 yellow LEDs indicate the status of each input (8 x DI) and output (6 x DO)
- RUN/STOP switch
- Screw type terminal block for onboard I/O fixed
- COM1 serial communication interface (RS485)
- DC power supply terminal block

Figure 14: ABB PLC AC500-eCo [10]

CHAPTER 4: RESULT AND DISCUSSION

INPUTS, OUTPUTS AND INDICATORS OF GLYCOL SKID PUMPS

Inputs are the signals or data received by the system, and outputs are the signals or data sent from it. These are the important elements that will be use in the construction of ladder diagram. Before develop a ladder diagram on PLC, we need to clarify how many inputs and outputs that will be used in the program. This is because we can choose the most suitable type of PLC that will be used based on the quantity of input and output. These are the input, output and the indicators for the Glycol Skid unit:

INPUTS AND OUTPUTS OF GLYCOL SKID PUMPS

INPUTS	DESCRIPTION
506-LT-1007	Flash drum V5-0631
506-LT-1009	Flash drum V5-0631 (hydrocarbon high level)
506-PT-1001	Cartrige filter
506-PT-1013	Cartrige filter
506-PT-1014	Discharge pressure pump
506-LT-1031	Surge drum E5-0646
506-LT-1033	Reboiler E5-0648
506-LT-1034	Surge drum E5-0646
506-LT-1035	Surge drum E5-0646
OUTPUT	**DESCRIPTION**
Pump P5-0624A	Glycol skid pump
Pump P5-0624 B	Glycol skid pump

Table 1: Inputs and outputs of glycol skid pumps

GLYCOL SKID PUMPS INDICATORS

INDICATORS	DESCRIPTION
506-LALL-1007	Shutdown flash drum low low level
506-LAHH-1007	Shutdown flash drum high high level
506-LAH-1009	Alarm-hydrocarbon level in flash drum
506-PDAH-1011	Alarm-high D.P. cartridge filter
506-PDAH-1013	Alarm-high D.P. carbon filter
506-PAL-1014	Alarm-low discharge pressure pumps
506-PAH-1014	Alarm-high discharge pressure pump
506-LAL-1031	Alarm-low level surge drum
506-LAH-1031	Alarm-high level surge drum
506-LALL-1033	Shutdown-low low level-reboiler
506-LAHH-1033	Shutdown-high high level-reboiler
506-LAL-1034	Alarm-low level surge drum
506-LALL-1035	Shutdown-low low level surge drum
XL-P0624AA	Running pump P5-0624A
XL-P0624AB	Stopped pump P5-0624A
XL-P0624BA	Running pump P5-0624B
XL-P0624BB	Stopped pump P5-0624B
XL-P0624CA	Running pump P5-0624C
XL-P0624CB	Stopped pump P5-0624C

Table 2: Indicators for glycol skid pumps

FLOW CHART FOR GLYCOL SKID UNIT

A flowchart is a type of diagram that represents an algorithm or process, showing the steps as boxes with different shapes, and their order by connecting all the boxes with arrows. This type of diagram can give a step by step solution to a problem. These boxes represented process operations, and arrows connecting them represent flow of control. Data flows are not always represented in a flowchart and they are rather implied by the sequencing of operations contrast with data flow diagrams. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields.

The way to use flowchart is by break a task down into lots of different steps arranged into a logical order. The steps are written inside different shaped boxes. Each box must be connected to the next by the use of an arrow. The arrows indicate the direction we must take through the chart. By understanding the process of Glycol Skid unit, flowchart for this process can be developing.

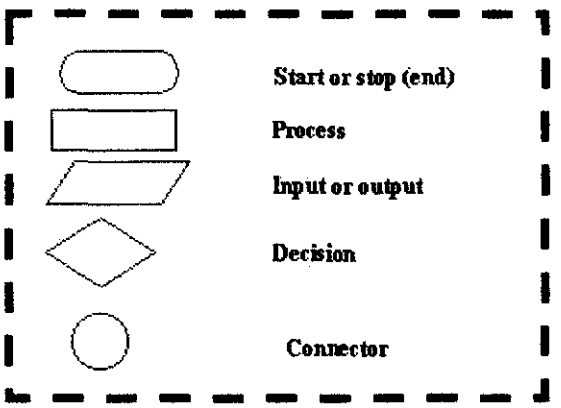


Figure 15: Flowchart Boxes [11]

This is the flowchart for Glycol Skid unit:-

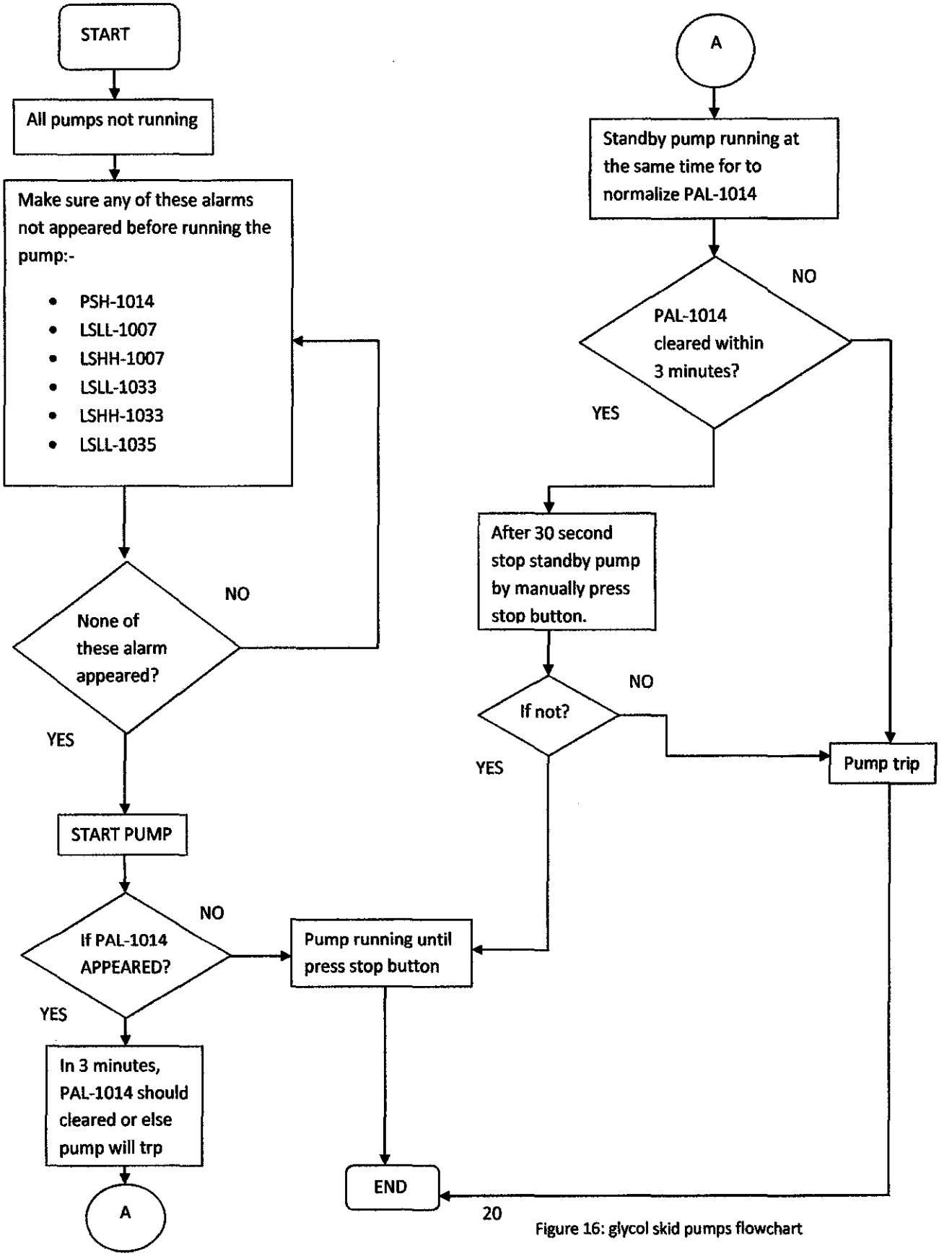


Figure 16: glycol skid pumps flowchart

CONSTRUCTION OF TIMING DIAGRAM

Timing diagrams are used to explore the behaviours of objects throughout a given period of time. A timing diagram is a special form of a sequence diagram. The differences between timing diagram and sequence diagram are the axes are reversed so that the time is increased from left to right. Based on the flowchart that has been constructed before, we can use the flowchart for development of timing diagram for each selected alarms:-

