

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Tomas Griffiths	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)

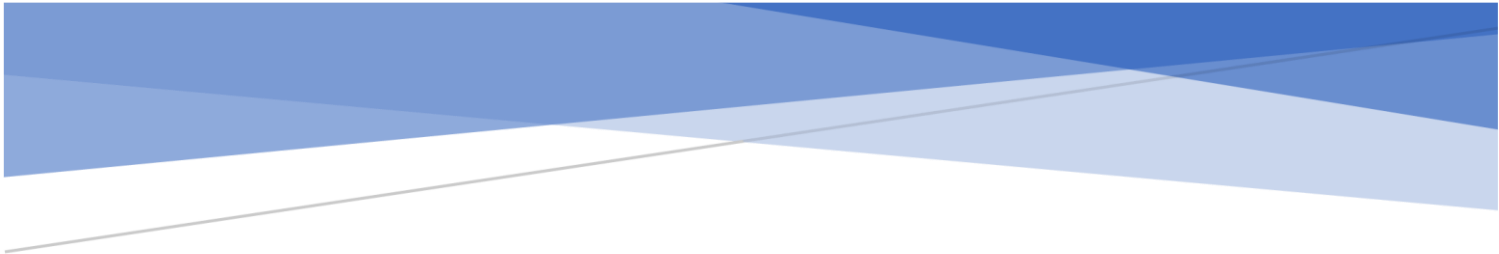
1. Demonstrate an understanding of the concepts of process control using an industry standard PLC.
2. Undertake basic PLC system design and implementation processes, comparing theoretical expectations to actual outputs ensuring correct operation and consideration of maintenance and reliability.

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	6.8
Engagement with a limited range of mostly relevant and credible sources. Generally sound referencing technique but should be using textbooks for direct quotes. Need to use the Harvard system for referencing.		
2. Knowledge and Understanding Skills	30	19.5
Task 1 achieved 60%. Task 2 achieved 55% Task 3 achieved 82% Showed some competent knowledge of the basic underlying concepts and principles for assessment but there were some elements in Task 1 that did not relate to the discussion. Need to include some diagrams to show the construction of the input devices. Excellent work producing the IL code for Task 3.		
3. Cognitive and Intellectual Skills	10	3.5
There is some minimum evaluation of the underlying concepts and principles applied to the construction of the programs for Task 4 and 5.		
4. Practical Application Skills	35	28.2
Task 4 achieved 78%. Task 5 achieved 83%. 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	5.5
Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed.		

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		63%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



PLC PROGRAM DESIGN AND SIMULATION

HNC Electrical/Electronic Engineering

Programmable Logic Controllers

PCEE4005

Tomas Griffiths

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Introduction

Programmable Logic Controllers are able to process both discrete and analogue inputs. They are also able to operate a range of equipment through the output interface. This assignment will examine these characteristics in detail.

Task 1 – PLC analogue and discrete I/O

Task 1. (a)

A temperature device that uses an input analogue signal is an RTD, also known as a resistance temperature device/detector which are calibrated resistors used to measure temperature. An RTD has a variable resistance with a positive temperature coefficient which means that with an increase in resistance there is an increase in temperature. RTDs are devices made of pure metal wire (usually platinum or copper). Due to their high accuracies and robust designs RTD's are widely used in many industrial processes such as the oil and gas industry. Since an RTD uses an analogue signal the resistance measurement obtained from the RTD transducer would be converted to a 4-20mA signal which would be further converted into a 1-5V signal for the PLC to use. The 4mA and 1V is the zero point on the RTD's calibrated range whilst the 20mA and 5V is the span of the RTD's calibrated range. ✓

A temperature device that uses a discrete input signal is a temperature switch. A temperature switch works the same as any typical electrical switch for an on/off application. (Author, 2020) A temperature switch will operate at a set process temperature, for example if a column is overheating then the temperature switch will switch at say a set temperature of 150°C and send a discrete signal to the PLC causing the process to maybe open a certain valve allowing cooling water into the column. Temperature switches have capillaries that are filled with either a hydraulic fluid or a silicone fluid that will expand when heated. This will then push up onto a bellows which at the set switching temperature will push up onto a microswitch changing the state of the temperature switch. This will then send the discrete signal to the PLC which will either be ON or OFF or 1 or 0. ✓

Could have included some diagrams

A pressure device that can be used to provide an analogue input to the PLC is a pressure transmitter. A pressure transmitter is a device that has been designed to measure pressure in liquids, fluids or gases. They are commonly used to measure pressure inside industrial machinery, vessels, tanks and columns in order to warn technicians and operators before an incident occurs through over pressuring. A pressure transmitter consists of many components, some of these components include a diaphragm, capacitor plates, reed switch assembly, sensing electronics (Wheatstone bridge), sensor module and an electronics board. The way in which a Pressure Transmitter works is when a pressure is applied to the transmitter itself, the applied pressure acts as a force on the diaphragm inside the pressure transmitter. The diaphragm then either expands or compresses depending on the applied pressure. This way in which the diaphragm expands, or compresses is dependent on a positive or negative pressure from the process. The sensing electronics are mounted on top of the diaphragm, so that when the diaphragm expands or compress, the resistance value changes. These resistors are connected in a standard Wheatstone bridge. The change in resistance is measured using a Wheatstone bridge. The bridge output is proportional to applied pressure. This value will then be converted into a 4-20mA signal which would be further converted into a 1-5V signal for the PLC to use. The 4mA and 1V is the zero point on the RTD's calibrated range whilst the 20mA and 5V is the span of the RTD's calibrated range. Depending on what the transmitter is used for (Shutdown or Indication) the operations control room will be able to see the pressure value. In Some types of pressure transmitters manufactures can use capacitance, inductance, conductivity, piezo electric

Why have you RTD in this part?

crystals etc in place of resistors. So, depending on the applied pressure the diaphragm expands or compress, then respective sensor parameter like resistance, capacitance, inductance and piezo electric crystal will change and it is proportional to the pressure. ✓

A pressure device that can be used to provide a discrete signal to the PLC is a pressure switch. Pressure switches are widely used in industry to automatically supervise and control systems that use pressurized fluids or gases. A pressure switch is a form of switch that is designed to monitor a process pressure and provide an output when a set pressure (setpoint) has been reached. A pressure switch closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall e.g. the switch may be set to trip on 2.5psi falling. A pressure switch does this by applying the process pressure to a diaphragm or a piston to generate a force which is compared to that of a pre-compressed range spring. The movement of this sensing element is used to actuate one or more switch contacts to indicate an alarm or initiate a control action which will potentially cause shutdown of specific equipment. When the switch has been triggered a discrete signal will be sent to the PLC which will either be ON or OFF or 1 or 0 which will change the state of the PLC and enable it to carry out a specified logic pattern usually a shutdown or an alarm of the equipment. ✓

Task 1. (b)

A stepper motor is an electromechanical device that converts electrical power into mechanical power. (Author, 2020). A stepper motors shaft rotates by performing steps by moving a fixed amount of degrees. (MPS Authour, 2021). Stepper motors have multiple coils that are organised in groups called phases which when energised, each phase in sequence will rotate, one step at a time. Stepper motors can be controlled so that precise positioning and speed control is capable. For this reason, stepper motors are commonly used in applications that require precision motion control. (Earl, 2014). The Stepper motor construction consists of a stationary part known as the stator and the moving part known as the rotor. On the stator there are teeth with coils wired around it while the rotor is a permanent magnet or a variable reluctance iron core. The permanent magnet that aligns with the magnetic field generated by the stator circuit enables the motor to have a good torque as well as a detent torque. This means that the motor will resist, even if not very strongly, to a change of position regardless of whether a coil is energized. (MPS Authour, 2021). To start the stepper motor, one electromagnet is given power, which makes its gear's teeth magnetically attracted to the electromagnet's teeth. At the point when the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet which means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one and from there the process is repeated. (Author, 2020). This is done in steps and when a number of steps have been achieved that is one full rotation of the motor. There are three main types of stepper motors, these include: ✓

- Permanent Magnetic Stepper
- Hybrid Synchronous Stepper
- Variable Reluctance Stepper

Are any of your reference direct quotes and if so they should be in quotation marks.

