

Automatic Control System Design of the Threshing Station Model, Case Study in PT. Perkebunan Nusantara V - PKS Sei Galuh

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ABSTRACT

This paper presents a design for the automatic control system of the threshing station model using PLC Zelio smart relay. Threshing station is a station where a process of separation palm kernel from the bunch by way of slamming into a rotating drum. The threshing station model is a shape which resembles of the threshing station palm oil mill of PT. Perkebunan Nusantara V-PKS Sei Galuh, it has been scaled 1:8. PLC (Programmable Logic Controller) is a microprocessor based on instrument that can be programmed to control the machining process automatically. This system design has 2 inputs and 3 outputs. The inputs are push button to turn on and turn off of the works system and a rotary encoder sensor to detect rotating screw conveyor. The outputs are 3 units of DC motors. The programming language is used the ladder diagram by using the Software Zelio Soft 2. This system includes design of ladder diagram program, design of control system on auto feeder and design of rotary encoder sensor. The result of this design is revealed that auto feeder runs automatically turn on for 60 seconds and turn off for 30 seconds, continuously. The sensor works with voltage is 4.4 Volt at the moment un-stunted and 0.1 Volt when the stunted.

KEY WORDS: *Automatic Control System, Threshing Station Model, PLC Zelio Smart Relay, Rotary Encoder Sensor.*

1.0 INTRODUCTION

The technological advance in industrial automation is now increasingly rapid and broad. It is driven by the needs of growing industries and vary from year to year that can be seen more and more industries that use automation system in running production process one using PLC [1].

PLC is a computerized industrial control system that continuously monitors the input devices and makes decisions based on a special program to control the output device. PLCs are usually small, have little memory, and the number of inputs and outputs is limited. CPU, power supply, and system I/O are all designed into a single unit [2].

The processing palm oil mill in PT. Perkebunan Nusantara V-PKS Sei Galuh consists of several stations, one of which is the threshing station. Threshing station is a station where there is a separation process palm kernel of empty bunches [4], consisting of auto feeder, thresher and screw conveyor.

Auto feeder is a device in the form of machine tool apron conveyor that can move and direct the fresh fruit bunches into the thresher to do separation process by way of fresh fruit bunches slammed into a rotating drum then palm kernel result of the thresher process fell to screw conveyor. Screw conveyor is a device machine tool that serves to move and direct palm kernel to bucket elevators for pulverized process by digester machine and further the process of suppression by the machine screw press to produce crude palm oil (CPO) [4].

Observation in the field at PT. Perkebunan Nusantara V-PKS Sei Galuh, auto feeder operation on threshing stations still use the operator to regulate incorporate fresh fruit bunches that have been boiled to be shredded into a thresher by pressing the on-off push button. When the operator press the on button and auto feeder operation, the operator returned to the pressing station to do other

work which is to reduce pulp palm kernel result of the emphasis by the press machine so that the dregs of the result of the emphasis does not accumulate and can optimize work process press machine. Palm kernel the threshed then brought by bucket elevator to be included in the digester and crushing process for optimize and to simplify the process of suppression by a press machine. The operator will observe palm kernel go inside digester and look at the capacity level digester. Once the level has enough capacity on digester, then operator is back to the threshing station and pressing the off button to turn off the auto feeder operation. Operator back to the pressing station to continue it is work reducing dregs of palm oil. When the operator see the dregs of palm oil result of the emphasis has been reduced, then operator back again to the threshing station and pressing the off button to turn off the auto feeder operation.

Observations in the field also in screw conveyor under thresher fractures/detachment shaft screw conveyor, which causes a buildup of palm kernel the screw conveyor is not spinning. To clean the screw conveyor from piling palm kernel takes quite a long time so that processing of oil palm should be dismissed and the impact on the company's losses due to the production of crude palm oil does not reach the target.

