

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	James Stevens	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

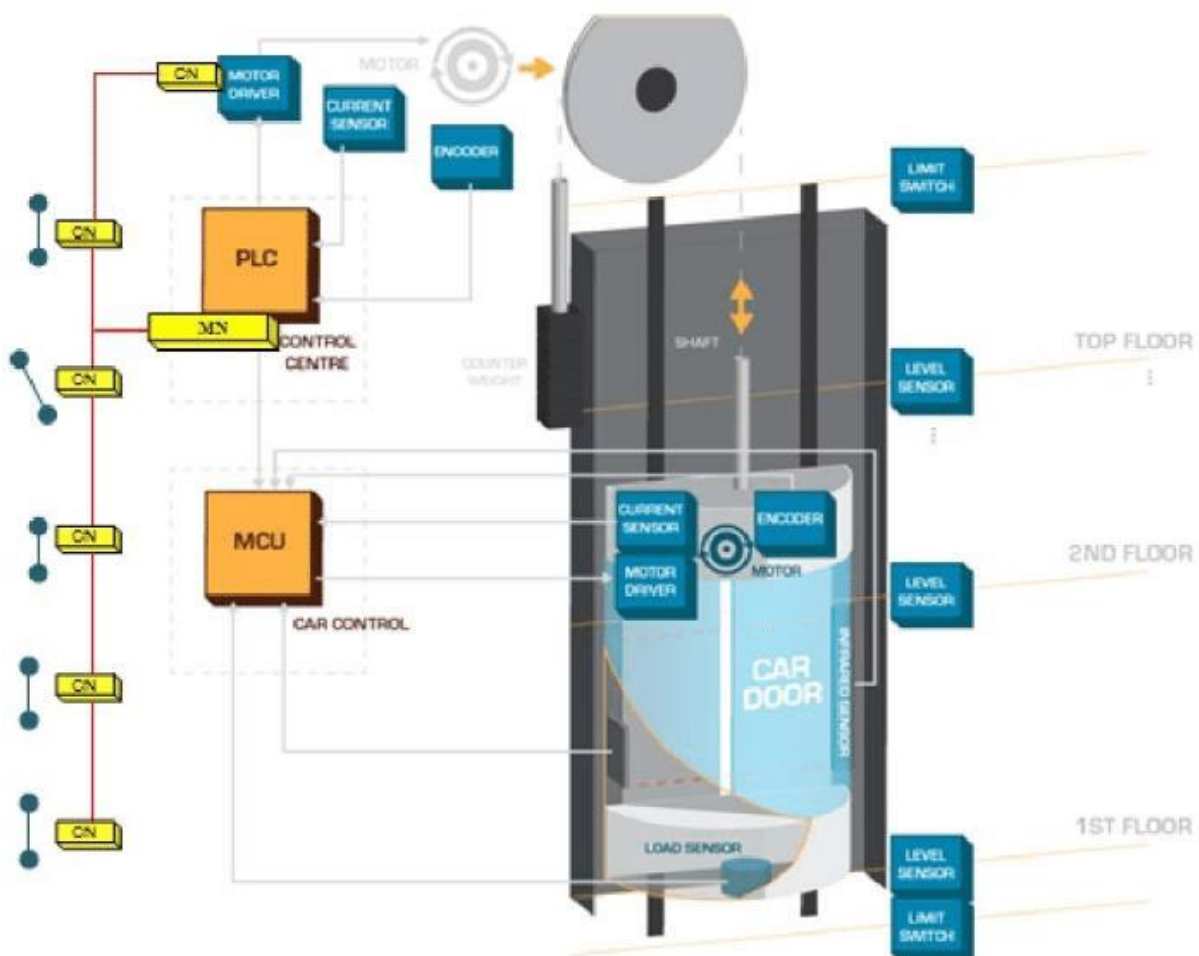
This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which 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	10.2
Engagement with a wide range of literature, including sources retrieved independently.		
2. Knowledge and Understanding Skills	30	20.3
Task 1 achieved 68%. Task 2 achieved 67% Task 3 achieved 68% Competent knowledge of the basic underlying concepts and principles for Task 1 and 2, could prove more detail in explanation of the operation of some of the input devices.		
3. Cognitive and Intellectual Skills	10	6
Sound evaluation of the underlying concepts and principles applied to the construction of the programs for Task 4 and 5, made a very good effort in discussing the construction of the programs.		
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	7.5
Work is coherent, very fluent and is presented professionally. Excellent layout making the assignment easy to read.		

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)		74%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

HNC Electrical and Electronic Engineering

PCEE 4005 Programmable Logic Controllers



Assessment 2

James Stevens

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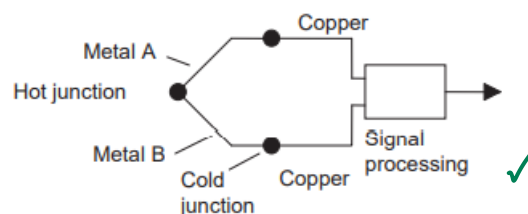
Appendix

Cover Image courtesy of Genon-Catalot. D (2015) Lift Control System [Online] available at https://www.researchgate.net/figure/Modified-safety-chain-in-lift-control-system_fig2_308499036 {Viewed on 10 May 2022}

Task 1 - Analogue and Discrete Inputs/Outputs

a) Temperature

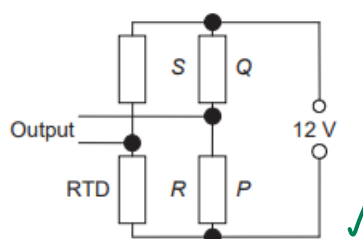
The thermocouple is a common method by which electrical signals suitable for detection by the input devices of a PLC can be produced. These devices rely on the principle that two dissimilar conductors (metals) when joined together create a potential difference at the junction (referred to as the hot junction) when exposed to varying ambient temperatures of the medium to which they are exposed. This potential difference, when suitably processed, can be interpreted as a temperature by the PLC. Common metals used in the construction of a thermocouple include copper, iron, platinum, and tungsten (Morris 2001, p272).