The more common type out of the three is the Permanent magnet stepper motor. Figure 1 shows a permanent magnet stepper motor. ✓

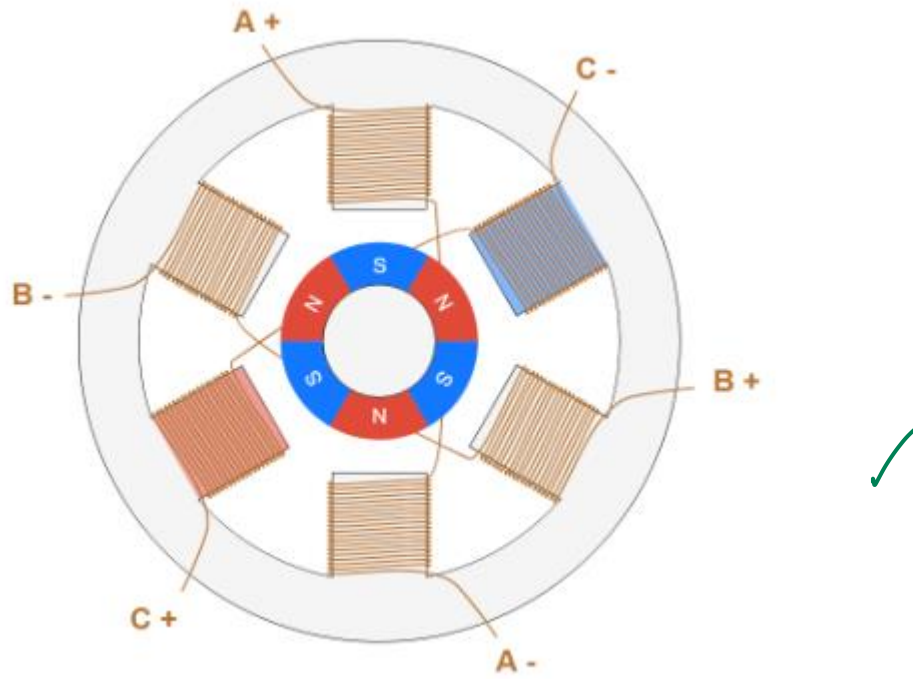


Figure 1 - Shows a Permanent Magnet Stepper motor

Task 2 – SCADA (Supervisory Control and Data Acquisition)

Task 2.

SCADA or Supervisory Control and Data Acquisition is a system of software and hardware elements that enables industrial and commercial companies to control processes locally or at specific remote location allowing them to monitor, gather, and process real-time data as well as recording the trends and saving them into a log file. (Inductive Automation, 2018). SCADA systems are used in many industries such as

- Oil and Gas
- Power/Energy
- Water and Waste Water
- Food and Drink
- Manufacturing
- Recycling
- Pharmaceutical ✓

With SCADA the control operator or trained personnel is also able to directly interact with devices such as transmitters, sensors, control valves, pumps, motors, and more through human-machine interface (HMI) software. (Inductive Automation, 2018). Human-Machine Interfaces or HMI's allows personal computers to display PLC variable values and has the potential to turn every personal computer into a Master Terminal Unit (MTU) where control operators can view process variables, change setpoints, and change the state of other process equipment such as control valves.

(Kuphaldt, 2008-2019). A HMI or Human-Machine Interface is a mixture of both hardware and software combined used to allow the control operator or trained personnel to communicate with the process machines, equipment and systems. HMI's are mostly used in industrial processes where a human-machine interaction is needed to either control or view the equipment or process . ✓

conditions in real time and monitor the machine inputs and outputs. HMI's typically give a visual representation of the equipment or process too enabling the control operator or trained personnel to get a visual example of what's going on so that it is made clearer to them. HMI's also have an alarm function as well as a trend history showing the correct equipment tag identification which is an important part of process control and maintenance fault finding. The main personnel that interact with HMIs are control operators, system integrators, and engineers, particularly control system engineers as HMIs are essential resources for these professionals, who use them to review and monitor processes, diagnose problems, and visualize data. (Inductive Automation, 2018). By using the HMI, the control operator can give instructions to the machine which allows a series of functions/sequences to be carried out. (Ashlin, 2020). An example of where a SCADA system would be used is at a refinery FCCU where slide valves are an essential piece of equipment that need to be monitored carefully. At the site of the slide valve location a HMI can be found, this gives the plant operator and maintenance workers that are trained to use it the option to access trends, slide valve equipment readings and any alarms that are outstanding. This means that they can diagnose any

What does FCCU stand for?

problems with the slide valve. The HMI also gives the slide valve position reading which is critical for the FCCU to run correctly and safely. The control operator will also be able to see the same readings, trends and alarms as the HMI through the use of the SCADA system but will be able to adjust the valve position if required. A PLC is also integrated into this system so that if the valve goes into an abnormal condition, then the PLC can identify the fault and will carry out the valve shutdown sequence which is used to help shutdown the unit fast and effectively. ✓

Task 3 – Instruction List

Task 3.

Figure 2 shows the ladder logic instruction list for a car barrier system.

