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1. Executive Summary

This is a good summary that provides an honest and straight forward explanation of all that was done

This report presents the design, development, and testing of a Pack Stopper System intended to improve production efficiency and reduce downtime on a food production line. The project was initiated to address a recurring fault on a tray sealer line caused by overcrowding of packs, leading to operational stoppages and productivity losses.

The system was developed using a Siemens S7-1200 PLC, integrating conveyor speed control, pack counting, emergency stop functionality, and an HMI interface. Delays in component deliveries meant full physical implementation could not be completed within the original schedule. To overcome this, Factory IO simulation software was used alongside TIA Portal to carefully test the system's functionality in a virtual environment.

Simulation testing confirmed the system's operational reliability, achieving an output of 30 packs per minute which was significantly above the initial target of 20 packs per minute. The revised test plan conducted in simulation achieved a 100% pass rate, validating the control logic and operational sequences.

The project remained within its allocated budget of £2,000, with a final total of £1,991, despite higher-than-expected labour costs due to additional programming and simulation requirements.

Recommendations for future work include completing the physical implementation when parts become available, integrating adjustable pack count settings via the HMI, adding data logging capabilities, and expanding simulation tools for operator training. Overall, the project successfully met its objectives through effective management, adaptive engineering, and strategic use of simulation software to validate the system in the absence of physical hardware.

2. Introduction

A very good introduction that outlines the objectives and contents of the report (with a few improvements suggested)

This report will cover the design, implementation and testing of the pack stopper system while looking at how it will improve production efficiency, downtime, company costing and waste material. The pack stopper system will be put in place to control the speed of the production line while minimising staff and decreasing downtime of the machine. This objective will be achieved by spacing out the packs on the infeed conveyor and minimising operator error causing the machine to go into error and causing a significant amount of downtime.

The design section of the report will include the ^{revised} FDS, block diagram, pack stopper design, panel schematics and electrical drawings for the system. It will also contain the design and programming of the Programmable Logic Controller (PLC), all this will be set ^{in order to achieve} by the FDS criteria.

The implementation section of the report will include the practical side of the system and how it is built. This will include the ^{simulated} panel assembly, and PLC programming and physically assembling the pack stoppers. It will also include project management skills such as creating a costing spreadsheet, WBS, and gantt chart to monitor the progression of the system.

WBS not needed in this report

The testing section will be an evaluation of the test plan and the results, while also looking at the performance from the FDS criteria and whether it has been met by using a pass/fail marking system. The way the system was tested will be discussed by also describing the challenges faced and how they were overcome by alternative methods in the timeframe given.

Also, the recommendations for the project will be discussed and how the system can be improved in the future.

3. Acknowledgements

During the process of creating and building this project, I received assistance from the Engineering manager of the company who helped me with resources that was required to create the project. I had also received assistance from the lecturer in college in terms of guidance with the testing and overhaul of the project design.

names should be included

4. Design

4.1 FDS

In Table 1 below is the FDS that was made in the first assignment and then amended to meet the specification. (Rogers, 2024)

This was created to ensure that the system will meet its specifications and also meet the criteria.

Table 1 - FDS

Functional Specification Design		
Criteria/Ref No.	Requirement	Updated Requirements
I.1	The new panel must be no smaller than that H = 400mm x W = 300mm x D= 200mm.	This cannot be achieved due to project being simulated and not physically built.
F.1	Panel must have a Start LED Indicator	This can be achieved by a simulated panel by using Factory IO.
F.2	The new panel will include a Stop control	This can be achieved by a simulated panel by using Factory IO.
F.3	The new panel will include a LED Reset button	This cannot be achieved due to project being simulated and not physically built. <i>this could have been achieved</i>
F.4	A start control will be included on the new panel.	This can be achieved by a simulated panel by using Factory IO.

F.5	The system must have a Speed control method to operate from the new panel	This can be achieved by a simulated panel by using Factory IO.
F.6	The Stopper cylinders must be able to fire manually	This cannot be achieved due to project being simulated and not physically built.
F.7	Stoppers must remain closed until pack arrives	This cannot be achieved due to project being simulated and not physically built.
F.8	Stoppers must Release when pack arrives	This can be achieved by a simulated panel by using Factory IO.
S.1	The Emergency Stop button will be included on the new panel	This can be achieved by a simulated panel by using Factory IO.
S.2	Isolator will be included on new panel	This cannot be achieved due to project being simulated and not physically built.
S.3	A guard will be mounted to cover pack stopper system	This cannot be achieved due to project being simulated and not physically built.
D.1	The system must be able to know how many packs goes into the machine	This can be achieved by a simulated panel by using Factory IO.
D.2	The system must be able to read the speed of the infeed conveyor in terms of packs per minute	This can be achieved by a simulated panel by using Factory IO.