- LSLL-1007
- LSHH-1007
- LSLL-1033
- LSHH-1033
- LSLL-103
- PSL-1014
- PSH-1014

a) LT-1007 (LSLL-1007)

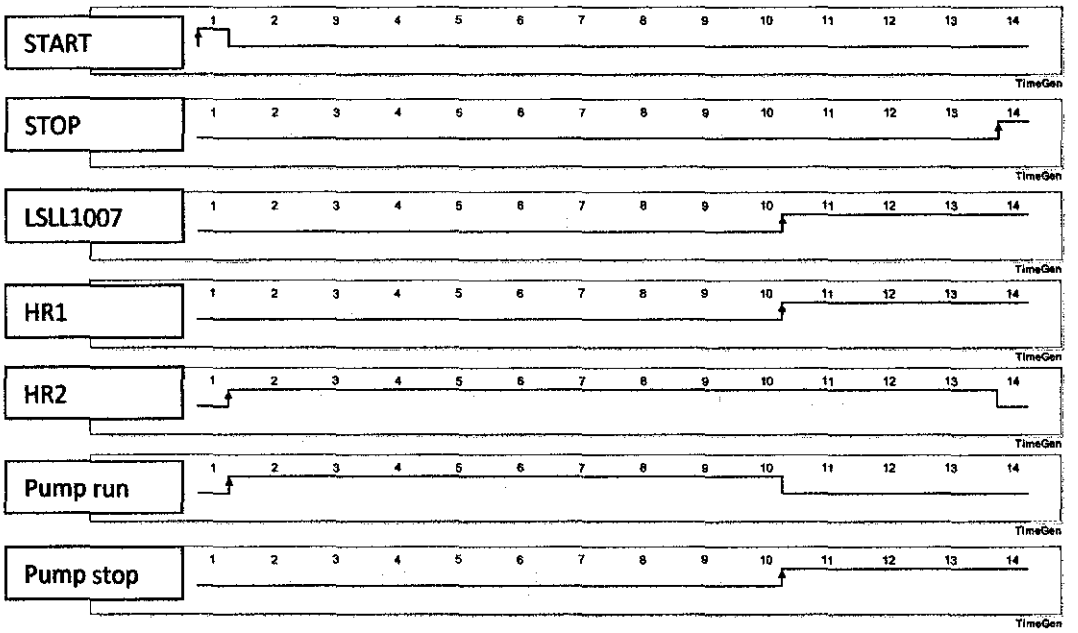


Figure 17: Timing diagram for LSLL-1007

HR1 = LSLL1007

HR2 = (START + HR2).$\overline{STOP}$

HR1 = PUMP STOP

HR2 = PUMP RUN

HR1&2 = Condition of running pump

b) LT-1007 (LSHH-1007)

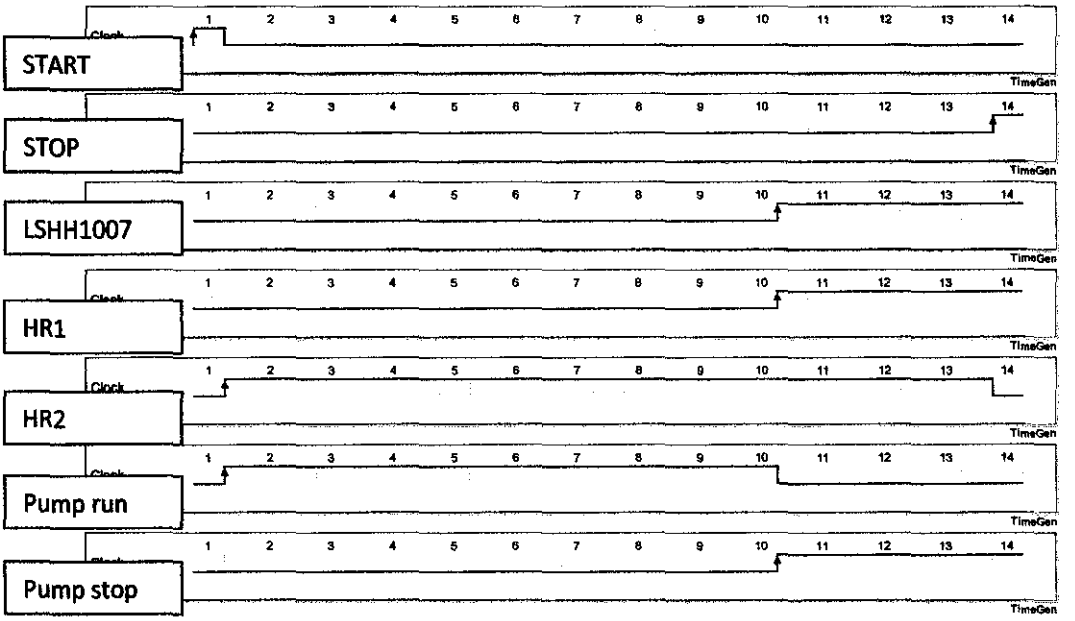


Figure 18: Timing diagram for LSHH-1007

HR1 = LSHH1007

HR2 = (START + HR2).$\overline{STOP}$

HR1 = PUMP STOP

HR2 = PUMP RUN

HR1&2 = Condition of running pump

c) LT-1033(LSLL-1033)

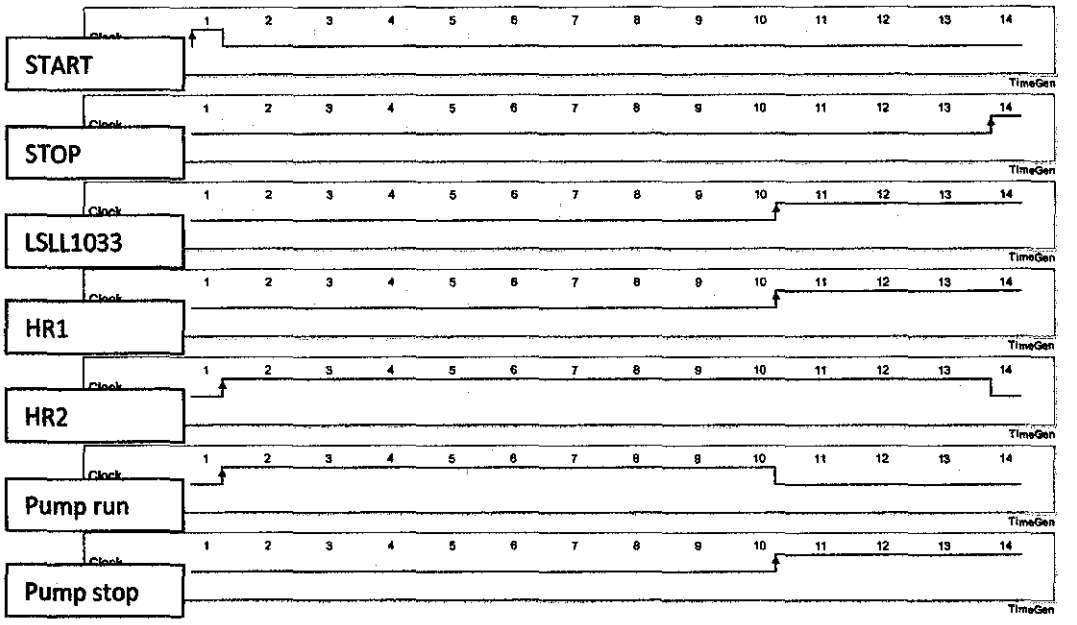


Figure 19: Timing diagram for LSLL-1003

HR1 = LSLL1033

HR2 = (START + HR2).$\overline{STOP}$

HR1 = PUMP STOP

HR2 = PUMP RUN

HR1&2 = Condition of running pump

d) LT-1033(LSHH-1033)

