

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Sian Nunnery	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:	Lance Rutherford
Assignment Title:	PLC Program design and simulation	Word count (or equivalent):	2000
Submission deadline:	05/05/22	Return date of provisional marks & written feedback:	19/05/22
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	8.7
Engagement with an appropriate range of literature, including sources retrieved independently but would like to see the use of more textbooks. Do need to include some direct references.		
2. Knowledge and Understanding Skills	30	21.1
Task 1 achieved 70%. Task 2 achieved 74% Task 3 achieved 66% Excellent knowledge and understanding of the basic underlying concepts and principles of the work required for Task 1 and 2. There were a couple error in your IL code for Task 3 which have been highlighted in the assignment.		
3. Cognitive and Intellectual Skills	10	5.8
Good evaluation of the underlying concepts and principles applied to the construction of the programs for Task 4 and 5.		
4. Practical Application Skills	35	30.1
Task 4 achieved 86%. Task 5 achieved 86%. 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	6.9
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)		73%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



PLC Program Design and Simulation

HNC ELECTRICAL/ELECTRONIC ENGINEERING -
PROGRAMMABLE LOGIC CONTROLLERS
SIAN NUNNERY

JASON POINTER

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Task 1 – PLC analogue and discrete I/O

Identify and describe two different devices that could be connected to the PLC with respect to input circuits for each of the following measurement:

- Temperature
- Pressure.

A device that can be connected to the PLC with respect to input circuits for pressure measurement is a pressure switch. A pressure switch is a type of discrete I/O device which is a simple electromechanical device. When pressure becomes built up and reaches the set point, the pressure point is activated, then triggers the device once it reaches its threshold that therefore deactivates the switch, known as the cut-off point. A pressure switch consists of the following components: a diaphragm, adjustment spring, an auto/off level, electrical contact, and terminals. There are two types of pressure switches with respect to normally open (NO) and normally closed (NC) pressure switches. The NO pressure switches function by the switch stays open when the pressure is within the set range until the pressure goes outside of its range and then the switch will close. Whereas NC pressure switches, the switch will have a set point, or a cut-off point where the switch will open once it has gone outside of its pre-calibrated normal range. Pressure switches are commonly used within industrial process control system. For example, a compressed air system is used to switch a compressor on / off at the set point. ✓

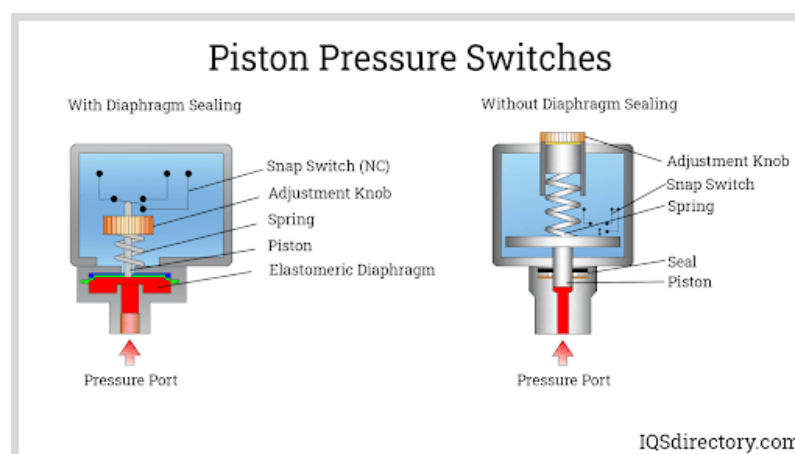


Figure 1.1 – Pressure Switch Diagram (Search and Switches, n.d.)

A pressure transmitter is a type of analogue measurement device where it is design to be capable of pressure in liquids, fluids and gases. A pressure transmitter is an instrument where is gets connected to a pressure transducer. The pressure transmitter produces an analogue electrical voltage or a current signal ~~that is represented by using 0 to 100% of the range that is sensed by the pressure transducer.~~ *Why is this crossed out?*

A transducer is a device where it transfers one type of energy into another. *“For example, an electrical transducer converts a sensed physical variable like temperature into an analogue electrical signal.” (Mortenson, 2020)* ✓

Whereas a transmitter is a device where it converts the electrical signal that is received from the transducer and projects it into a larger electrical signal which then gets sent to a PLC or DCS. The output signals the pressure transmitter produced is either a voltage (1 to 5V) or current (4 to 20mA) signal, where the ranges of voltage and current represent 0 to 100% of the physical variable that has been sensed. ✓



REALPARS

Figure 1.2 – Signal from transducer to transmitter (Mortenson, 2020)

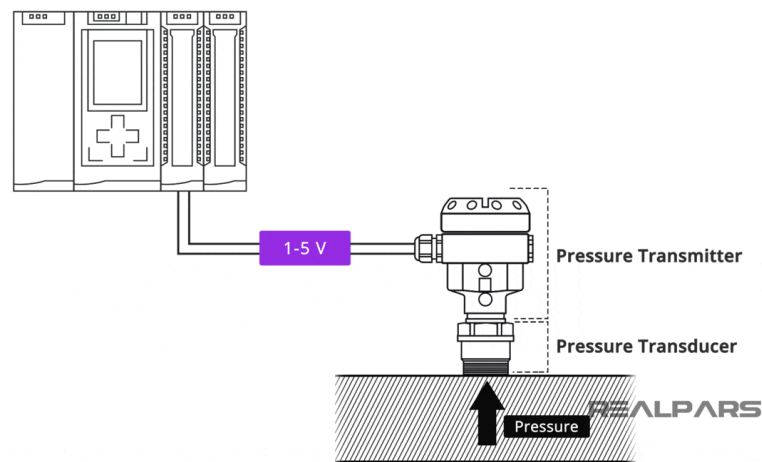


Figure 1.3 – Overall diagram of components (Mortenson, 2020)

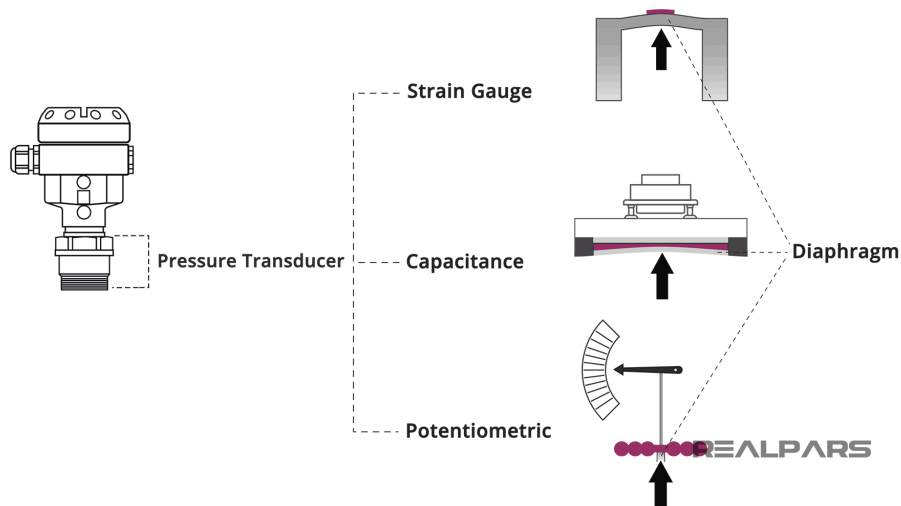


Figure 1.4 – Types of Pressure Transducers (Mortenson, 2020)

“The actual sensor part of the transducer which makes contact with the pressure being sensed is based on several technologies and materials such as Strain Gauge, Capacitance, and Potentiometric.

The actual process is separated from the sensing material by a measuring diaphragm.

The type of sensor chosen is decided by the application and environment it is being used in.”
(Mortenson, 2020) ✓

A pressure transmitter is capable of measuring absolute, gauge and differential pressures. Absolute pressure is a vacuum which is regarded as 0 psi, atmospheric pressure is typically

14.7 psi. Gauge pressure is a common form of pressure measurement, this measurement is conducted by taking the pressure value then minus the atmospheric pressure.

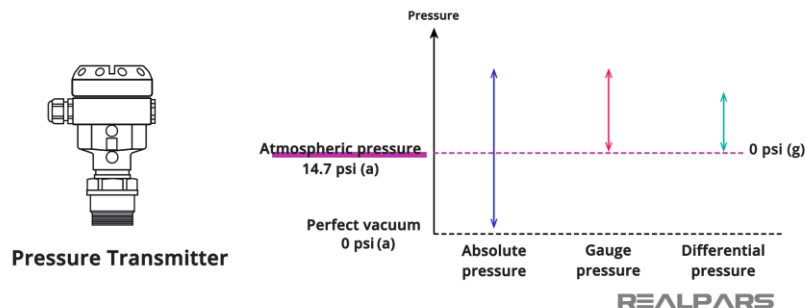


Figure 1.5 – Pressure Types – Graph (Mortenson, 2020)

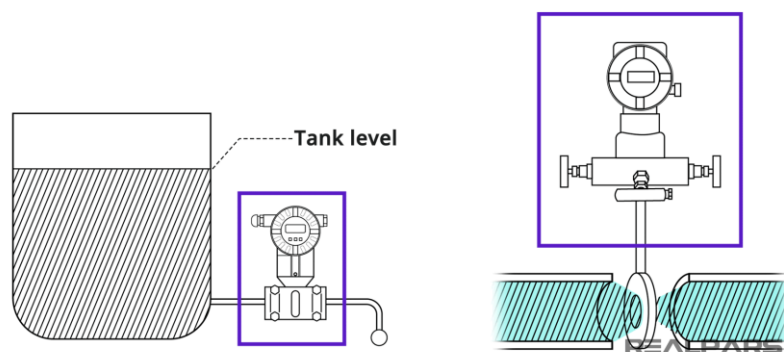


Figure 1.6 – Application of a Pressure Transmitter (Mortenson, 2020)

