

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Byron Grey	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
Engagement with a wide range of literature, including sources retrieved independently. Generally sound referencing technique.		
2. Knowledge and Understanding Skills	40	26.7
Task 1 achieved 68%. Task 2 achieved 68% Task 3 achieved 65% Showed competent knowledge of the basic underlying concepts and principles for assessment. Some good work in producing the IL code for Task 3 but should have used a branch command for the first rung.		
3. Cognitive and Intellectual Skills	5	3.3
Sound evaluation of the underlying concepts and principles applied to the construction of the programs for Task 4 and 5.		
4. Practical Application Skills	30	24.5
Task 4 achieved 78%. Task 5 achieved 85%. 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	7.4
Work is accurate, coherent, fluent, well-structured and organised.		

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)		71%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



Programmable Logic Controllers

Assignment 2

HNC Electrical and Electronic Engineering

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Task 1

a)

Many devices can be connected to a PLC in respect to the input circuits to pass information for the PLC to process. These devices can use different types of measurements to gather information, two common types are proximity and displacement.

Bolton states that "Proximity Switches are used to detect the presence of an item without making contact with it" (Bolton, 2009, P.31). One type of device which uses this method is the Inductive Proximity sensor that uses the principle of electromagnetic induction to operate, seen in figure 1. The sensor has a constant alternating magnetic field caused by the coil within it being energized by the constant alternating current from the oscillator circuit. When a metallic object comes within the range of this electromagnetic field, it induces eddy currents in the metal, which, in turn, cause changes in the sensor's electromagnetic field. The sensor detects these changes and triggers an output signal accordingly. This output signal can then be used as an input for the PLC to process and control a system. ✓

An application where an inductive proximity is used is within the manufacturing industry where it is used for presence detection in assembly lines, part positioning and counting. ✓

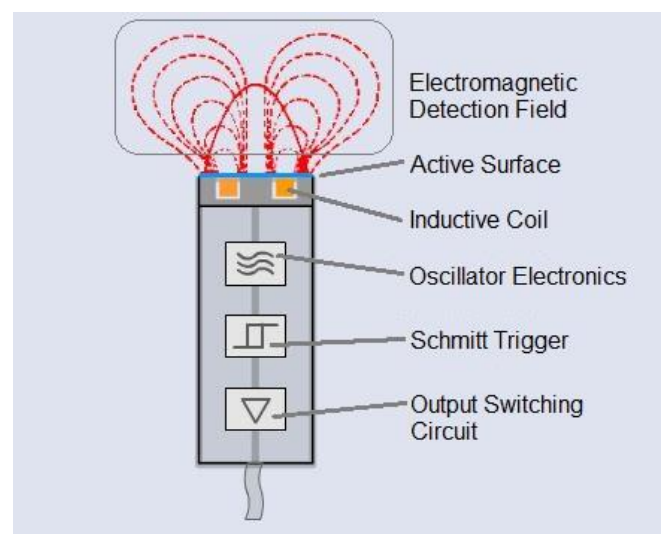


Figure 1- Inductive Proximity Sensor (Menke, 2024)

Another form of proximity sensor is Capacitive Proximity Sensor which can be used with metallic and non-metallic objects and uses the change in capacitance to determine the size and distance of the sensing object. The capacitive proximity sensor is constructed with a high-frequency oscillator and a sensing surface created by two metal electrodes, seen in figure 2. When an object becomes in range of the sensing surface, it enters the electrostatic field produced by the electrodes, altering the capacitance of the oscillator. Therefore, the oscillator circuit begins oscillating and alters the sensor's output state when it reaches a certain amplitude. As the object moves away from the sensor, the amplitude of the oscillator decreases, returning the sensor to its initial state.

This type of proximity sensor can also be used “to detect non-metallic objects since the capacitance of a capacitor depends on the dielectric between its plates. In this case the plates are the sensor and the earth, and the non-metallic object is the dielectric.” (Bolton, 2009, P.32).

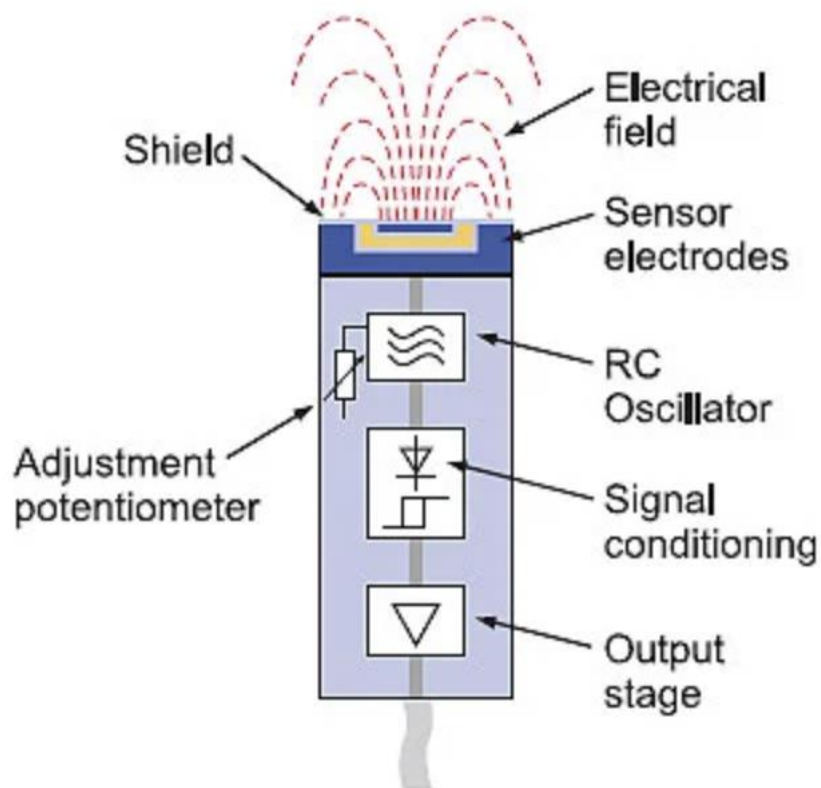


Figure 2- Capacitive Proximity Sensor (ROBU, 2020)

Other forms of devices can use displacement for its measurement and records the present and previous position of the target to gain its displacement. One device which uses this method is a strain gauge sensor which uses the change in strain to measure electrical resistance, which can then be used to transfer data onto a digital screen. The Strain gauge is constructed of gauge backing, resistive foil, solder pads and electrical wires, as seen in figure 2. T. Nachazel states “Stress is the deformation or displacement of material that results from an applied stress. Stress is the force applied to a material, divided by the material’s cross-sectional area.” (T. Nachazel, 2020).

When the object to which the sensor is attached undergoes mechanical deformation, such as stretching, compression, bending, or twisting, the strain gauge deforms along with it. This deformation causes changes in the electrical resistance of the gauge, which can be measured and correlated with the amount of strain experienced by the object.

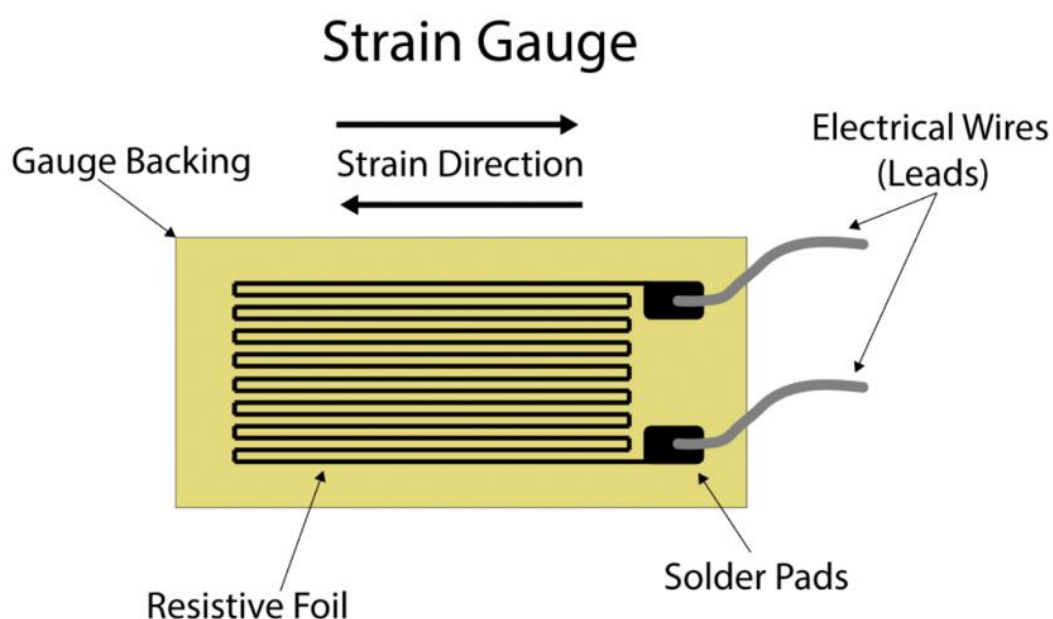


Figure 3- Construction of a resistive strain gauge(T.Nachazel, 2020)

Another device that uses displacement as the measurement to be used in the input circuit for a PLC is a Linear Variable Differential Transformer (LVDT), seen in figure 4. LVDT is a type of electromechanical sensor used to measure linear displacement or position by creating an output voltage that is related to the displacement of a ferrous rod. Demonstrated in figure 4 the LVDT is made up of three coils positioned around a ferrous rod, once the alternating current is passed through the primary coil it will induce voltages v_1 and v_2 into the secondary coils. At the point the rod is centred between the two secondary coils the difference in voltage induced in each coil is 0, resulting in no output voltage. Once the rod is displaced this will cause a difference in voltage across each secondary coil and cause an output voltage that depends on the position of the rod. This output voltage can become an input for a PLC that can convert into a figure for the displacement of the rod.

LVDTs find applications in various industries, such as aerospace, automotive, manufacturing, and robotics, where accurate and reliable position sensing is crucial. They are often used in scenarios where environmental conditions might be harsh, as they are resistant to shock, vibration, and contamination.