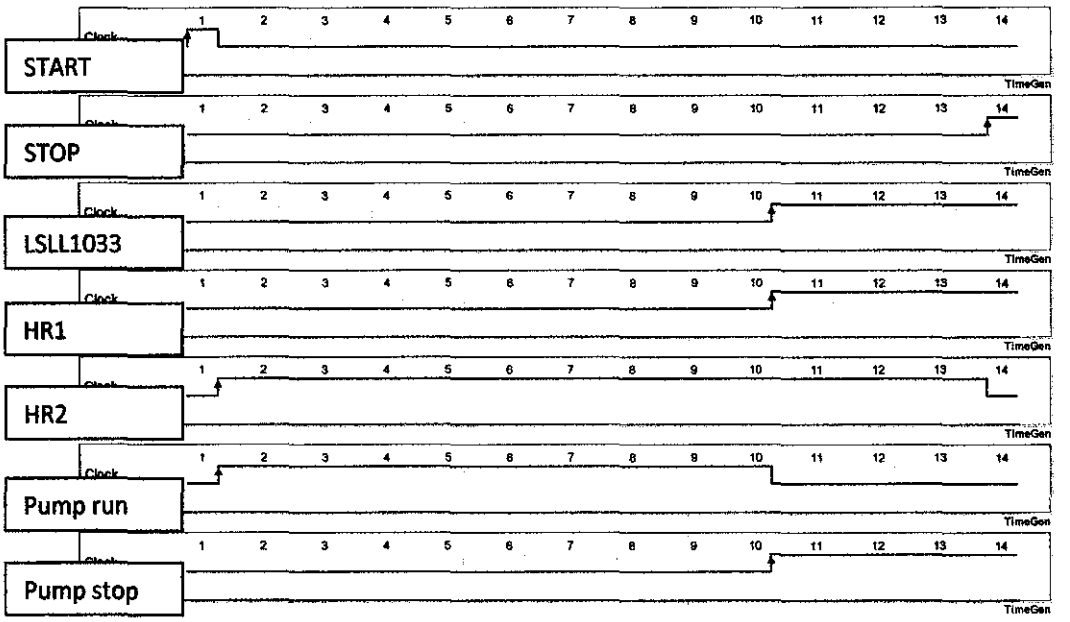


Figure 20: timing diagram for LSHH-1033

HR1 = LSHH1033

HR2 = (START + HR2).$\overline{STOP}$

HR1 = PUMP STOP

HR2 = PUMP RUN

HR1&2 = Condition of running pump

e) LT-1035(LSLL-1035)

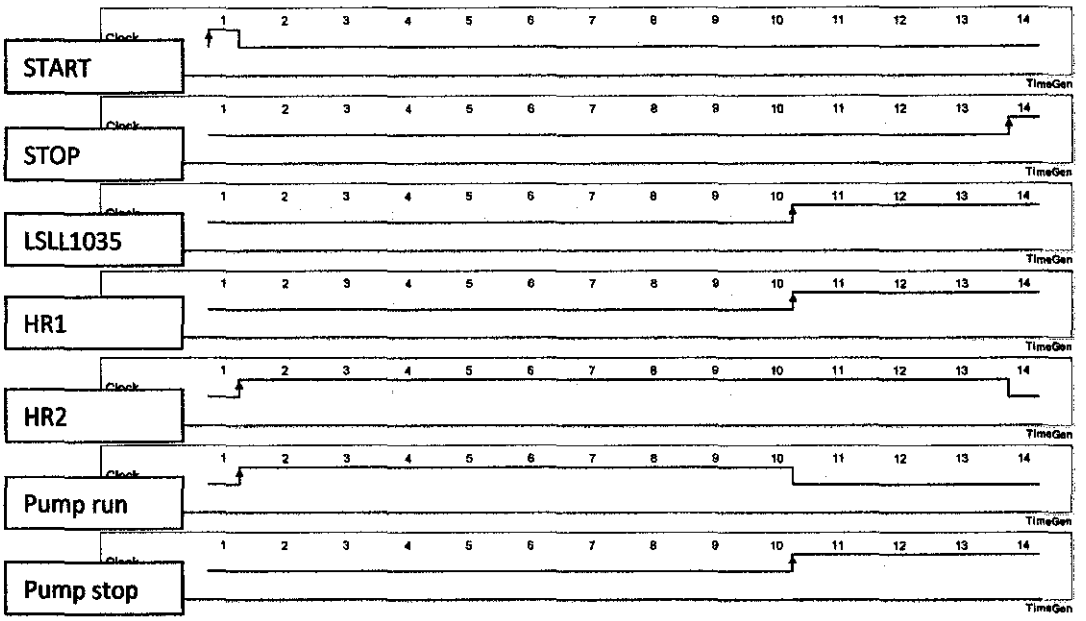


Figure 21: Timing diagram for LSLL-1035

HR1 = LSHH1035

HR2 = (START + HR2).$\overline{STOP}$

HR1 = PUMP STOP

HR2 = PUMP RUN

HR1&2 = Condition of running pump

f) PT-1014 (PSH1014)