An example of pressure transmitter being used in a process where there is pressure of gases need to be measured within a pipeline. The pressure transmitter will be calibrated to the requirements of the client for the specific process pressure that are expected within the service for example 0 to 350 psi, this range will be calibrated against the current range of 4 to 20mA, therefore 4mA = 0 psi and 20mA = 350 psi. this is demonstrated within figure 1.7. ✓

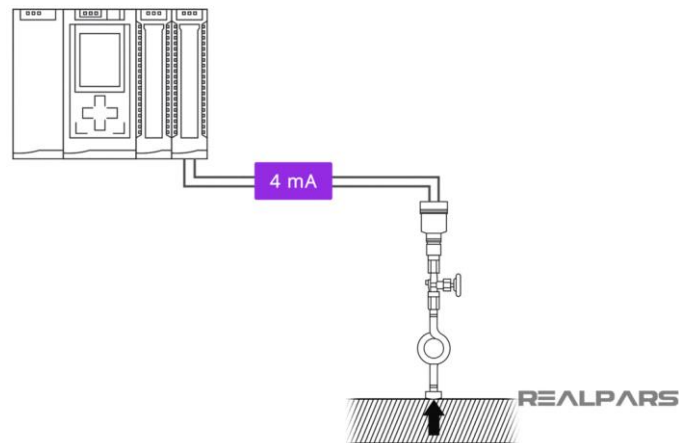


Figure 1.7 – Measuring using a Pressure Transmitter (Mortenson, 2020)

A temperature device that can be connected to the PLC with respect the input circuits is a temperature switch. A temperature switch is a switch or thermal switch that is used to either open or close the contacts in a switch, which is a discrete type I/O device. The status of the switch is dependent upon the input temperature, the purpose of this is to provide protection from overheating or overcooling. These types of switches are used to monitor the temperature of any equipment or machinery that has temperature limitations. There are different types of temperature switches, such as mechanical and electronic switches. The mechanical temperature switches come in various models such as bimetal and gas-actuated temperature switches. An electrical temperature switch is used when high accuracy is required, with electrical switch it allows the user to change the limit values and allows them to set several switch points themselves. Whereas bimetal switch has low accuracy, however they are compact and are inexpensive. Gas-actuated temperature switches are typically used in safety-critical applications.

A bimetal temperature switch obtains the temperature through using a bimetal disc. This disc consists of two metals, that are either arranged in strips or platelets that have different thermal coefficients. Typical metals that are used are zinc and steel or brass and steel. When a rising ambient temperature occurs, and the set point of the switch has been reached, the bimetal disc will reverse its position. When the temperature begins to decline the temperature switch will reset once it reaches its set point to its previous state.

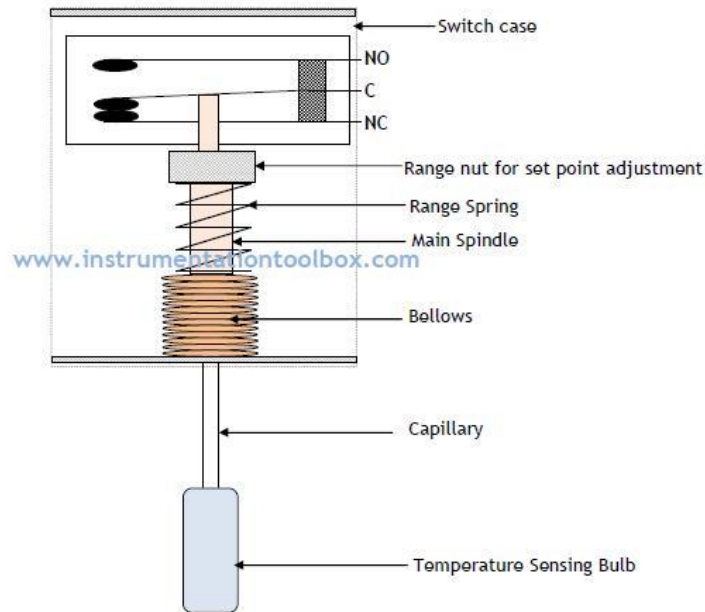


Figure 1.8 – Temperature Switch Diagram (How Temperature Switches Work, n.d.)

A type of analogue temperature device that can be connected to the PLC is a RTD (Resistance Temperature Detector). An RTD is a sensor where the temperature changes the resistance also changes. This works by as there is an increase in temperature, correspondingly there is an increase in resistance. A RTD does not produce an output on its own, to be able to obtain a measurement / reading from the RTD an external electronic device is connected to measure the resistance on the sensor by applying an electrical current through the sensor that then generates a voltage.

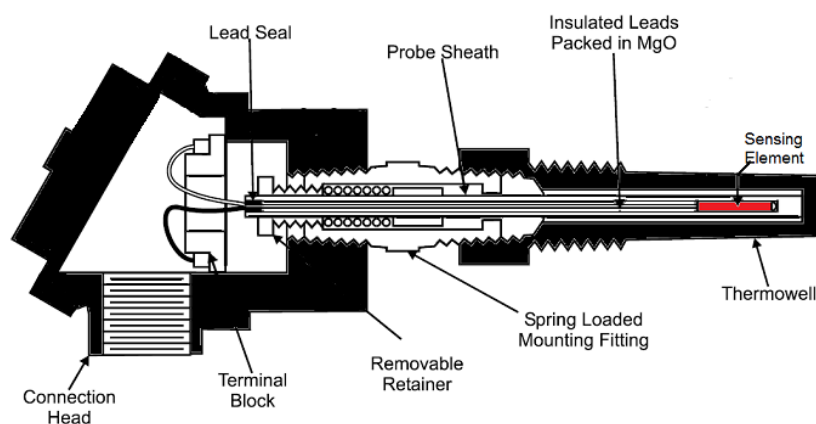


Figure 1.9 – Block Diagram of RTD (Mohanty, 2020)

An RTD can be connected in various configurations with either two, three or four wires. Two wire connections are used in non-critical applications, this is a simple measurement configuration, but is inaccurate due to the resistance of the sensor leads. This is caused by there not being a way to directly compensate for the lead wires of the resistance, which then causes an offset in resistance measurement. A three wire RTD are commonly used and are both accurate and convenient. Three wire sensors are made up of a compensation loop that allows the measurement to be taken through the resistance of the leads. With the three-wire configuration the controller/measurement device takes two measurements, one is of the compensation loop resistance measurement and the other is the total resistance of the sensor including the connecting lead wires. To obtain the overall measurement, this is done by subtracting the compensation loop resistance from the total resistance. A four wire RTD takes measurement of the resistance sensor, without impact from the lead wires, this configuration gives the best accuracy. ✓

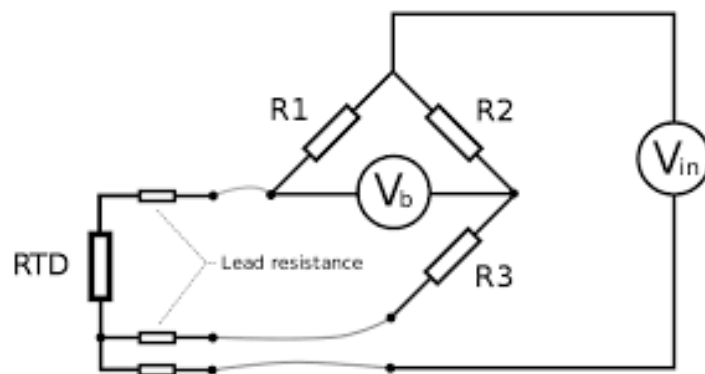


Figure 1.10 – 3 Wire RTD Diagram (Resistance thermometer - Wikipedia, n.d.)

Very well done, showed a good understanding of temperature devices,

- b) A stepper motor is an output device that can be connected to a PLC. Using diagrams example the construction and operation of a stepper motor.

"A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation. Its normal shaft motion consists of discrete angular movements of essentially uniform magnitude when driven from sequentially switched DC power supply."
(Output Devices, 2019) ✓

A stepper motor is broken down into several steps, as many as 200 steps, the motor is sent an individual pulse for each step. Each step of the stepper motor is the same size and can only conduct one step at a time. ✓

The construction of the stepper motor includes a permanent magnet, stator, coil, shaft, flange, rotor, and ball bearings (as illustrated in Figure 1.11).

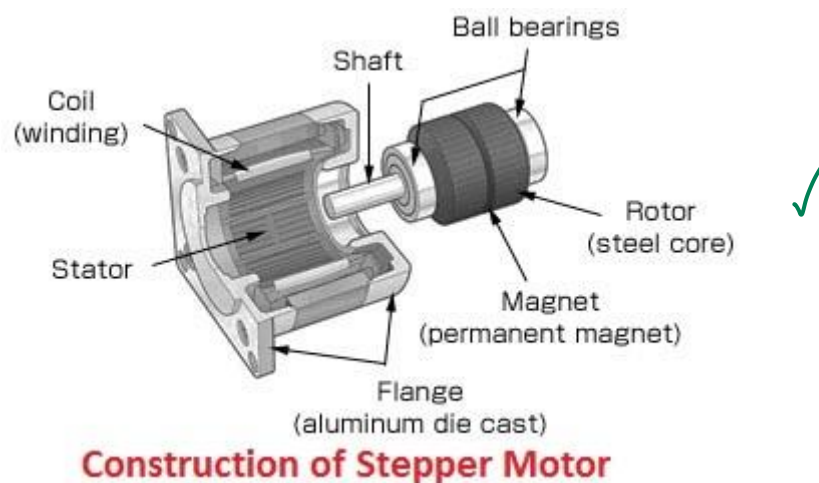


Figure 1.11 – Stepper Motor Diagram (What is a Stepper Motor? Types, Construction, Operation and Applications, n.d.)

