

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Parry Phillips	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering & HNC Instrumentation Engineering		
Module:	Programmable Logic Controllers		
Module code:	PCEE4005	Contribution to Overall Module Assessment (%):	50%
Lecturer:	Jason Pointer	Internal Verifier:	Nigel Richards
Assignment Title:	PLC Program design and simulation	Word count (or equivalent):	2000
Submission deadline:	02/05/24	Return date of provisional marks & written feedback:	19/05/24
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

1. Demonstrate an understanding of the concepts of process control using an industry standard PLC.
2. Undertake basic PLC system design and implementation processes, comparing theoretical expectations to actual outputs ensuring correct operation and consideration of maintenance and reliability.

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	15	9.3
Engagement with a wide range of literature, including sources retrieved independently. Generally sound referencing technique.		
2. Knowledge and Understanding Skills	40	29.1
Task 1 achieved 74%. Task 2 achieved 70% Task 3 achieved 74% Excellent knowledge and understanding of the basic underlying concepts and principles of the work required for Task 1 and 2. Excellent work in producing the IL code for Task 3.		
3. Cognitive and Intellectual Skills	5	2.4
Little evaluation of the underlying concepts and principles applied to the construction of the programs for Task 4 and 5.		
4. Practical Application Skills	30	24.3
Task 4 achieved 80%. Task 5 achieved 82%. An excellent application of the different software to produce fully functional programs to cover the requirements of Task 4 and 5. Required very little support in the development of these programs and was able to show full operation within the classroom.		
5. Transferable Skills for Life and Professional Practice	10	6.8
Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed.		

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		72%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

Programmable Logic Controllers



Author: Parry Phillips

Lecturer: Jason Pointer

Module: Programmable Logic Controllers

Assignment: PLC Program design and simulation

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Task 1 - PLC analogue and discrete I/O

Proximity Measurement Devices:

A proximity sensor purpose is to perform non-contact detection. Proximity sensors convert information on the detection of movement or the presence of an object (Omron Industrial Automation, 2016). The detection of the object generates an electrical signal that is outputted by the system. Various detection systems can be used to convert movement and presence of an object into an electrical signal.

Inductive Proximity Sensor:

An inductive proximity sensor contains four basic components. A sensor coil and ferrite core, an oscillator circuit, a detector and trigger circuit and a solid-state output circuit.

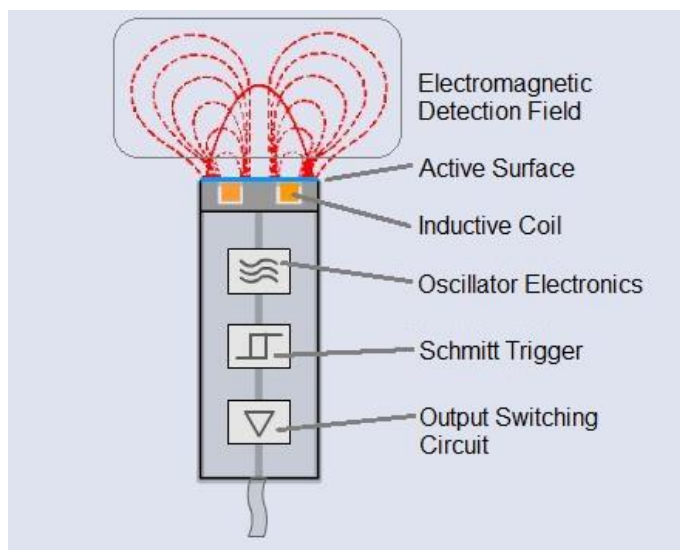


Figure 1. Internal Components of an Inductive Proximity Sensor

The function of the inductive proximity sensor starts with the oscillator circuit generating an oscillating electromagnetic field that radiates from the ferrite core and coil components (Soloman, 1998). When then opposing metal target approaches the sensor and enters the magnetic field, eddy currents are induced into the surface of the metallic target. These induced eddy currents decrease the amplitude of the oscillation this effect is known as 'damping'. The detector circuit will switch on when the oscillations reach a certain threshold depending on the sensor. This on signal generates a signal to turn on the solid state output this effect is known as the

'damped' condition. The damped oscillation will remain in this amplitude and the ON signal will remain in this state until the target retracts. As the target retracts from the electromagnetic field the oscillator responds with increased amplitude, when this amplitude increases above the desired threshold it is detected by the detector circuit and switches off causing the output signal to return to off or 'undamped'.

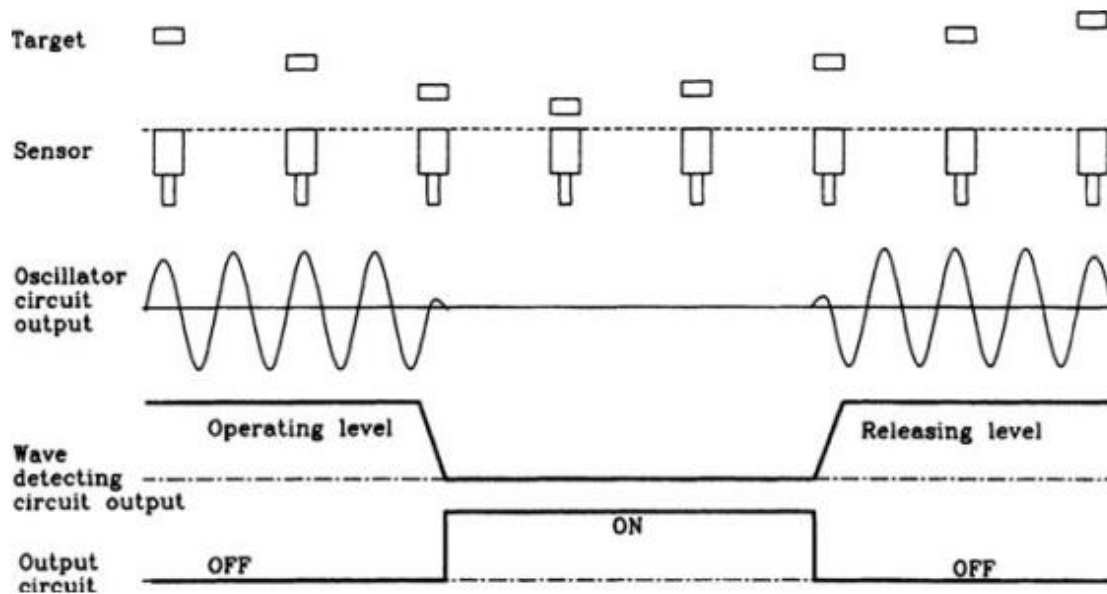


Figure 2. Diagram explaining the effects of the target on multiple components in the inductive proximity sensor.

Capacitive Proximity Sensor:

Capacitive proximity sensors consist of the components a Dielectric plate, an Oscillator, a trigger and an output sensor. Capacitive sensing works on a dielectric capacitance. Capacitance is property of insulators holding an electric charge. When an object is near the dielectric plate and enters the electrostatic field generated by the electrode plate the capacitance of the of the oscillator circuit is altered and starts to oscillate. The trigger circuit then will then monitor the oscillations once the threshold is reached the output signal will be sent to the PLC. As the object gradually moves away and retreats out of the electrostatic field the oscillations decrease continuously until the oscillation stops. At a certain point in the oscillation, it will not exceed the threshold for the output signal to be activated (McGee, 2013).

Which part is being quoted.