Reference quotes need to be in quotation marks.

Image depicting thermocouple construction principles (Bolton 2015, p36)

The resistive temperature device (RTD) is another commonly used temperature sensing device. This uses the physical principal that metallic conductors' resistance changes with varying temperatures. When arranged within a Wheatstone bridge, the difference of the RTD and resistor S should be balanced so as to equal that of the difference of resistors Q and P (Bolton 2015, p34). Any variation in the resistance of RTD caused by changes in ambient temperature will then cause an imbalance in the circuit, thus producing a signal to the bridge output. Common metals used in RTDs include platinum, copper, nickel and tungsten (Morris 2001, p284).



Need to explain the operation of a RTD in more detail.

Common arrangement of RTD within Wheatstone bridge (Bolton 2015, p34)

a) Pressure

Pressure sensors operate within two main categories. They are said either to be measuring gauge pressure in which case they are making a measurement relative to atmospheric pressure, or

alternatively they are said to be measuring absolute pressure which is conducted in reference to a vacuum (Morris 2001, p304). ✓

A strain gauge affixed to a diaphragm is a popular method of measuring changes in pressure. A strain gauge is a metallic strip affixed to a backing strip. As the backing strip deforms, which is attached to the diaphragm, this has the effect of changing the resistance of the metallic strip (Bolton 2015, p39). 4 strain gauges are often used in a Wheatstone bridge arrangement on the diaphragm, the function of which can be used to derive the relative pressure change (Morris 2001, p305). ✓

4 strain gauges, 2 for radial strain, 2 for circumferential strain



Image depicting typical diaphragm and strain gauge arrangement (Bolton 2015, p39)

Strain gauges produce a low output and so require the application of an amplifier, thus increasing the complexity and cost of the sensor. Alternatively, a diaphragm might also be used in conjunction with a piezo-electric crystal. The crystal, when pressure is applied, produces a more significant potential difference (Bolton 2015, p40). This requires no amplification and can be processed directly by a PLC. ✓

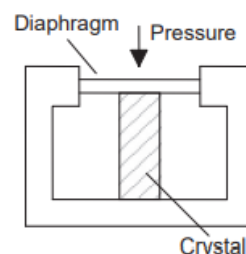


Image depicting typical diaphragm and piezo electric crystal (Bolton 2015, p40)

b) Stepper Motors

Stepper motors are devices that provide a predetermined and fixed rotational motion. They can be set to any increment, with each increment being referred to as a step. The number of steps to be progressed are set by the number of electrical pulses received by the motor.

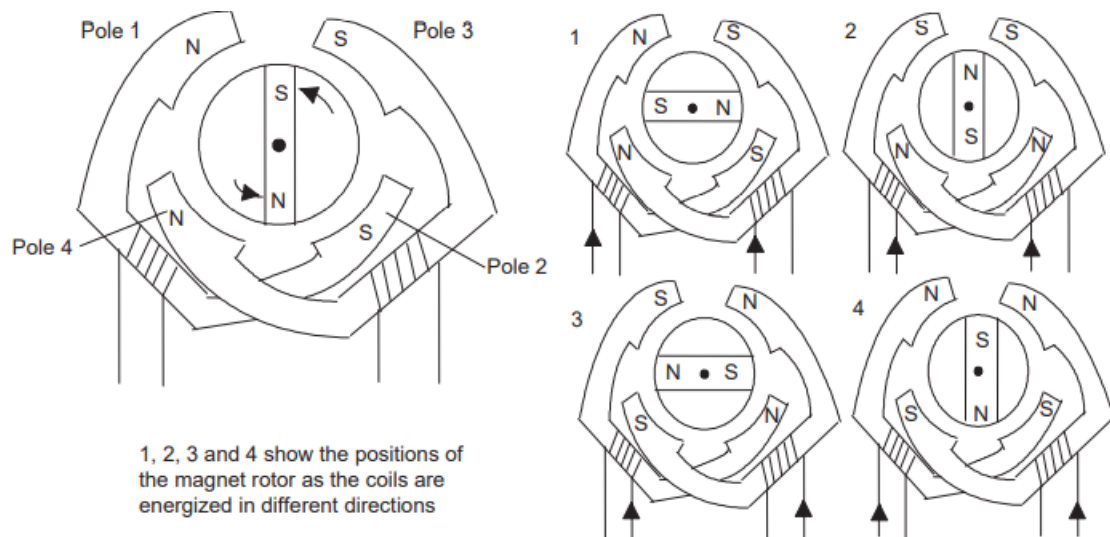


Image depicting a stepper motor with permanent magnets (Bolton 2015, p50)

The above image depicts how a 2 paired pole permanent magnet set can be used to achieve a simple stepper motor. Each pulse through the field windings around the permanent magnets will cause the activation of the poles. If pulsed in turn, the creation of a magnetic field will cause the stator to rotate exactly 90° . A further pulse will cause the further movement of the stator another 90° .

Such a device has many industrial applications, including “computer printers, robots, machines tools, and a wide range of instruments” (Bolton 2015, p49). In addition, stepper motors are used extensively in the automotive industry, not least when joined to a vacuum pump to create a method of control for variable vane turbochargers. ✓

Good.

