

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Byron Grey	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering & Instrumentation Engineering		
Module:	Programmable Logic Controllers		
Module code:	PCEE4005	Contribution to Overall Module Assessment (%):	50%
Lecturer:	Jason Pointer	Internal Verifier:	Nigel Richards
Assignment Title:	Introduction to PLC Systems & Program Design	Word count (or equivalent):	2000
Submission deadline:	11/01/24	Return date of provisional marks & written feedback:	25/01/24
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

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

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	15	9.3
Engagement with a wide range of literature sources, including sources retrieved independently. Generally sound referencing, with very few inaccuracies.		
2. Knowledge and Understanding Skills	30	19.2
Task 1 achieved 50%. Task 2 achieved 72%, Task 3 achieved 70%. Excellent knowledge of the basic underlying concepts and principles of the work required for Task 2 and 3. Showed basic knowledge and understanding of the requirements of Task 1.		
3. Cognitive and Intellectual Skills	5	2
Limited evaluation of the underlying concepts and principles applied to the construction of the auto drill system.		
4. Practical Application Skills	40	32.8
Task 4 achieved 80%. Task 5 achieved 84%. An excellent application of the 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.		
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)

Up to 1 week late (40% Max)

Over 1 week late (0%)

70%



Programmable Logic Controllers

Assignment 1

HNC Electrical and Electronic Engineering

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Task 1

a)

When looking into the different types of PLC's (Programmable Logic Controller) there are two types to choose from, these are the Unitary PLC (or single box/brick) and the Modular/ Rack mounted PLC. The unitary PLC, shown in figure 1 are a compact unit that has the input/output modules, processing unit and all other necessary components integrated within a single housing. Bolton states that "Such PLC might have 6, 8, 12 or 24 inputs and 4, 8 or 16 outputs and a memory that can store some 300 to 1000 instructions." (Bolton, 2009, P.23). If more inputs or outputs for more complex programs are needed, some models of unitary PLC will accommodate for input/output boxes to be able to extend the capacity.



Figure 1- Unitary PLC Example (RS Components,2024)

The specifications that define the Unitary PLC is the fact it come in one singular unit and will only have a limited number of inputs, outputs and memory available for the program, this makes it perfect for small programmable controllers. Some applications of where this type of PLC will be used include;

- Machine control
- Automated Systems
- Heating/Ventilation systems
- Water Treatment
- Food Processing
- Pumping Stations

The second type of PLC that needs to be considered when choosing is the Modular/ Rack mounted PLC. For “Systems with larger numbers of inputs and outputs are likely to be modular and designed to fit in racks.” (Bolton, 2009, P.23), This is due to the modular PLC’s combining separate modules for processors, power supplies I/O modules and communication interfaces to accommodate more complex systems that require the additional inputs, outputs and memory. These PLC’s will be installed on rails within cabinet as shown in figure 2. This will allow for flexible configuration and easy replacement or expansion of components based on the requirements of the system.

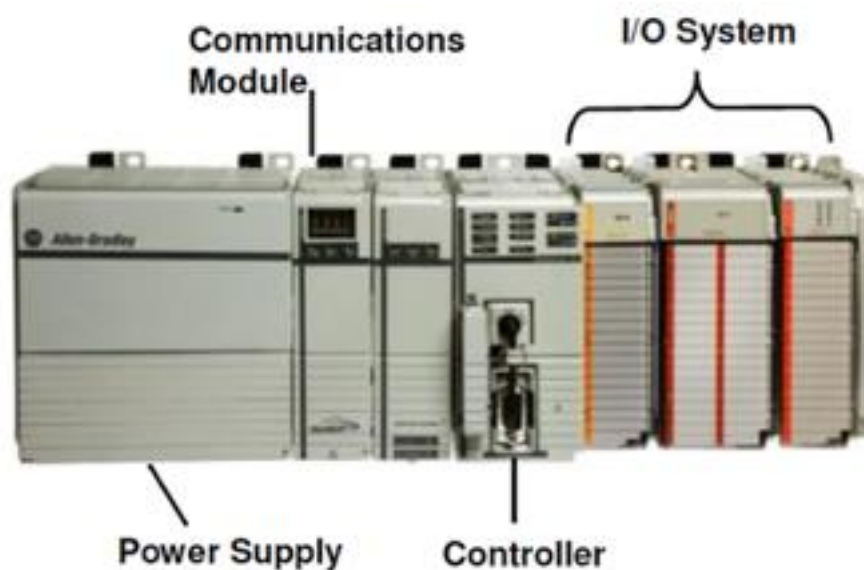


Figure 2- Modular PLC Example (R.Phillips, 2022)

The specifications that define the Modular PLC is the fact it comes as singular modules for each function of inputs, outputs, communication and processor modules that allows it to be interchangeable to suit the system it is required for. These PLCs also allows for different types of Inputs/Outputs as it accommodates for analog and digital inputs and to be transmitted to relay and transistor outputs to work alongside other equipment such as actuators and sensors. Some applications for this type of PLC include;

- Manufacturing Automation
- Process controls
- Packaging Systems

- Building Automation
- Petrochemical Industry
- Renewable Energy Systems

The considerations that need to be assessed when selecting a PLC type all depends on the specific requirements of the application, however these requirements can be broken down to factors that include System Complexity, Scalability, Cost, Installation Space, Maintenance and Programming Requirements. These factors will need to be assessed in detail to make sure the PLC can meet the requirements for the automation system. ✓

b)

The internal architecture of a PLC is shown in figure 3 and consist of central processing unit, battery/ power supply, user program RAM, system ROM, data RAM and an input/ output unit. To process and control the operations of the PLC the CPU (central processing unit) is used as it contains the systems memory, microprocessor and the input/ output circuitry. The clock in the PLC is used to provide a frequency of typically between 1 and 8MHz to control the operating speed and allow the elements within the system to work in synchronization. If the PLC has a power supply and not a battery it will be used to convert the AC mains voltage into the required low DC voltage. To store the program within the PLC the memory unit will be used to control the actions that the microprocessor will need to exercise and to store the processed inputs, along with the outputs that have be created. ✓

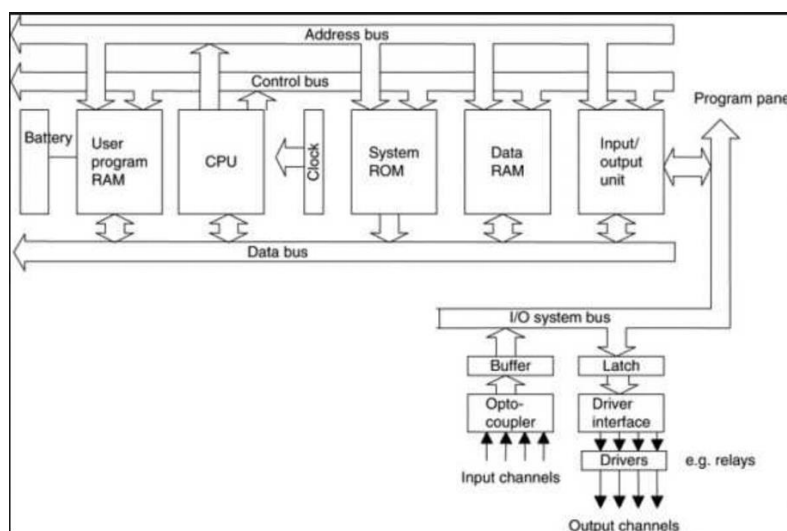


Figure 3- Internal architecture of a PLC (Bolton, 2009, P.19)

In figure 3 you can see buses linking everything in the PLC and these are used to send digital signals which contain information through the PLC. Bolton states “In the Physical sense, a bus is just a number of conductors along which electrical signals can flow. It might be tracks on a printed circuit board or wires in a ribbon cable.” (Bolton, 2009, P.19). All the buses within the PLC are used for different applications. The Address bus is used by the CPU to send location addresses for stored data that needs to be accessed. The CPU uses the data bus to send data between the constituent elements of the PLC. Internal control action signals from the CPU use the control bus to transfer information. The final bus is used for the input/ output ports and the input/output unit to be able to communicate and this is the system bus. ✓

Once the PLC is programmed to the appropriate requirements for the application it is being used for it will operate using 3 steps, these are inputs, execution of the program and outputs. The first step is the PLC will gather data from the signals from the inputs, these could be sensors, start/stops or switches. These inputs are then evaluated through the stored program of the PLC which will then decide what signal and information to send to the outputs, so that the outputs can perform the correct outcome for the application. These outputs could be to close/open a valve, move an object or even turn a motor on/off. ✓

c)

To be able to protect the PLC’s input/output interfaces from potential electrical fault conditions and overcurrent there are many methods that could be used, these include;

- Surge protection
- Overload protection
- Isolation barriers
- Current limiting
- EMI (electromagnetic Interference) Filter

Figure 4 shows an example of a surge protection device which can be installed in line with the I/O signals to suppress any voltage spikes that could occur from EMI, lightning or any other events that cause a spike in voltage. When there is any

unwanted voltage the surge protection device will lessen the supply voltage or shorting to ground back to a safe standard.



Figure 4- Surge Protection Device (Hager UK, 2024)

Isolation barriers such as transformers or optocouplers can be used to provide a separation between the PLC and field device to protect the PLC from any faults that might occur from the field device. For overload protection a Zener barrier is used to limit/ clamps the over voltage to become a safe voltage so no damage can occur on the PLC's I/O circuits, an example of a Zener barrier is seen in figure 5.



