

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Jaden Chapman	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	5.7
Poor engagement with essential reading, no text books listed have only included web sites. No evidence of wider reading and reliance on inappropriate sources. Inconsistent and weak use of referencing, no direct quotes.		
2. Knowledge and Understanding Skills	30	16.2
Task 1 achieved 58%. Task 2 achieved 52%, Task 3 achieved 52%. Knowledge of the basic underlying concepts and principles of the work required for Task 1, 2 and 3.		
3. Cognitive and Intellectual Skills	5	2.3
Limited evaluation of the underlying concepts and principles applied to the construction of the auto drill system.		
4. Practical Application Skills	40	30
Task 4 achieved 70%. Task 5 achieved 80%. 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	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)		60%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

JADEN CHAPMAN

PLC ASSIGNMENT 1

Lecturer: JASON POINTER



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TASK 1A

Unitary

The unitary PLC is a singular machine and ^{is not} isn't capable of working in conjunction with other PLCs. It is provided to the customer complete with a power supply, processor, memory, and multiple input/output ports. The selection of this PLC would depend on the required amount of input/output ports that the clients have decided are necessary. This type of PLC will typically have anywhere between 6-24 inputs and 4-15 outputs, and this decides the number of instructions the unit is capable of storing. For programs that are more complex, a PLC with more inputs and outputs will be better suited as it enables the user to write more instructions. A unitary PLC is capable of storing anywhere between 300 and 1000 instructions. This kind of PLC is considered the cheapest due to its inability to work with other units. The price point of this unit varies but ^{or lower} manufacturers such as Mitsubishi will charge around £350 for their model. ✓

The unitary PLC is most commonly used to carry out less complex operations in smaller engineering companies. Some examples of the actions the PLC is capable of carrying out include counting components travelling along a conveyor belt, turning a motor on and off via a switch, or programming a drill to operate every time an engineering component reaches a certain point in the conveyor belt. ✓



Figure 1 - Unitary PLC

Modular

Modular systems contain a much larger selection of inputs and outputs when compared to the unitary PLC and are regularly fitted within a rack system enabling them to work in conjunction with one another. This type of unit consists of separate modules that individually host power supply, processor and memory to name a few. Compared to the unitary PLC, this system is capable of further expansion due to its increased number of available modules. The user can decide on which modules they would like to use for a particular purpose and

then connect these via a rack. This makes expanding the number of input/output connections effortless as modules can be continuously added to the system. These systems are slightly more expensive when compared to the unitary PLC due to their ability to operate as part of a larger system. Siemens have priced their model at around £500.

This type of PLC may be more suited to a larger company that is operating a variety of complex operations simultaneously. Although the modular PLC costs a larger amount than the unitary PLC, it offers the client much more convenience when programming and managing these more complex operations.



Figure 2 - Modular PLC

TASK 1B

Power Supply

One of the aspects that allows a PLC to operate effectively is the power supply. This component is capable of converting high-input alternating current into lower-regulated direct current. The voltage is then reduced as necessary using an input power transformer which can then be utilised by the PLC circuit. As an example, the power supply is capable of taking mains voltage, which operates at around 230V, and converting it to give a required output of 12V.

The power supply is essentially responsible for providing the PLC with power although some supplies are capable of doing much more than that with some featuring ground fault detection systems, overload detection systems as well as methods of protection against these common issues.

CPU

Another component that is essential to the smooth operation of the PLC is the central processing unit, also known as the CPU. It is considered to be the most complex component in the PLC system due to it hosting a microprocessor, memory chip and many more micro-components that are all responsible for interpreting instructions given by the program and then delivering an output.