There are many applications that include a stepper motor such as 3D printing, textile machines, printing presses, gaming machines, medical imaging machinery, small robotics, CNC milling machines, and welding equipment. ✓

You could discussed other types of stepper motors.

Task 2 – SCADA (Supervisory Control and Data Acquisition)

SCADA systems are now used in multiply engineering industries like Valero where they are an essential part of the refinery's operation.

Produce a report discussing the key features of SCADA systems and how HMI and PLCs are integrated into them and were possible include industrial examples.

Supervisory Control and Data Acquisition (SCADA) is a computer control system that is put in place to monitor and control plant processes. The software uses a graphic user interface, data communications and extended management to be able to monitor and control systems. The operator interface allows the user to monitor and input process commands. For example, controller set points, this can be controlled/adjusted through the SCADA system. ✓

SCADA systems are widely used through various types of industries / sectors that have various types of production backgrounds implement SCADA systems. These industries/sectors include oil and gas, energy, power, manufacturing, and many others. The SCADA system allows the user to communicate between various types of equipment/productions, which allows them to be integrated into the same system, by implementing this system allows for process data to be more effective in maintenance and decision making. SCADA allows the system to monitor and gather information throughout the various stages of production. The SCADA system minimises the occurrence of human error, as it minimises the involvement and amount of people operating the system. Due to industrial sites increase in size many sites implemented SCADA system. Relays and timers were a sufficient but when faults occur, they are extremely difficult to reconfigure. ✓

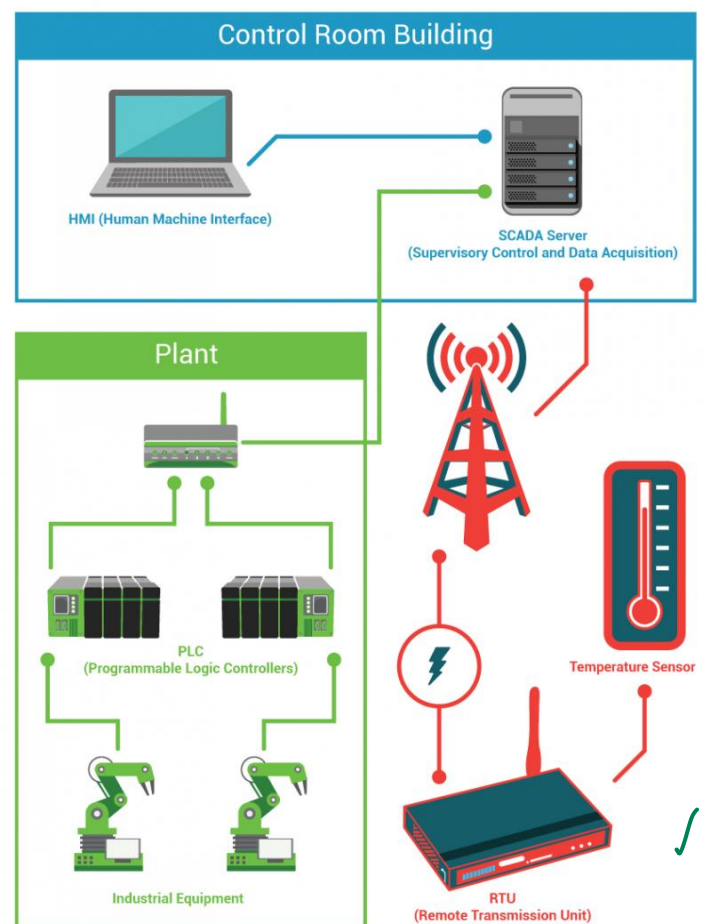


*Figure 2.1 - System Overview
(Telstar Instruments & Control
System Integrators in California,
2019)*

“Modern SCADA systems allow real-time data from the plant floor to be accessed from anywhere in the world. This access to real-time information allows governments, businesses, and individuals to make data-driven decisions about how to improve their processes.” ✓
(Inductive automations).

By applying the data that is communicated through the SCADA system to the PLC allows for efficient communication between the HMC, SCADA and PLC, this allows operations on site to work effectively. The development of the SCADA systems design to significantly improve. HMI and SCADA are a like in operation, but they are different, SCADA stores and records data, whereas the HMI allows the operator to access the system. The PLC is integrated into the system to logical tasks and monitoring tasks in operation such as sensors, which allow outputs to be produced. ✓

“SCADA is most easily understood as the central database that stores and controls your operations at large. This communicates with the PLC, which is how the system functions and communicates within the operational environment.” (Telstrar Instruments). ✓

There are various features of SCADA the following includes a few of these features:

Alarms

A largely used and important element of SCADA is the implementation of alarm handling. The system monitors the conditions that have been pre-set and whether an alarm condition is satisfied, this will then determine if an alarm event has occurred. In the event of an alarm being detected, there are more than one actions that can be taken, for example, when one or more alarm indicators have been activated. In some cases, the operator of the SCADA system may be able to acknowledge the alarm and deactivate the alarm. However, in other circumstances dependant on the set up of the alarm, it may remain active until the alarm conditions have been cleared. ✓

Tags

Tags are used to within SCADA programming. A tag is used to represent a variable within the network device or within the computers memory (RAM). There are internal and external types of tags. An example of an internal tag is the result of a calculation is made by the SCADA script. External tags are information from the PLC or OPC servers. Tags have three

main parameters, these are the tag name, this is used to name the parts within the SCADA system that is used to call the information stored. The tag address, this is the location of the information stored to enable communication links. Lastly, the data type must be defined whether the type of tag used is real, an integer or a Boolean data type. ✓

User Access / Security

Within the SCADA control system, SCADA stores information which users are allowed to access parts of. User authentication validates the user's identity and user authorisation validates whether the users have access rights and privileges that have been defined within the set up. An example of user access is when a user logs onto the SCADA, the security service will firstly validate the user's identity. If authentication is successful, then the security service will then check the permission level the user is assigned to. Dependent on the access level the user maybe able to access all of the software or may just have 'monitor' rights so they can only see certain parts of the software but do not have permission to manipulate the software in any way. ✓

Excellent work, showed a very good understanding of SCADA systems.

Task 3 – Instruction List

Within this task an instruction list will be produced from the ladder logic arrangement that has been provided, as seen in figure 3.1, this will be able to control the operation of the valves. The ladder logic is produced by using the Mitsubishi PLC software, the instruction list method utilises this.

Table 3.1 illustrates the instructional list

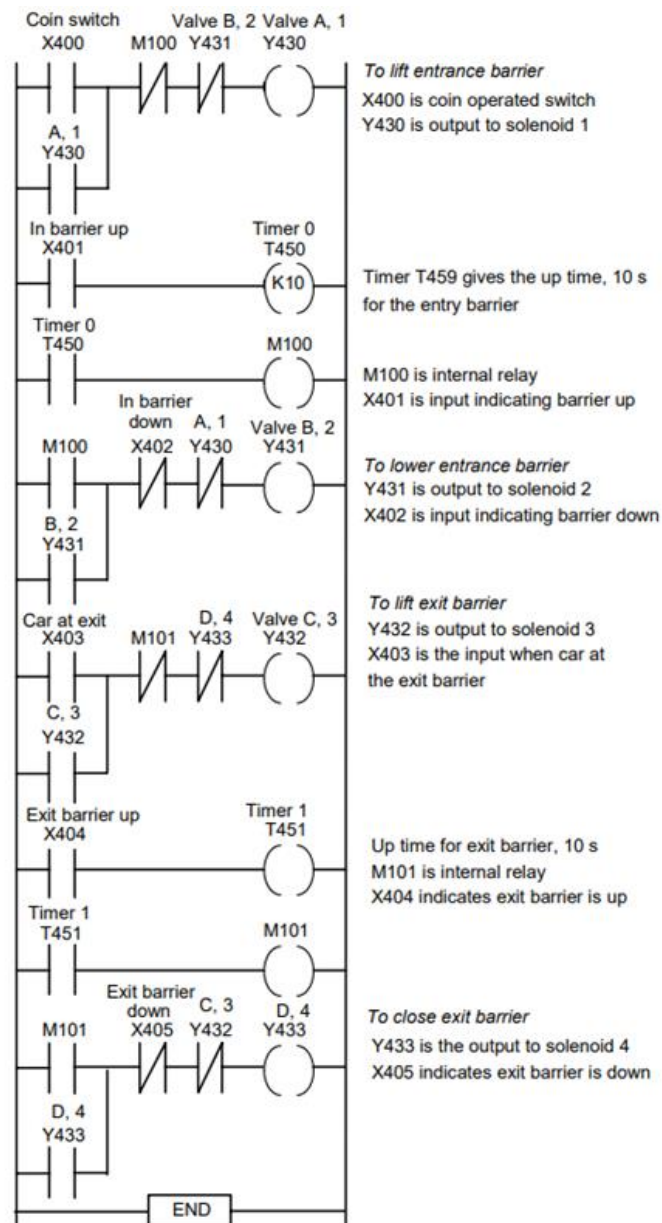


Figure 3.1 – Ladder Logic Arrangement

Row Number	Command	Tag
1	LD OR ANI ANI OUT	X400 Y430 M100 Y431 Y430
2	LD OUT K	X401 T450 10
3	LD OUT	T450 M100
4	LD OR ANI ANI OUT	M100 Y431 X402 Y430 ~~T431~~ 7431
5	LD OR ANI ANI OUT	X403 Y432 M101 Y433 Y432
6	LD OUT	X404 T451
7	LD OUT	T451 M101
8	LD OR ANI ANI OUT	M101 Y433 X405 Y432 Y433
END		

Table 3.1 – Instructional List

You have a couple of mistakes in IL code.

