BUSCS Development using AUTOMGEN and PLC Ladder Support Software

by

Bobby anak Ranggau

Dissertation submitted in partial fulfilment of
the requirements for the
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CERTIFICATION OF APPROVAL

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TRONOH, PERAK

May 2004

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.

[BOBBY ANAK RANGGAU]

ABSTRACT

This project of "BUSCS Development using AUTOMGEN and PLC Ladder Support Software" is basically controlling a simplified process based on an actual production line of Bulk Urea Storage Control System (BUSCS) of Asean Bintulu Fertilizer Sdn. Bhd. using Programmable Logic Controller (PLC) and AUTOMGEN^7 software. In this project, the student has developed a hardware system using PLC as the main controller and AUTOMGEN^7 software which is used to control as well as monitor the operation of the whole system.

The designing comprises three major elements that need to be developed. First, to develop PLC program using ladder diagrams as the main controller. Then, developing the hardware system using the input and output devices required in controlling the whole process. Lastly, to develop the Human Machine Interface (HMI) using AUTOMGEN^7 to simulate the whole operation of the system.

The hardware system is based on the actual production line of Bulk Urea Storage Extension Project of ASEAN Bintulu Fertilizer Sdn. Bhd. Therefore, the initial stage of the project has been focused on studying the production line and also produces the complete sequence of operations. This is a crucial phase of the project since the student need to have detailed understanding of the complete operation and the control logic of the BUSCS.

The main objective for this project is to compare the existing system of using relay logics with the use of Programmable Logic Controller (PLC) system in controlling industrial processes. Both systems have been compared in terms of advantages and disadvantages and also in terms of system configuration and complexity.

Based on this study, it has been found that PLC is a viable method in controlling an industrial process due to its reliability and maintainability. Supported by industrial standard software like AUTOMGEN^7 and other PLC support components, the future of PLC in industrial control is borderless.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

The Programmable Logic Controller (PLC) is in essence a device that is specifically designed to receive input signals and emit output signals according to the program logic. PLCs come in many shapes and sizes from small, self-contained units with very limited input/output capacity to large, modular units that can be configured to provide hundreds or even thousands of inputs/outputs [1].

PLCs are used extensively in industrial control because they are easy to set up and program, behave predictably, and are tough enough to keep working in even the dirtiest production environment. It is also constructed to make it easy for the user to put together a PLC-controlled system and come pre-programmed with an operating system or application programs optimized for industrial control.

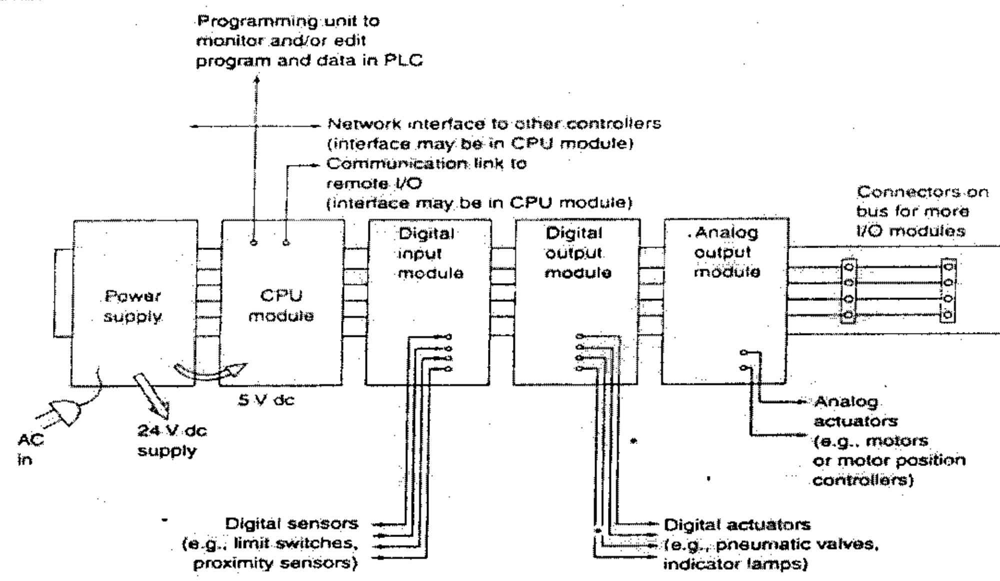


FIGURE 1.2
PLC in an automated system.

Figure 1.1: The Basic Elements of PLC

1.2 Problem Statement

Before the PLC, automated manufacturing processes had to be controlled using hardware devices. Later, control systems used electrical relays to control widely dispersed systems. Some circuits contained sensors that controlled relay switches. The relays controlled electric current in other circuits to control electric actuators and/or other relays. With timers and counters in the system, systems of relays could control sequential manufacturing processes [2].

The term relay logic was used to describe control systems based on interconnected relays. Programming a relay logic controller actually meant building it. Typically, a control system would consist of hundred of relays, connected by kilometres of wire and housed in large control cabinets with the need for hundreds of connections.

In addition to this, any changes to the plant or machine operating sequences/logic would involve the physical repositioning and rewiring of relays. To modify a relay logic program, the control system had to be rebuilt. Debugging a faulty relay logic control system requires tedious electrical troubleshooting of the electrical components and contacts.

The PLC was developed to overcome many of the problems inherent in electro-mechanical relay type control systems. As the cost of the PLCs has reduced and their functionality and reliability have increased, they have taken over from relays as the most used means of controlling plants and machines.

A PLC can replace all the relays that would have been used to provide control logic. It is compact and easily mounted in a much smaller cabinet, requires much less wiring and because the logic is contained within its software program, changes can be implemented much more easily.

1.3 Objectives and Scope of Study

1.3.1 Objectives

The objectives for the project include:-

1. To design the Programmable Logic Controller (PLC) programming according to the Bulk Urea Storage Extension Project sequence of operation.
2. To develop hardware system using sensors and other I/O devices.
3. To use AUTOMGEN[7] for simulation and also monitoring of the system.

1.3.2 Scope of Study

This project will involve the development of hardware system using sensors and other I/O devices. Therefore, the student has referred to the Bulk Urea Storage Extension Project of ASEAN Bintulu Fertilizer Sdn. Bhd. as the reference production line that will be controlled using Programmable Logic Controller (PLC). Then, the student has developed the hardware system using equipments that is based on the simplified design of Bulk Urea Storage Control System. Next, the process has been monitored and simulated using AUTOMGEN[7].

The first semester has been used by the student to do the case study of an actual production line. Therefore, the student had chosen the Bulk Urea Storage Extension Project of ASEAN Bintulu Fertilizer Sdn. Bhd. as the reference unit and then produced a simplified process, design PLC programming and also develops the hardware system. After that, the second semester has been used to learn using the AUTOMGEN[7] and also interfacing it with the PLC for monitoring and simulation purposes.

1.3.3 The Relevancy of the Project

The project is a branch of knowledge on programmable logic controllers and automation. It includes real-world processes such as control of machinery in a production line. As mentioned, automation in industries is the use of computers to control machinery and processes.

In this project, we will illustrate the use of Programmable Logic Controllers (PLC) to synchronize the flow of input from sensors or other input devices and also the events with the flow of outputs and to actuators or other output components. Therefore, we can produce precisely controlled actions that permit a tight control of the whole production line.

1.3.4 Feasibility of the Project within the Scope and Time Frame

The time frame of the project is set for two semesters. The time length is around thirty weeks for both semesters. Basically the project can be divided into 5 subsections:-

1. Analysing the actual production line Bulk Urea Storage Extension Project.
2. Programmable Logic Controller (PLC) programming.
3. Construct the hardware system.
4. Construct the input/output devices.
5. Interface the PLC with Personal Computer (AUTOMGEN[7]).

The exact time frame can be seen in the project Gantt Chart. As for the feasibility, the project should be completed on time if the Gantt Chart is followed accordingly. The only foreseeable problem is in the system integration of all subsections and analysing the actual production line of Bulk Urea Storage Control System Extension Project where a longer time would be required.

CHAPTER 2
LITERATURE REVIEW / THEORY

2.1 PROGRAMMABLE LOGIC CONTROLLER

A programmable logic controller or PLC is a small computer used for automation of real-world processes, such as control of machinery on factory assembly lines. Where older automated systems would use hundreds or thousands of relays and cam timers, a single PLC can be programmed as a replacement [3].

The PLC is a microprocessor based device with either modular or integral input/output circuitry that monitors the status of the field connected "sensor" inputs and controls the attached output "actuators" (motor starters, solenoids, pilot lights/displays, speed drives, valves, etc.) according to a user-created, logic program stored in the microprocessor's battery-backed RAM memory.

2.1.1 Introduction to Programmable Logic Controller

Programmable Logic Controller originated from the creation of computerized versions of relay control systems used to control manufacturing and chemical process systems. The programming is done using a special technique called ladder logic, which allows sequences of logical actions to be set up, inter-linked and timed. A standard task in logic control is batch control and sequencing in a process system.

Programmable Logic Controllers (PLC) has been used since 1969 and since this time, they have become firmly established and most popular means of controlling the operation of plant and machinery. They have evolved in terms of hardware and software. Since around 1974 "microprocessor" has been used as the "brain" of the PLC and this, has enabled cheaper, smaller, more powerful and reliable units to be developed.

Finally, the Programmable Logic Controller is the equipment used at the remote sites where the facilities under the supervision of the Control Centre are to be monitored. The PLC is capable of handling various types of input and output signals from and to the facility equipment.

2.1.2 Construction of a Programmable Logic Controller

Some PLCs are integrated into a single unit, whereas others are modular. Modular PLCs consists of optional components required for a more complex control application, as selected and assembled by the user. A PLC-controlled system consists of:-

- The CPU Module

  It contains the central computer and its main memory. The memory includes pre-programmed ROM memory containing the PLC's operating system, driver programs, applications programs and the RAM memory where the user-written programs and working data are stored [1].

- Input and Output Modules (I/O modules)

  It allows the PLC to be connected to sensors and actuators. It also isolates the low-voltage, low-current signals that the PLC uses internally from the higher-power electrical circuits required by most sensors and actuators. Digital I/O modules can only switch on and off. Each module can typically be connected to several digital sensors and/or to several digital actuators of similar electrical characteristics.

- A Power Supply Module

  The power supply module converts available power to dc power at the level(s) required by the CPU and I/O module internal circuitry. It may be connected to the bus or may have wired to the CPU module in modular PLC systems.

- The Rack or Bus

  During every scan cycle, a CPU module read and writes I/O modules that are part of the modular PLC. The CPU module is connected to each of those I/O modules via a set of parallel conductors called a bus. Bus conductors are used for data that the CPU can send to or receive from the I/O modules, several bits at a time.

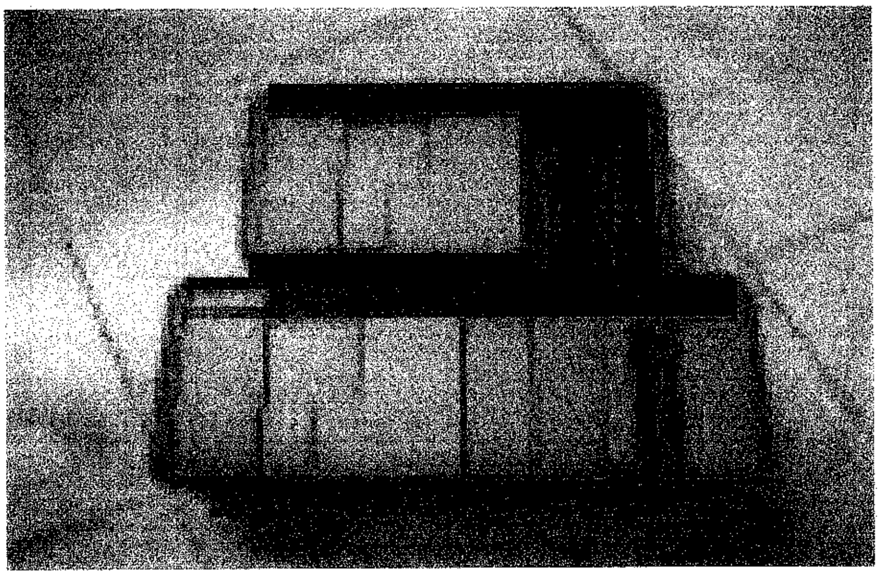


Figure 2.1: Assembly of a Modular PLC

The proposed PLC to be used in the project is the PLC manufactured by OMRON CQM1 Controller. The CQM1 is a compact, high speed PLC composed of Power Supply Module, a CPU and I/O Modules. All CQM1 CPUs are equipped with an RS-232C port that can be connected directly to a host computer or other serial devices. This PLC is supported and compatible with the CX-Programmer ver. 3.0 software which has been used by the student for ladder diagram construction [4].

