



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Factory Control 2

Control Technology

By Saeid Salimi – 1911294

ACMA6001

Word Count = 2139

TABLE OF CONTENTS

1.0	<i>Introduction</i>	3
2.0	<i>Factory Operation.....</i>	4
2.1	Ladder Logic Program.....	4
3.0	<i>Alarm and Warning Strategy</i>	19
3.1	Alarm Strategy.....	19
	Please See Appendix A.....	19
3.2	Warning Strategy	19
	Please See Appendix B	19
4.0	<i>HMI and Control Screens.....</i>	19
4.1	HMI Control Screens	19
	Please See Appendix C	19
5.0	<i>Conclusion</i>	19
6.0	<i>Bibliography</i>	20
7.0	<i>Appendix A</i>	21
8.0	<i>Appendix B</i>	23
9.0	<i>Appendix C.....</i>	25
		29

1.0 Introduction

In this formal report you can find details surrounding a factory operation. This simulation replicating a factory has been created using Factory I/O. The operation is simply 2 parts that are machined to different specifications, one a base and the other a lid. These parts are then put onto a conveyor belt where a pick and place arm stack them together. The part then travels down the conveyor where another pick and place arm will stack finished goods into a box.

With the use of Siemens Totally Integrated Automation Portal (TIA 16), a ladder logic program was created to control the factory simulation within Factory I/O. This then allows the simulation to function to operational design. This report goes into detail of the operational flow, explaining each network used and reasons why. Included alongside this is an alarm and warning strategy that has been created and reasons why each parameter was used for this factory. Also in this report, you will find a design breakdown of the HMI and control screens created for the factory operation. The factory can be controlled from these screens by inputting specific parameters to alter operation to the needs of the user. The user is also able to see the process from the screens and perform interventions should any problems arise.

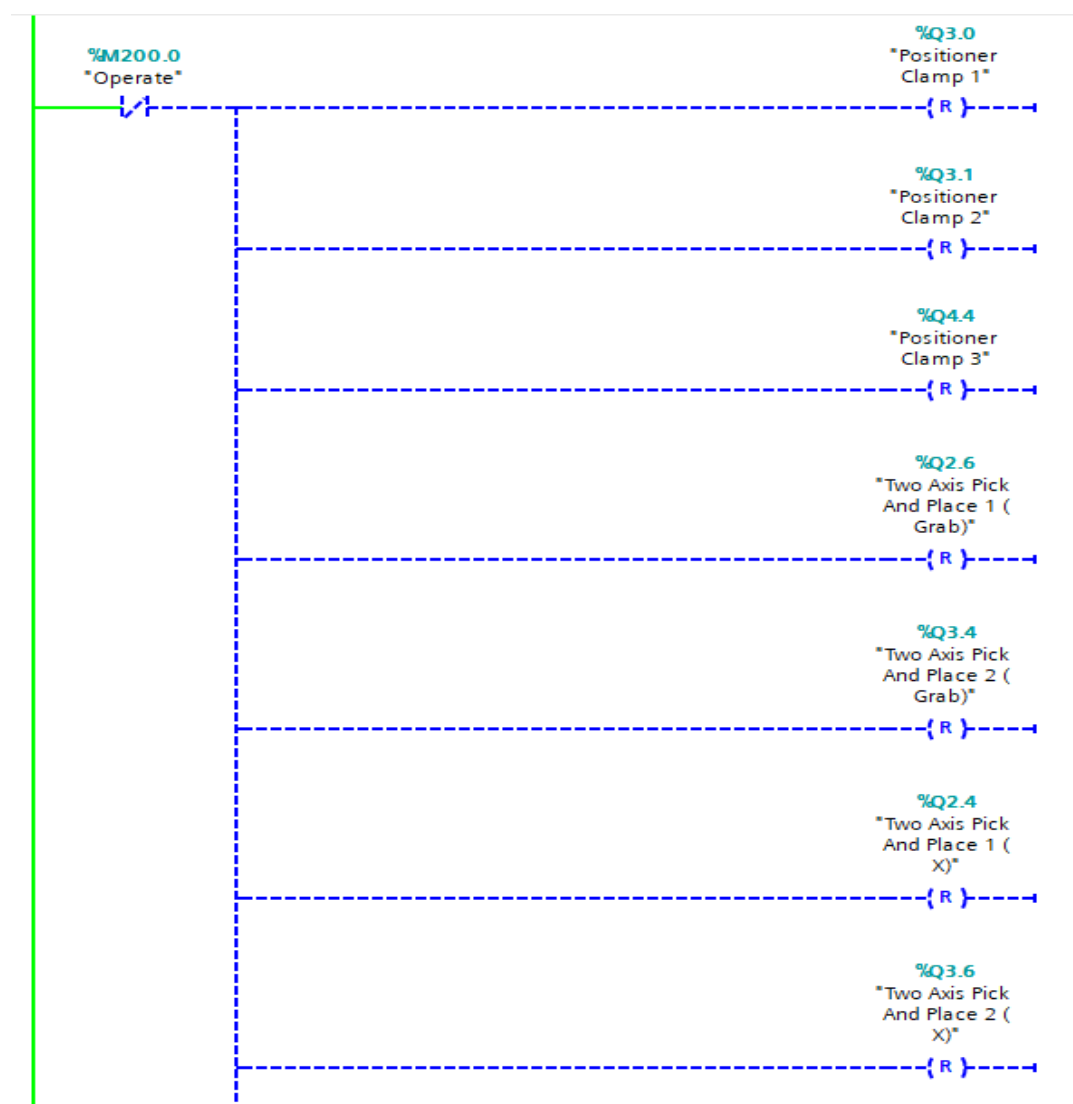
2.0 Factory Operation

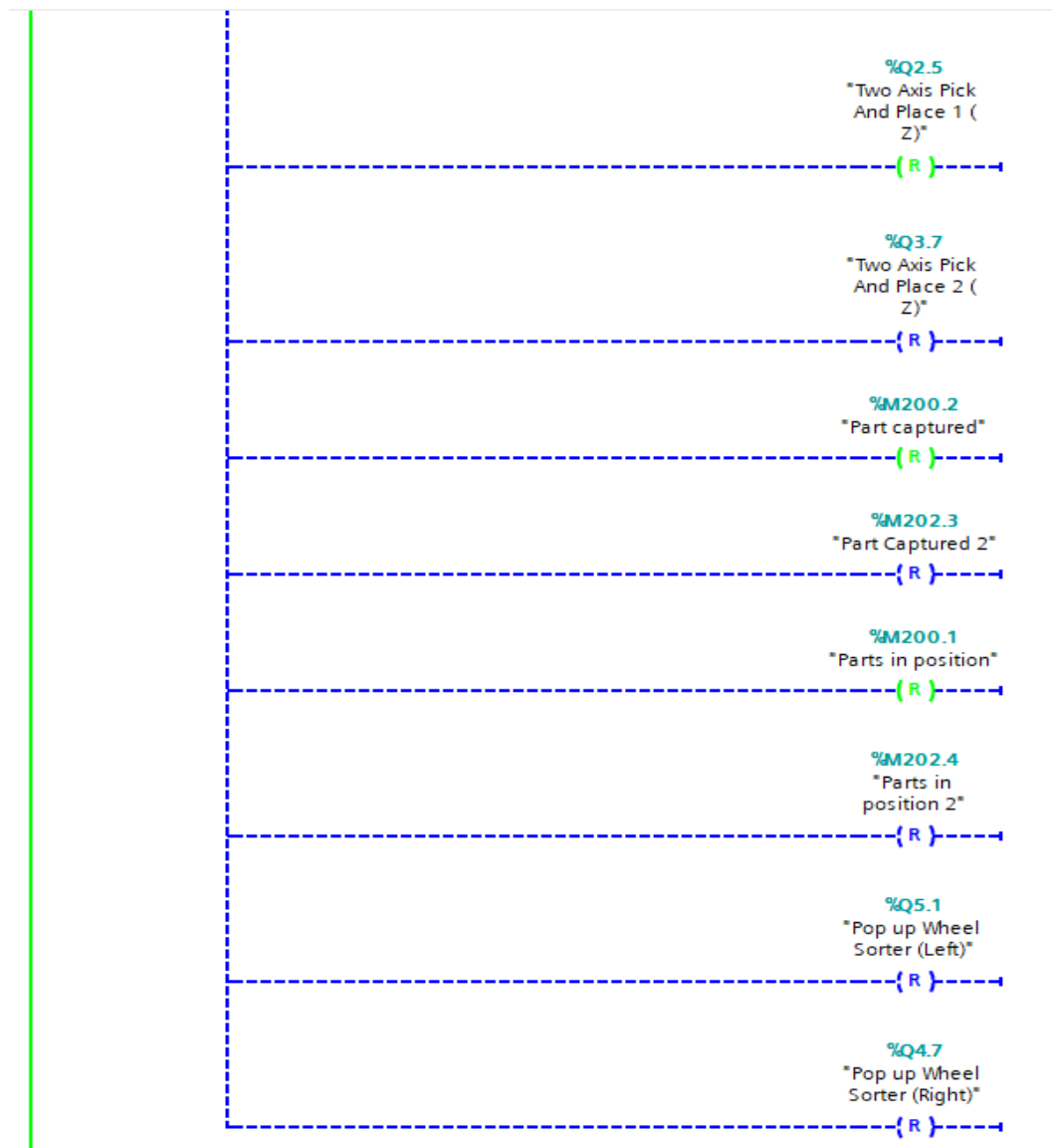
2.1 Ladder Logic Program

Ladder logic is a programming language used to program a PLC (programmable logic controller). It is a fast and simple way of creating logic expressions for a PLC in order to automate repetitive machine tasks as described in (Ladder Logic World, no date).

Reset All Components

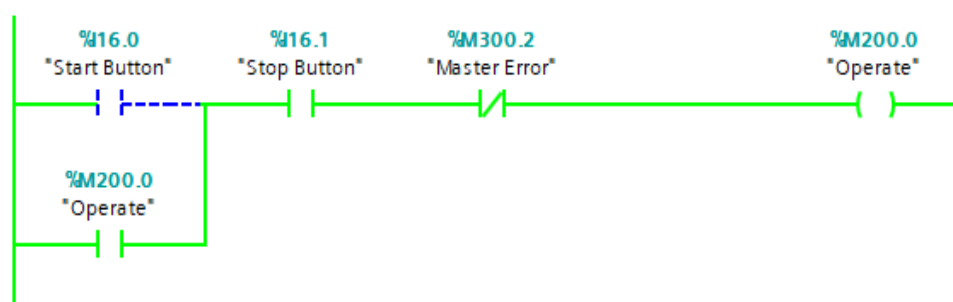
The purpose of this network is to ensure that all assembly components are reset. If for any reason a component is triggered without a part being present, the engineer can perform this reset simply by pressing the stop button which is linked to 'operate'. The breakdown of this network is simply a 'normally closed contact' input 'operate'. When operate is not active, all reset outputs attached to this network are triggered.





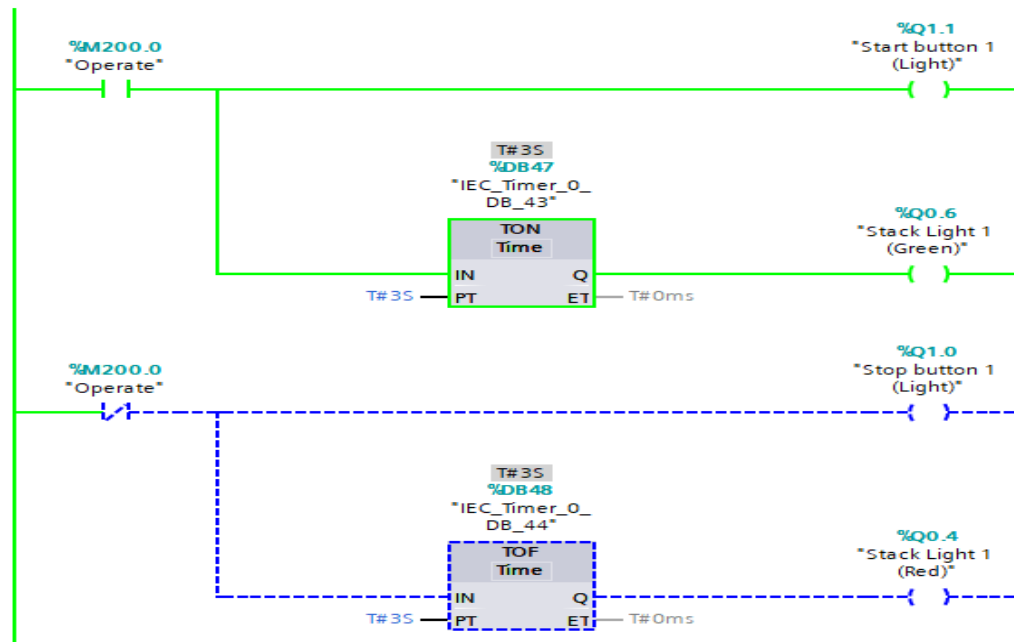
Start, Stop and Operate

This network starts the whole factory process. When 'Start' is actioned, operate receives an input signal. Operate actions the start of all the factory components that are linked to it. Also in this network is a 'normally closed contact' 'master error'. This links to the alarms and warning triggers. If any errors are present, the master error will stop the user from starting the process until the problem is cleared. If the stop button is pressed, operate will become inactive.