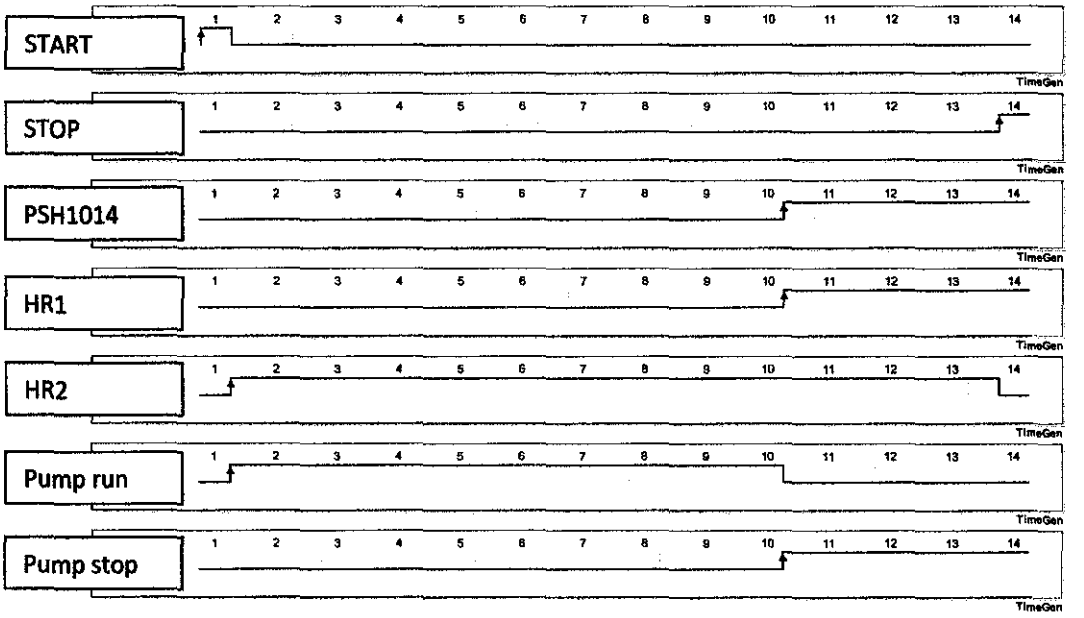


Figure 22: Timing Diagram for PSH-1014

HR1 = PSH1014

HR2 = (START + HR2).$\overline{STOP}$

HR1 = PUMP STOP

HR2 = PUMP RUN

HR1&2 = Condition of running pump

g) PT-1014 (PSL-1014) cleared in 3 minutes

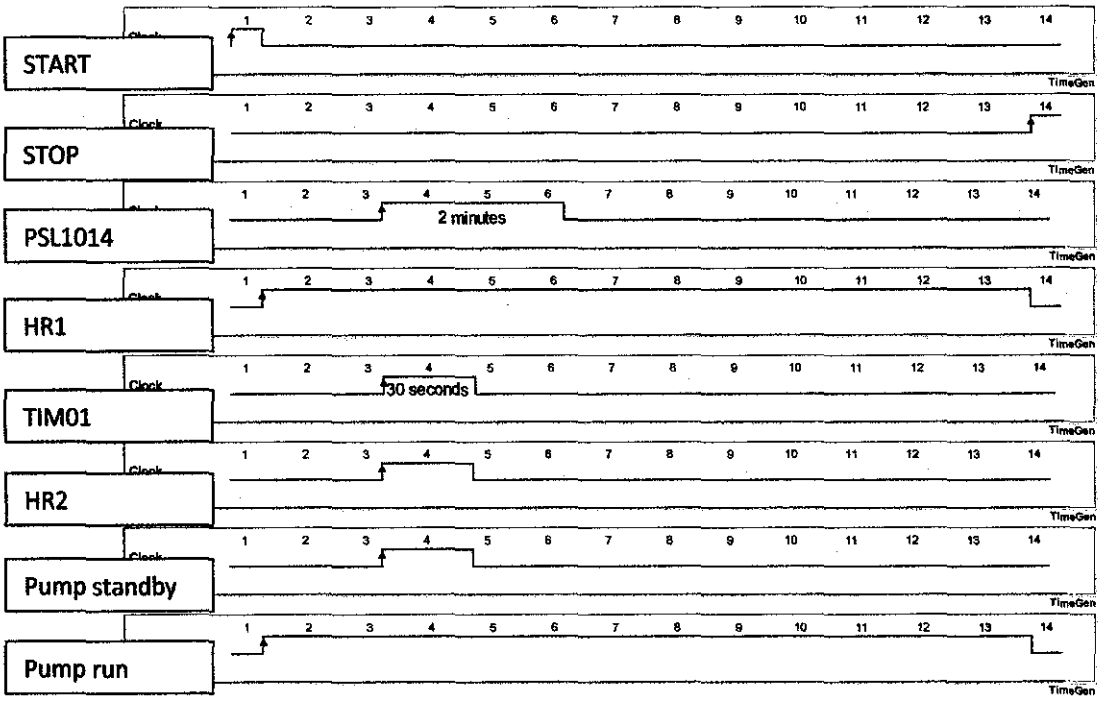


Figure 23: Timing diagram for PSL-1014

HR1 = (START + HR1).$\overline{STOP}$

HR2 = TIM01

PUMP RUN = HR1

PUMP STANDBY = HR2

HR1&2 = Condition of running pump

Analysis of the result for:-

- LSLL-1007
- LSHH-1007
- LSLL-1033
- LSHH-1033
- LSLL-1035
- PSH-1014

a) START button is use to start the whole operation while STOP button to stop the whole operation.
b) When the START button is push, holding relay 2 (HR2) will be activated.
c) Holding relay 1(HR1) will be only activated when alarm of the system appeared.
d) At any time, when the STOP button is push, the whole operation will be stop.
e) From the timing diagram, we can express the equations that will be used for development of ladder diagram.

Analysis of the result for:-

- PSL-1014

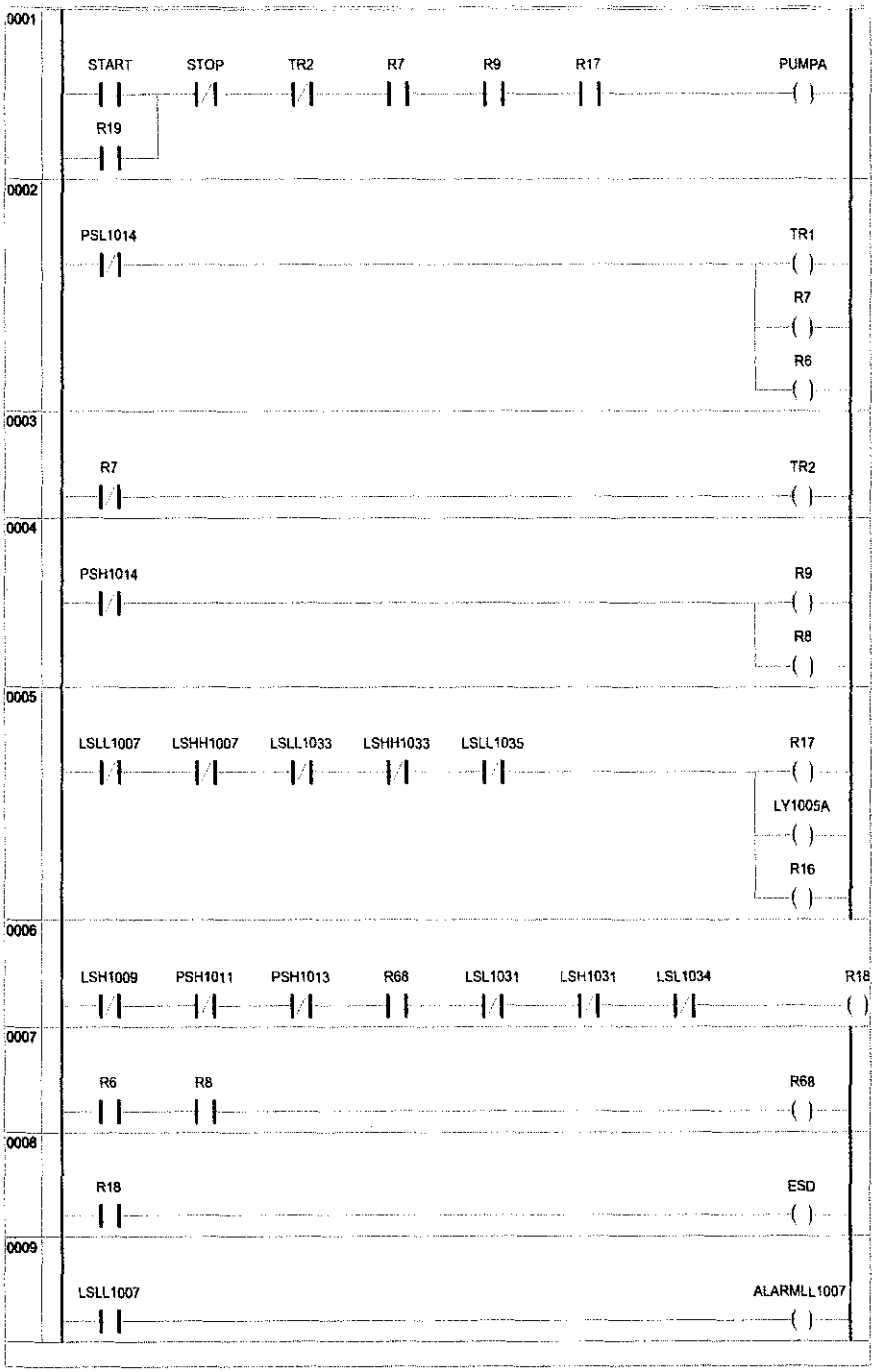
a) START button is use to start the whole operation while STOP button to stop the whole operation.
b) When the START button is push, holding relay 1 (HR1) will be activated.
c) When the alarm PSL-1014 appeared, the TIM01 will activated and stat counting the alarm.
d) If the alarm is appeared less than 3 minutes, the pump will continue running or else if the alarm appeared more than 3 minutes the pump will stop.
e) At any time, when the STOP button is push, the whole operation will be stop.
f) From the timing diagram, we can express the equations that will be used for development of ladder diagram.

