

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Matthew Rawlings	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)

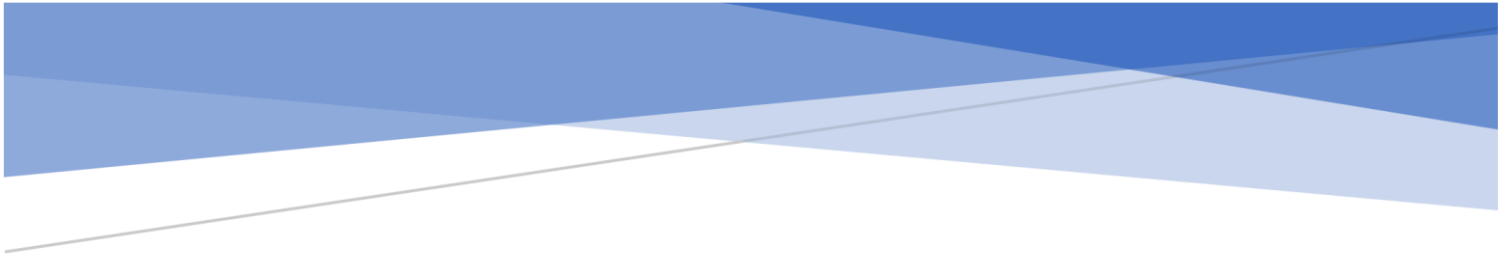
1. Demonstrate an understanding of the concepts of process control using an industry standard PLC.
2. Undertake basic PLC system design and implementation processes, comparing theoretical expectations to actual outputs ensuring correct operation and consideration of maintenance and reliability.

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	21.7
Task 1 achieved 70%. Task 2 achieved 66% Task 3 achieved 82% Excellent knowledge and understanding of the basic underlying concepts and principles of the work required for Task 1 and 2. Excellent work producing the IL code for Task 3.		
3. Cognitive and Intellectual Skills	10	5.2
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	29.9
Task 4 achieved 86%. 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	6.5
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)		72%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



HNC ELECTRICAL/ELECTRONIC ENGINEERING

Programmable Logic Controllers

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Task 1 - PLC analogue and discrete I/O

a)

PLCs can be used with analogue and digital inputs. An example of a discrete pressure input is a switch, pressure switches are used as inputs for PLCs to determine an output or contribute to the change of an output. Pressure switches operate at either 0 or 1, making it a discrete input. ✓

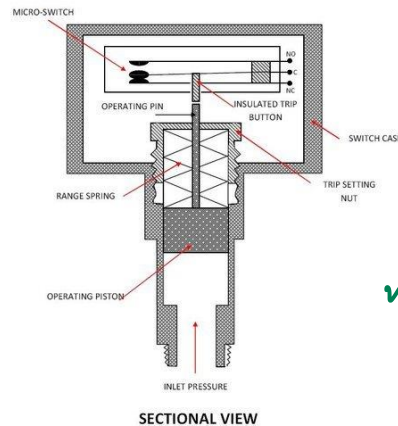


Figure 1 - Pressure Switch

Figure 1 shows the internals of a discrete input instrument in the form of a pressure switch. As seen, the pressure inlet operates a piston or a diaphragm which compresses a range spring, pushing an operating pin which completes or breaks a contact within the head. The switch can be wired normally open or normally closed depending on the use of the switch. Commonly for system safety reasons, the switch is wired normally closed, so that a failure in the system can be identified. (Airtrol INC., 2019) (InstrumentationToolbox, 2022) ✓

Are you referencing any direct quotes.

An example of an analogue pressure input is a pressure transmitter. Pressure transmitters are used for pressure, flow and level though this example is pressure. Pressure transmitters can operate throughout its complete range 0-100% whether the range is 0 – 10 kg/cm³ or 0 – 1 kg/cm³. When operating through a PLC, pressure transmitters are commonly used as solely indication or more critically, a shutdown input, operating an output to close valves or stop pumps for example. ✓

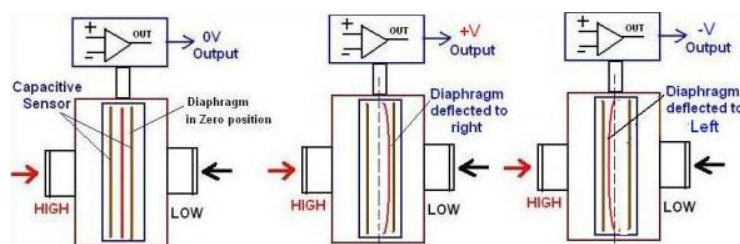


Figure 2 - Pressure Transmitter

The majority of industrial Differential Pressure Transmitters are fitted with diaphragm as the pressure sensing element. The diaphragm is a mechanical device which is moved by the inlet pressure. The diaphragm or measuring element in this case is a capacitive element. It is fitted in between the two pressure inlet ports, high and low. When the capacitive diaphragm or dielectric is moved further, the capacitance changes, changing the output between 4-20mA. From these ✓

pressures, the transmitter is able to send a 4-20 mA analogue signal to a PLC where a change in process can occur as a result of the reading. ✓

There are few discrete temperature elements though most commonly is a bimetallic strip. A bimetallic strip uses two metals with different properties to create a discrete signal. The bimetallic strip consists of two metals which due to their different properties expand and contract at different rates when subjected to heat. When heated, the expansion of one of the metals will pull the metals towards or away from an electrical contact either making or breaking a switch. ✓

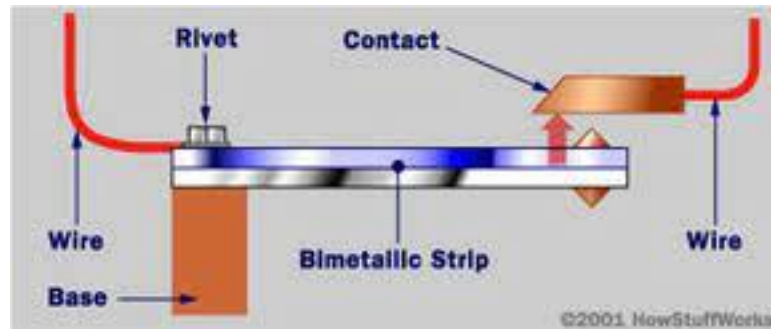


Figure 3 - Bimetallic Strip

There are different metals used in this instrument, one pairing is steel and copper and another is steel and brass. The metals are paired by welding or brazing. In this case, brass will expand at a faster rate so the brass would be mounted on the outside to curve towards the contact. This type of input will provide a 0 or 1 signal to a PLC which will contribute to a program change, starting a timer, opening or closing a contact. (Circuit Globe, n.d.) ✓

There are multiple analogue temperature devices such as a thermocouple, thermistor and RTD or resistive temperature device. Each of these serve the same purpose in the sense that all represent temperature with a change in resistance or voltage. For this example, an RTD is a useful instrument for measuring temperature and using as an input to a PLC. A Platinum Resistance Device or PT100 is a commonly used Resistance Temperature Detector due to its convenient 100Ω at 0°C, this is one of its key features. A PT100 utilises a platinum strip as its measuring device. As the temperature of the measured process changes, the resistance also changes. Opposing the previous instrument discussed, as the temperature of the RTD increases, the resistance increases, then decrease as the temperature drops. ✓

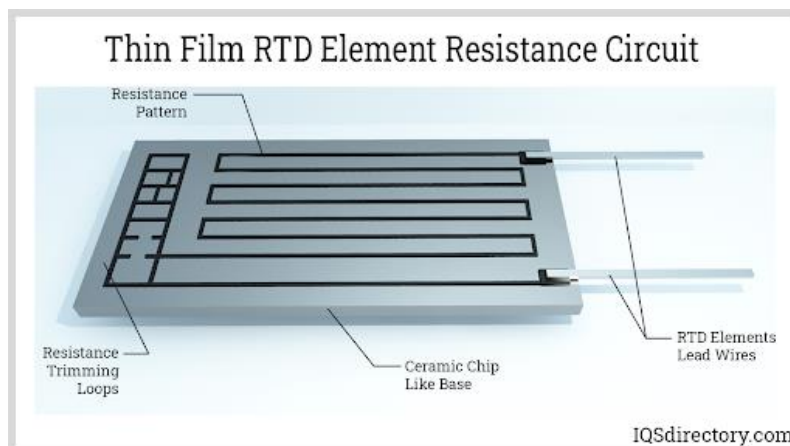


Figure 4 - RTD

The RTD is a fairly simple but intricate design. In terms of a PT100, a platinum film is laid on to a ceramic base, connected to two lead wires which provide voltage to the sensor carry a change in voltage back to the sensor head. This sensor head will be fed into a junction box where an accurate reading will be seen in a control room. An advantage of using a PT100 RTD is that it is available in multiple configurations such as 2-wire, 3-wire and 4-wire. By using a 3 or 4-wire RTD, the lead wire resistance is eliminated and reduces self-heating which can cause inaccuracies in measurement. ✓