Based on the above problems, the authors designed the shape and dimension threshing station model using AutoCAD 2014 Software [5] and then, together with the planning of production processes and modeling threshing station in the laboratory of Mechanical Engineering University of Riau based threshing station PKS Sei Galuh [6]. The author also designed the control system automatically on the threshing station model based Programmable Logic Controller (PLC) in the auto feeder using a timer and designing a sensor system on a screw conveyor to detect the rotation screw conveyor, so that in case of breaking up/stop the screw conveyor, the sensor will send a signal to PLC for output is auto feeder, thresher and screw conveyor are dismissed then the author will apply the results to the automatic control system design threshing station model.

This paper aims to provide an automatic control system on the threshing station model using PLC Zelio smart relay.

2.0 METHODOLOGY

This paper was conducted with several stages :

2.1 Field Observation and Data Collection

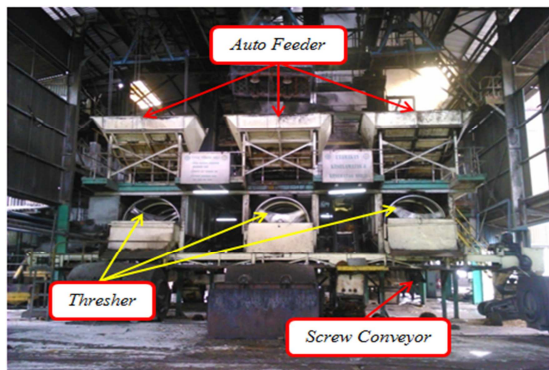
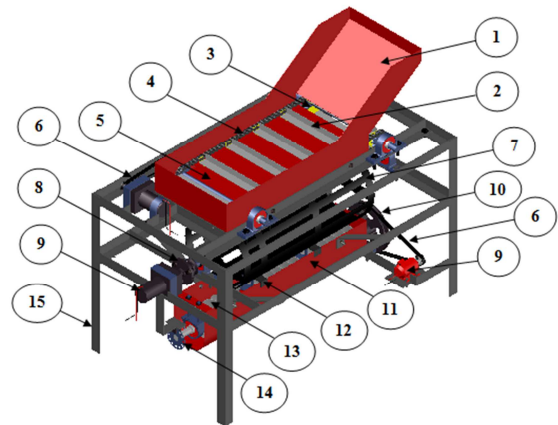


Figure 1: Threshing Station in PTPN V-PKS Sei Galuh

The data taken is measurement data in auto feeder, measurement thresher, measurement screw conveyor and operating data for auto feeder on and off at the threshing station palm oil mills in Sei Galuh. The threshing station PKS Sei Galuh can be seen in Figure 1.

2.2 Form and Dimensional Threshing Station Model

The shape and dimensions of the threshing station model adapted to palm oil mill PT. Perkebunan Nusantara PKS-V Sei Galuh using Software Autodesk Autocad 2014, with a scale of 1:8 [5]. threshing station model can be seen in Figure 2.



Caption:

- | | |
|-----------------------|---------------------------|
| 1. Casing Auto feeder | 9. DC Motor |
| 2. Carrier Plate | 10. Pulley |
| 3. Buffer Plate | 11. Casing Screw Conveyor |
| 4. Chain | 12. Hanging Bearing Plate |
| 5. Base Auto Feeder | 13. Screw Conveyor |
| 6. Belting | 14. Rotary Encoder Sensor |
| 7. Thresher | 15. Chassis |
| 8. Clutch | |

Figure 2: Threshing Stasion Model

2.3 Automated Control System Design

Input used in this design as much as 2 inputs and output are used as much as 3 outputs. The address list of input and output that are used can be seen in Table 1.

Table 1: Address Input and Output

No.	Address	Device
1	Input I1	Push Button On - Off
2	Input Ib	Encoder Sensor
3	Output Q1	Screw Conveyor Motor
4	Output Q2	Thresher Motor
5	Output Q3	Auto Feeder Motor

Stage of automatic control system consists of the design ladder diagram program using Zelio Soft 2 Software and rotary encoder sensor design.