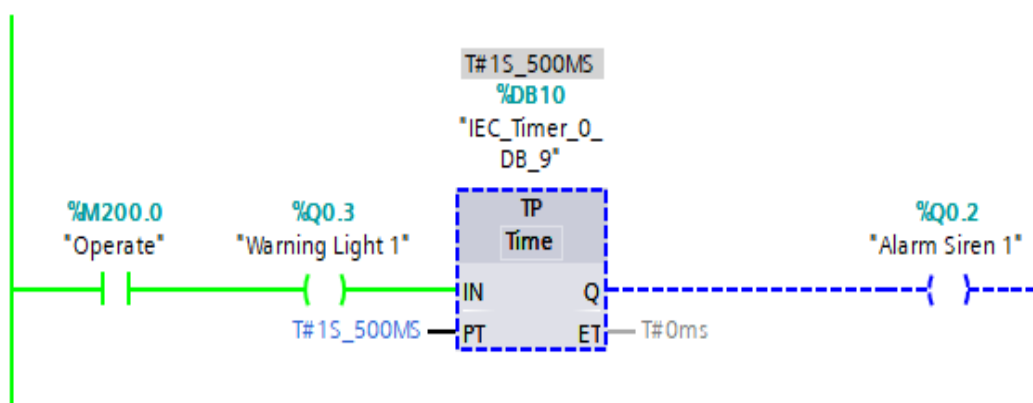
Stop and Start Lights

This network indicates the user of current factory operation. If operate is on, the green stack light and the start light located on the control panel will turn on to indicate the process has started. When operate is not on, the red stack light and stop light will both indicate the factory is stopped



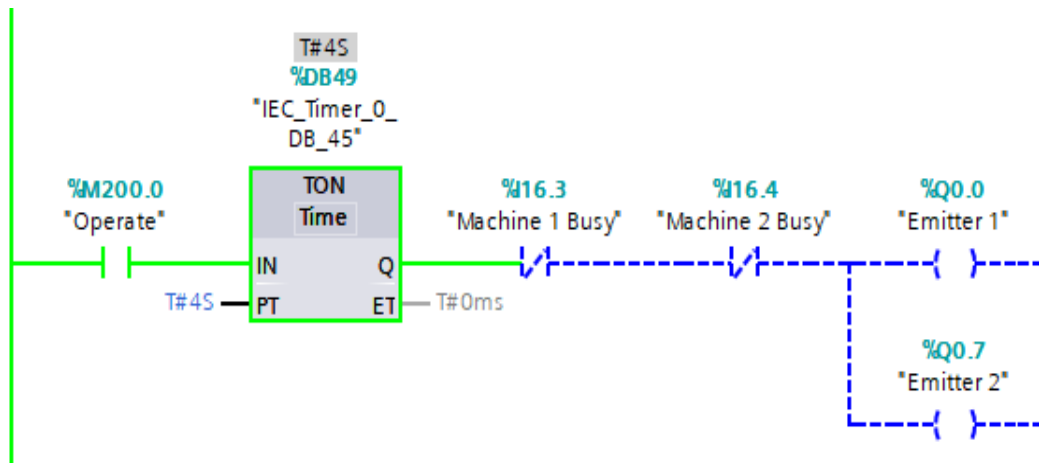
Siren

The siren indicates the factory is about to start. Operate is used to send the input signal to the warning light. With the use of a pulse generator, the signal will sound the siren for 1.5 seconds before turning off.



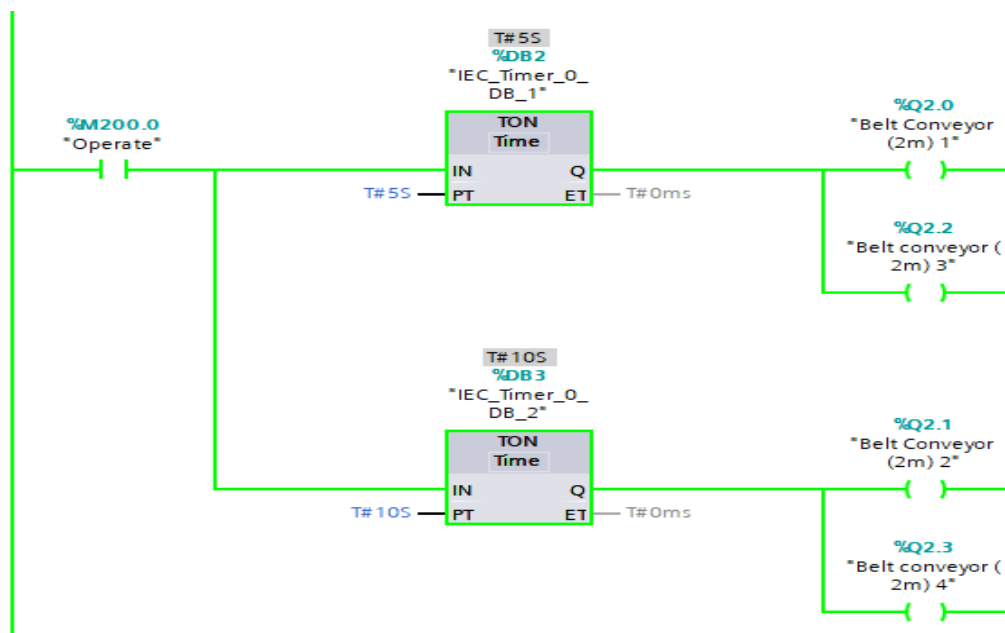
Emitters

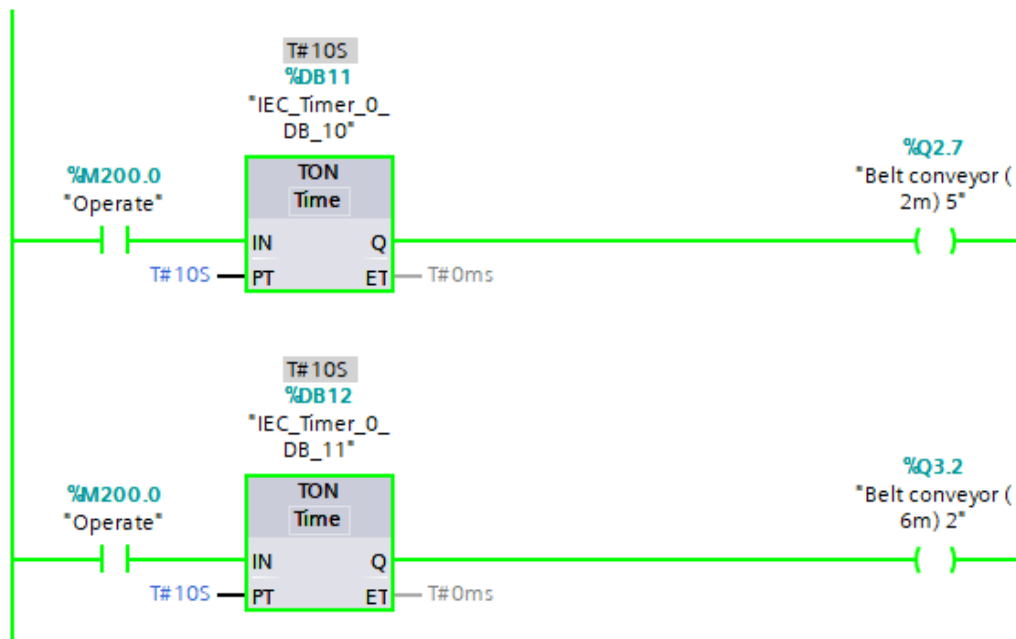
In this network, the input signal is actioned by operate. An on-timer delay of 4 seconds before actioning conveyor belts. A 'normally closed contact' is used for both machines showing 'busy'. If they are not busy, the emitters will emit a part ready for machining.



Conveyor Belts

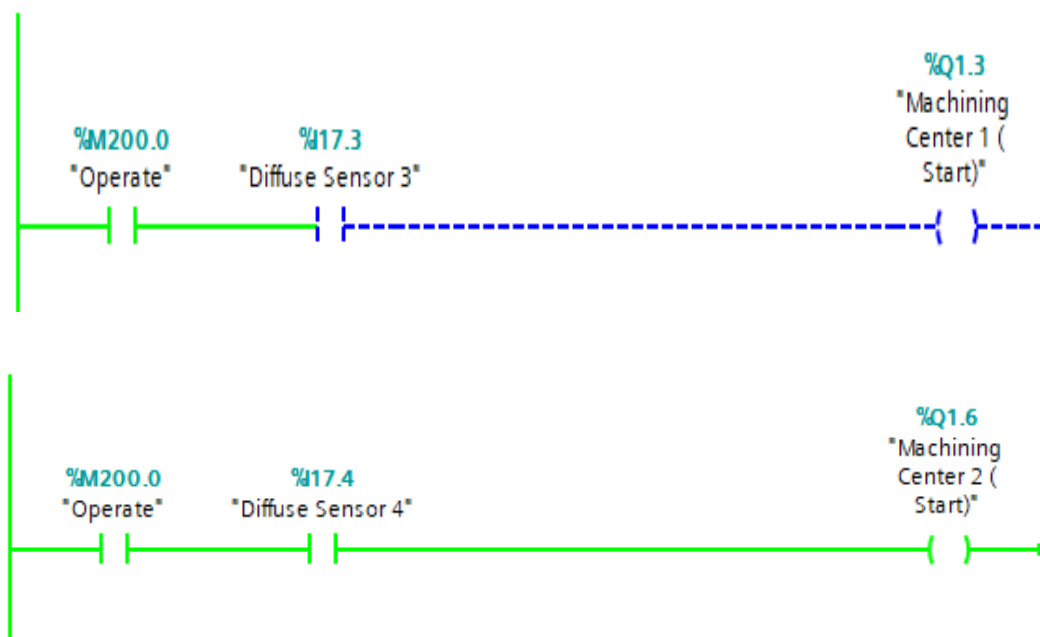
Operate will action all conveyor belts once factory starts. A series of on delay timers are used to delay turning belts on at the same time to limit the current draw at start up.





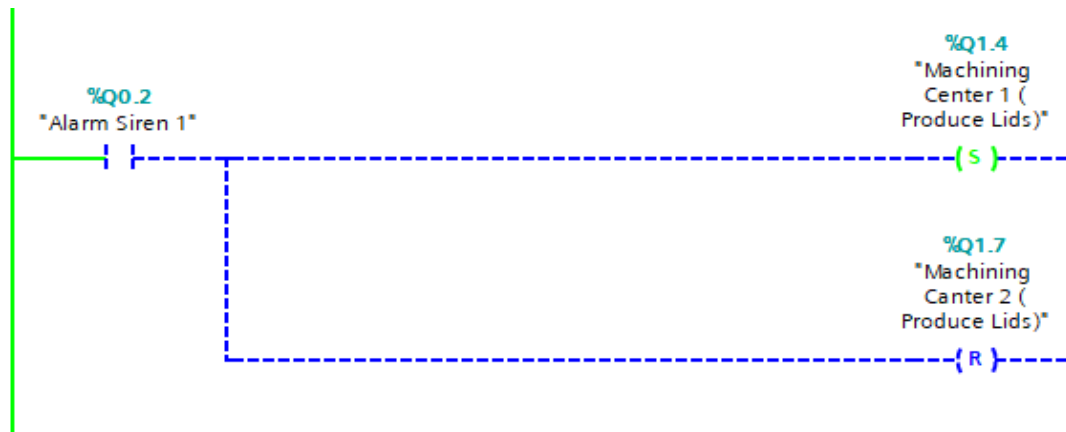
Machine Start

On the assembly line is a series of diffuse sensors, each one is used to trigger different parts of the assembly for different things. In these networks the sensors are triggered by a part ready for machining.