(Variohm, 2019)

A good explanation.

b)

A stepper motor is a type of electric motor which does not operate the same as other standard motors. This type of motor bases its operation on a digital input/output or pulse signal. They are commonly used for precise movements and where frequent starting and stopping is required. When current passes through the motor, it hits a series of coils arranged in phases, which can be powered on and off in quick succession. When this happens, the motor rotates a fraction of a turn at a time, this can be referred to as a stepping, when the motor is powered for short periods. ✓

(RS Online, 2022)

A stepper motor can be used in series with another stepper motor on a conveyer belt to produce precise linear and angular movements. An example of the precision of a stepper motor for example, if one pulse is equal to 1.8 degrees, 200 pulses would be required for 360 degrees of movement.

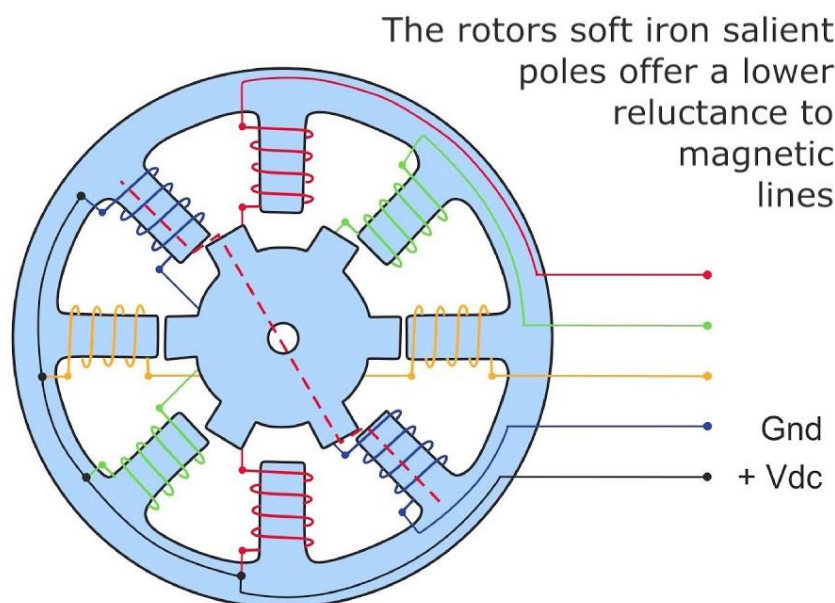


Figure 5 - Stepper Motor

_(Bone, 2015)

A variable reluctance stepper motor type which uses non-permanent magnet to generate movement and torque. The stator consists of multiple electromagnet poles. The rotor consists of soft magnetic material, which has multiple projections acting as magnetic poles through magnetic reluctance. ✓

Task 2 - SCADA

SCADA means Supervisory Control and Data Acquisition. SCADA is a system which incorporates hardware and software elements, this configuration allows industrial process control either locally or on a wider scale across a site. It is also used to collect, process and analyse real time data to carry out various actions. ✓

These actions are carried out using the data collected and process measure by devices such as instrumentation, measuring temperature, pressure, flow and level. From these measuring devices, analogue and discrete values in order to gather data. Collected data can be sent to a PLC where it can be used to alter or contribute to a process change. Information gathered and changes are transmitter to an HMI or Human Machine Interface such as a control pane or screen where it can be read and shared. This is an example of how HMIs are integrated with SCADA. ✓

An HMI is a Human Machine Interface which allows process variables to be shown in figures and real time data. An HMI can be designed and configured to match the needs of the operator or company. Human Machine Interface can connect an operator to a process across site through SCADA and PLCs. From a control room, an operator using an HMI can change process variables such as valve positions, process sequences and shutting down areas of an industrial site or refinery such as Valero. Key features include visually display data, trends, equipment identification and key performance indicators. ✓

PLC stands for Programmable Logic Controller and is available in multiple sizes, brands and types so can be used in a variety of situation in conjunction with SCADA and HMIs. PLCs are used for industrial automation and control. PLCs can operate using functional blocks, ladder logic and instructional lists. PLCs in a control loop will connect process measurements to SCADA and the appropriate HMI. *A PLC serves as a bridge between the process and its control. As such, a PLC is often used in conjunction with SCADA systems and HMIs.* (Inductive Automation, 2018) ✓

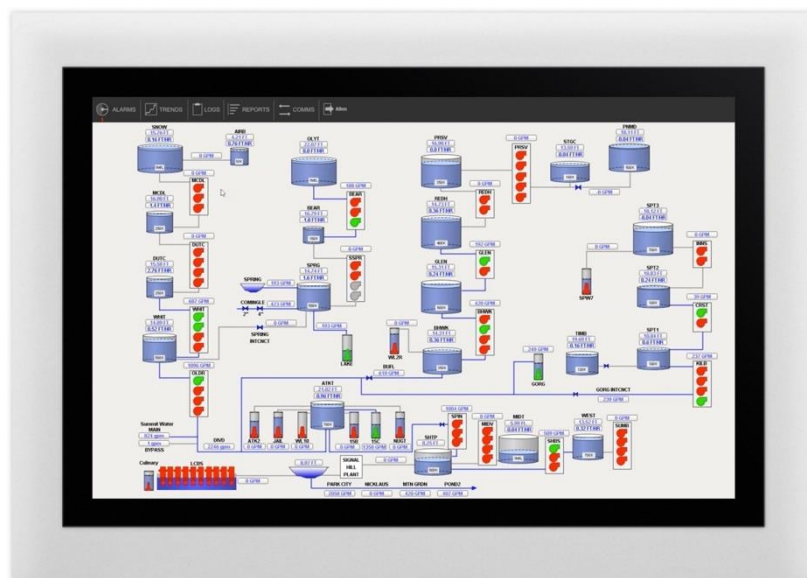


Figure 6 - HMI

Pictured is a typical HMI. This example is a similar layout to the HMI used for the Valero Tank Farm. Feeds to the tanks can be switched and these rates can be changed along with run down rates and real time level readings. ✓

SCADA systems consist of:

- One of more field data interface devices, which interface to sensing field devices and local control switch boxes and valve actuators.
- A communications system used to transfer data between field data interface and control units and the computers in the SCADA central host. The system can be radio, telephone, cable, satellite etc., or any combination of these.
- (National Telecommunications System, 2004) ✓

Could included a diagram to show a SCADA set up.