Task 4 – Temperature Alarm Panel

Within this task a temperature alarm system has been produced using Mitsubishi PLC analogue functionality. There was a set criterion of what the design had to simulate, the system gas to be able to monitor temperatures between the range of 0 to 100°C, the system will also indicate using a light the temperature intervals between 0 and 100°C, these temperature intervals are indicated within table 4.1.

Table 1 – Alarm Outputs

Temperature Settings (°C)	Blue light	Green Light	Yellow Light	Red Light	Sounder
0 to 25	On				
26 to 50		On			
51 to 70			On		
71 to 100	On	On	On	On	On

Table 4.1 – Alarm outputs

The lights produce a visual output and gives the user a warning of how high / low the temperature is.

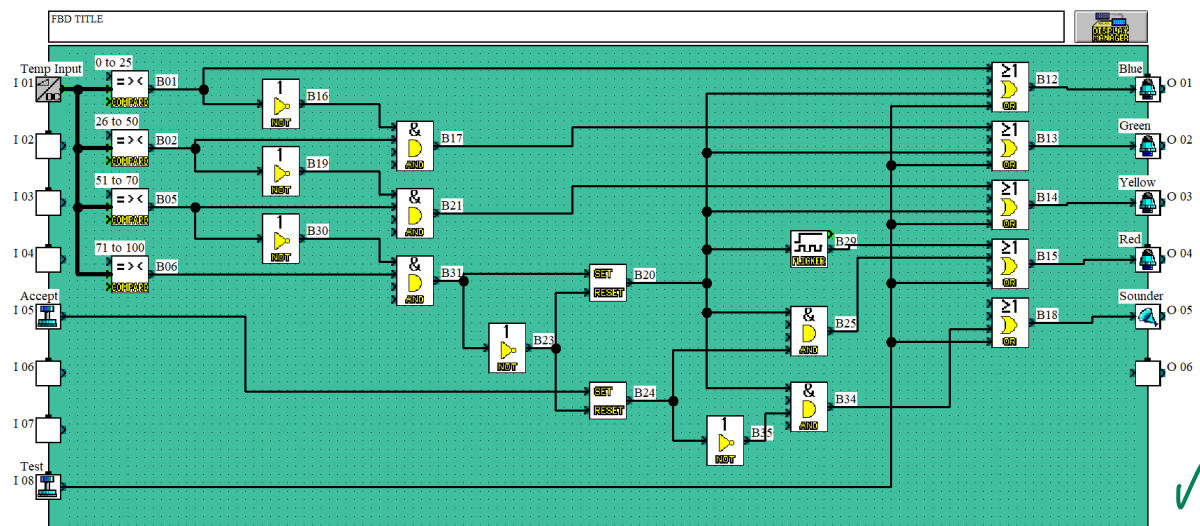


Figure 4.1 – Temperature alarm program

Figure 4.1 illustrates the overall program produced using Mitsubishi PLC software. It is visible that there are various types of logic gates used throughout the program such as NOT, AND, and OR.

Excellent layout.

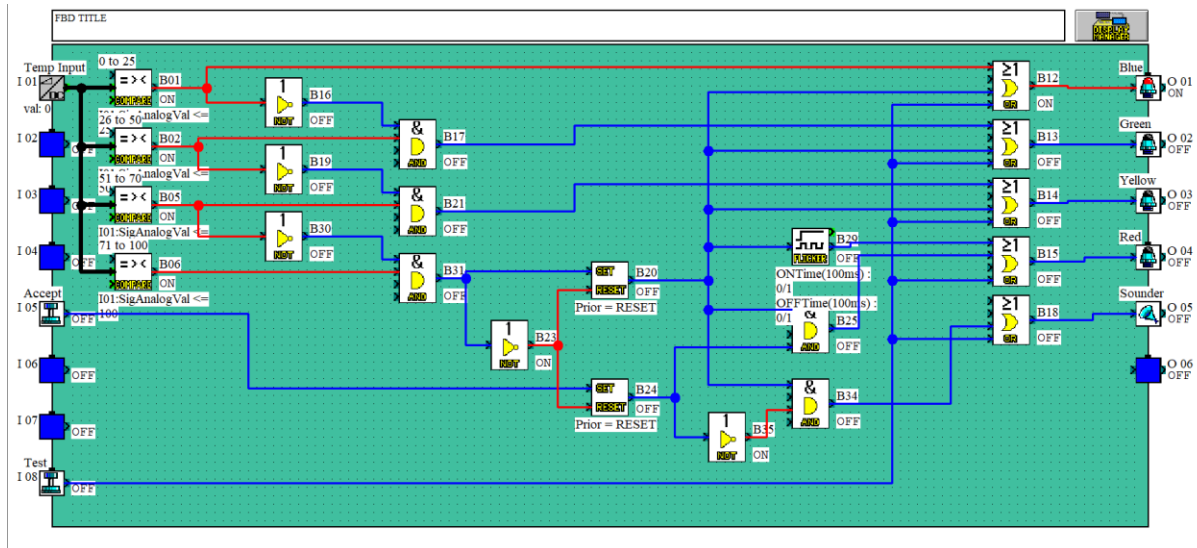


Figure 4.2 – Program where the input = 0°C

The screenshot above in figure 4.2 shows the input to the program is 0°C, this gives an output of a blue light. The blue light will appear when the temperature is between 0°C to 25°C.

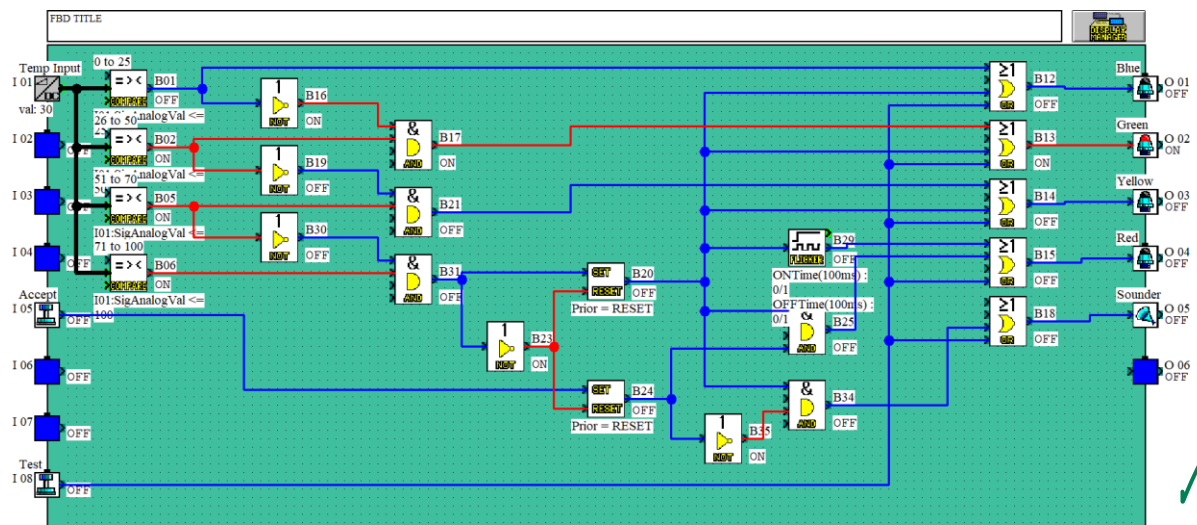


Figure 4.3 – Program where the input = 30°C

Figure 4.3 illustrates when the input to the program is 30°C, this gives an output of a green light. The green light will appear when the temperature is between 26°C to 50°C.

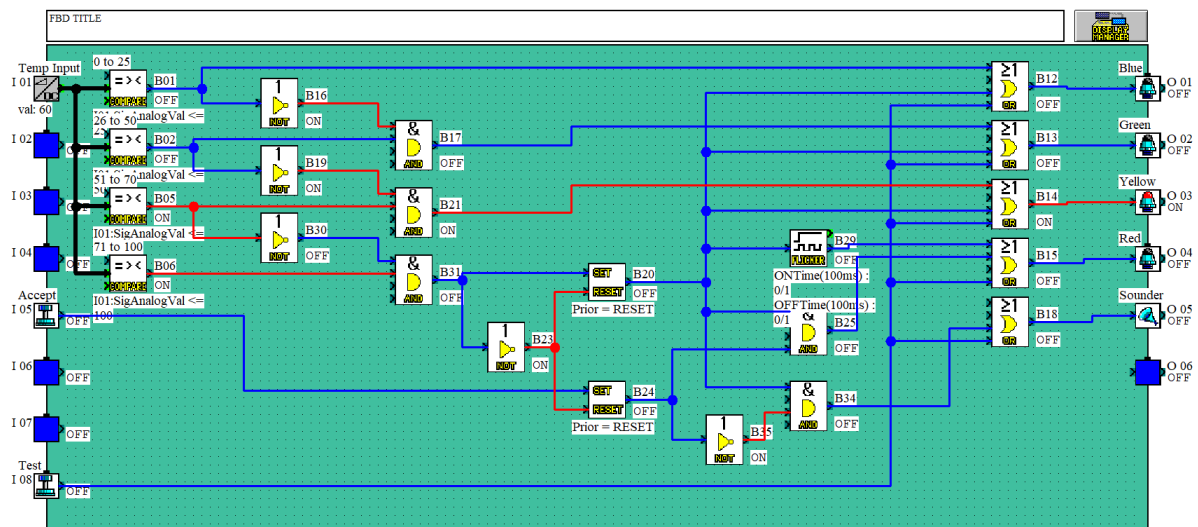
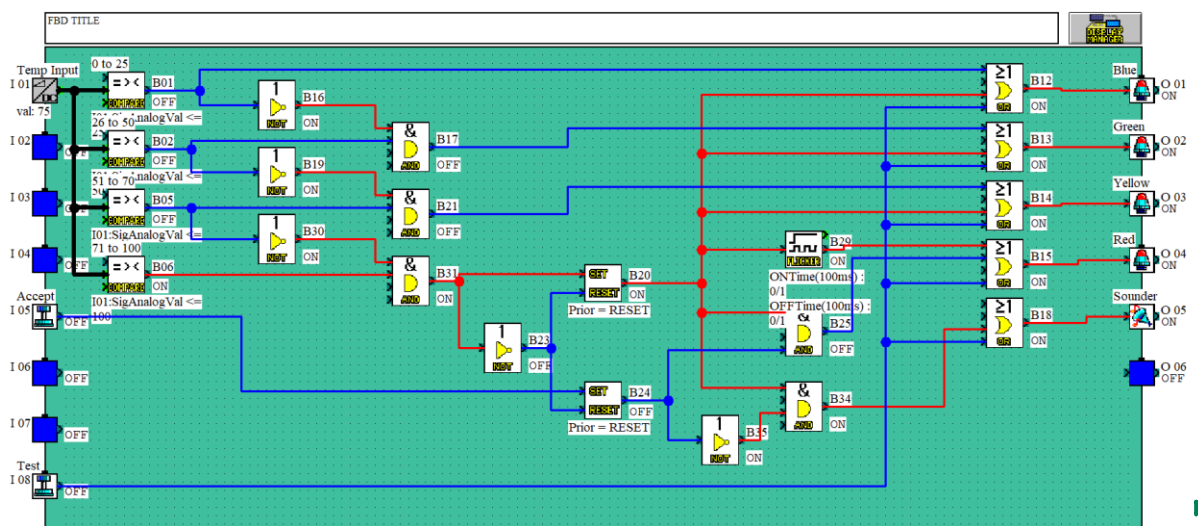