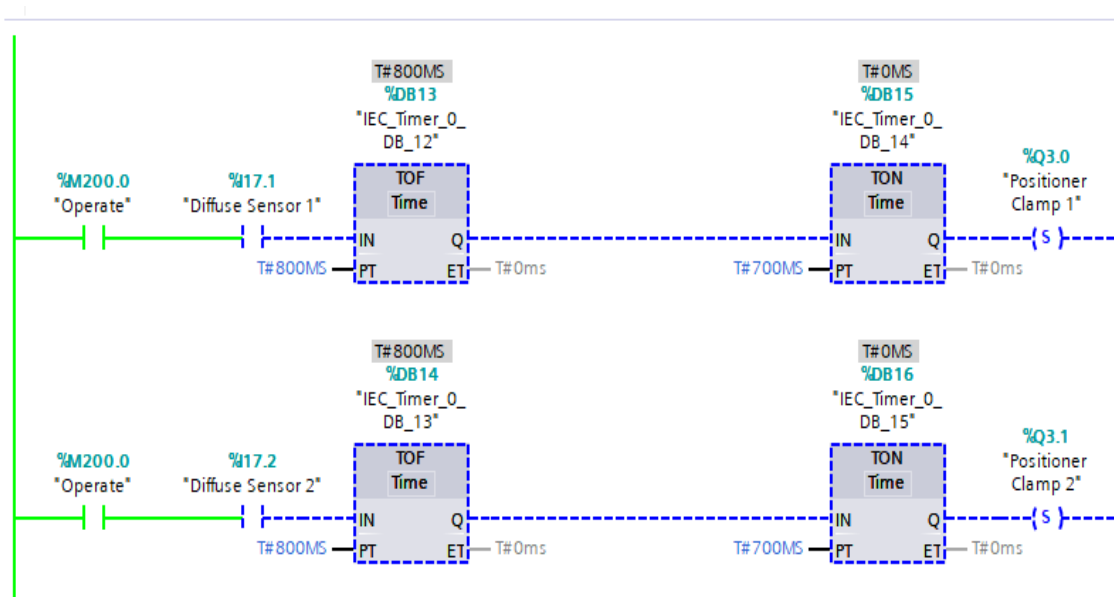
Machining Types

In this network, the alarm siren will send an input signal to both machining centres. The machining centres are producing different parts. Therefore, one centre is a set output whilst the other is a reset output to achieve these parts. Once the siren is triggered, the machining centres will continually machine these parts until the process is stopped.



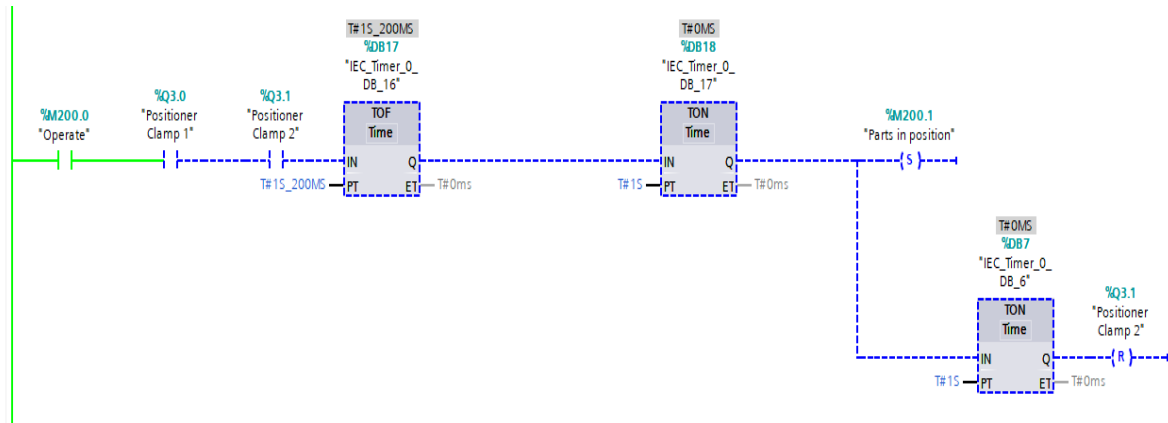
Clamp Positioners

This network is linked to the first two positioner clamps. With the use of sensors that are triggered when a part breaks the laser, an off timer and an on timer both receive and send an input signal to the positioner clamps. The positioner clamp is then set and will clamp the part into position.



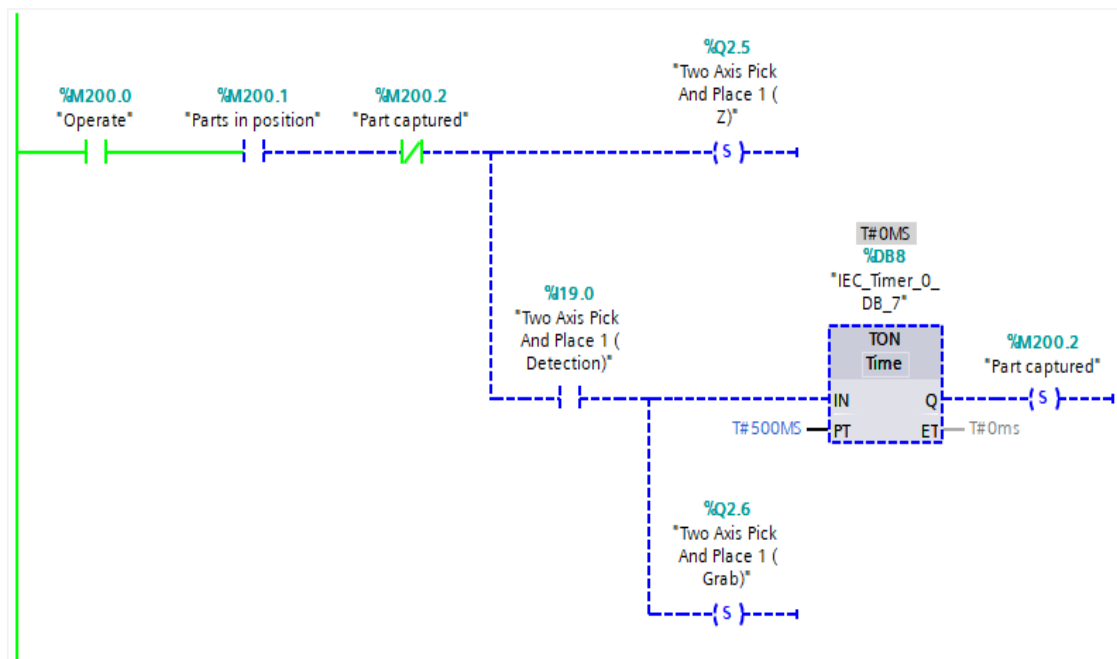
Clamp Positioner 2

Once the positioner clamps are set from the previous network, a signal is sent to 'parts in position' after an on and on delay. This set output is then used for the pick and place. The input signal is also received by another on delay and after 1 second, will reset positioner clamp 2 ready for the next part.



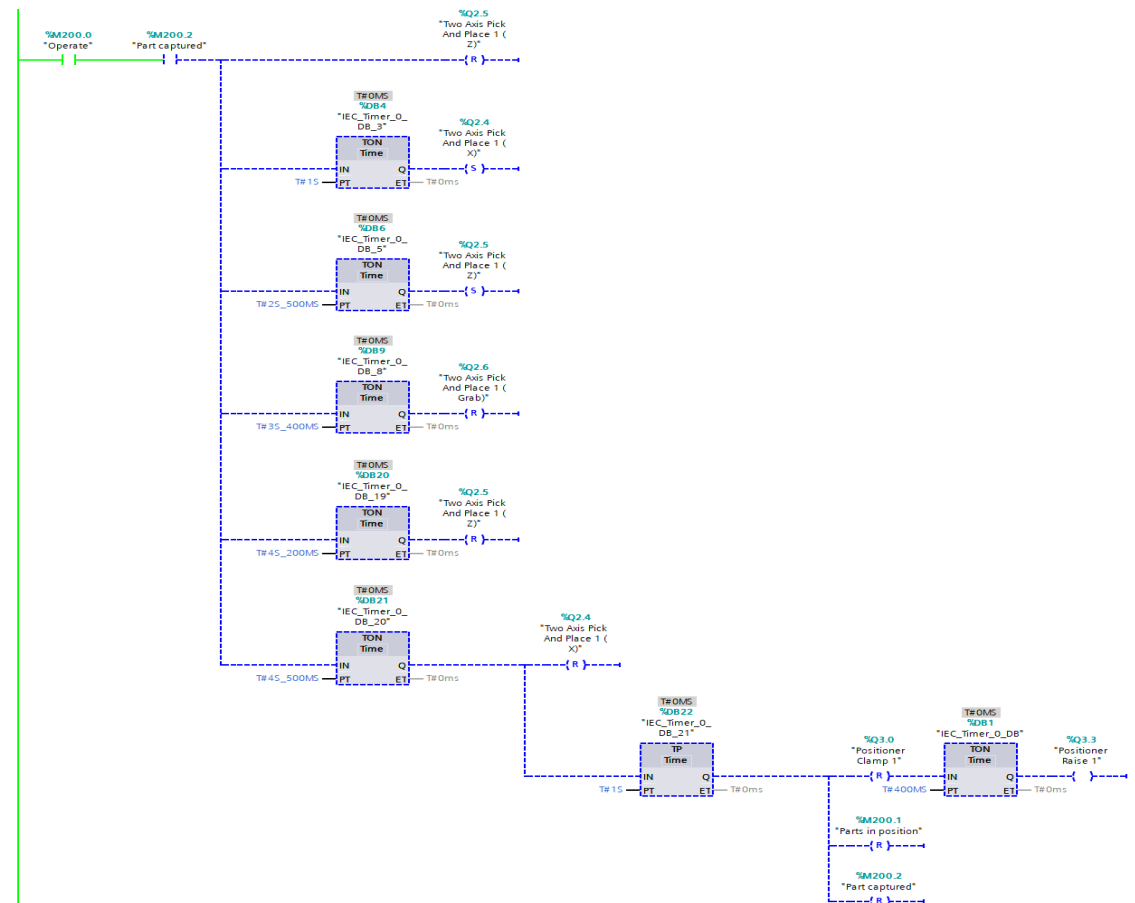
Pick And Place 1

This network will now initiate the pick and place. Once 'parts in position' is set in the previous network, a 'normally closed contact' for part captured is also used to show the arm that the part is still in the clamped position. The signal is then received and sets the 'Z' direction of the pick and place. The pick and place detection will send a signal and set 'grab' and after 0.5s set 'part captured'. This then tells the pick and place that the arm has grabbed the lid and is ready for further instructions.



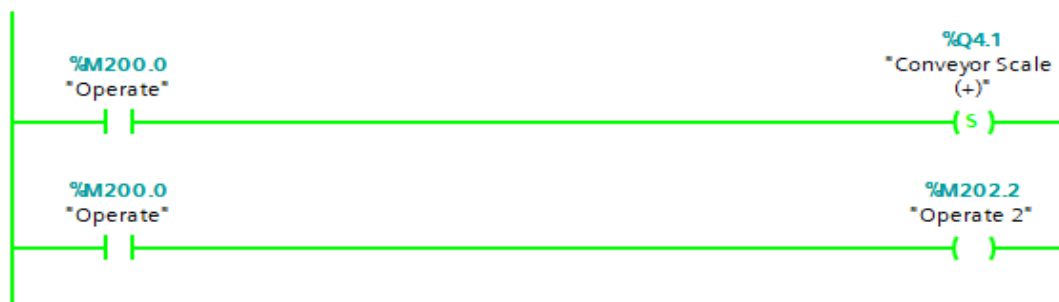
Pick And Place 1 Movement

Once 'part captured' has been set in the previous network, this network will trigger the remainder of the sequence starting with the resetting the 'Z' direction. Using a series of on delay timers in a systematic order, the arm is set in 'X' direction, then set in the 'Z' direction. The pick and place 'grab' is then reset to place the lid onto the base. Once stacked, the arm is reset in the 'Z' direction and then in the 'X' direction to return to its original position. Once returned, the input signal is then met with a pulse generator that holds the signal for 1 second to reset 'positioner 1' 'part captured' and 'parts in position'. After the 'clamp positioner' has reset, an on-delay initiates the raise function of the positioner to allow for the stacked part to continue down the assembly.