2.3.1 Ladder Diagram Program Design

This design using software Zelio Soft 2 with programming languages Ladder Diagram (LD). The design of ladder diagram program is accompanied by an explanation can be seen in Figure 3.

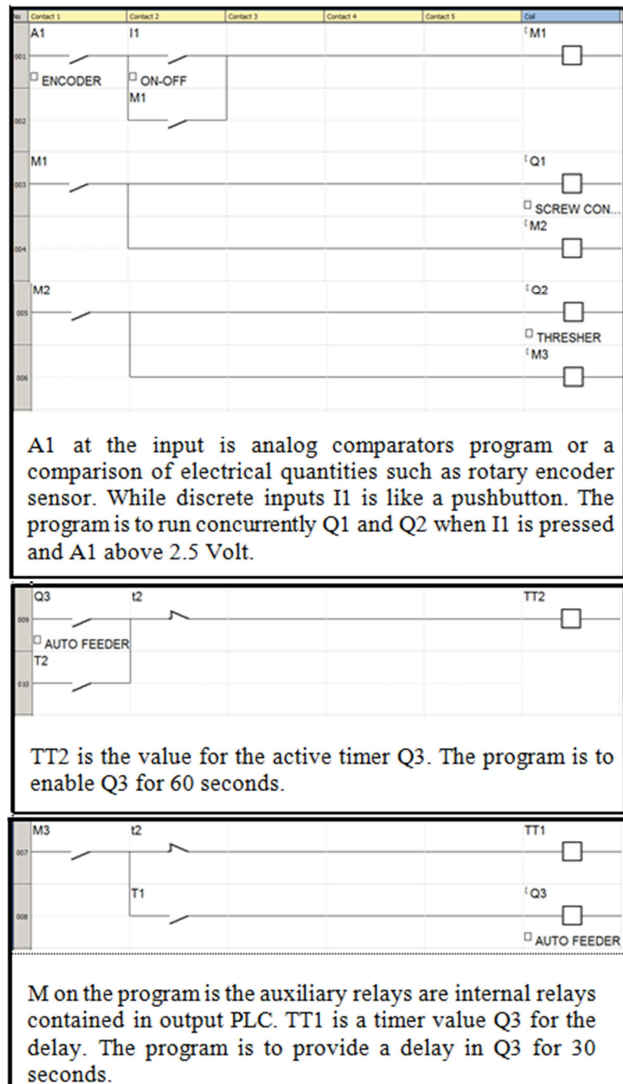


Figure 3: Ladder Diagram Program Design

2.3.2 Rotary Encoder Sensor Design

Sensor is a device that measures certain characteristics of an object or system. In the field of engineering, sensors are used for testing and monitoring applications. The sensor itself is generally used as monitoring, controlling, and protection [7].

Rotary encoder sensors are used to detect light from the LED opposite. Rotary encoder composed of a thin disc that has holes in the circular disc. Disc with 36 holes at its circumference with an angle between the two holes adjacent to the midpoint is 10 degrees. When the position of the disk result in light of the LED reaches the photodiode through the hole, then the photodiode will

experience saturation and will generate a pulse wave. Rotary encoder sensor connected to the PLC input terminal for processing. Thin disc coupled with the end of the shaft screw conveyor, screw conveyor so that when the motor spins the disc will not rotate.

Photodiode function to generate infrared light at the unblock rotary encoder sensor. The electrical circuit schematic drive optocoupler in the rotary encoder sensor can be seen in Figure 4.