2.1.3 Types of Programmable Logic Controller

Today PLCs are available in a wide range of capabilities and cost. There are five general categories of PLCs available:-

- Micro PLCs

  Generally have basic relay instructions, counters and timers with up to 32 digital inputs/outputs points and 2K words of program memory built into a compact unit [5].

- Small PLCs

  Added capability of analogue I/O, expandable I/O of up to 128 points, and 4K words program memory, shift register and sequencer instructions and primitive communications with other PLCs.

- Medium PLCs

  Expandable I/O of up to 1024 points and 32K words program memory, basic math and data handling instructions, subroutines, interrupts, functional block and local area network connection.

- Large PLCs

  Expandable I/O of up to 2048 points and 256K words program memory, enhanced math and data handling instructions and PID control.

- Very Large PLCs

  Expandable I/O of up to 8192 points and 4M words program memory.

A PLC is a user-friendly, microprocessor-based, specialized computer that carries out control functions of many types and levels of complexity. It can be programmed, controlled and easily operated by an unskilled person. There are several advantages and disadvantages of using a PLC.

2.1.4 Advantages of Programmable Logic Controller

Below are the lists of advantages of using a Programmable Logic Controller (PLC):-

1. Flexibility – one PLC can run on many machines [3].
2. Implementing Changes and Correcting Errors – changes in PLC programming can easily be implemented and cost-effective.
3. Large Quantities of Contacts – PLC memory is getting bigger and we can generate more contacts, coils, timers, sequencers, counters and so on.
4. Lower Cost – cost less when compared to conventional system when the number of I/Os is very large and control functions are complex.
5. Testing – programs can be tested, validated and modified saving valuable time.
6. Visual Observation – the circuit's operation can be seen on a screen. Hence, troubleshooting is quick, easy and simple.
7. Reliability and Maintainability – likely to operate for years before failure.

2.1.5 Disadvantages of Programmable Logic Controller

1. Fixed Program Applications – some applications are single function.
2. Environmental Considerations – certain process environments, such as high heat and vibration, interfere with the electronic devices in PLCs, which limit their use.
3. Fail-safe Operation – initially there is no fail-safe operation but it could be overcome by adding safety relays to a PLC system.
4. Fixed-circuit Operation – if the circuit in operation is never altered, a fixed control system might be less costly than a PLC.

2.1.6 Operating System and Application Programs

The CPU module of a PLC comes with a very different operating system program than those used in most other computers, and comes complete with application programs pre-programmed into the CPU's memory [1].

The operating system programs cause the PLC to start when power is turned on, to run the user program when the PLC is switched to run mode, and to respond to user commands by running the appropriate application programs. The application programs allow the user to enter programs and data into the PLC's memory.

A PLC retains its operating system, application programs, user-programs and some data in retentive memory (non-volatile memory) while the PLC is turned off and even when disconnected from the power supply. A PLC can therefore resume running a user-program as soon as power is restored, although PLCs are often programmed to require some operator action before restarting for safety reasons.

All PLCs also come pre-programmed with application programs that run in response to commands the PLC receives from the programming unit, operator interface panels, or other computer connected to the PLC. Application programs allow users to do things such as writing and storing programs and data in the PLC's RAM memory, and allow the user to command that the PLC run programs and send status information to operator interface terminals, allowing monitoring of program execution and monitoring of data PLC's memory.

2.2 PLC User Programs

User-programs are not part of pre-programmed set of programs purchased with PLC. They must be entered into a PLC's RAM memory by a programmer using a programming unit. PLC's save user-programs in memory that is either unaffected by power loss or is maintained by a life-long battery. The user-program remains in the PLC's memory until a programming unit is used to change it [1].

PLC user-programs are usually written in ladder logic. Ladder logic diagrams are graphics-based. Each rung in a ladder logic program consists of a logical statement that can be evaluated as being either true or false, and which controls whether the rung's output function is performed.

A PLC repeatedly executes its scan cycle, which includes the user-program, at intervals measured in milliseconds. Since PLCs execute their scan cycles at intervals as short as few milliseconds, the delay usually is not a problem.

2.2.1 CX-Programmer version 3.0

CX-Programmer version 3.0 is a 32-bits windows programming support tool for OMRON PLCs. It is a software package that supports many of the windows features, such as cut and paste between application, point and click editing, viewing and editing multiple applications program at the same time and browsers. CX-Programmer is the software that makes it easy to create, monitor and online edit programs for OMRON PLCs. There are several new features that are provided by this CX-Programmer version 3.0:-

- Support for program 'sections' – a program can be divided into definable, named sections for easier management of large programs.
- Improved search/replace – including with cards and memory range movement.
- Improved ladder and mnemonic editors – much greater clarity and improved zooming.
- Use of colour – global and local symbols is colored differently in the ladder/mnemonic views. Errors in ladder elements are shown a definable 'Error' colour.
- The shortcut keys and toolbars can be customized.
- An instruction can be entered using its instruction number, in the new instruction dialogue.

- Improved 'go to' facilities – go to an input or output function using a particular address, and go back again. Or go to a rung/step or commented rung.
- Monitoring can be attached to a ladder element (contact/coil or instruction).
- Monitoring can be set to work in hexadecimal format only.
- Addresses that are included within the PLC I/O table are shown with an IQ prefix in the programming windows.
- It is possible to define what is shown on the split in an editing window – the same type of view, ladder/mnemonic, or the local symbol table.
- Improved ladder printing.
- Improved CX-Server components.

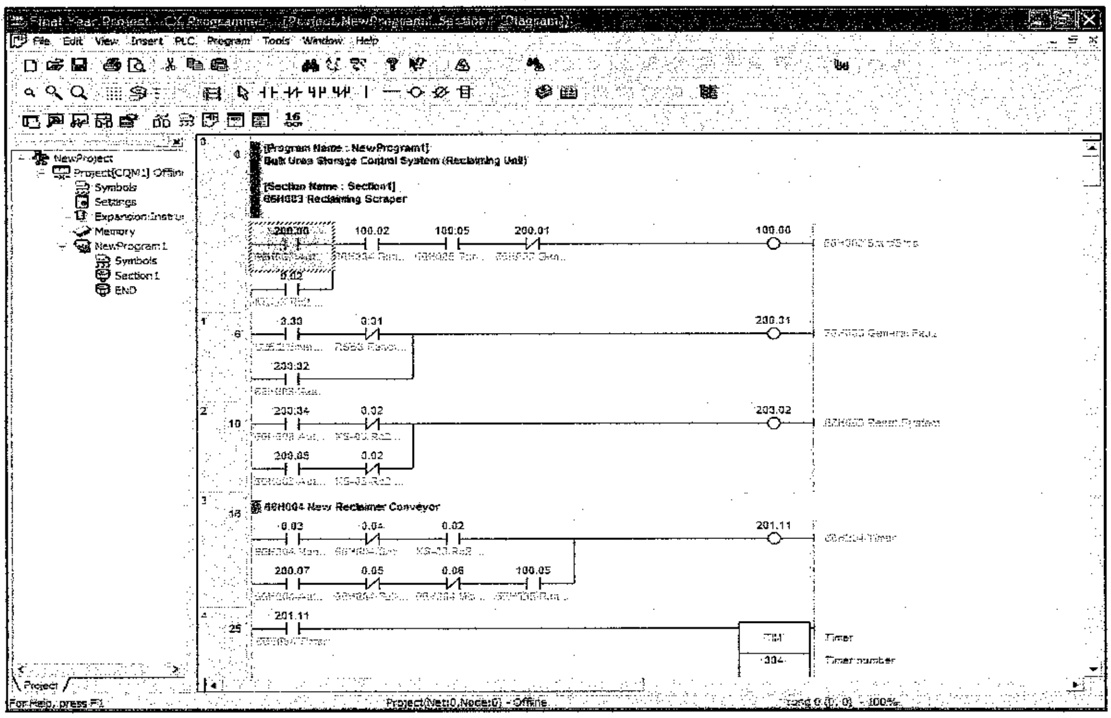


Figure 2.2: Ladder Diagram Construction using CX-Programmer

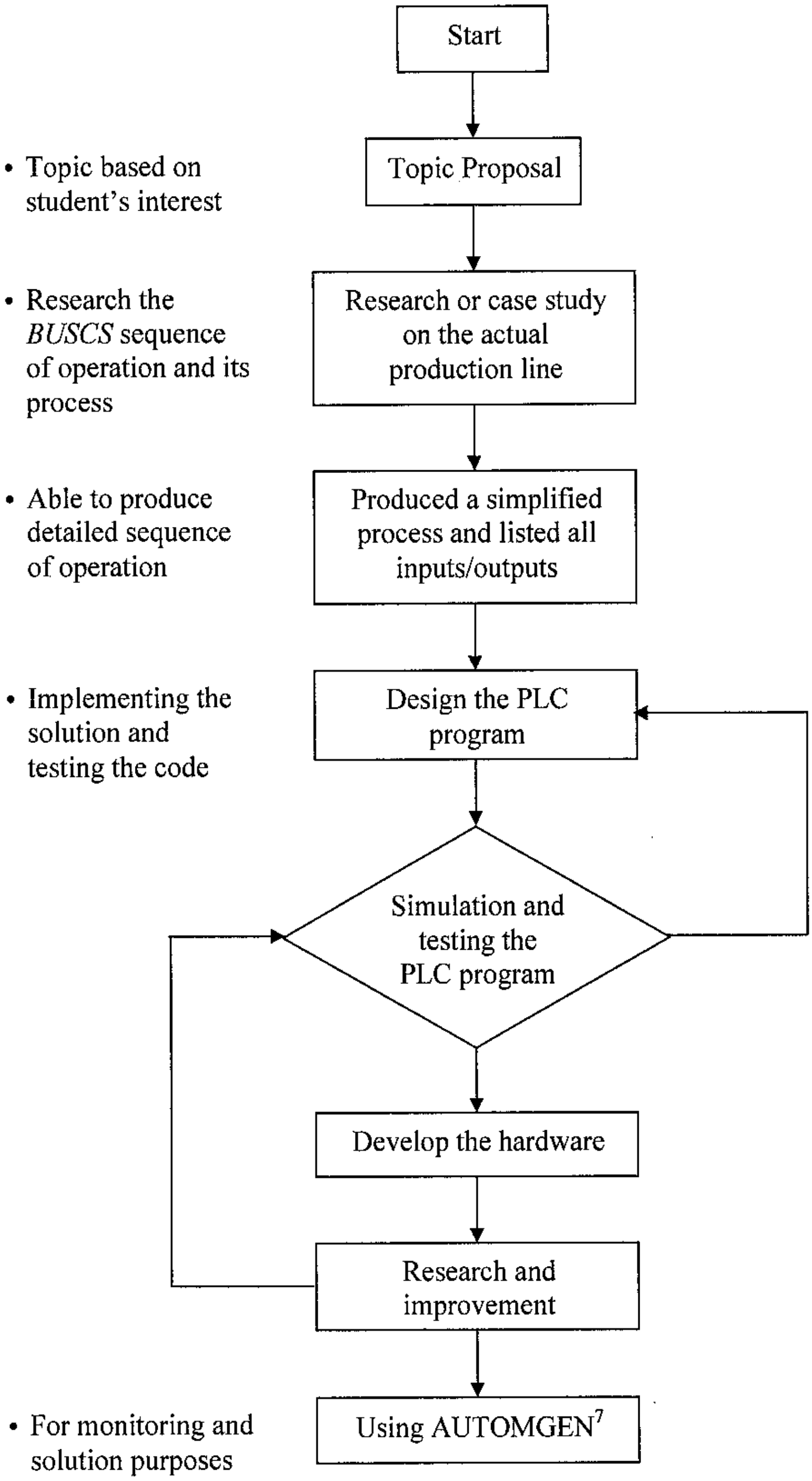
2.3 AUTOMGEN ver. 7.0

AUTOMSIM is a pneumatic / electrical / hydraulic simulation module. It can be used alone or as an addition to AUTOMGEN[7] functions. IRIS is used for SCADA and 3D process simulation while AUTOMSIM is used for electrical, pneumatic and hydraulic simulation. Therefore, the student can simulate the operational elements in 3D with IRIS3D to test the applications and demonstrate the machine's capabilities [6].