Task 3 – Instructional List

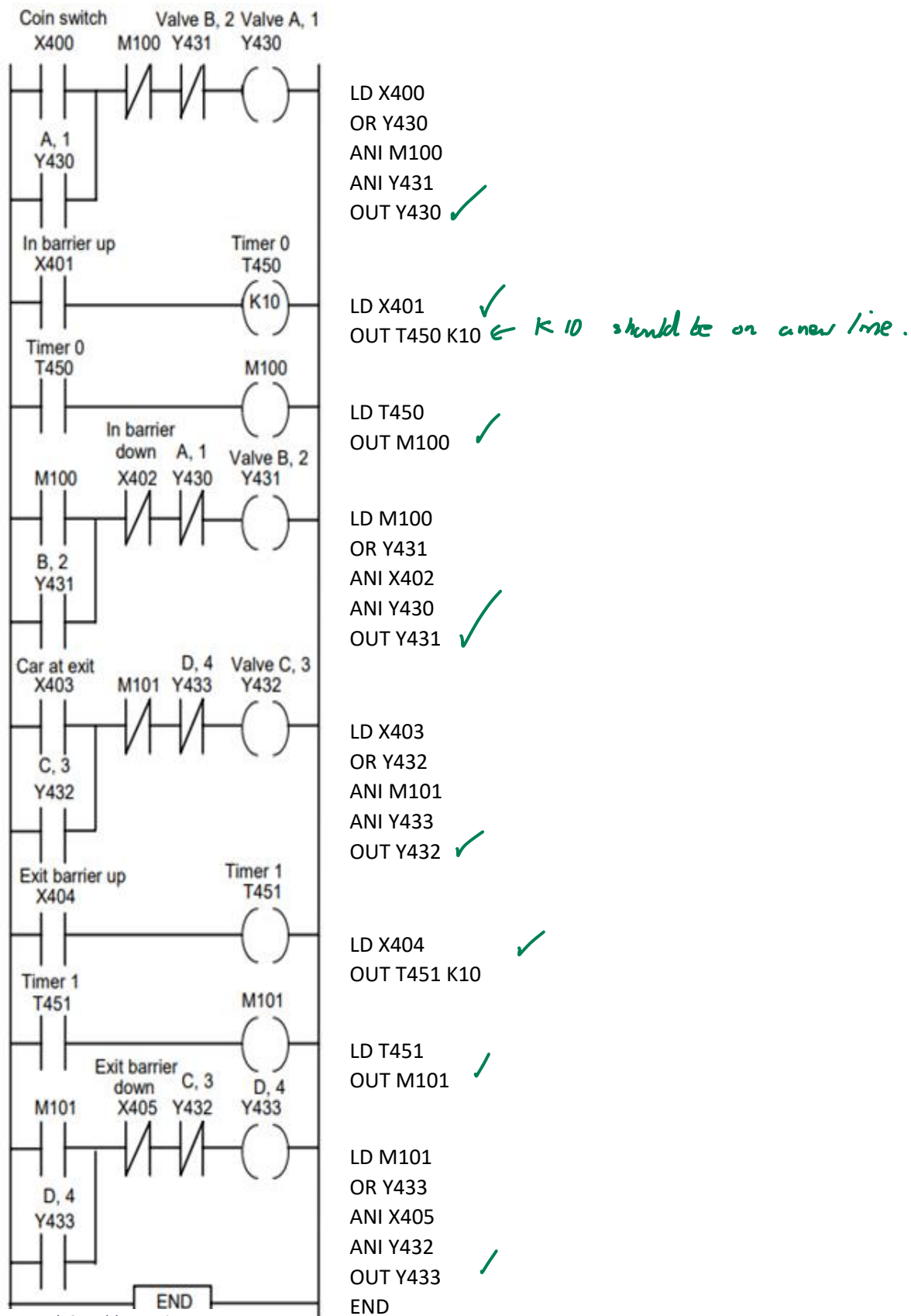


Figure 7 - Task 3 Ladder Logic

Task 4 - Temperature Alarm Panel

Shown below is a program designed in functional blocks to indicate temperature through lighting and operate an alarm when required.

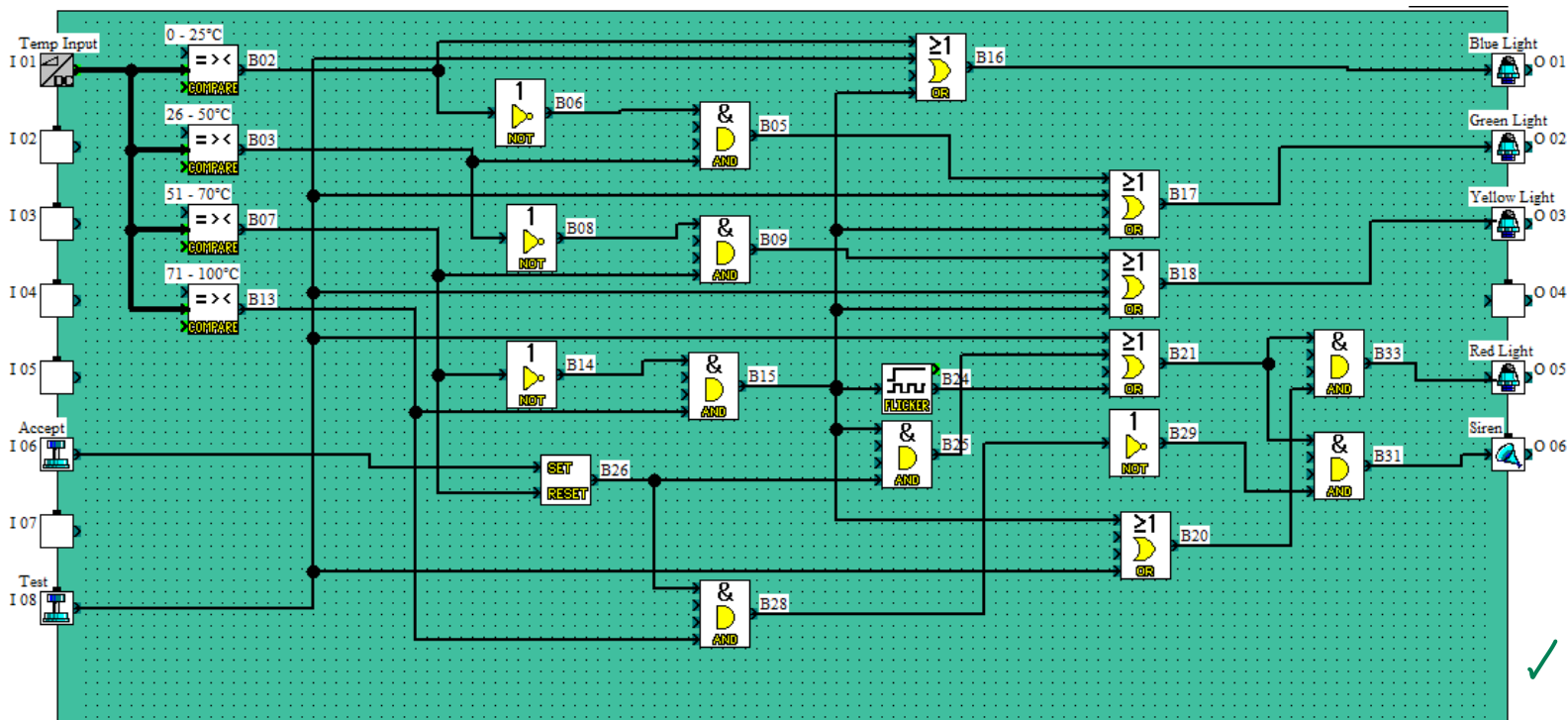


Figure 8 - Functional block program

A very good design that covered all the requirements.

Shown is the program at resting state before starting the system.