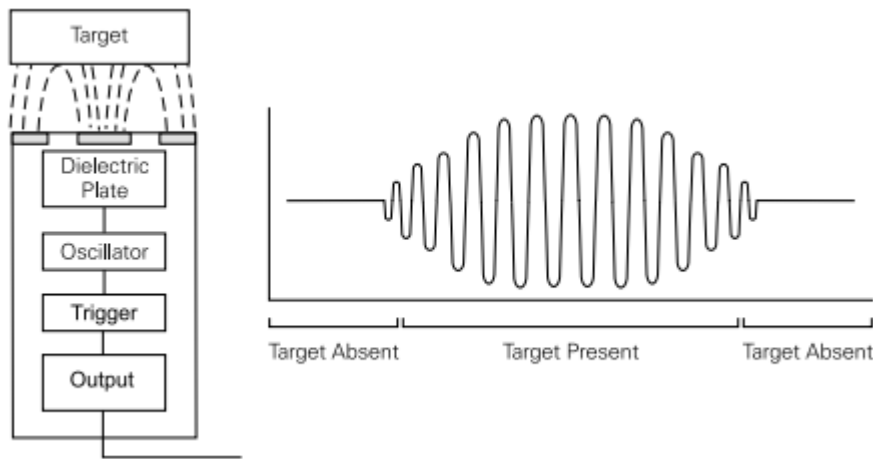


Figure 3. Construction of Capacitive Proximity Sensor and the graph monitoring the objects position in relation to the sensor.

Displacement Measurement Devices:

A displacement sensor is a measurement component that measures the distance between the sensor and the object by detecting the amount of displacement using different elements to convert the displacement into a distance measurement (Omron, 2021).

Linear Variable Differential Transformer (LVDT):

A linear variable differential transformer is an electromechanical position transducer that converts linear motion into an electrical signal. The construction of an LVDT is a primary coil, two secondary coils and a moveable ferromagnetic core.

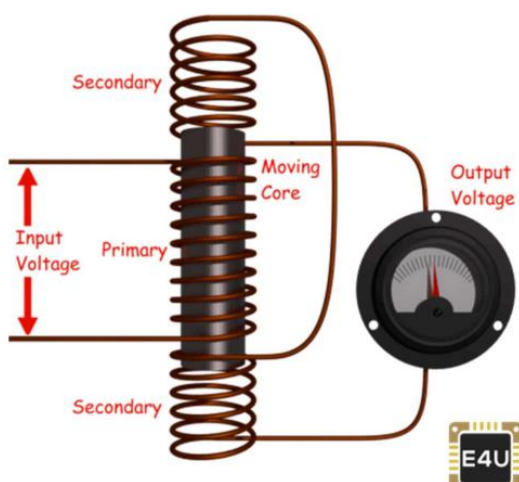


Figure 4. Construction of a LVDT

An alternating current is supplied to the primary coil which generates a magnetic field, inducing voltages in the secondary coils. In the central position of the core, the voltages in these coils are equal but opposite equalling net output of zero.

Displacement of the core affects the magnetic flux linkage in each secondary coil differently, altering the induced voltages and thus unbalancing them. The resulting differential voltage between the secondary coils is an indication of the magnitude and direction of displacement which is processed to measure the position of the core (Ranchi University, 2020).

Ultrasonic Displacement Sensors:

An ultrasonic displacement sensor operates on the principle of echolocation. The principle of the device involves ultrasonic sound waves being emitted towards a target, which reflects these sound waves back to the sensor. The time elapsed between the emission and reception of these waves is directly proportional to the distance between the sensor and the target object (Omron, 2021).

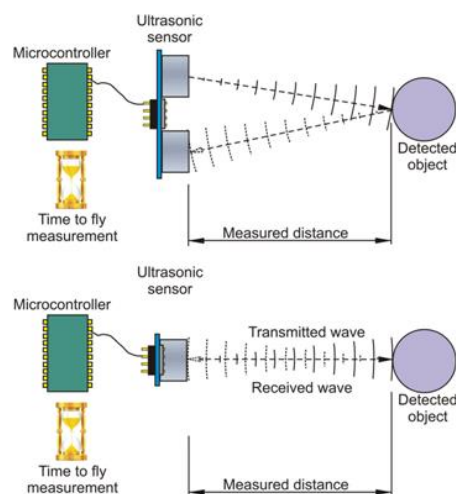


Figure 5. Ultrasonic Sensor

The transducer's purpose is to convert electrical energy into ultrasonic sound waves and vice versa. The transducer utilises a piezoelectric which can generate mechanical stress in response to an applied electrical voltage. This material contracts or expands, producing ultrasonic sound waves when voltage is applied. Conversely, when ultrasonic waves reach the piezoelectric, it generates an electrical charge that can be measured. The electronics in the device are required for initiating

the pulse of ultrasonic waves, receiving the echoes, processing the time data, and converting this into a displacement measurement (Texas Instruments , 2022).

Connection of Sensors to PLC's:

Digital PLC inputs are either ON or OFF signals that are supplied from the discrete field devices such as an inductive and capacitive proximity sensor. Analogue inputs can either be a voltage or a current that are continuous data that can be converted by the PLC to relevant data variables. Each sensor has output type that must be compatible with the input of the connected PLC.

Sinking outputs (Negative, Positive, Negative) is where the output of the sensor is connected to the negative or ground wire, when the sensor activates due it the threshold of the oscillations triggering a signal it completes the circuit by connecting the load to the ground (Yamaha Motor, 2020).

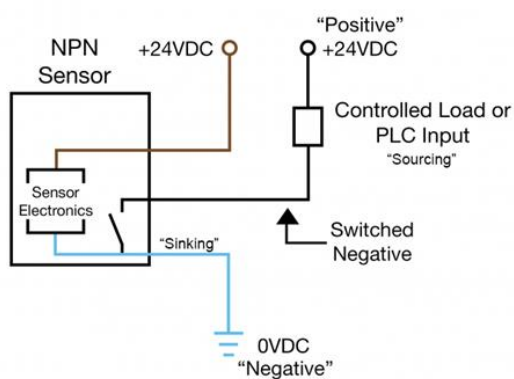


Figure 6. NPN Wiring configuration.

Positive negative positive, is where the load is connected to the negative or ground and when the limit of threshold activates the signal the switch closes to connect positive.

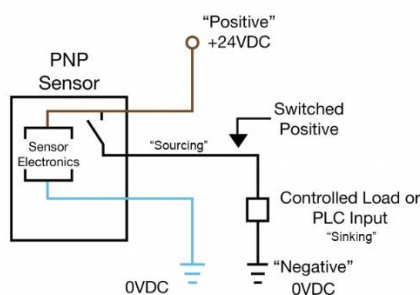


Figure 7. PNP Wiring Configuration.

b.)

Stepper Motors:

Stepper motors are electromechanical motors that convert electrical pulses into discrete mechanical movements. Stepper motors are used where precise positioning and speed control is needed without the need of feedback sensors. The basic operation of a stepper motor allows the shaft to move a certain number of degrees each time a pulse of electricity is sent to the motor.