In addition to that, AUTOMGEN[7] also make productivity savings while benefiting from a great range of targets to carry out your applications. Many models and different interfaces (PLC) are compatible with the software. Therefore, the use of many objects (push buttons, motors, sensors and etc.) can be replaced using this software where we will make simulation of the BUSCS and minimizing the cost for testing the PLC program before applying it to the real system for industrial applications.

CHAPTER 3

METHODOLOGY / PROJECT WORK



3.1 Procedure Identification

In order to accomplish the objectives of this project, a few steps of procedure are listed in the flow chart on the previous page. The project is divided into 4 phases. The first phase started with preliminary research and literature review, which related to the subject matter of this project. Then, the next phase is to have complete study of the production line and prepare the user-program for the PLC. Testing is done after the user-program had been completed to test for its functionality.

The next phase of the project is combining and integrating the PLC program with the software for the controlling and monitoring process. After the PLC and the monitoring software have been integrated, testing process is being implemented to ensure the project is working properly. Finally, the last phase would be constructing and designing the hardware application on a smaller scale based on the actual construction of the system.

3.2 Preliminary Research and Literature Review

The first step of the project is to carry out a preliminary research and literature review. The research is needed to gather the information and understanding on the actual production line of Bulk Urea Storage Extension Project of ASEAN Bintulu Fertilizer Sdn. Bhd. This includes producing the complete sequence of operation and also the flowchart for the actual production line in order to have a better understanding of the system.

Literature review is also being carried out to widen the knowledge on the PLC that will be used in this project. This will include the programming software and also the monitoring software that are suitable to be integrated with the PLC that is being used as the main controller of the system. These researches are done through journals, paper conferences, Internet, magazines as well as newspapers to find related topics on the subject matter involved in the project.

3.3 Develop PLC Program

The process of designing a PLC program starts with understanding the system requirement. Therefore, the student had produced the detailed sequence of operation for the whole system and flowchart to assist in having a clearer view of the operation for each units involved in this system. Finally, the student had produced a list of input and output for the PLC system.

The main controller for this project will be Programmable Logic Controller (PLC). The program is translated into ladder diagram to create the PLC user-program. At the initial stage, the ladder diagram construction was aided by software supported by OMRON which is CX-Programmer version 3.0. It is a PLC programming tool for creation, testing and maintenance of programs associated with OMRON CS/CJ-series PLCs, CV-series PLCs and C-series PLCs.

CX-Programmer ver. 3.0 also comes with a context sensitive online help system which is designed to complement the manual and provide quick reference. In other hand, the general help system also allow information to be obtained either by typing or selecting specified keywords.

After the complete PLC program for the whole system has been produced, the complete ladder diagram is then downloaded into the PLC. Then, the programs are compiled and tested online. Testing stage is done after compilation process to ensure the functionality of the program. If the test is success, documentation and operation is carried out as the last step.

3.4 Hardware Preparation

The main task in developing the hardware system is to build the local display of the Bulk Urea Storage Control System (BUSCS) Extension Project. It will be used to interact with people for the purpose of configuration, alarm reporting or controlling the production line.

One important aspect of developing the hardware system is making the right connections between input and output devices. Complete wiring connections need to be correct in order to ensure the applicability of the equipment together with the communication of equipments with each other.

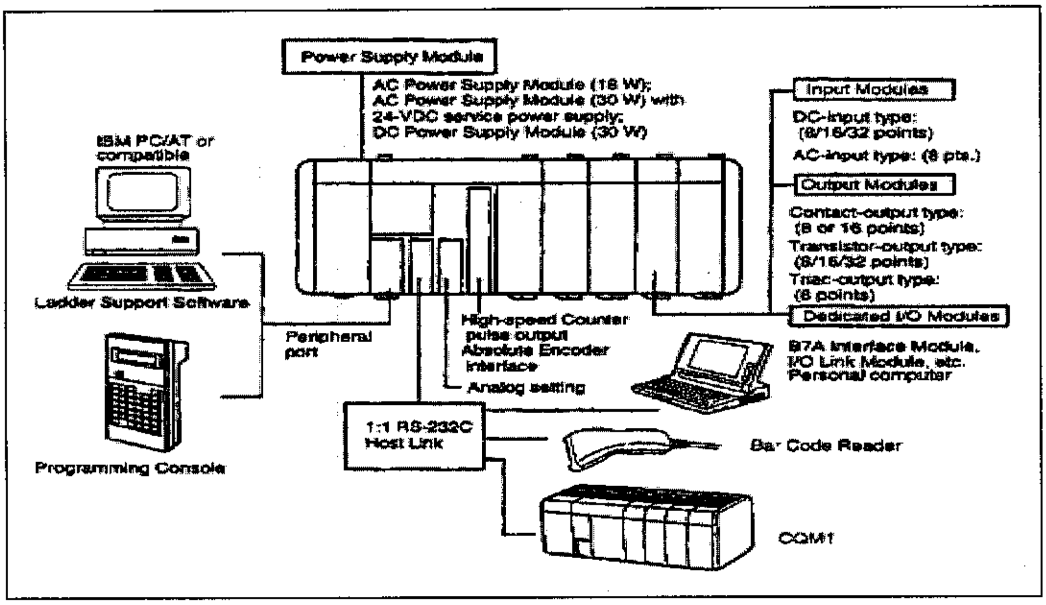


Figure 3.2: Application of OMRON CQM1 Controller

3.5 Designing an User Interface

After completing the programming of the whole production line of Bulk Urea Storage Extension Project using PLC, the student should design or interface between AUTOMGEN[7] and OMRON PLC. The AUTOMGEN[7] software will be used for monitoring purposes where the user can view the whole process only by observing at the specified monitor.

Therefore, the main purpose of designing the user interface is to build a Human Machine Interface (HMI). It is the layer that separates a human who is operating a machine from the machine itself. It consists of computer hardware and software that enables a single operator to monitor and control large machinery while being comfortable in the Workstation or the Control Centre [5].

A communication link should be established between the Personal Computer (PC) and also the PLC. In this project, serial communication is needed and a communication path needs to be specified for both the OMRON CQM1 Programmable Logic Controller Unit and also the AUTOMGEN[7] software. The communication parameters can be set in the connection setting for CX-Programmer and by selecting OMRON post-processor on the AUTOMGEN[7] software.

The common cable that is being used by both of CX-Programmer versions 3.0 and also the AUTOMGEN[7] is the RS-232 cable. RS-232 (also referred to as EIA RS-232C) is a standard for serial binary data interchange between a DTE (Data Terminal Equipment) and a DCE (Data Communication Equipment). It is commonly used in personal computer serial ports.

3.6 Tools Required

There are several hardware and also software which were used by the student to complete the project. The Programmable Logic Controller (PLC) is needed to control the whole production line and sequence of operation. A computer is also needed to develop an interface between OMRON PLC and AUTOMGEN[7]. Therefore, below is the list of hardware used in this project:-

- Programmable Logic Controller Console (OMRON)
- Personal Computer (PC)
- Push-buttons and sensors
- RS-232 cable

Besides that, the student also needs to use several software to aid in the construction of the ladder diagrams and also for simulation purposes. This type of proceeding is called Human Machine Interface (HMI). Below is the list of software used by the student in this project:-

- SYSWIN version 3.2 for OMRON
- CX-Programmer version 3.0 for OMRON
- AUTOMGEN version 7.0 (trial version)

CHAPTER 4
RESULTS AND DISCUSSION

4.1 FINDINGS

The project include four major parts which are analysing the actual production line of Bulk Urea Storage Control System (BUS), develop the Programmable Logic Controller (PLC) program, develop the hardware system and also interfacing between PLC and AUTOMGEN[7].

The whole process will be controlled by the PLC and uses AUTOMGEN[7] for monitoring purposes. The PLC will control the DC motors for the belt conveyors and other input/output devices required for controlling the process.

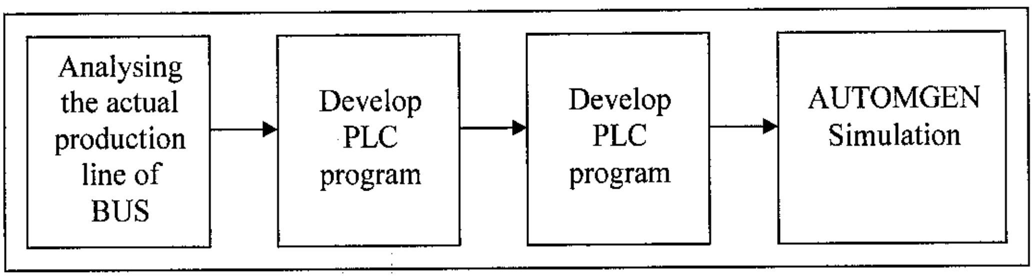


Figure 4.1: The Overall View of the Project

4.2 BULK UREA STORAGE SYSTEM

4.2.1 System Description

ASEAN Bintulu Fertilizer Sdn. Bhd. is planning to increase their bulk urea storage facilities at their plant for the production of ammonia and granular urea located in Bintulu, Sarawak. An extension of storage facility (BUS2), with bulk urea handling facilities, is being built adjacent to the storage building (BUS) [7].

A new Bulk Urea Storage Control System (BUSCS), a new stockpiling and reclaim control system for BUS2 will be integrated to the present system. The existing bulk urea handling facilities are controlled by relay based conveyor system located in Shipping Control Room (SCR).

The Storage Facilities are provided to keep and maintain the quality of the product urea according to the required specifications. It consists of the following existing facilities:-

- Six piles building (BUS)
- Reclaiming Scraper (60-H003)
- Stockpiling Conveyor (60-H001)
- Reclaimer Conveyor (60-H004)
- Tripper Car (60-H001-A01)
- All downstream ship loading conveyor system