LADDER DIAGRAM OF GLYCOL REGENERATION SKID

Ladder diagram for Glycol Regeneration Skid controller can be develop based on the development of the flowchart, timing diagram and the procedures of Glycol Skid pump. The ladder diagram for each condition has been simulating using ABB PLC programming software and the result is successful and according to the Glycol Regeneration Skid procedures. Based on the all the data that has been constructed before, we can used all the data for development of ladder diagram for each condition:-

- Ladder diagram for running pump without any timer.
- Ladder diagram for running pump with timer.
- Ladder diagram for running pump, standby pump, timer and selector switch.

- **LADDER DIAGRAM FOR RUNNING MOTOR WITHOUT TIMER**



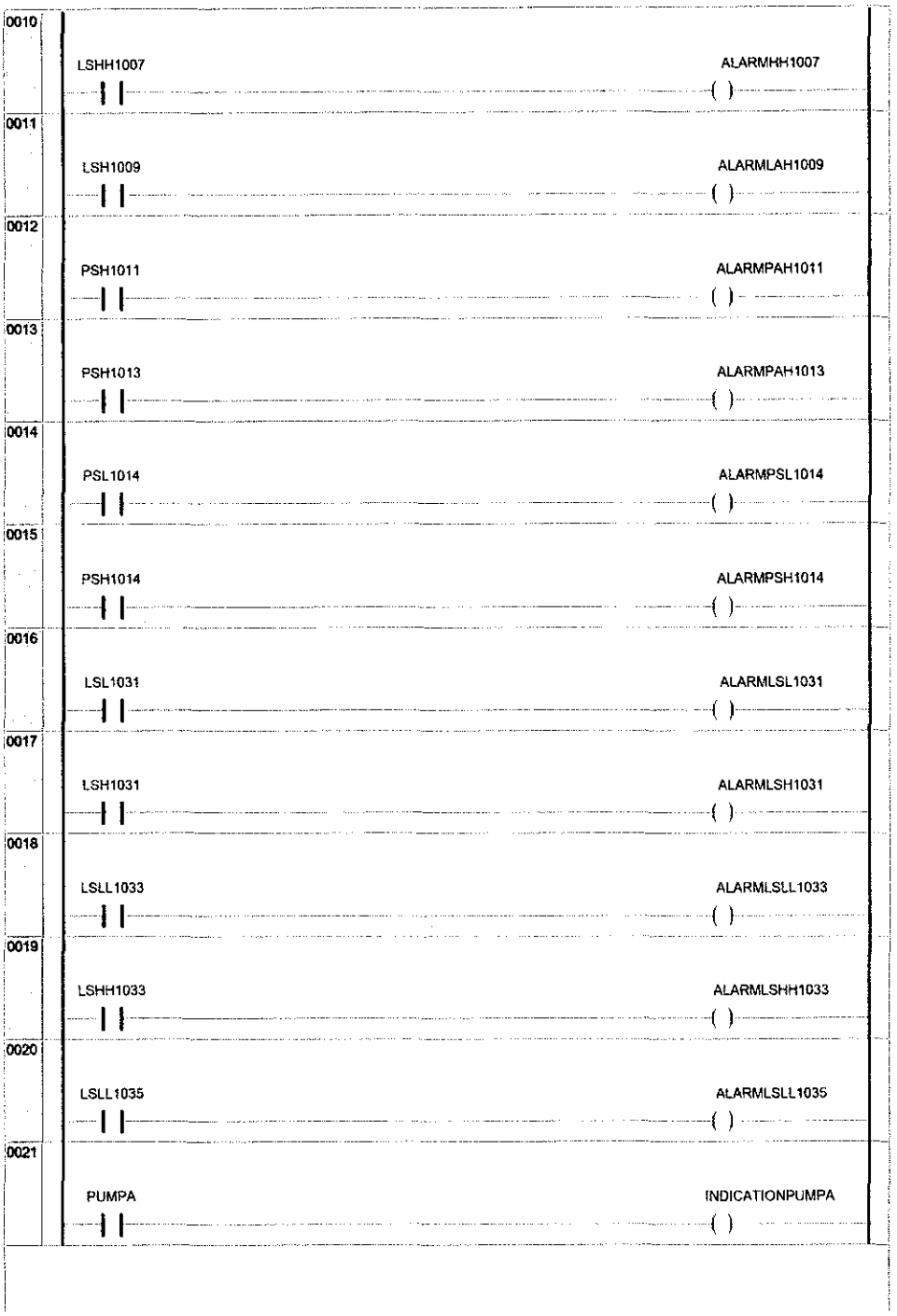
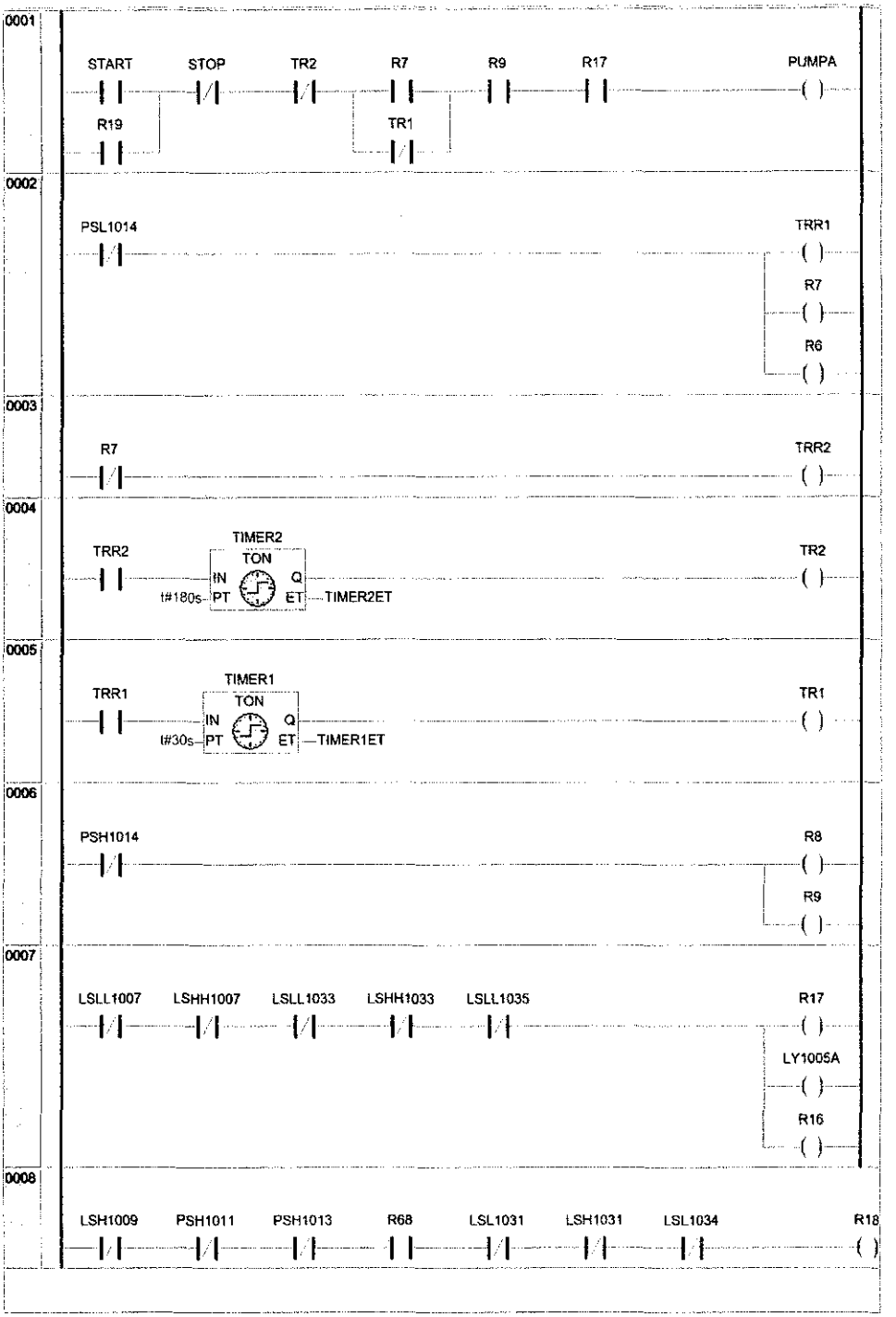
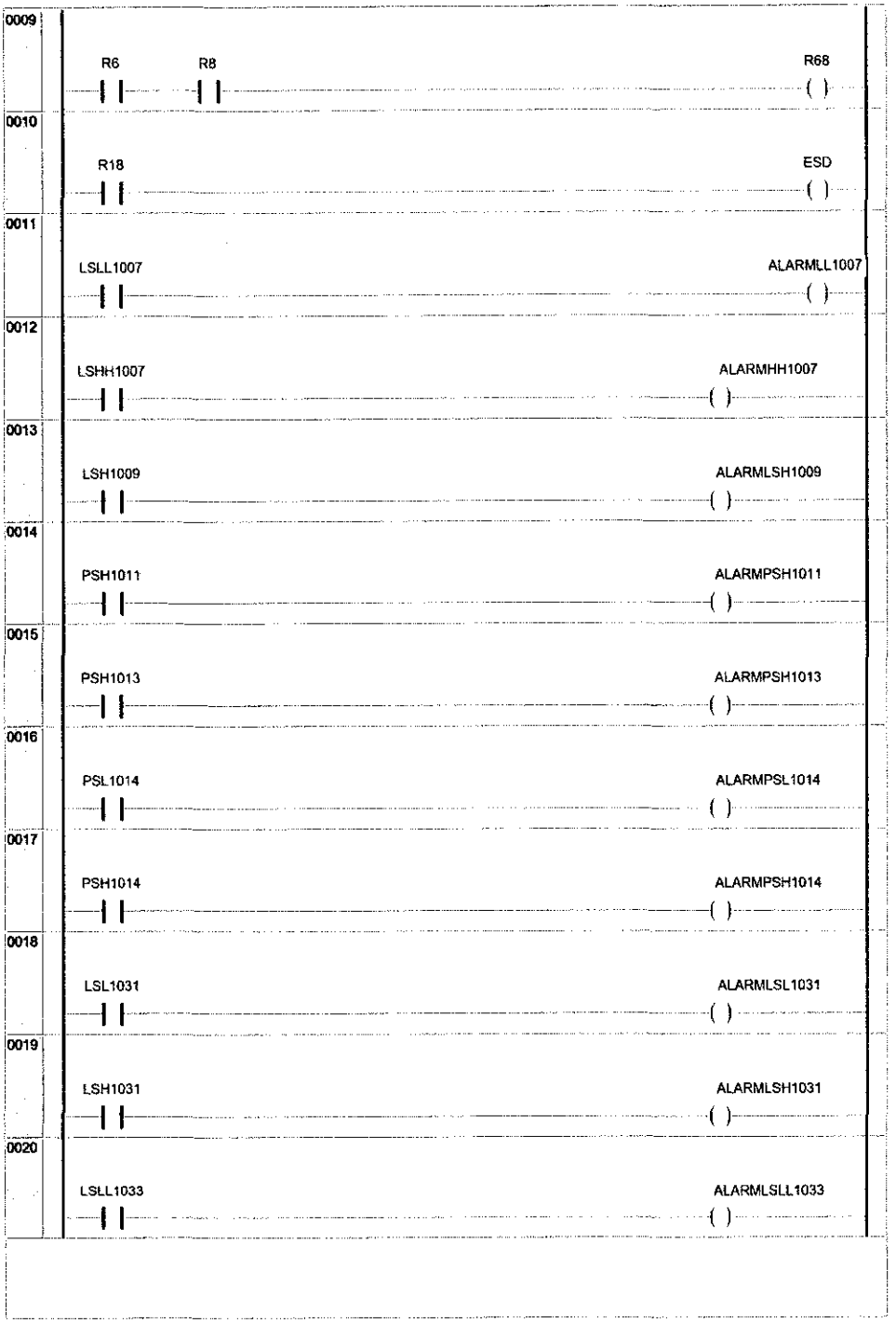