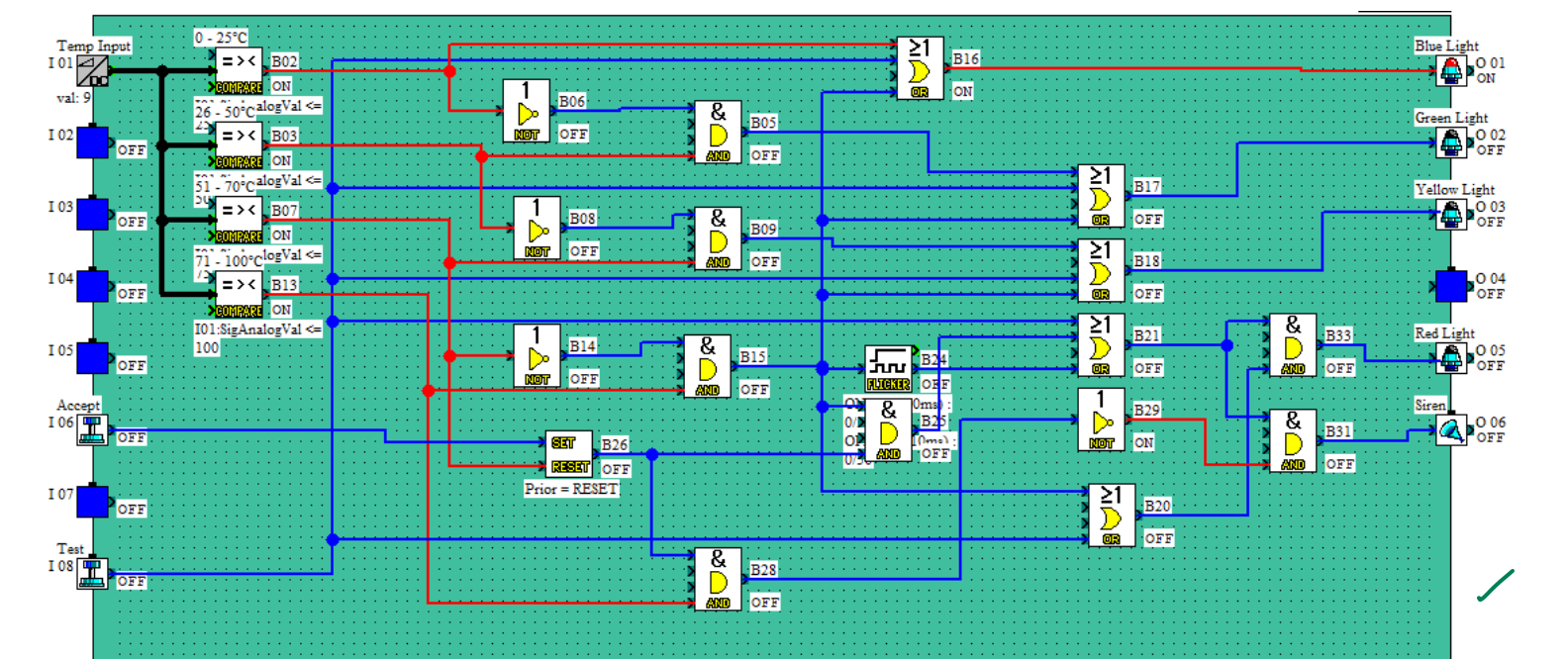


Figure 9 – Stage 1 of program

As the measured temperature increases, a variety of lights operate. This shows the first light operating when the temperature is at 0 °C and 25 °C, this operates correctly as the simulated temperature is 9 °C.

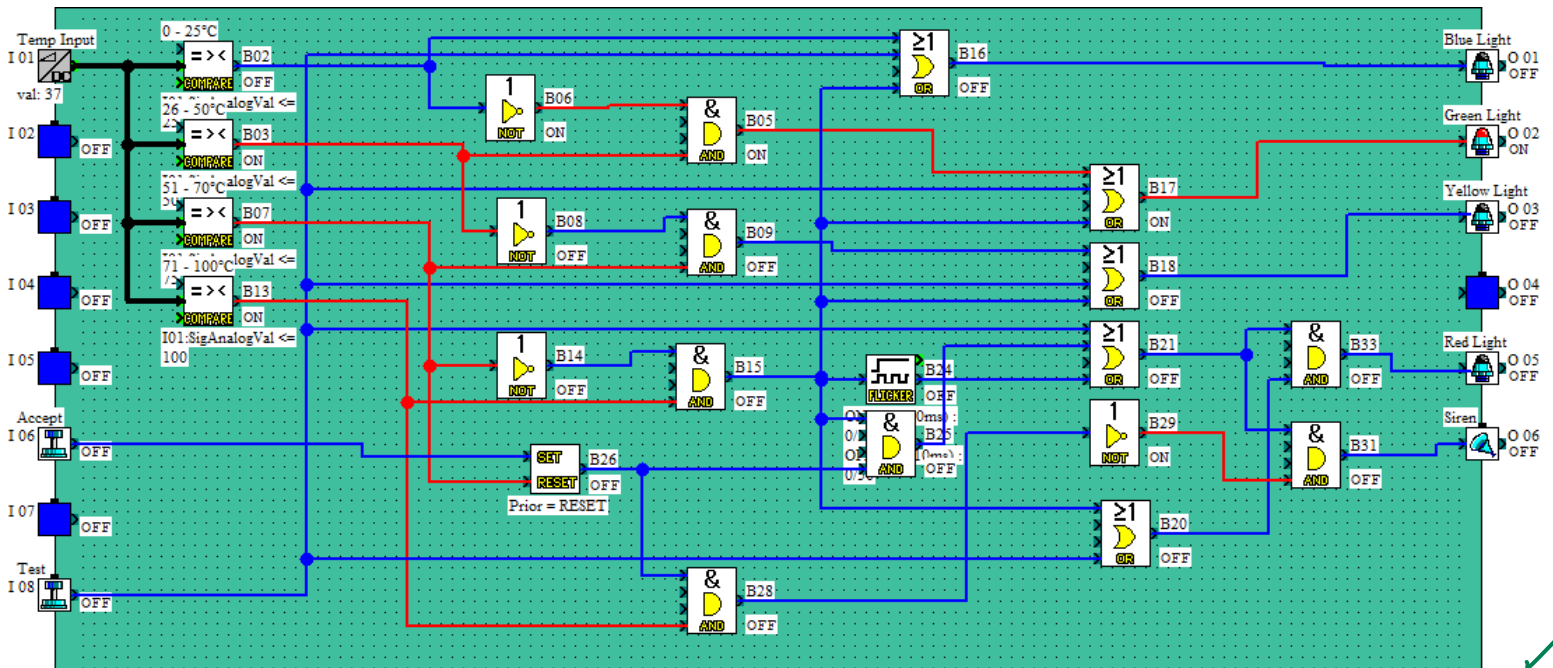


Figure 10 - Stage 2 of program

Shown is the logic when the second light operates and the first turns off between 26 °C and 50 °C, this is correct as the simulated temperature is 37 °C.

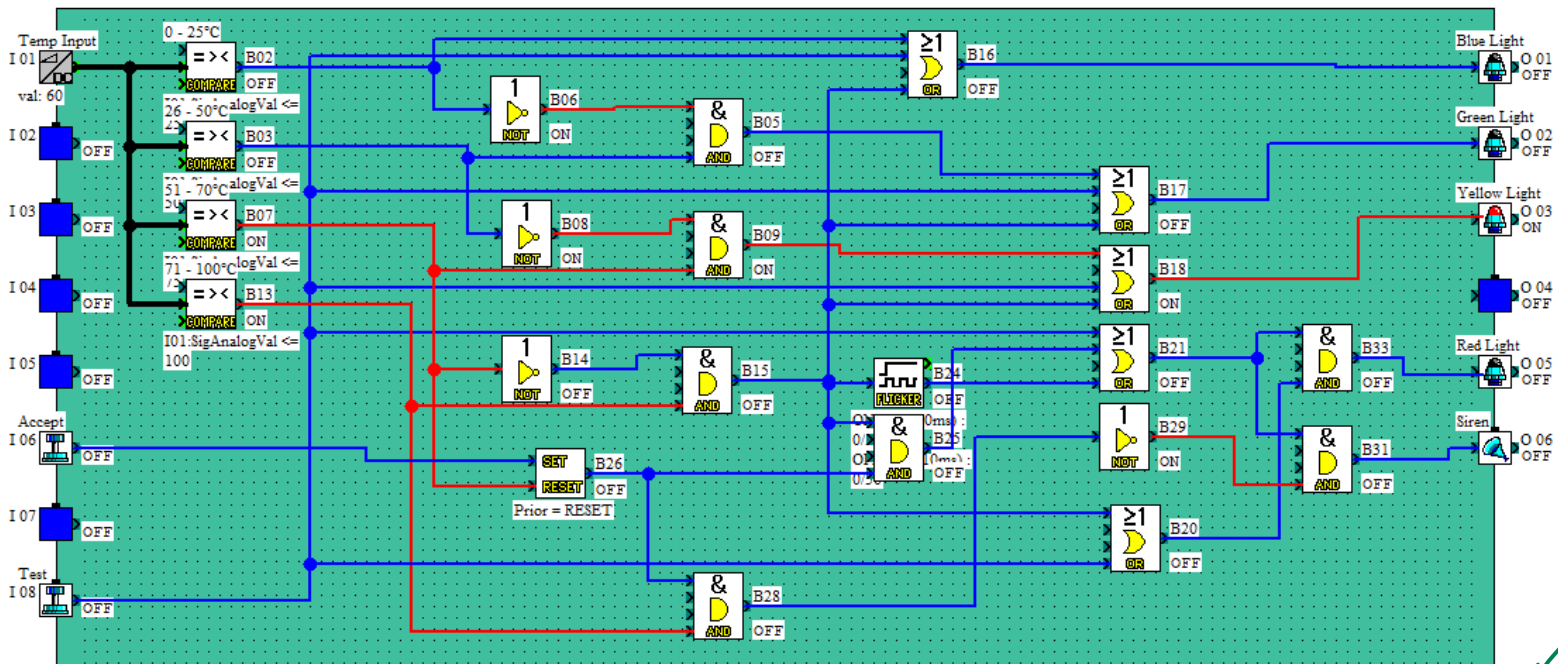


Figure 11 - Stage 3 of program

The yellow activates when the temperature is between 51 °C and 70 °C. This operates correctly as the first and second light have deactivated. The system is at 60 °C in this example.