D.3	The machine must be able to count how many packs per minute (ppm) the system is actually producing.	This can be achieved by a simulated panel by using Factory IO.
D.4	The system must improve downtime of machine	This can be achieved by a simulated panel by using Factory IO.
P.1	Stoppers must count 5 packs then stop until cycle has cleared	This can be achieved by a simulated panel by using Factory IO.
P.2	The product waste should be below 10%	This cannot be achieved due to project being simulated and not physically built.
P.3	The system must produce downtime below 20%	This can be achieved by a simulated panel by using Factory IO.
P.4	The system must include an air supply	This cannot be achieved due to project being simulated and not physically built.
C.1	Is the project within the budget	This can be achieved.
T.1	Is the project complete within timescale	This cannot be achieved due to project being simulated and not physically built.

The above table was used at a criteria guideline for creating and building this project.

4.2 Block Diagram of System

In figure 1 below solution 2 block diagram of the system can be seen.

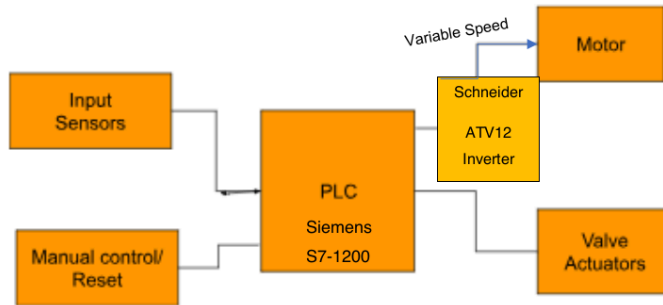


Figure 1 - Block Diagram of System

Above is an updated version of the block diagram that was created in assignment 1, as the development of the project went on, the choices for which PLC to be used was simple as a s7-1200 series was more practical due to its availability and its cost was within the budget and also due to it's number of inputs and outputs being more than was required. The ATV12 inverter was the simple choice as it can link up with the PLC well via Modbus or profinet and also this type of inverter is what the company standardises in most of its electrical conveyor panels. (Rogers, 2024)

The input sensors will be the signal from the reflective sensors with a digital signal giving feedback to the PLC to indicate when a pack arrives and another to count the packs. The counter will reach 5 on the PLC then reset while giving an output signal to activate the valves and push in the pack stop cylinder. Once the 5th pack has left the second sensor the sequence starts again. The speed control will work off a 10K potentiometer to give a precise reading for controlling the speed of the conveyor.

4.3 Panel Schematics

In Figures 1 and in the appendix the panel layout can be seen, this will show the design of the panel that was constructed by the FDS and to make sure that all the components are required for the system function. The panel had to be big enough to leave plenty of room for the high temperature working components such as the ATV12 inverter to ensure for cooling.

4.5 Electrical Drawings

In Figures 3-7 in the appendix the electrical drawings for the pack stopper panel can be shown. The system has a single-phase supply of 240v from a 16A plug going to an isolator, then going through a 4A MCB to ensure that the circuit is protected. L1 will then go through the ATV12 inverter and then connect to the 3-phase motor.

The power supply will take a link from the MCB and be labelled as L2. The power supply will then feed the 24v to the control circuit which is seen in figures 4 and 5 in the appendix. The control circuit will be going through a two channel E-stop, which will then go to the A1 of the safety relay indicating that when the e-stop is pressed in the safety relay is deactivated. The control circuit also connects the 24v to the PLC.

In Figure 6 in the appendix the Inverter control drawings can be seen. This shows the connections needed for the potentiometer to be connected to which are labelled up 0V, A/1 and 5V on the inverter. Also, L11 is the start signal on the inverter that will be supplied from the PLC start process output.

In figure 7 in the appendix the PLC drawings can be seen. This shows the digital inputs that will be connected to the PLC such as sensor 1, sensor 2 and the e-stop. The PLC digital outputs are then listed as these will control the start and stop of the conveyor and the Stopper solenoid which will then actuate the push cylinders.