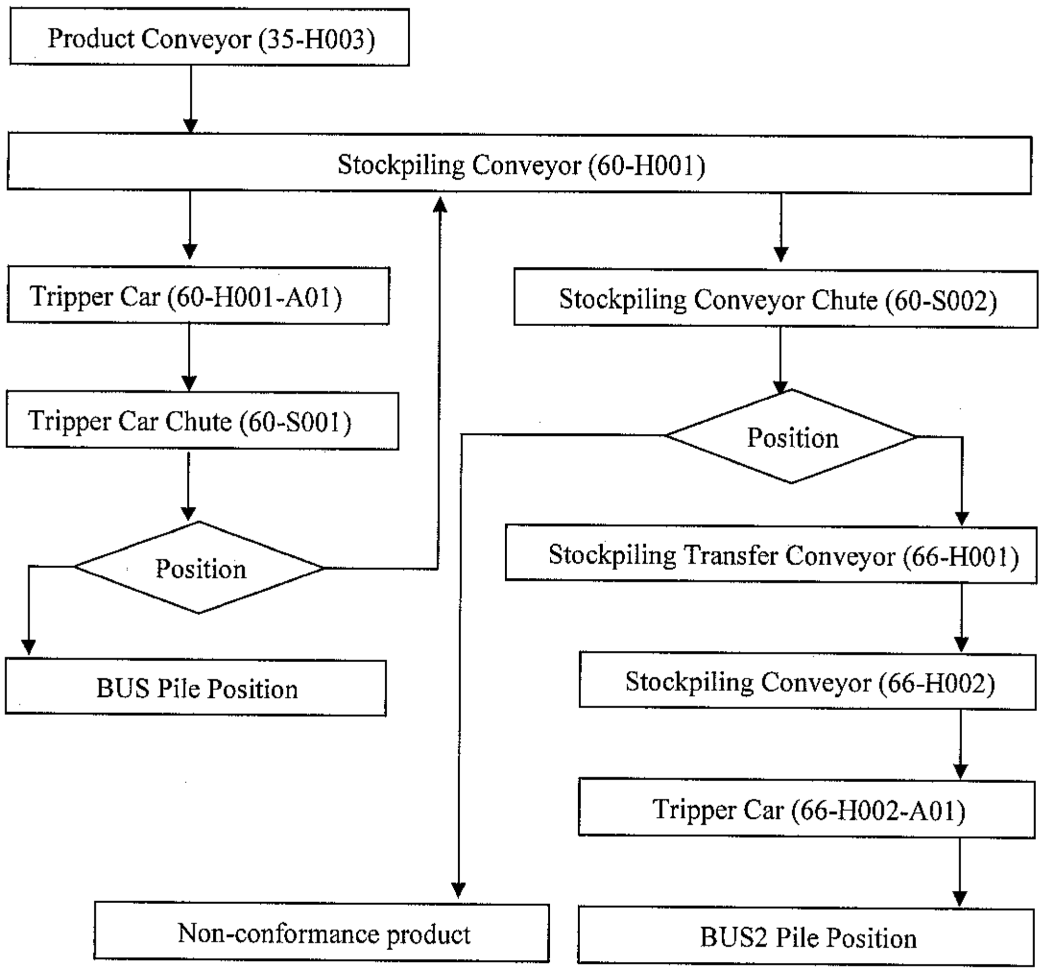
The Ship loading Facilities deliver the bulk urea storage to the ship in a safe and smooth operation in order to meet the demand in flow rate and time. It consists of the following new facilities:-

- Stockpiling Conveyor Chute (60-S002)
- Tripper Car Chute (60-S001)
- Reclaiming Scraper (66-H003)
- Reclaimer Conveyor (66-H004)
- Reclaimer Transfer Conveyor (66-H005)
- Tripper Car (66-H002-A01)
- Stockpiling Conveyor (66-H002)
- Stockpiling Transfer Conveyor (66-H001)
- Three piles building (BUS2)

Stockpiling System

The urea product will be delivered from Granulation Building to the existing storage building via Stockpiling Conveyor (60-H001). When the flow of granular urea is to be directed to the storage building, BUS2, the Tripper Car Chute (60-S001) will be set to position 'B'. In this way, the material flow to the head end of this conveyor outside the storage building (BUS) to transfer tower (L67). The Stockpiling Conveyor Chute (60-S002) at L67 shall be set to position 'B' [7].

From here the material will be transported to the Stockpiling Transfer Conveyor (66-H001) which will further lead to another transfer tower (L68) where the material will be cast onto a Stockpiling Conveyor (66-H002). All conveyors outside the buildings will be placed in fully closed galleries. With the help of Tripper Car (66-H002-A01) the urea will be cast onto a stockpile in storage building (BUS2).



Reclaiming System

From BUS2, the urea will be reclaimed from the stockpile with the aid of a mobile Reclaiming Scraper (66H003). The material will be scraped over a protruding edge under which Reclaimer Conveyor (66H004) will be located [7].

This conveyor will run along the full length of the stockpile to the Reclaimer Transfer Conveyor (66H005), the material will be delivered to the extended tail end of the Reclaimer Conveyor (60H004) in the existing storage building and transported to the Screening Station and further downstream bagging or ship loading facilities. The tail end of the Reclaimer Conveyor (60H004) shall be extended to accommodate installation of a discharge point for the Reclaimer Transfer Conveyor (66H005).

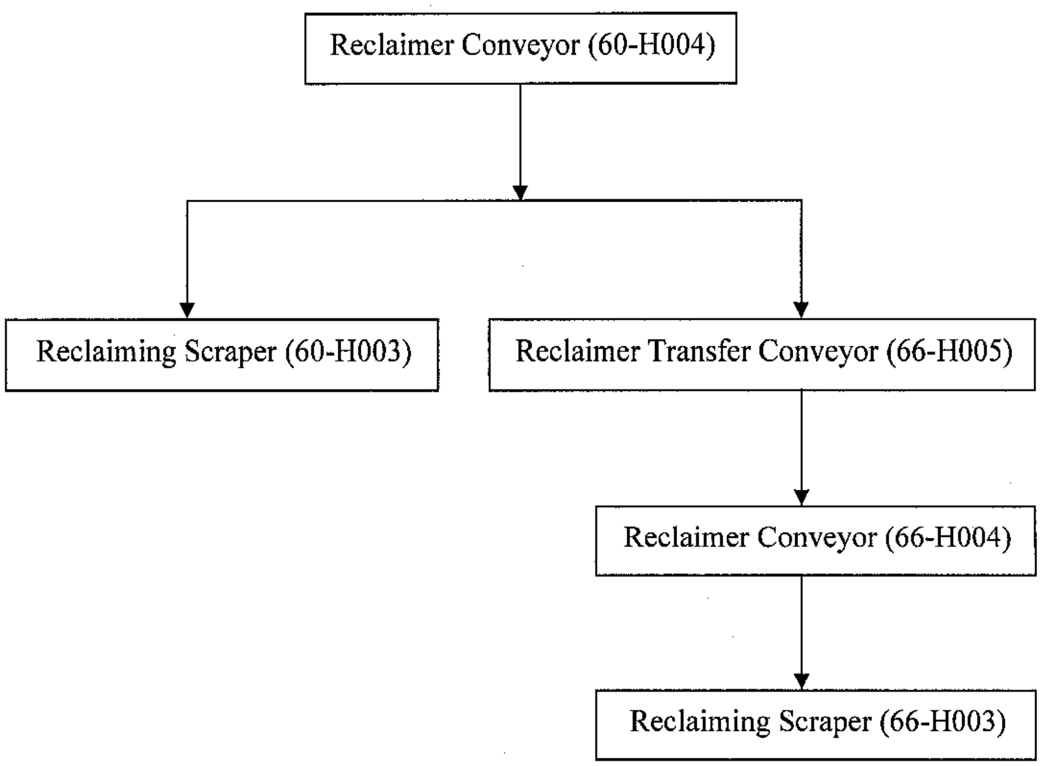


Figure 4.3: Reclaiming Unit Flow Diagram

Conveyor Belts

The conveyor systems will be divided into stockpiling system and reclaiming system. All stockpiling conveyor systems and the BUS2 Reclaiming System operation will be controlled by BUSCS located in Shipping Control Room (SCR). The BUSCS shall interlock all unit 66 conveyor operations with tripper cars, reclaimers operation and unit 60 conveyor system operations [7].

For reclaim system, any tripping of downstream conveyors or facilities (i.e. bagging and ship loading facilities) shall trip the Reclaimer Conveyor (60-H004) and hence Reclaimer Conveyor (66-H004) and Reclaimer Transfer Conveyor (66-H005) if the later two conveyors are in operation. Tripping of these reclaim conveyors shall immediately trip the operation of reclaimers (i.e. Reclaiming Scraper 60-H003 and Reclaiming Scraper 66-H003 whichever in operation.)

For stockpiling system, tripping of downstream conveyors (i.e. Stockpiling Transfer Conveyor 66-H001 and Stockpiling Conveyor 66-H002 shall not trip the Stockpiling Conveyor 60-H001 but to divert the flapper gate of the 2-way Tripper Car Chute 60-S001 of the Tripper Car 60-H001-A01 to pile material at the BUS building.

For both Tripper Cars (Trip), the Stockpiling System shall shutdown sequentially after 60 minutes.

4.2.2 Discussion

At the initial stage, the student has to understand the actual production line of Bulk Urea Storage (BUS) and list down all the inputs and outputs needed for the whole process. The definitions of all the terms used in the whole process had to be determined and also the sequence of operation for both units (Stockpiling and Reclaiming).

4.3 DEVELOPING PLC PROGRAM

Ladder logic programs and ladder logic elements are graphic-based. Ladder logic programs look similar to the relay logic circuit diagrams. A ladder logic program consists of horizontal rungs drawn between two vertical rails, so programs looks like stepladders. The left rail can be considered an electrical power rail and the right rail as a common connection [1].

Each rung contains instruction elements that examine memory bits and contains at least one output element that controls a memory bit. The electrical analogy is that if a path exists for electrical current to flow from the supply rail through switches to the common rail, the current will turn actuators in the circuit on.

The PLC repeatedly executes the ladder logic user-program, one rung at a time, from the first element at the top left to the last element at the bottom right. Actual input conditions are read during the first scan cycle step before the user-program starts executing, and actual output states are changed during the third scan cycle step, after the user-program ends.

The repeating three-step scan cycle consisting of:-

- An Input Scan

  The PLC reads data from all of its input modules (acquiring data from sensors attached to the input modules). This input data is placed into an area of the CPU module's memory reserved for images of input data.

- A User-program Scan

  The user-written control program is run once from beginning to end. The program will contain instructions to examine input image data and to determine what values the PLC should output to the actuators. The output data is saved in the area of the CPU's RAM memory reserved for images of output data.

- An Output Scan

  During this step, the PLC copies all data from the CPU's output image area of RAM to the output modules.

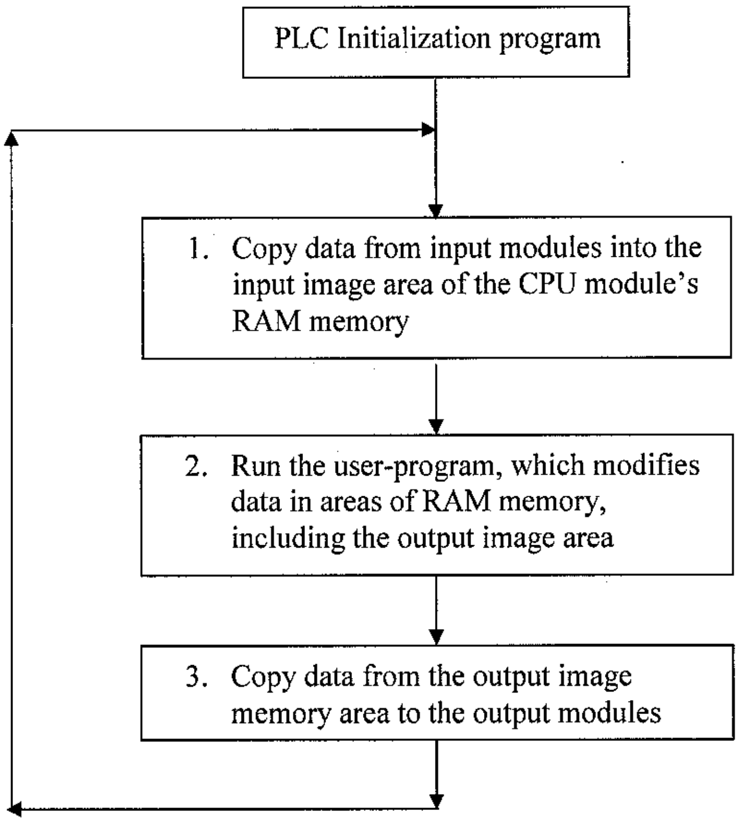


Figure 4.4: Standard PLC Cycle

4.3.1 Discussion

The Programmable Logic Controller (PLC) program using ladder diagrams are developed in CX-Programmer ver. 3.0 software in order to control the process. For automatic operation, the whole process will work sequentially according to the sequence of operations defined by the student. Lastly, the logic program can be manipulated by the user in order to control the process.

4.4 WIRING CONNECTIONS

During the process of developing the hardware system, the wiring connections between the sensors and inputs devices as well as output devices is one of the vital elements in constructing the whole system. With the help of technicians, complete connections from the PLC I/O port to the input/output devices are carried out and tested.

All of the push buttons, two-way switches and sensors that are connected to the PLC are considered I/O interrupt. An I/O interrupt is initiated by a signal from an input module, usually because of a change at a sensor attached to the input module. When the signal from the input module is received, the CPU module sets aside what it is doing and executes the interrupt service routine (ISR) assigned for that input condition.