Task 2 – Supervisory Control and Data Acquisition

Supervisory control and data acquisition (SCADA) is a form of system architecture that allows for the monitoring and control of large, complex industrial process systems which are often comprised of many discrete and sometimes remote sub systems. SCADA utilises a centralised computer system to coordinate the operation and function of separate sub systems to achieve the wider goal of the system. Often several human machine interfaces (HMI) controlling discrete operations will be networked together, with the information transmitted by these devices being coordinated and interpreted by a supervisory level computer. ✓

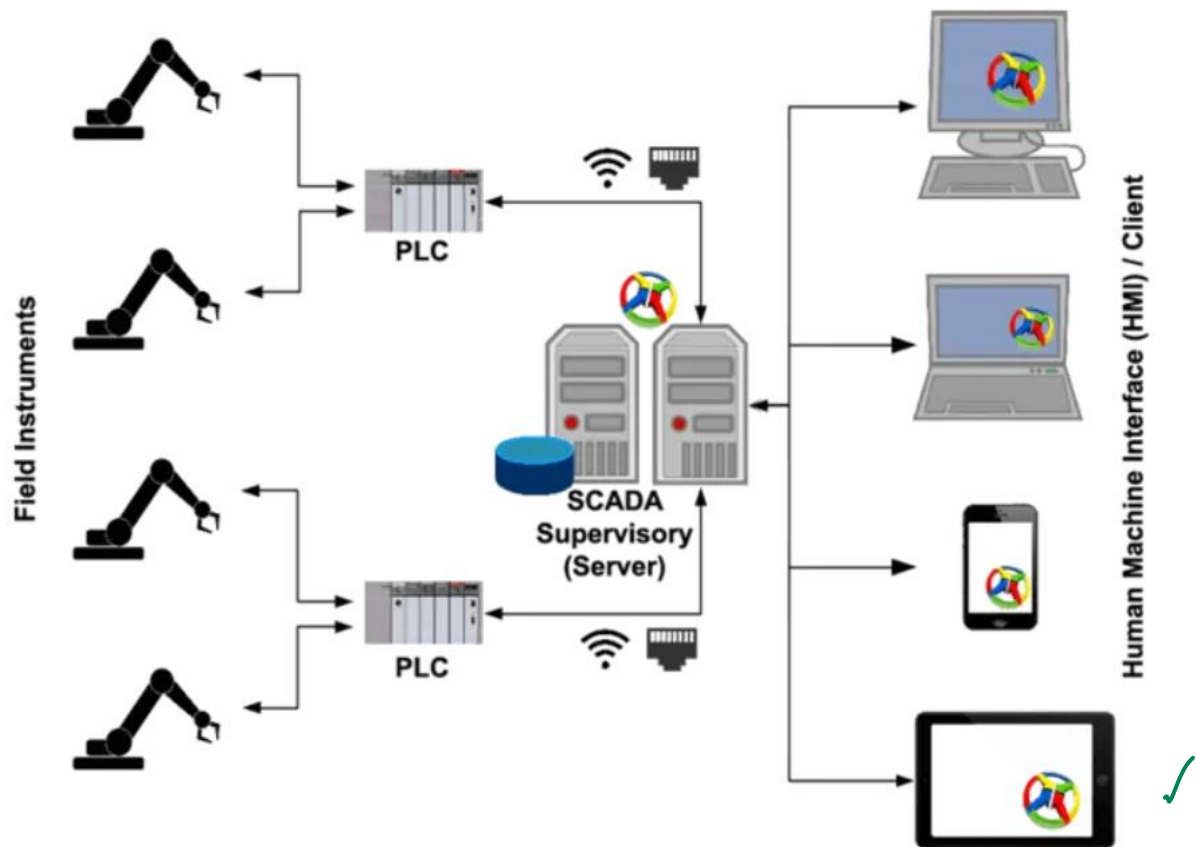


Illustration of typical SCADA controlled automated system (Muthukrishnan (2021) [Online] viewed on 10 May 2022)

The above diagram provides a depiction of a typical industrial process organised to operate under a SCADA system. At the base level, the 'field instruments' conduct the desired task (in this case, it appears to be the manipulation of physical objects). At the next level, the PLCs are used to control the operation of the field instruments. These will contain a simple program to perform the desired task. The PLCs will also transmit the progress and activities of the field instruments to the SCADA server. The PLC will also be capable of receiving instructions in return from the SCADA server, and modify its activities in accordance with its instructions. The SCADA system has also been connected to a variety of HMIs that allow for the monitoring and amendment of the system's activity. ✓

Task 3 – Instructional List

Task 3 requires the design of a programme for the operation of a car barrier system using instructional lists. The following table contains the instructional list as required:

Rung 1	LD	X400	(*Load coin operated switch*)
	OR	Y430	(*OR output to solenoid 1*)

	ANI	M100	(*NOR memory coil to lower entrance barrier*)	
	ANI	Y431	(*NOR output to solenoid 2*)	
	OUT	Y430	(*Output to solenoid 1*)	✓
Rung 2	LD	X401	(*Load entrance barrier up*)	
	OUT	T450	(*Output Timer No.0 for 10 seconds*)	✗
Rung 3	LD	T450	(*Load Timer No.0 at end of count*)	✗
	OUT	M100	(*Output memory coil to lower entrance barrier*)	
Rung 4	LD	M100	(*Load memory coil to lower entrance barrier*)	
	OR	Y431	(*OR output to solenoid 2*)	
	ANI	X402	(*NOR input indicating entrance barrier down*)	
	ANI	Y430	(*NOR output to solenoid 1*)	✓
	OUT	Y431	(*Output to solenoid 2*)	
Rung 5	LD	X403	(*Load input when car at exit barrier*)	
	OR	Y432	(*OR output to solenoid 3*)	
	ANI	M101	(*NOR memory coil to close exit barrier*)	
	ANI	Y433	(*NOR output to solenoid 4*)	✓
	OUT	Y432	(*Output to solenoid 3*)	
Rung 6	LD	X404	(*Load indicator for exit barrier up*)	
	OUT	T451	(*Output Timer No.1 for 10 seconds*)	✗
Rung 7	LD	T451	(*Load Timer No.1 at end of count*)	
	OUT	M101	(*Output memory coil to close exit barrier*)	
Rung 8	LD	M101	(*Load memory coil to close exit barrier*)	✓
	OR	Y433	(*OR output to solenoid 4*)	
	ANI	X405	(*NOR input to indicate car at exit barrier*)	
	ANI	Y432	(*NOR output to solenoid 3*)	
	OUT	Y433	(*Output to solenoid 4*)	✓

You have not included the time values in the IL code.
ie. k 10.