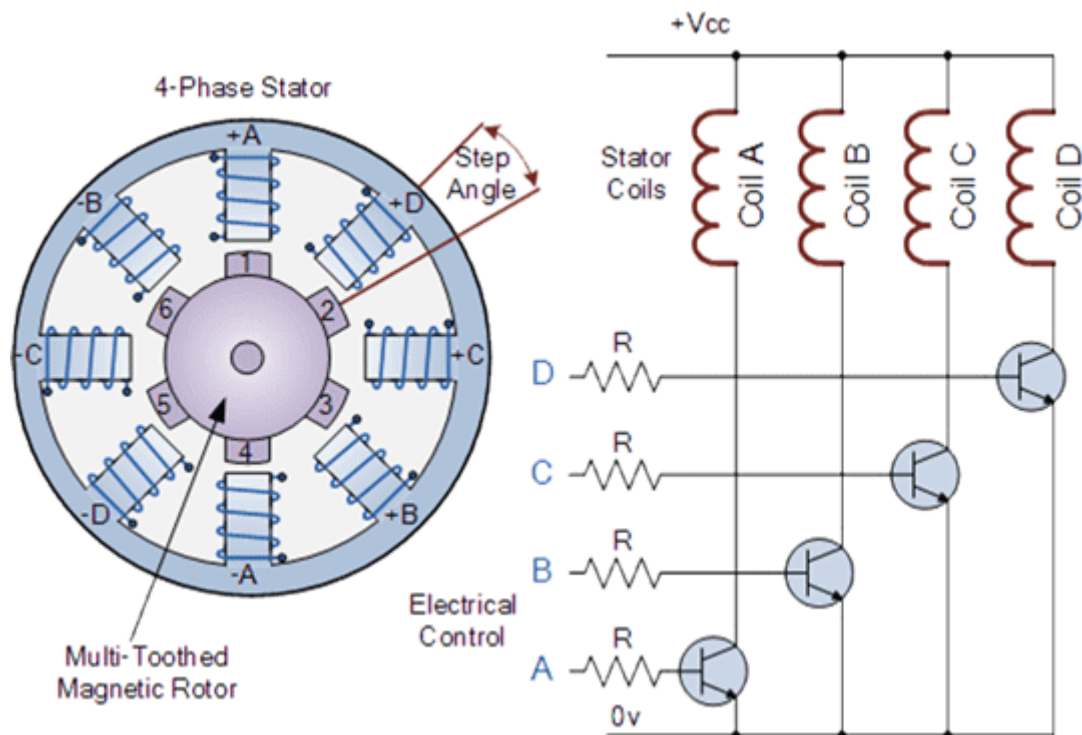


Figure 8. 4-Phase Stepper Motor Diagram

Construction Of A Stepper Motor:

Stator:

The stator is a stationary part of the motor. They have multiple “toothed” electromagnets arranged as a stator, it is constructed with multiple poles each wound with a wire coil. Each winding is connected to the winding of the opposite pole so that both poles are magnetised with the same polarity when a current is put through the windings, this represents one phase. The number of poles varies on the stepper motor’s purpose (Oriental Motors, 2007).

Rotor:

The rotor is located inside of the stator, this is moving part of the motor. Its material can either be a permanent magnet or a metal alloy depending on the type of rotor. The function of the rotor with a permanent magnet aligns with the magnetic field generated by the stator (Fiore, 2022). The energised coil will commence the rotation of the rotor due to the force of the magnetic field.

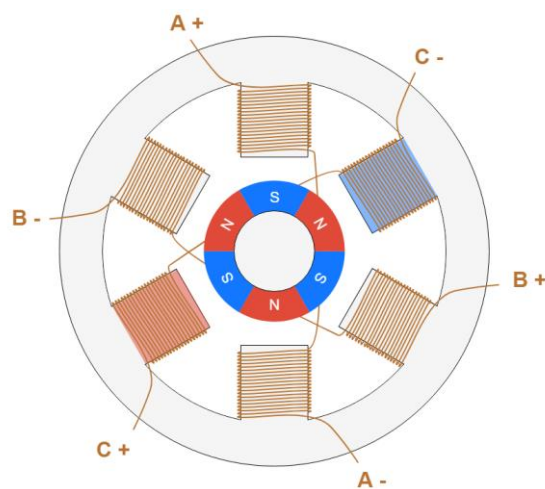


Figure 9. Permanent Magnet Rotor

A variable reluctance rotor is constructed with an iron core and has a specific shape that allows the rotor to align with the magnetic field generated by the coils (Fiore, 2022).

A hybrid rotor has a specific construction that consists of the rotor being a permanent magnet and a variable reluctance rotor. Its design is two caps with alternating teeth and being axially magnetised. This configuration allows for the motor to have attributes such as increased resolution, speed and torque (Fiore, 2022).

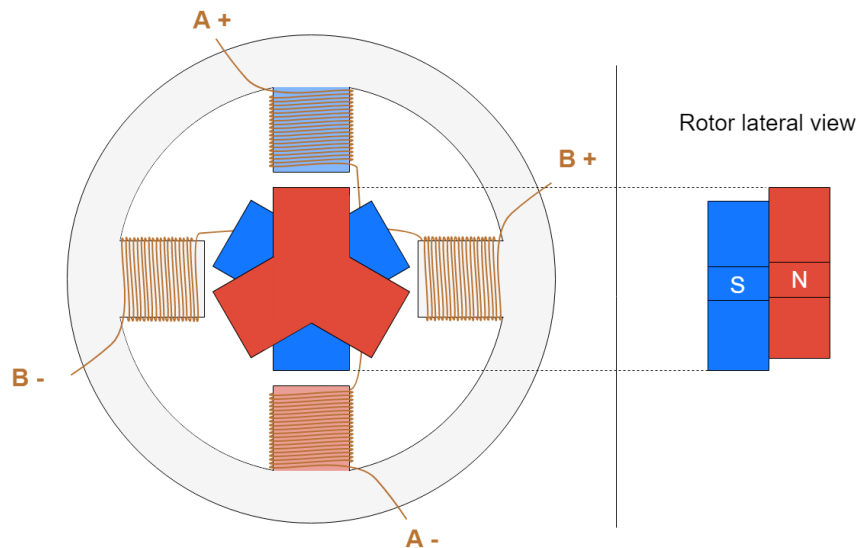


Figure 10. Hybrid Rotor

Operation of a Stepper Motor:

During start up of a stepper motor a coil will be energised which creates an electromagnetic field with a north and south pole. This electromagnetic field generated by the winding will orientate the magnetic rotor to align with the magnetic field since opposite poles attract. The direction of the magnetic field can be changed and programmed to create specific rotation of the motor.

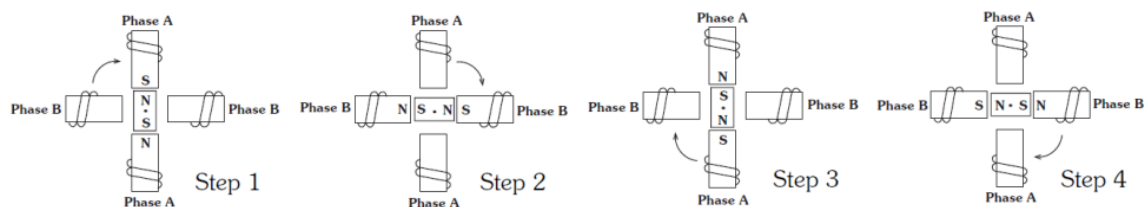


Figure 11. Step Sequence two-phase motor (Wave Drive)

Firstly, phase A is energised; the magnetic field generated locks the rotor in position demonstrated in step 1 of Figure 11. In step two phase B is energised and phase A is turned off causing the rotor to rotate 90 degrees clockwise. In step 3 phase A is energised however with a reversed polarity and phase B is de-energised causing another 90-degree rotation. Finally, in step 4 phase B is energised with a reverse polarity while phase A is turned off completing a full turn of the rotor (Hu, 2011).