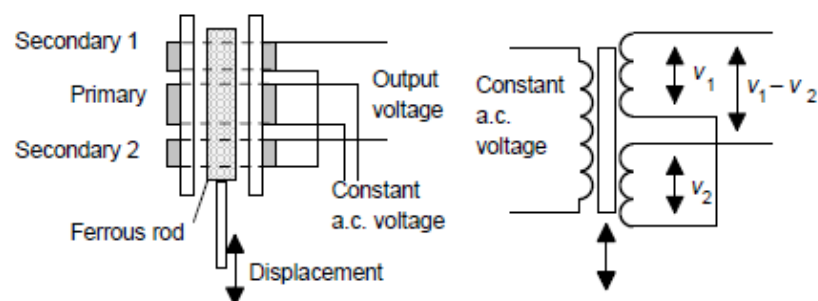


Figure 4- LVDT Construction (Bolton, 2009, P.37)

b)

PLC will also have output devices that will receive instructions from the PLC to carry out, one of these devices are a stepper motor that is used to convert electrical pulses from a PLC into mechanical movements. The construction of a stepper motor is demonstrated within figure 5 and like any electrical motor it has the stator as a stationary part and the rotor as the moving part. The teeth of the stator are wound with coils and positioned in a particular way around the rotor, which typically consists of a permanent magnet or a series of magnetic teeth.

The working principle of a stepper motor is based on electromagnetism so when an electrical current flows through one or more coils in the stator, it creates a magnetic field and will cause the rotor to align with this field. By energizing different phases in a sequence, it allows the rotor to rotate a specific amount to end up at the desired position for the application. The amount the rotor moves with each step is down to the step angle which is the angle through which the motor rotates for each step. For example, a stepper motor with a 1.8° step angle will move 1.8° for each step.

Due to the stepper motor having a precise control over the movement of the rotor it is a desirable component for equipment such as 3D printers to CNC machines and robotic arms, stepper motors play a crucial role in translating electrical signals into precise mechanical motion.

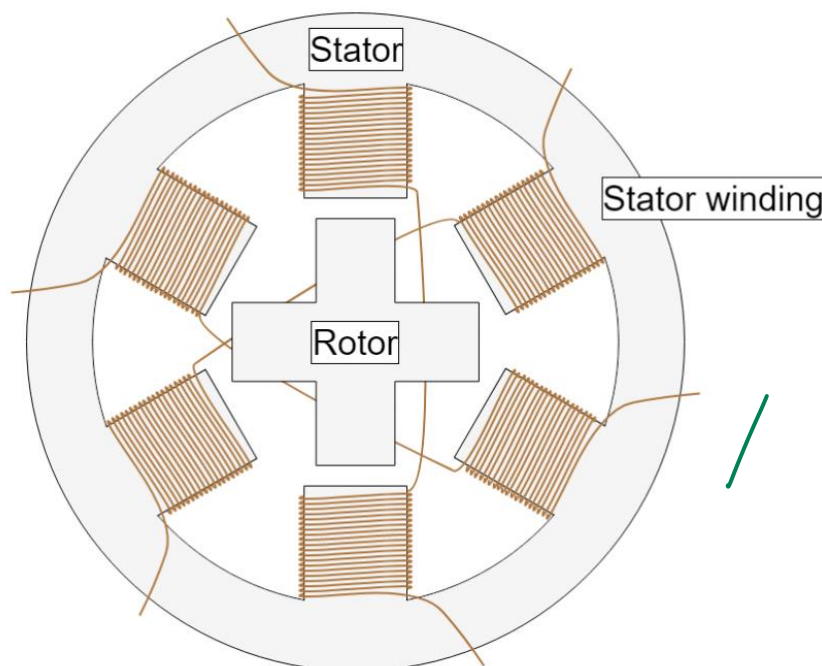


Figure 5- Stepper Motor construction (Monolithic Power, 2024)

Task 2

SCADA systems are heavily used in modern industries such as Oil and Gas, Transportation and water managements and stands for Supervisory Control and Data Acquisitions. Inductive Automation states that SCADA is “a system of software and hardware elements that allows organizations to control and monitor industrial processes by directly interfacing with plant-floor machinery and viewing real-time data” (Inductive Automation, 2018).

SCADA allows organizations to control processes, gather and monitor real-time data, interact with components in the system such as pumps, motors, valves, or sensors and have records of any events that happened from a remote or local location.

Figure 6 demonstrates a basic SCADA diagram and shows that the start of the systems architecture is with a PLC that communicates with components within the system to gather data ready for the SCADA system to process, distribute and display the data to help operators use it to make decisions to help the process work efficiently and effectively.

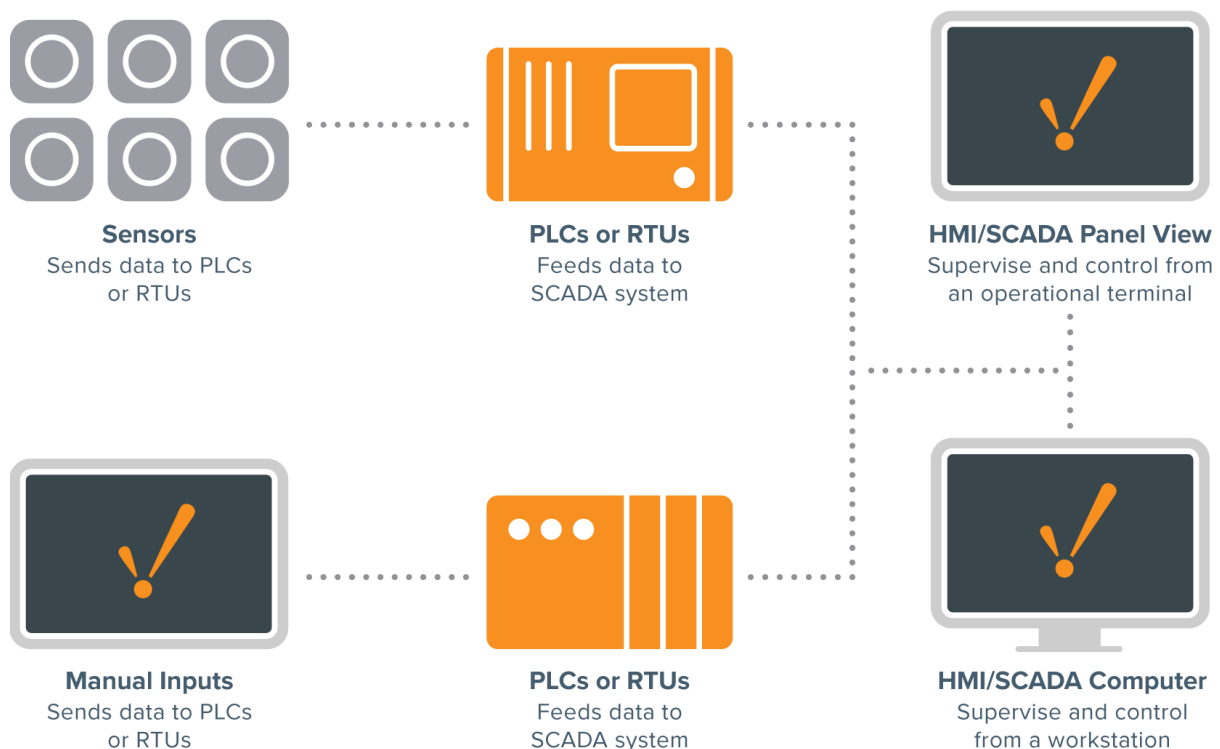


Figure 6- Basic SCADA Diagram (Inductive Automation, 2018)

Key features of the SCADA system are real-time monitoring of industrial processes by collecting data from input devices distributed throughout the process, data acquisition which stores this data to allow for analysis and decision making to take

place of the data. Another feature is that the system allows operators to control industrial processes remotely or automatically based on predefined conditions and offers visualization and alarm system for the operator to be able to see the system working and will monitor the system for abnormal conditions and trigger alarms to alert and enable a quick response.

As spoken about above Programmable Logic Controllers (PLCs) play an integral role within the SCADA system as they are used to control output devices such as machinery and processes, communicate with sensors, actuators, and other input devices to monitor and control process variables. PLCs also execute control logic based on inputs received and programmed instructions.

The integration of Human-Machine Interface (HMI) serves as the primary interface between operators and the SCADA system and allows a visual representation of the industrial process, including status, trends, and alarms, seen in figure 7. The HMI also allows the operator to be able to interact with the system, monitoring process variables and issuing commands.

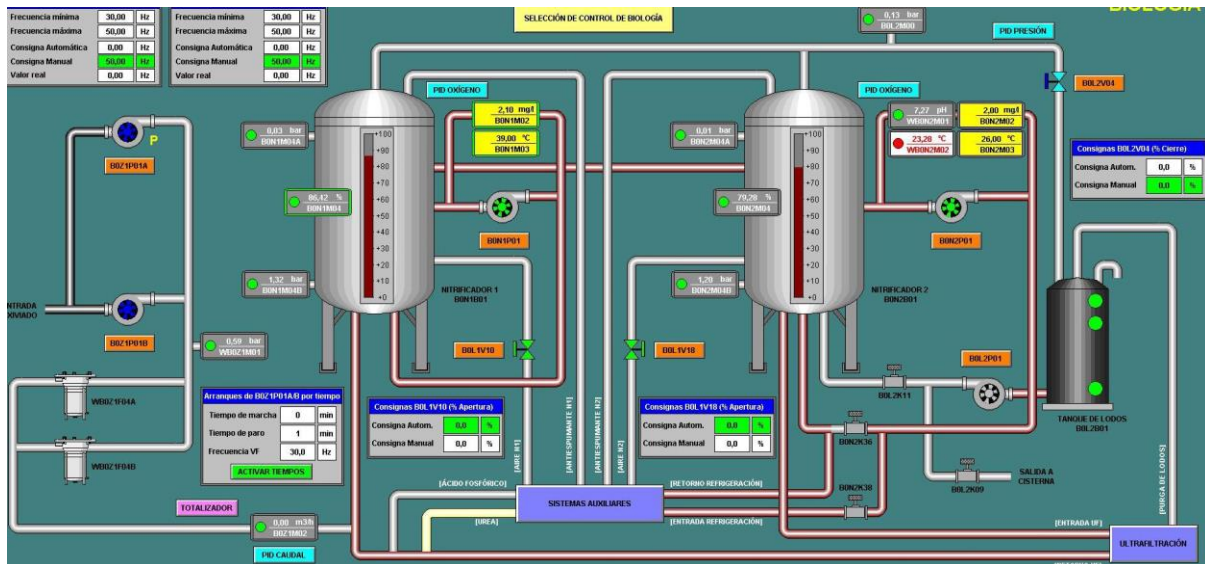


Figure 7- Example of a SCADA system with HMI integrated (IC Systems, 2013)

The SCADA system is widely used across industries especially within the oil and gas industry where they use it for refining processes and for the movement and transfer of product from one location to another. The SCADA system allows the organization to control the refinery process such as distillation, cracking and blending by

optimizing production by adjusting process parameters based on real-time data and demand. It also allows the operator to complete quality checks by monitoring product quality parameters such as composition, density, and viscosity at various stages of refining and distribution. The SCADA system offers Tank Farm Management by monitoring tank levels, temperature and quality of stored oil and gas and offer automation and operator control over pipelines, pumps and valves to be able to move product tank to tank or to distribute to external locations such as the jetty ready to be exported.

well done, showed a very good understanding.