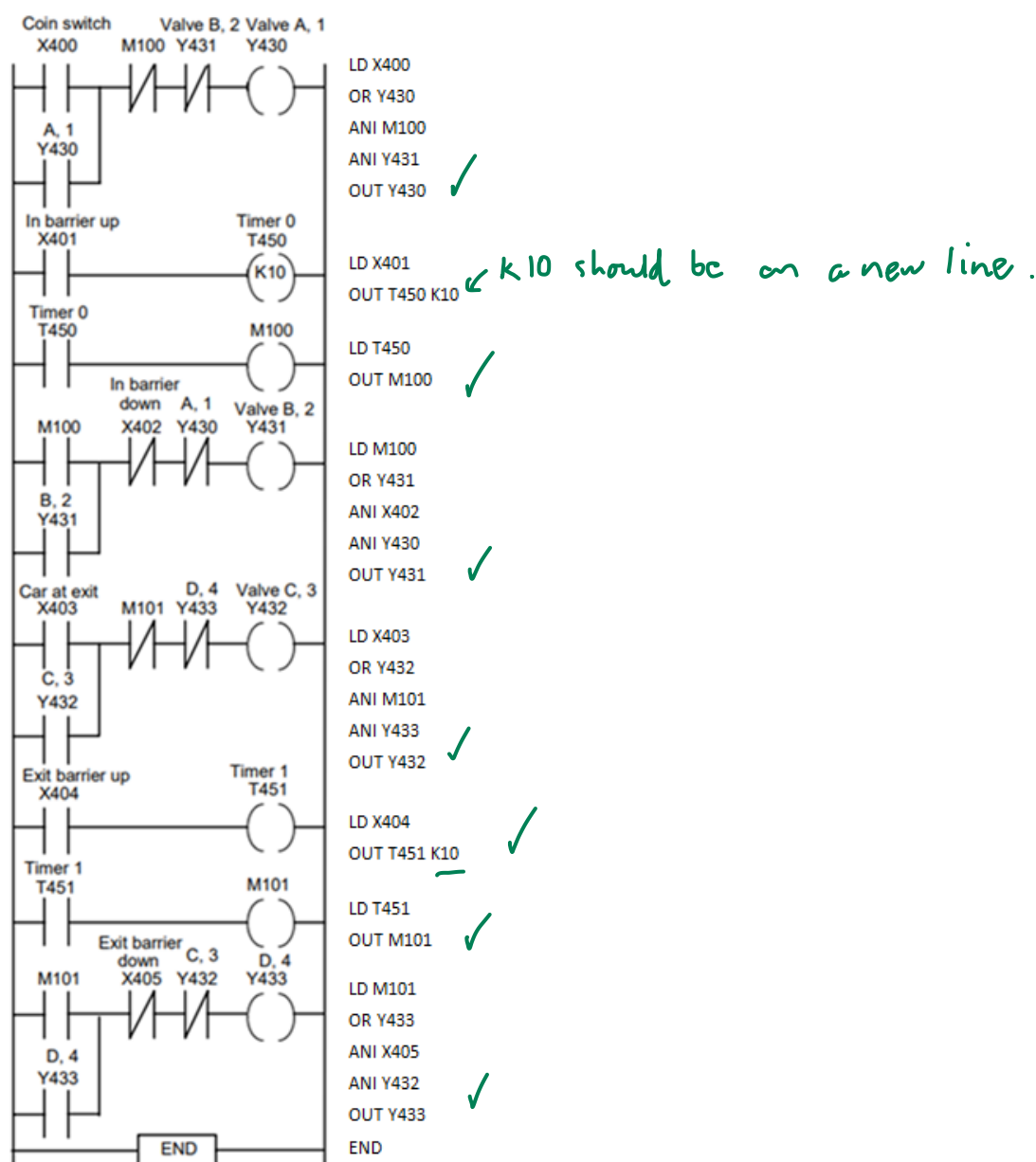


Figure 2 - Shows the Ladder Logic Instruction List

Task 4 – Temperature Alarm Panel

Task 4.

Figures 3 and 4 shows the program when the temperature device is between 0-25°C. It can be seen that the blue lamp is lit when the temperature device is between 0-25°C.

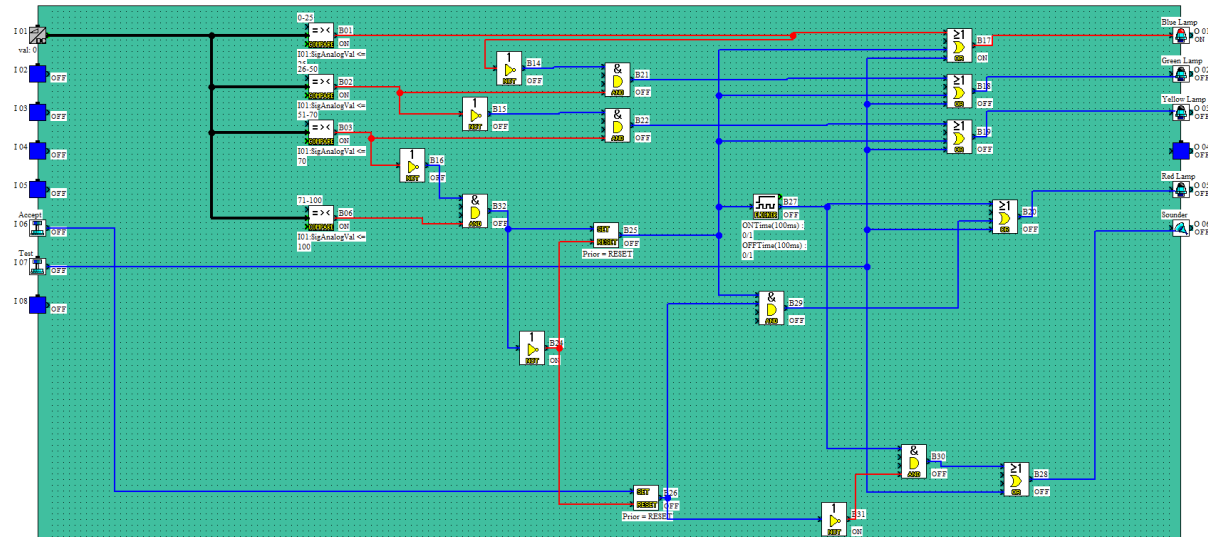


Figure 3 - Shows the program between 0-25°C

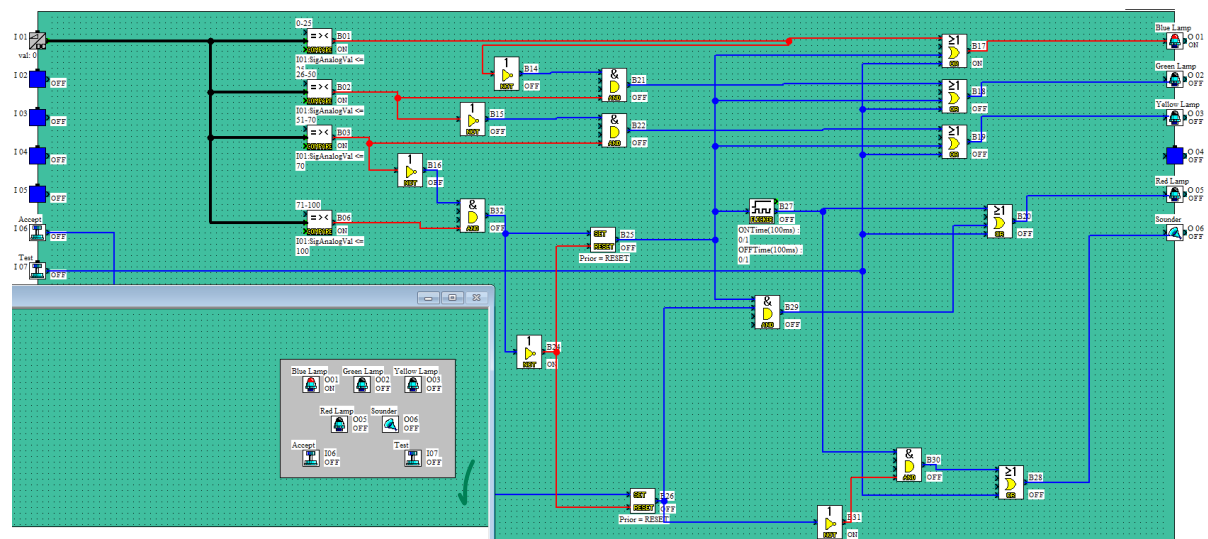


Figure 4 - Shows the HMI Screen between 0-25°C

Difficult to see your HMI.

Figures 5 and 6 shows the program when the temperature device is between 26-50 °C. It can be seen that the green lamp is lit when the temperature device is between 26-50 °C.