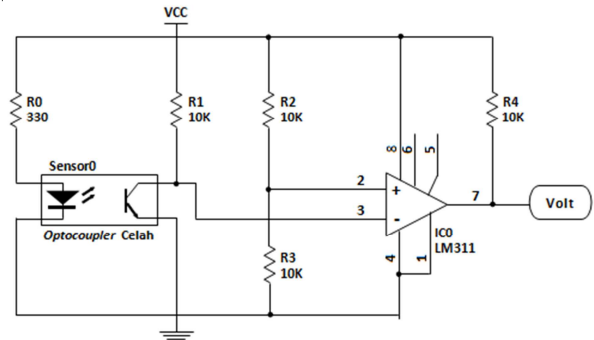


Figure 4: Schematic Sensor Circuit Drive Optocoupler in Rotary Encoder Sensor

The rotary encoder sensor is a circuit function to operate photodiode rotary encoder sensor. This circuit has the input of the circuit and lowering the voltage output to drive the optocoupler photodiode rotary encoder sensor. Electrical circuit schematic rotary encoder sensor can be seen in Figure 9.

Flow chart of the overall system program in this design can be seen in Figure 5.

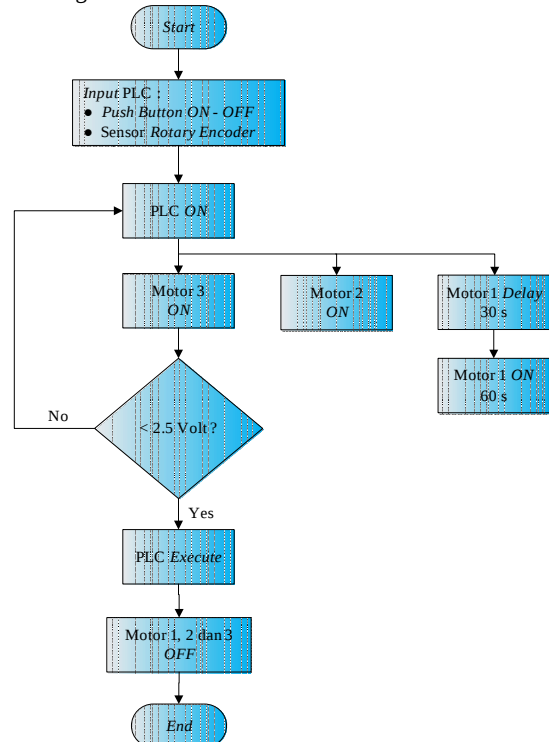


Figure 5: Flow Chart of Overall System Program

From the flow chart overall system program in Figure 11, starting with press on - off so that the PLC Zelio smart relay ON then the automated process is carried out to completion. There are several processes performed by the PLC:

1. The first process, PLC Zelio smart relay in the ON state with a 24 Volt DC supply voltage of the power supply, input I1 to the ON position, the input I1 serves as a digital input of the on-off to drive the screw conveyor motor, thresher motor simultaneously.
2. The second process, auto feeder motor delay for 30 seconds, then the auto feeder motor will be on for 60 seconds continuously.
3. The third process, input on PLC Zelio smart relay Ib is used as a input rotary encoder sensor, a rotary encoder sensor using input voltages from 3 to 5.5 Volts DC and has an output in the form of an analog voltage. The way it works is when the operating voltage output at below 2.5 Volt PLC, PLC detects the voltage drop across the sensor so that the PLC executes three DC motors to turn off or off.

2.4 Testing Automated Control System on Threshing Station Model

Testing the control system on the threshing station model is the stage of testing/simulation of the control system on the machine auto feeder using a timer on and off then testing/simulation of rotary encoder sensor on a screw conveyor.

3.0 RESULTS AND ANALYSIS

The result of the testing of the automatic control system on the the threshing station model consists of three test result, the test results ladder diagram program, the results of testing auto feeder and the rotary encoder sensor test result.

3.1 Program Testing Result

Testing program ladder diagram by mean of simulation program using Zelio Soft 2 Software. This simulation aims to determine whether the input and output that have been in the program can work as expected.

The stages in the testing program using the ladder diagram Zelio Soft 2 Software:

1. The first step to test/simulate ladder diagram program that is created by clicking the icon on the toolbar Edit Mode S as shown in Figure 6.