When the system reaches between 71 °C and 100 °C, all lights flash and the siren operate until accepted or the measure values falls below this range. Shown is this in operation at 97 °C.

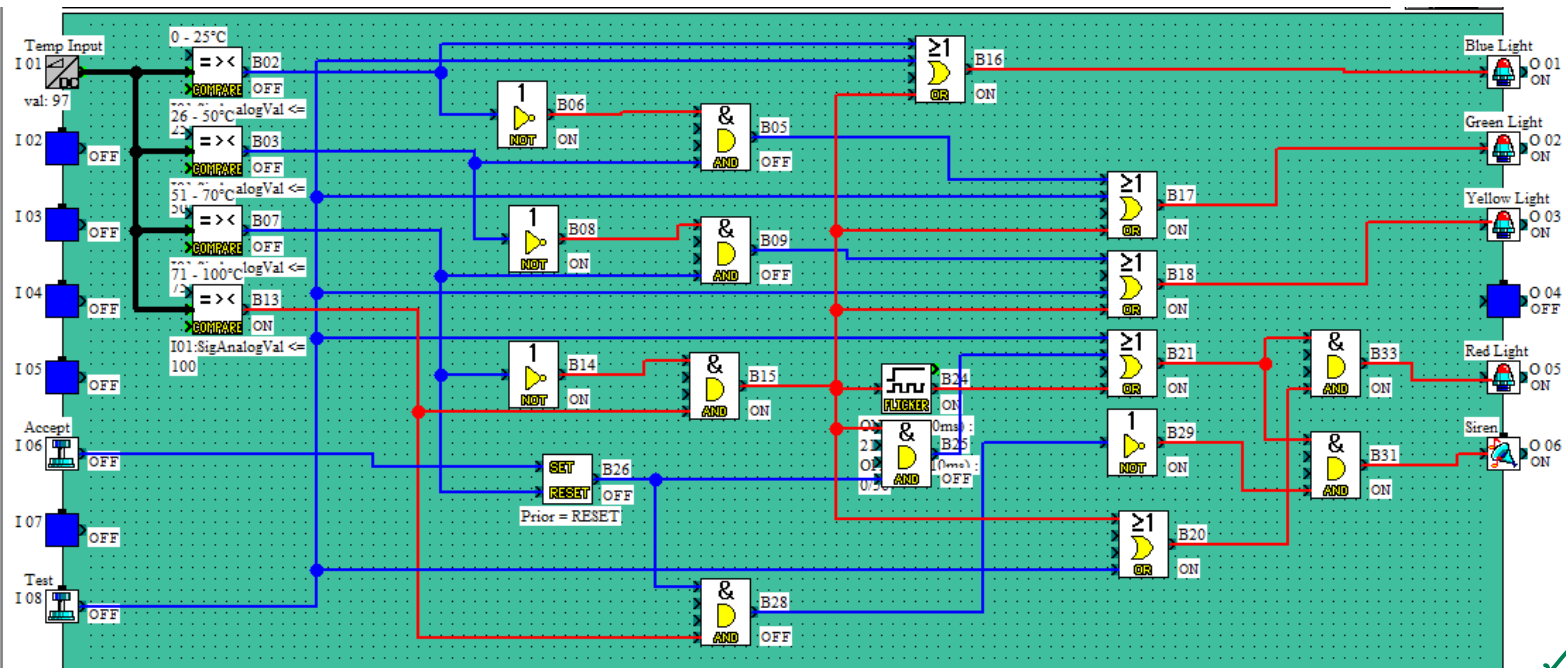


Figure 12 - Stage 4 alarm operation

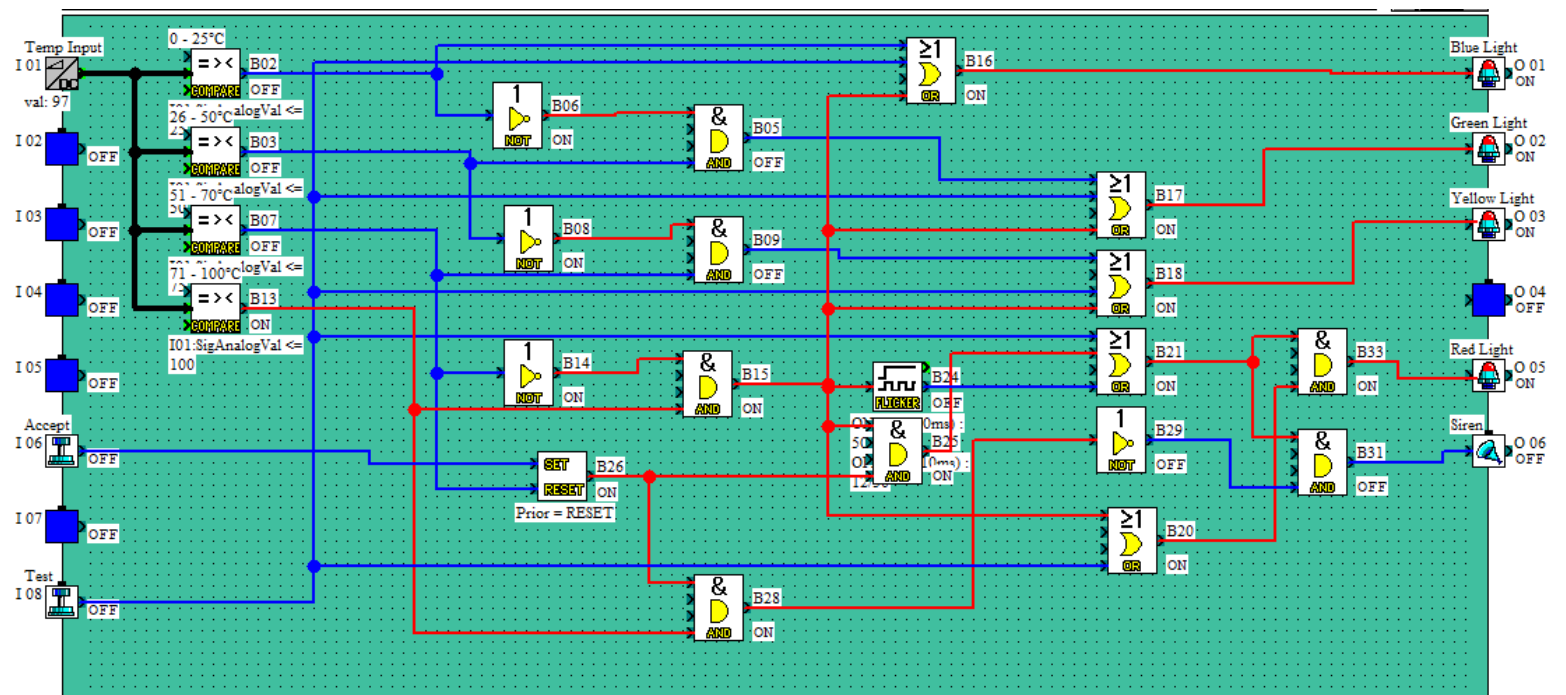


Figure 13 - Alarm acknowledge

Upon accepting, the lights should stop flashing and stay constant while silencing the siren. This operated correctly while the system stayed at 97 °C.