Figure 5-Zener Barrier (RS, 2024)

Alongside the Zener barrier a current limiting resistor or fuse can be used to protect the PLC's input/output interfaces. These can be used in series with the I/O signals to limit the current to the PLC in the case of an increased current flow or short circuit. When a PLC is located around other equipment that can cause damage through high levels of radiation emitted, an EMI (electromagnetic Interference) Filter will be used. This is to not allow any current to be absorbed through wires and cabling, as this could damage and interfere with the PLC's power supply or signals but allow the normal current to flow as desired.

*These are external devices
you should be talking about
internal methods - opto isolators*

Task 2

a)

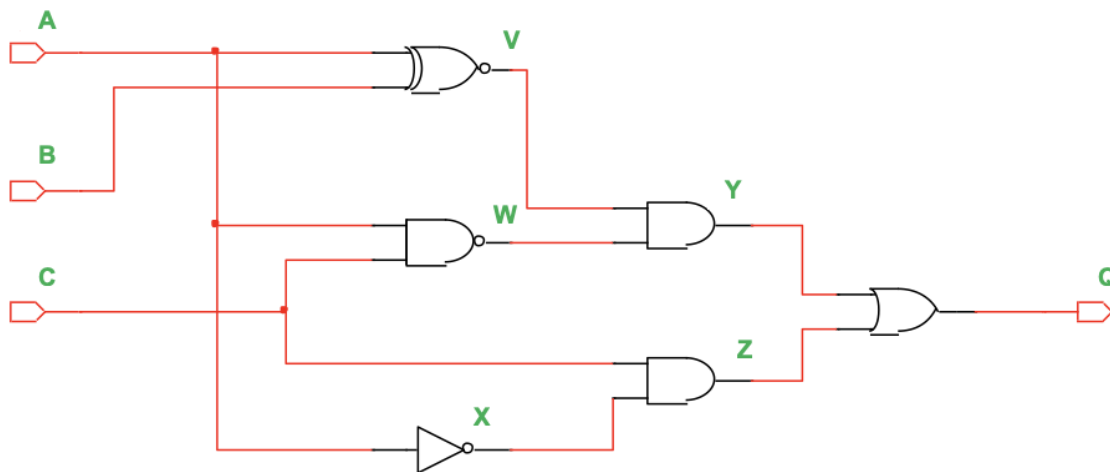


Figure 6- Logic Gate Circuit

Inputs			Gate Outputs					Output
A	B	C	V	W	X	Y	Z	Q
0	0	0	1	1	1	1	0	1
0	0	1	1	1	1	1	1	1
0	1	0	0	1	1	0	0	0
0	1	1	0	1	1	0	1	1
1	0	0	0	1	0	0	0	0
1	0	1	0	0	0	0	0	0
1	1	0	1	1	0	1	0	1
1	1	1	1	0	0	0	0	0

Table 1- Truth Table

Using the truth table, the Boolean expression is shown below.

$$Q = \bar{A}.\bar{B}.\bar{C} + \bar{A}.\bar{B}.C + \bar{A}.B.C + A.B.\bar{C} \quad \checkmark$$

Looking at the circuit above it is an over complicated system which can cause a lot of issues. The system should be simplified to reduce the number of gates and the number of different gates used as this can cause complex logical operations. Some of the issues that can occur with an over complicated system is that it could have propagation delays as the signal has to propagate through gates, it could also cause a higher manufacturing cost due to more gates typically meaning a larger chip size. $\checkmark$

b)

		BC			
A		00	01	11	10
	0	1	1	1	0
	1	0	0	0	1

$\checkmark$

From the Karnaugh Map, The Boolean equation can be simplified to;

$$Q = \bar{A}.C + \bar{A}.\bar{B} + A.B.\bar{C} \quad \checkmark$$

The Boolean expression can be converted into a ladder logic diagram for the circuit as seen in figure 7, which I have used Multisim software to produce.

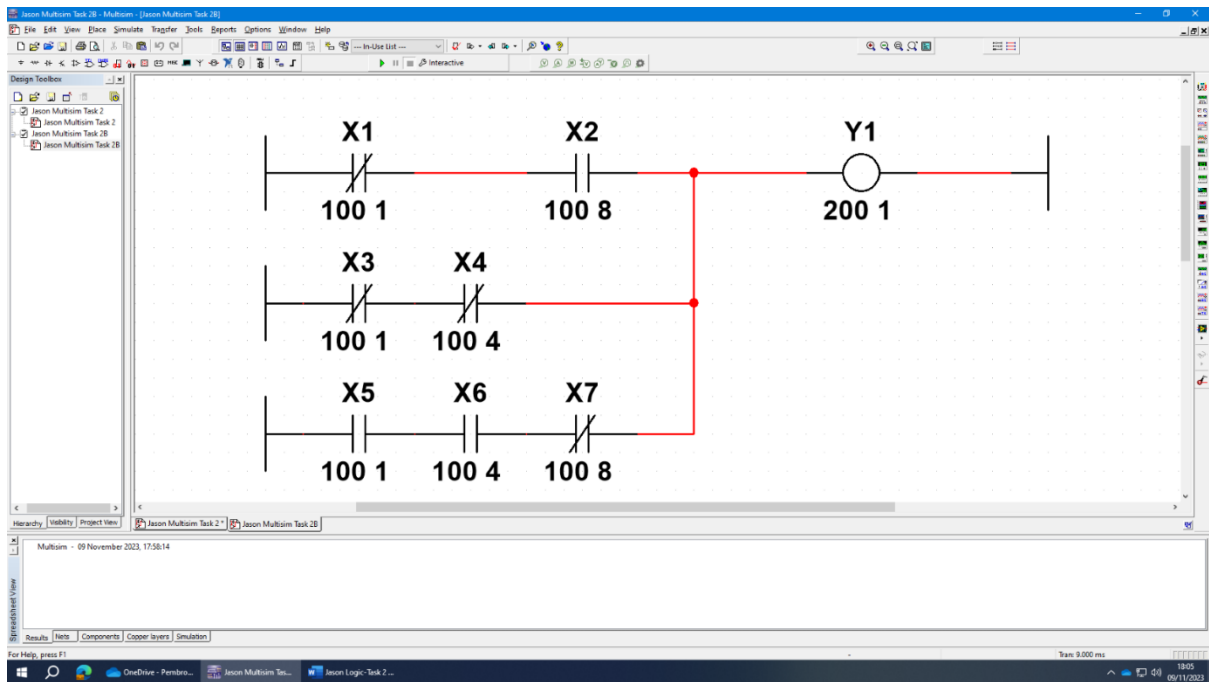


Figure 7- Ladder Logic Diagram for the circuit

Using the Multisim software, it can simulate the ladder logic design and confirm its function. Figure 8 shows the system built ready for it to begin the simulation to confirm its function.

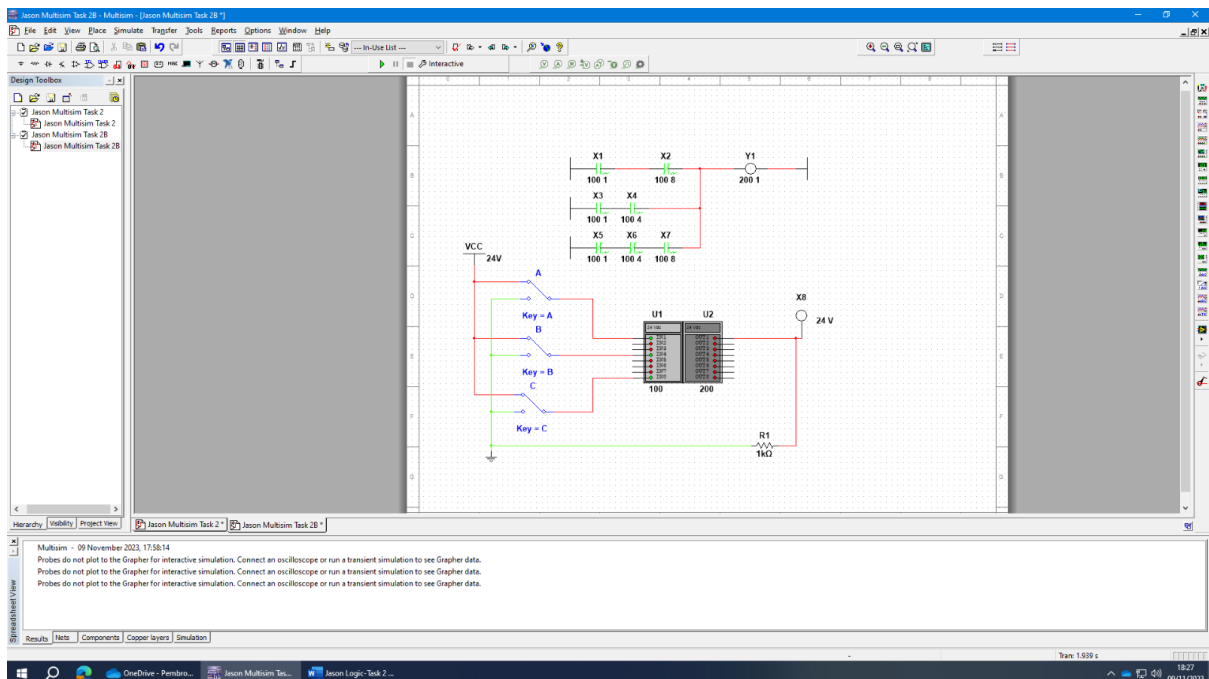


Figure 8- System Built in Multisim for simulation

The function tests that occurred during simulation on Multisim is the 8 possible inputs for the system and following the tests it confirmed that my truth table and my Ladder Logic diagram were correct. For example, when A, B and C gave the input 000 the output was high and the probe came on, as seen in figure 9. ✓