Task 3

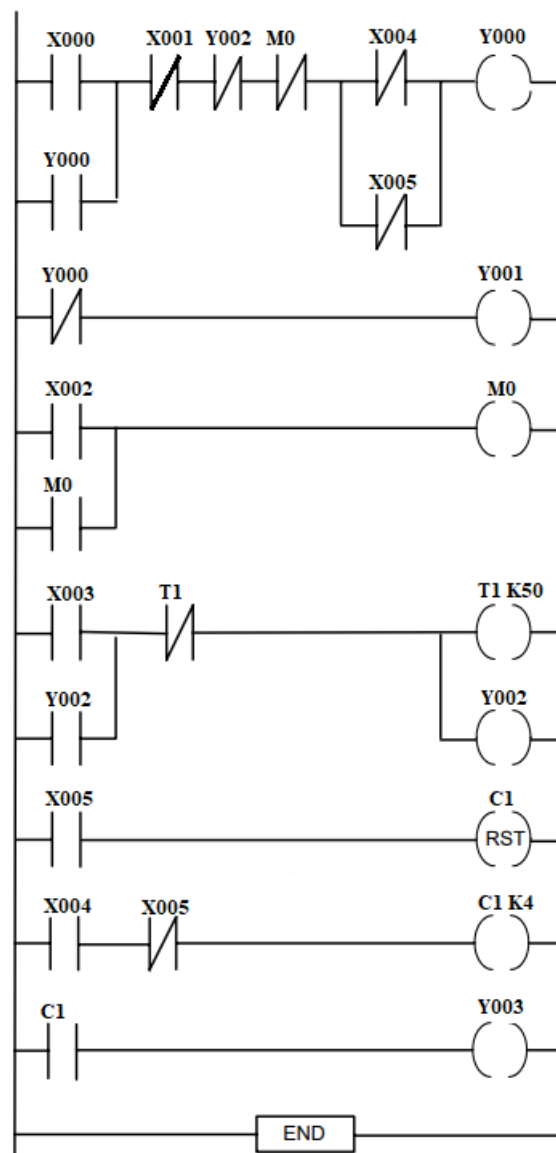


Figure 8- Ladder Logic for a bottle packing production line

Below is the Instruction list for a bottle packing production line that meets all the required control actions, seen in figure 8.

```
LD X000
OR Y000
ANI X001
ANI Y002
ANI M0
ANI X004
ORI X005
OUT Y000
```

*This might cause an issue
should have used ORB.*

```
LDI Y000 /
OUT Y001
```

```
LD X002 /
OR M0
OUT M0
```

```
LD X003
OR Y002
ANI T1
OUT T1 /
K 50
OUT Y002
```

```
LD X005 /
RST C1
```

```
LD X004 /
ANI X005
OUT C1
K 4
```

```
LD C1 /
OUT Y003
```

```
END
```

Task 4

Figure 9 demonstrates the completed Alpha program for the Mitsubishi PLC temperature alarm system to be able to monitor the temperature range for 0 to 50°C which will indicate the user using a series of lights.

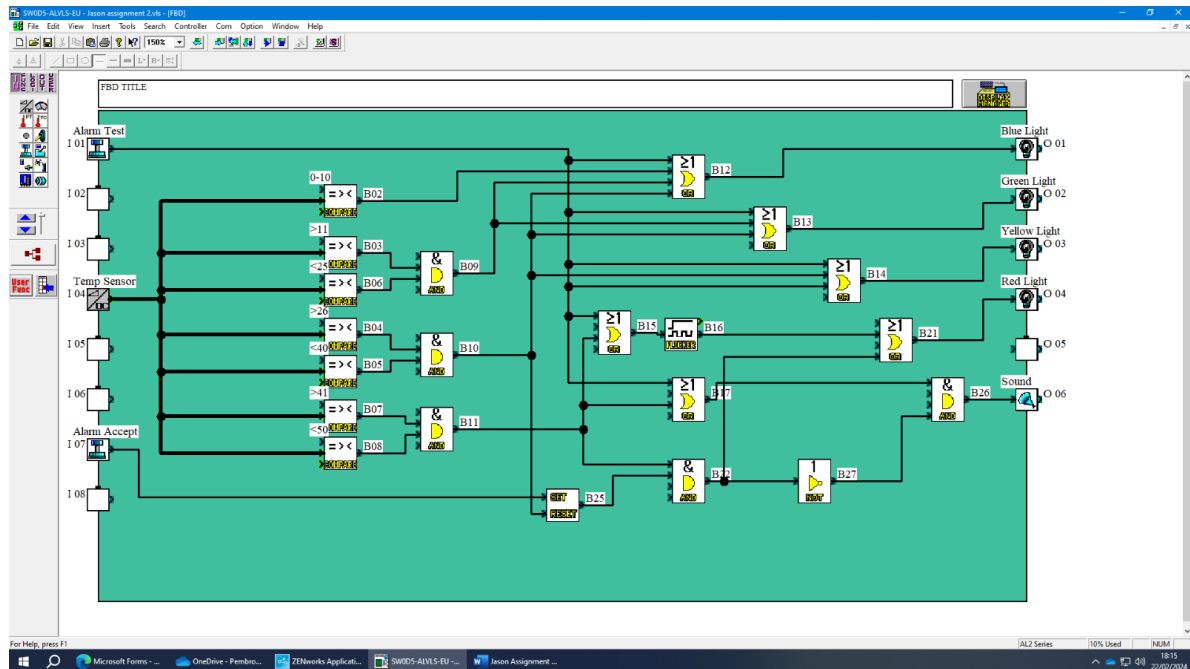


Figure 9- Completed program

From this testing of the program can take place starting with the alarm test button which triggers all lights to come on as well as the audible alarm showing its functioning correct as seen in figure 10.

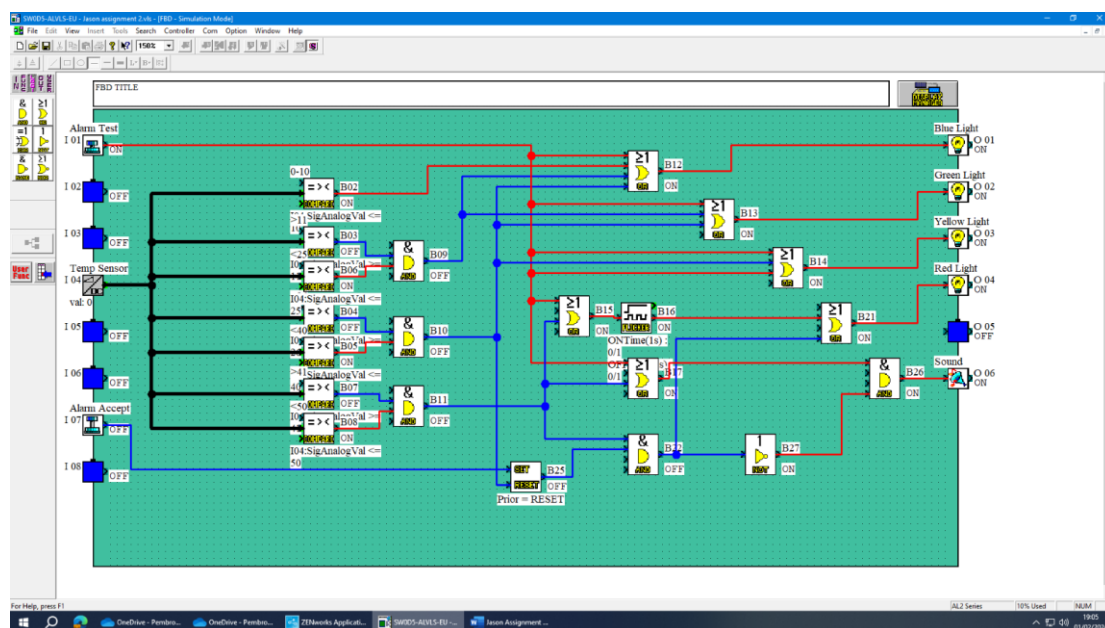


Figure 10- Alarm test button test

Figures 11 to 14 shows all the ranges of the program functioning correctly and activating the appropriate outputs.