Figure 4.4 – Program where the input = 60°C

Figure 4.4 illustrates when the input to the program is 60°C, this gives an output of a yellow light. The yellow light will appear when the temperature is between 51°C to 70°C.



Program 4.5 – Program where the input = 75°C

Figure 4.5 illustrates when the input to the program is 75°C, this gives an output where all the lights switch on (blue, green, yellow, and red lights), but the red light will flash on and off, as well as sounding the sounder alarm. All the lights and sounder will switch on when the temperature is between 71°C to 100°C.

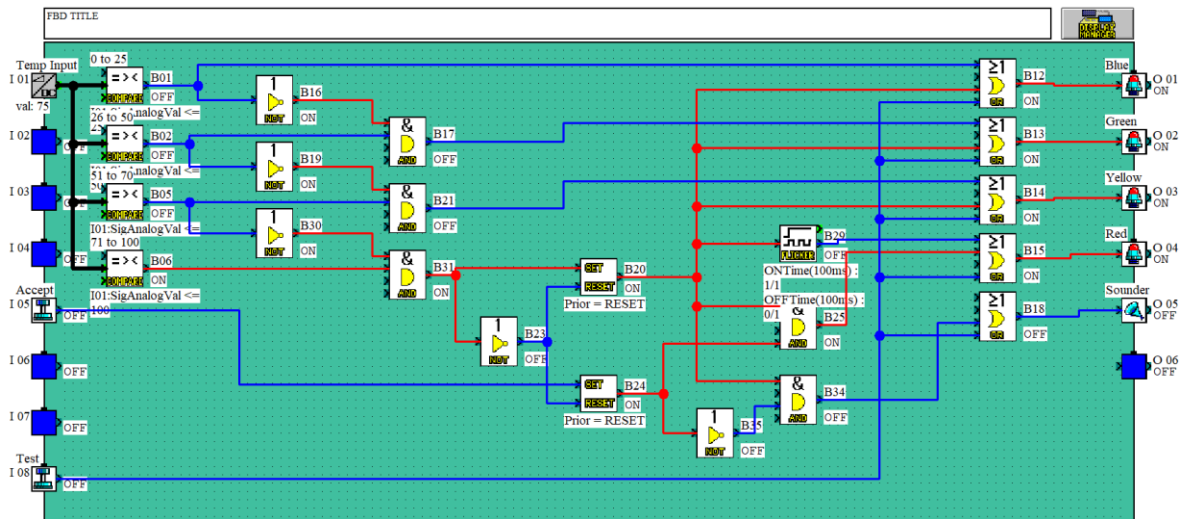


Figure 4.6 – Program where the input is the 'Accept' button

Figure 4.6 illustrates when the input to the program is the 'accept' button, the accept button is used when the sounder alarm goes off and the red light will stop flashing, by pressing the accept button will stop the sounder alarm and the red light will stay on but no longer flash, this is used to ensure that the user has registered that an alarm/warning has sounded.

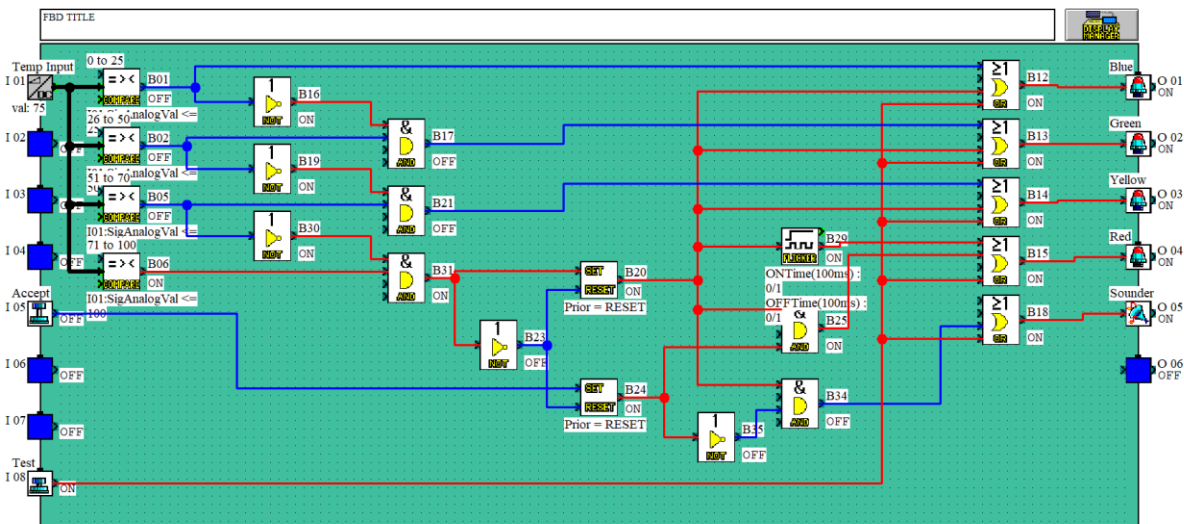


Figure 4.7 – Program where the system is tested

Figure 4.7 illustrates when the input to the program is the 'test' button, by using the test button ensures the users that all the outputs are working as they should, this will include checking that all the lights have come on as well as the sounder.

To complete this task, an HMI (Human Machine Interface) panel had to be created to demonstrate the operation of the program using the Mitsubishi Alpha program through the 'sketch window' of the program to construct the HMI.

Within the HMI panel window allows the user to select the temperature input and manually input a temperature figure to trigger the corresponding output. The HMI panel also allows the user to accept the alarm when the temperature exceeds 71°C. As well as being able to test the system by using the test button provided.

Nice layout

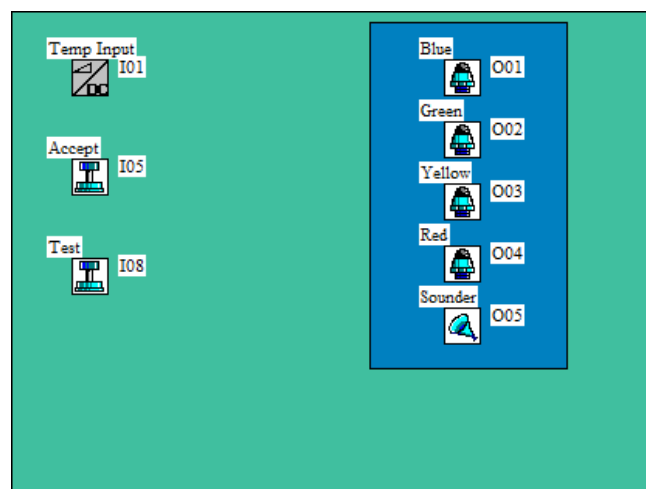


Figure 4.8 – Temperature Alarm Program HMI Panel

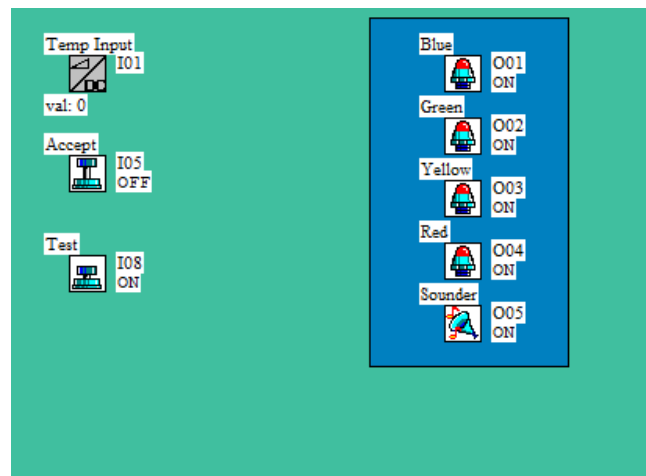


Figure 4.9 – 'Test' Button indicated on HMI Panel

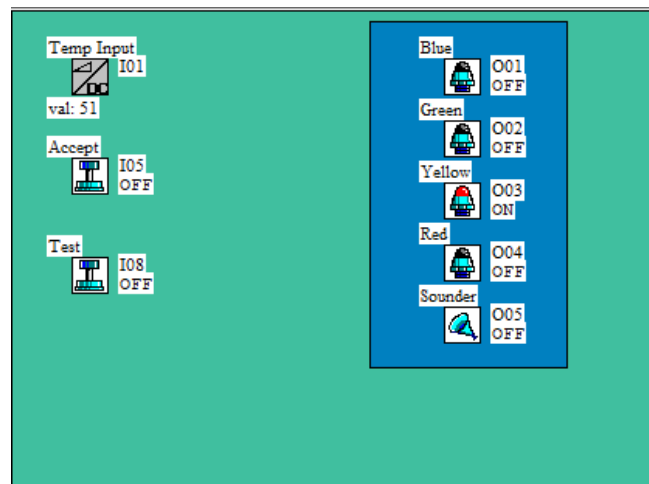


Figure 4.10 - Program where the input = 51°C

The program was fully functional and achieved the required spec.
Well done.