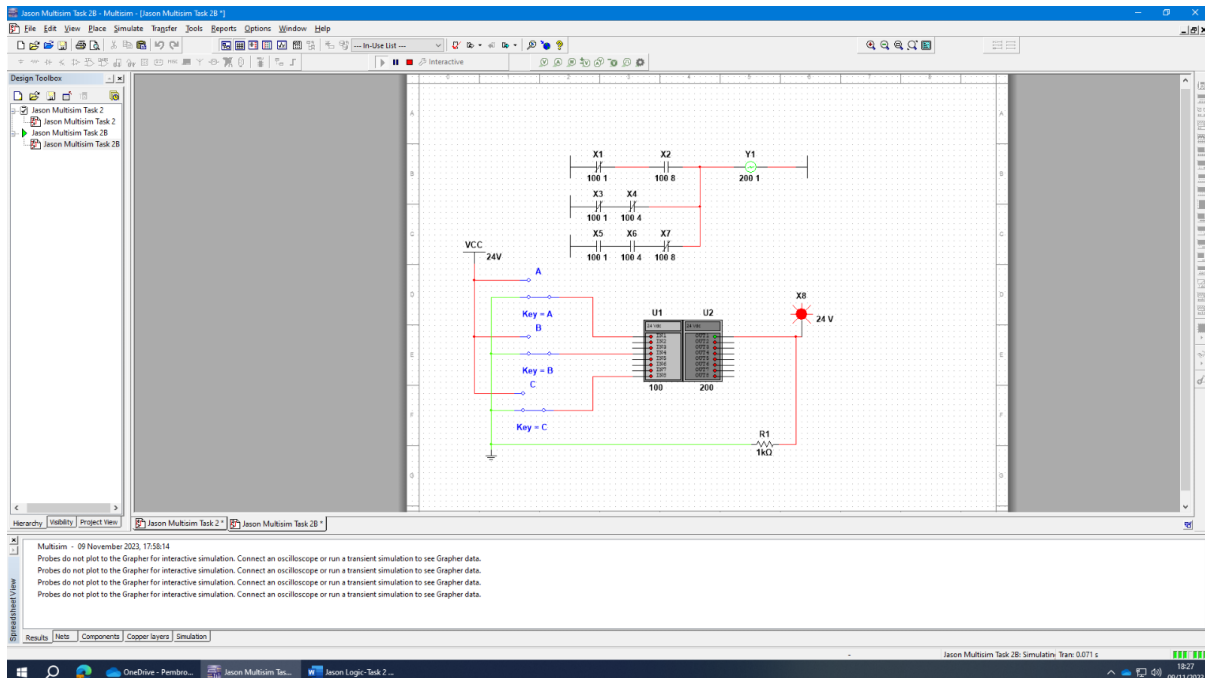


Figure 9- Function test for input 000

However, when A, B and C gave the input 010 the output was low and the probe stayed off, as seen in figure 10.

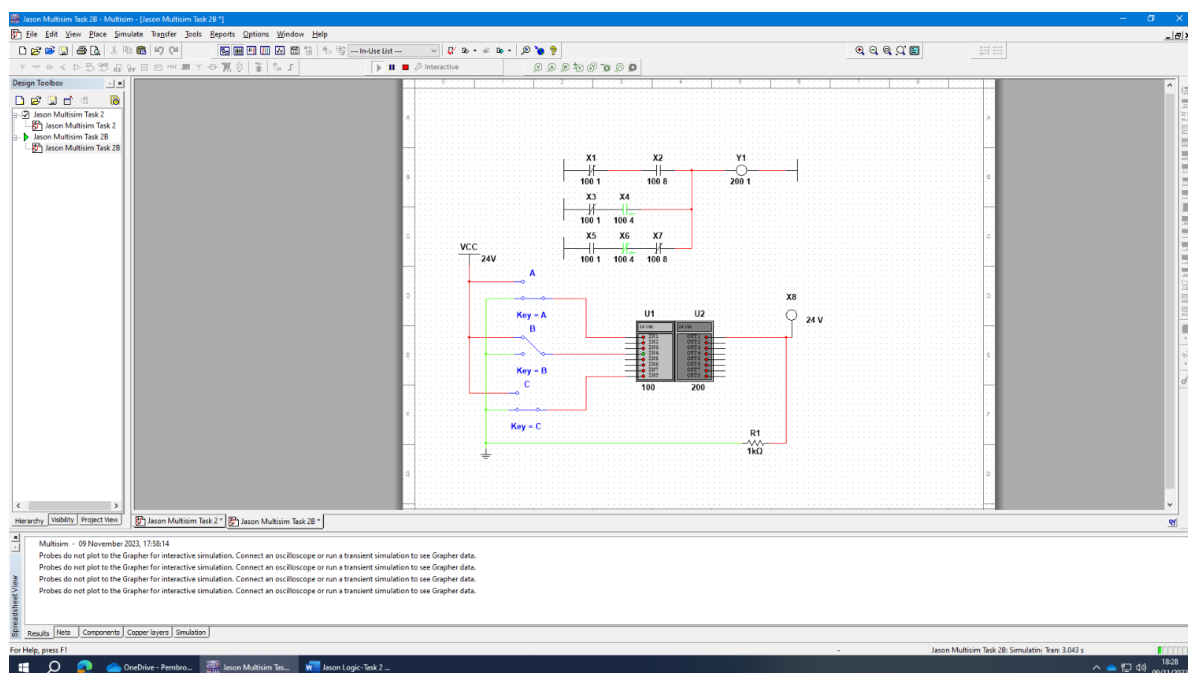


Figure 10-Function test for input 010

Task 3

a)

For many process operations timing elements will be used to allow the control task to operate to its requirements, for example this could be a motor starting and stopping at different intervals. To do this the PLC's will have built-in timing devices to allow the required operation to happen, these timers can come in 3 types, including;

- On-delay timer
- Off-delay timer
- Pulse timer

An on-delay timer is used within control systems to provide a delay in activation of a process or piece of equipment after a trigger has occurred to start the process.

Figure 11 shows the timing diagram and ladder logic of an on-delay timer and demonstrates as the input signal comes in it has a timing delay before the output is applied. To explain the ladder logic for an on-delay timer, Bolton states "The timer is like a relay with a coil which is energized when the input X400 occurs (rung 1). It then closes, after some pre-set time delay, its contacts on rung 2. Thus the output from Y430 occurs some pre-set time after the input X400 occurs."

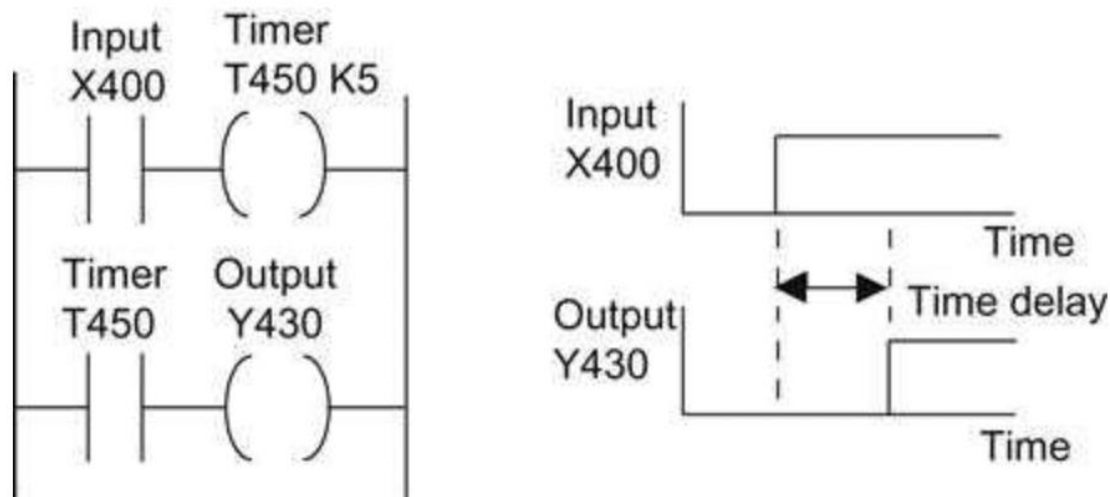


Figure 11- Timing diagram and ladder logic of an on-delay timer
(Bolton, 2015, P.177)

An off-delay is the opposite of the on-delay as once the trigger has been activated the process or piece of equipment will be on for a set period until it turns off. As seen

in figure 12 as the input signals changes from 1 to 0 the timer will start and once the timer is finished the output will change to 0 also. ✓

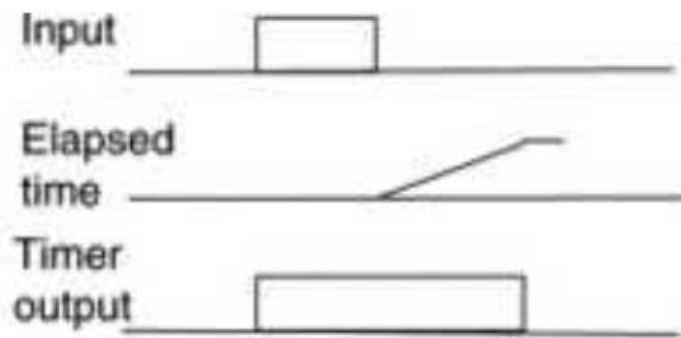


Figure 12- Timing diagram for an off-delay

Figure 13 shows the timing diagram for a pulse timer, which Bolton states is a “timer that gives an output 1 for a fixed period of time, starting when the input goes from 0 to 1 and switching back to 0 when the set time PT has elapsed”. Meaning once the trigger has changed the input to high the output will be high for a period and change back to low, no matter what the input does. ✓