All components are earthed due to safety and to ensure the compliance of the IET regulations. Also the software that was used to create all these images was 'Circuit Diagram'. (Diagram, 2025)

4.6 Pack Stopper Design

In Figure 8 in the appendix the design of the pack stopper can be seen. The unique customization of these pack stoppers are critical as they will need to be a mirror image of each other, the reason for the thin stopper is so that it has a precise point to where it stops the pack and creates an even pack stop to prevent pack twisting. This design was made by using the software Autodesk CAD design. (Inc, 2025) The initial pointed section will be made out of a metal detectable [Correctly cited](#) rules to ensure that it can be easily replaced as it will be the most worn section of the design. (Group, 2025) The rest of the stoppers will be made out of stainless to comply with the regulations of the company and to ensure that they are metal detectable. (PACKSYS, 2025) [Correctly cited](#)

4.7 PLC Program

4.7.1 PLC and ProfiNet Address

In Figure 9 in the appendix the PLC was put into the program and as can be seen that a 1211c (DC/DC/DC) PLC was used.

The Profinet Address was then then set as this can be seen in figure 10 in the appendix. The Address is set for class A address that means only the value 10 is the Net Address and 13.90.230 is the device number. This is set for the implementation and test on any given network.

4.7.2 Default and HMI Tag Table

In figure 11 in the appendix the default tag table can be seen, showing a total of 38 different tags with different data types between Real, Bool and Dint. Also, each tag has its own address to ensure the differences between each input, output, memory, and data. In Figure 12 in the appendix, the HMI tag table can be seen. (Siemens, 2017) [Correctly cited](#)

4.7.3 Main Function Block

In figure 13 the main function block can be seen, this is the downloaded communication block from Factory IO supplied by Siemens for communications with the 1200 and 1500 PLC models of PLC. In figure 14 network 2 can be seen, this block contains the analogue control for the two main conveyors and the display of the speed on the HMI and control panel. The separate function block keeps the program more structured and more manageable for maintenance purposes. (Edema, 2025) [Correctly cited](#)

4.7.4 Network 3

In figures 15 and 16 network 3 can be seen. This network includes the start and stop functions with all the resets and sets needed to logically operate these two states. Both start and stop functions are created in this network to be operated from the control panel or the HMI.

The emergency stop is implemented in the start process so that start is prevented from functioning when E-STOP is activated. The condition for E-STOP is created in another network.

All conveyor control contacts are set (activated) when start push button is pressed and there is a reset (deactivate) for the stop blade. This condition is necessary so that when the system is stopped at any time during the process, the stop blade could be in the 'up' activated state. When the system start button is pressed the stop blade will always reset to the down position so that the process can regain its sequence control using the counters. The start indicator is set every time the process is started.

The stop function resets all the conveyor control contacts and uses a condition to make sure the process stopped indicator is activated and process running indicator is deactivated.

4.7.5 Network 4

In figure 17 in the appendix network 4 can be seen. This function block includes a counter for the first and second retroreflective sensors and count the objects on the negative edge (once passed the sensor on falling edge). This type of sensor is used to detect transparent objects and only need a disturbance in the light emitted to the reflector to create a trigger for the sensor.

The counters are reset using the stop indicator in manual control mode and conveyor 1 and conveyor 2 control contacts for the auto sequence mode.

The MOVE functions are used to move data to the display panels for both counters.

4.7.6 Networks 5, 6, 7

In figure 18 in the appendix network 5 can be seen. The condition for the count variable is set to 5 and once 5 is reached the conveyor 1 is stopped and the display for this counter is reset to 0. The stop blade is set (activated) and the 5 passed the conveyor carry onto the next stage (packing system).

Nothing starts back until the delay time set at 5 seconds times out, stop blade is reset, conveyor 1 control is set which starts the conveyor running, and also conveyor 2 counter is reset.

In figure 19 in the appendix network 6 can be seen. This is the ESTOP condition that resets the output buffer from Q2.0 up to Q2.5 and resets conveyor controls 1 and 2 on the system.

In figure 20 in the appendix network 7 can be seen. This counter has been added to keep track of the total package number passed through the system and is triggered by the retroreflective sensor and reset by the stop indicator condition.