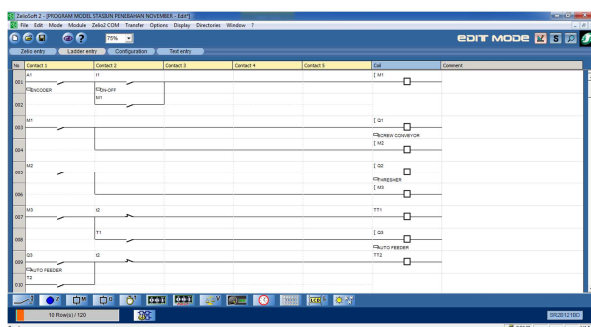


Figure 6: Ladder Diagram Program

2. After the icon S clicked it will go to the Simulation Mode, ladder diagram program will be blue overall as seen in Figure 7.

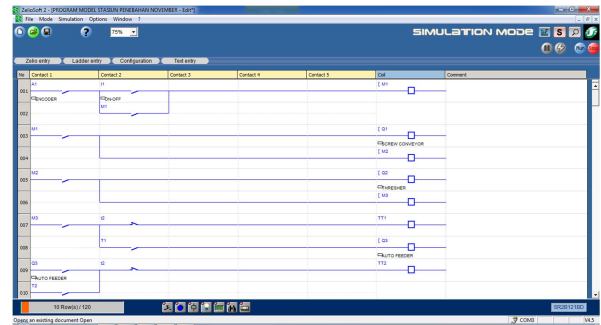


Figure 7: Simulation Mode Program

3. To display the result of the simulation program in Zelio Soft 2 Software, click the icon discrete input, analog input icon, icon discrete output and timer icon will appear on the spreadsheet program as shown in Figure 8.

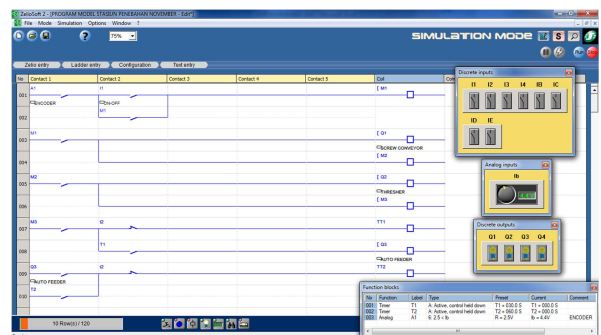


Figure 8: Display Input and Output Program

4. To run a start-up program click on the icon RUN mode simulation program, then the program is ready to be simulated as shown in Figure 9. Contact or coil blue indicates the program is not active (0) and red indicates an active program (1).

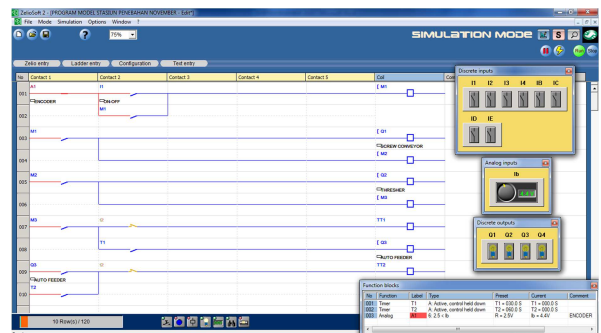


Figure 9: Program Ready Simulasi

Click on discrete input I1 to activate the program ladder diagram, set or position on the analog input voltage above 2.5 volts so that the coil [Q1] or screw conveyor and [Q2] or thresher active simultaneously. Program output simulation Q1 and Q2 can be seen in Figure 10.