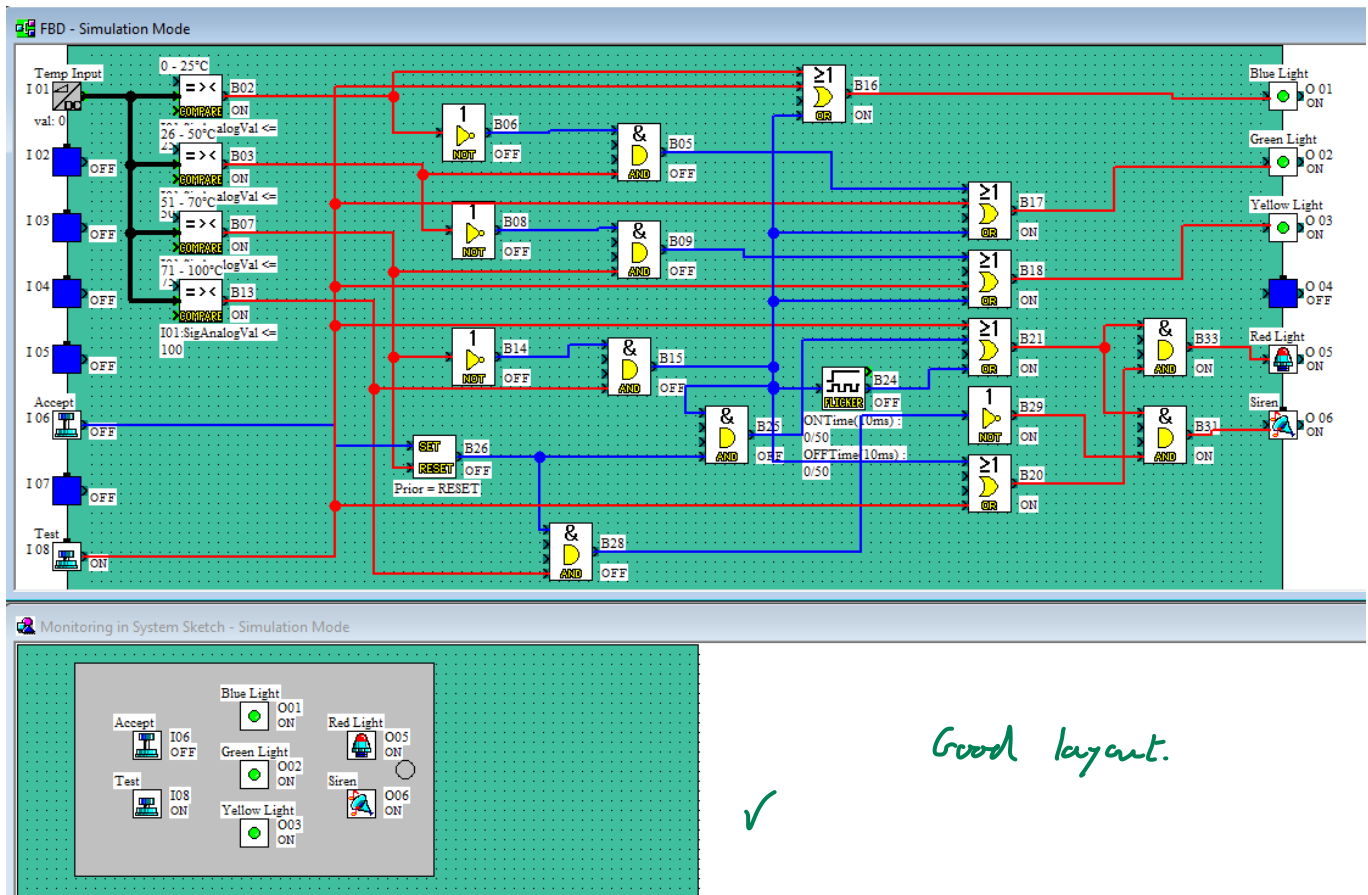
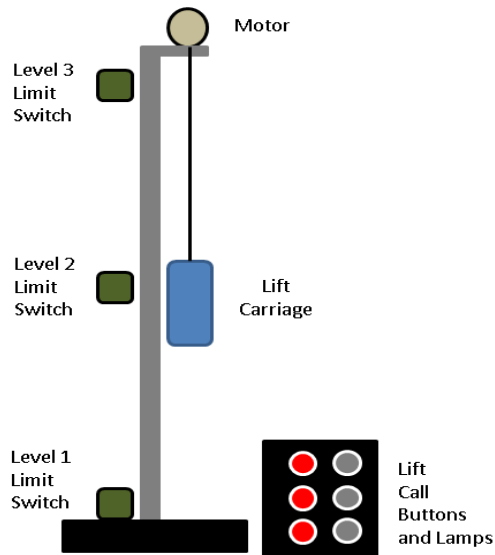


Figure 14 - HMI and Test

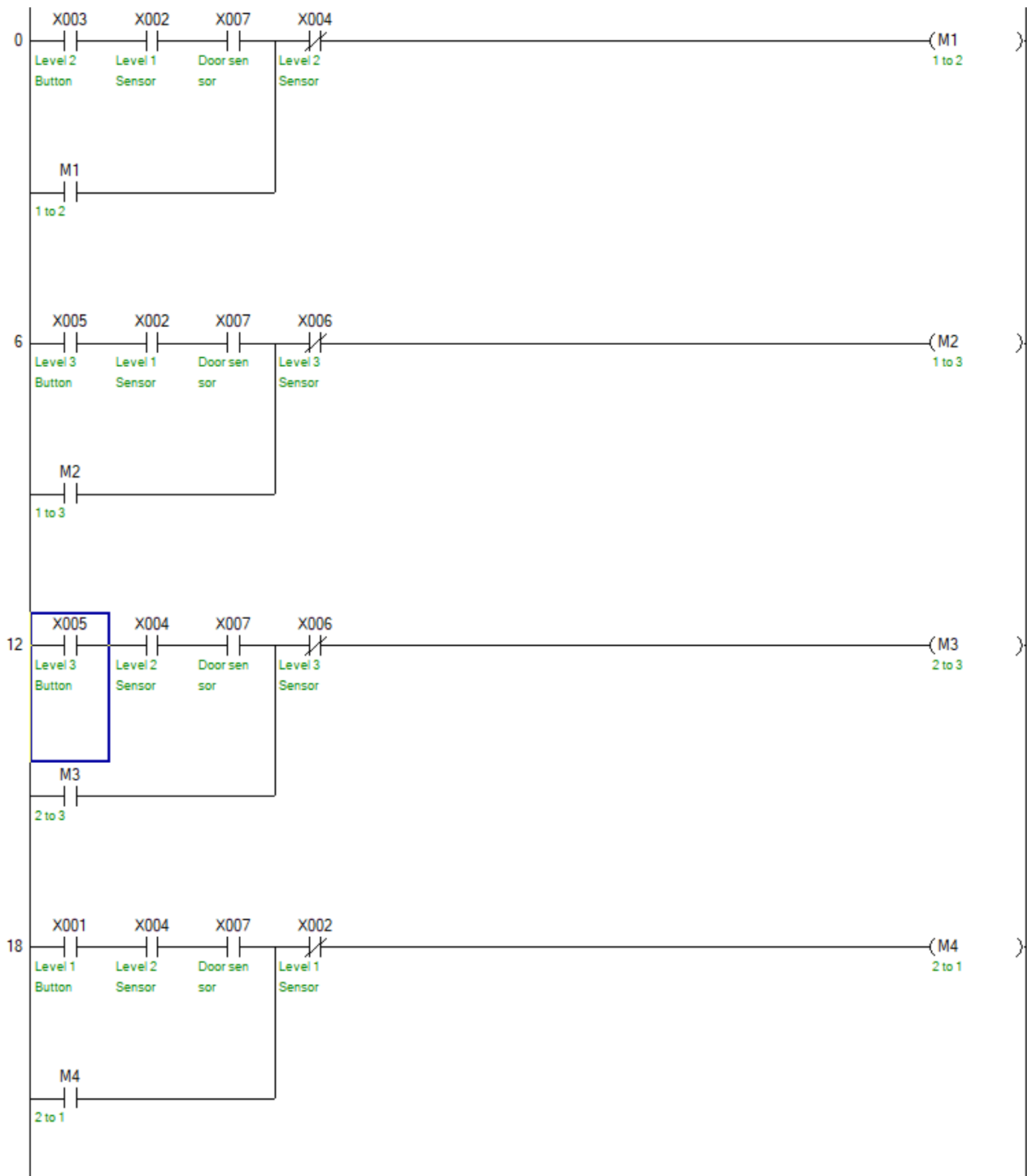
A test button was included in the program to ensure the operation of all outputs and the program prior to and after using the program. Also included is an HMI or Human Machine Interface which would be seen by the operator. Also shown is the HMI operating correctly alongside the program. ✓