Task 4 – Temperature Alarm Panel

Task 4 describes the need to design a temperature alarm panel using the Mitsubishi Alpha software program which must be capable of producing visible and audible warnings at set temperature increments. The system must be capable of processing analogue inputs from temperature-sensitive sensors, and must trigger alarm responses of coloured LEDs and audible alarms when the temperature range changes from 0°C to 25°C, 26°C to 50°C, 51°C to 70°C, and 71°C to 100°C. The visual and audible alarms should activate according the requirements of Table 1 below:

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

The following image depicts the static program as designed using the Mitsubishi Alpha Software:

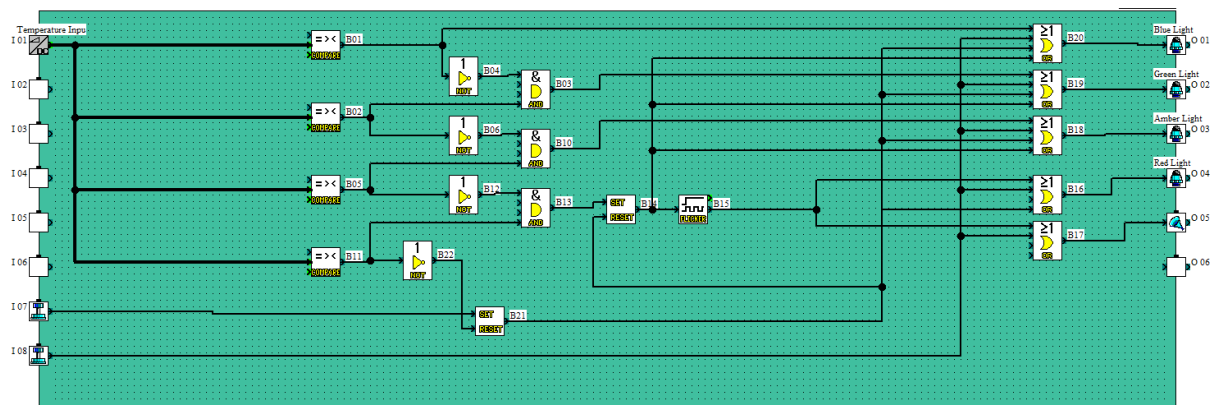


Image depicting static program for temperature control panel

Well designed program.

As can be seen in the above image, the signal produced by the temperature input device is transmitted to four separate differentiators. These differentiators separate out the stipulated temperature ranges. The signal is then passed from one of the differentiators through to the appropriate output device (either light and/or audible signal) via a series of NOT gates, AND gates and OR gates. In the case of the signal from the 71°C to 100°C differentiator, the signal passes through an additional latch function which, in turn, maintains a flicker function to allow for the pulsing of the light and audible alarm. A press-button input switch has been added to reset the first latch, and also sets an additional latch to cancel the visual alarms. Finally, a press button input switch has been connected directly to all of the output devices as a method for testing their functionality.

As an example of the functioning of an OR gate in this program, the Blue Light output will operate under the following conditions:

- Direct input from the 0°C to 25°C differentiator

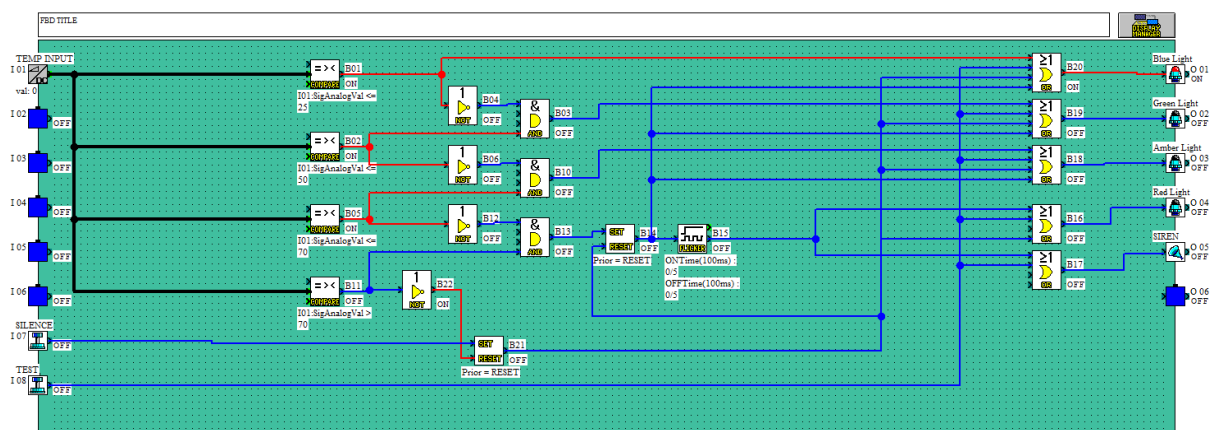


Image depicting the active circuit with a temperature input of 0°C

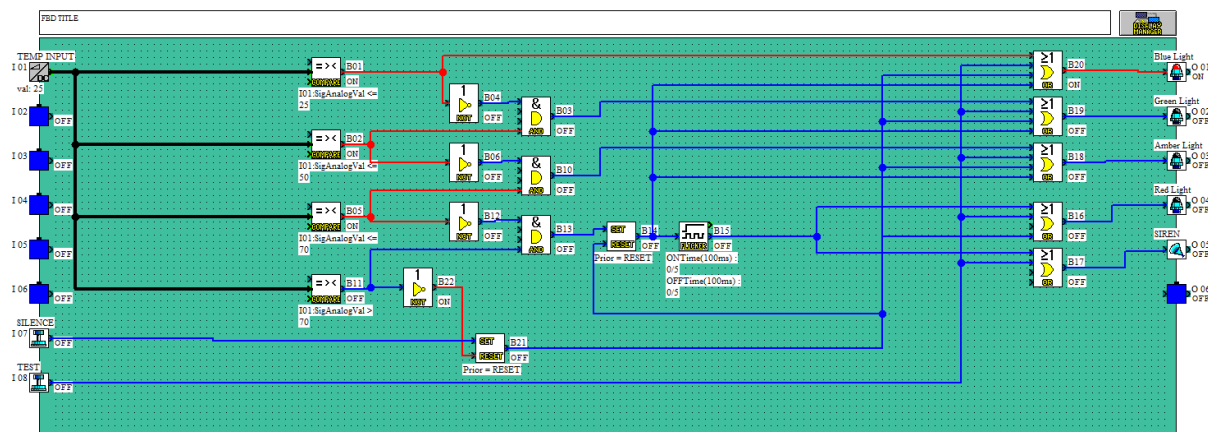


Image depicting the active circuit with a temperature input of 25°C

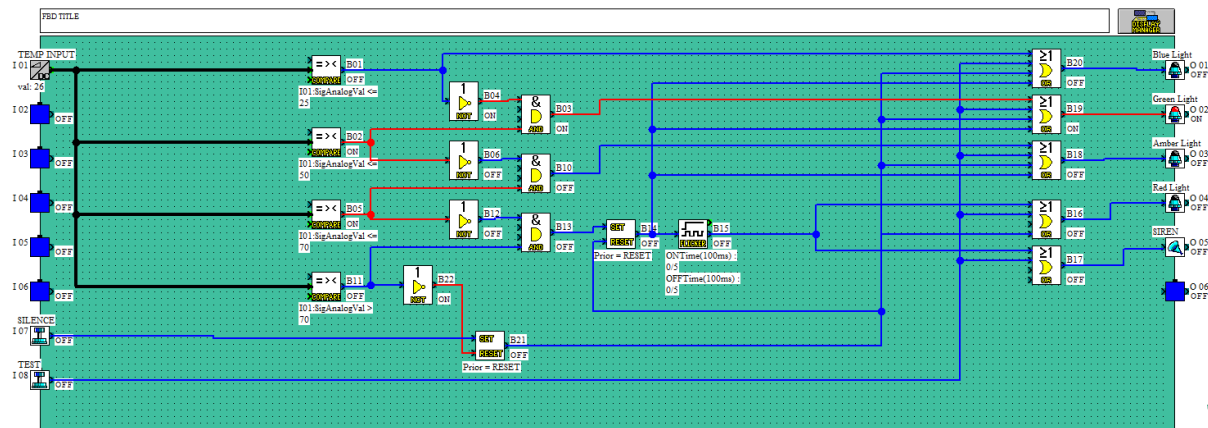


Image depicting the active circuit with a temperature input of 26°C

- Direct input from the “Alarm Test” press button switch

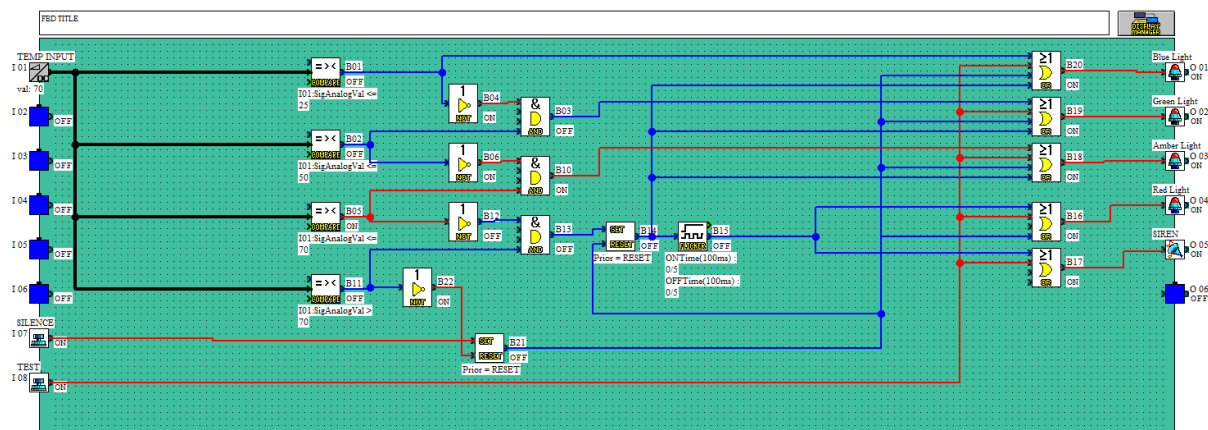


Image depicting the active circuit with the “Alarm Test” press button active

- Direct input from the latch controlling the flicker function

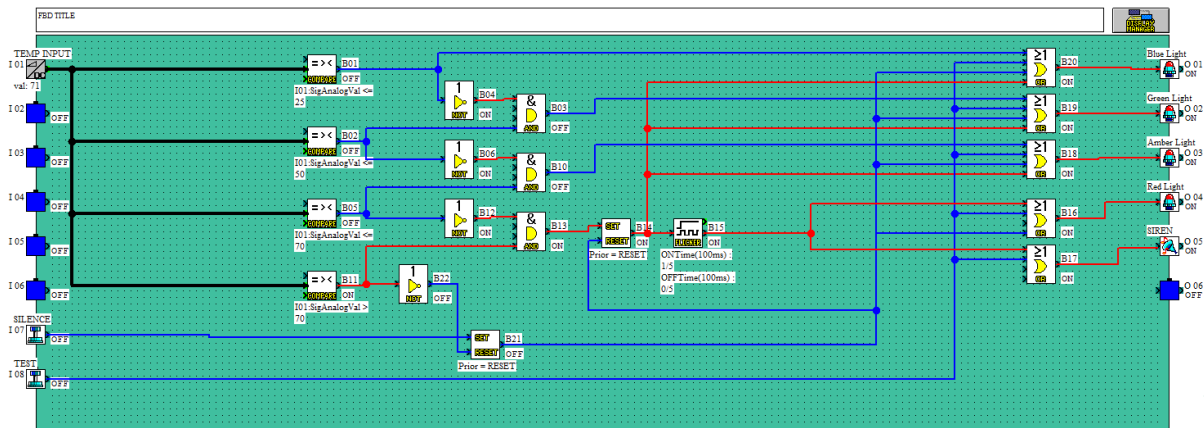


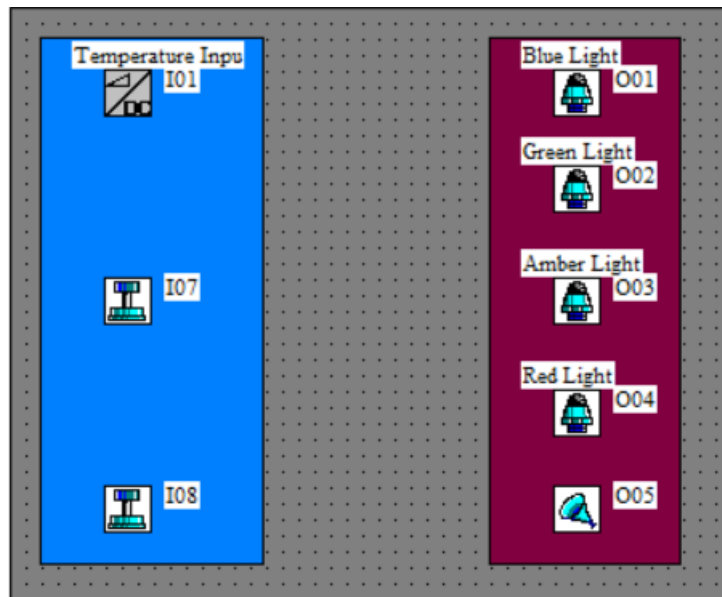
Image depicting the active circuit with a temperature input of 71°C, with activated flicker function and audible alarm

The Blue Light output device will not operate when a signal from the “Alarm Accept” latch is operated. A signal from the “Alarm Accept” latch will only be made at a time when another signal is also being transmitted to this OR gate. Following the design parameters of the OR, this will allow the lighting of the Blue Light as an OR gate will operate with multiple active inputs.

The previous images also indicate the correct operation of the differentiators in discriminating between the variable signal provided by the temperature input device.

The Mitsubishi Alpha software also allows for the design and demonstration of a simple human machine interface (HMI).

*Have produced a fully functional program.
well done.*



Nice layout.



Image depicting HMI for Task 4 temperature control panel

A human user interface is a system component designed as a method of transferring information between a software-governed system or device and a human operative. In this case, a simple software interface allows the human operator to monitor the visual and audible indicators of the system's performance and respond to these by either operating the "Silence Alarm" or "Test" press buttons. Peter Morville (2016) writes that an effective information interface can only be considered "valuable" if the information is portrayed in a "useful, desirable, accessible, credible, findable [and] usable" manner. This HMI fulfils this brief due to its simplicity of layout, ease of access to a limited number of functions, and a high level of automation.



Task 5 – Programming Problem

This task requires the use of the Mitsubishi FX PLC and attendant GX Works software to operate a simple lift motor control programme. Appendix 1 contains a copy of this software as represented in ladder logic form.

Runs 0 to 30 in the ladder logic programme refer to latch mechanisms which trigger the lift motor operating up (run 36) or down (run 40). These latches operate where the level call button is depressed, where the lift is at the appropriate level sensor, and the door lock sensor is active. The latch is deactivated when the lift reaches its intended destination level sensor.