Well done showed a very good understanding

Task 2 – SCADA (Supervisory Control and Data Acquisition)

Introduction:

SCADA stands for ‘Supervisory Control and Data Acquisition.’ Industrial process companies that require real-time data and response utilise SCADA within the control system to monitor and remotely control equipment on site. This equipment can vary from valves, pumps, compressors, sensors etc. It is the combination of telemetry and data acquisition of the devices and equipment on site (Sharma, 2010). The data can be utilised by the control system or operator allowing for both to alter the inputs into the SCADA system to maintain a safe and efficient process. ✓

Setup of SCADA System:

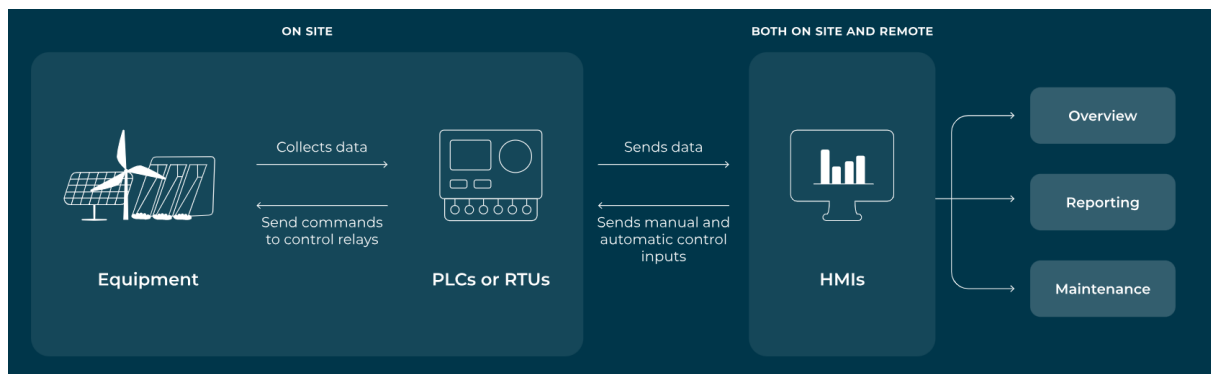


Figure 12. SCADA Computing Setup

At the base of the SCADA set up is the instrumentation. Instrumentation is an element of the SCADA system. Instrumentation monitors and measures equipment's variables such as pressure, temperature, flows, vibration etc. These readings are necessary for the safe and efficient running of the plant hence why the data is communicated throughout the system. ✓

PLC and RTU integration:

The instrumentation is connected to remote terminal units (RTU) or programmable logic controllers (PLC's) which convert digital and analogue signals as needed and the PLC or RTU executes pre-programmed logic to respond to the data and to transfer the data into data streams to the central data controller which is known as the telemetry. Data loggers record, review and use the data to minimise the operator's constant attention. These functions have transformed telemetry into ✓

modern monitoring and response systems (Revere Control Systems, 2024). The operator can interact with the SCADA system by utilising the human machine interfaces that operate both ways in the SCADA system presenting the data and sending manual and automatic control inputs to the PLC's and RTU's. ✓

Human Machine Interface (HMI) Integration:

HMIs are any panel such as touch screens or computer panels that allows for data to be presented and for the operator to be able to interact with the SCADA system. Graphical representation of the plant and data in the corresponding locations of the plant ease the use of the system. The purpose of HMIs is to make it as simple as possible for the user to safely react with control inputs or to extract the correct data from a complex system to safely operate the process (Man, 2019). ✓

Key Features of SCADA Systems:

Real Time Data Monitoring and Alarms:

SCADA systems are utilised at Dragon LNG where it plays a critical role in monitoring and managing the process. A crucial component of the SCADA system at Dragon LNG is the real time data acquisition. The system is continuously collecting data from all instrumentation on site and converting these analogue and digital signals into readable data for the user of the system. The operational parameters will be programmed into the control system and will cause alarms if data exceeds its safe operating limits. This data is crucial in being able to react to alarms quickly enough if the SCADA system notifies the user that the process is not running as intended the operator can assess the data and decide on an action (SCADA International, 2024). ✓

Remote control of the process:

SCADA systems incorporate human machine interfaces (HMI) to allow the user to interact with the process from a remote location. The HMI should provide data trends and figures to allow the user to respond to the data accordingly. ✓

Historical Data Logging:

The SCADA system is capable of recording data and trends over time. The data is crucial for analysing trends for fault analysis and condition-based maintenance which contribute to the safe and efficient running of the process. ✓

Scalability:

SCADA systems can be expanded to accommodate additional equipment with ability to integrate additional instrumentation, PLC's and RTUs to expand the SCADA system to deal with the expansion of process plants. ✓

Conclusion:

SCADA systems are necessary to the management of industrial processes as they offer comprehensive real-time monitoring, data logging, acquisition and remote control. The SCADA system is reliant on many components that play crucial roles in the functioning of the SCADA system such as PLCs, RTUs and HMIs. The PLCs allow for the analogue and digital signals from the instrumentation on site to be converted to relevant readable data while also allowing for control inputs from the panel operators to safely operate the plant or for the plant to automatically control its parameters through pre-programmed instructions thus being an integral part of the SCADA system. The HMI's facilitate human interaction by simplifying the complex process system with graphical representation of the plant and corresponding data values to ensure the safe interaction of the plant. SCADA systems have significantly enhanced operational efficiency and safety. ✓

Very well written .

Task 3 – Instruction List

Inputs	
X000	Start switch
X001	Stop switch
X002	Sensor for bottle not full position 1
X003	Sensor for bottle present
X004	Sensor for bottle not full position 2
X005	Stop conveyor switch

Outputs	
Y000	Conveyor motor
Y001	Alarm
Y002	Capping
Y003	Packing Machine

Table 1 – Input/Output connections

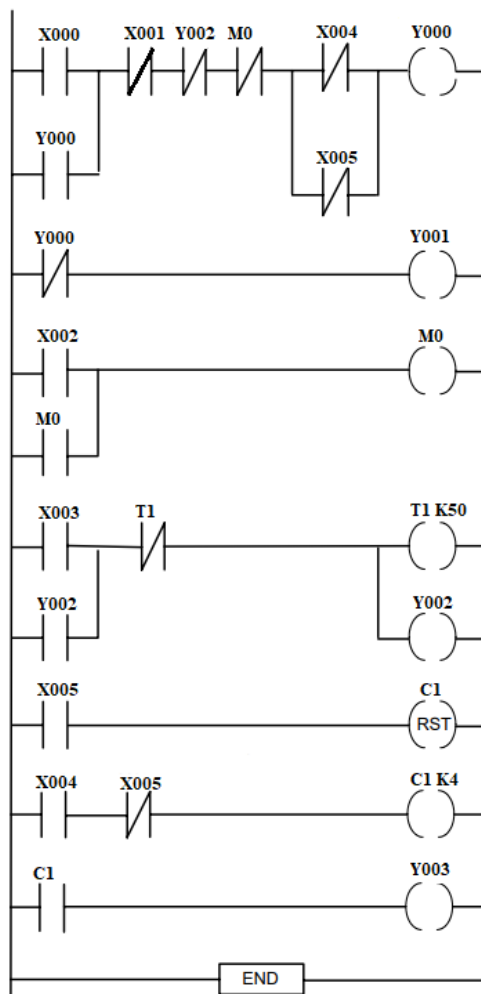


Figure 2 – Ladder logic

From the ladder logic develop the **instruction list** that will also control the conveyor systems.