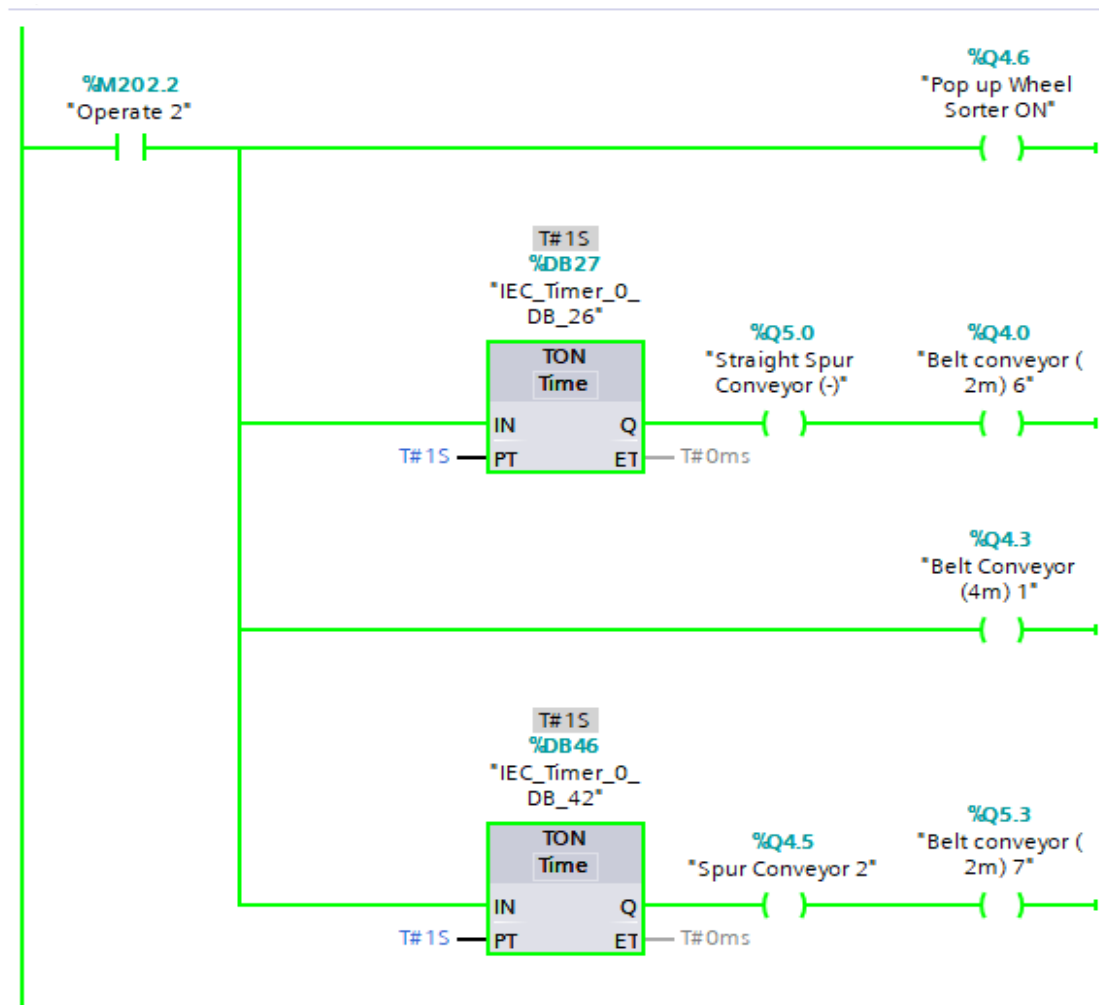
Scale Conveyor

When operate is active, the 'scale conveyor' is set on. In this network, operate also sends an input signal to output 'operate 2'.



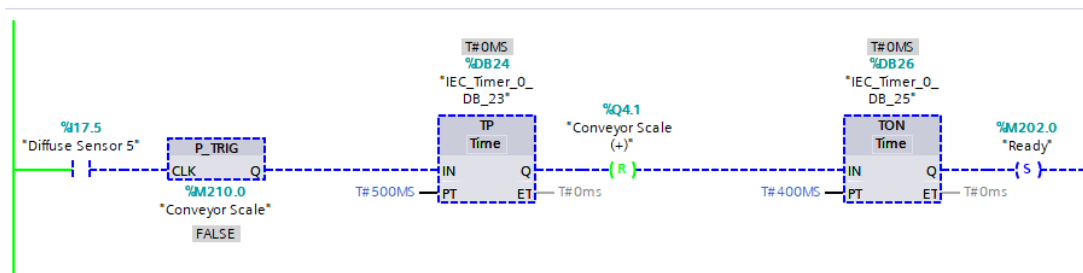
Operate 2

This network activates the remaining components of the assembly line. These remaining components are for fault intervention. The pop-up wheel sorter, spur conveyors and 2 m conveyors are used for when error parts need to be separated from the main process line. The 4m belt is the main line.



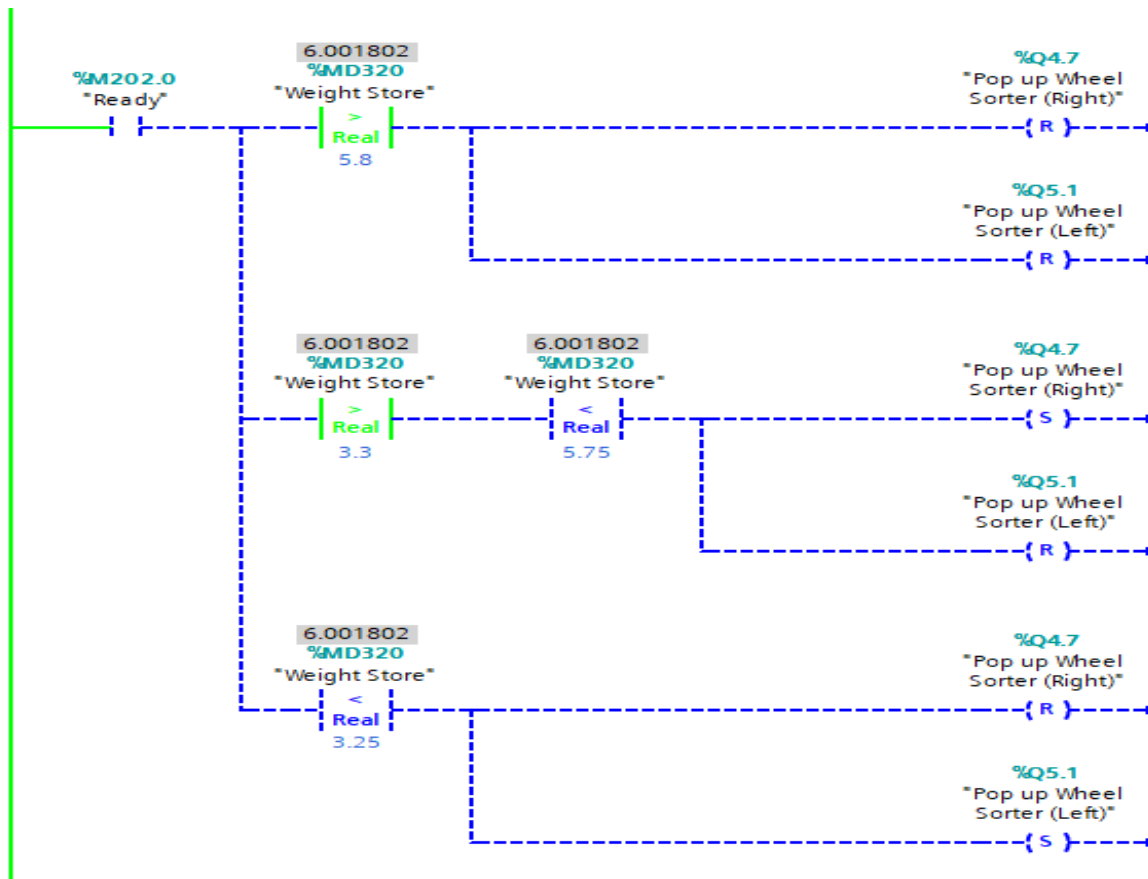
Scale Conveyor Weigher Sequence

When the part triggers diffuse sensor 5, it generates a pulse for 0.5s and resets the 'scale conveyor' momentarily to measure the weight. The signal then reaches an on delay of 0.4s before setting 'ready'.



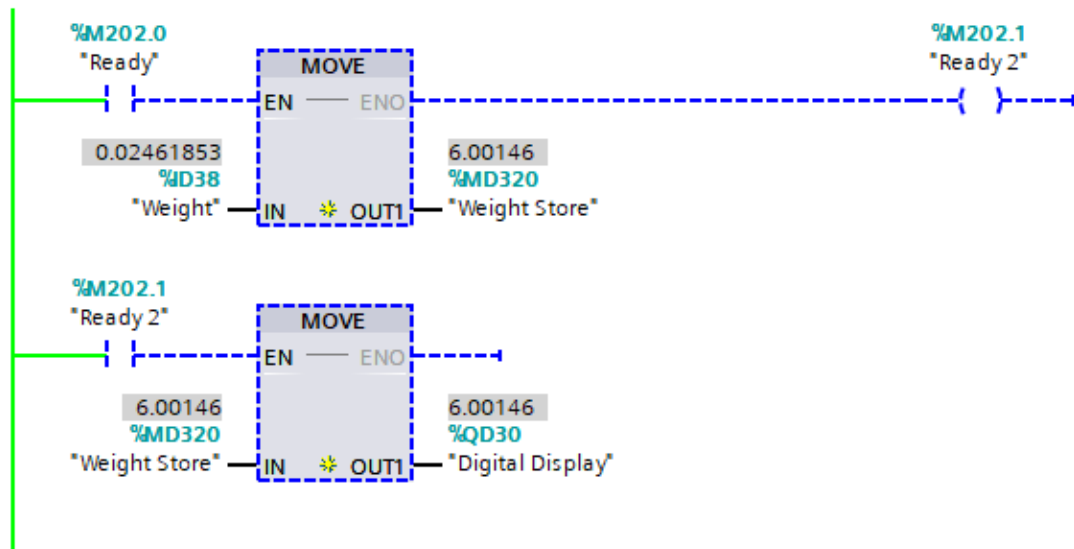
Pop Up Wheel Sorter

This network controls the pop-up wheel sorters added in for sorting any error parts that make it down the line. If the weight of the part is > 5.8 then the part will continue down line. If the weight measured is < 5.75 but > 3.3 then the line assumes this is a base part and will set 'Right'. If the part weighed is < 3.25 then the line assumes this is a lid and will set 'Left'.



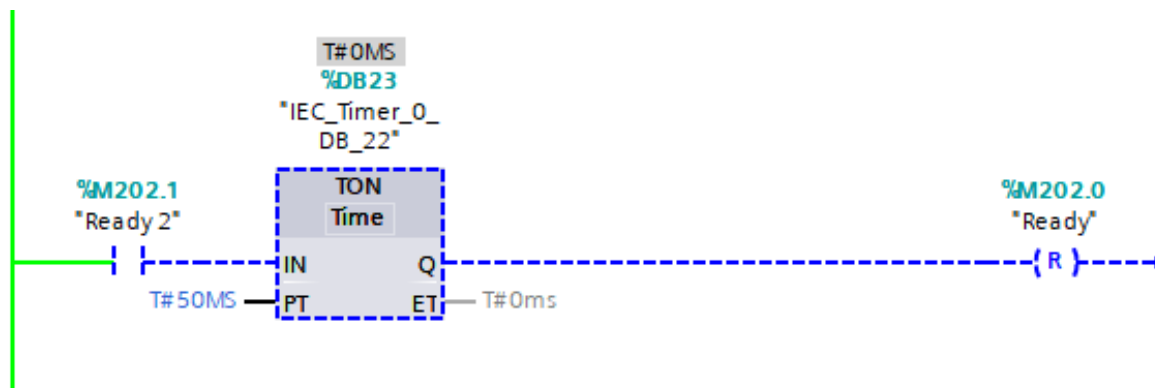
Weight Store

When ready is triggered by the part reaching the scale conveyor, the move function stores the measured weight 'IN' into the memory store 'OUT' and then activates 'ready 2'. 'Ready 2' then triggers the move function and the weight store is 'IN' but this time the 'OUT' is the digital display. This shows the weight on the control panel of the factory.



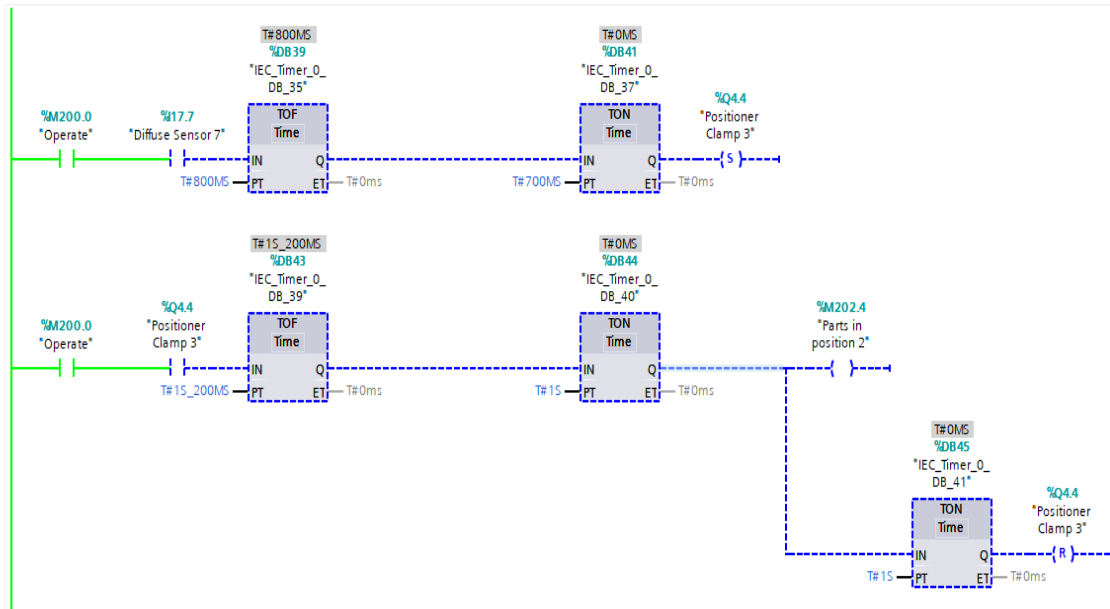
Weight Store Reset

Once 'ready 2' is activated, an on-delay of 50ms triggers before resetting 'ready'. This is now ready for the next part to be weighed.