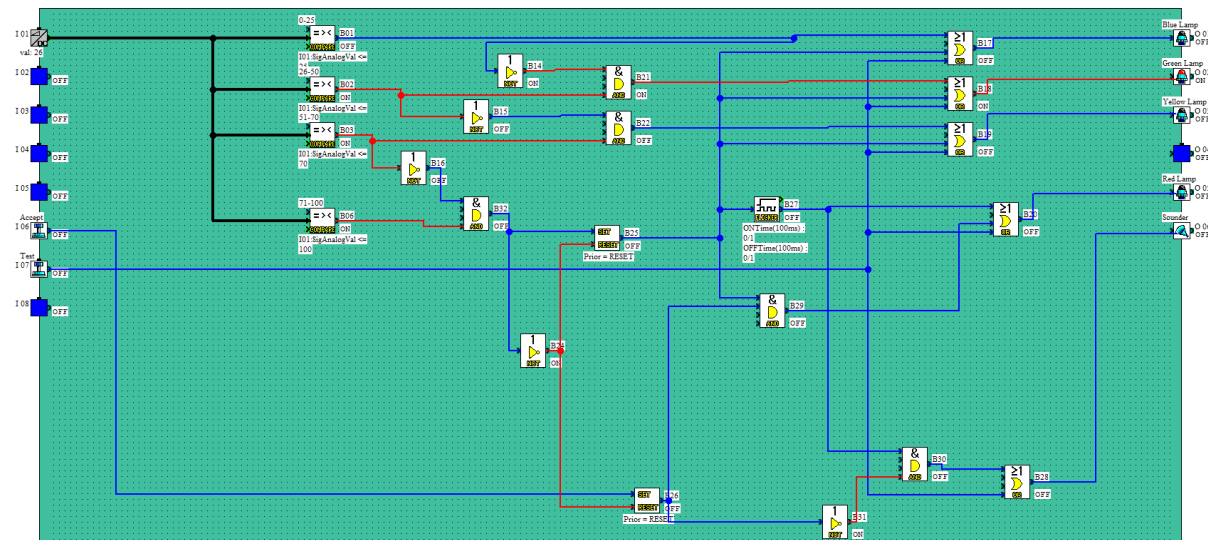


Figure 5 - Shows the program between 26-50°C

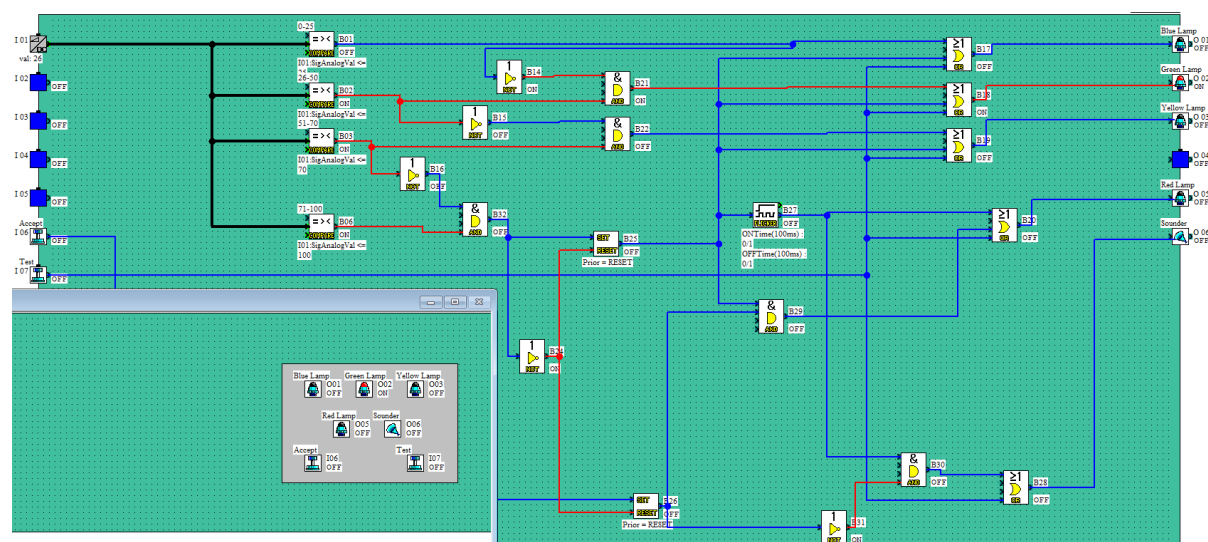


Figure 6 - Shows the HMI Screen between 26-50°C

Figures 7 and 8 shows the program when the temperature device is between 51-70 °C. It can be seen that the yellow lamp is lit when the temperature device is between 51-70 °C.

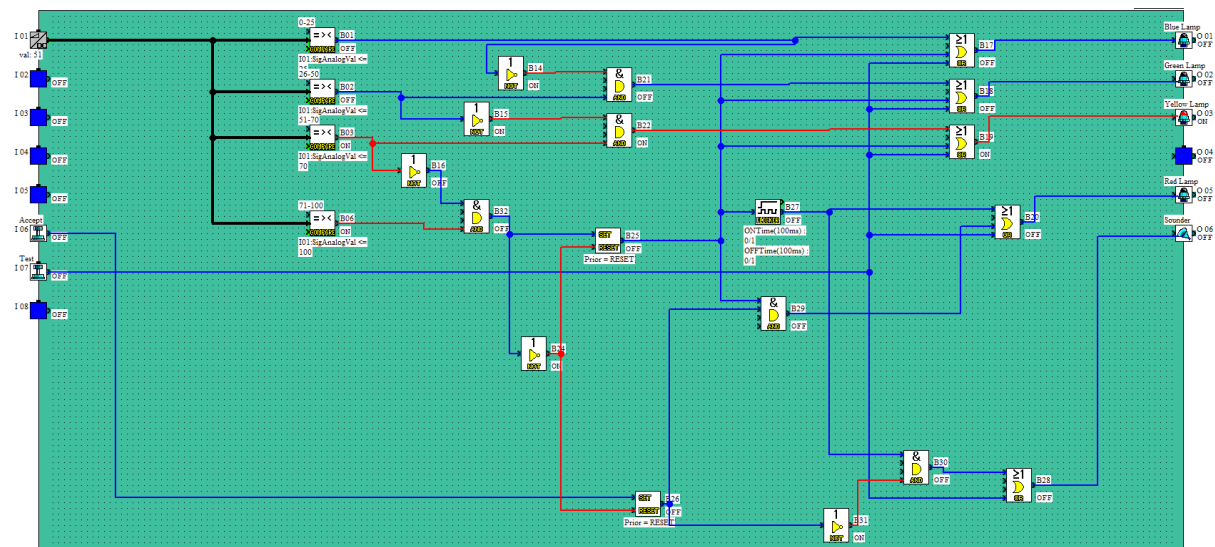


Figure 7 - Shows the program between 51-70 °C

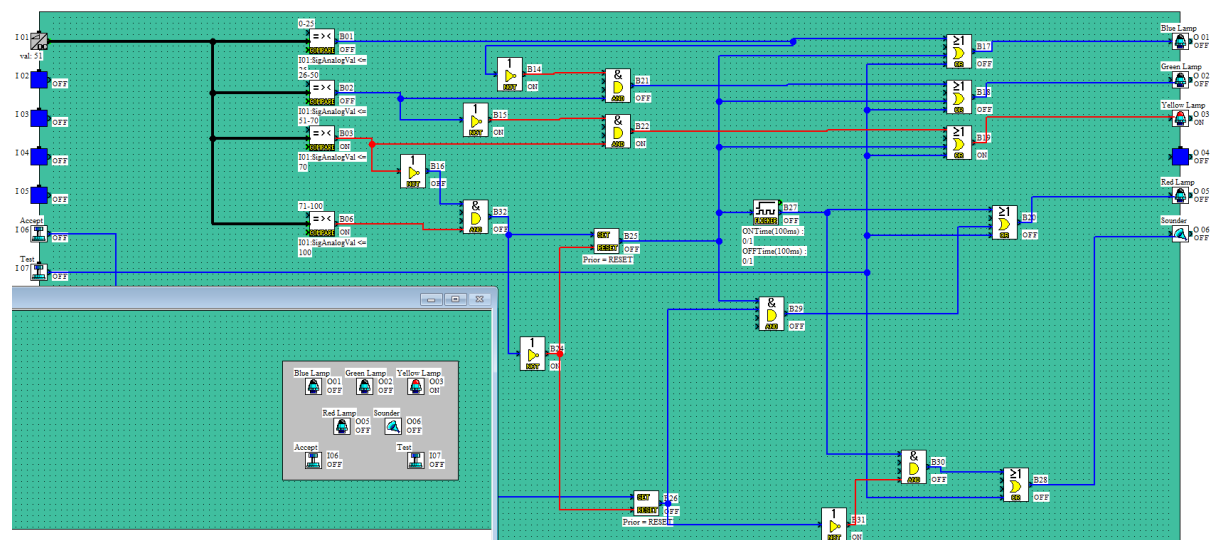


Figure 8 - Shows the HMI Screen between 51-70 °C

Figures 9 and 10 shows the program when the temperature device is between 71-100°C. It can be seen that the all lamps are lit and the sounder is on when the temperature device is between this temperature range.