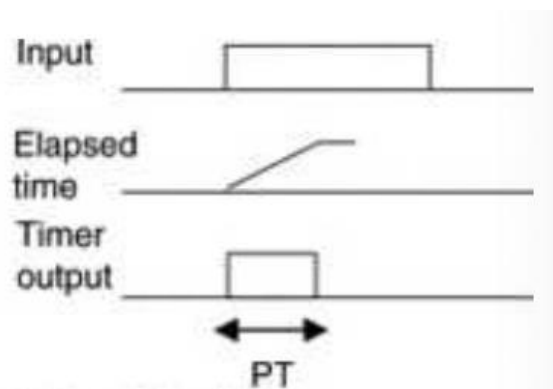


Figure 13- Timing diagram for a pulse delay

b)

With the use of these timers sequenced outputs and cascaded timers can be programmed to meet requirements of specific systems. To create sequenced outputs a ladder logic such as figure 14 will be made from timers stated above. Looking at the ladder logic if you have the first input as high, this will switch on output 1 and the timer for any associated contacts will start. Once the preset time is complete, in this case 5.5 seconds, output 2 will be high. To summaries Bolton states “following the input 1, output 1 is switched on and followed 5.5s later by output 2.”. ✓

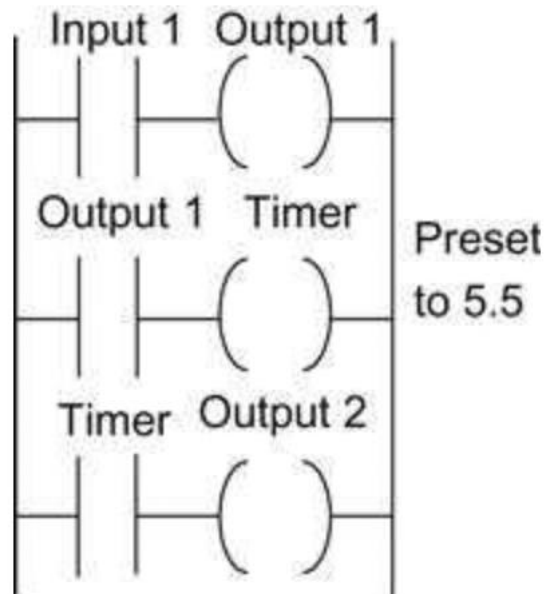


Figure 14-Ladder logic for sequenced output (Bolton, 2015, P.177)

When a single timer is not long enough of a delay for a system, then more than one will be linked together and this is called cascaded timers as seen in the timing diagram and ladder logic seen in figure 15. To explain the ladder logic the input will have a high signal and from this the first timer will start and be present in this case for 999 seconds. Once this is completed then the second timer will start and be present for 100 seconds and from this the output will then be high. This allows the system to have a timer of 1099 seconds from when the input goes high and the output going high.

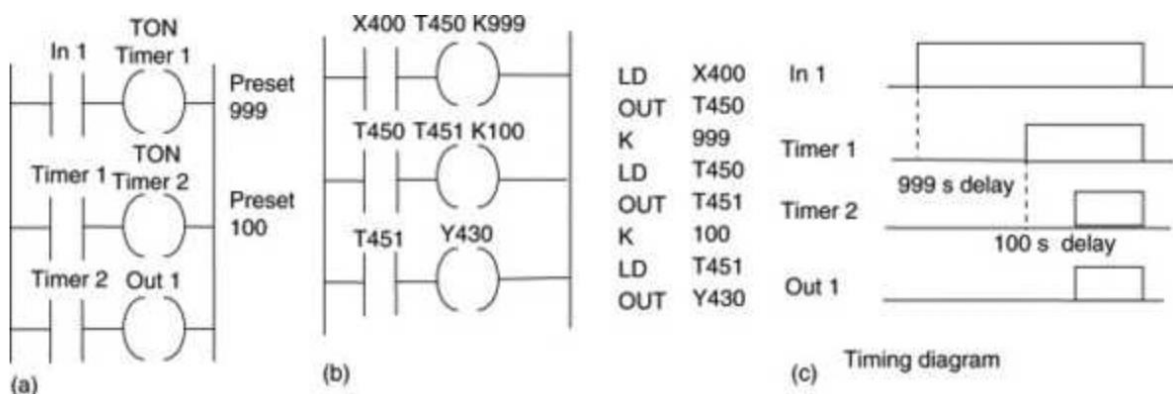


Figure 15- Ladder logic and timing diagram for cascaded timers
(Bolton, 2009, P.167)

Well done.

Task 4

a)

Using the Mitsubishi Alpha software, I was able to develop a food processing blending system that successfully follows the sequential operations of 30 seconds of slow blending, followed by 20 seconds of fast blending and 60 second period containing pulses of 10 seconds of fast blending and 5 seconds off. The blending system on the Alpha software is shown in figure 16.

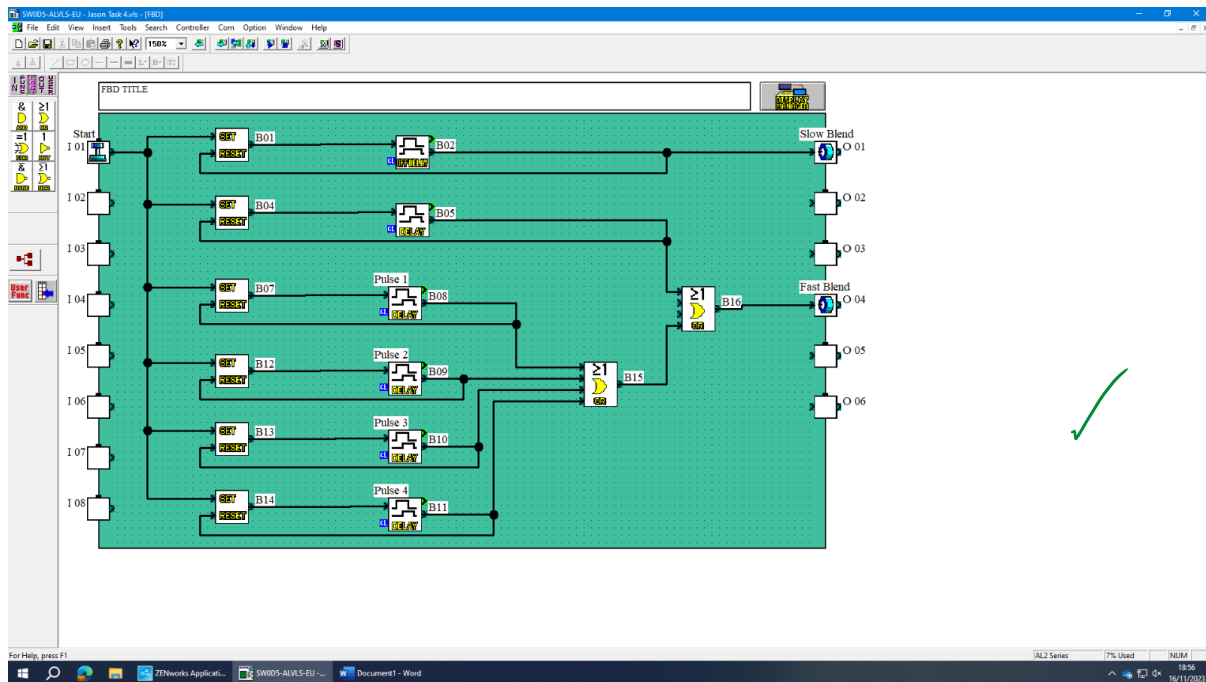


Figure 16- Complete Food Blending System

The program was mainly made up of on and off delays seen in the completed system, to help me get the timings right a timing diagram was created, as seen in figure 17.

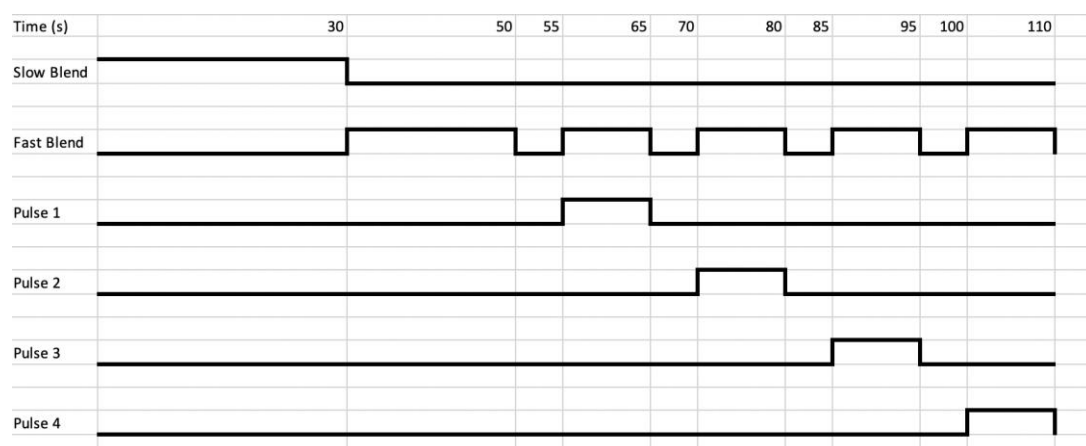


Figure 17-Timing Diagram

Good.

To prove the operation of the program the Alpha software allows you to simulate the system, as seen in figure 18 where it shows the first step of the system when the start button is pressed the slow blend will start and will stay on for 30 seconds and then go off.