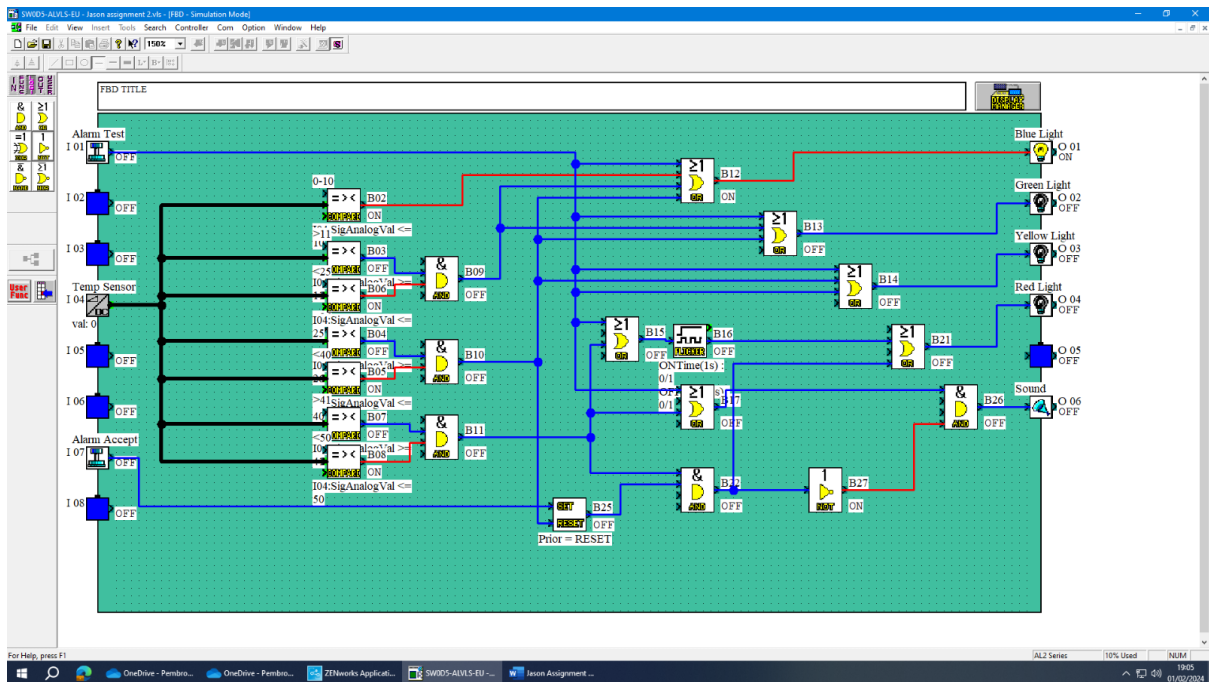


Figure 11- Temperature below 10°C and blue light activated

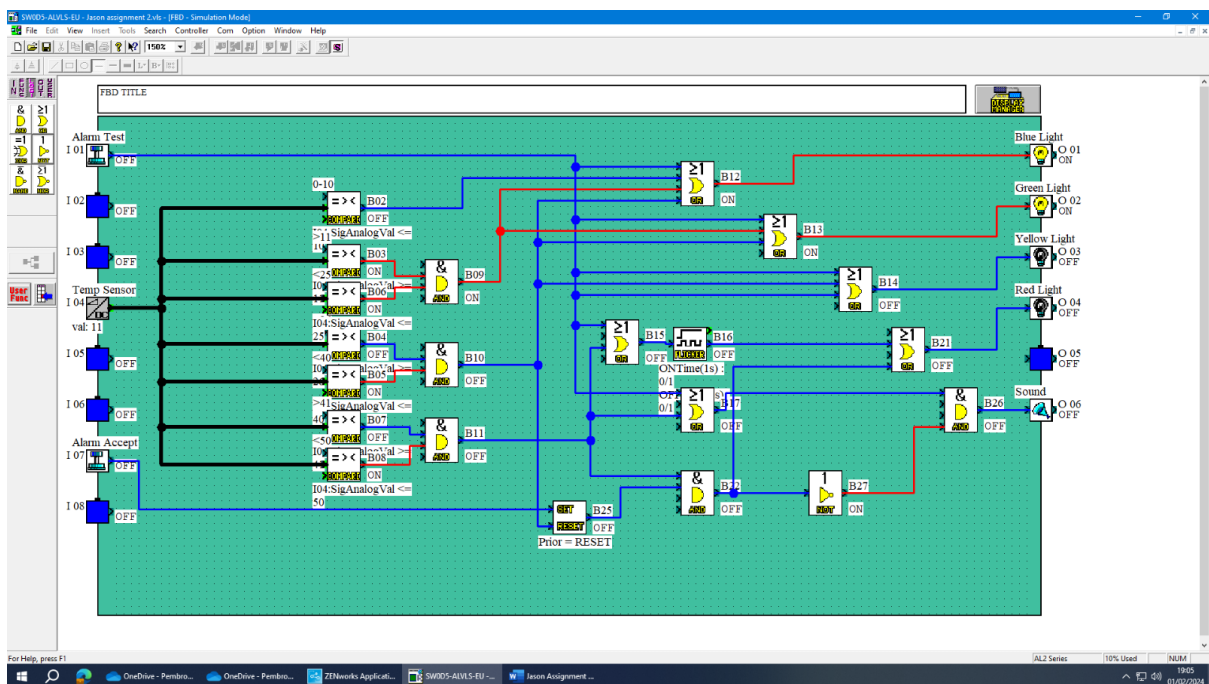


Figure 12- Temperature between 11 and 25°C activating blue and green lights

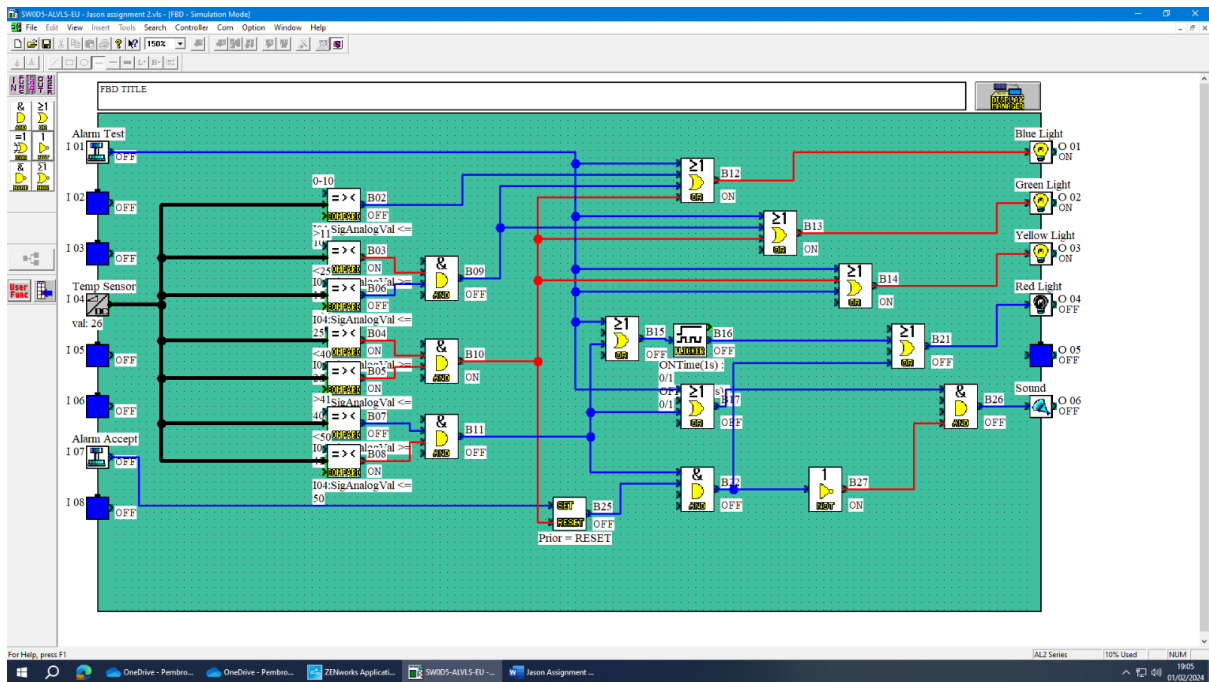


Figure 13- Temperature between 26 and 40°C activating blue, green and yellow lights

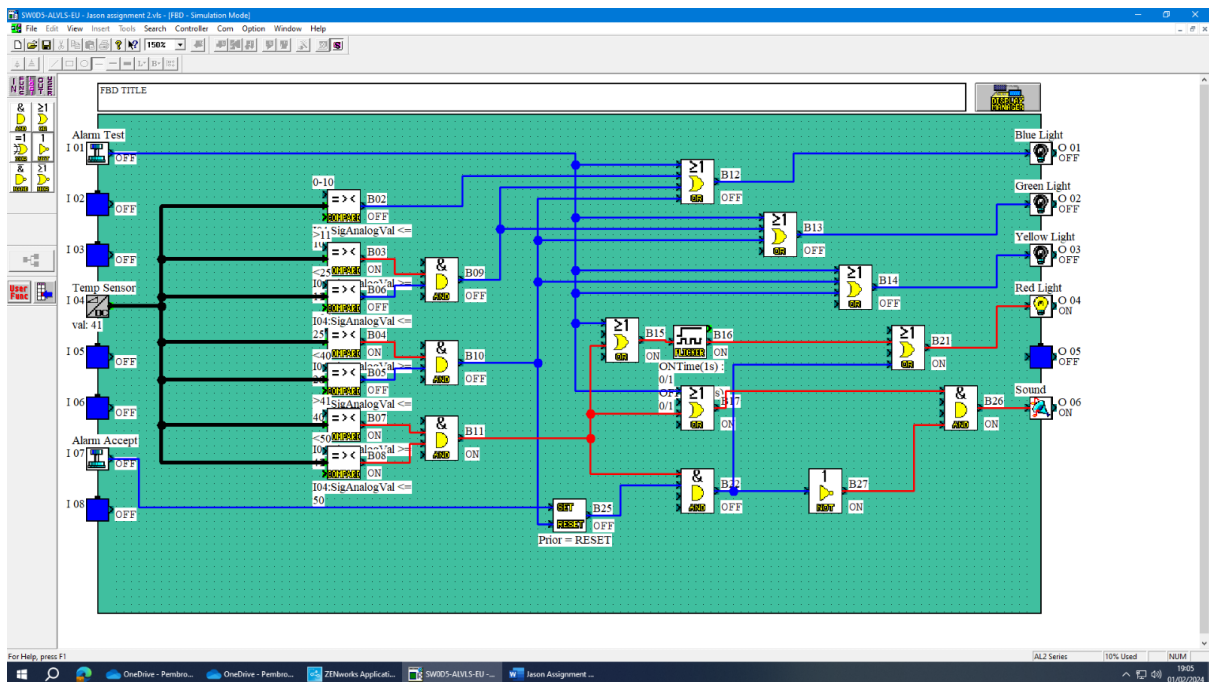


Figure 14- Temperature between 41 and 50°C activating the red light and audible alarm

Once the temperature goes above 40°C the alarm accept button can be pressed to cancel the audible alarm as well as set the red light from flashing to a steady state condition, as seen in figure 15.