Input & Output Interfaces

An input/output unit provides the interface between the PLC and any external devices. Therefore, the interface unit must provide the PLC with the correct signal to protect it from higher voltages that are capable of causing damage to the system. A device that helps to guard the PLC from these high voltages is an opto-isolator. This device connects the input and output sides with a beam of light which is modulated by the input current. It transforms the necessary signals into light and sends it across the dielectric channel where it is transformed back to an electric signal at the output side. This device is also capable of feeding output back into a control system within the input circuit of the PLC. ✓

Some of the output units found within a PLC are relay and triac. Relay outputs are mechanical contacts that, when the coil is energised, closed, and when it is de-energised, opened. Triacs are built of semiconductors and put in place to control the distribution level of alternating current. Triacs are almost always preferred over relays due to their silent operation. It is also a more desirable output unit when working in dangerous environments as it doesn't rely on a mechanism. For this reason, they also last longer than relays. ✓

Input & Output Devices

Input devices are any devices that provide the PLC with a data signal. This signal is then processed by the PLC and an instruction is sent to the output device. Examples of some of the common input devices include switches, buttons and proximity sensors. Switches and buttons are methods of stopping and starting a piece of equipment. Proximity sensors can be a method of detecting when a component has reached a certain point in the conveyor belt and then delivering this information to the PLC for interpretation. ✓

An output device is capable of receiving information from the PLC and carrying out an action. Examples of this include valves, pumps, motors and alarms. Valves will be instructed by the PLC whether to open or close based on the input signal it receives. A PLC might communicate with a pump to turn on when the level in a drum has reached a certain point. The motor found within a system will also be instructed by the PLC on when to operate and when not to. Alarms can also be instructed to sound when flow, level, pressure and temperature become too low or too high. ✓

Memory

There are two types of memory found within a PLC and they are known as RAM (random access memory) and ROM (read-only memory). RAM is where all of the programs and data are stored allowing the user to not only read the information but also overwrite and make changes to it. ROM is where data that the user doesn't have access to overwrite is stored such as the operating system and firmware version. Data stored inside the PLC memory can be classified as volatile and non-volatile. Volatile memory is memory that will not be retained if the PLC is powered off. As an example, if the last known reading for a specific instrument was 30 and the PLC is powered off, when it reboots the value will read 0 due to it having no record of the reading prior to being shut down. However, non-volatile memory will remember its value even after a reboot has been carried out. ✓

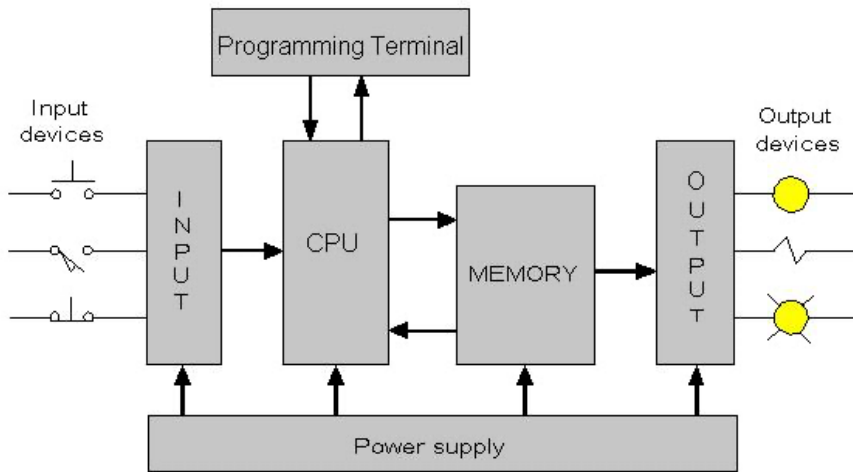


Figure 3 - Main Components of PLC

TASK 1C

Due to the PLC being in configuration with so many different instruments, there's always the possibility of an electrical overload occurring or an instrument going into fault. To protect the PLC from being damaged during these events, there are several components that can be installed within the circuit.

Fuses prevent the fault of an instrument from affecting the PLC by causing a break in the circuit when the current flow becomes too much. The electronics in the output card are sensitive to any changes so it is important to protect each of the outputs individually to prevent them from becoming damaged. Investing in fuses for each of the outputs will ensure that that's the only component required to be replaced rather than an entire system.