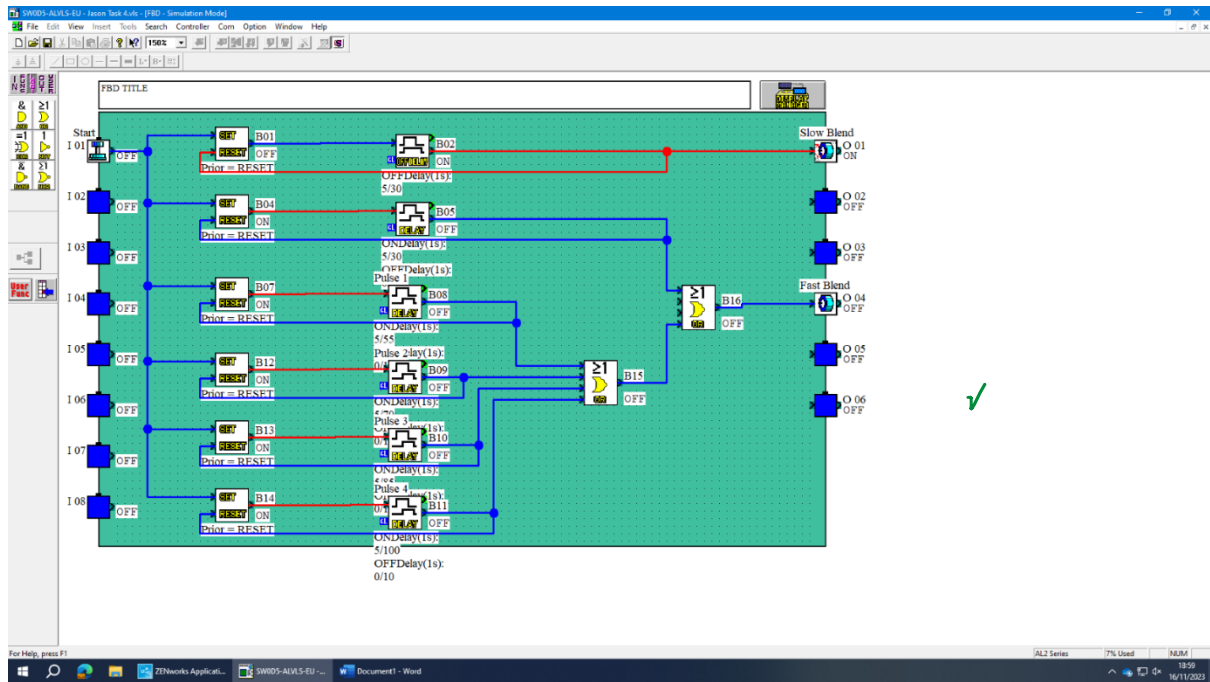


Figure 18- Program started and slow blend begins

Once the slow blend has completed its 30 seconds it will reset and stop, allowing the fast blend to start as it was on an on-delay for the initial 30 seconds and will stay on for 20 seconds as it was on an off delay of 20 seconds, shown in figure 19. ✓

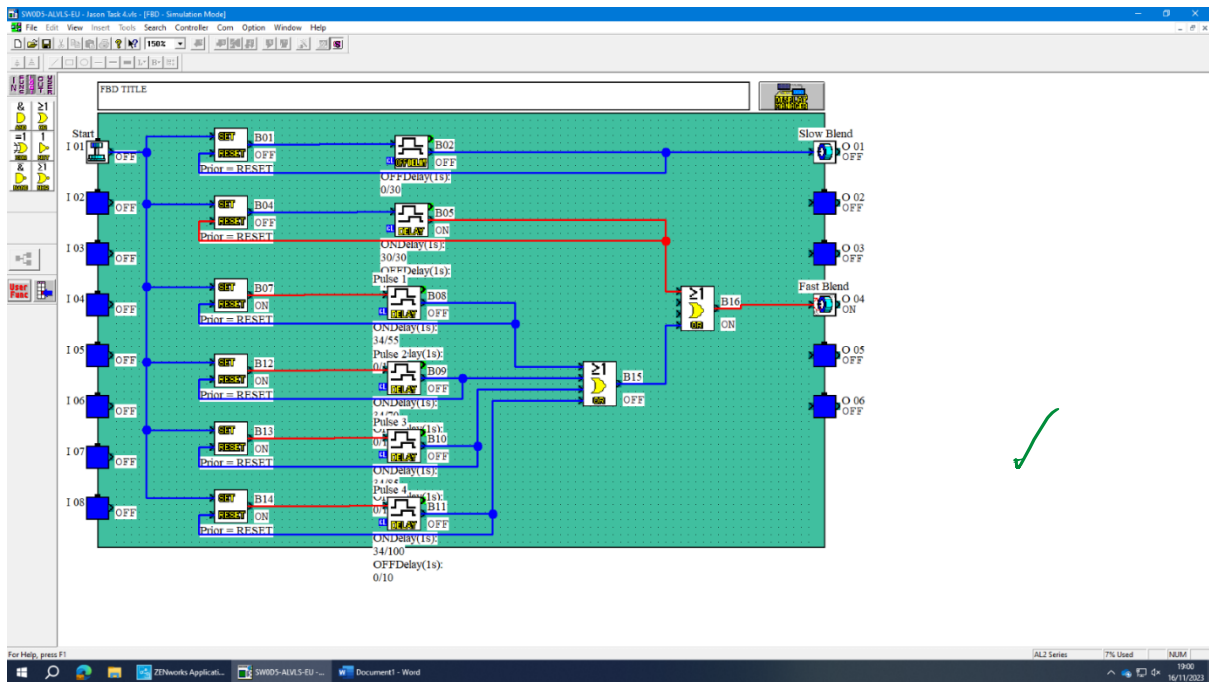


Figure 19- 20 Seconds of fast blend

From this the 60 second sequence can begin of 5 seconds off and 10 seconds of fast blend. With the use of on and off delays can create 4 pulses for each 5 seconds off and 10 of fast blend. For example, pulse 2 will off from 65 to 70 seconds and fast blend on from 70 to 80 seconds, seen in figures 20 and 21.