Task 5 – Control Lift System - Programming Problems

Within this task a control lift system on a building site had to be programmed using Mitsubishi FX PLC – Ladder Logic to control the process.

To view the full PLC Ladder Logic program refer to appendix A.

The software tags that were used to build the ladder logic for the control lift system are as follows:

- X001 – Level 1 Call Button
- X002 – Level 1 Sensor
- X003 – Level 2 Call Button
- X004 – Level 2 Sensor
- X005 – Level 3 Call Button
- X006 – Level 3 Sensor
- X007 – Locked Door Sensor
- M1 – Level 1 to 2 Latch up
- M2 – Level 1 to 3 Latch up
- M3 – Level 2 to 1 Latch Down
- M4 – Level 2 to 3 Latch Up
- M5 – Level 3 to 1 Latch Down
- M6 – Level 3 to 2 Latch Down
- M7 – Level 2 Light Latch
- M8 – Level 1 Light Latch
- M9 – Level 3 Light Latch
- M10 – Door Locked Latch
- M11 – Timer Latch
- Y1 – Motor Up Command
- Y2 – Motor Down Command
- Y6 – Solenoid latch for door
- Y7 – Open door indicator light

The following figures are images of the program whilst various elements are being switched on / off.

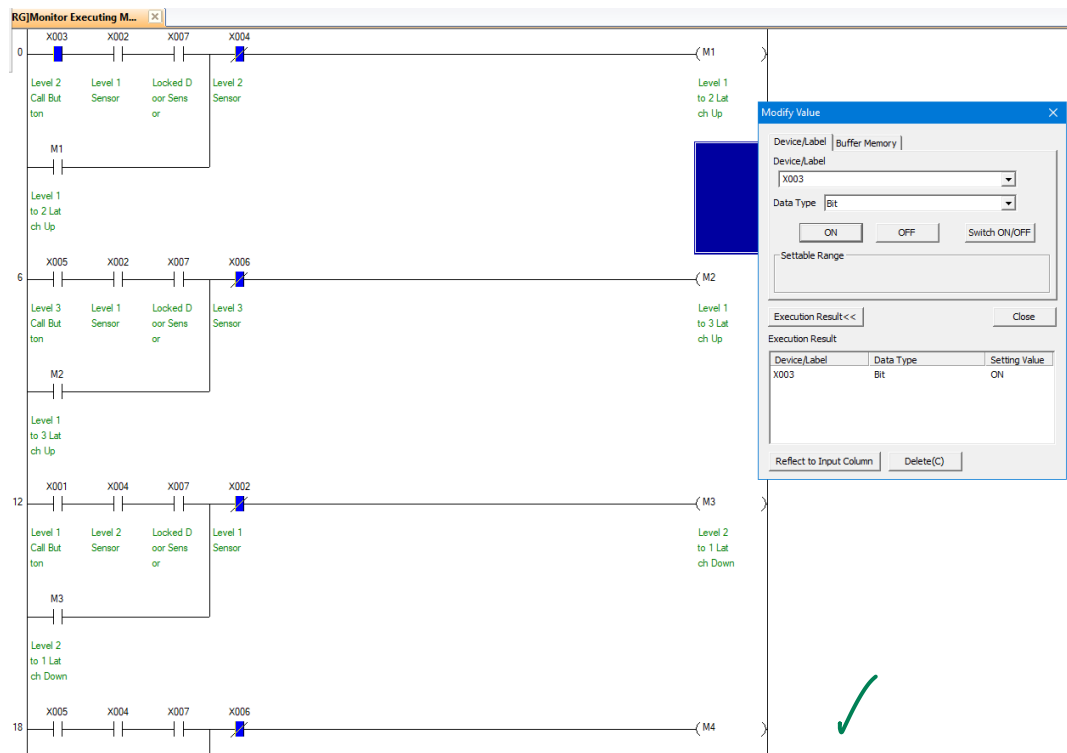


Figure 5.1

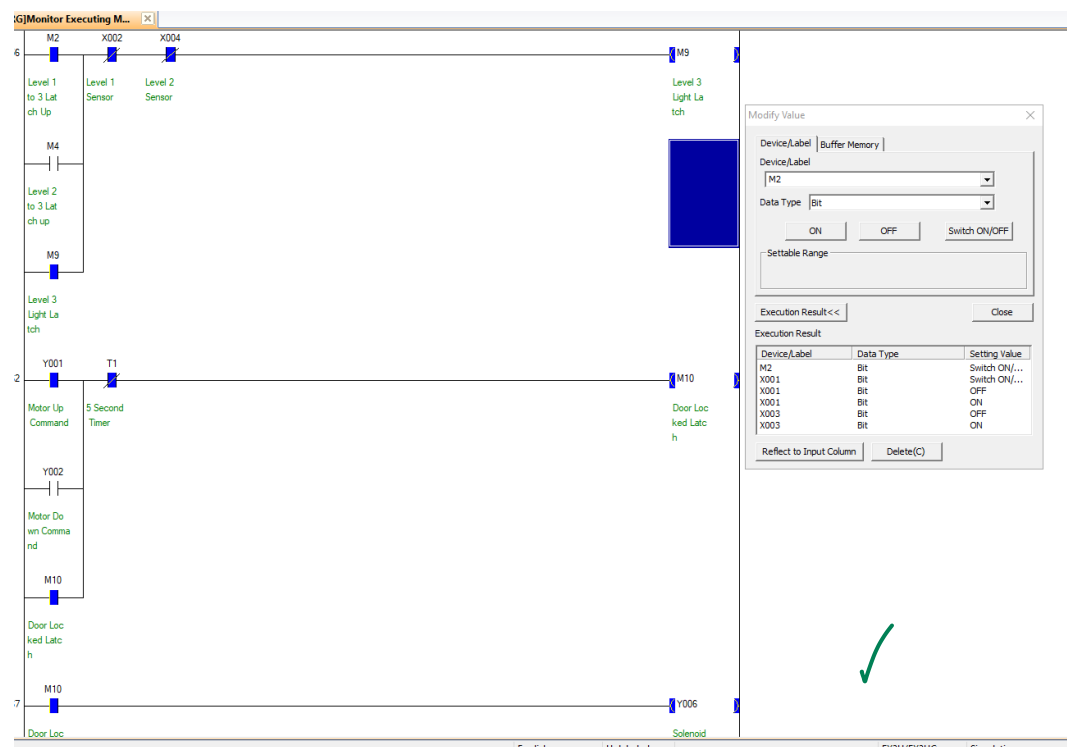


Figure 5.2

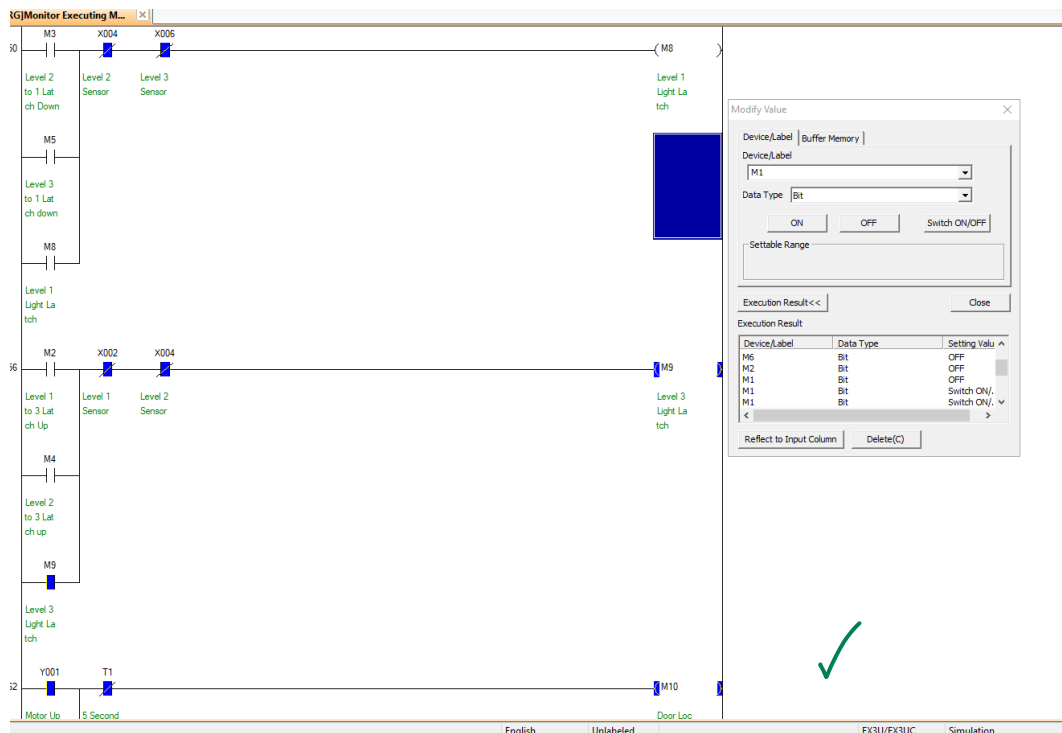


Figure 5.3

Improvements that could improve the program produced could be adding additional features to the system to ensure safety is adding a weighing scale to the lift, this would allow for a maximum load for the lift. As well as a counter for people going in / out of the lift, this would allow maximum capacity allocation to the lift. Another feather that could have been added is a door sensor, so if there is an object or someone in the way of the doors closing then the doors will stay open instead of closing automatically. An additional safety feature that could be added is an alarm and/or a call putting so if the lift gets stuck then the people in the lift can sound the alarm and call for help. ✓

Be careful with sentence structure.