Diodes are another component that can be installed in order to protect the PLC. The diode module is a device that enables current to flow in one direction only. If current attempts to flow in the other direction, it will be blocked from passing as shown in the figure below:

There are other methods that are more likely to be used.



Figure 4 - Diode Module

Terminals 2, 4, 6 and 8 are only enabled to flow to 1, 3, 5 and 7 respectively.

TASK 2A

Truth Table

A	B	C	R	S	T	U	V	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

Boolean Expression

$$Q = \bar{A} \cdot \bar{B} \cdot \bar{C} + \bar{A} \cdot \bar{B} \cdot C + \bar{A} \cdot B \cdot C + A \cdot B \cdot \bar{C}$$

This configuration of logic gates is currently very busy making it complicated to figure out the final output. To find the output of Q, I've broken down the circuit into sections labelled 'R' through 'V' and found what the output of each section would be.

In this instance, this circuit can be simplified by removing and replacing some of the logic gates that are currently being used. For this step, we need to utilise a Karnaugh Map. ✓

TASK 2B

Simplified Boolean Expression

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

Plus = in Parallel

. = in Series

NC = Logic 0

NO = Logic 1

Where is your Karnaugh Map?

Simulation of Ladder Logic Diagram

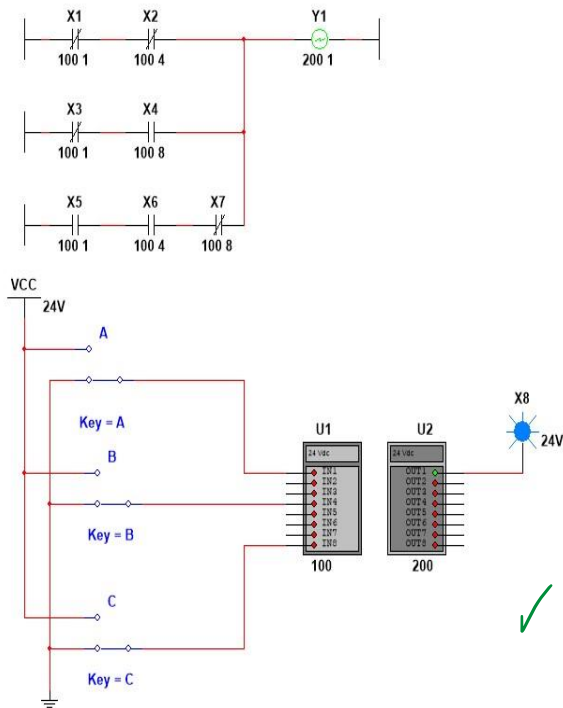


Figure 5 - Logic 1 Output

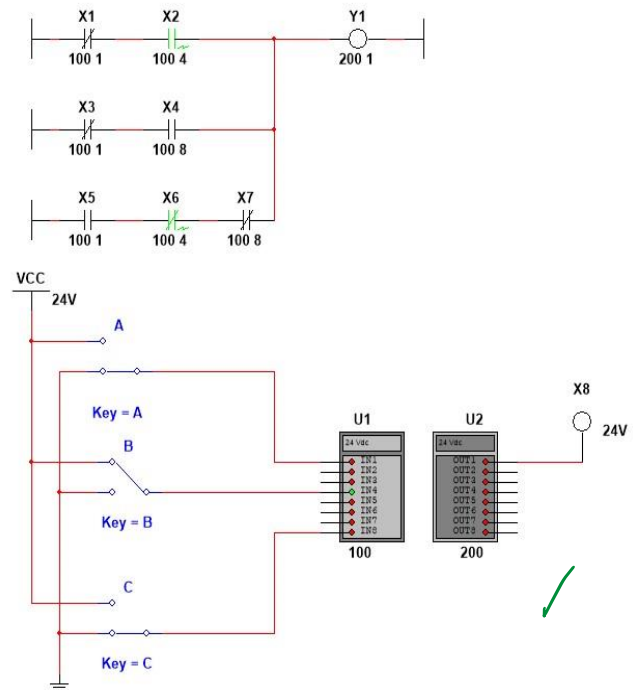


Figure 6 - Logic 0 Output