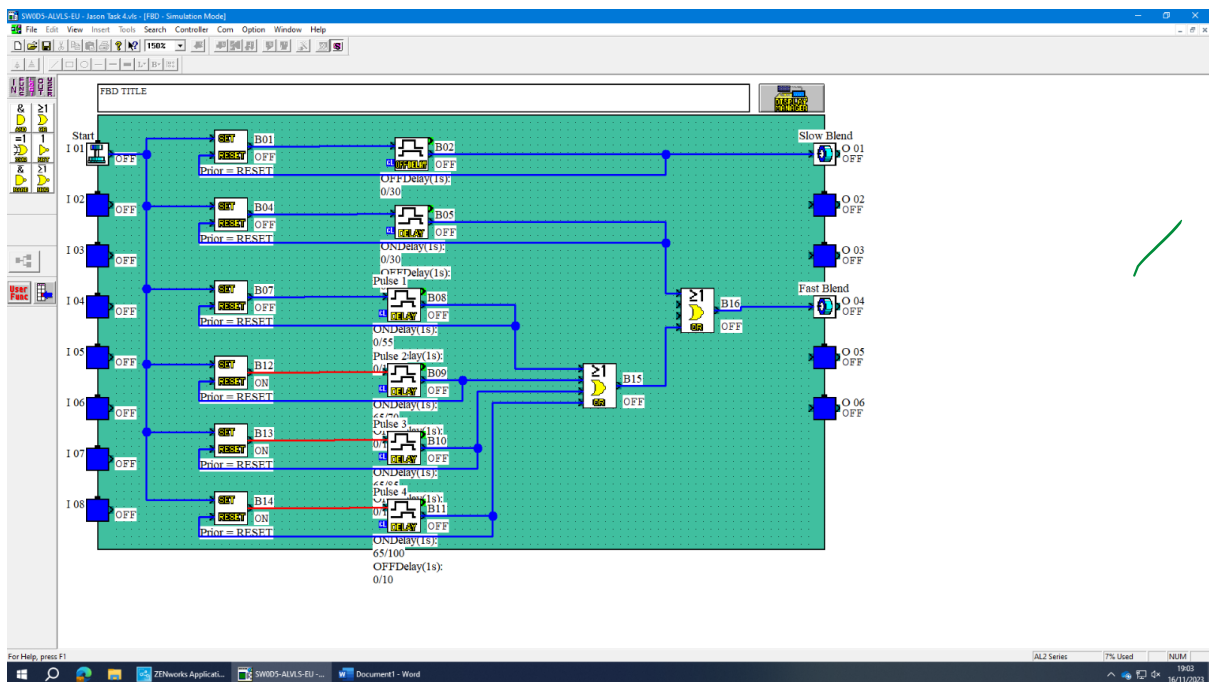


Figure 20- Pulse 1 On-delay for 5 Seconds

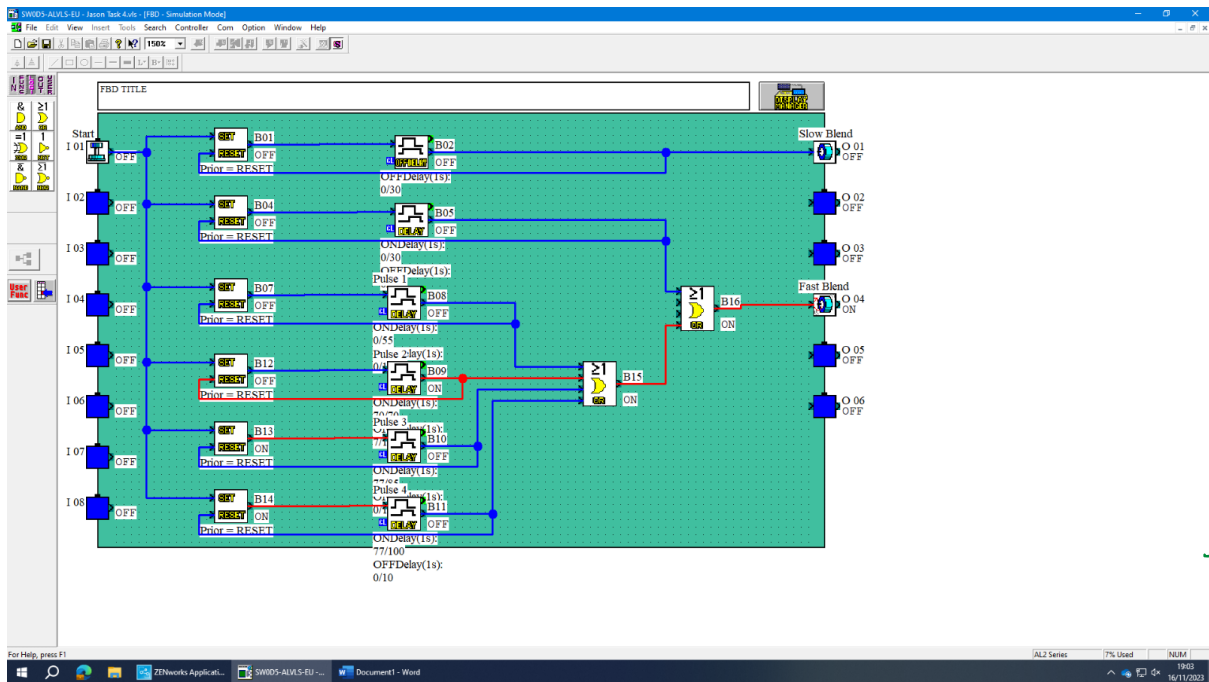


Figure 21- Pulse 1 Off-delay for 10 seconds

b)

Using the Mitsubishi Alpha software, I was able to develop a coin counting system to determine the totals of 10, 20 and 50 pence coins for when each type of coin reaches a pound that an LED will indicate this as well as when the total amount reaches £10 it will give another LED indication. The complete system is demonstrated in figure 22.

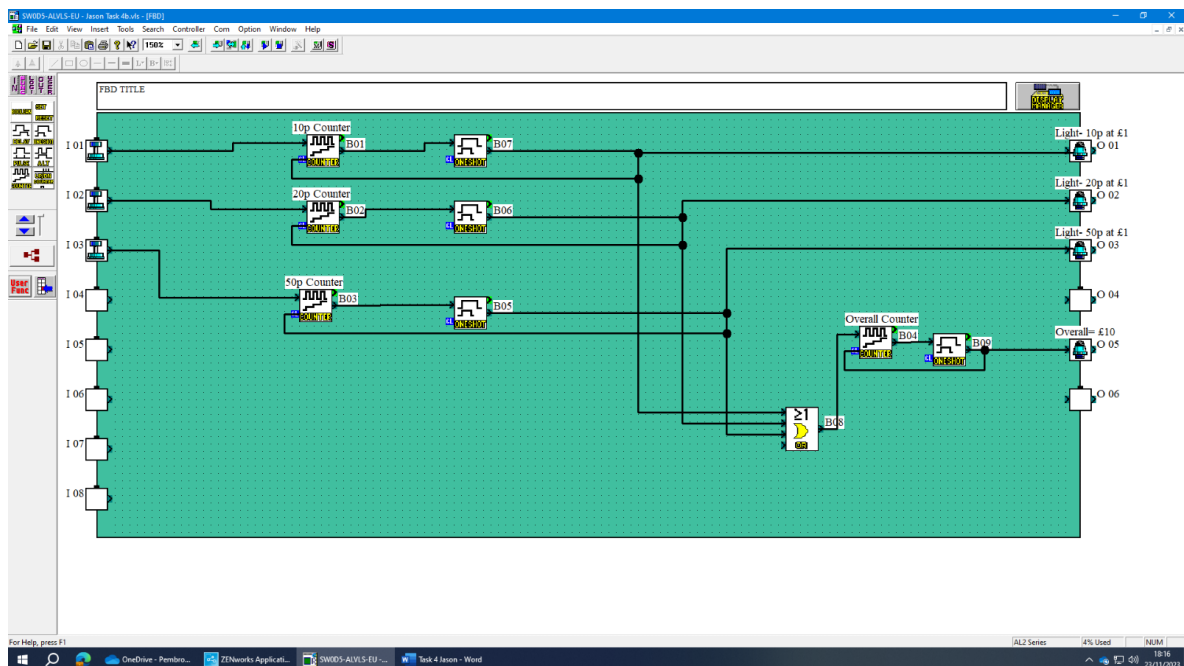


Figure 22- Complete Coin Counting system

To prove the operation of the program the Alpha software allows you to simulate the system, as seen in figure 23 where it shows the 10p counter getting to 10 and lighting up the 10p light for 2 seconds indicating it reached a pound and at the same time adding a count to the £10 total.

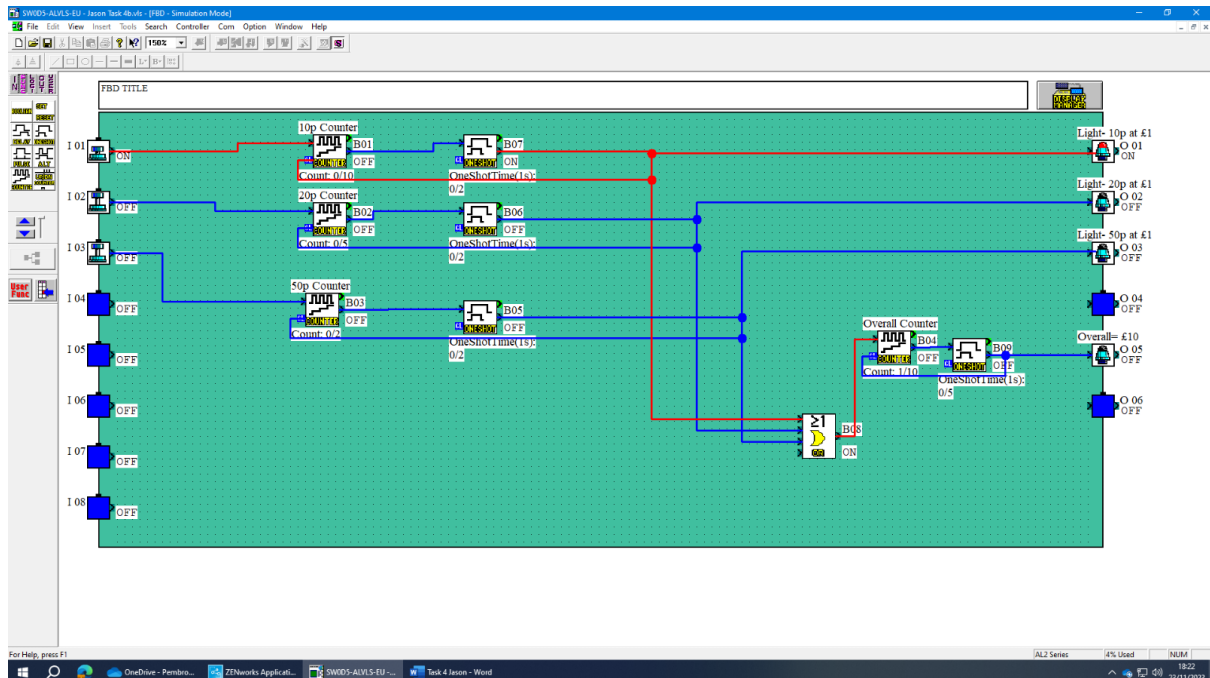


Figure 23- 10p light indication function test

In figure 24 the function test for the 20p counter is being shown for when the counter gets to 5 it lights up the 20p light for 2 seconds indicating it reached a pound and at the same time adding a count to the £10 total.

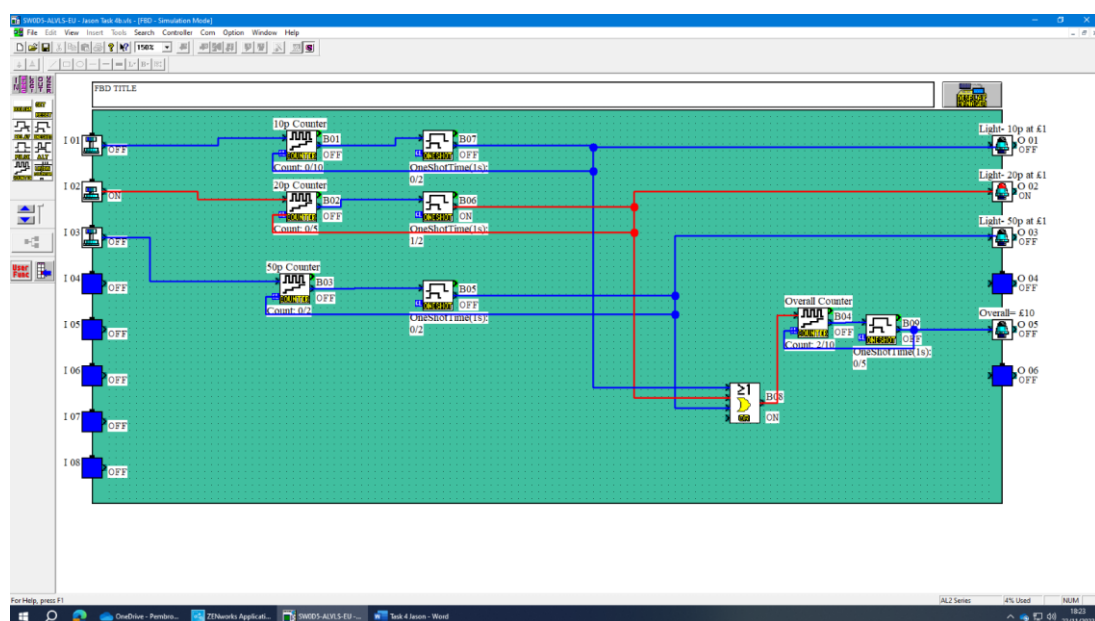


Figure 24- 20p light indication function test

In figure 25 the function test for the 50p counter is being shown for when the counter gets to 2 it lights up the 50p light for 2 seconds indicating it reached a pound and at the same time adding a count to the £10 total.