LD X000
OR Y001
ANI X001
ANI Y002
ANI M0
LDI X004
ORI X005
ANB
OUT Y000

LDI Y000
OUT Y001

LD X002
OR M0
OUT M0

LD X003
OR Y002
ANI T1
OUT T1
K50
OUT Y002

LD X005
OUT RST C1

LD X004
ANI X005
OUT C1

K4

LD C1

OUT Y003

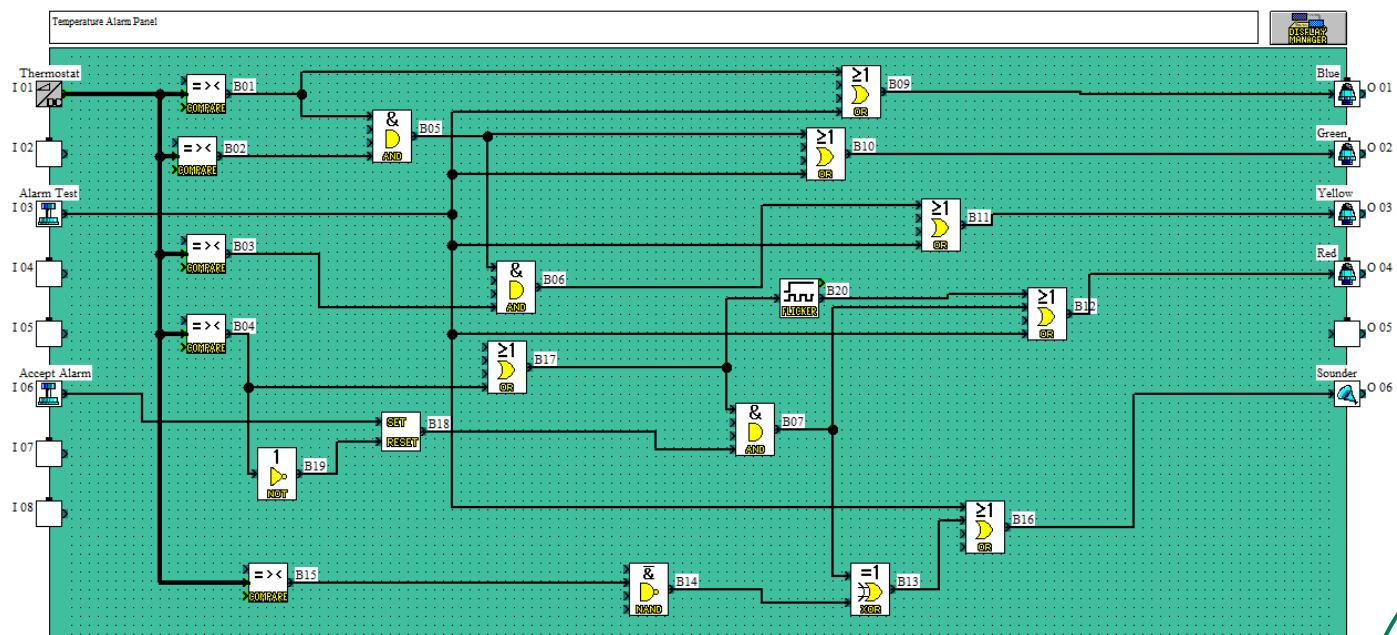
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Excellent work.

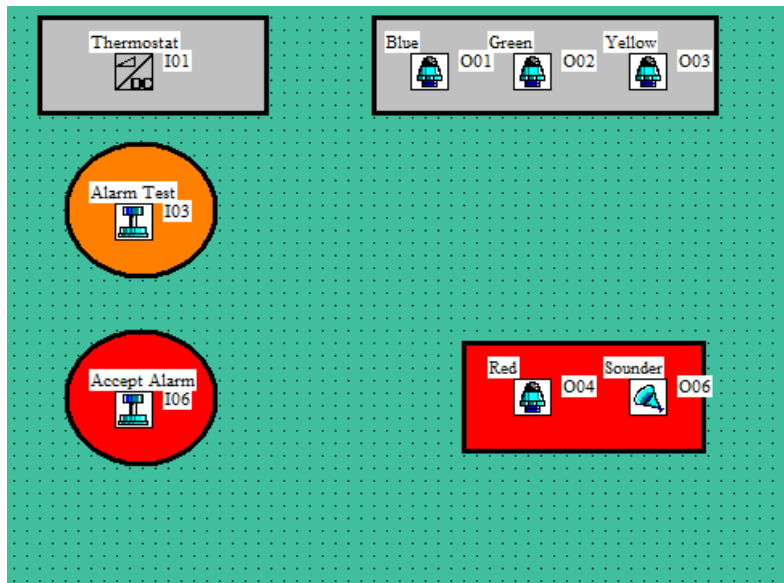
Task 4 - Temperature Alarm Panel

Table 2 – Alarm Outputs

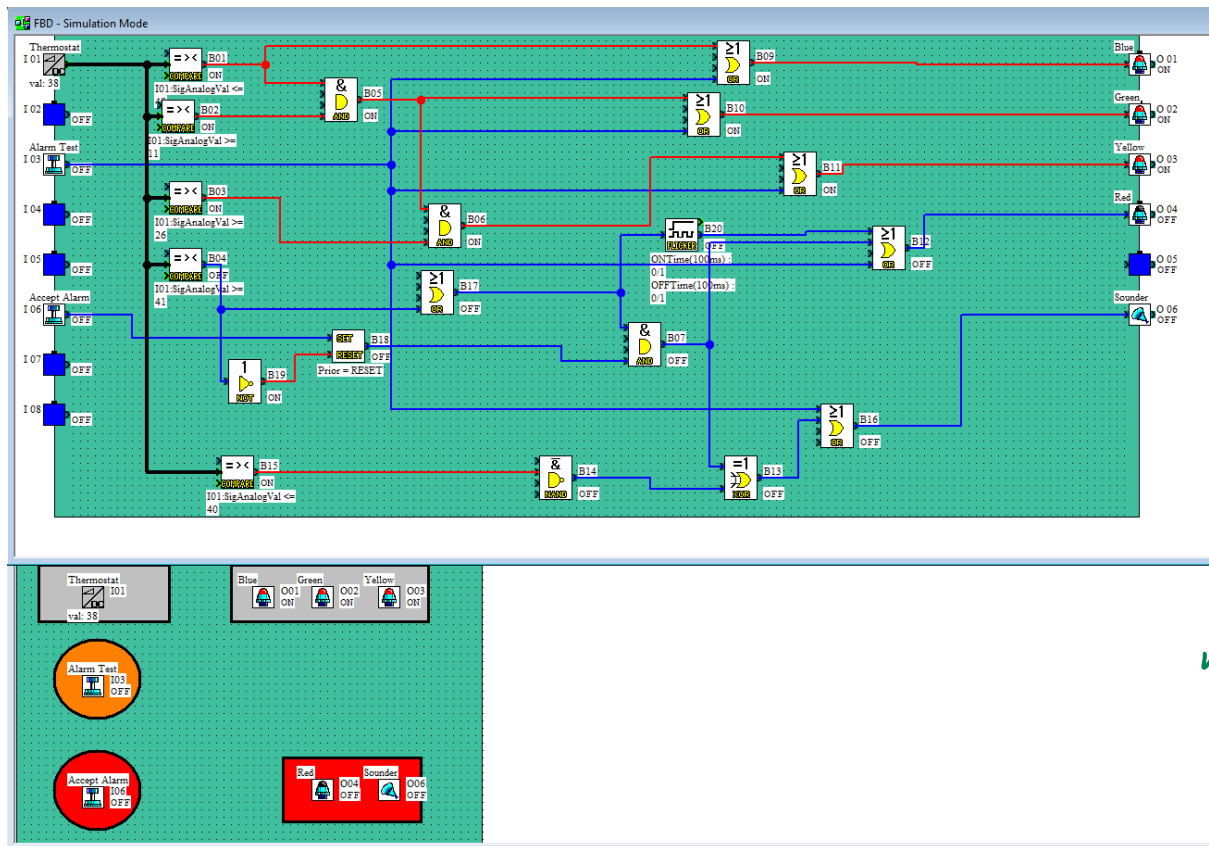
Temperature Settings (°C)	Blue light	Green Light	Yellow Light	Red Light	Sounder
0 to 10	On				
11 to 25	On	On			
26 to 40	On	On	On		
41 to 50				On	On