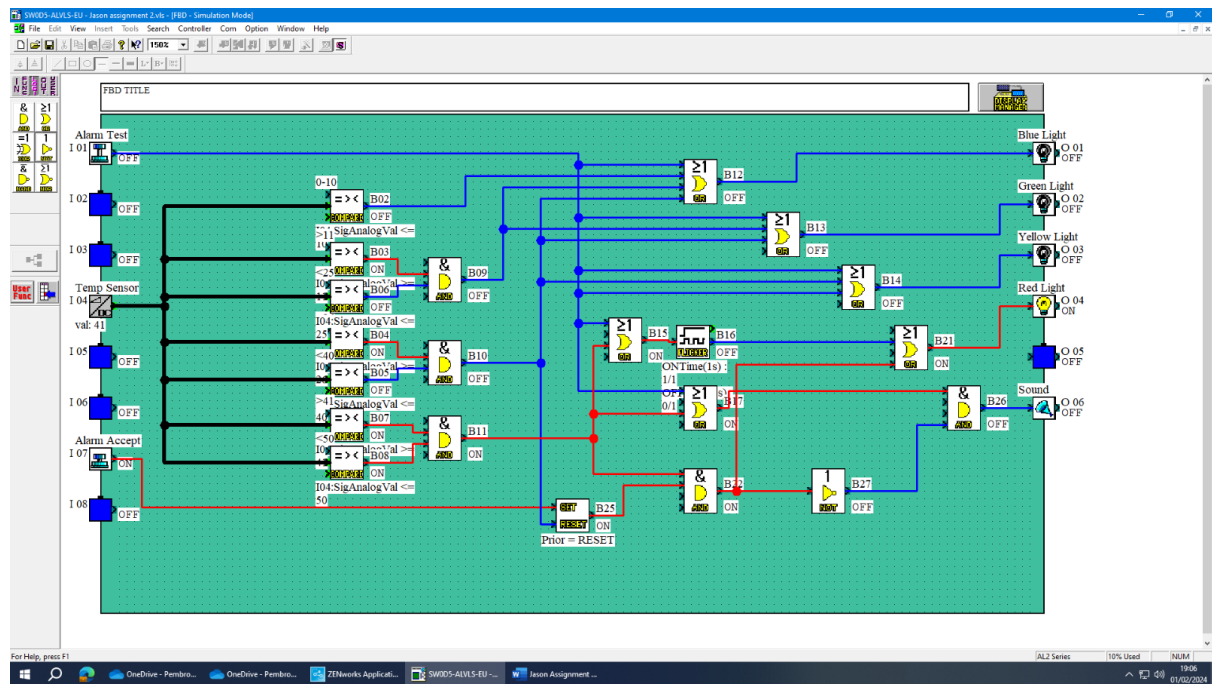


Figure 15- Alarm accept button working correctly

As the temperature reduces to below 40°C it will allow the program to then reset the alarm accept and carry on functioning correctly for the temperature range it is in and activate the blue, green and yellow light seen in figure 16.

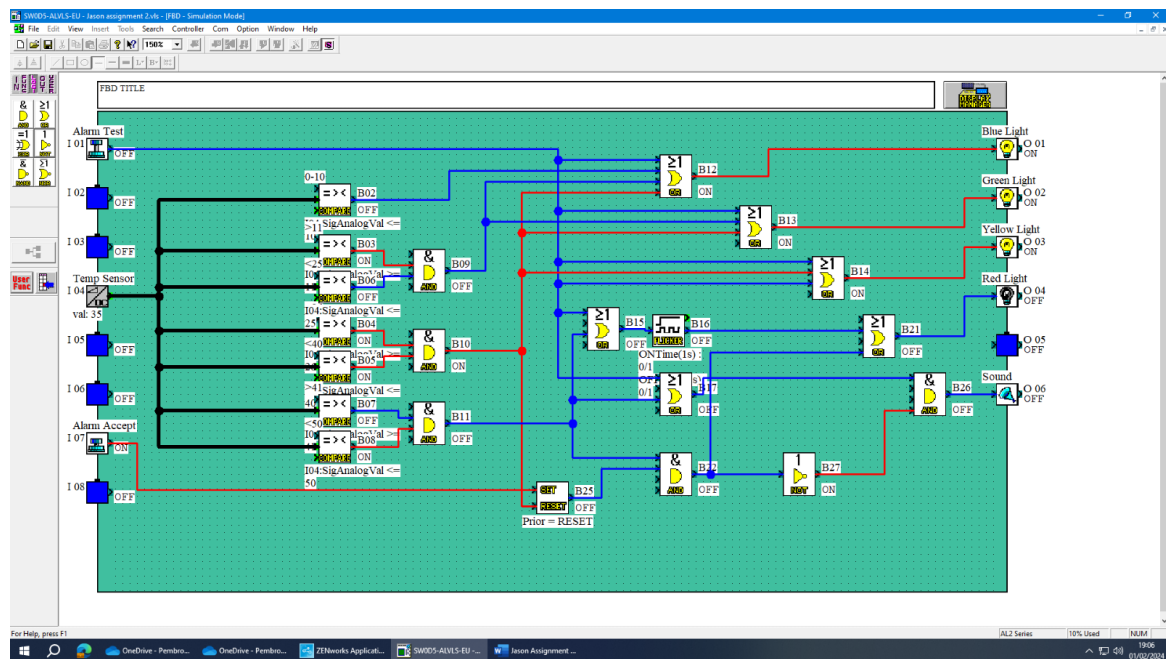


Figure 17- Accept alarm reset

For the user to be able to see the PLC in operation a Monitor is created with the lights and buttons for them to be able to use the temperature alarm system, seen in figure 18.

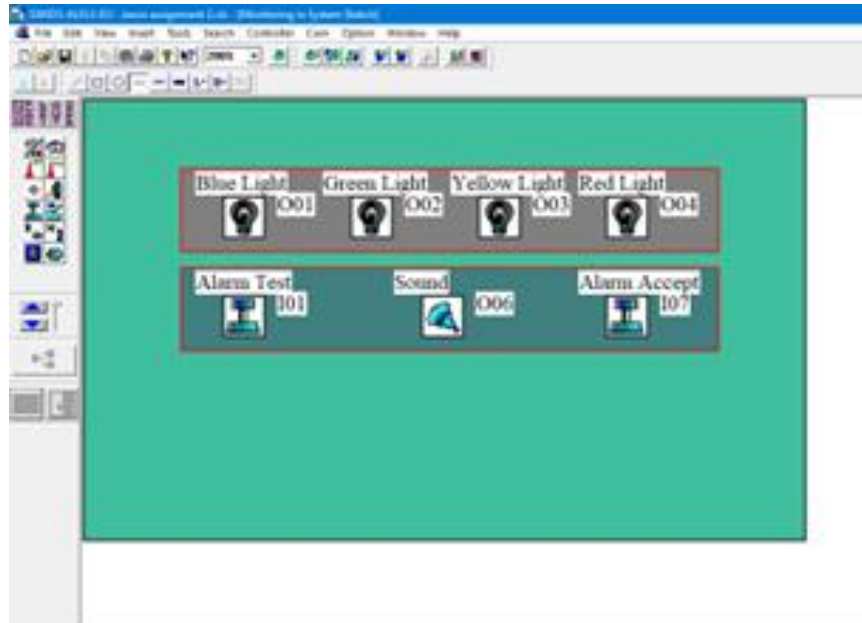


Figure 18- Completed Monitor

Figures 19 and 20 demonstrates the monitor as the program is on. Figure 19 shows when the test alarm is pressed and figure 20 shows the monitor when the temperature is at 30°C.

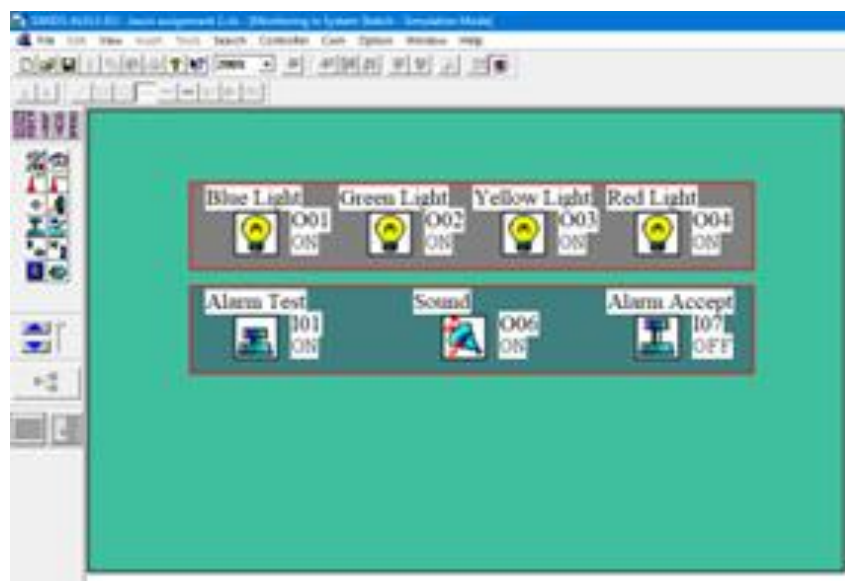


Figure 19- Test alarm on monitor

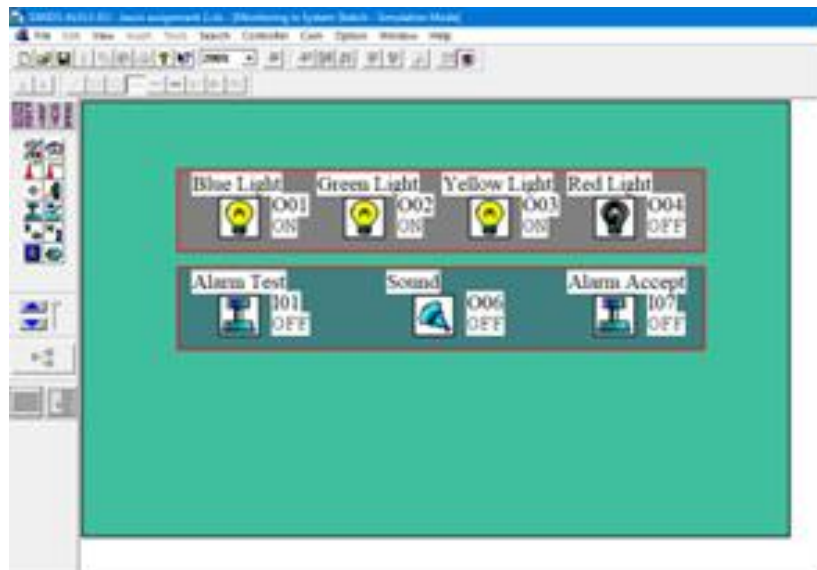


Figure 20- Monitor at temperature 30°C

You have produced a working design but could have been done using less functions.