Program achieved full function,

References

Fabacademy.org. 2019. *Output Devices*. [online] Available at: <<https://fabacademy.org/2019/labs/qbic/students/rania-zarandah/Assignment%2012.html#:~:text=A%20stepper%20motor%20is%20a,sequentially%20switched%20DC%20power%20supply>> [Accessed 11 April 2022].

ELECTRICAL TECHNOLOGY. n.d. *What is a Stepper Motor? Types, Construction, Operation and Applications*. [online] Available at: <<https://www.electricaltechnology.org/2016/12/stepper-motor-construction-types-and-modes-of-operation.html>> [Accessed 11 April 2022].

Search, I. and Switches, P., n.d. *Pressure Switch: What Is It? How Does It Work? Types Of*. [online] Iqsdirectory.com. Available at: <<https://www.iqsdirectory.com/articles/pressure-switch.html>> [Accessed 13 May 2022].

Instrumentationtoolbox.com. n.d. *How Temperature Switches Work*. [online] Available at: <<https://www.instrumentationtoolbox.com/2015/11/how-temperature-switches-work.html>> [Accessed 13 May 2022].

Mortenson, T., 2020. *Pressure Transmitter Explained / Working Principle - RealPars*. [online] PLC Programming Courses for Beginners | RealPars. Available at: <<https://realpars.com/pressure-transmitter/#:~:text=A%20Pressure%20Transmitter%20is%20an,range%20sensed%20by%20the%20transducer.>> [Accessed 13 May 2022].

Inductive Automation. *What is SCADA?* [Accessed: 13.May 2022].

Telstar Instruments. *How SCADA, HMI, and PLC working together?* [Accessed: 13 May 2022]

En.wikipedia.org. n.d. *Resistance thermometer - Wikipedia*. [online] Available at: <https://en.wikipedia.org/wiki/Resistance_thermometer> [Accessed 13 May 2022].

Mohanty, P., 2020. *RTD(Resistance Temperature Detector) (Defination,types,formula ,application of RTD,Working principal.)*. [online] Thewisdompoint.com. Available at: <<https://thewisdompoint.com/2020/07/26/rtdresistance-temperature-detector-definationtypesformula-application-of-rtdworking-principal/>> [Accessed 13 May 2022]. ✓

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Bibliography

onupkeep. n.d. *SCADA Systems / What Is a SCADA System?*. [online] Available at: <<https://www.upkeep.com/learning/maintenance-tools/scada-system>> [Accessed 13 May 2022].

Telstarinc.com. 2019. *Telstar Instruments & Control System Integrators in California*. [online] Available at: <<https://www.telstarinc.com/>> [Accessed 13 May 2022].

BM Engineering. n.d. *How Do Pressure Transmitters Work? / What is a Pressure Transmitter?*. [online] Available at: <<https://www.bmengineering.co.uk/how-do-pressure-transmitters-work/#:~:text=A%20pressure%20transmitter%20is%20a,an%20industrial%20or%20automotive%20nature.>> [Accessed 13 May 2022].

Wika.com. n.d. *Pressure transmitter - WIKA*. [online] Available at: <https://www.wika.com/en-gb/lp_pressure_transmitter.WIKA?utm_source=google&utm_medium=cpc&utm_term=pressure%20transmitter&utm_content=AD_Pressuretransmitters&utm_campaign=Pressure&gclid=EAIaIQobChMI5PW8_5Pc9wIVDJBoCR2PzggqEAAYASAAEgJV-_D_BwE> [Accessed 13 May 2022].

Inc, A., 2020. *How Pressure Switches Work • Airtrol Components Inc.*. [online] Airtrol Components Inc. Available at: <<https://airtrolinc.com/how-does-a-pressure-switch-work/#:~:text=A%20pressure%20switch%20is%20a,called%20the%20cut%20out%20point.>> [Accessed 13 May 2022].

Wika.com. 2022. *Temperature switches - Product overview - WIKA*. [online] Available at: <https://www.wika.com/en-gb/temperature_switches.WIKA#:~:text=What%20is%20a%20temperature%20switch,protection%20against%20overheating%20or%20overcooling.> [Accessed 13 May 2022].

TE Connectivity. n.d. *Understanding RTDs*. [online] Available at: <[https://www.te.com/usa-en/industries/sensor-solutions/insights/understanding-rtds.html#:~:text=An%20RTD%20\(Resistance%20Temperature%20Detector,RTD%20is%20a%20passive%20device.](https://www.te.com/usa-en/industries/sensor-solutions/insights/understanding-rtds.html#:~:text=An%20RTD%20(Resistance%20Temperature%20Detector,RTD%20is%20a%20passive%20device.)> [Accessed 13 May 2022].

Electrical Concepts. 2020. *RTD Sensor-Definition, Working Principle, Characteristics and Limitation*. [online] Available at: <<https://electricalbaba.com/rtd-sensor/>> [Accessed 13 May 2022].

Swapna Basu, Ajay Kumar Debnath, in *Power Plant Instrumentation and Control Handbook* (Second Edition), 2019 [Accessed 13 May 2022].

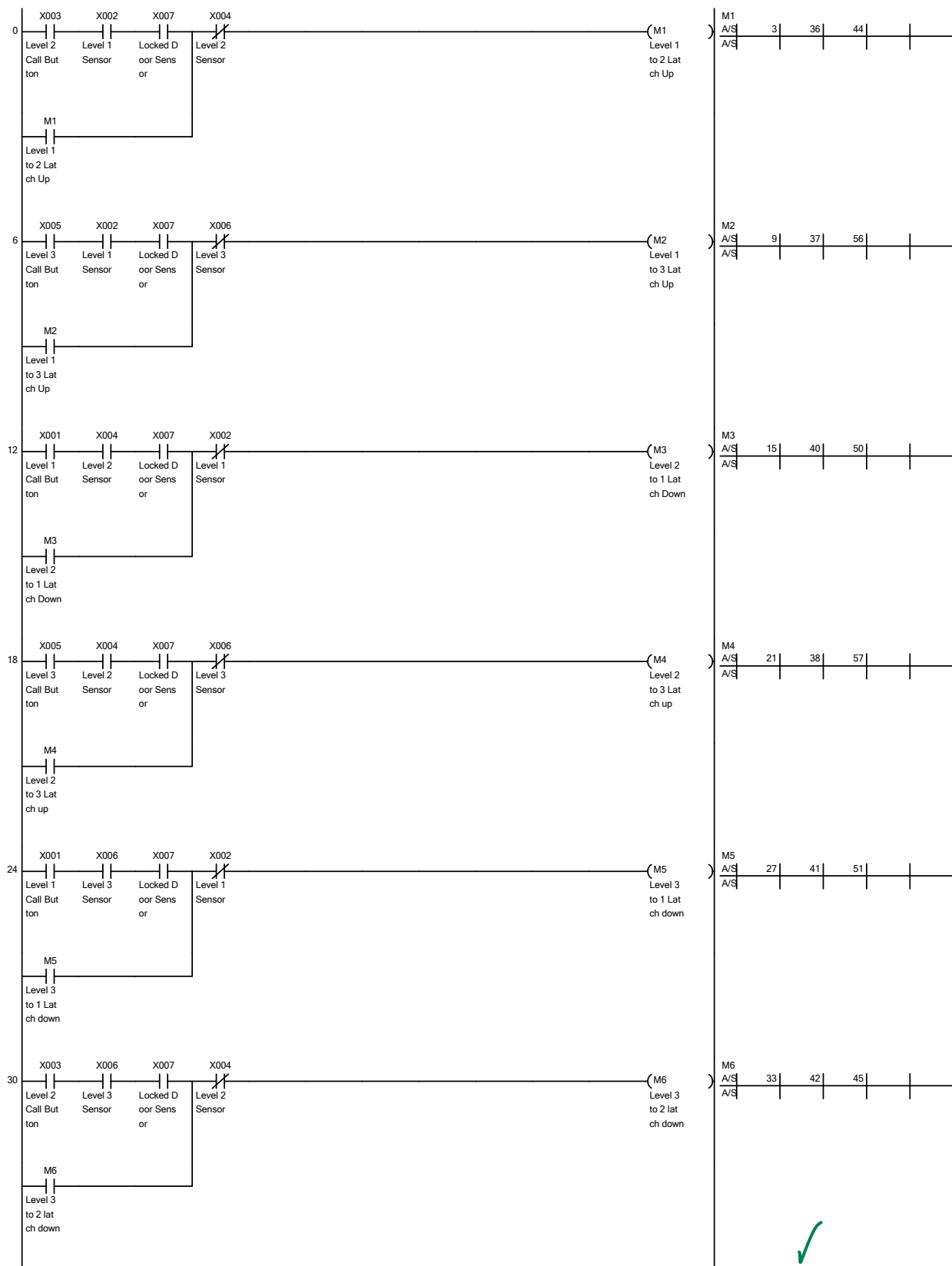
Saeid Mokhtab, ... John Y. Mak, in *Handbook of Natural Gas Transmission and Processing* (Fourth Edition), 2019 [Accessed 13 May 2022].