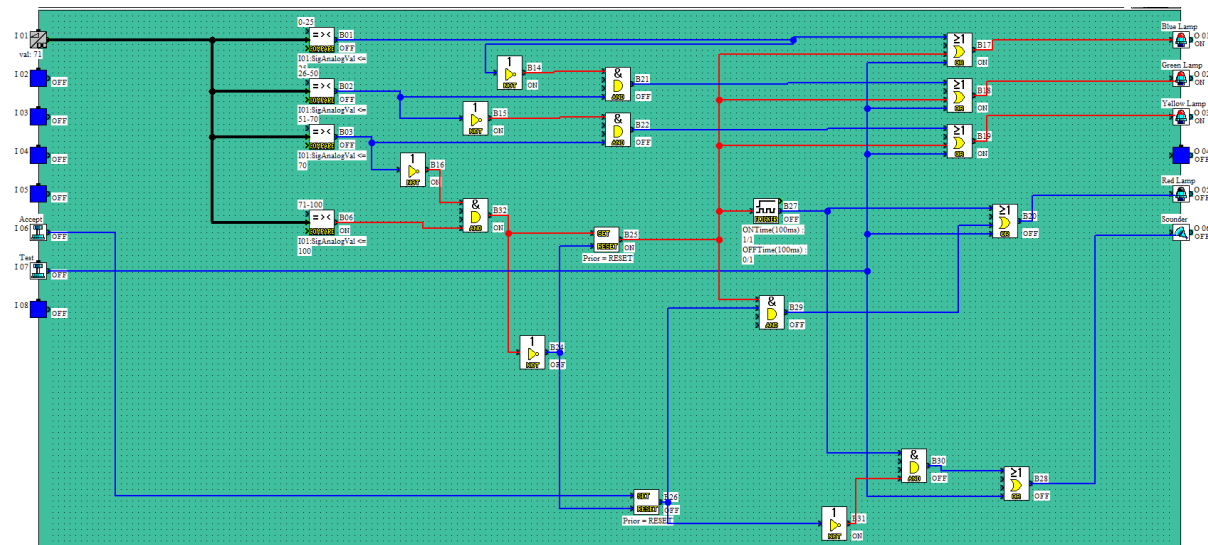


Figure 9 - Shows the program between 71-100°C alarms OFF

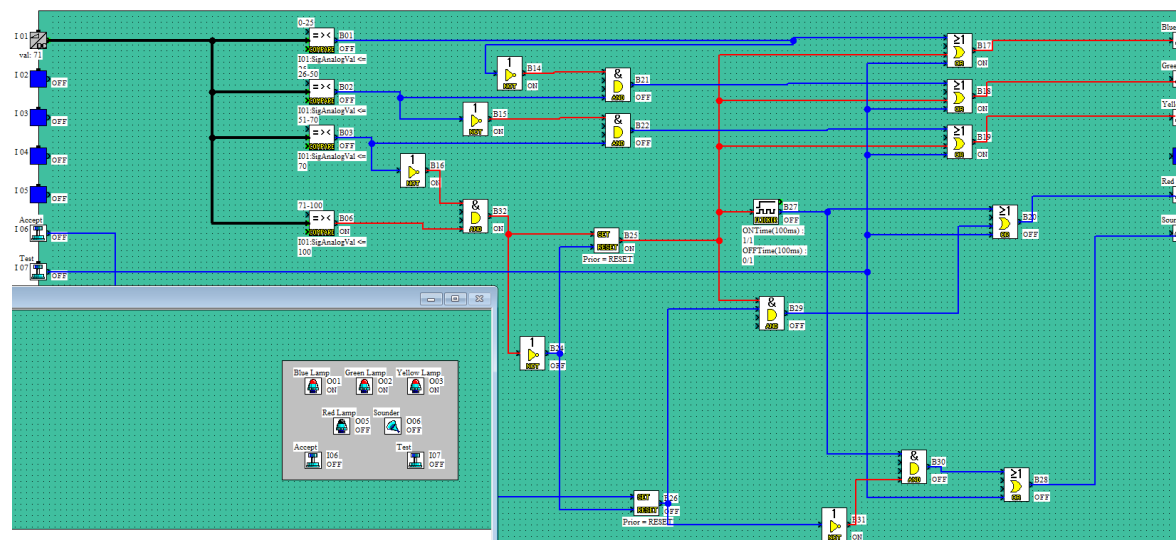


Figure 10 - Shows the HMI Screen between 71-100°C alarms OFF

The screenshot displays a complex PLC Ladder Logic program for a traffic light control system. The program is organized into several rungs, each representing a different logic function. Key components include:

- Inputs:** Accel (I 0.0), Test (I 0.1), and various sensor outputs (Q01-Q06) are used as inputs to the logic.
- Logic Blocks:** The program utilizes numerous logic blocks for comparison (e.g., $\geq$, $\leq$, $\neq$), timing (e.g., ONTime, OFFTime), and output control (e.g., Set, Reset, Pulse).
- Outputs:** The program controls six outputs: Blue Lamp (Q 0.1), Green Lamp (Q 0.2), Yellow Lamp (Q 0.3), Red Lamp (Q 0.4), Red Lamp (Q 0.5), and Sounder (Q 0.6).
- Interlocks:** The logic includes interlocking mechanisms to ensure that only one lamp is active at a time, preventing conflicting signals.

Figures 13 and 14 shows the program when the temperature device has been accepted and is between 71-100°C. It can be seen that the all lamps are lit and the sounder has been accepted and is off when the temperature device is between this temperature range and has been accepted.