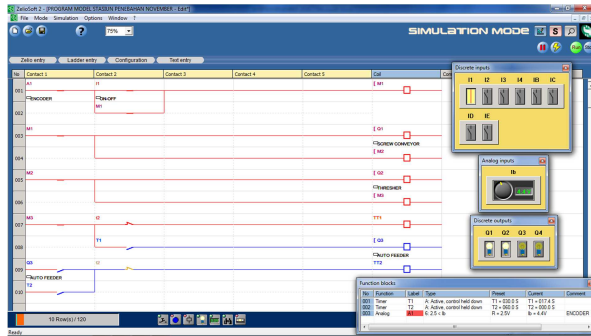


Figure 10: Program Output Q1 and Q2

Program blue ladder diagram shows that output [Q3] delay for 30 seconds, after 30 seconds, the [Q3] will be active for 60 seconds continuously. Contact or coil in red shows the program ladder diagram program is active (1) as shown in Figure 11.

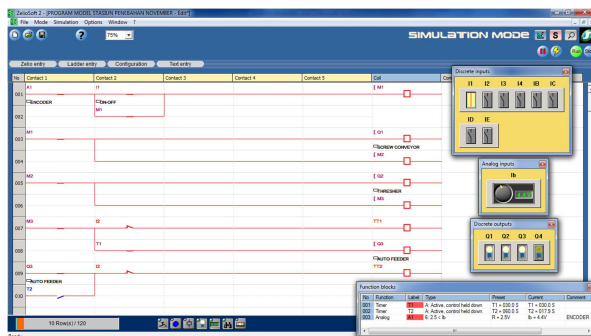


Figure 11: Simulation Program Output Q1, Q2 and Q3

- Next is testing rotary encoder sensor on the ladder diagram program by lowering the voltage at the analog input (Ib) to below 2.5 Volt as shown in Figure 12.

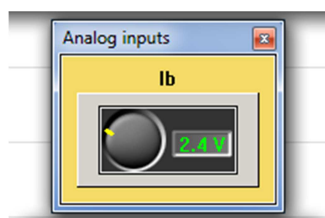


Figure 12: Analog Inputs

At the time of the voltage below 2.5 Volts, output [Q1], [Q2] and [Q3] will off button simultaneously, the program shows the blue ladder diagram not active (0) as shown in Figure 13.

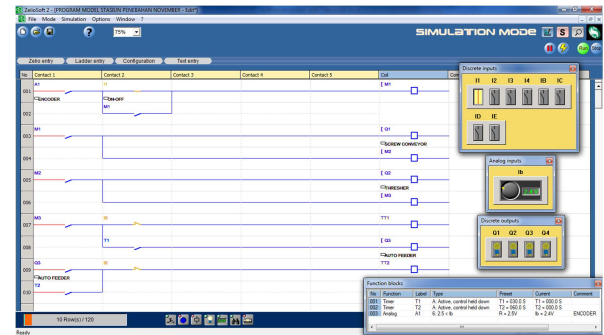


Figure 13: Testing Rotary Encoder Sensor Program

The result of the simulation program using the ladder diagram Zelio Soft 2 Software work as expected. Programs have been simulated on a notebook and then sent to the PLC module via a USB cable (COM PORT) with type SR2 USB01 for the implementation of the automatic control system on the threshing station model.

3.2 The Result of The Test Automatic Control Systems on Auto Feeder

The result of these test are auto feeder operated on for 60 seconds and off for 30 seconds automatically and continuously with a timer that has been input into the ladder diagram program based on the retrieval time auto feeder on and off at a palm oil mill threshing station Sei Galuh.

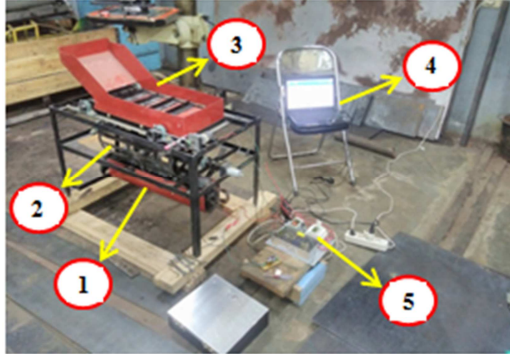
3.3 The Result of The Test Rotary Encoder Sensor

Rotary encoder sensor is a sensor that detects the rotation with the output of the analog input on a PLC. Analog input are input that serves as a comparison of analog data (voltage, current) measured with reference data/reference.