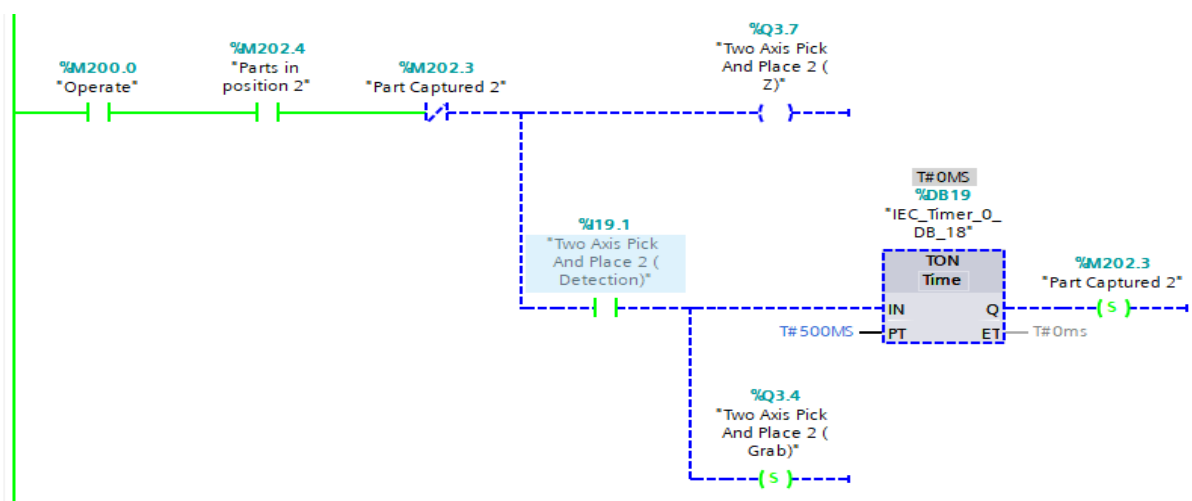
Positioner Clamp 3

This network controls the third positioner clamp. Using a diffuse sensor, when the laser is broken a series of off and on delays trigger and set the 'positioner clamp' which then clamps the part into position. Once the positioner is set, the second line receives an input signal that the off and on delay will send to 'parts in position 2' after 2.2s. This signal after on delay of 1s will reset 'positioner clamp'.



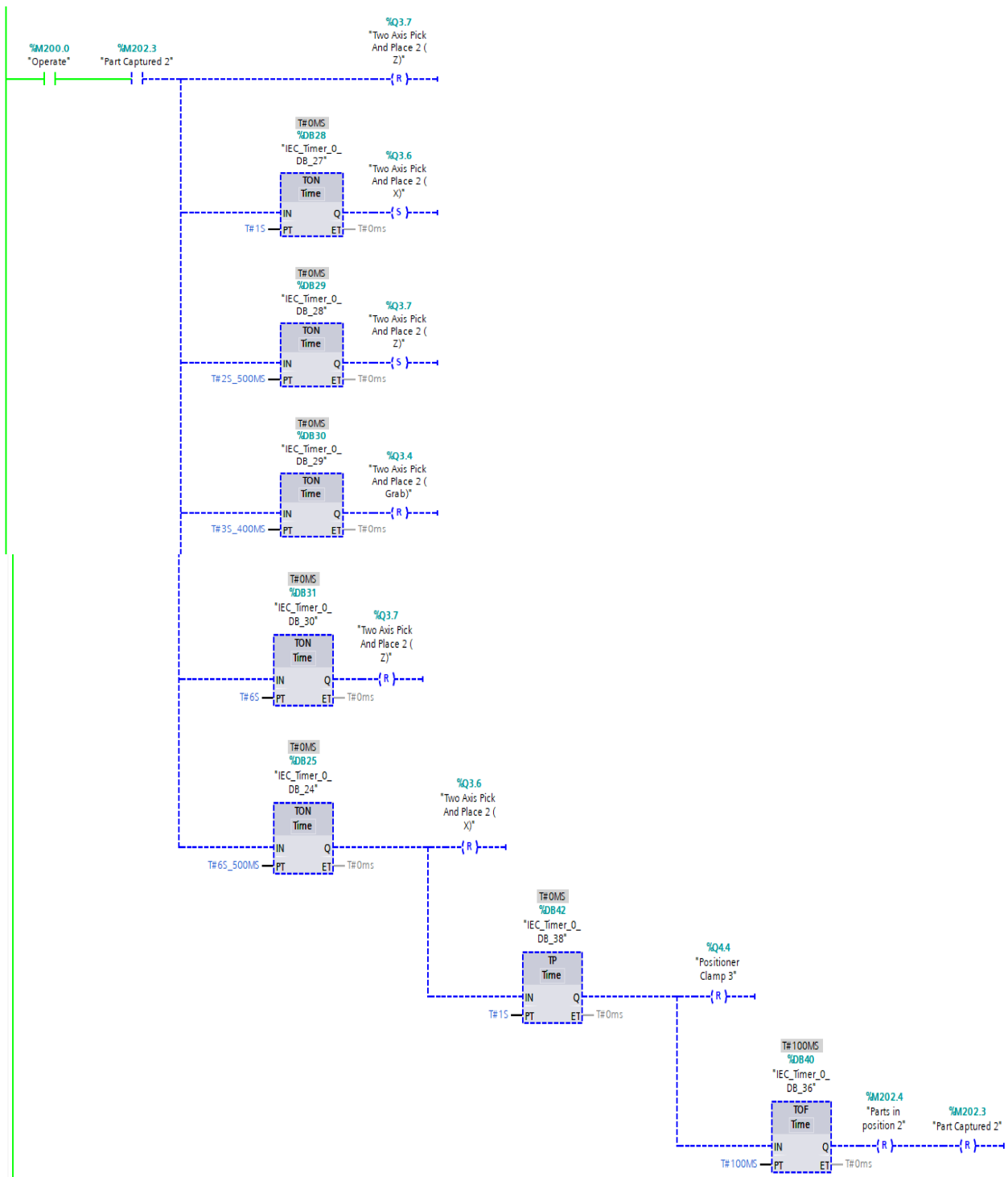
Pick And Place 2

For the second pick and place, a mimic of the first one was created, and all corresponding tags were duplicated. Once 'parts in position 2' is triggered, the pick and place can begin sequence. Starting with moving down in the 'Z' direction. Simultaneously, the detection will detect the part in position and set 'grab' and an on delay of 0.5s before setting 'part captured 2'. Once 'Part captured 2' is set, the arm can finish sequence.



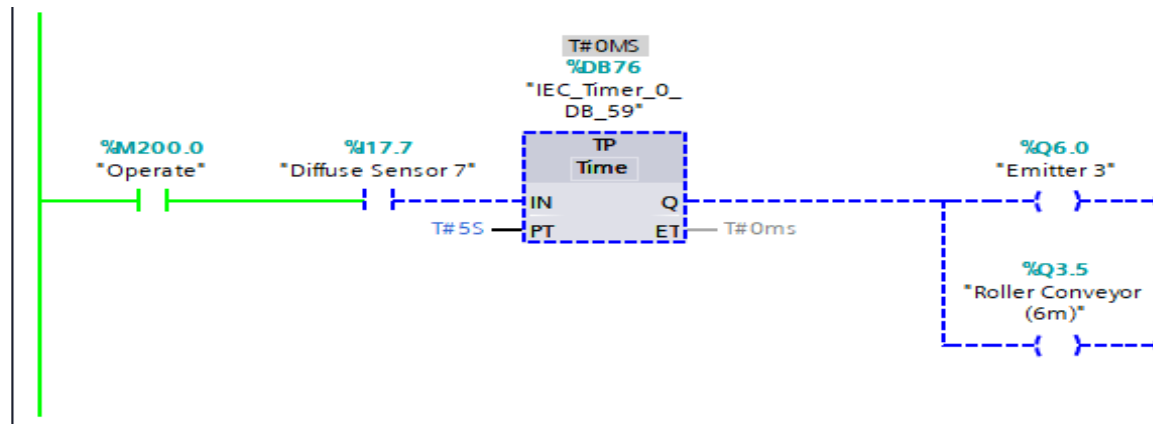
Pick And Place 2 Stack

Once 'part captured 2' is set, the pick and place can finish placing part into box. The first movement is a reset in the 'Z' direction. This returns the arm into its original position whilst still holding the part with the grab. Using a series of on delay timers, the pick and place begins its sequence. Set into the 'X' direction after 1 second, set into 'Z' direction after 2.5 seconds, reset 'grab' after 3.4 seconds to drop part into box and then reset back into original position after 6 and 6.5 seconds. Once the pick and place has reset from the 'X' position, a pulse generator holds an input signal for 1 second, initiating a reset of 'positioner clamp' 'parts in position 2' and 'part captured 2'. Once these three outputs are reset, the assembly is ready for another part to be stacked.



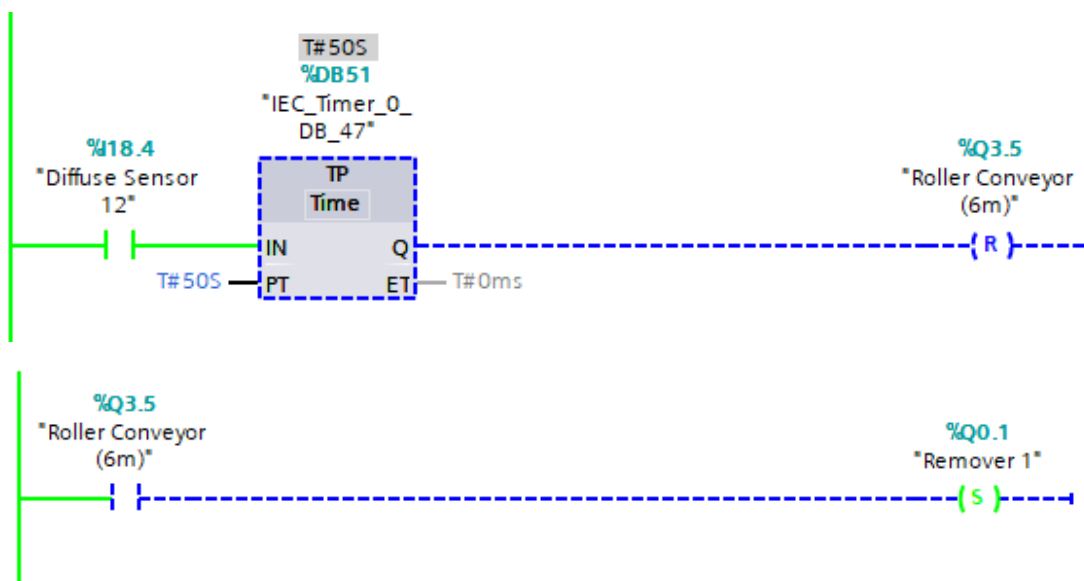
Box Emitter

Once diffuse sensor 7 has been triggered, a pulse is generated for 5s which activates the roller conveyor for this amount of time and will emit a box for the finished parts to be stacked into.



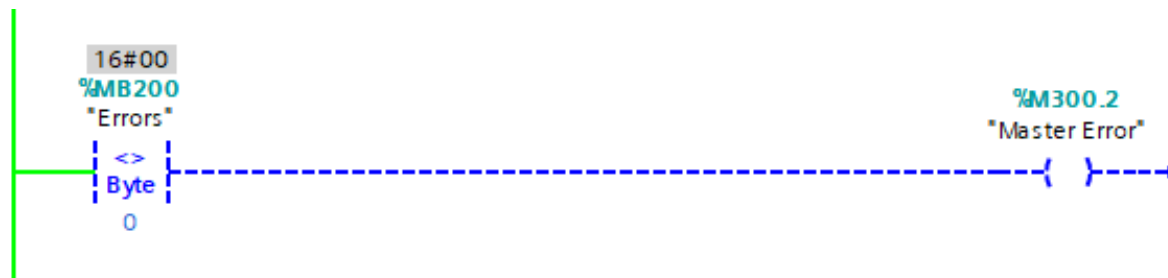
Roller Conveyor

Diffuse sensor 12 is triggered by the box. The 'roller conveyor' will reset for 50s from the generated pulse. This is to give the assembly line enough time to stack a second finished part into the box before the box moves on towards the remover at the end of the roller conveyor.