An I/O interrupt is classified as hardware interrupt because it is initiated by a signal from equipment (hardware) rather than by an instruction in the program (software). Input interrupts, which execute in response to an input signal going on, are defined by OMRON as the highest-priority CQM1 interrupts, so they can interrupt any other ISR that might be running.

4.4.1 Discussion

In order to achieve success in terms of communication between the PLC controller and its I/O devices, exact connections between devices need to be done. This can be achieved with help from the manual and also with help from the technicians. Another important aspect of this task is to label the connections as we want to avoid disorder of the input/output devices.

4.5 DEVELOPING AUTOSIM SIMULATION

The student had built several electrical simulations of the Reclaiming System for the Bulk Urea Storage Control System (BUSCS). The simulation will be based on the actual PLC programming that had been done in the first semester of the Final Year Project.

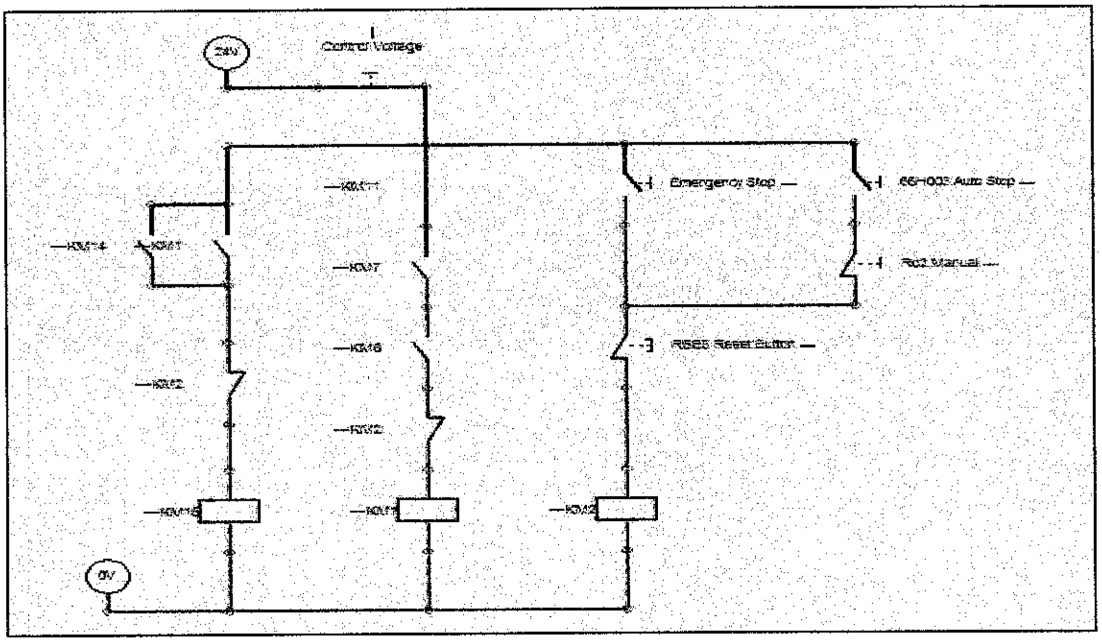


Figure 4.5: Electrical Simulation using AUTOSIM

4.4.1 Discussion

The components needed to build the simulation are already available in the AUTOMGEN[7] software. The AUTOSIM page is used to build the electrical simulation of the whole process. In this page, we can choose several components that are related to complete the whole Reclaiming System and this page can also be used to build other types of simulation such as the pneumatic and hydraulic simulations.

The main purpose of using AUTOMGEN[7] is to provide the student a platform to test programs on a virtual machine before guiding the real operative element. It also uses simplified graphic functions enables the student to formalise ideas using a language that is both simple and natural [6].

The IRIS 2D page is used to place the components needed for the graphical purposes. For example, the user can use this page for the main control of the system rather than using the AUTOSIM page where the user will find it troublesome to find the appropriate switches to operate the Reclaiming System.

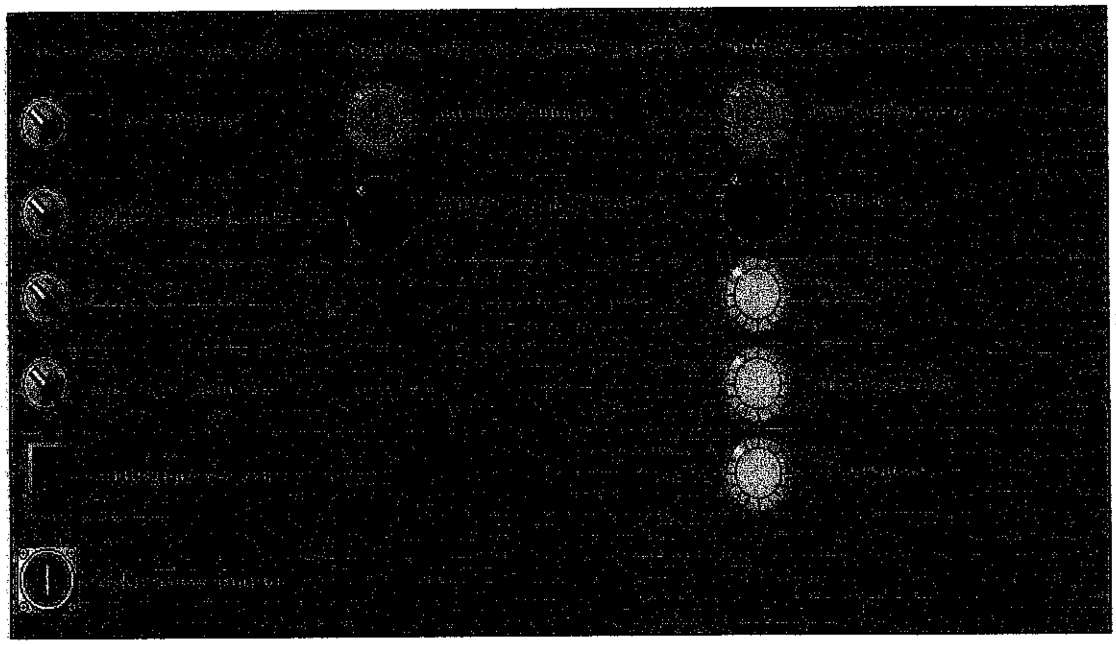


Figure 4.6: IRIS 2D Simulation of the Control Centre

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 RECOMMENDATIONS

5.1.1 The System Architecture

The Bulk Urea Storage Extension Project for ASEAN Bintulu Fertilizer Sdn. Bhd. can be improved with several recommendations particularly regarding the future development. One of the vital improvements is to provide a Programmable Logic Controller Unit that can cater the demand of inputs and outputs for the real system.

At the moment, the present CQM1 Programmable Logic Controller Unit available can only supply up to 16 inputs and 16 outputs. Therefore, the project can only give attention to controlling one unit of the BUSCS which is the Reclaiming Unit.

5.1.2 Teamwork Project

It is highly recommended that the project is handled by teamwork and a group of two or three students which would be ideal to complete this project. With different professional ideas and skills from each team member, the scope of this project can be broadened and more application could be added.

A genuine result in creating an intelligent environment can be fully achieved with the application of theories learned in control and programming courses into experiment and real application.

5.1.3 Monitoring Control

The present system architecture includes the PLC programming, hardware implementation and also software implementation. Therefore, the student will use

AUTOMGEN[7] as the software tools for monitoring purposes. The software will be used to monitor the whole process and also cater for the real-time inputs and outputs of the process.

Moreover, this software will resemble the real Work Station or Control Room at the plant where operators and engineers will monitor the process and response to any triggered alarms or trips.

5.1.4 Future Development

Several aspects of this project can be further developed in the future. Firstly, the PLC itself can be improved by adding more digital I/O modules in order to cater for industrial demands. It can also include analogue I/O modules so that we can control more complex production line and provide real-time control system.

Next, the graphical display can also be further improved by adding the 2D and 3D image of the whole production line by using the software supported by the AUTOMGEN[7]. It can help the operators to control as well as monitor the whole production line from the Work Station or the Control Room.

5.2 CONCLUSION

This project will be a good experience and enhance the understanding of the student in electrical and electronics field especially in control system and PLC implementation. Moreover, the student has the opportunity to learn, integrate and put into practice the learning experience for the past four years of study in Universiti Teknologi PETRONAS. In addition, the project is based on an actual production line and the student will have the opportunity to learn how to use the Programmable Logic Controller (PLC) to control the whole process.

In the first semester of the final year project, the literature review and researches are done mostly on learning on how to operate the PLC system as well as integrating AUTOMGEN[7] with PLC. The studies are conducted in order to ensure that a strong foundation have been developed to proceed on designing the PLC program, hardware system and also the Human Machine Interface (HMI).

This project consists of three large elements which are the PLC with the CX-Programmer ver. 3.0 Programmer Software, the hardware system which consists of input/output devices and lastly AUTOMGEN[7] that develops the Human Machine Interface (HMI) feature. During the completion of this project, there are lots of problems encountered especially understanding the actual production line of Bulk Urea Storage Extension Project (BUSCS) and also PLC programming. Therefore, the student had to solve the problems based on previous experience and also discussion with supervisors involved in this project.

This is a great exposure to the student on the future working experience since PLC will be used by most plants to replace the traditional electromechanical devices (relay logic) in controlling sequence of operation for their process. Therefore, the student had set the goal to design his own PLC program based on the actual production line and also build the hardware system as well as the simulation of the whole process using AUTOMGEN[7].

CHAPTER 6
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APPENDIX 1.0

GANNT CHART

Appendix 1.0

Planned Activities for the First Semester of Final Year Project

No	Detail Description / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic														
2	Preliminary Research Work														
	Project Planning														
	Actual case study of BUS														
	Produced a simplified version														
	List down all inputs / outputs														
3	Submission of Preliminary Report			√											
4	Project Work														
	Reference / Literature														
	Practical / Laboratory work														
	Programming of PLC														
5	Submission of Progress Report								√						
6	Project work continue														
	Programming of PLC														
	Practical / Laboratory work														
7	Submission of Interim Report Final Draft												√		
8	Oral Presentation													√	
9	Submission of Interim Report														√