Above, screenshots of the ladder logic diagrams show how the output will change based on how the switches are configured. This is a representation of the 'Q' output in our truth table being 1 or 0. By referring to the truth table, we can see that the switch configuration will give a 'Logic 1' output. In this example, it results in the LED turning on when 24v is outputted. We can also see that the switch configuration will not provide us with a 'Logic 1' output and therefore the LED remains off in this instance.

TASK 3A

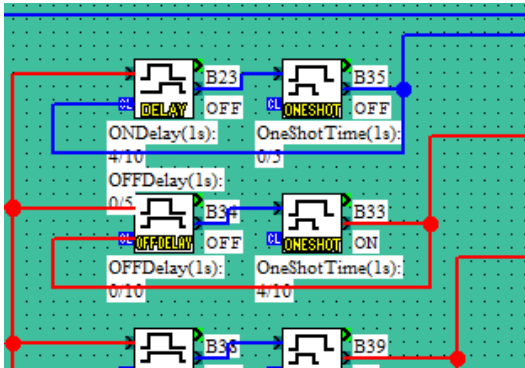


Figure 7 - On-Delay Timer

On-delay timers are utilised when the user requires a certain amount of time to pass before the signal is allowed to continue its path. For example, in the figure above, the timer has an On-delay of 10 seconds. This means that when the timer is activated, 10 seconds must pass before the signal continues flowing through the circuit. The on-delay timer is useful in situations where the same input signal is being used for two or more separate actions but requires the other action to be completed first. The on-delay timer affords the other function time to complete its action before continuing its own path through the circuit.

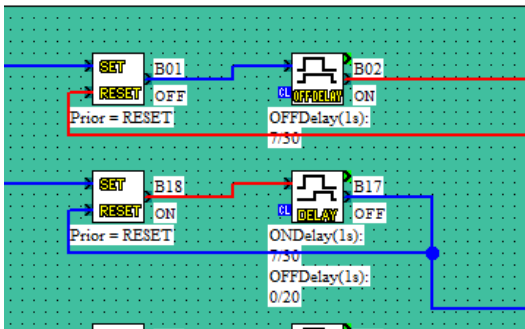


Figure 8 - Off-Delay Timer

Off-delay timers are put in place when the user requires the flow of signal to stop after a certain amount of time has passed. In the figure above, I have utilised a timer with an off-delay of 30 seconds. This ensures that 30 seconds after the signal has flowed through the timer, it will be deactivated. The off-delay timer is especially useful when the user requires the action only to be carried out for a certain period of time.

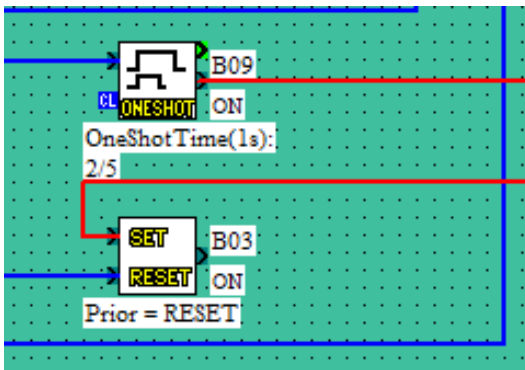


Figure 9 - Pulse Timer

Do not refer to yourself in a report.