Master Error

Any errors that are triggered will cause the 'master error' to initiate. Once master error is active, the error flag becomes active.



Warnings Flag

Any warnings that pop up when the factory is on will activate the warning flag.



3.0 Alarm and Warning Strategy

3.1 Alarm Strategy

Alarm systems are an integral part of 'human-machine interface' as stated by (Edvard, 2016). For any type of operation, the alarm system will indicate to the operator/engineer that the process is currently not running at normal conditions. This indicates that there is a problem that needs to be resolved and depending on the industry, could potentially lead to significant failures.

Please See Appendix A

3.2 Warning Strategy

Traditionally, production counting systems are used to keep track of the number of items produced in a line or plant as described by (Vorne, no date). Alongside this, the technology in the modern era can produce a vast series of data about the process it is monitoring. This is extremely important for businesses as it can highlight improvement opportunities.

Please See Appendix B

4.0 HMI and Control Screens

4.1 HMI Control Screens

A HMI (human machine interface) is an intuitive interface that allows the user to control, interact and operate a machine or process as described by (Indra, 2022). The complexity of the design can range from a very simple screen mounted on a machine to a more complex, touch enabled control panel with multiple buttons all linked to specific parameters. The HMI screen can also contain live data linked to a factory operation e.g., a counting system.

Please See Appendix C

5.0 Conclusion

To conclude this report, the factory operation was designed well. The strategies used for the alarm and warning system was creative and allowed the user to overlook the whole process from the screens. The HMI screens were simple to use and effective to operate. This would be extremely value adding in a real factory operation as production is optimal for achieving greater profit margins. Therefore, performing interventions without the need to halt production will achieve greater returns. However, there is always room for improvement in any given process as no process is perfect and there will always be areas of waste that can be eliminated. In other words, always strive for improvement.

6.0 Bibliography

Edvard (2016) 'This is why every industrial plant MUST have an alarm system (for monitoring processes) | EEP', *Electrical Engineering Portal*. Available at: <https://electrical-engineering-portal.com/alarm-system-industrial-plants> (Accessed: 23 May 2022).

Indra (2022) *What Is HMI? - TECHniTAB.in*. Available at: <https://technitab.in/featured/what-is-hmi/> (Accessed: 23 May 2022).

Ladder Logic World (no date) *Ladder Logic Basics - Ladder Logic World*. Available at: <https://ladderlogicworld.com/ladder-logic-basics/> (Accessed: 22 May 2022).

Vorne (no date) *Production Counters | Vorne*. Available at: <https://www.vorne.com/solutions/applications/production-counters/> (Accessed: 23 May 2022).

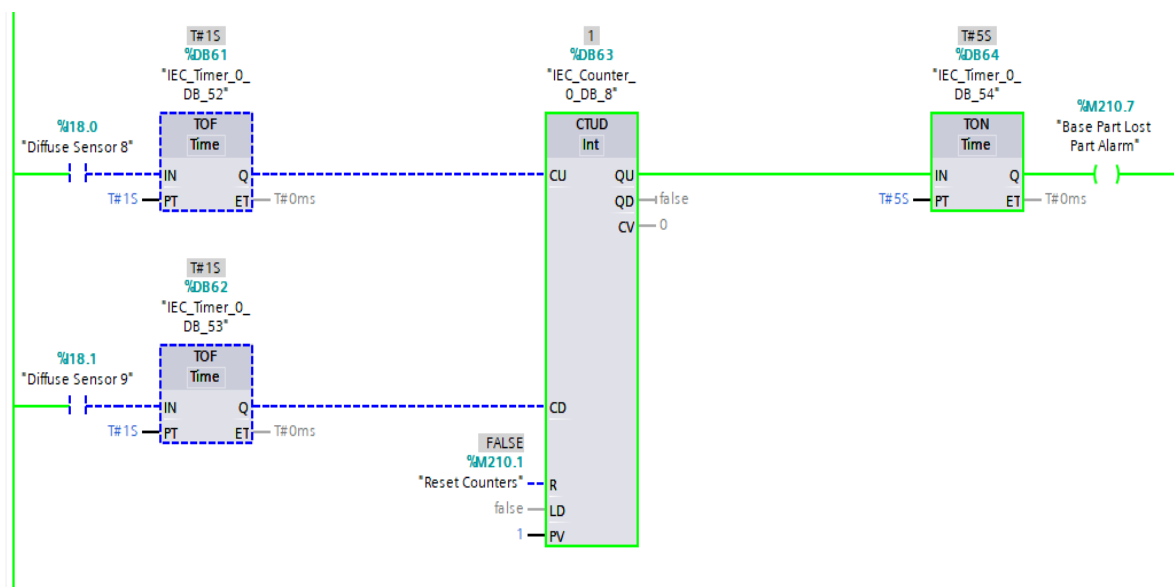
7.0 Appendix A

Error Strategy

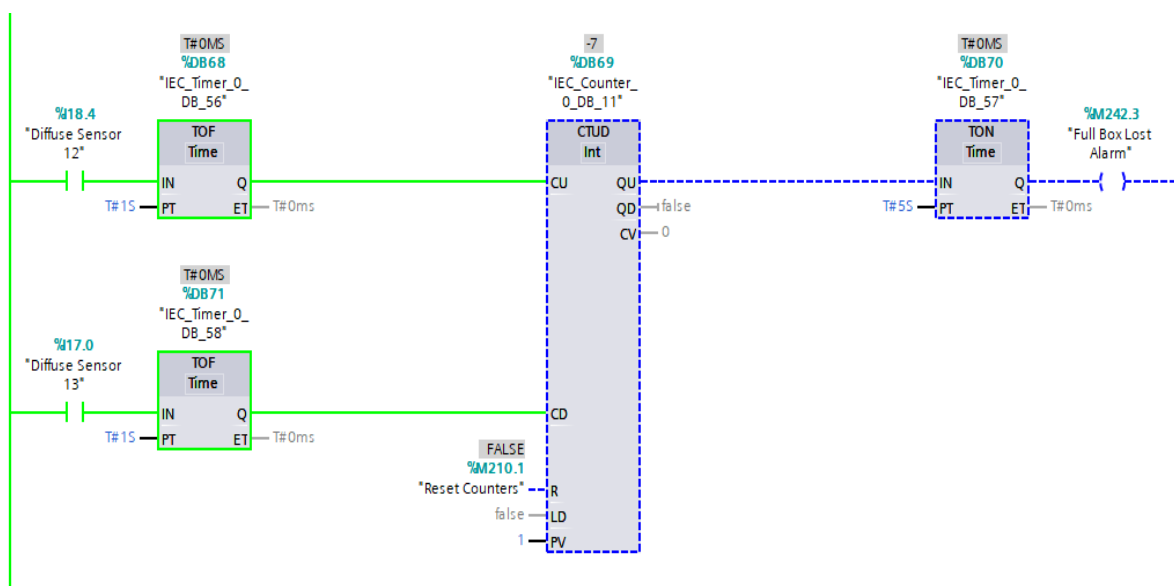
For this operation, strategies were put in place to help create an efficient operation. This strategy would help eliminate issues that usually occur in a factory operation, such as errors due to material handling.

To ensure that every part emitted is accounted for throughout the process, each counter network also has a lost part system. With the use of a 'count up and down counter' and two sensors per line, the first sensor is triggered the same way as the other counters. The box must then trigger the second sensor before reaching the end of its line. If for any reason the box doesn't trigger the second sensor, then after a short delay the lost part alarm is activated. This will also light up the engineer screen, prompting the engineer to inspect and resolve the issue without stopping the process.