Figure 24: Ladder diagram for running motor without timer

- **LADDER DIAGRAM FOR RUNNING PUMP WITH TIMER 1**




0009
R6
R8
R68
0010
R18
ESD
0011
LSLL1007
ALARMLL1007
0012
LSHH1007
ALARMHH1007
0013
LSH1009
ALARMLSH1009
0014
PSH1011
ALARMPSH1011
0015
PSH1013
ALARMPSH1013
0016
PSL1014
ALARMPSL1014
0017
PSH1014
ALARMPSH1014
0018
LSL1031
ALARMLSL1031
0019
LSH1031
ALARMLSH1031
0020
LSLL1033
ALARMLSLL1033

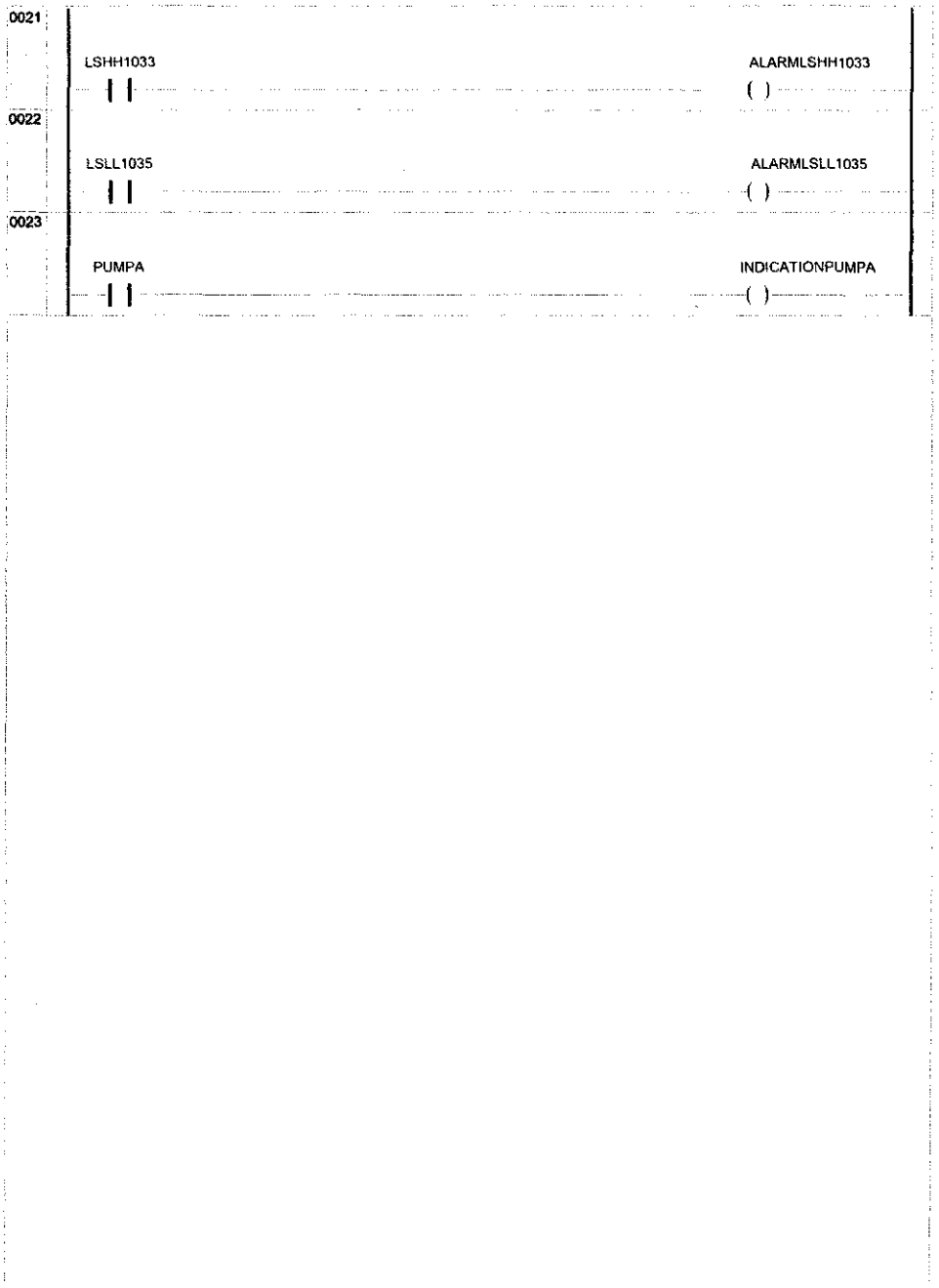
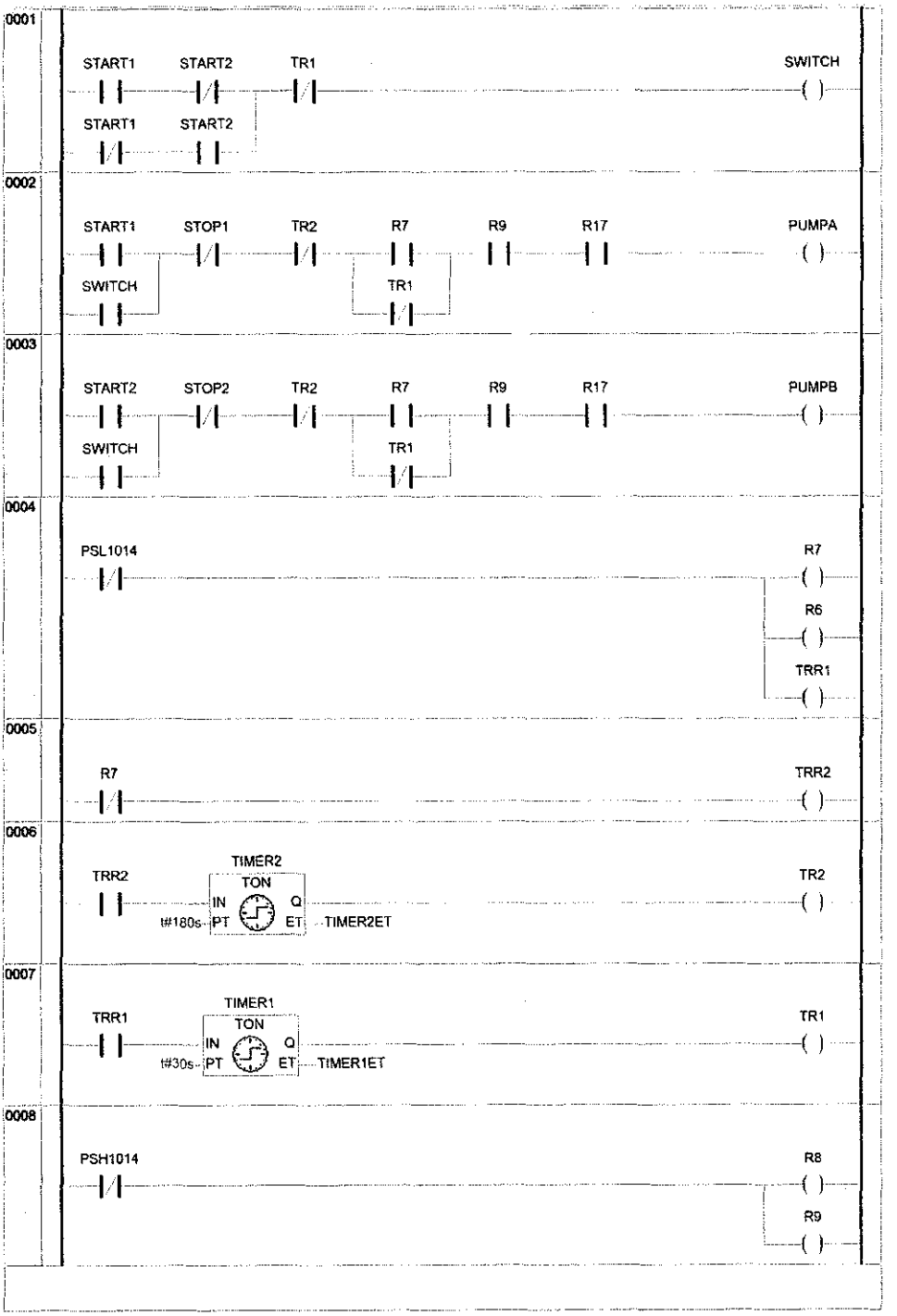
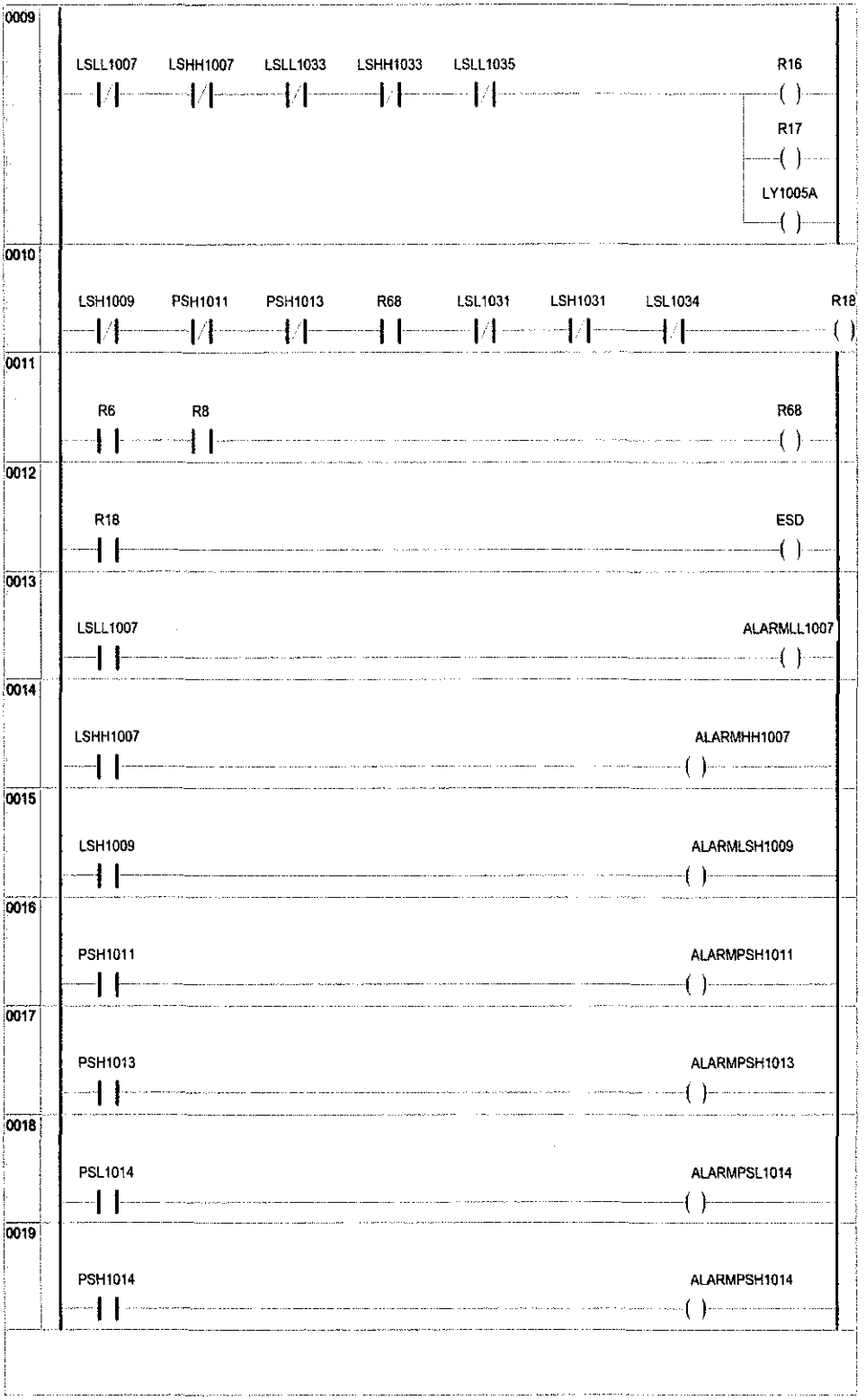