Pulse timers are utilised when the user requires its output signal to intermittently enable and disable the signal from flowing. In the figure above, I have placed a pulse timer into the circuit and chosen 'time priority' which means that even if the input signal is deactivated, the timer will continue to output a signal until the period of time set by the user passes. In the example above, I have configured the timer to output a signal for 5 seconds once an input signal has been received. We can see that even though the input signal to the timer has been deactivated, the output signal remains activated as I have selected 'time priority' rather than 'input priority'. By selecting input priority, it would result in the state of the input signal overriding the set time of the pulse and therefore altering the state of the output signal accordingly. The pulse timer might be opted for when the user wants to briefly display an output every time a specific action occurs.

TASK 3B

Mapping timers in sequence is desirable when the user requires one input device to control several different outputs at different timing intervals. This can be done using on-delay and off-delay timers. As an example, the user can map the signal from a single start button to 3 separate pumps that all operate at different times. 3 timers can be set with on-delays of 0, 15 and 30 each with an off-delay of 15 seconds. When running, this results in each of the pumps operating for 15 seconds before being shut off and the next pump being turned on.

Delay timers can also be programmed to only give an output signal for a set amount of time. For example, turning an LED on every time a sensor is activated. Similarly, they can also be used to hold out an output from being given until a certain amount of time has passed. This is useful in cases where the user requires one input to control a number of different outputs as part of a sequence.

Every programming software will have a maximum amount of time that a delay can be set for but this can be combatted by placing two timers in series with one another. For example, if the user requires a timer of 1500 seconds and the program only allows timers up to 999 seconds, a timer of 999 seconds and 501 seconds can be placed in sequence with one another so that when the first timer ends, the second timer is activated.