There are two types of test are testing detector when the rotary encoder is un-block and block gap.

- Testing rotary encoder detector when the gap is un-block.
The result obtained in the test voltage detector sensor is a rotary encoder that is 4.4 Volt. Voltage result obtained are included in the normal operating voltage range is from 3 to 5.5 Volts (rotary encoder sensor data sheet).
- Testing detector when the rotary encoder sensor is blocked.
The second test is to measure the voltage at the detector rotary encoder using a paper at the sensor opening rotary encoder as a barrier to light/infrared light. Testing is characterized by its flame green light on the rotary encoder sensor.

Application of automatic control system on the threshing station model can be seen in Figure 14.



Caption:

- | | |
|-------------------|---------------------|
| 1. Screw Conveyor | 4. Notebook |
| 2. Thresher | 5. PLC Unit Control |
| 3. Auto Feeder | |

Figure 14: Application of Automatic Control System on Threshing Station Model

Schematic electrical automatic control system on the threshing staasiun model can be seen in Figure 15.

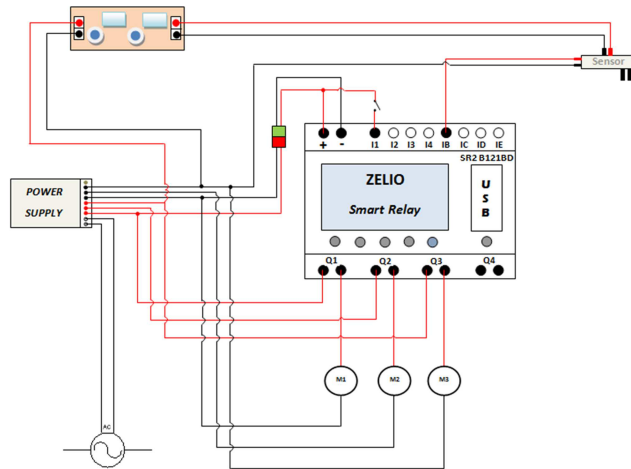


Figure 15: The Circuit Schematic Overall System

Based on the result of testing that has been done, ladder diagram program designed in Zelio Soft 2 Software can be simulated as expected. Automation system applied to the threshing station model work based ladder diagram program that has been transferred into the PLC module.

Auto feeder on the threshing station model can be run automatically on and off continuously by the design of ladder diagram program. At the time of press on the button is pressed and the sensor input PLC has reached a voltage above 2.5 Volts then the screw conveyor motor and the thresher motor on simultaneously, while the auto feeder motor delayed for 30 seconds and will be on for 60 seconds.

Rotary encoder sensor can work with supply voltages below 6 Volt, This is because the normal operating voltage required rotary encoder sensor is just 3 to 5.5 Volts so the 24 Volt supply voltage rotary encoder sensor can not work /active. At the time of screw conveyor shaft removable/end, sensor voltage will decrease, this is due to the disc sensor that block light/infrared at the gap rotary encoder sensor. PLC received a signal of a voltage drop below 2.5 Volts based on the input voltage has been in setting the analog comparators.

4.0 CONCLUSION

In this paper, an automatic control system of the threshing station model using PLC Zelio smart relay is presented. Auto feeder can operate on and off automatically and continuously with time on for 60 seconds and off for 30 seconds. Rotary encoder sensor is used to detect screw conveyor stop. Threshing stations model have been made without reducing the functionality of the threshing station in PKS Sei Galuh and can be applied to an automatic control system on the threshing stations model in accordance with the design.

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