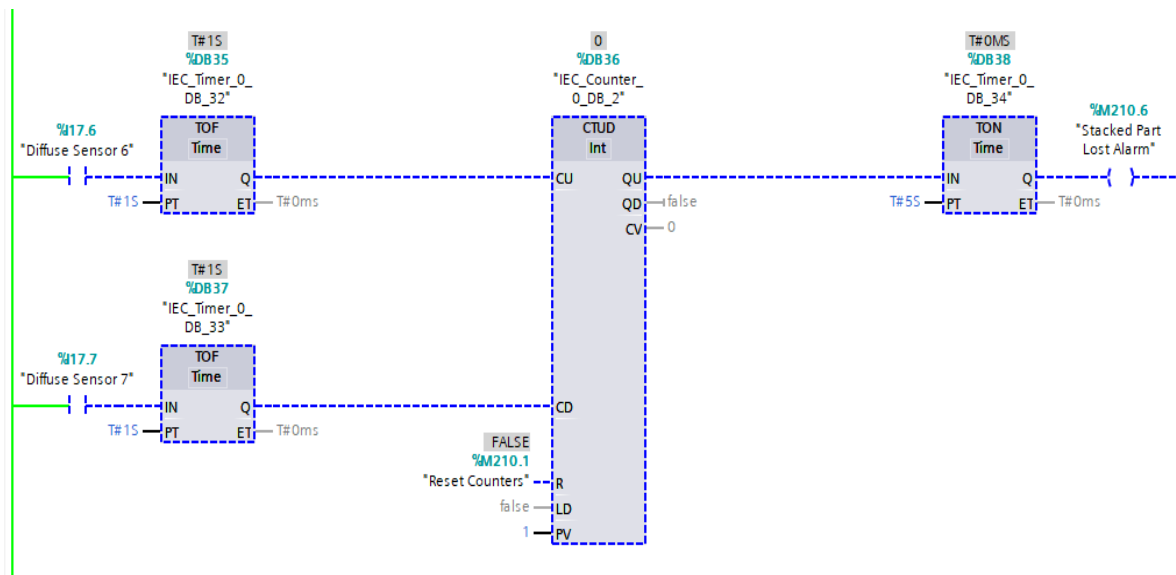
Lost Base Part



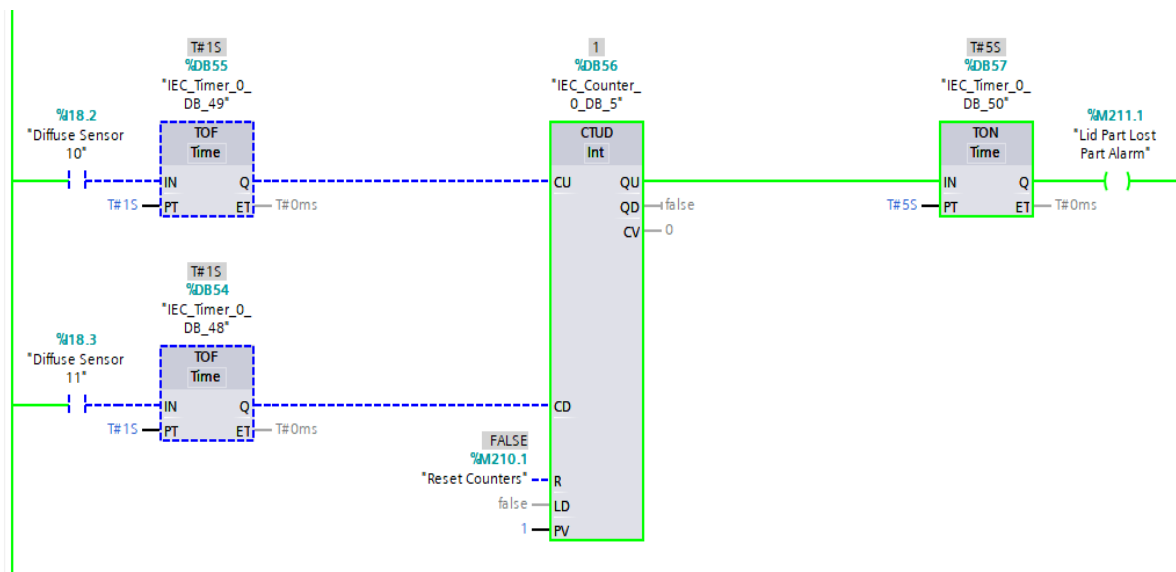
Lost Full Box



Lost Stacked Part



Lost Lid Part

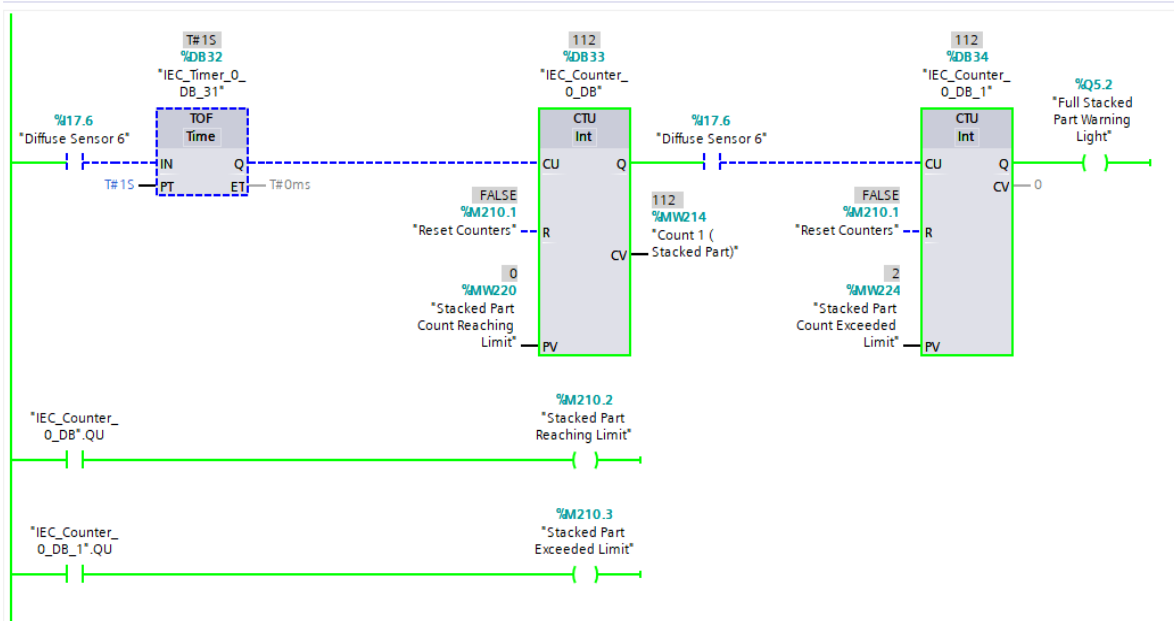


8.0 Appendix B

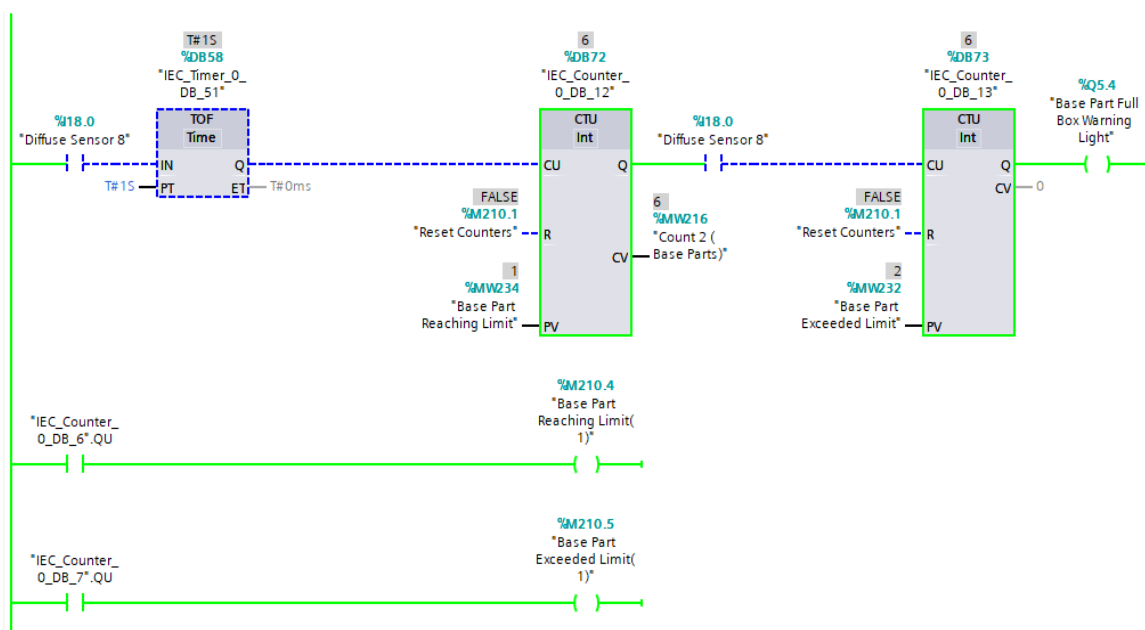
The warning strategy implemented into this operation allows an engineer to intervene without stopping the process.

Each line within the factory has a counting system. This system uses the various diffuse sensors that are located at the starting point of the line and at the end of each designated area. For each counter, an off timer of 1 second after the sensor input signal is triggered was added to avoid any double counts. After 1 second, the sensor input is received and counts by 1. The limit can be altered on each counter and once it has reached the set limit, a signal is generated for the next part of the network. The next section indicates the counter has exceeded the set limit. Once the box count exceeds the upper limit set by the user, a signal is sent to the warning light output, indicating an exceeded limit on that line. The user can input any limits they wish for each specific line.

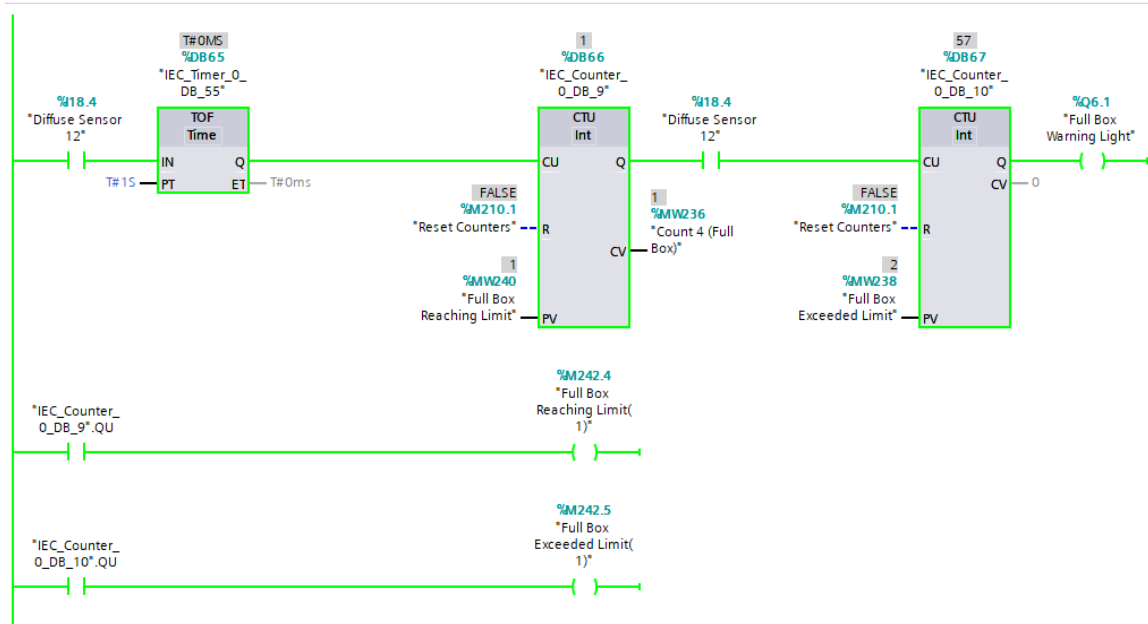
Stack Warning Light



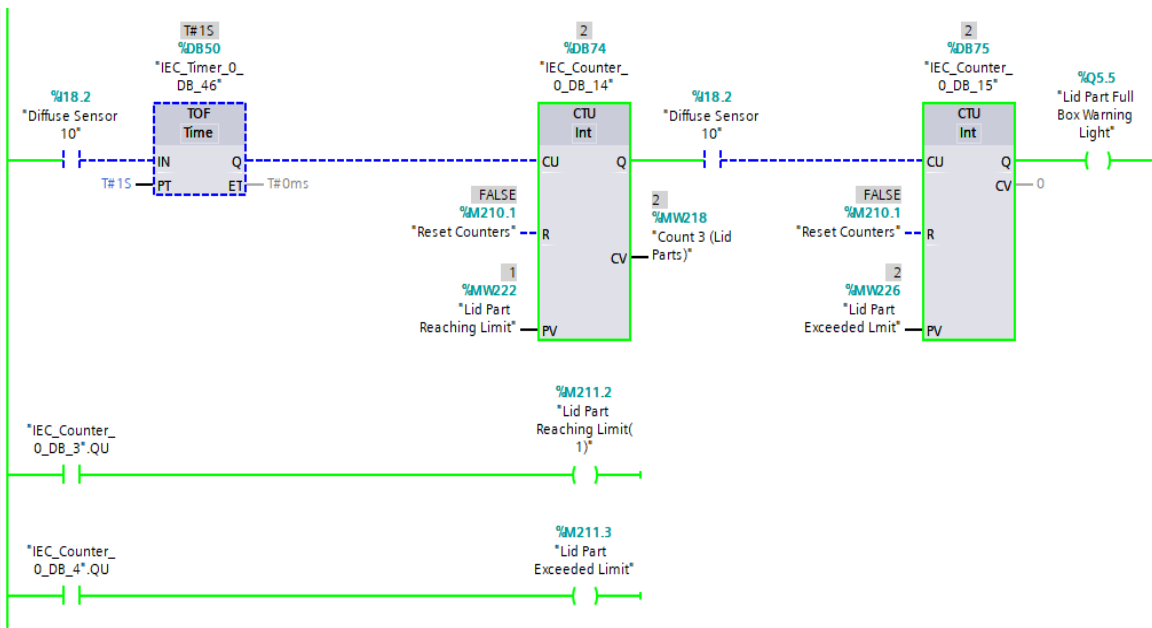
Base Warning Light



Box Warning Light

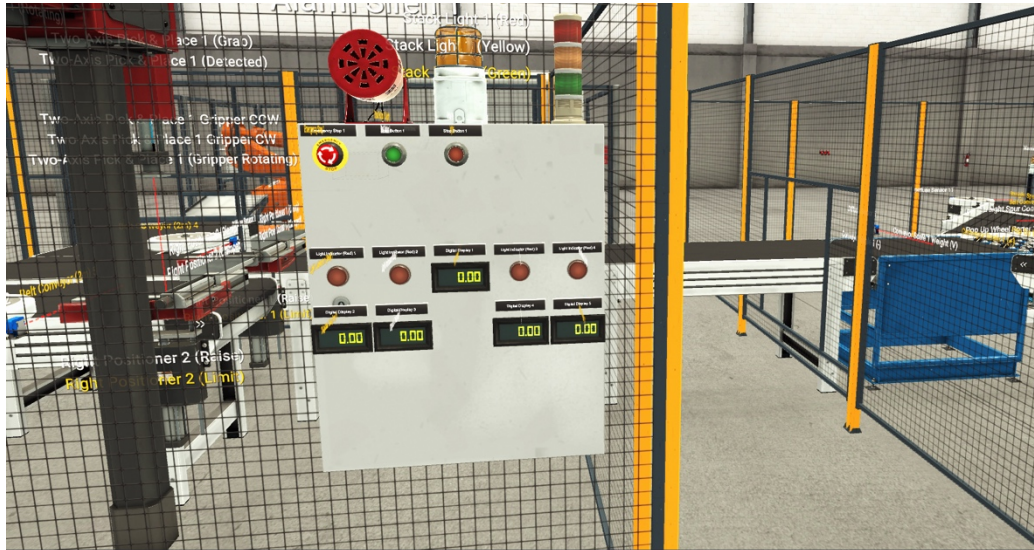


Lid Warning Light

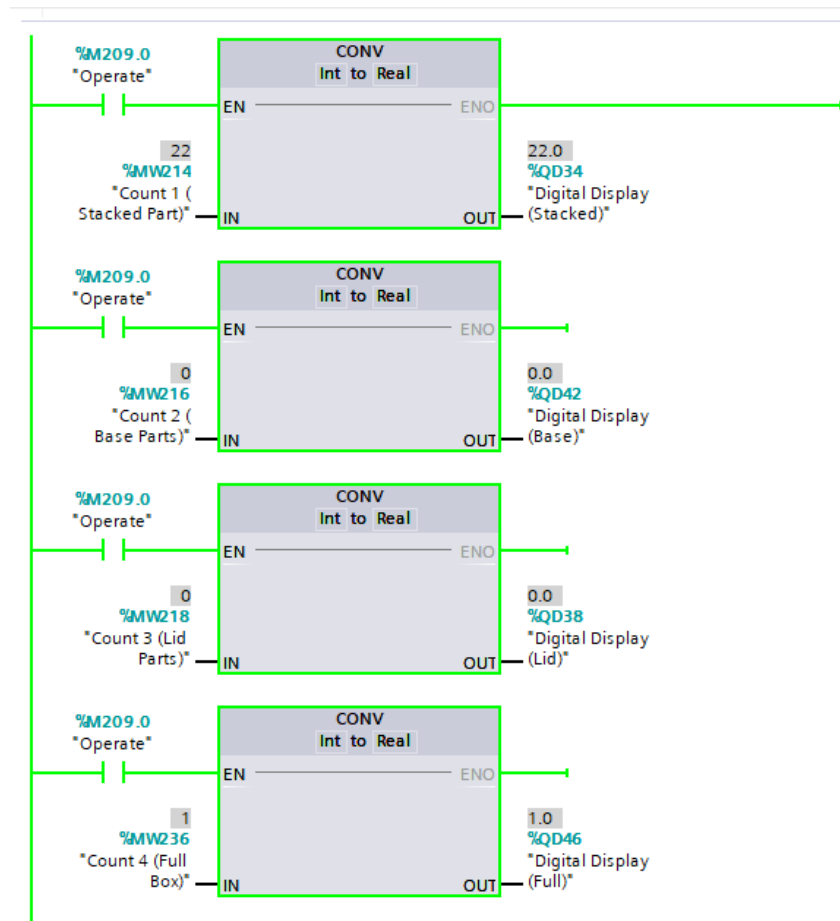


9.0 Appendix C

The simulation user will find the control panel located on the safeguarding behind the first pick and place. It is important that the user presses the stop button to reset the factory to normal working standards. The stored weight can also be found on this control panel indicating the weight of the part. Also on the panel, the user has a visual of the total parts that have reached each designated area. The warning lights will trigger once the total parts exceed the set limit.