TASK 4A

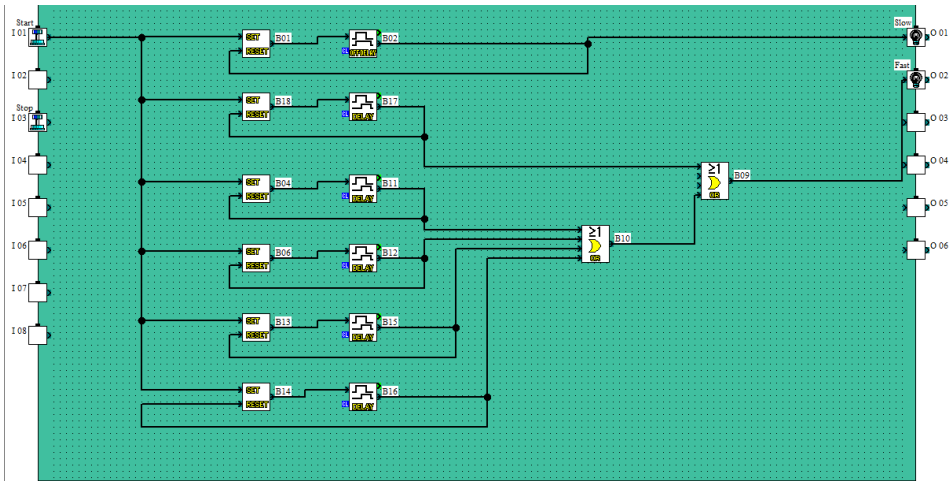


Figure 10 - Food Processing Blending System

TASK 4B

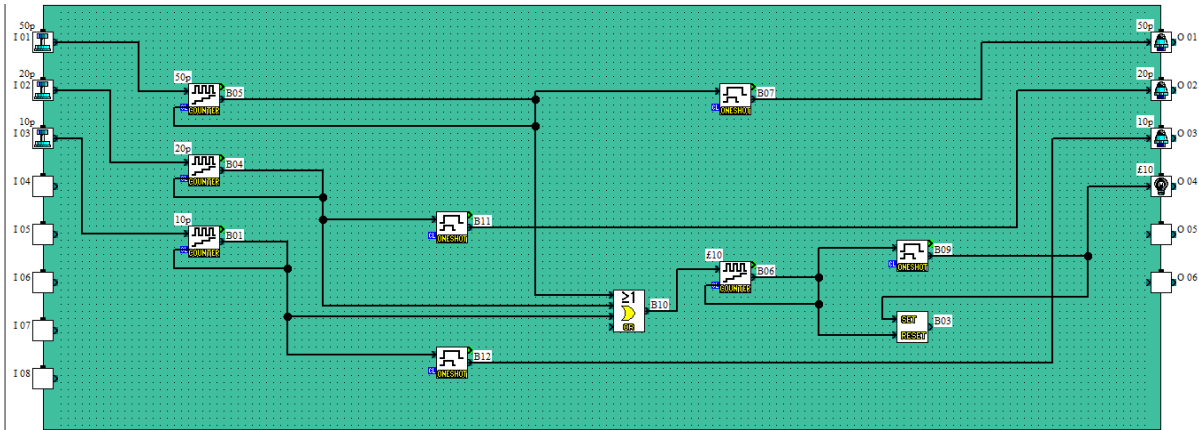


Figure 11 - Coin Counting System

Have not included operation screen shots.