Legends : √ Milestone that had been achieved

Appendix 1.1

Planned Activities for the Second Semester of Final Year Project

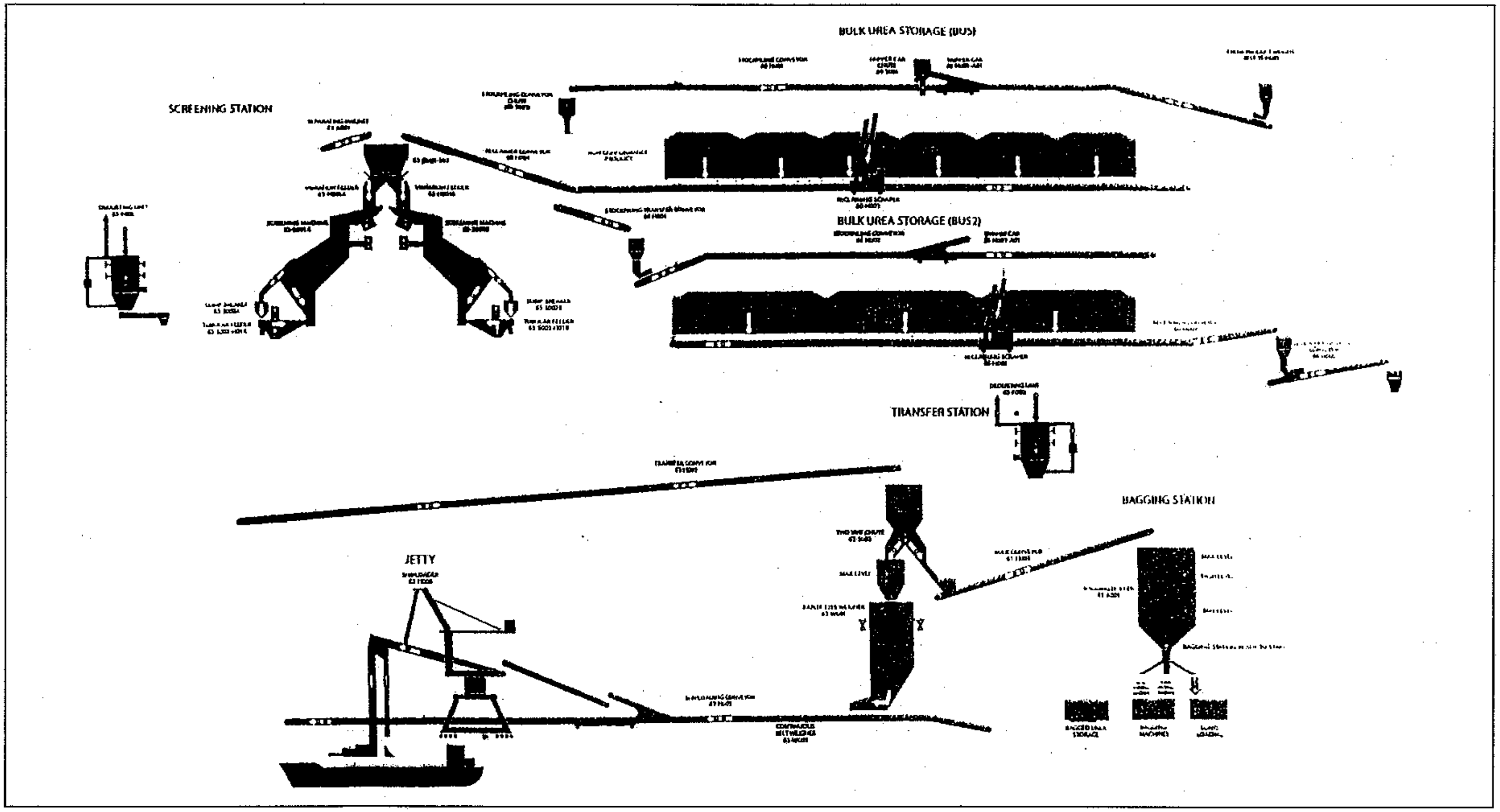
No	Detail Description / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project work continue		■	■											
	Practical / Laboratory work														
	Programming of PLC														
3	Submission of Progress Report I			√											
4	Project Work				■	■	■	■							
	Hardware implementation														
	Practical / Laboratory work														
	Programming of PLC														
5	Submission of Progress Report II								√						
6	Project work continue								■	■	■	■			
	Hardware implementation														
	AUTOMGEN interface														
7	Submission of Dissertation Final Draft												√		
8	Oral Presentation													√	
9	Submission of Project Dissertation														√

Legend : √ Milestone that had been achieved

APPENDIX 2.0

OVERALL DIAGRAM OF BUSCS

APPENDIX 2 : The Overall Diagram of the Bulk Urea Storage System



APPENDIX 3.0

I/O LIST OF RECLAIMING UNIT

FINAL YEAR PROJECT
BULK UREA STORAGE CONTROL SYSTEM
Input List for PLC

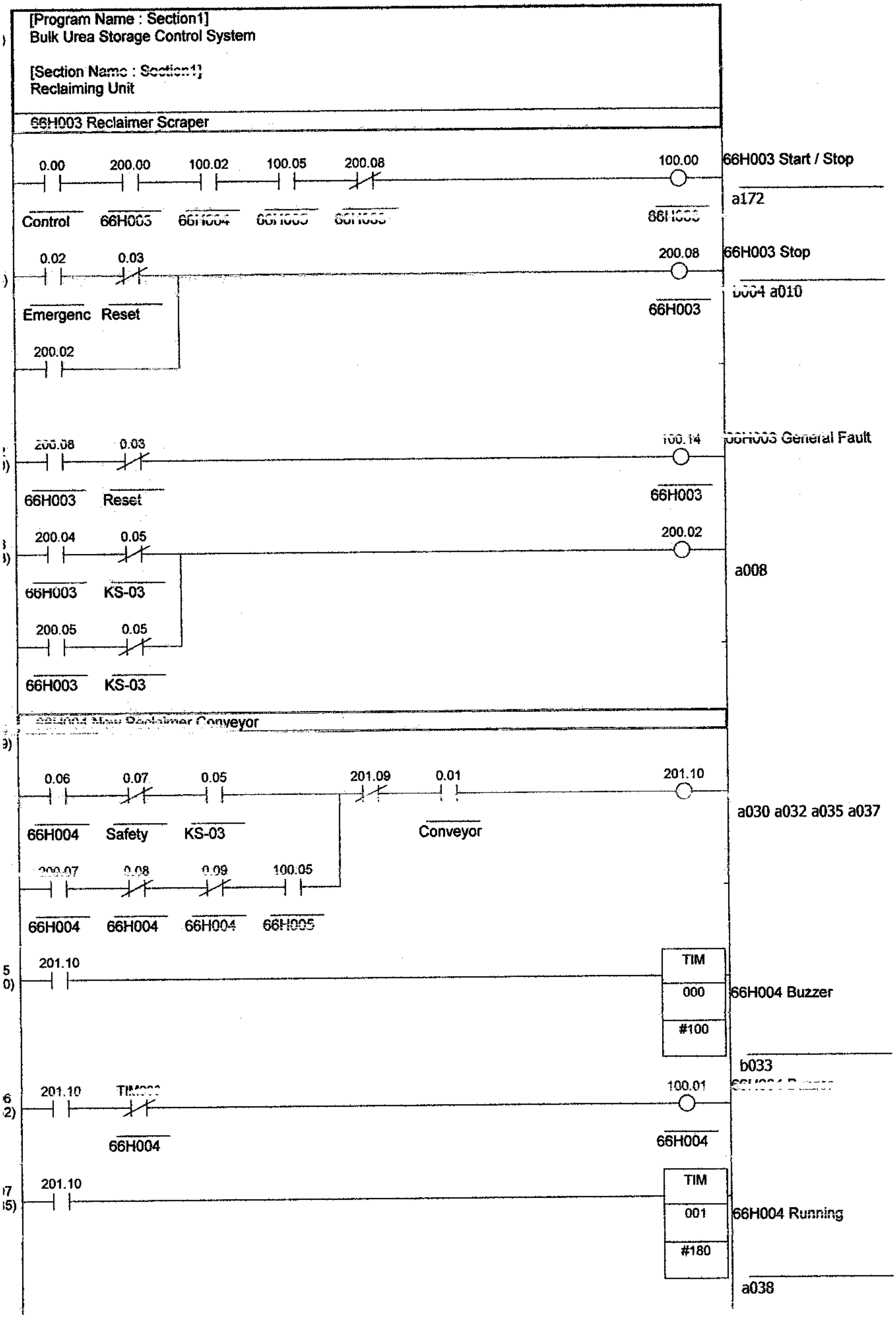
No	Address	Location	Status	Equipment/Instr.	Relay	Condition
1	0.00	BUSCS	Control Voltage	S25.1	KA1221	On when selected
2	0.01	BUSCS	Conveyor Control	S27.2	KA1220	On when selected
3	0.02	BUSCS	Emergency Stop	S25.2	KA1222	Off when activated
4	0.03	BUSCS	Press to reset	RSB3	KA13A81	On when press
5	0.04	BUSCS	Mode 1: Rc2 Auto	KS-03	KA13A72	On when selected
6	0.05	BUSCS	Mode 2: Rc2 Manual	KS-03	KA13A71	On when selected
7	0.06	Local	Manual Start	66H004	RL1161	On when activated
8	0.07	Local	Safety key switch on	66H004	RL1151	Off when activated
9	0.08	Local	Pull cord	66H004	RL0421	Off when activated
10	0.09	Local	Misallignment	66H004	RL0431	Off when activated
11	0.10	Local	Speed switch	66H004	RL0441	Off when activated
12	0.11	Local	Manual Start	66H005	RL1172	On when activated
13	0.12	Local	Pull cord	66H005	RL0451	Off when activated
14	0.13	Local	Misallignment	66H005	RL0461	Off when activated
15	0.14	Local	Speed switch	66H005	RL0471	Off when activated
16	0.15	IRP	STTS: Max level	Bagg hopper	KA4371	On when max level

FINAL YEAR PROJECT
BULK UREA STORAGE CONTROL SYSTEM
Output List for PLC

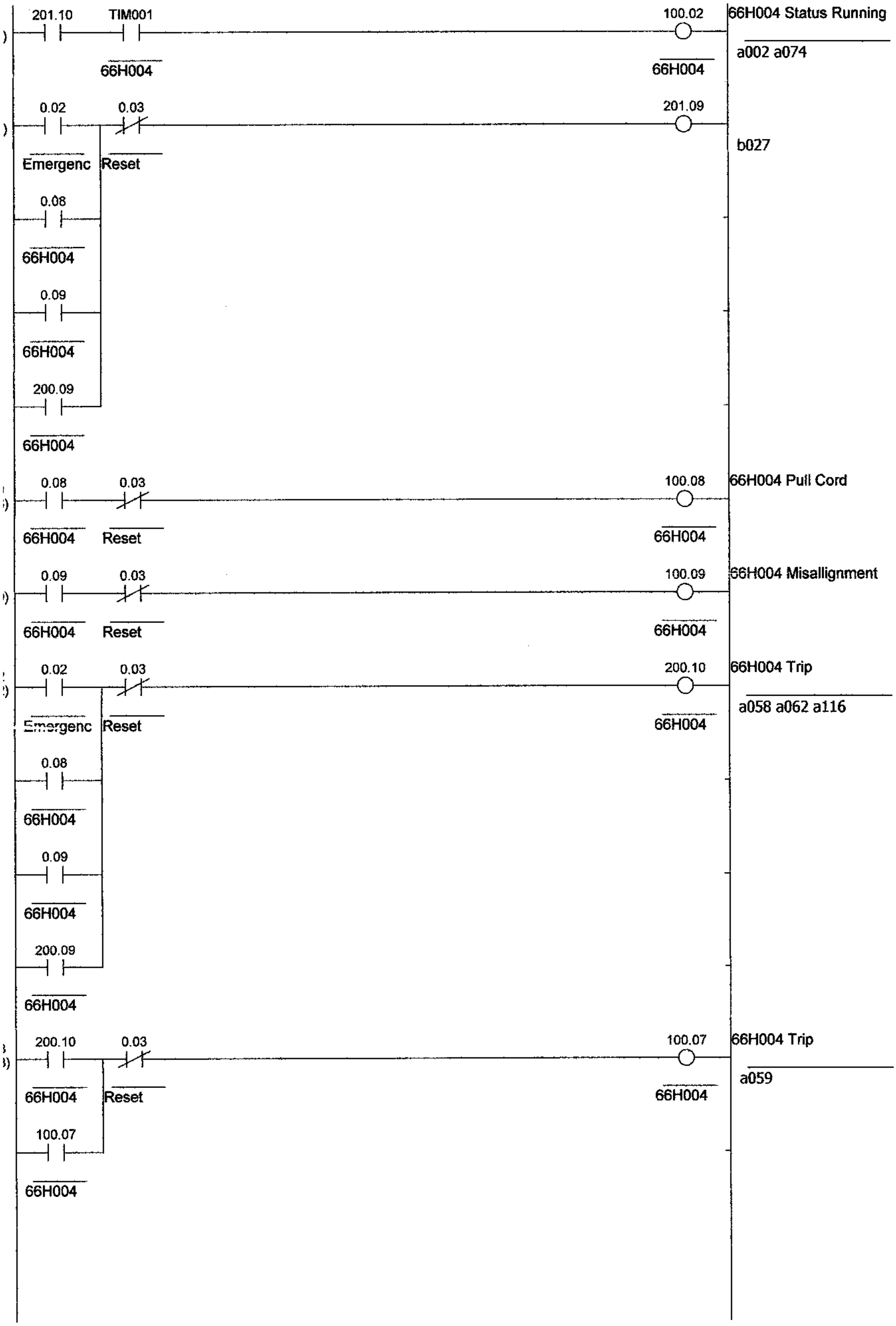
No	Address	Location	Status	Equipment/Instr.	Relay
1	100.00	BUSCS	In operation	66H003	RL0861
2	100.14	BUSCS	General Fault	66H003	
3	100.01	Local	Buzzer	66H004	RL0831
4	100.02	BUSCS	Status Running	66H004	RL0811
5	100.03	BUSCS	Status Stop	66H004	RL0821
6	100.07	BUSCS	Trip	66H004	RL0841
7	100.08	Local	Pull Cord	66H004	
8	100.09	Local	Misallignment	66H004	
9	100.10	Local	Over Speed	66H004	
10	100.04	Local	Buzzer	66H005	RL0851
11	100.05	BUSCS	Status Running	66H005	RL0832
12	100.06	BUSCS	Trip	66H005	RL0841
13	100.11	Local	Pull Cord	66H005	
14	100.12	Local	Misallignment	66H005	
15	100.13	Local	Over Speed	66H005	