4.7.7 VFD Analogue Function Blocks

In figure 21 network 1 for the VFD analogue function blocks can be seen. The first conveyor speed control analogue value is created using input values 0 – 10 and in the SCALE_X block the speed is limited to 30% to prevent the operator running the conveyor at speeds that would jam up the process or cause damage to the system components. (Siemens, 2018) Correctly cited

In figure 22 in the appendix network 2 can be shown. Conveyor 2 is configured the same as conveyor 1 with the same 30% speed limit restriction, and as in the first conveyor, this is to prevent the operator from setting a fast speed that would jam up the process or damage the system components.

Figure 23 shows the conveyor 1 speed setting is set from the HMI as a percentage of 100 and is restricted to 30%, and because the actual speed to the conveyor is from 0 to 3, then this is divided by 10 for the correct speed actual value.

The HMI select contact can be enabled to read speed from panel or HMI. If the HMI is not selected, then speed value is taken from panel POT settings.

Figure 24 and 25 shows the function sets the conveyor actual speed to 0 depending on conveyor 1 control contact. The value set from the panel POT is multiplied by 10 to display as a percentage on the panel indicator.

Figure 26 in the appendix shows that the functions in this network are the same as for conveyor 1 and set the actual speed for conveyor from 0 – 3 and display from 0 – 30%.

Figure 27 in the appendix shows that network 7 sets the speed value to 0 when the conveyor 2 control contact is reset which is the same function as for conveyor 1.

Figure 28 in the appendix shows that the function multiplies the speed value to display as 0 - 30% on control panel. Just as with conveyor 1, the actual speed is converted from 0 -3 to 0 – 30% for display.

4.7.8 HMI Operators Screen

Figure 29 in the appendix shows the operator screen on the HMI. On this screen there is no option to set the speed of the conveyors. Only the indicators are available with a start and stop option. This only gives the operator the option for start and stop with indication of the state included. The ESTOP is on the panel only, however a condition ESTOP could easily be added if spec changes. This will help in minimizing operator error and making sure that no settings or speeds can be altered that will effect the efficiency of the system.

4.7.9 HMI Control Screen

Figure 30 in the appendix shows the HMI control screen. The Control screen allows the speed setting of the conveyors to be altered and allows the settings with no restriction as this is for test purposes. The engineer / technician will need to navigate back to operator screen to start or start from panel. This feature is to ensure that if the screen was accidentally on then if someone had altered any incorrect settings then they would have to leave the screen in order to start the system.

4.8 Factory IO Scene and Configuration

4.8.1 Conveyor Scene

In figure 31 in the appendix the conveyor layout can be seen by using the software Factory IO. (Games, 2025) For the purpose of testing the theory a slightly different conveyor layout was made due to Factory IO having limitations on what objects that can be selected. Instead of the sealing machine that would take the packs away from the original two conveyor belts, conveyors 3 and 4 have been added to take away the packs just for theory testing purposes.

Factory IO only simulates motor behaviour. This behaviour is characteristic of a DC motor or a VFD-controlled AC motor. From a control standpoint, analogue = variable speed = DC motor model or VFD-simulated behaviour.

4.8.2 Retroreflective Sensors with Reflectors

In figure 32 in the appendix, the Retroreflective sensors are shown mounted to conveyor 2. The retroreflective sensors are capable of detecting transparent packages using refraction and both sensors need the reflective plates. This is crucial that these sensors are used as

usually the packs that go down the line are see through, therefore the sensitivity will need altering depending on what pack and product is used.

4.8.3 Pack Stoppers (Stop Blade)

In figure 33 the pack stoppers can be seen. As the software will not have the original design for the pack stoppers, for testing and simulation purposes, a 'Stop blade' was used in Factory IO. The Stop blade is digitally operated and is set and reset from the PLC program and is labelled up as stop blade to make it easier for the programmer to understand.

4.8.4 In-feeding and Out-feeding the packs

In figure 34 in the appendix the emitter can be seen and is implemented on Conveyor 1 (infeed conveyor). The Emitter is needed to auto feed the packs / objects and has to be part of the PLC program in order for the system to function correctly.

Figure 34 also shows the remover which is located on the outfeed section of the system. This is needed to auto remove the objects and keep the system presentable and prevent system obstructions. It also has to be part of the PLC program in order for the system to function.