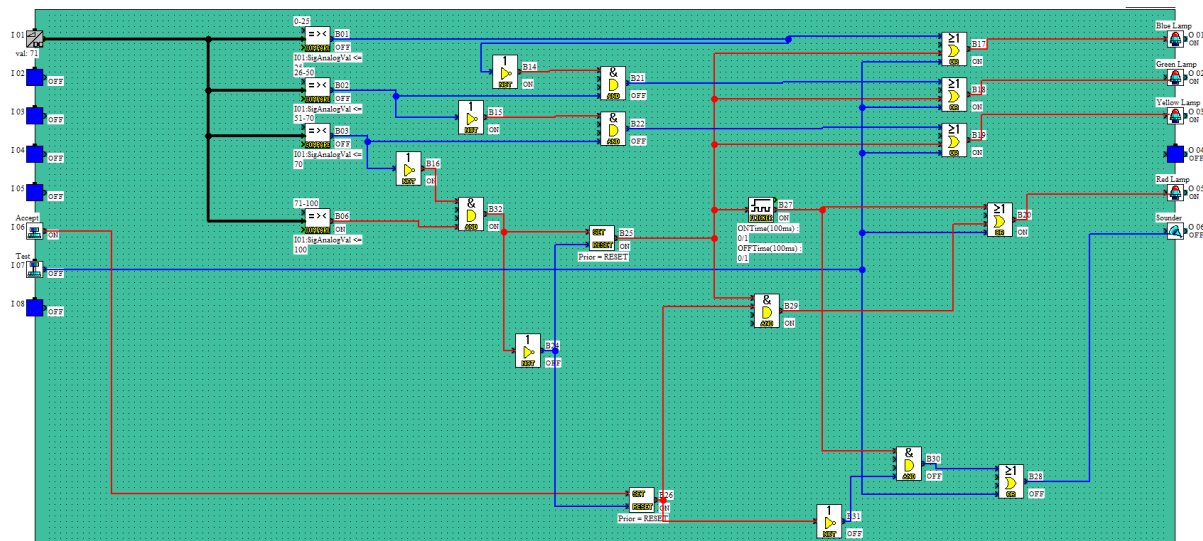


Figure 13 - Shows the program between 71-100°C when accepted

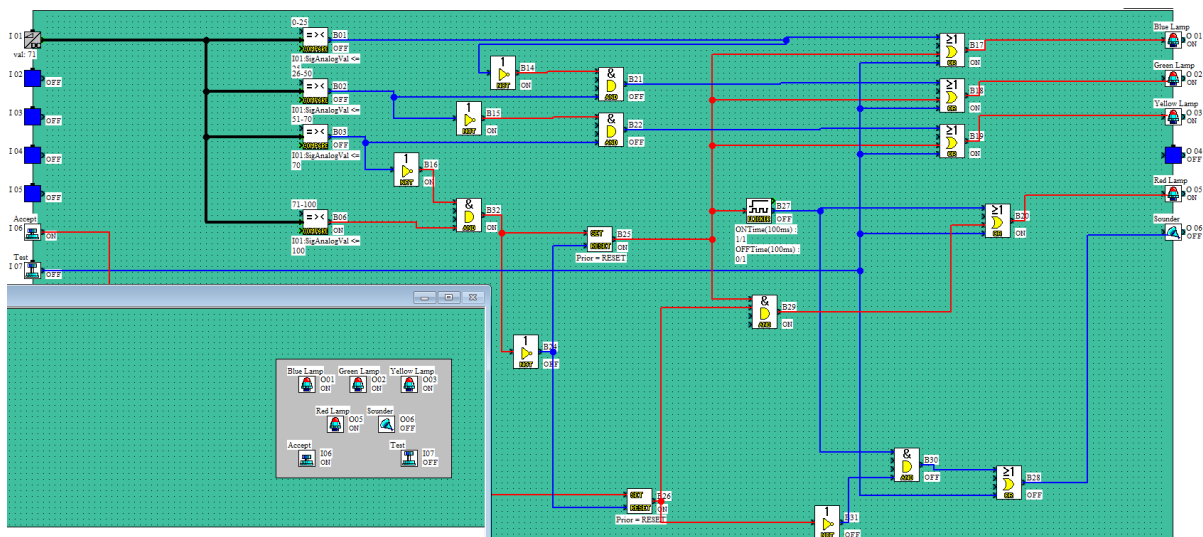


Figure 14 - Shows the HMI Screen between 71-100 °C when accepted

Figures 15 and 16 shows the program when the lamp test button has been pressed. It can be seen that all lamps are lit and the sounder is on which is correct.