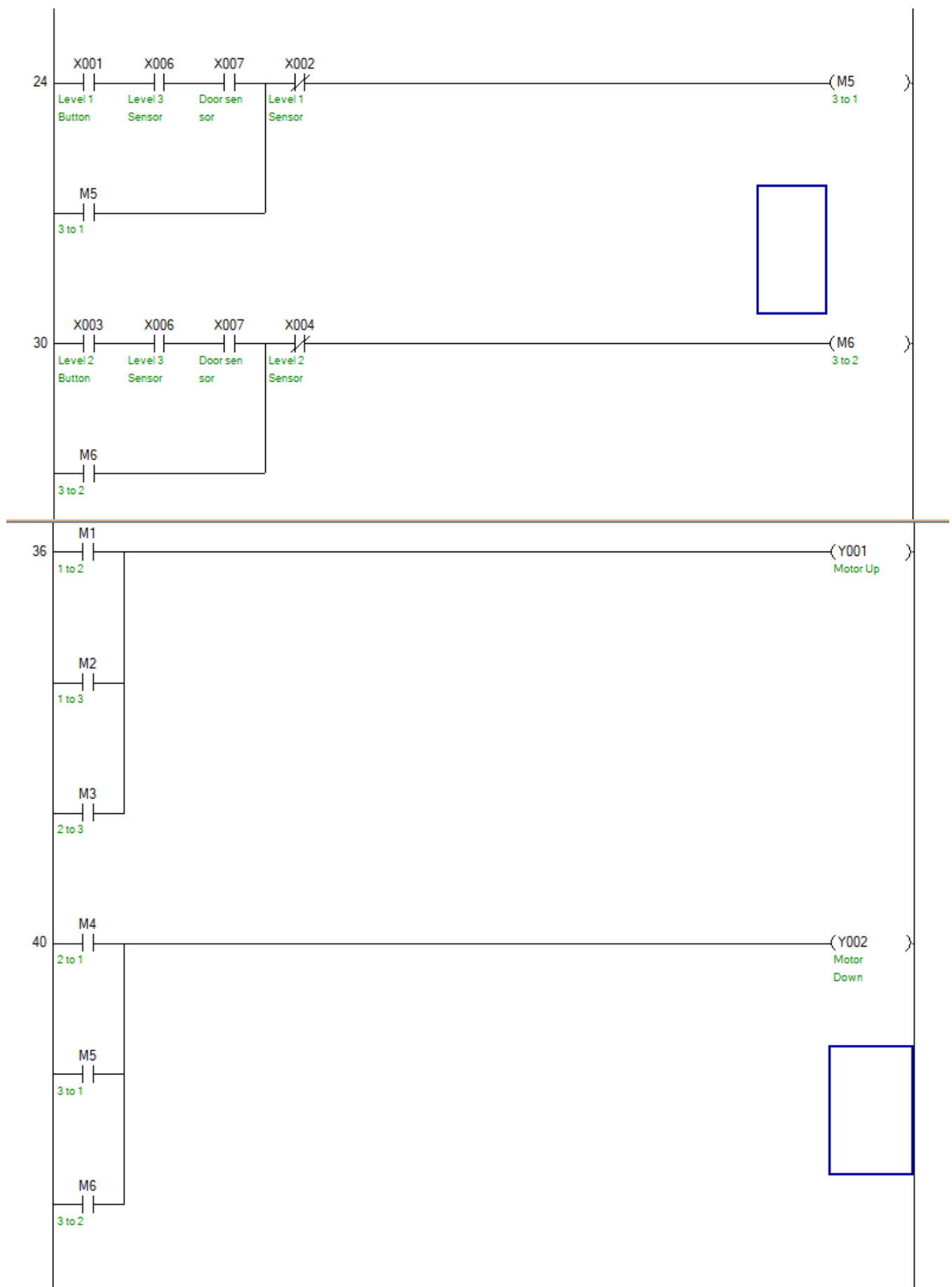
Task 5 – Programming Problems

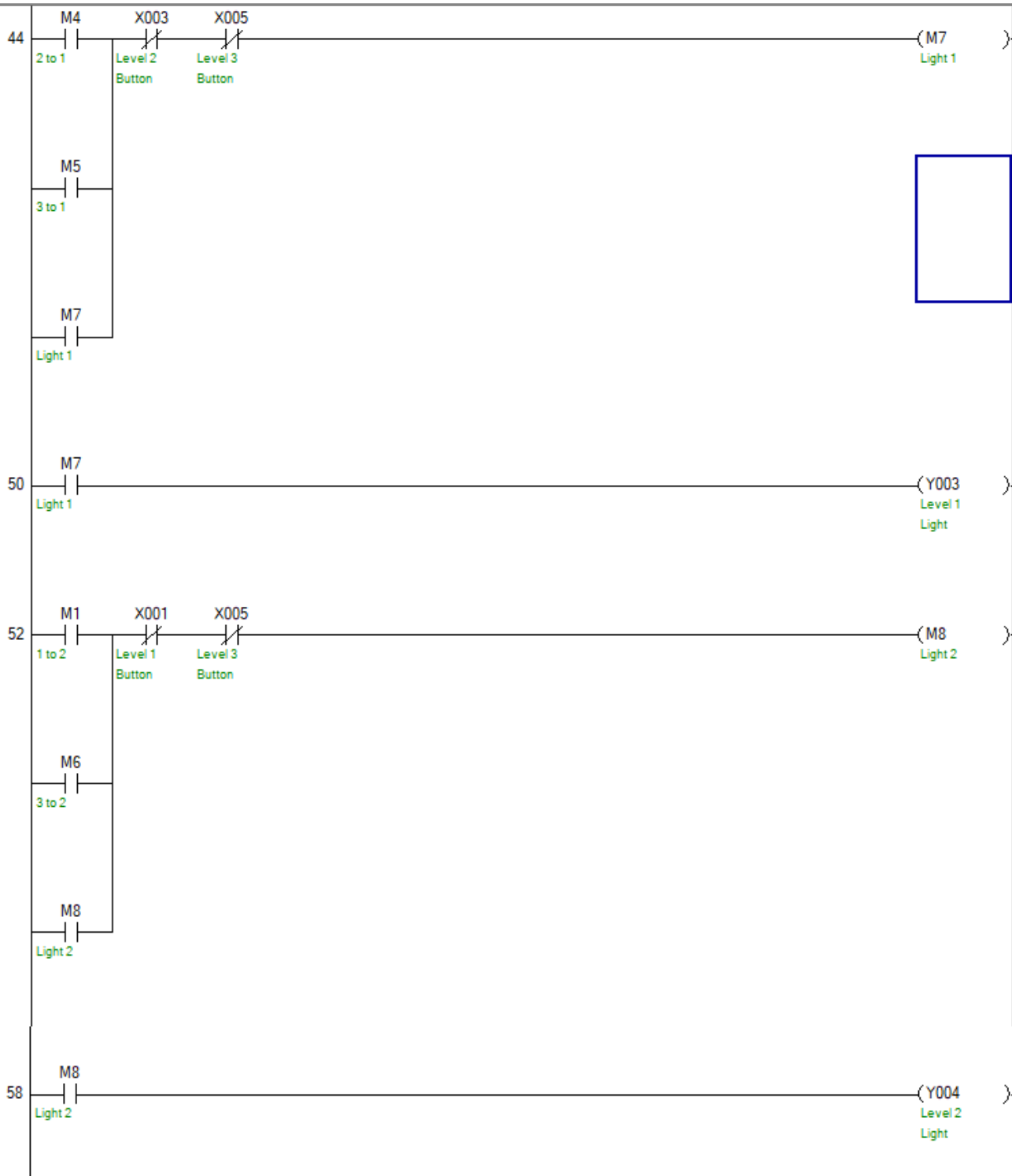
In this task, using GX works 2 and ladder logic, a 3-level lift was to be designed and proof tested using the following example, inputs and outputs.