4.8.5 The Control Panel Instruments

In figure 35 in the appendix the control panel design can be shown. (Games, 2024) All the controls and instruments are taken from the library and implemented on the panel and the displays will configure to whatever data type is set for the tag. The 2 Potentiometers are for setting the speed for conveyors 1 and 2. All controls and instruments must be included as part of the PLC program. The reason for the panel looking slightly different than the original panel layout is for testing and simulation purposes. Slight alterations had to be made to prove the theory.

4.8.6 Factory IO PLC configuration

Figure 36 shows the PLC configuration on Factory IO. The IO is offset because the first bytes are used as memory bits for the SIM software and the analogue data types are set from the PLC configuration and must be setup in the Factory IO setup configuration. As shown in figure 36 there are 5 digital inputs to the PLC for this program and there are 6 digital outputs required.

4.8.6 Factory IO Setup Configuration

In figure 37 in the appendix the Set up configuration in Factory IO can be seen. When using the plc Simulator, the IP address does not need to be set. If a S7 1211C is being used practically then the PLC and the IP address will be needed. All IO offsets are set in this section along with start addresses.

5. Implementation and Management

5.1 Costing Spreadsheet

Below in table 1 the costing spreadsheet of the physical side and labour side of the project can be seen.

Table 1 - Costing Spreadsheet

Costing Spreadsheet for Project		
Components	Predicted Cost	Actual Cost
Labour 48 (Hours)	£700	£823
PLC (Siemens Simatic S7 1211c)	£300	£210
Inverter (Schinder ATV12 Single to 3 phase 0.33Kw)	£150	£120
Relays 24v	£20	£27
Panel (Schinder stainless steel)	£250	£300
Start button (Schinder 24v)	£10	£12
Stop button (Schinder 24v)	£10	£12
Reset Button (Schinder 24v)	£10	£12
Wiring (1.5mm cable)	£30	£25
Siemens Power Supply (	£80	£100
E-stop Button (Schinder 24v)	£15	£12
Contactors	£50	£48
Retroflected Sensors	£100	£95
Pusher cylinder	£40	£45
Pack stoppers	£100	£150
Total	£1,815	£1,991
Budget	£2,000	

The costing of the parts was calculated and rounded up, also majority of the parts were ordered via RS components. (Ltd., 2025)

Spelling

The predicted cost of the project was less than the actual cost due to the labour costing more than expected. The reason for this is because alterations to the project had to be made and therefore more time was needed to spend on the implementation of the system. Overall, by looking at the sheet the cost of the project is within the budget as the total cost came to £1991 and the budget given was £2000. This indicates that the project was within budget.

This was a very important part of the project management side of the implementation as the budget had to be considered and the spreadsheet had to be followed carefully to ensure that the cost can be monitored, early identification of any errors, correct decision making and risk management were taken so that the correct actions can be put into place.

In quality management, the costing spreadsheet helps ensure consistent processes and adherence to industry regulations. It enhances documentation and makes audits easier, both of which are essential for maintaining quality standards. Additionally, analysing the spreadsheet can reveal patterns that support ongoing process improvements.

5.2 Project Plan

Figure 39 in the appendix shows the Gantt chart that was created in assignment 1 but with appendments to date. (Rogers, 2024) The purpose of using this Gantt chart is to manage the project on a timescale and to make sure that each step is recorded so that any contingencies that arise they can be seen, and corrective actions can be put into place to avoid failure or deadlines missed.

As shown in figure 39, the projects actual plan did not meet its expected plan as this was due to delays in the implementation part of the process which also had an effect on the design and testing sections.

If the project could not be implemented in the timescale given, then a simulation test can be implemented to prove the working system by using the software Factory I/O. This will also need the program from the software TIA Portal to link the two together. If the panel could not be built then the inverter can be programmed, wired to a potentiometer and connected to a motor to prove the speed control works.

5.3 Constraints

In regard to technical constraints the PLC, Inverter and the HMI are the different types of components that will be integrated to the system. The system requires these components to be correctly implemented while also in communication with each other to ensure a smooth working operation.

With budgetary constraints, these refer to the financial side of the project. Having a low budget can affect the choice in components, material and labour depending on the demand of the project. The costing spreadsheet used in table 1 was used to monitor the cost and spending required for the project.

In regard to safety constrains, the design and implementation of using safety features in the project such as e-stops and guarding are required to make sure that all operations of the system is done in a safe manner.

5.4 Project Building

5.4.1 Programming and connecting ATV12 Inverter

Due to the limitations of the implementation of the project the inverter was connected to a supply so that the parameters can be set to meet the specifications of the project.