The network below is linked to the digital displays. When the count increases, the digital display will show the current number.



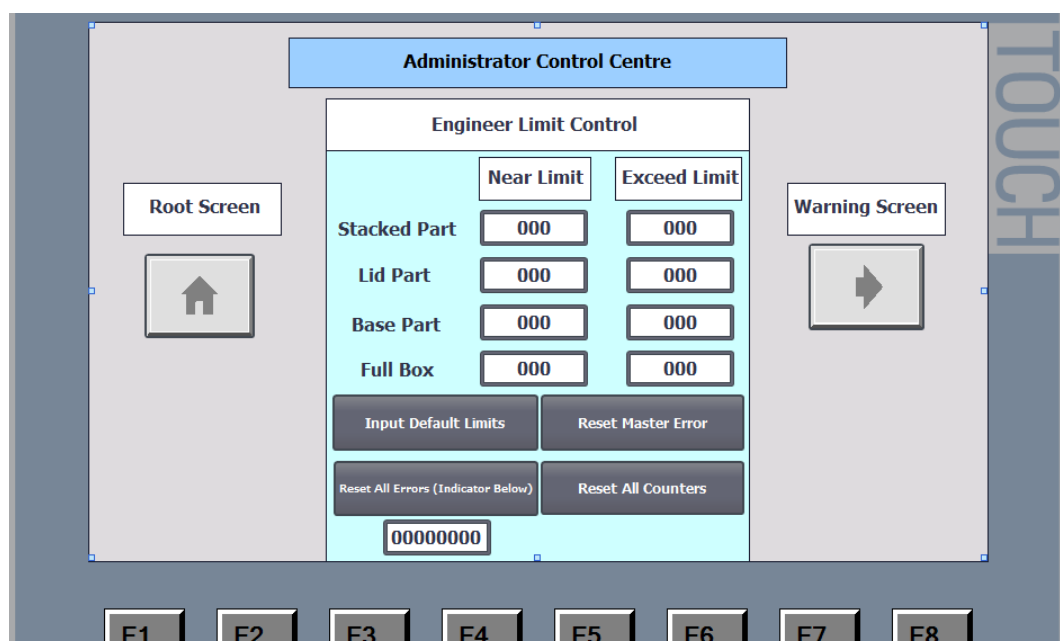
Root Screen

The aim of the root screen was to have a visual of all important aspects of the factory process. This allows the engineer to control the factory with ease if any issues should arise. The ease of navigation between the screens also allows for quick interventions and troubleshooting. In the real world, production is paramount. Therefore, optimum production time is vital for generating profit.

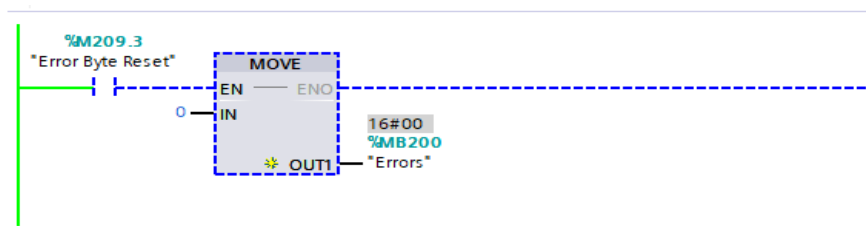


Engineer Screen

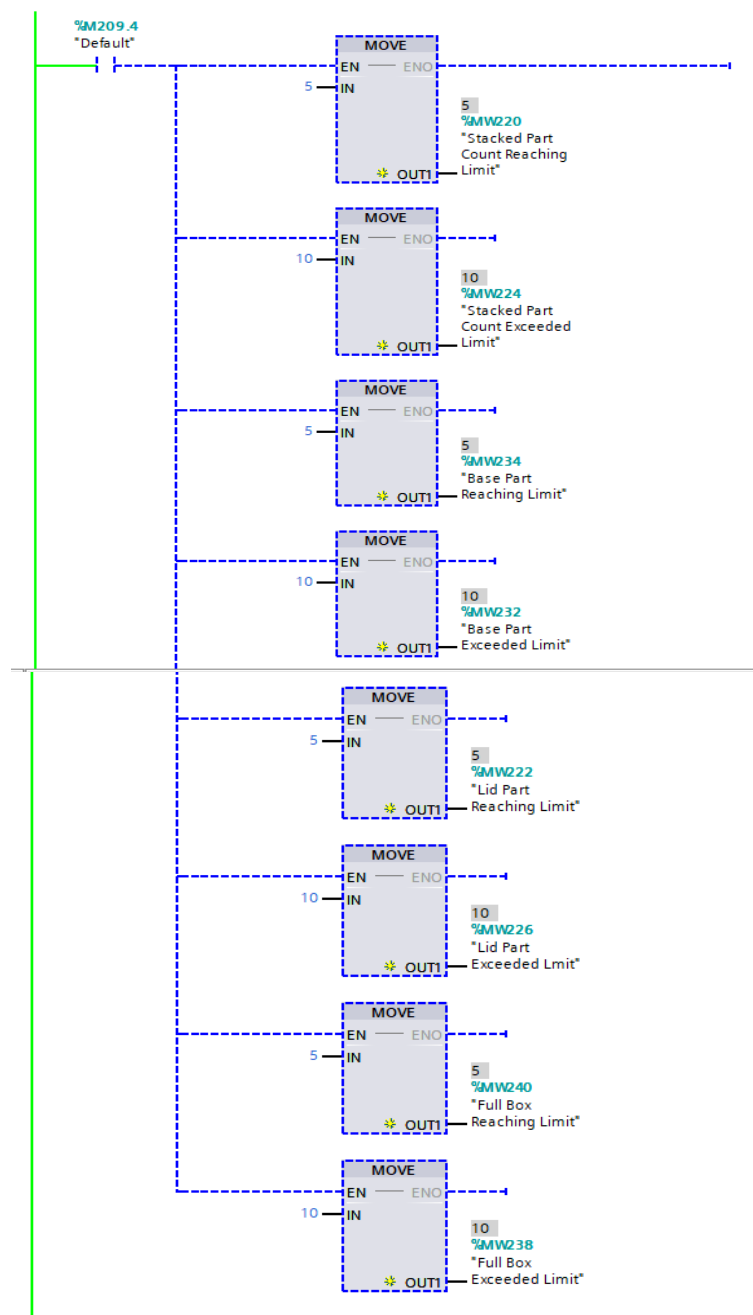
The engineer screen allows the user to control limits and solve issues quickly. The default button allows the user to input limits with a click. Once these limits have been set, the factory will start producing normally. Any accidental parts that do not process properly will be separated by the scale conveyor into their designated areas. Once the set limit is reached, a warning light will trigger in the factory and on the warning screen. The easy navigation between screens continues with this screen. The engineer is also able to perform resets when issues pop up. Any errors will show on the counter located underneath the error reset.



The reset all errors is linked to this network below.

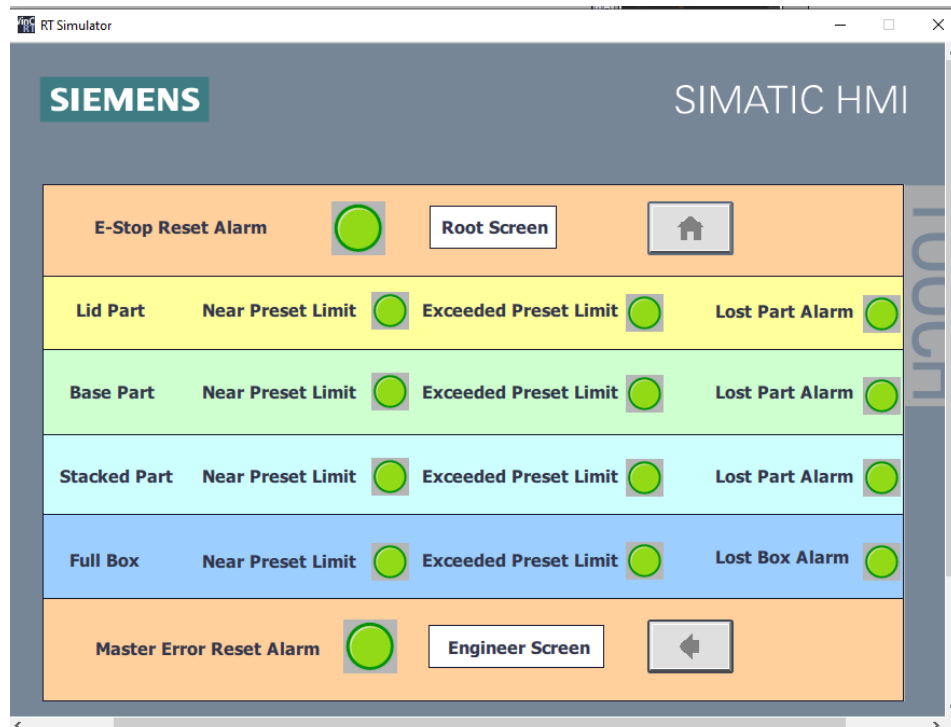


This network was created for the default inputs. This allows the user to quickly add limits during production from one click.

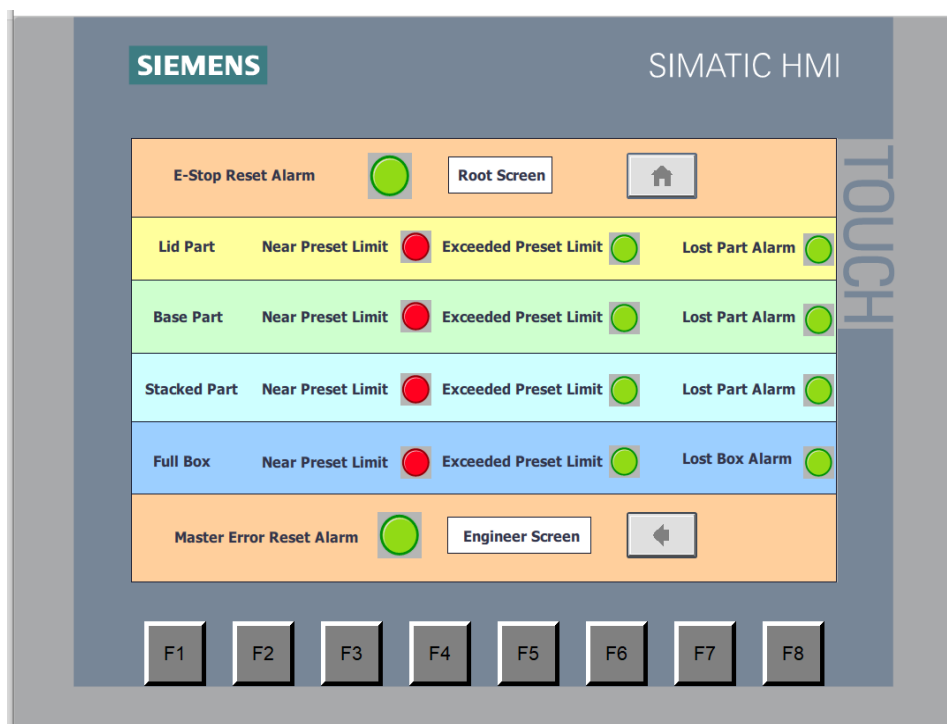


Alarm And Warning Screens

Part of the alarm and warning strategy for the factory was to create a visually diverse screen. This screen directly links to all the limits and alarms which can be altered in the engineer screen. The navigation between the screens is smooth and all interlinked when errors pop up.



If the set limit is approaching in the factory, then this screen will indicate by flashing in red.



When any errors pop up and warning lights are all activated, the screen will flash red and white, and all the lights should turn red. The engineer would then need to perform a series of resets and potentially change any previously set inputs.