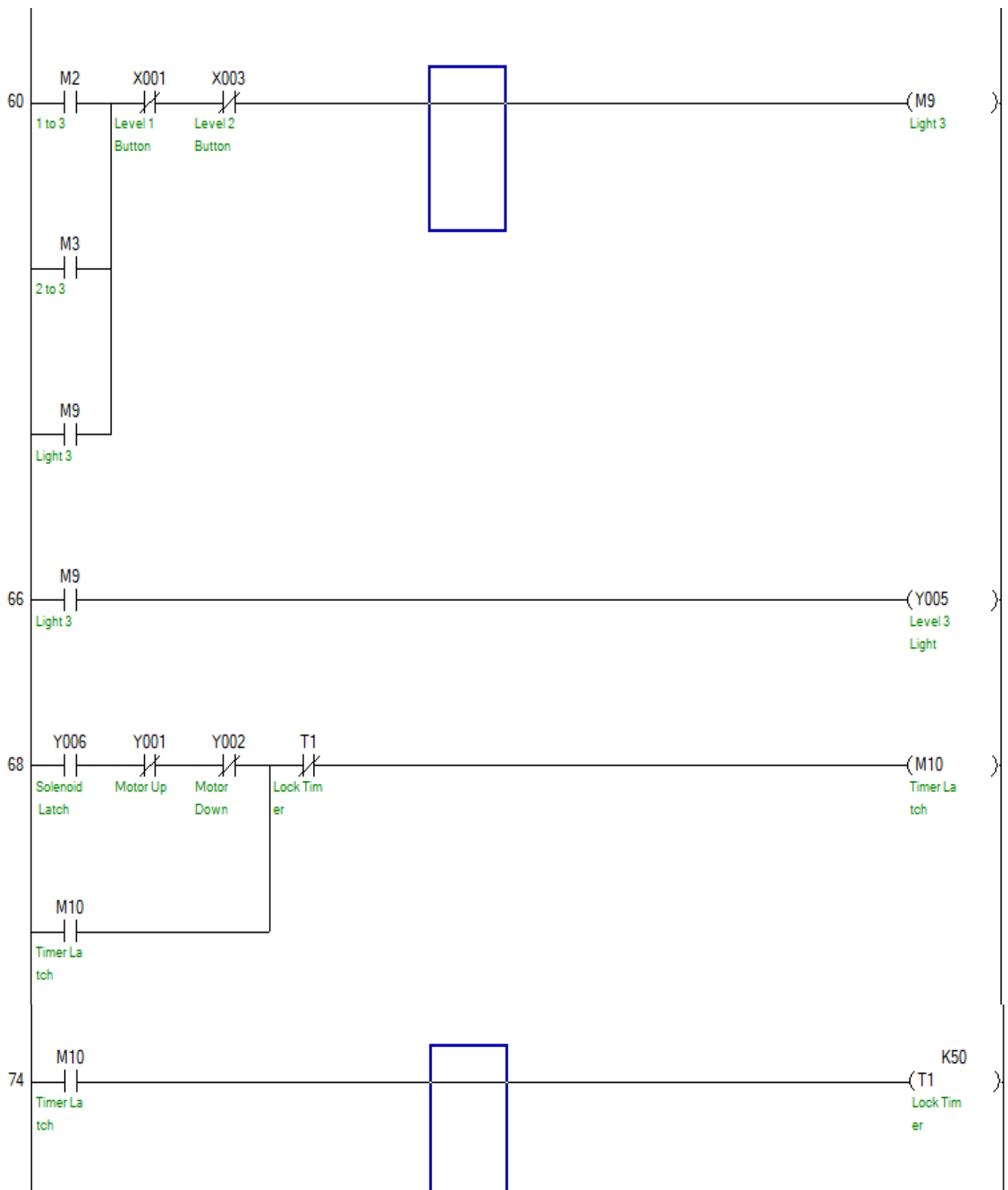


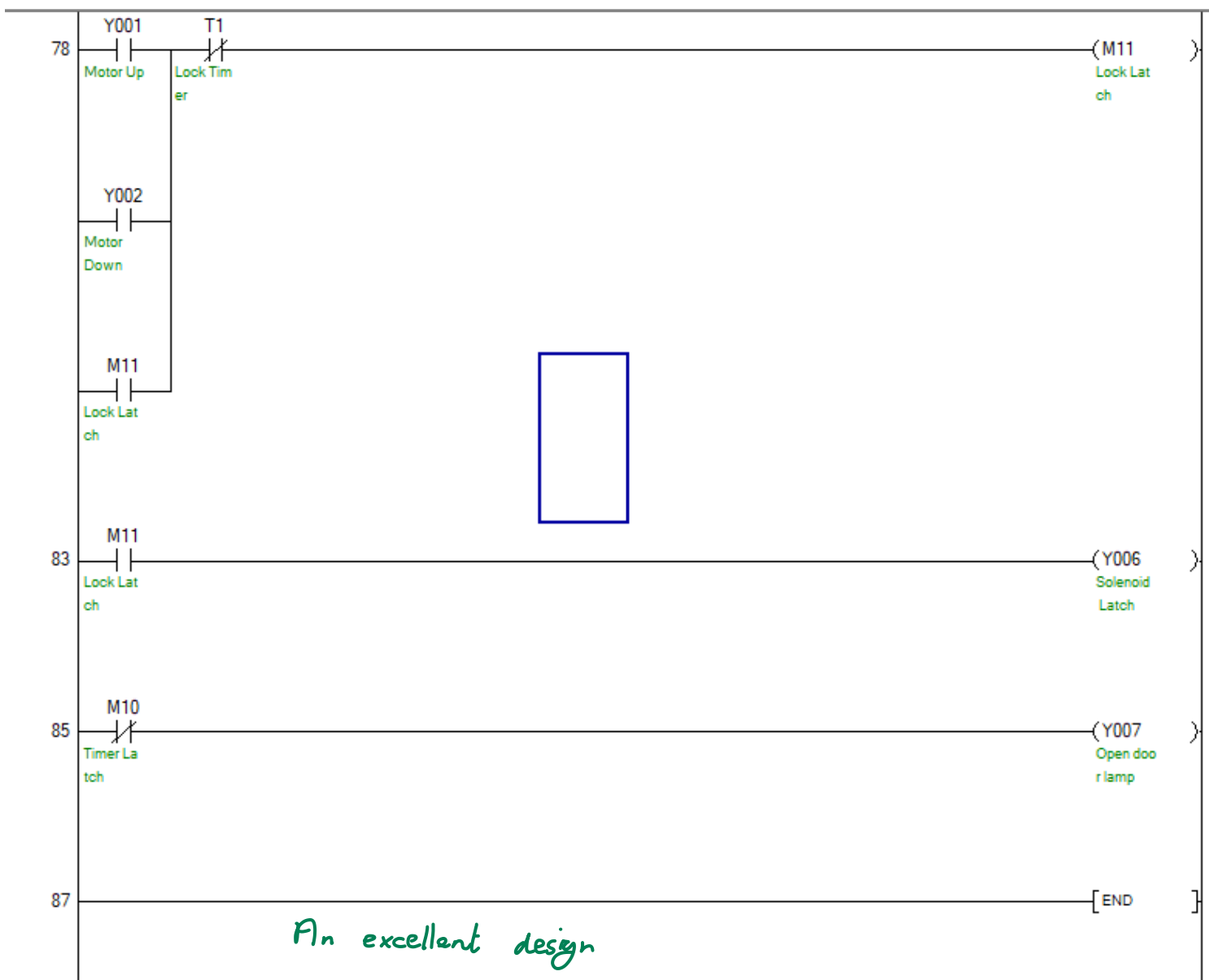
PLC Input		PLC Output	
01	Level 1 call button	01	Motors up
02	Level 1 sensor	02	Motor down
03	Level 2 call button	03	Level 1 indicator light
04	Level 2 sensor	04	Level 2 indicator light
05	Level 3 call button	05	Level 3 indicator light
06	Level 3 sensor	06	Solenoid latch for door
07	Locked door sensor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











Normally open, normally closed, timers, memory coils and output coils have been used for this ladder for correct functionality. Rungs, 1 to 6, numbered 0 to 30 are allocated to the level call buttons, ensuring all outcomes were accounted for. When satisfied, either the motor up or motor down output in rungs numbered 36 and 40 would operate, moving the lift carriage to the desired floor. Level sensors for both levels, locked door sensor and call button must be made before moving. Rungs numbered 44 to 60 are allocated to the level light outputs, Y3, Y4 and Y5. Rungs numbered 68 to 83 operate the solenoid latch or Y6, utilising a five second timer T1. Rung numbered 85, utilises a normally closed contact using memory coil M10 for T1 to operate the final output Y7, the open-door lamp. From operating the program, it can be seen that it is fully functional and meets the design specification in that upon starting the program, the carriage is stationary prior to 'calling' it. The light corresponding the required level operates upon calling, turning off the current illuminated light. The five second timer operates correctly, engaging the lock and light as per specification. The carriage also does not move when the door is open. Additional functionality which could have been included is automatic doors which operate when the carriage has arrived at the desired floor. ✓

Are there any improvements you would make to the system.

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