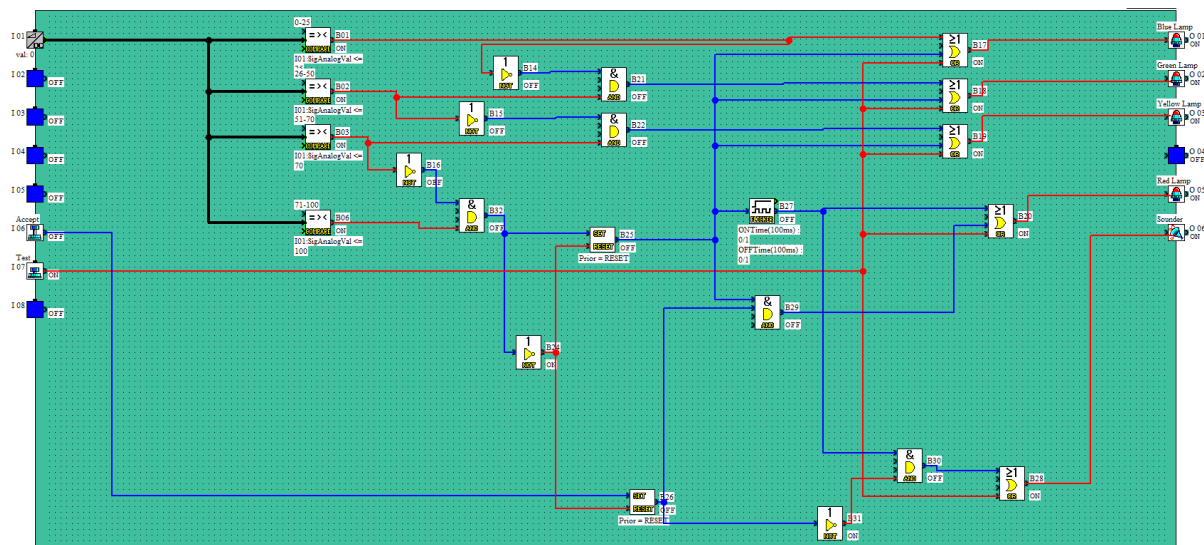


Figure 15 - Shows the program lamp test

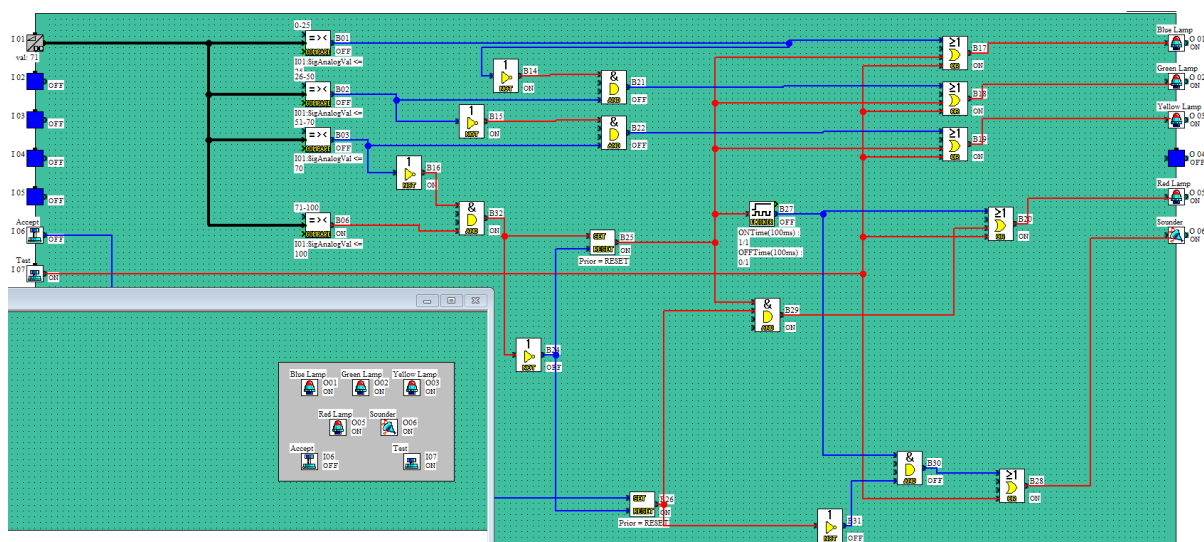


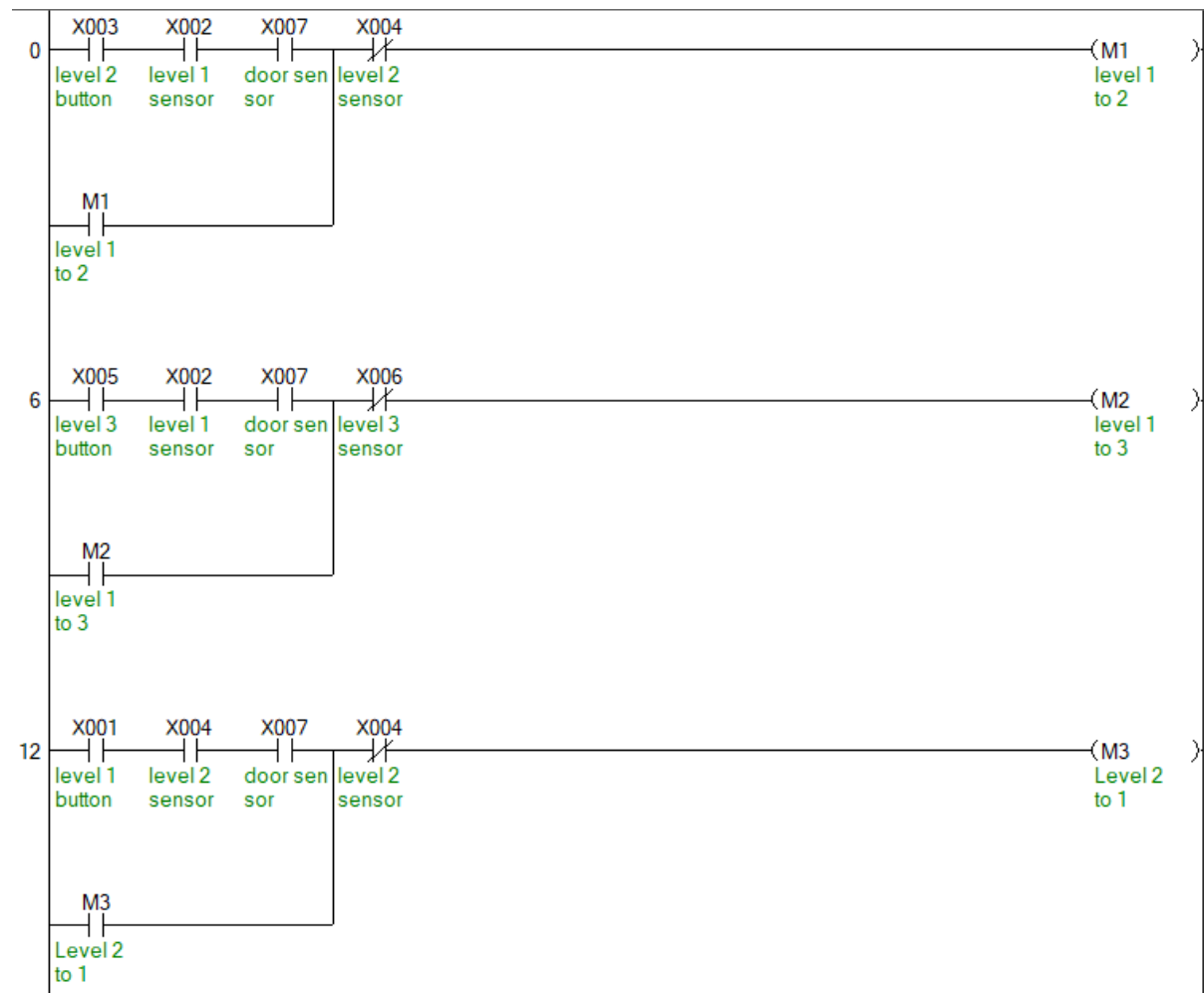
Figure 16 - Shows the HMI lamp test

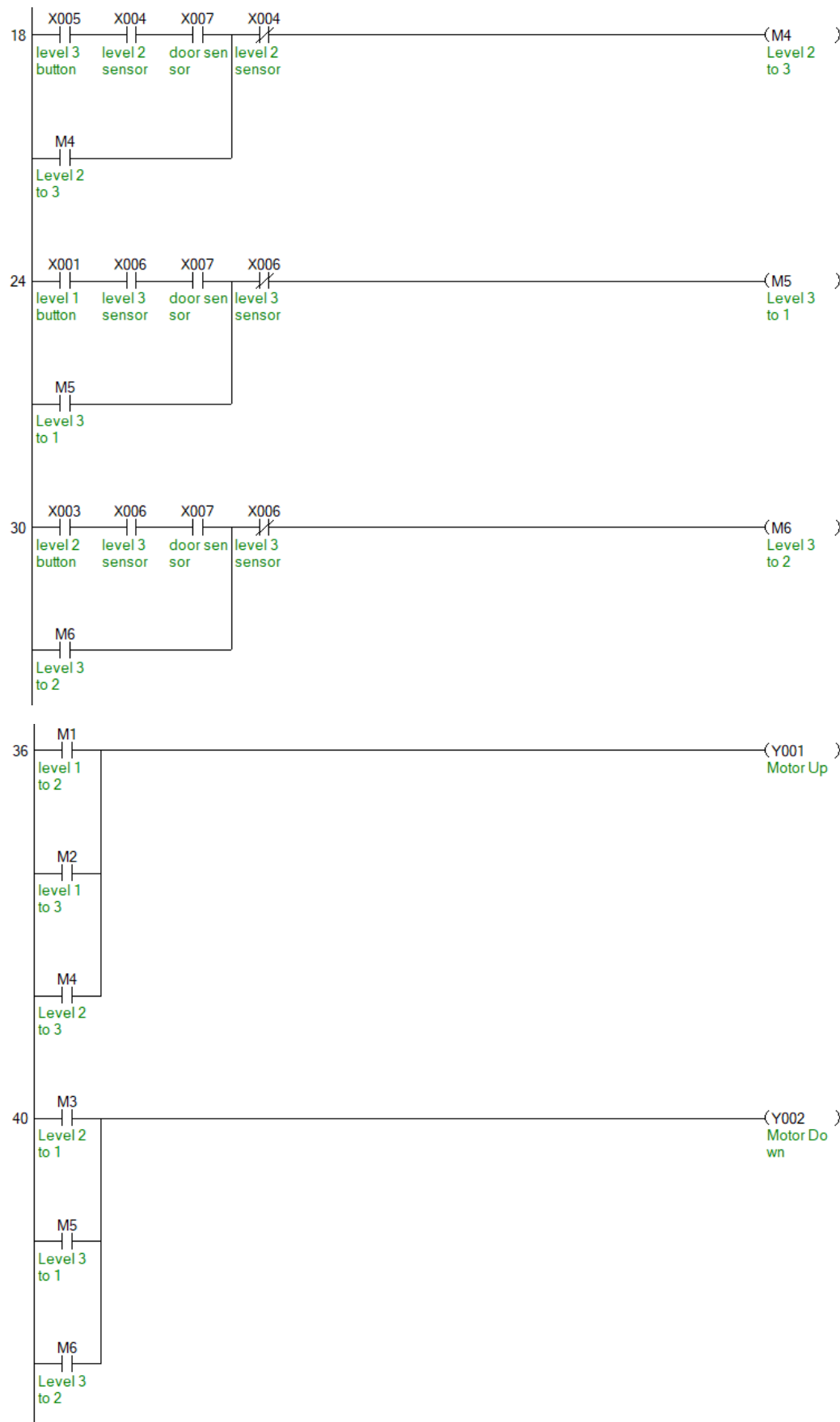
You have produced a fully functional program but in places it is difficult to follow.