The parameter list for the inverter used for this project can be shown in figure 40 of the appendix. Figure 41 shows the characteristics and functions of power terminals for the inverter. (Components, 2025) Correctly cited

The LSP in figure 41 was set to 10. This setting was implemented and can be shown in figure 42 in the appendix. (Ltd, 2025)

In figure 43 in the appendix the inverter can be seen wired up to a supply. The image shows that the brown (live) is connected to L1 while the blue (neutral) is connected to N and the yellow/green (earth) is connected to the earth terminal on the device. These were followed by the wiring diagram in figure 5 in the appendix.

Figure 43 also shows that the 10k potentiometer is connected to the speed control on the inverter. These connections were followed by the wiring diagram for the inverter in figure 5.

The lth shown in figure 41 was set to 1.5 A as this was the driver rating on the motor.

5.4.2 Panel Building

Due to contingencies with the delay in parts the panel cannot be shown, although the panel layout in figures 1 and 2 would be followed along with the wiring diagrams in figures 3-7 in the appendix. These would be used to implement the building of the panel to ensure all connections are made and all components are located in the correct are to ensure cooling and working temperatures don't fluctuate.

5.4.3 Building Pack Stoppers

In figure 44 the building of the pack stoppers can be seen. These pack stoppers were manufactured by using the AutoCAD design that was created in figure 8 of the appendix. As stated in the design of the pack stoppers the pointed part of the design (white bottom) was manufactured by using nylon to protect the system and make it cost effective when the part will need replacing due to wear and tear.

5.5 Engineering Management Principles

5.5.1 Project Planning

By defining the scope for project planning there are many variables to consider such as setting timelines, managing resources and creating a schedule. This includes a Gantt chart to ensure that all tasks are completed to a set schedule (Figure 39 in appendix).

5.5.2 Risk Management

The risk management of the project can be done by identifying potential contingencies and risks to the project, such as parts of the project being delayed. A good contingency plan would be to ensure that if the system cannot be implemented then a simulation proving its working function can be made and presented.

5.5.3 Continuous Improvement

The performance and efficiency of the system will be evaluated on a regular basis to ensure that the correct improvements can be made to the system and helping it reach its full potential. This will help reduce downtime and cost within production while also making it a more efficient production line and increasing its reliability.

5.6 Commercial Context

In terms of market demand, the pack stopper system is created to increase the smoothness and speed of the production line, this will help with efficiency and decrease waste material. This will be taken into consideration as most food industries thrive off these factors. The pack stopper system can be expended by using a wide range of different sensors and quality control and adding more modules for the PLC to interact with.

5.7 Factory IO Prototype

In figure 45 the prototype of the Factory IO integrated system can be seen. Due to contingencies with the physical implementation of the project this gives a simulation design that can be seen to replicate the project and prove its functions. Although slight modifications had to be made testing and results needed to achieve are similar.

6. Testing and Results

6.1 Amended Test Plan

Due to the limitations of physically testing the system, a wide range of simulation testes were carried out to prove the working function of the system. Below in table 2 is the test plan that was created in assignment 1 that has been amended and that shows the requirements from the FDS and if they have been met by a PASS/FAIL marking scheme. (Rogers, 2024)

Table 2 Amended Test Plan

Test Plan Table					
Criteria/Ref No.	Requirement	Test Description	Expected Result	Decision Pass/Fail	Evidence
F.1	Panel must have a Start LED Indicator	Start the system for the panel.	System will run, and the Start LED will come on.	Pass	Figure 47
F.2	The new panel will include a Stop control	While the system is running, press the stop button on the new panel.	The system will stop.	Pass	Figure 46
F.4	A start control will be included on the new panel.	While the system is on stop and all faults have been reset, press the start button on the new panel.	The system will start.	Pass	Figure 47