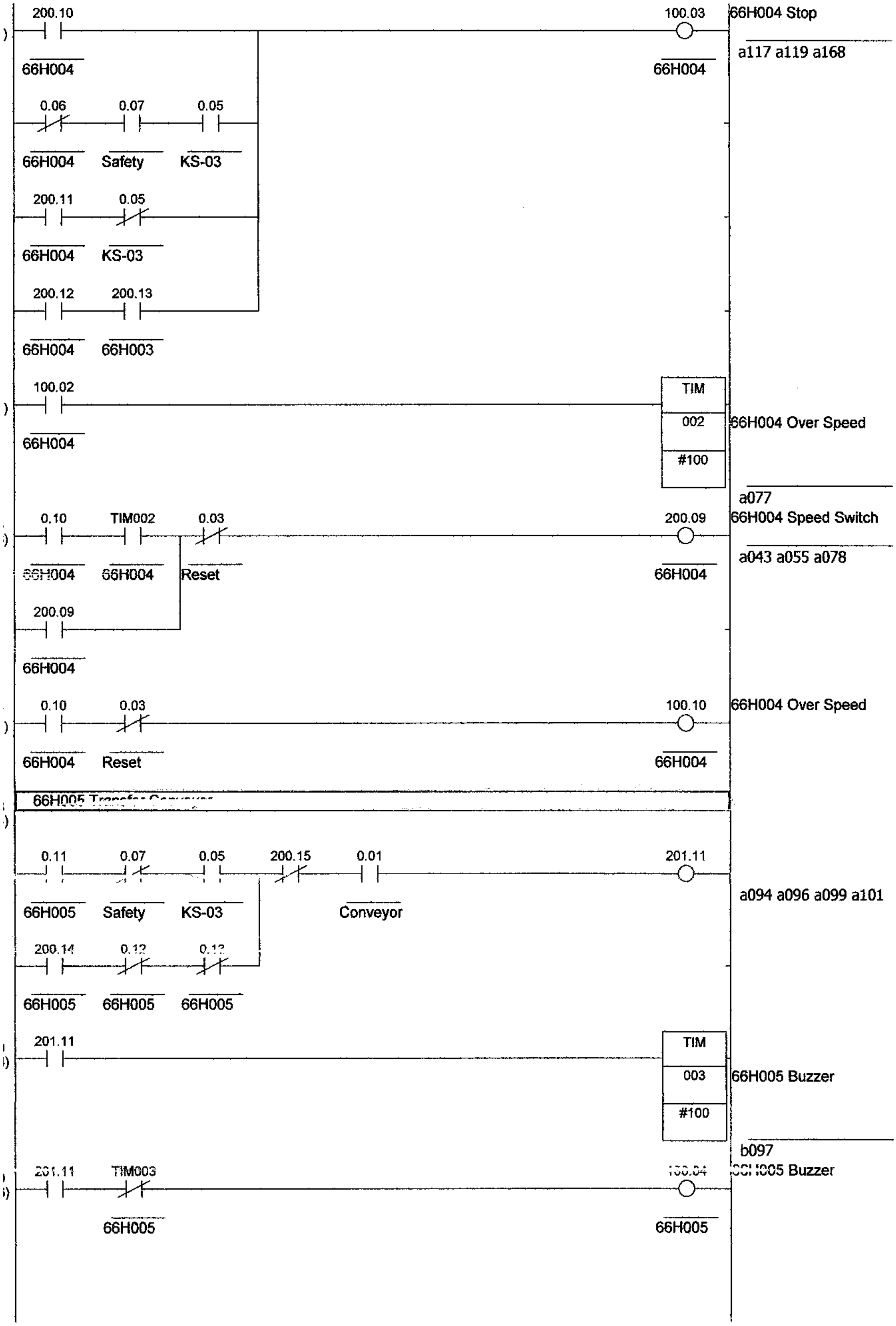
APPENDIX 4.0

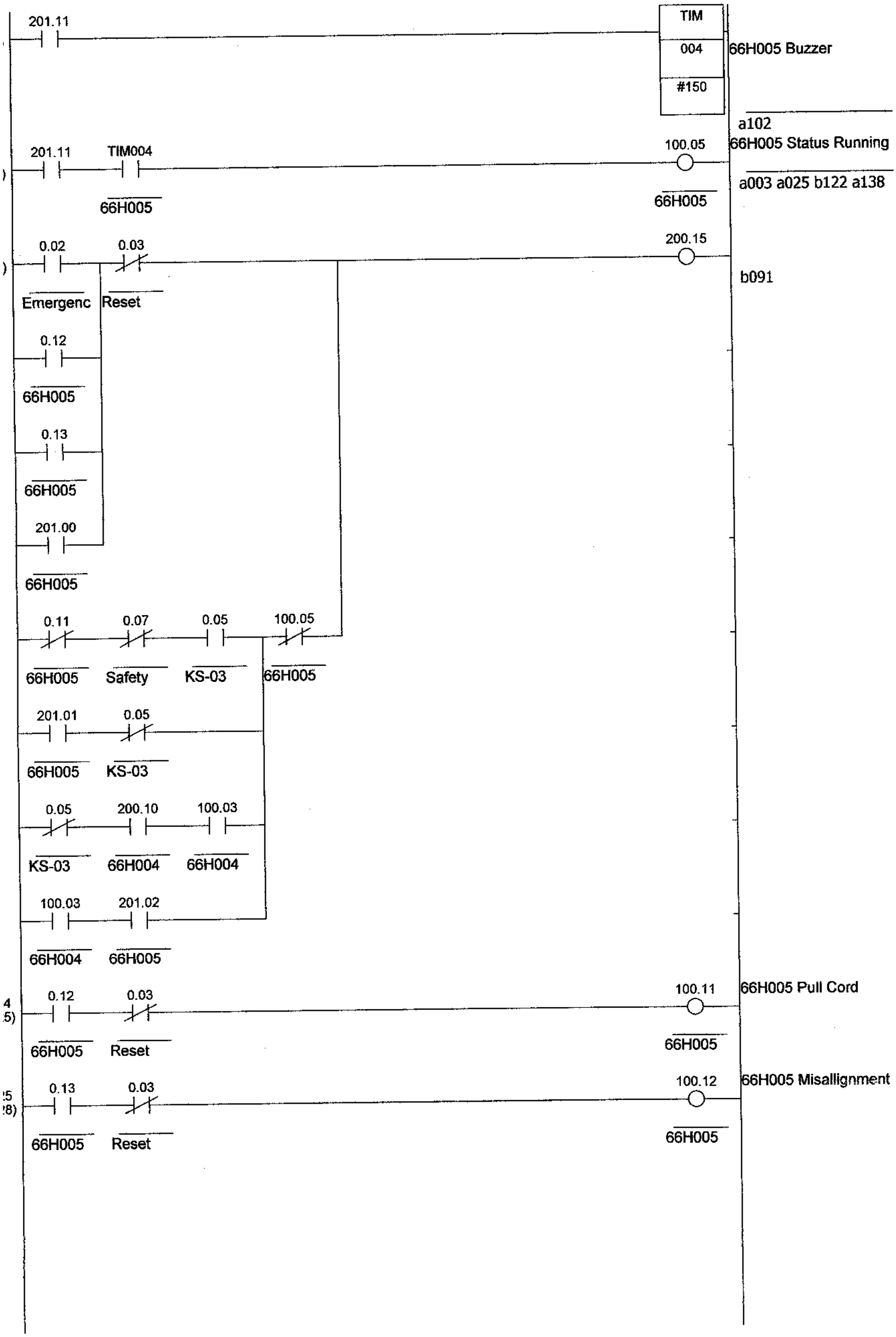
PLC LADDER DIAGRAM



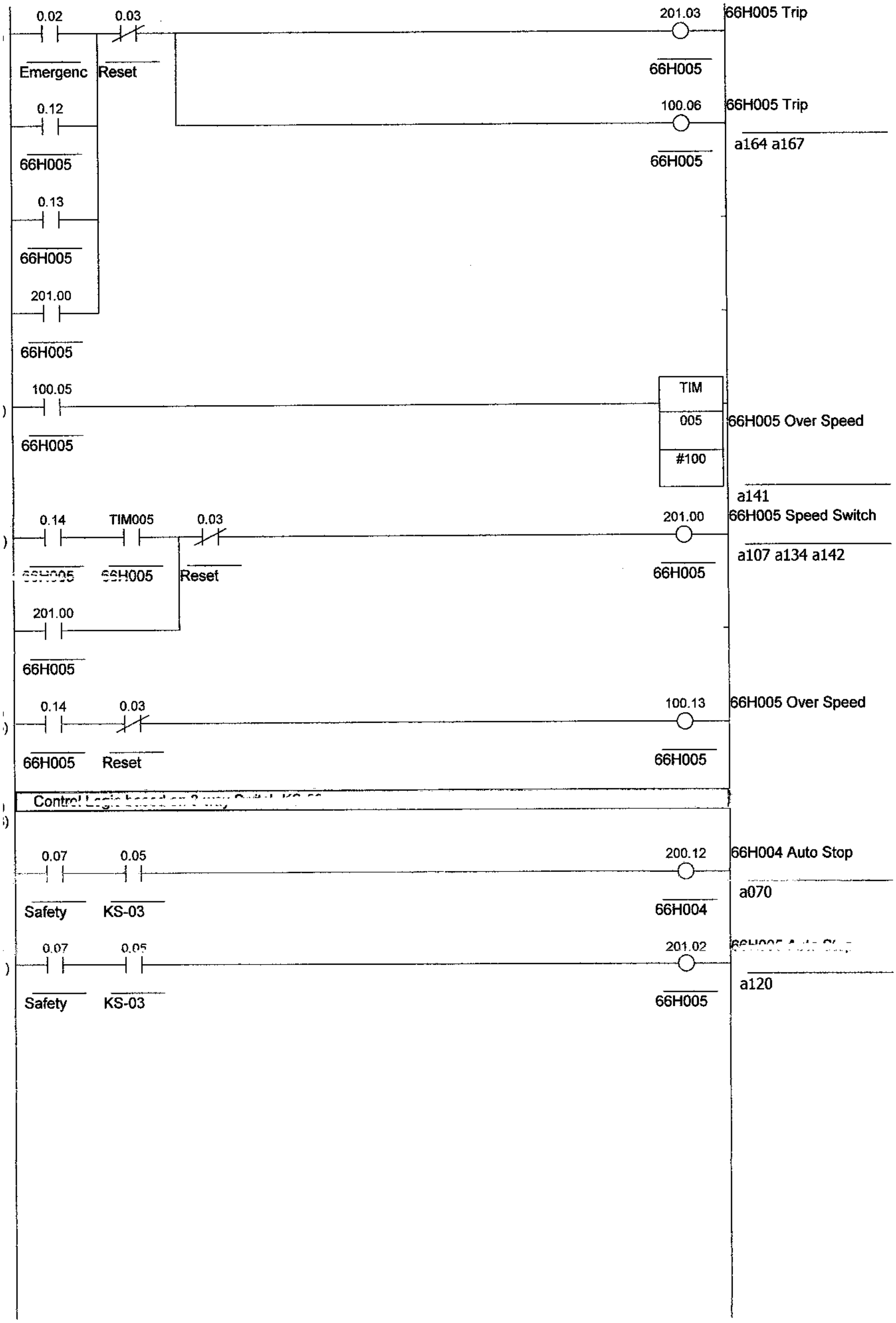
[Program Name : Section1]
Bulk Urea Storage Control System
[Section Name : Section1]
Reclaiming Unit
66H003 Reclaimer Scraper
0.00
Control
200.00
100.02
100.05
200.08
100.00
66H003 Start / Stop
a172
0.02
Emergenc
0.03
Reset
200.02
200.08
66H003
66H003 Stop
a010
200.08
66H003
0.03
Reset
66H003
66H003 General Fault
200.04
66H003
0.05
KS-03
200.05
66H003
0.05
KS-03
200.02
a008
Conveyor
0.06
66H004
0.07
Safety
0.05
KS-03
201.09
0.01
Conveyor
201.10
a030 a032 a035 a037
0.08
66H004
0.09
66H004
100.05
66H005
201.10
TIM
000
#100
66H004 Buzzer
b033
201.10
66H004
100.01
66H004
201.10
TIM
001
#180
66H004 Running
a038