Runs 44 to 63 describe latches designed to operate the various level indicator lights. The latch will operate where the appropriate level call button is pressed. The latch is disengaged when either of the other level call buttons are operated.



Runs 65 to 78 describe the operations required to operate the door lock system. Run 65 describes the latch used to operate the door lock, which is triggered by the operation of the motor up, motor down, or door lock latch operations, and which is cancelled by the conclusion of timer "T1". The door unlock latch described in run 72 is triggered if the motor up and motor down functions are not

in operation but where the solenoid lock is in operation, and is cancelled by the conclusion of the timer T1. Run 78 describes the operation of the T1 timer, which is triggered where both the motor up and motor down operations are inactive and runs for five seconds in duration. ✓

Run 84 describes the operation of the door open light which is operated when the solenoid lock for door is not active. ✓

The programme as completed using the ladder logic method achieved operated as envisioned and has achieved the main requirements of the task brief, namely:

- The lift will only accept instructions when the lift is stationary
- A level light indicates the level at which the lift is positioned
- The lift moves from one level to another upon receipt of instructions via the lift call buttons
- The lift door can be locked prior to the lift moving, and will not reopen until a five second grace period has been reached once the lift arrives at a new level
- A light indicates when the door is open
- The lift is prevented from opening if the lift is in motion
- The lift cannot receive any instructions to change level during transition between levels

Functionality of the lift operation could be improved by an automated door opening mechanism, perhaps triggered initially by the lift call button (if the lift is at the required level) and again triggered once the lift has reached its destination. In addition, perhaps the introduction of a visual indicator of the lift position placed besides the lift call button would be useful. ✓

The addition of an audible alarm when the door is in operation would be an effective safety feature. In addition, the use of some form of weigh scales that might prevent the operation of the lift in overload conditions should be considered. If an automated door were to be fitted, a proximity sensor must necessarily be introduced to prevent the accidental trapping of persons in the door during operation. ✓

A good explanation of your program but could have included some screen shots of these operations.