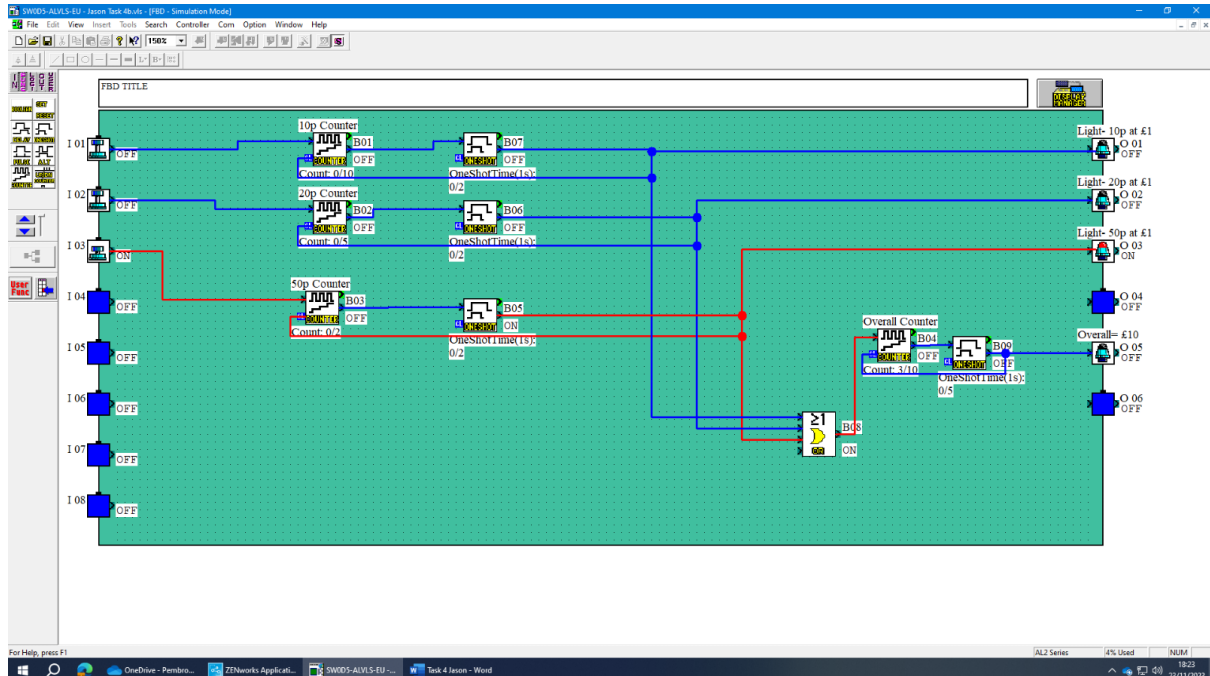


Figure 25- 50p light indication function test

In figure 26 the function test for the total £10 counter is being shown for when the counter gets to 10 it lights up the total £10 light for 5 seconds indicating it reached £10.

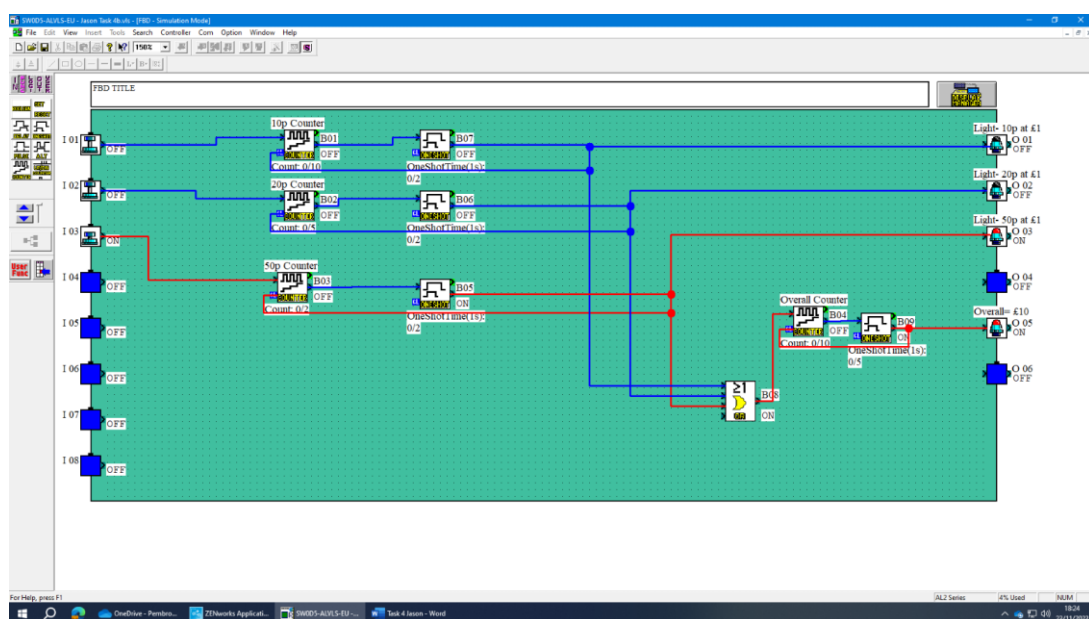


Figure 26- Total £10 light indication function test

Task 5

Using the Mitsubishi Alpha software, I was able to develop an automatic drilling system that meets these 7 specifications;

- “ The process will start when the safety guard is pulled down and start button is pressed.
- The motor will move the bar to position 1, this will start the drill.
- The bar will be clamped and the drill will be lowered. It will take 10 seconds to drill through the bar and 5 seconds to return to its start position.
- The clamp will be released and the motor will move the bar to position 2 and step 3 is repeated.
- The clamp will be released and the motor will move the bar to position 3 and step 3 is repeated.
- The drill will be stop, bar will be unclamped and the motor will return to start position.
- If the stop button is pressed the drill will return to its up position and stop. The bar will be unclamped and the motor return to its start position.”(PLC Assignment, 2023)

In figure 27 you will find the completed automatic drilling system program within the Alpha software.

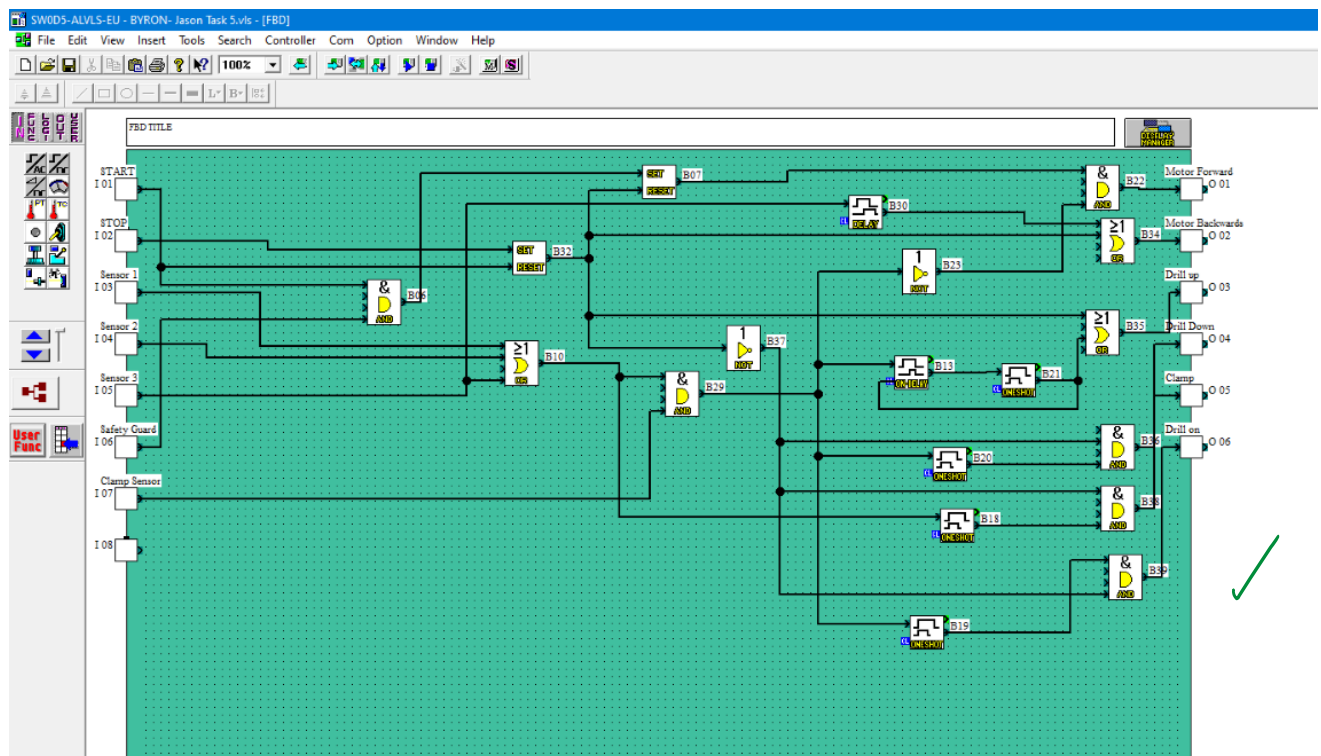


Figure 27-Completed automatic drilling system program

Figure 28 proves that the system meets the first specification for when the start button is pressed and the safety guard is down it will begin the process of drilling the holes.