Figure 25: Ladder diagram for running motor with timer 1

- **LADDER DIAGRAM FOR RUNNING AND STANDBY PUMP WITH TIMER 1 & 2 AND SELECTOR SWITCH**




0009
LSLL1007
LSHH1007
LSLL1033
LSHH1033
LSLL1035
R16
R17
LY1005A
0010
LSH1009
PSH1011
PSH1013
R68
LSL1031
LSH1031
LSL1034
R18
0011
R6
R8
R68
0012
R18
ESD
0013
LSLL1007
ALARMLL1007
0014
LSHH1007
ALARMHH1007
0015
LSH1009
ALARMLSH1009
0016
PSH1011
ALARMPSH1011
0017
PSH1013
ALARMPSH1013
0018
PSL1014
ALARMPSL1014
0019
PSH1014
ALARMPSH1014

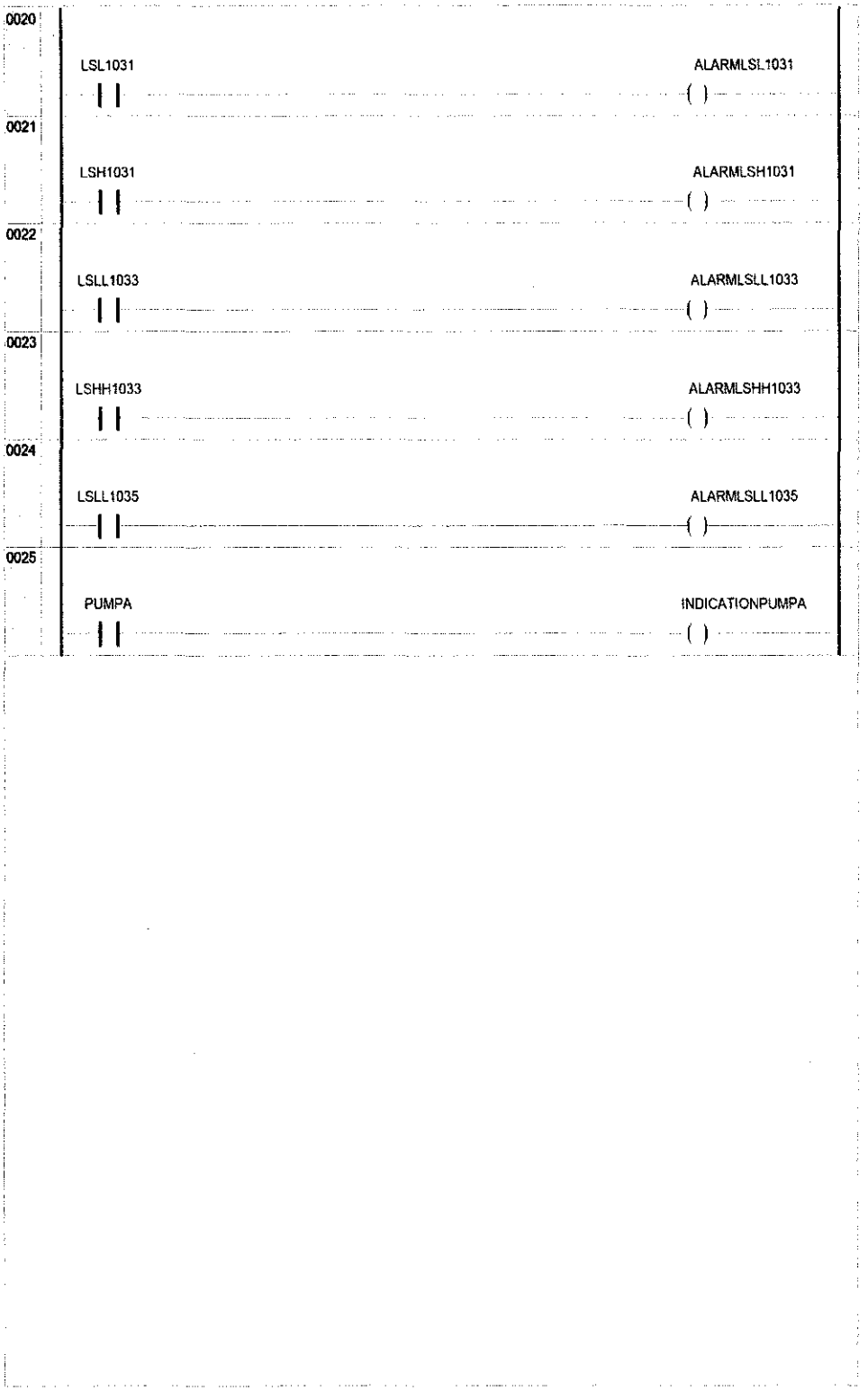


Figure 26: Ladder diagram for running and standby pump with timer 1 & 2 and selector switch

CHAPTER 5: CONCLUSION AND RECOMENDATION

As a conclusion, development of Glycol Skid Unit controller using PLC is in progress and hopefully the development of flowchart and timing diagram for this unit will be able to help to develop a ladder diagram for the PLC. After development of timing diagram finished, construction of ladder diagram for this unit will take place. There are a few changes that have been made for the ladder diagram to improve the operation of Glycol Skid controller.

Since the author is majoring in Instrumentation and Control System and the author has the credibility as an Electrical and Electronics Engineering student, this is an acceptable project to be accomplished for the fulfilment of Final Year Project. Finally this project help author to have better understanding of Automation Control System.

This project has no plan on choose the best type of PLC that will be used at the Glycol Skid unit. Even though simulation is the best way to illustrate the process but understanding on important part of PLC such as type of power supply, input and output module, serial communication card and knowledge on sinking and sourcing will help the author more appreciate on this technology.

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APPENDICES