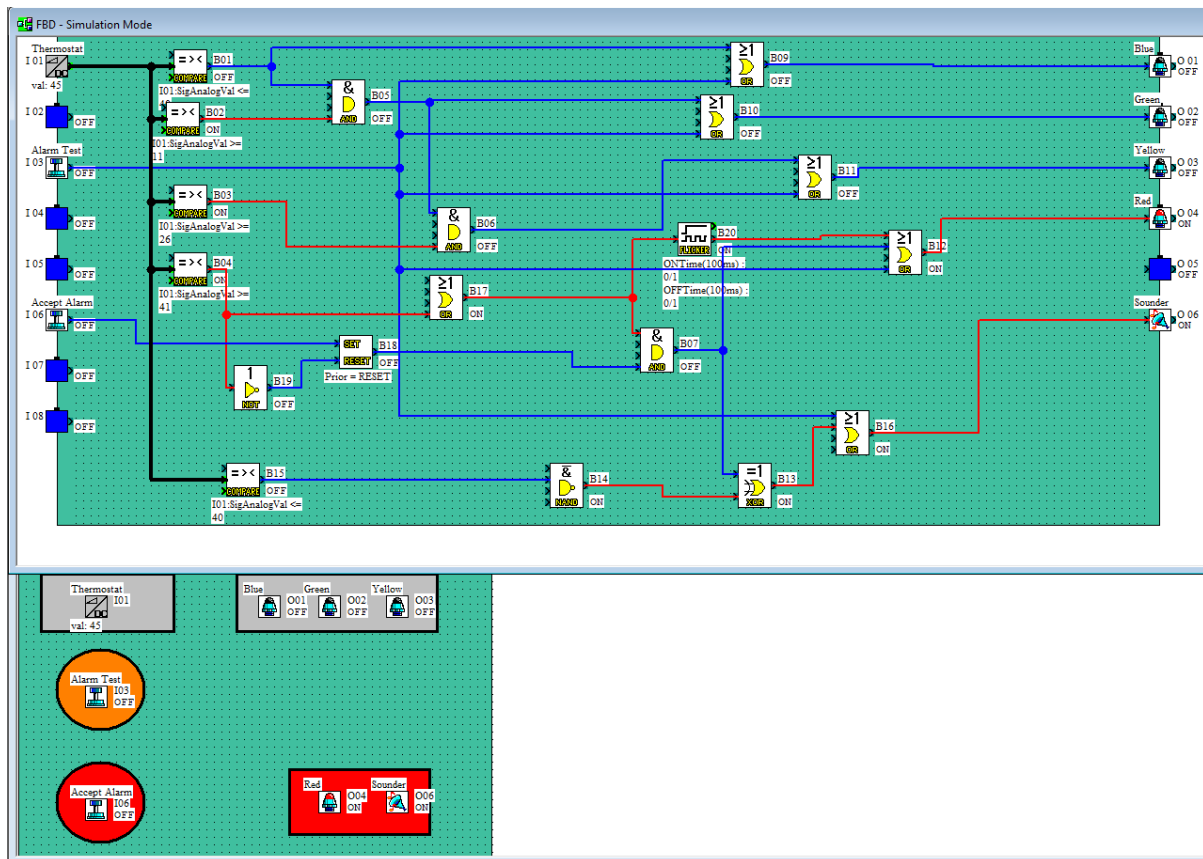
Logic for temperature alarm.



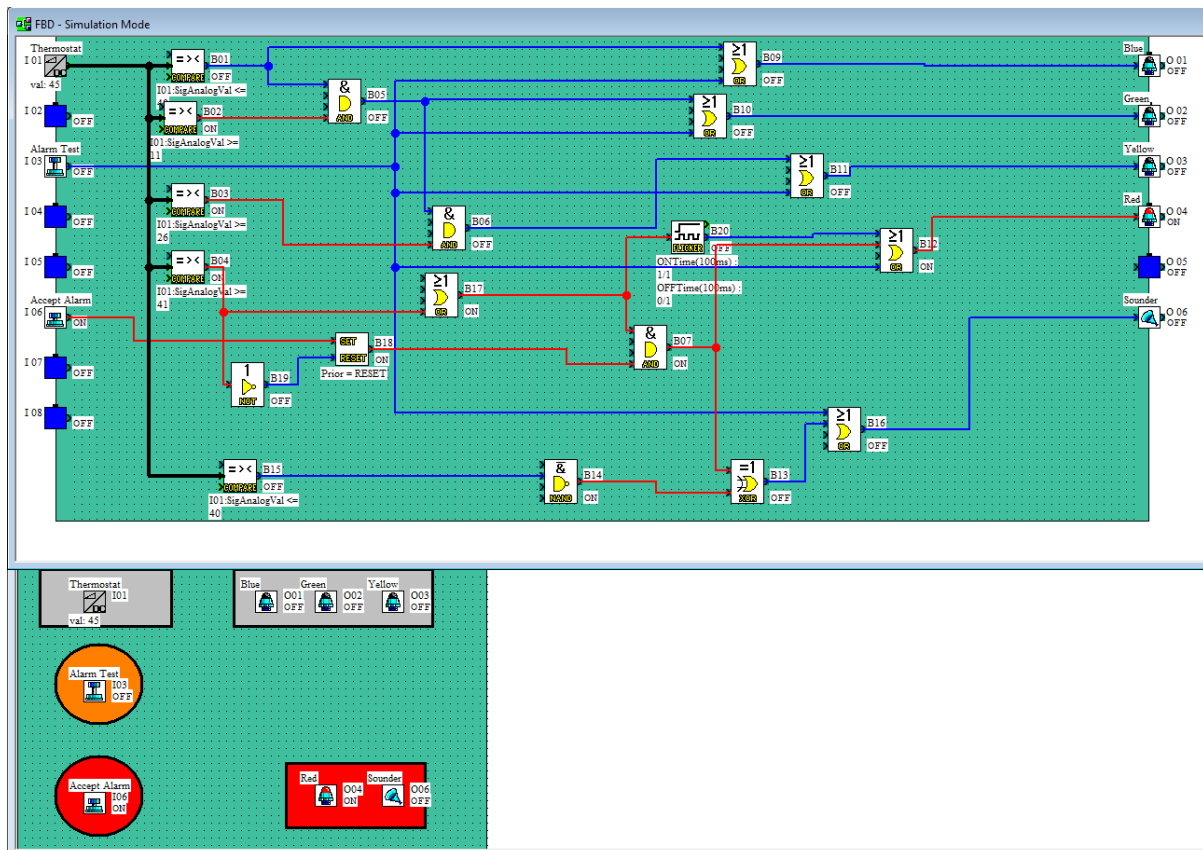
Human Interface panel for temperature alarm panel.