Reference List

Genon-Catalot. D (2015) Lift Control System [Online] available at https://www.researchgate.net/figure/Modified-safety-chain-in-lift-control-system_fig2_308499036 {Viewed on 19 May 2022}

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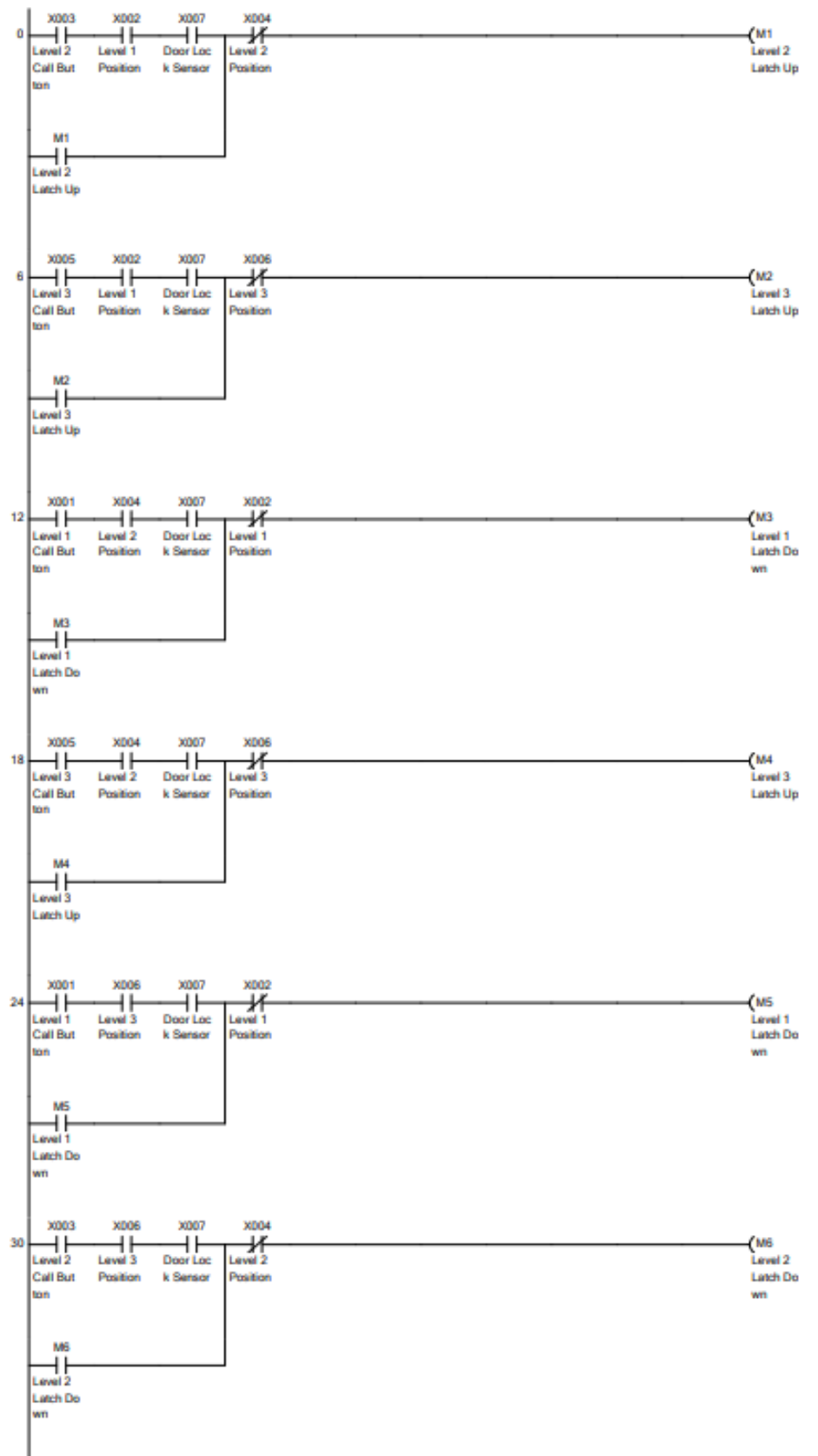