Task 5

In figure 21 it illustrates the GX Works 2 ladder logic for the lift system on a building site, seen in figure 22. The program is used on a Mitsubishi FX PLC to control the process and to meet all operational requirements.

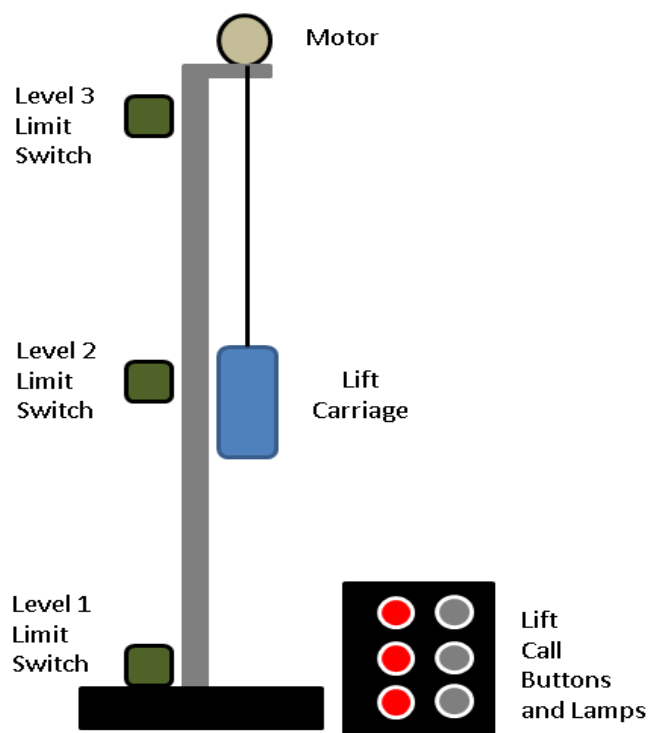
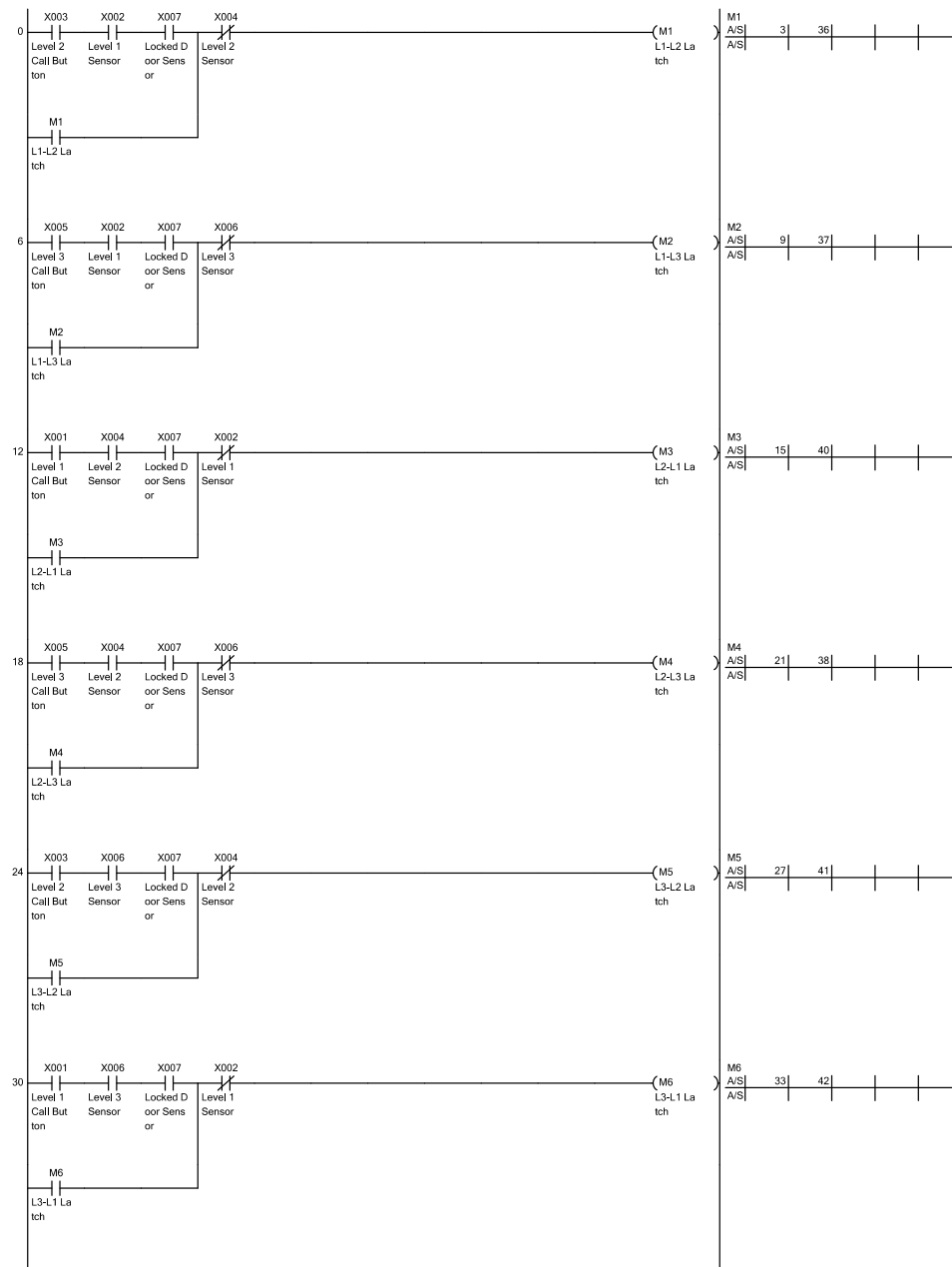
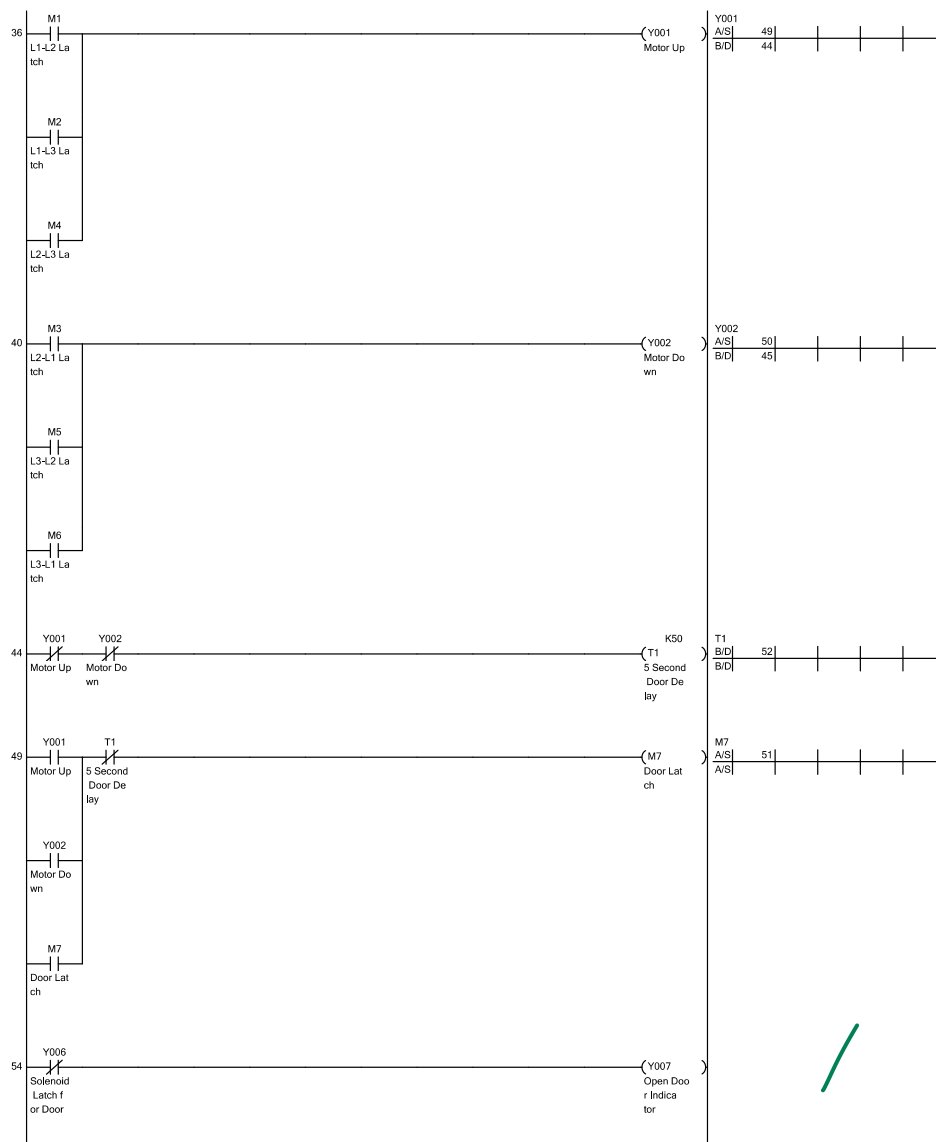
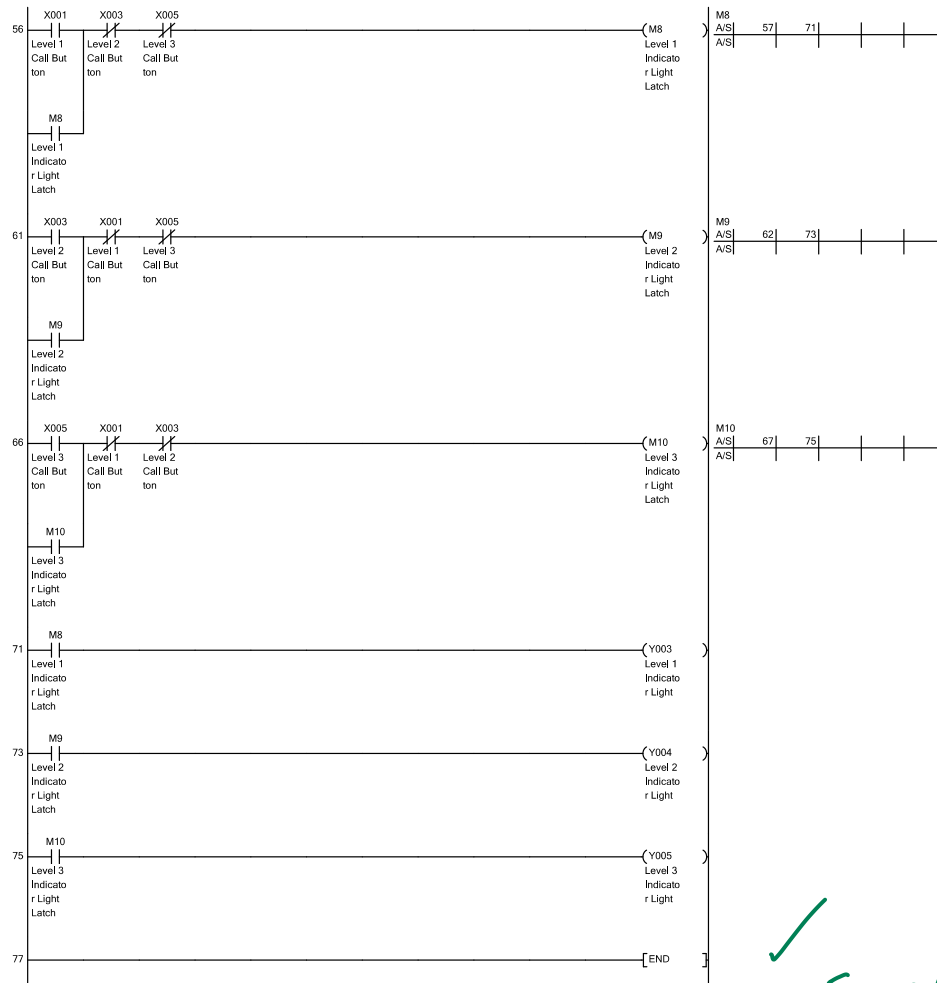