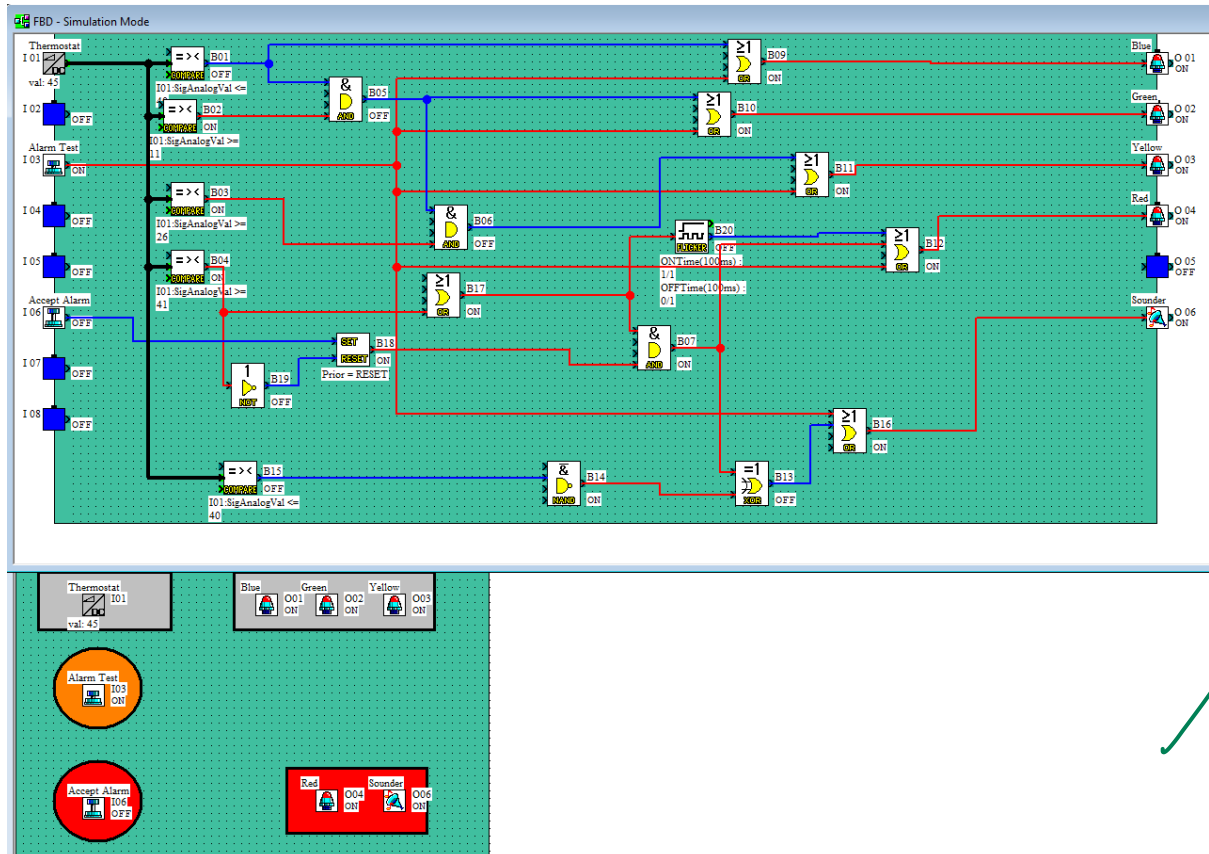
Temperature alarm logic and panel simulation (Temperature 38 Degrees Celsius).



Temperature alarm logic and panel simulation (Temperature >40 Degrees Celsius).



Alarm accept function test.



Alarm test function tested.

Task 5 – Construction Site Lift

PLC and Simulator Termination

PLC Input		PLC Output	
01	Level 1 call button	01	Motors up
02	Level 1 sensor	02	Motor down
03	Level 2 call button	03	Level 1 indicator light
04	Level 2 sensor	04	Level 2 indicator light
05	Level 3 call button	05	Level 3 indicator light
06	Level 3 sensor	06	Solenoid latch for door
07	Locked door sensor	07	Open door indicator light

Lift System

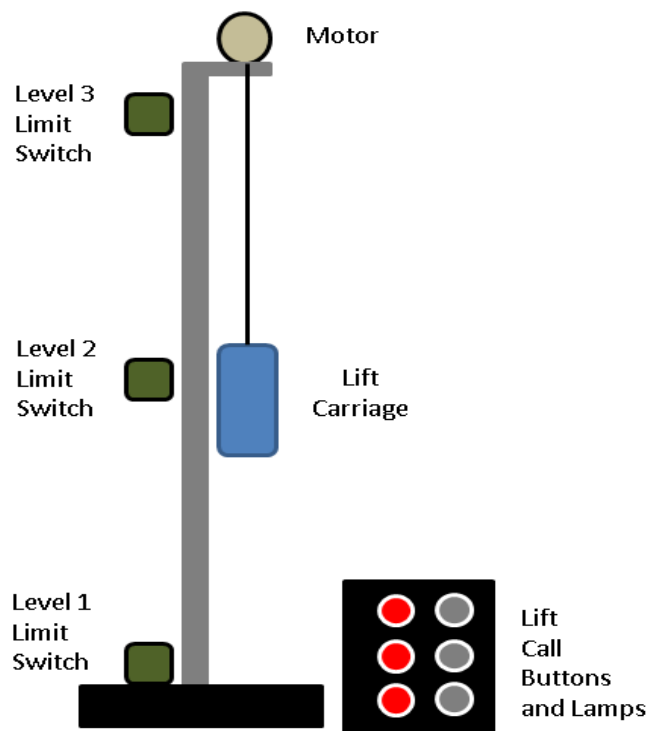
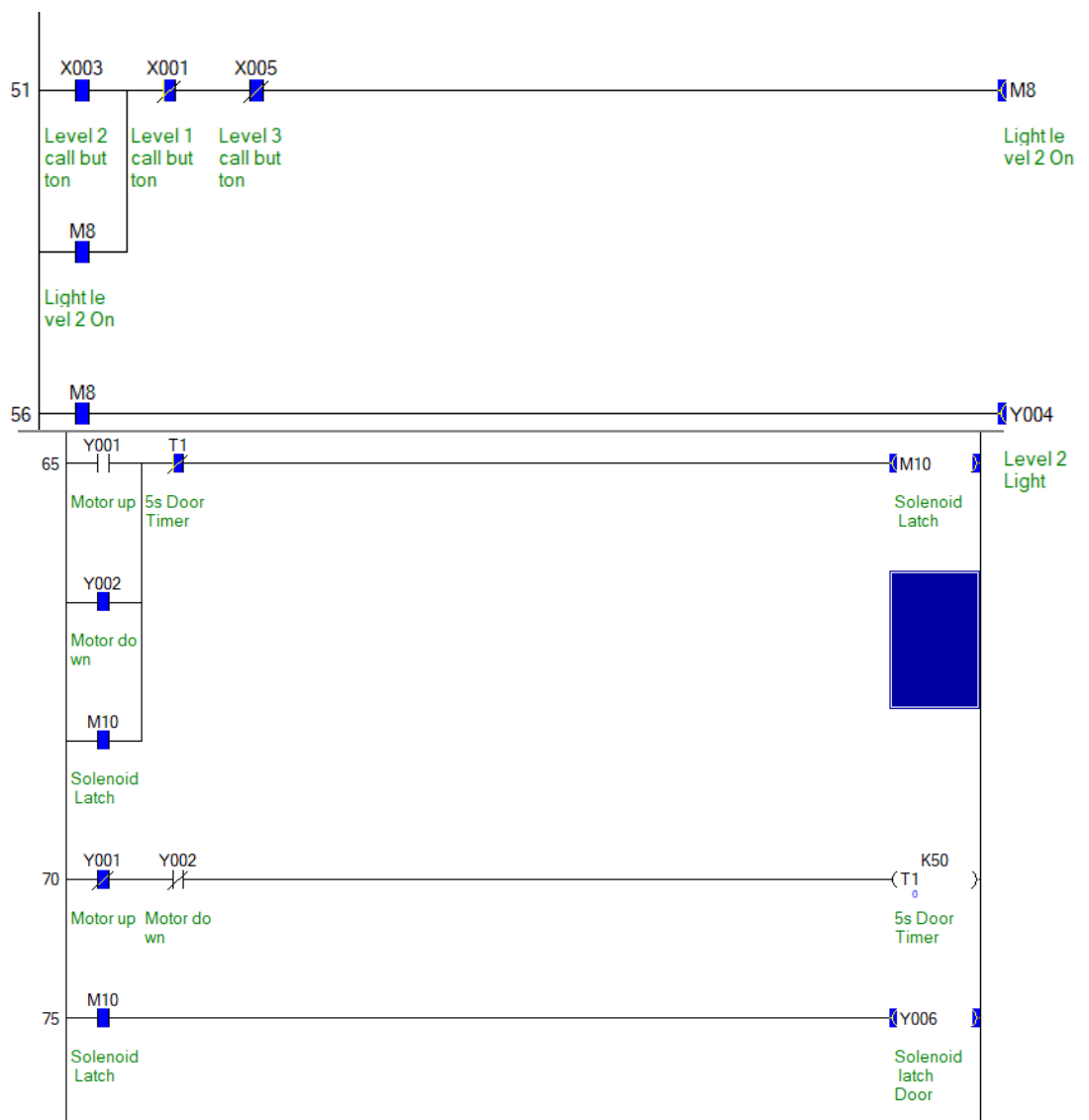
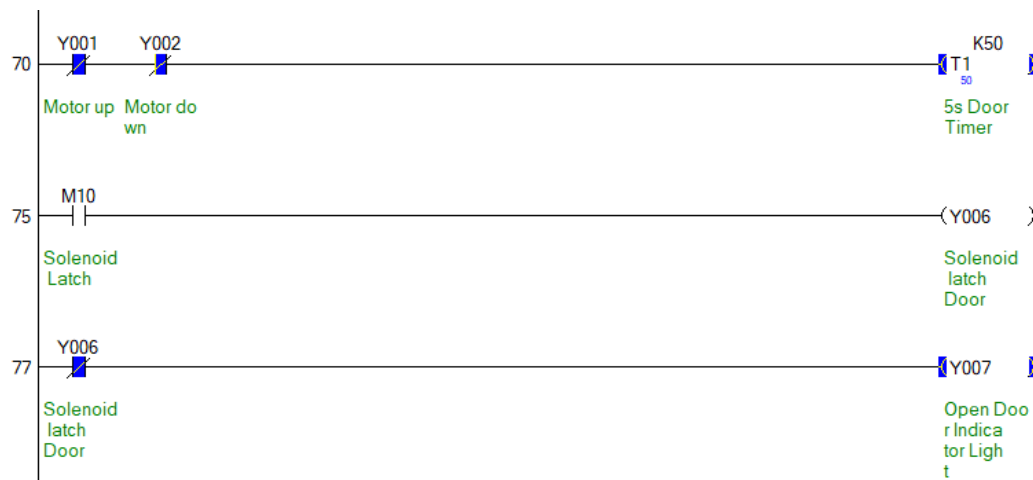