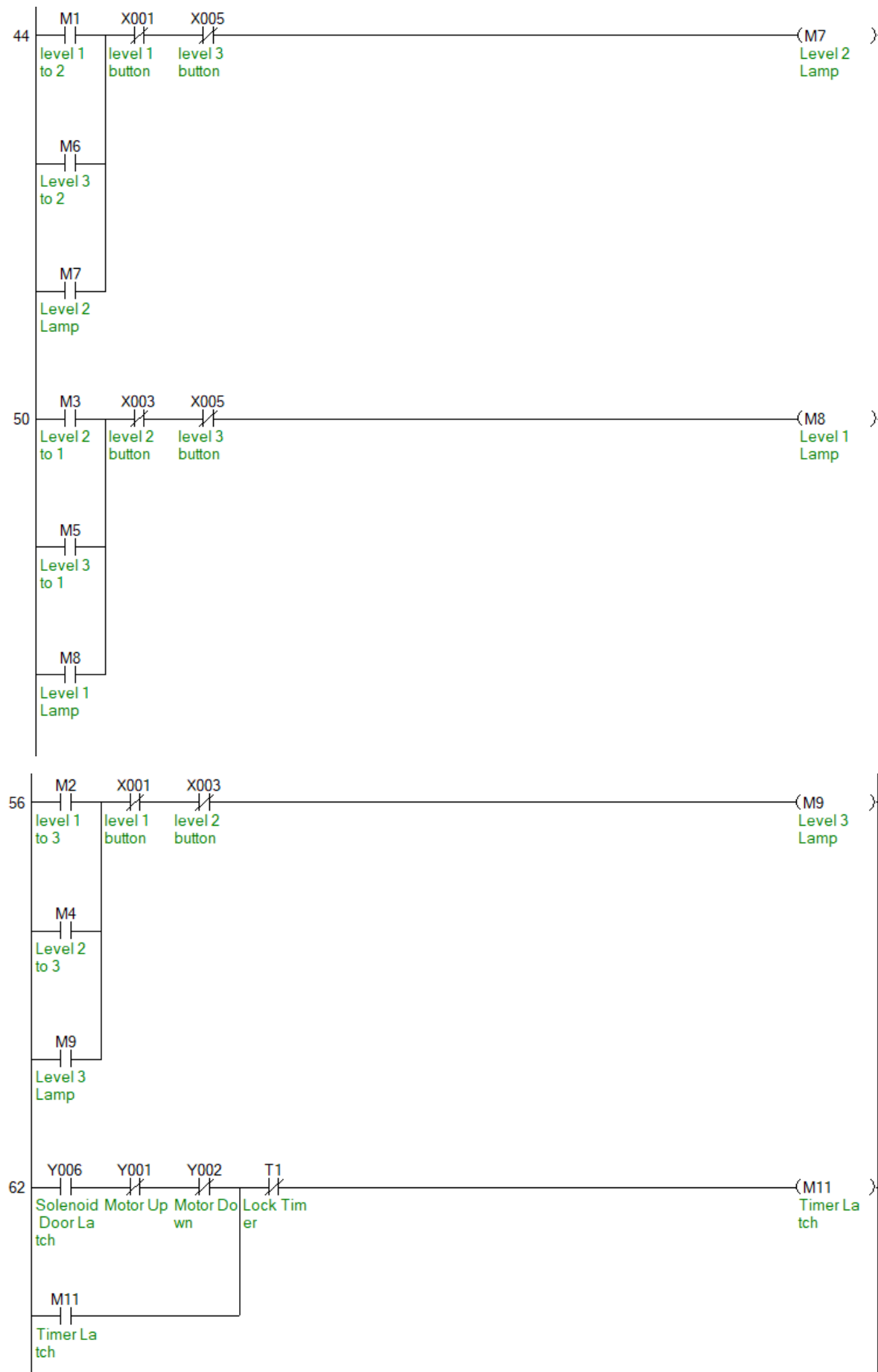
Task 5 – Programming Problems

Task 5.

Figure 18 shows the ladder logic for the lift system. As seen in figure 18 the movement of the lift to each level can be seen in lines 0, 6, 12, 18, 24, 30. The motor up and down logic can be seen in lines 36 (motor up) and 40 (motor down). The level indication lamps are found on lines 44 (level 2 indication lamp), 50 (level 1 indication lamp) and 56 (level 3 indication lamp). The door lock and door lock timer are found on lines 68 and 73, these are logic specified for the door lock function and timer whilst the timer latch is found on line 62. The solenoid door latch is found on line 77 which latches the door and allows the lift function to take place and the open door lamp is found on line 79 which indicates that the door has been opened. ✓







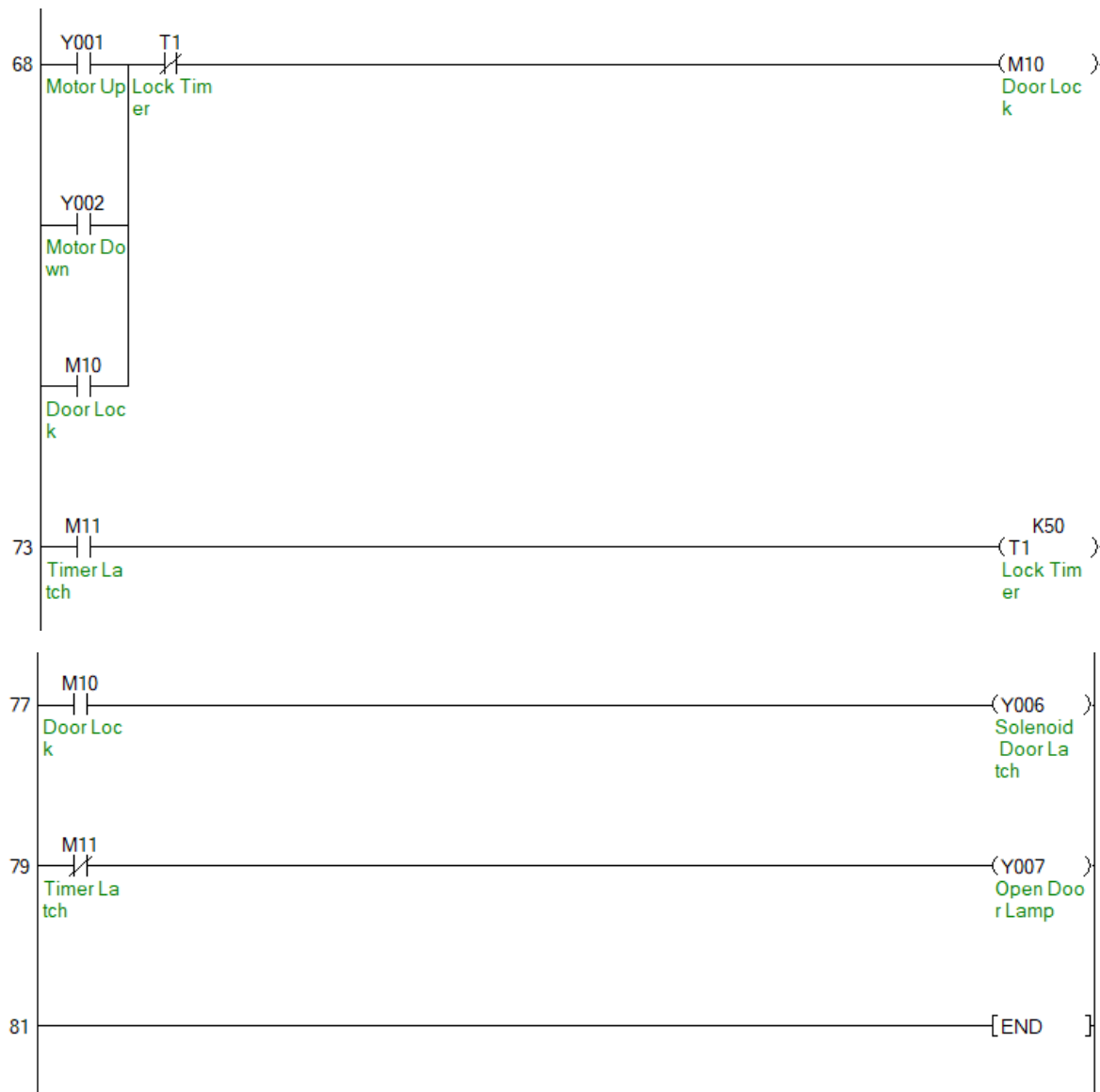


Figure 17 - Shows the Ladder Logic for the Lift System

Very good program that was fully functional.

Are there any improvements you would make to the system?

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