Figure 21- Lift system on a building site (Assignment, 2024)







✓
Excellent program.

Figure 22- Ladder Logic for lift system

To test the program within GX Works 2 it will need to be simulated to make sure that the system is functioning correctly with the motors, buttons, sensors, latches, and lights. The first test simulated is the lift being called to level 2 from level 1, figure 23 shows the level 2 call button being activated along with the level 1 sensor and the door being locked causing the latch for that memory coil to operate.

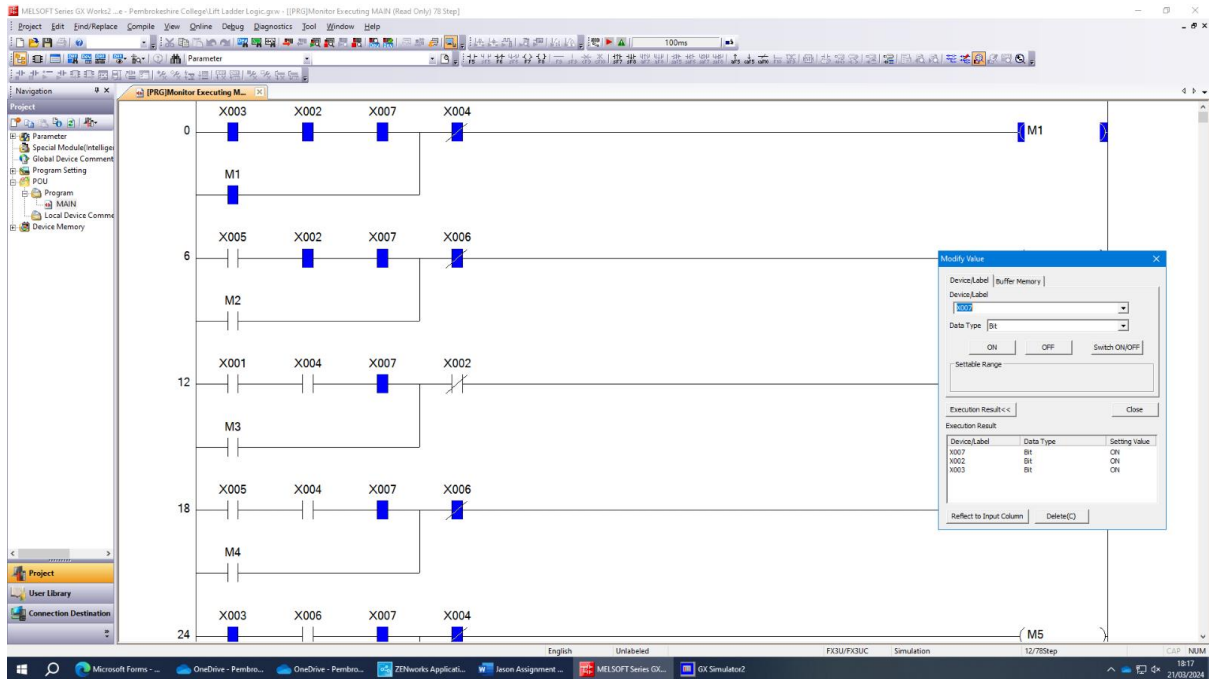


Figure 23- Level 1 to 2 latch activated

Therefore, the memory coil will activate the motor up output, as seen in figure 24.

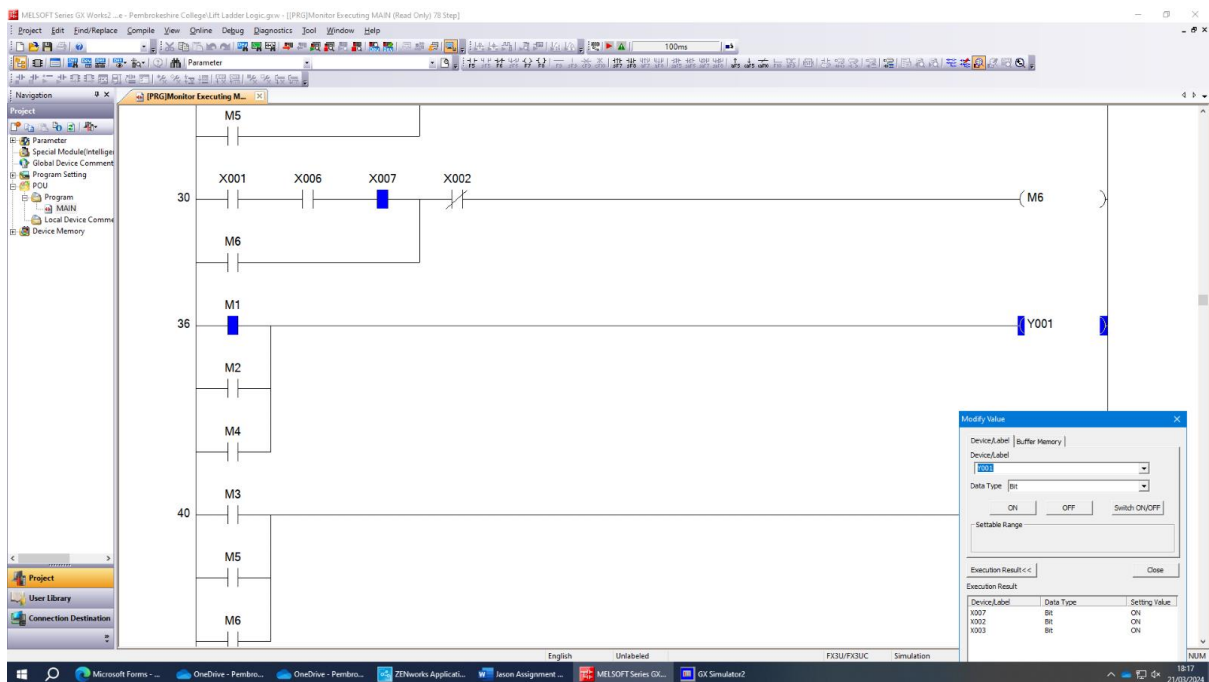


Figure 24- Motor up activated

In figure 25 it illustrates that the door latch and solenoid latch for the door is activated which allows the memory coil from above to be latched and the motor to move. This

also shows that the door open indicator is off, demonstrating g that it is functioning correctly.

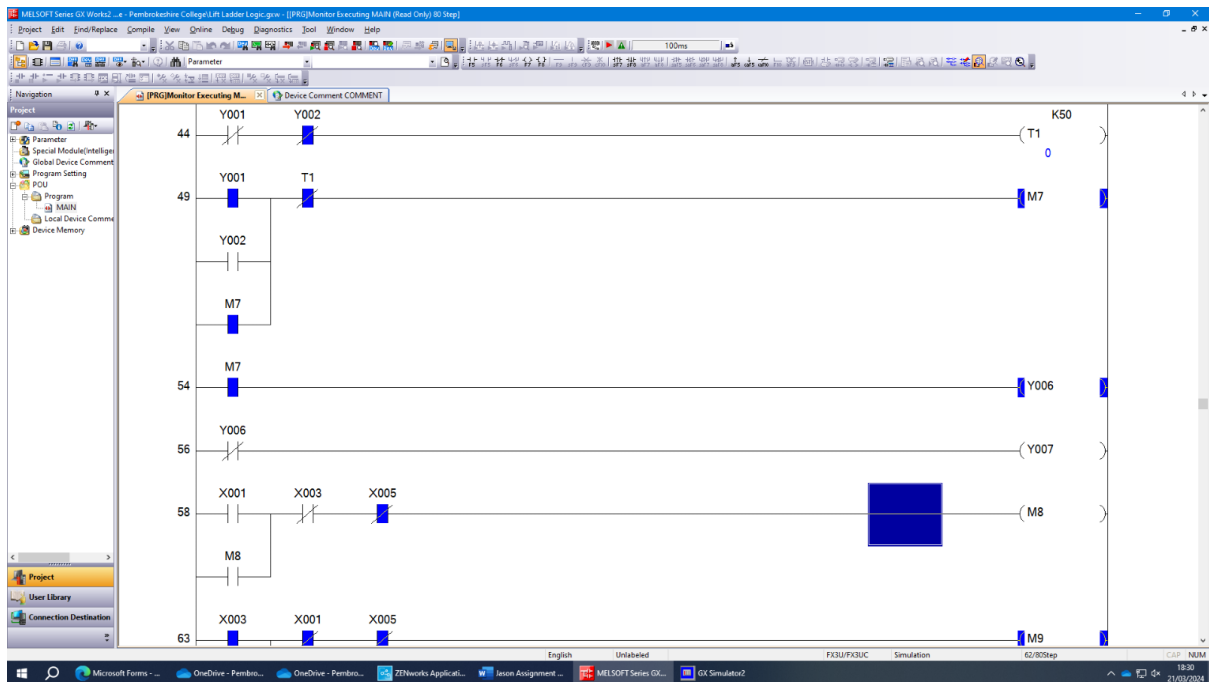


Figure 25- Door latches working with the motor and indicating lights

When the call button is pressed for level 2, the level 2 indicator light will activate as shown in figure 26.