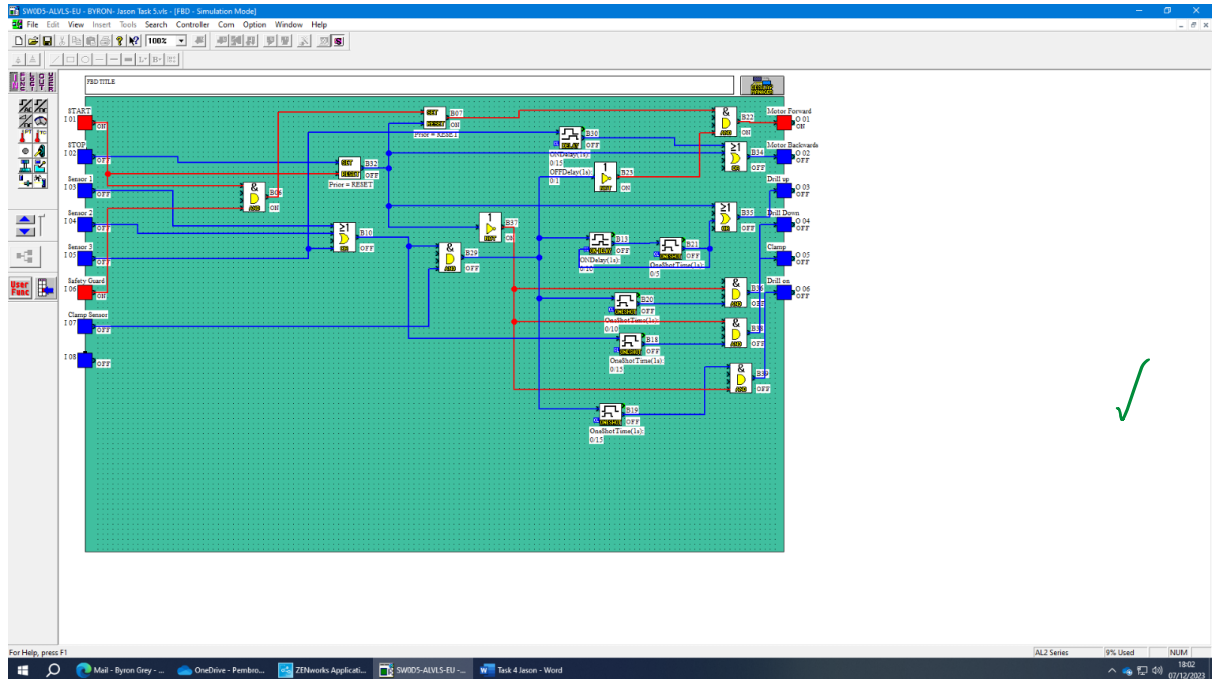


Figure 28-Start button in and safety guard down to start the program

Once sensor 1 is activated the motor will stop going forward and the process of drilling the hole will start, as seen in figure 29. As the process of drilling the hole comes to an end the drill will go up and allow the motor to carry on too sensor 2 where the same process will happen to what is shown in figure 29.

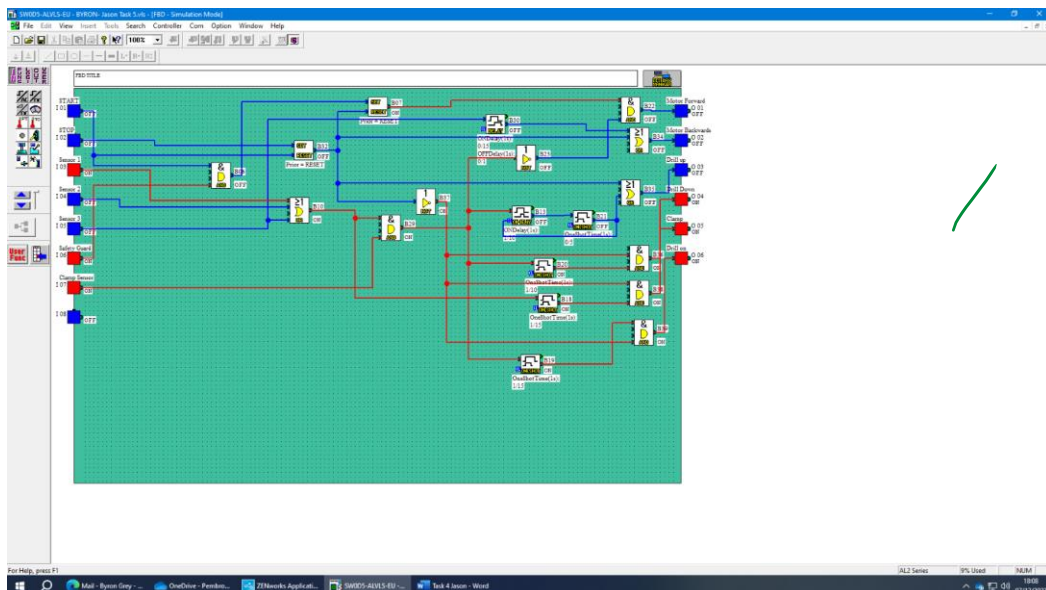


Figure 29-Sensor 1 Activated to stop the motor and to begin cycle of drilling

When the motor activates sensor 3 the same process will happen with drilling the hole as sensor 1 and 2 did, however once the cycle is complete the motor will move backwards to finish the program and be ready to start the next, as demonstrated in figure 30.

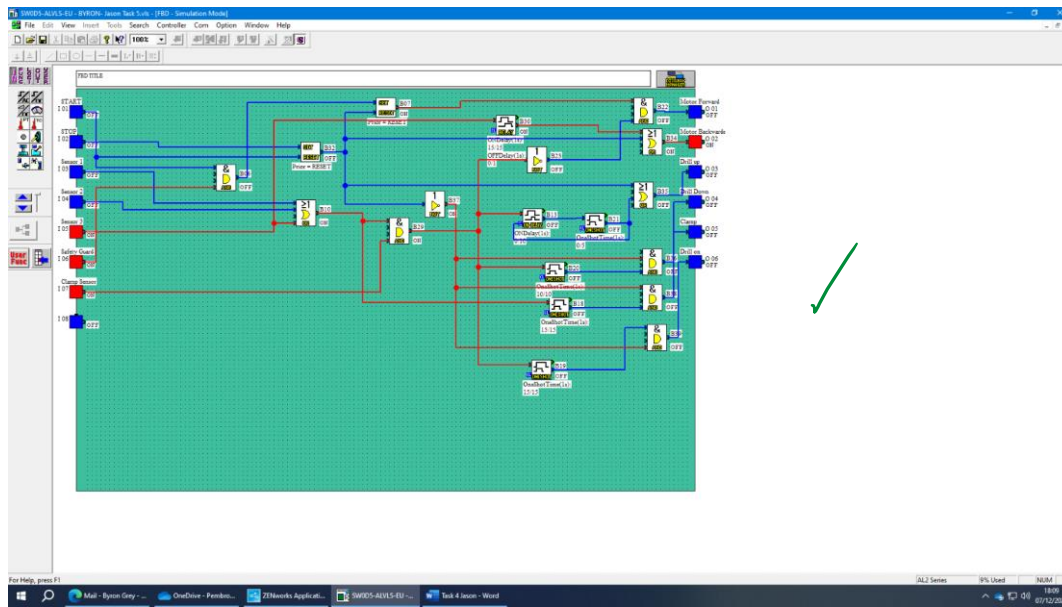


Figure 30- Motor moving back after finishing the cycle of 3 holes

For safety precautions we were asked to include a stop button, so in the case of emergency the stop button can be pressed and the process will be stopped, drill will return to normal position along with the motor returning to its normal position as well. Figure 31 shows the stop button in action when it is pressed.

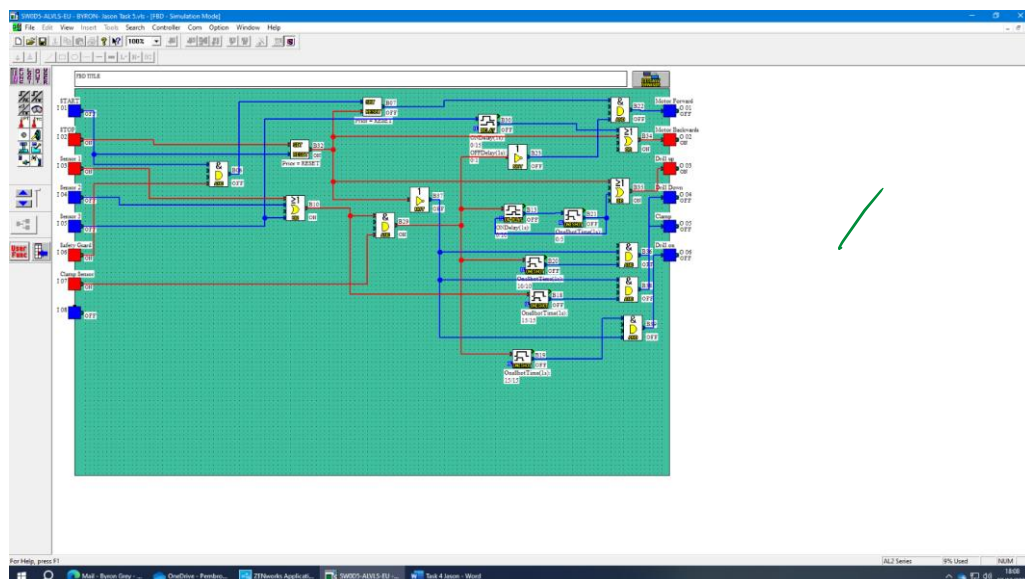


Figure 31- Stop button activated

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