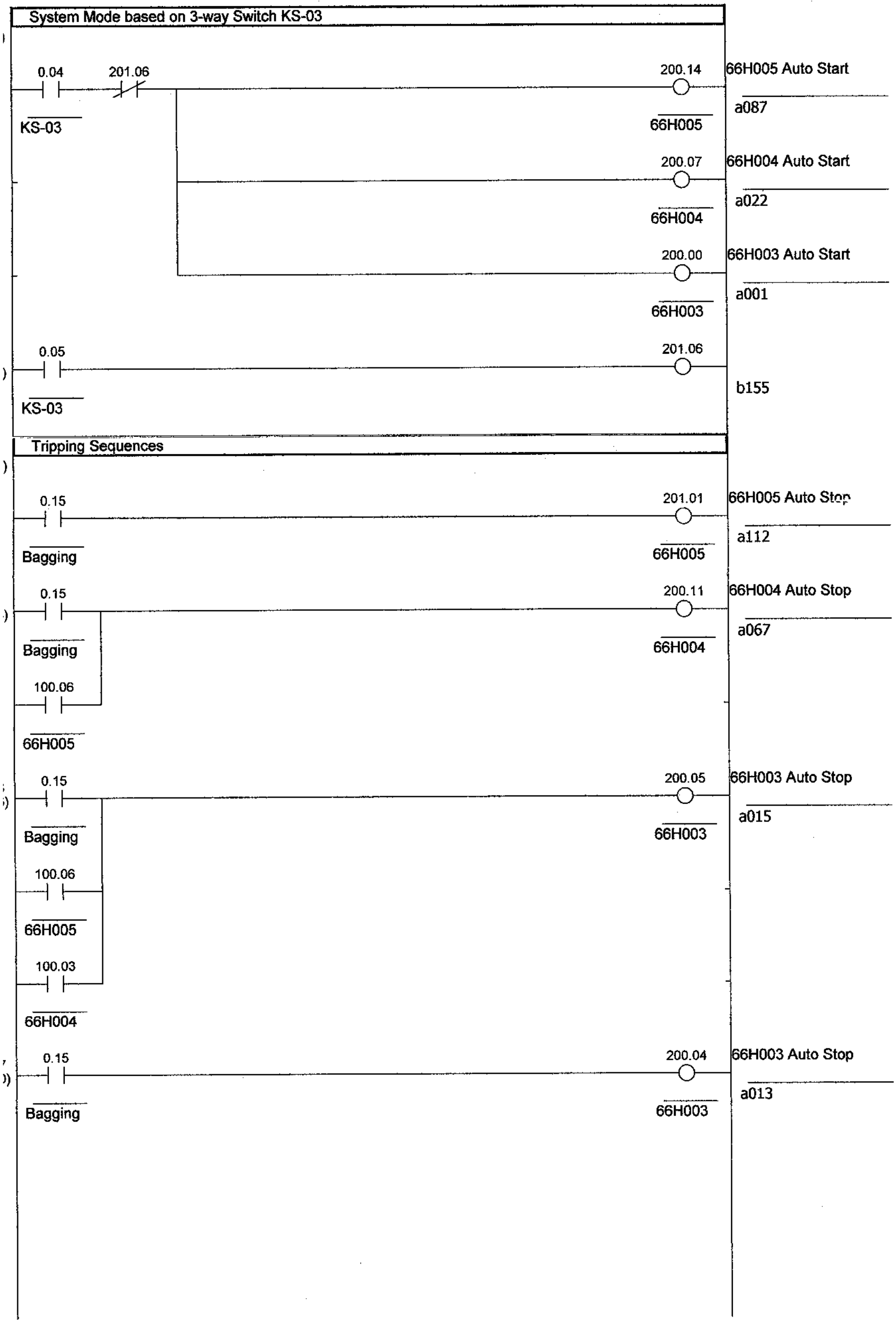

201.10
TIM001
66H004
100.02
66H004
66H004 Status Running
a002 a074
0.02
0.03
Emergenc
Reset
201.09
b027
0.08
66H004
0.09
66H004
200.09
66H004
0.08
0.03
66H004
Reset
100.08
66H004
66H004 Pull Cord
0.09
0.03
66H004
Reset
100.09
66H004
66H004 Misallignment
0.02
0.03
Emergenc
Reset
200.10
66H004
66H004 Trip
a058 a062 a116
0.08
66H004
0.09
66H004
200.09
66H004
200.10
0.03
66H004
Reset
100.07
66H004
66H004 Trip
a059
100.07
66H004

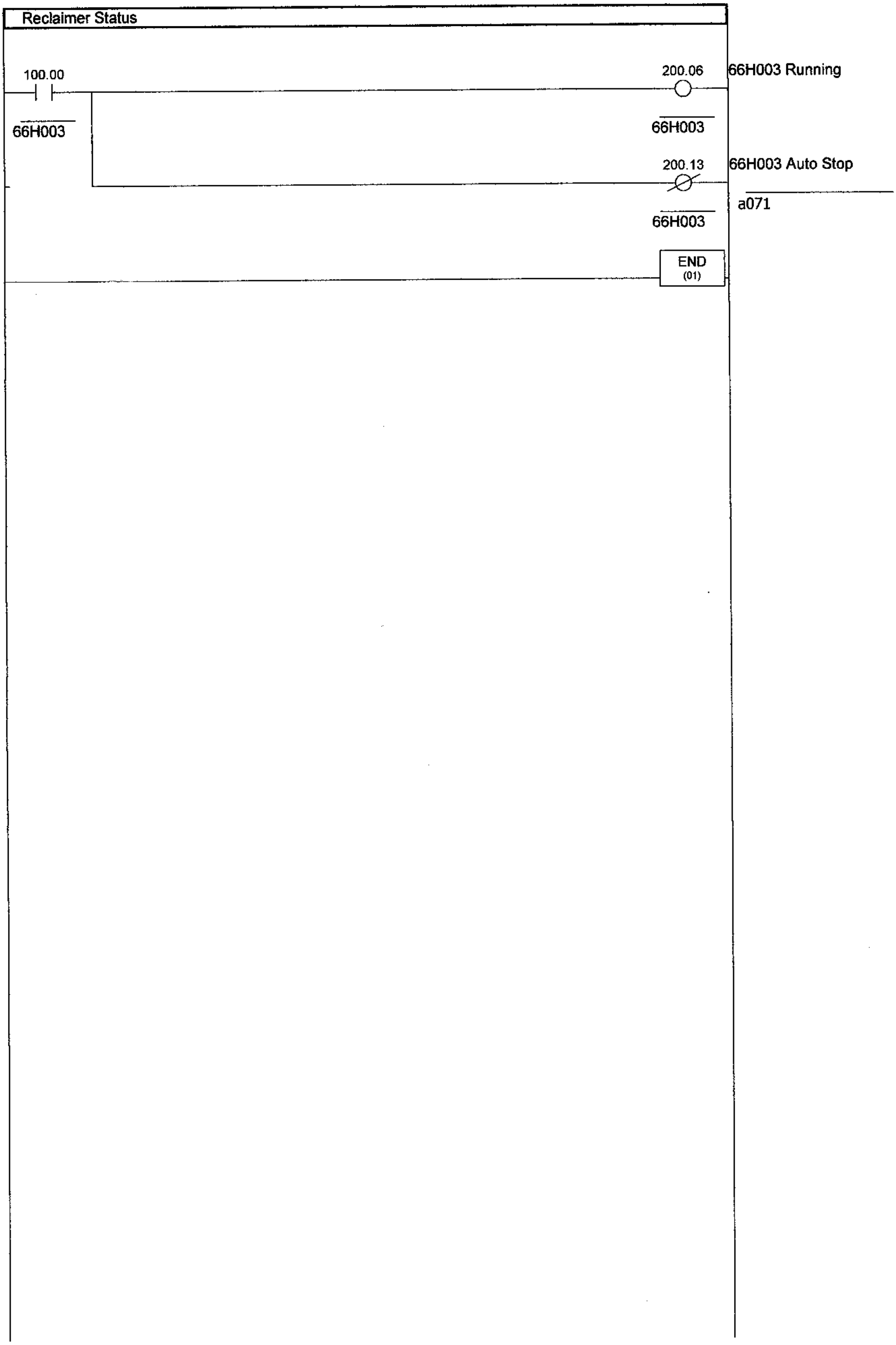

200.10
66H004
100.03
66H004
66H004 Stop
a117 a119 a168
0.06
0.07
0.05
66H004
Safety
KS-03
200.11
0.05
66H004
KS-03
200.12
200.13
66H004
66H003
100.02
66H004
TIM
002
#100
66H004 Over Speed
a077
0.10
TIM002
0.03
200.09
66H004 Speed Switch
a043 a055 a078
66H004
66H004
Reset
66H004
200.09
66H004
0.10
0.03
100.10
66H004 Over Speed
66H004
Reset
66H004
0.11
0.07
0.05
200.15
0.01
201.11
a094 a096 a099 a101
66H005
Safety
KS-03
Conveyor
200.14
66H005
66H005
66H005
201.11
TIM
003
#100
66H005 Buzzer
b097
TIM003
66H005 Buzzer
66H005
66H005



201.11
TIM
004
#150
66H005 Buzzer
a102
201.11
TIM004
66H005
100.05
66H005 Status Running
66H005
a003 a025 b122 a138
0.02
0.03
Emergenc
Reset
200.15
b091
0.12
66H005
0.13
66H005
201.00
66H005
0.11
0.07
0.05
100.05
66H005
Safety
KS-03
66H005
201.01
0.05
66H005
KS-03
0.05
200.10
100.03
KS-03
66H004
66H004
100.03
201.02
66H004
66H005
4
5)
0.12
0.03
66H005
Reset
100.11
66H005 Pull Cord
66H005
25
28)
0.13
0.03
66H005
Reset
100.12
66H005 Misallignment
66H005


0.02
Emergenc
0.03
Reset
201.03
66H005
66H005 Trip
0.12
66H005
100.06
66H005
66H005 Trip
a164 a167
0.13
66H005
201.00
66H005
100.05
66H005
TIM
005
#100
66H005 Over Speed
a141
0.14
TIM005
66H005
0.03
Reset
201.00
66H005
66H005 Speed Switch
a107 a134 a142
201.00
66H005
0.14
66H005
0.03
Reset
100.13
66H005
66H005 Over Speed
0.07
Safety
0.05
KS-03
200.12
66H004
66H004 Auto Stop
a070
0.07
Safety
KS-03
201.02
66H005
a120


System Mode based on 3-way Switch KS-03
0.04
KS-03
201.06
200.14
66H005
66H005 Auto Start
a087
200.07
66H004
66H004 Auto Start
a022
200.00
66H003
66H003 Auto Start
a001
0.05
KS-03
201.06
b155
Tripping Sequences
0.15
Bagging
201.01
66H005
66H005 Auto Stop
a112
0.15
Bagging
100.06
66H005
200.11
66H004
66H004 Auto Stop
a067
0.15
Bagging
100.06
66H005
100.03
66H004
200.05
66H003
66H003 Auto Stop
a015
0.15
Bagging
200.04
66H003
66H003 Auto Stop
a013


Reclaimer Status
100.00
66H003
200.06
66H003 Running
66H003
200.13
66H003 Auto Stop
a071
66H003
END
(01)