Figure 3 – Lift System

Testing





Program function:

The lift operates at a fixed level position. The level indicator light highlights the current position which is stated on the local panel (Level 1, 2 or 3.) When a call button for a specific level is activated the system checks if the door is locked and closed. The latched coil on the ladder logic represents this step of the process. If the door is locked, the lift motor starts to move the carriage to the designated level. The level light for the previous level turns off, and the light for the current level will turn on once the lift reaches it. During the lift movement, the door remains locked. Once the lift reaches the desired level and is stationary, there is a 5-second delay before the door lock disengages. After the delay, an indicator light turns on to show the door

can be opened by the user. The lift cannot be called to another level during level changes. Level calls cannot be activated if the door is not confirmed as locked.

Additional Functionality and Safety Features:

To improve safety an automatic door system could be installed to the lift. Automating the door to open or close after reaching the designated level to ensure the door is properly locked before moving would reduce human error of the door not getting latched properly by the user. Another safety feature that could be added is an emergency stop button that immediately stops the lift regardless of its current position. Finally, installing a communication device within the lift could help in emergencies, allowing users to communicate with corresponding aid on site.

References

Fiore, C., 2022. *Stepper Motors: Types, uses and working principle: Article: Mps.* [Online]

Available at: <https://www.monolithicpower.com/stepper-motors-basics-types-uses#:~:text=As%20all%20with%20electric%20motors,a%20variable%20reluctance%20iron%20core.>

[Accessed 14 March 2024].

McGee, T., 2013. *Capacitive Proximity Sensors.* [Online]

Available at: <https://www.softnoze.com/downloads/Sensor%20Basics%203.pdf>

[Accessed 18 March 2024].

Omron Industrial Automation, 2016. *Technical Explanation For Proximity Sensors.* [Online]

Available at: https://www.ia.omron.com/data_pdf/guide/41/proximity_tg_e_6_2.pdf

[Accessed 21 February 2024].

Omron, 2021. *Technical Explanation for Displacement Sensors and.* [Online]

Available at:

https://www.ia.omron.com/data_pdf/guide/56/displacemente_linewidth_tg_e_2_2_cs_m1051430.pdf

[Accessed 2024 March 15].

Oriental Motors, 2007. *Stepping Motors.* [Online]

Available at: https://www.orientalmotor.com/products/pdfs/F_TecRef/TecSt.pdf

[Accessed 23 March 2024].

Ranchi University, 2020. *Linear Variable Differential Transformer LVDT.* [Online]

Available at: <https://dspmuranchi.ac.in/pdf/Blog/lvdt.pdf>

[Accessed 23 March 2024].

Revere Control Systems, 2024. *SCADA Basics: What are SCADA and Telemetry?.* [Online]

Available at: <https://www.reverecontrol.com/scada-basics-what-are-scada-and-telemetry/>

[Accessed 22 March 2024].

Sharma, K., 2010. *INTRODUCTION TO SCADA.* [Online]

Available at:

<https://kaushalsharmaautomation.files.wordpress.com/2014/09/introduction-of-automation.pdf>

[Accessed 21 March 2024].

Soloman, S., 1998. *Sensors Handbook (McGraw-Hill Handbooks).* s.l.:McGraw-Hill Education.

Texas Instruments , 2022. *Ultrasonic Sensing Basics.* [Online]

Available at:

[https://www.ti.com/lit/an/slaa907d/slaa907d.pdf?ts=1714728417906&ref_url=https%](https://www.ti.com/lit/an/slaa907d/slaa907d.pdf?ts=1714728417906&ref_url=https%3A%2F%2Fwww.ti.com%2Fproduct%2Fultra100)

253A%252F%252Fwww.google.com%252F

[Accessed 25 March 2024].

Yamaha Motor, 2020. *NPN type I/O circuit details*. [Online]

Available at: [https://global.yamaha-](https://global.yamaha-motor.com/business/robot/lineup/controller/ts/pdf/index/ts-option08.pdf)

[motor.com/business/robot/lineup/controller/ts/pdf/index/ts-option08.pdf](https://global.yamaha-motor.com/business/robot/lineup/controller/ts/pdf/index/ts-option08.pdf)

[Accessed 16 March 2024].



Need to include some more text books.