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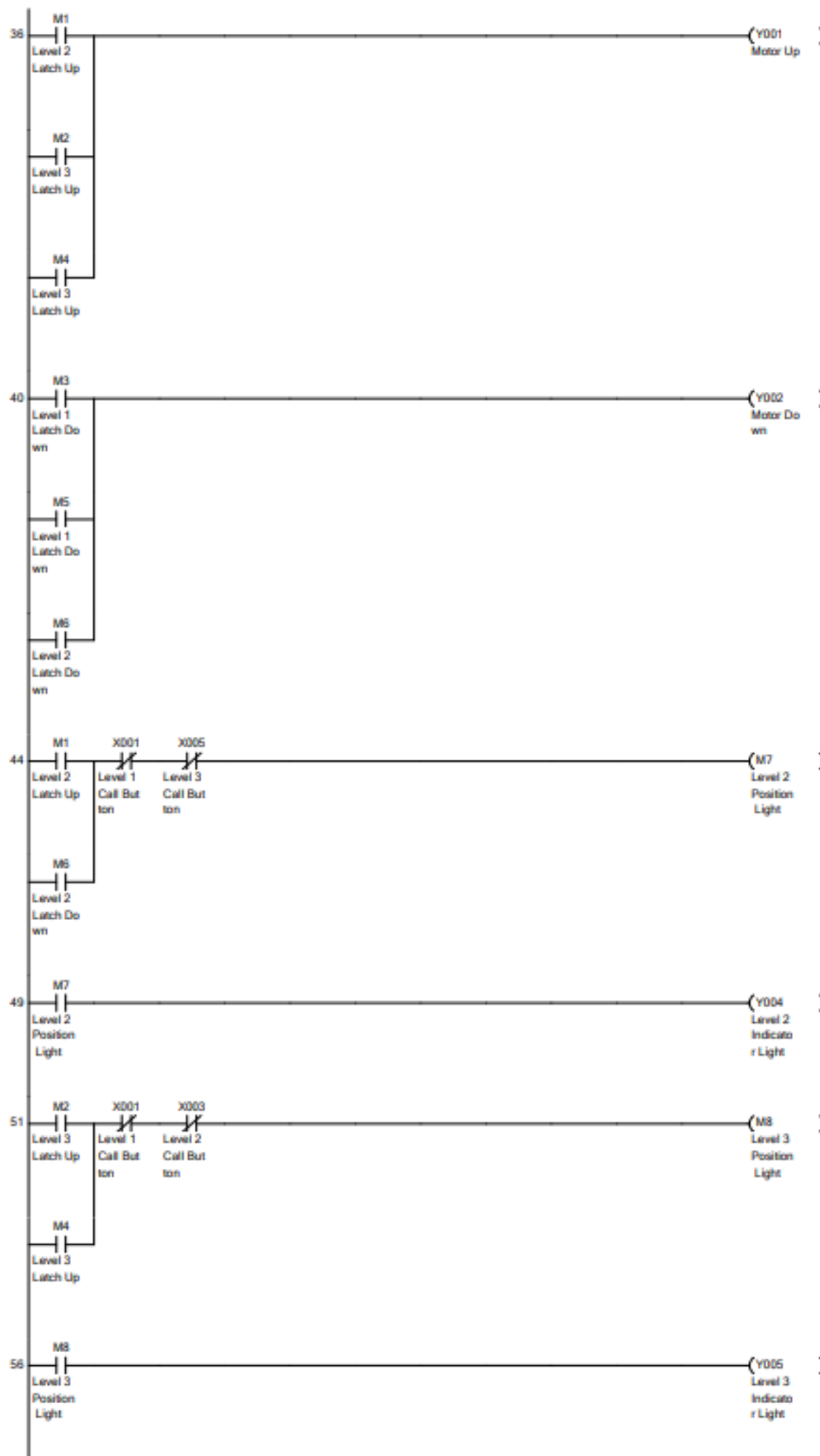
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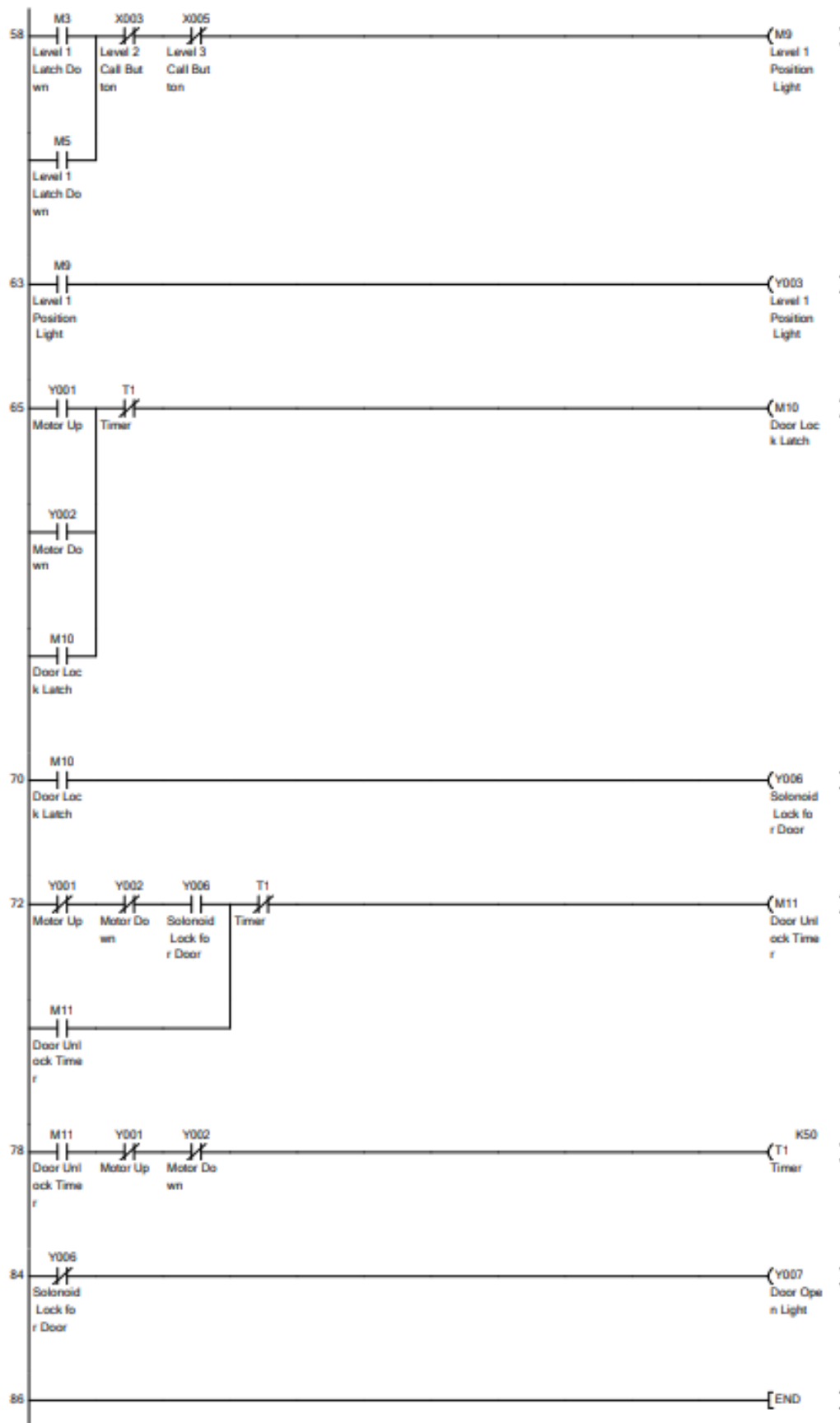
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Appendix 1 – Ladder Logic Programme for Lift Control







A very well designed program which was fully functional.
Excellent work.