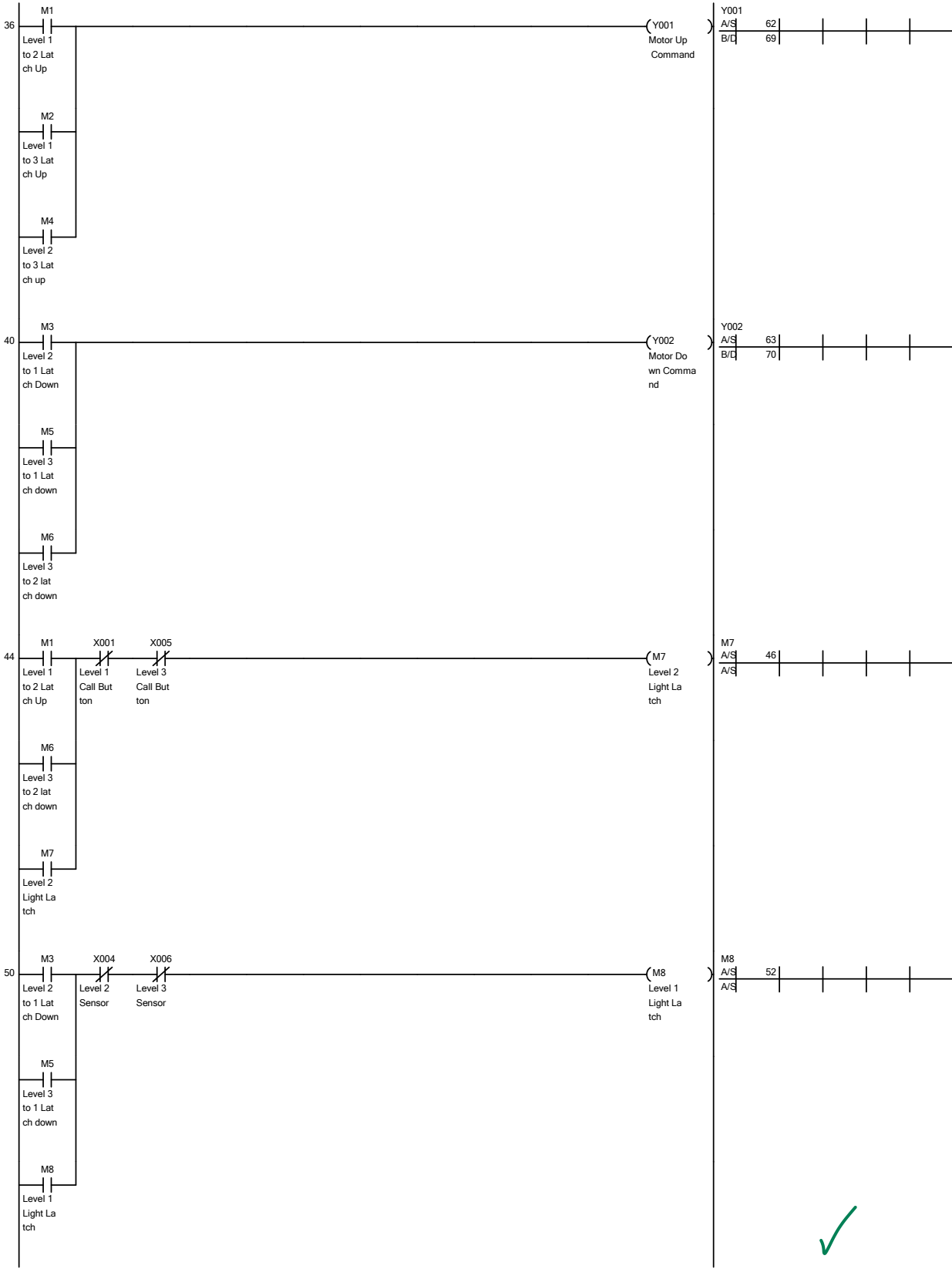
Correge.fr. n.d. *RTD sensor with head - Correge*. [online] Available at: <<http://www.correge.fr/rtd-sensor-head-type.html>> [Accessed 13 May 2022].

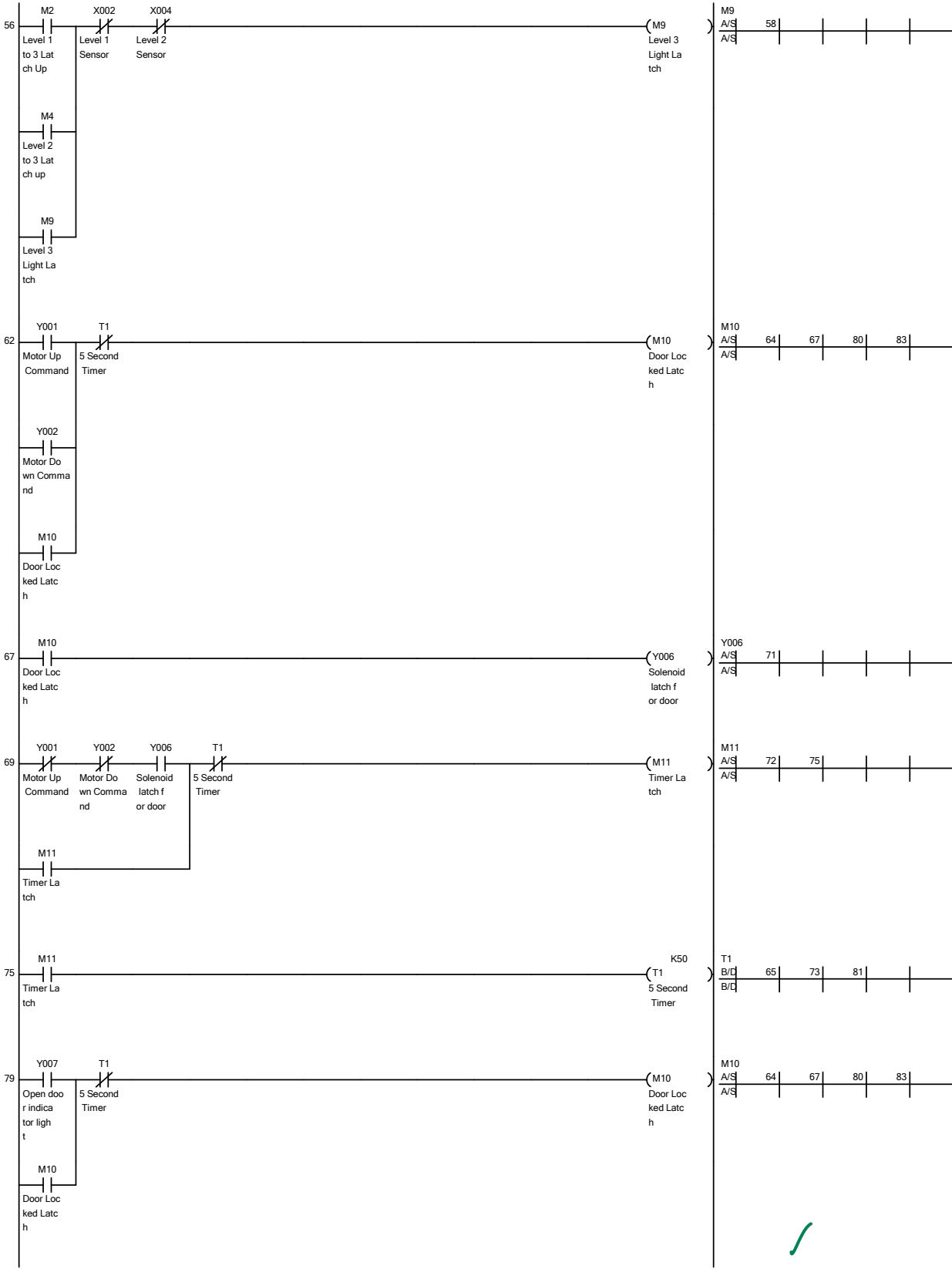


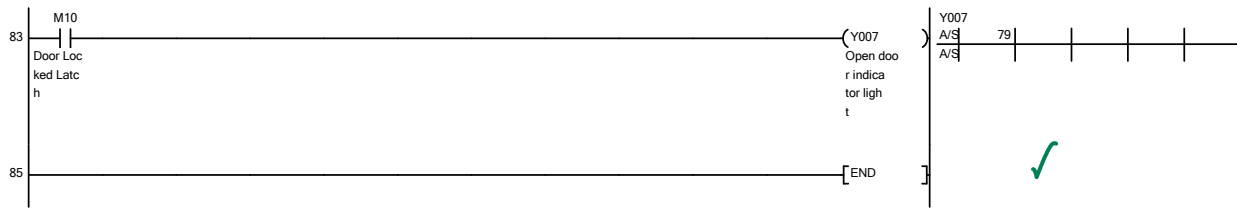
Appendix

Appendix A









Excellent construction of a ladder logic program.
The comments clearly explain the function of
the contacts and coil.
Well done.

Device Comment
Data Name : COMMENT

4/14/2022

Device Name	Comment
M1	Level 1 to 2 Latch Up
M2	Level 1 to 3 Latch Up
M3	Level 2 to 1 Latch Down
M4	Level 2 to 3 Latch up
M5	Level 3 to 1 Latch down
M6	Level 3 to 2 latch down
M7	Level 2 Light Latch
M8	Level 1 Light Latch
M9	Level 3 Light Latch
M10	Door Locked Latch
M11	Timer Latch
X001	Level 1 Call Button
X002	Level 1 Sensor
X003	Level 2 Call Button
X004	Level 2 Sensor
X005	Level 3 Call Button
X006	Level 3 Sensor
X007	Locked Door Sensor
Y001	Motor Up Command
Y002	Motor Down Command
Y006	Solenoid latch for door
Y007	Open door indicator light
T1	5 Second Timer