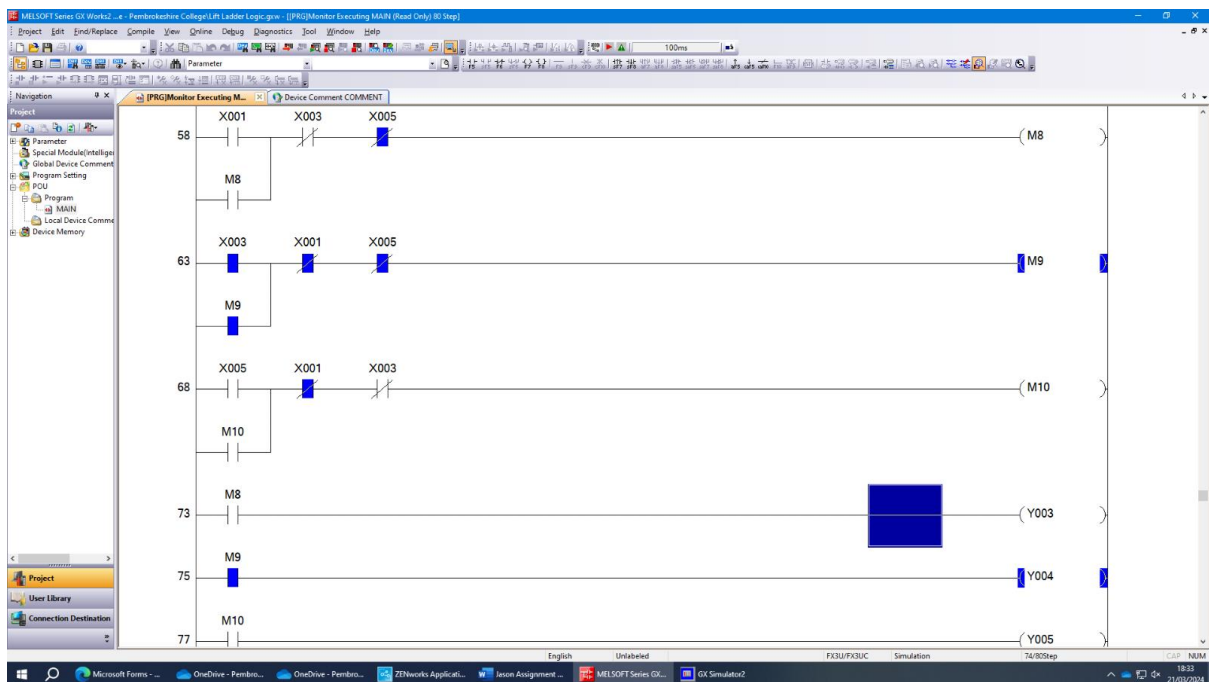


Figure 26- Level 2 indicator light working correctly

Once the level 2 sensor is activated the latch is de-activated, motor stopped and door timer activated before the door is unlatched and open-door indicator is activated, seen in figures 27 and 28.

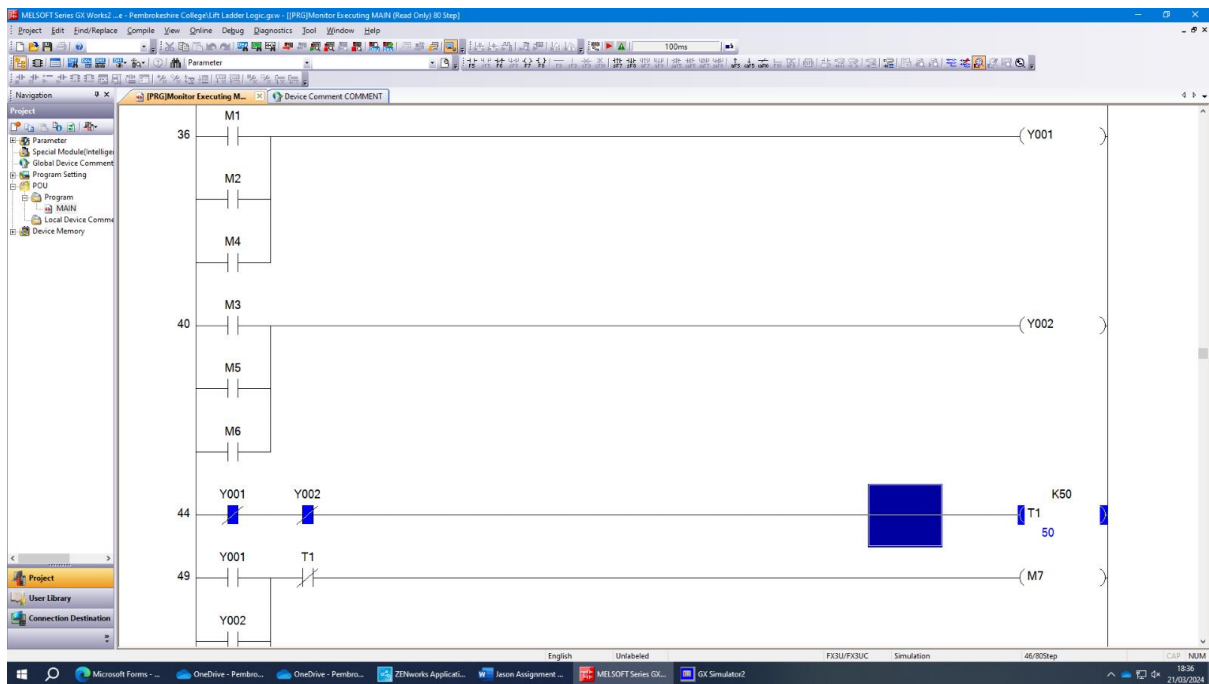


Figure 27- Motor up stopped

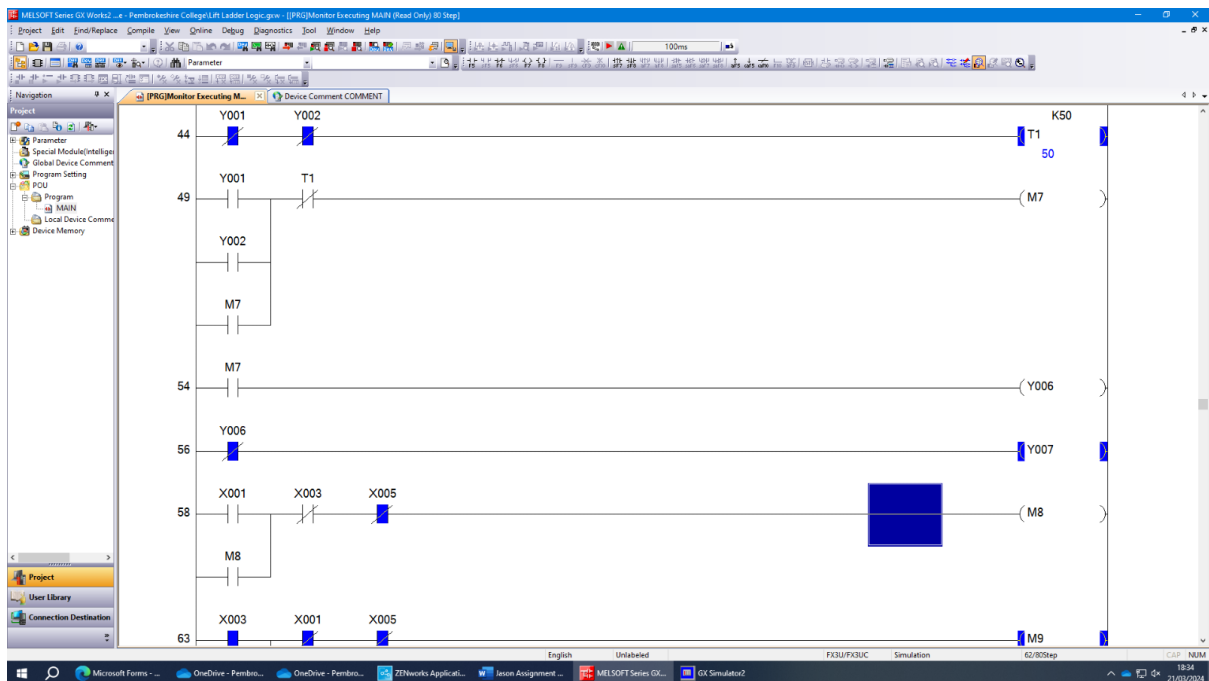


Figure 28- Door timer activated, and door unlatched

The simulating tests seen above prove that the program functions correctly for the lift to move from level 1 to level 2, these tests were completed for the other 5 movements in the system which all were successful in functioning correctly. Overall, the program functioned correctly and met all the criteria set out in the requirements and design specifications, however there are additional functionalities that could be incorporated to improve the programs overall process operations and some additional safety features.

These include incorporating sensor and monitor to show where the lift is positioned at any given time and an automatic door so that the people inside don't have to lower the door themselves to make it safer and more effective. Also, safety features such as weight sensor to reduce likelihood of overcrowding the lift and causing any problems with the motors being over worked and emergency procedure that if there is a malfunction it lowers the lift carriage to level 1 and opens the door to reduce anyone getting injured. Along with this emergency procedure there could be an emergency stop button integrated into the carriage to be used in an event of emergency.

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would like to see more text books in the
reference list.