TASK 5

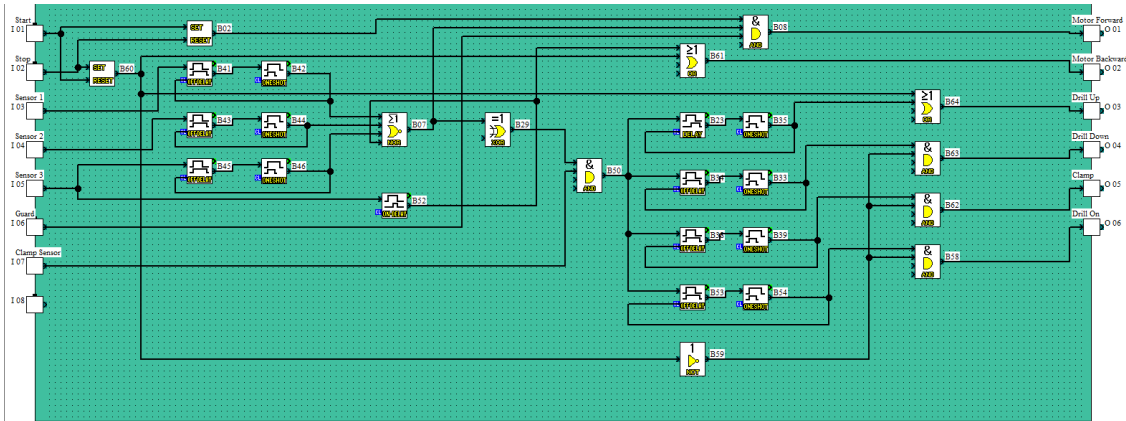


Figure 12 - Automatic Drilling System

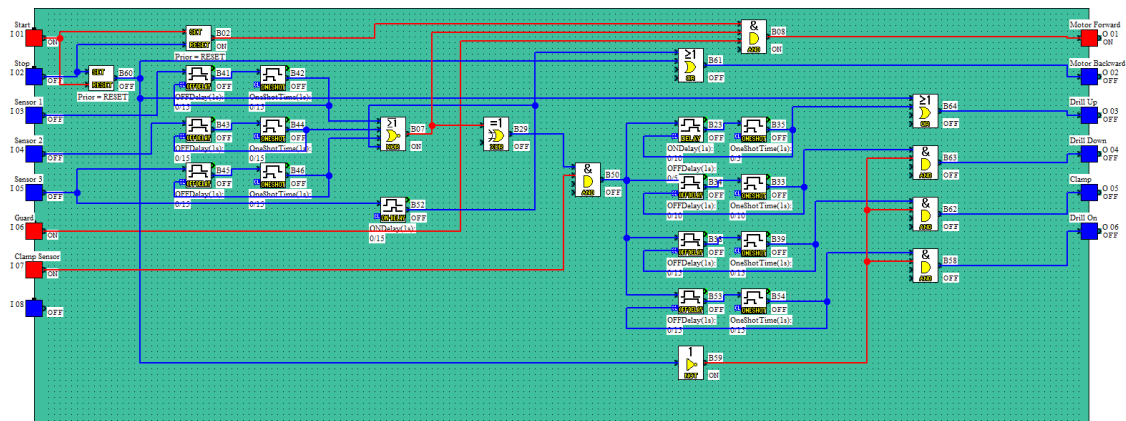


Figure 13 - Start

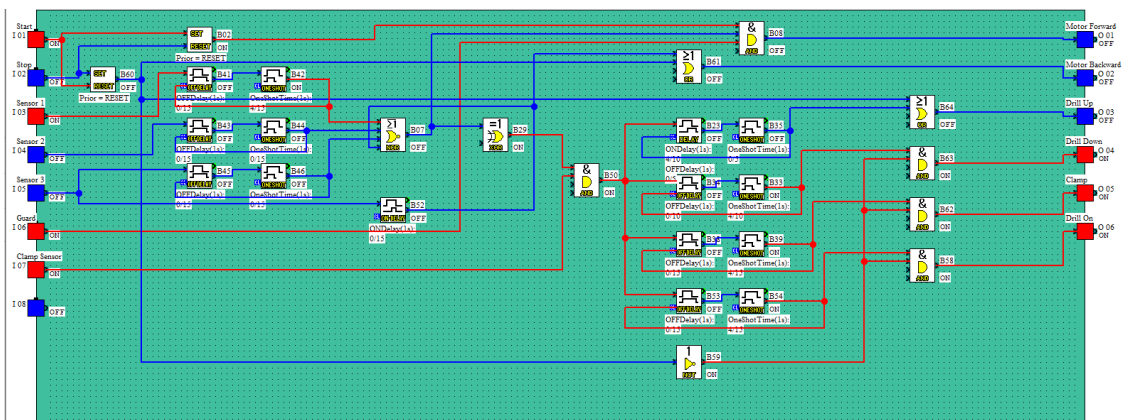


Figure 14 - Sensor 1 Drill Down

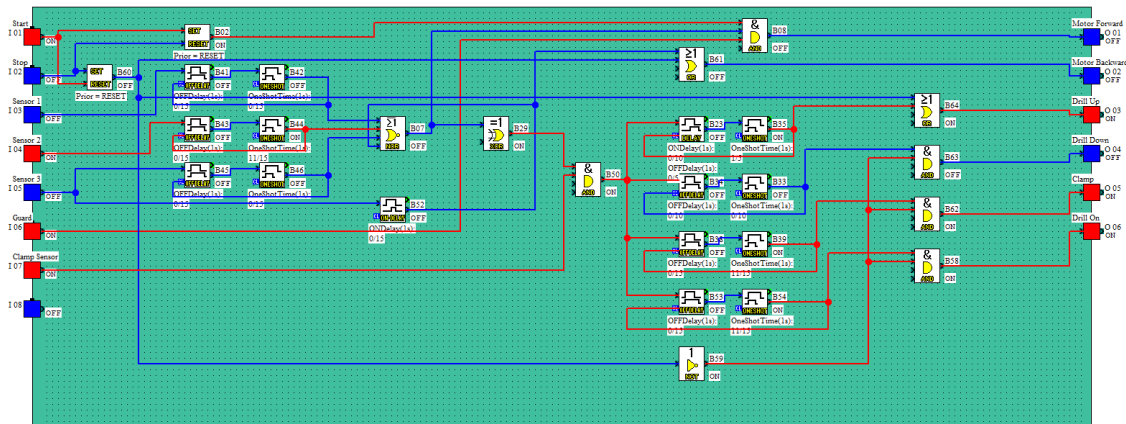


Figure 15 - Sensor 2 Drill Up

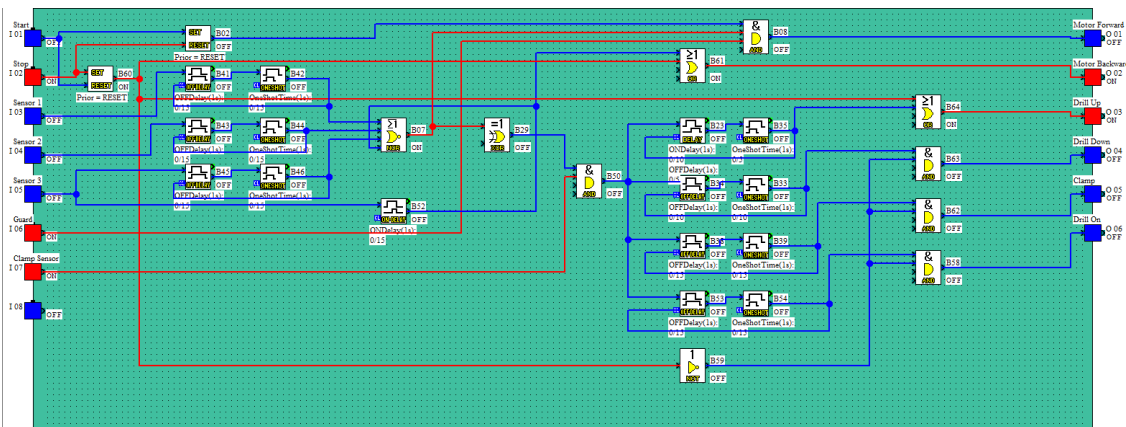


Figure 16 - Stop

The purpose of the automatic drilling system is to drill three holes into a steel bar. The system will be held out from operating until the safety guard is down and the start button is pushed. Once the start button is pushed, the motor will begin to push the steel bar forward and this will continue until sensor 1 is activated. When sensor 1 is activated, the motor will stop moving forward due to the sensor's signal being sent to the NOR gate. As long as the clamp sensor is also activated, this will begin the next part of the sequence which consists of the steel bar being clamped, the drill being turned on and the drill moving downwards. Delayed timers are in place to enable the drill to move up and down for a set period which, in my system, is a total of 10 seconds downwards to ensure the steel bar is drilled and 5 seconds upwards. When sensor 1 is disabled, the motor then begins to push the steel bar forward again until the next sensor is met. The system operates the same for both sensor 2 and sensor 3. If the stop button is pushed during any point of operation, the current action being carried out is abandoned, and the drill begins to move up and the motor backward.

Although the system operates smoothly, there are still a few improvements that could be made and one of the major improvements in this system could be made to the sensors. In the system that I've designed, the program only functions correctly when one sensor is activated at a time. For example, once the first hole has been drilled, the motor will only continue moving forward when the sensor is deactivated. For as long as sensor 1 is still activated, the motor cannot move the drill toward the second hole. This could be an inconvenience when in normal running as sensor 1 is still going to remain activated as it moves through the sequence. A way to improve this would be to reset and latch the sensor

after a certain amount of time has passed allowing for the motor to continue moving forward without the requirement for manually resetting it.

Another issue with the program is that although the safety guard is required to be down for the program to start, lifting the safety guard will not stop the system from operating. This is a potential safety hazard and could be improved by configuring the guard in a similar way to the stop button. This would result in all actions being abandoned as soon as the guard is lifted, the drill moved upward and the motor moving backward.

Currently, the program I have written has no end. When the stop button is pressed, the drill moves upward and the motor backward for an ^{unset} amount of time. This is unrealistic as the drill and motor can only move upwards and backwards as far as the system allows them. An improvement would be to set a timer so that the two components have enough to return to their starting position. We could also place a sensor at the starting position of both components so that when it is reached again, the operation stops.



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You need to include text books.