F.5	The system must have a Speed control method to operate from the new panel	Turn the speed control all the way to the left and then all the way to the right.	The system will decrease in speed and then increase in speed.	Pass	Tables 9 and 10
S.1	The Emergency Stop button will be included on the new panel	Press the emergency stop button on the new panel while the system is operating.	Machine should stop running instantly and the reset LED should come on.	Pass	Figure 46
D.1	The system must be able to know how many packs goes into the machine	Put 5 packs onto the infeed conveyor of the machine.	The HMI of the existing machine shows that 5 packs have entered the sealing station.	Pass	Figures 49 and 50
D.2	The system must be able to read the speed of the infeed conveyor in terms of packs per minute	Load up the infeed conveyor full of packs continuously.	The HMI of the existing machine shows the rate of PPM the Infeed conveyor is running at.	Pass	Tables 9 and 10
D.3	The machine must be able to count how many packs per minute (ppm) the system is actually producing.	Load up the infeed conveyor full of packs continuously.	The HMI of the existing machine shows the rate of PPM the system is producing.	Pass	Figures 49 and 50

P.1	Stoppers must count 5 packs then stop until cycle has cleared	Put 5 packs onto the infeed conveyor of the machine.	Stoppers will count 5 packs then stop until cycle has cleared and then continue to feed the machine.	Pass	Figures 49 and 50
P.3	The system must produce downtime below 20%	Run the machine for an hour and record how much downtime the machine has produced.	The system downtime will be below 20%.	Pass	Equation after test results
C.1	Is the project within the budget	Calculate the cost of the whole project.	The project will be within the budget.	Pass	Table 1
T.1	Is the project complete within the timescale given.	Keep record of how long the project takes to be completed.	The project will be completed within timescale given.	Fail	Figure 39

The overall pass percentage of the *modified* original test plan can be determined by the calculation created below:

$$\frac{12}{12} \times 100 = 100\%$$

The overall pass rate percentage for the original test plan is 100%.

6.2 Modified Test Tables

Due to contingencies that took place which limited the implementation phase and affected the testing, alternative test tables were created for the simulation process of the system. The modified test tables can be seen in tables 3-10 in the report.

6.2.1 System Test using HMI Functions

Table 3 - System Test using HMI Functions

Test No	HMI Conveyor 1 Speed Set	HMI Conveyor 2 Speed Set	No of Objects Detected	Stop Blade Activated	Reset Timers after 5 Objects	HMI Stop Function Activation	HMI Start function with Auto Blade Reset	Sequence continues in Auto Mode	HMI Total Count	Pass / Fail
1	10	12	5	Pass	Pass	Pass	Pass	Pass	Pass	Pass
2	12	14	5	Pass	Pass	Pass	Pass	Pass	Pass	Pass
3	14	16	5	Pass	Pass	Pass	Pass	Pass	Pass	Pass
4	16	18	5	Pass	Pass	Pass	Pass	Pass	Pass	Pass
5	18	20	5	Pass	Pass	Pass	Pass	Pass	Pass	Pass
6	20	22	5	Pass	Pass	Pass	Pass	Pass	Pass	Pass

The results of the tests above can be seen in figures 46 – 56 in the appendix.

6.2.2 ESTOP Function Test

Table 4 - E-Stop Function Test

Test No	ESTOP	Panel Start Function	HMI Start Function	Conveyor 1	Conveyor 2	Conveyor 3	Conveyor 4	Pass / Fail
1	Not Set	Active	Active	ON	ON	ON	ON	Pass
2	Set	Inactive	Inactive	OFF	OFF	OFF	OFF	Pass

The results of the tests above can be seen in figures 46 – 56 in the appendix.

6.2.3 Panel Speed Regulation Test (Regulation at 30% Speed)

Table 5 - Panel Speed Regulation Test (at 30%)

Test No	Panel Set Speed Conveyor 1	Panel Set Speed Conveyor 2	Panel Speed Regulation Conveyor 1	Panel Speed Regulation Conveyor 2	Pass / Fail
1	15	18	15	18	Pass
2	32	34	30	30	Pass

The results of the tests above can be seen in figures 46 – 56 in the appendix.

6.2.4 HMI Function Test Start / Stop

Table 6 - HMI Start / Stop Function

Test No	HMI Start Function	HMI Stop Function	Conveyor 1	Conveyor 2	Conveyor 3	Conveyor 4	Pass / Fail
1	OFF	ON	OFF	OFF	OFF	OFF	Pass
2	ON	OFF	ON	ON	ON	ON	Pass

The results of the tests above can be seen in figures 46 – 56 in the appendix.

6.2.5 Panel Function Test Start / Stop

Table 7 - Panel Start / Stop Function

Test No	Panel Start Function	Panel Stop Function	Conveyor 1	Conveyor 2	Conveyor 3	Conveyor 4	Pass / Fail
1	OFF	ON	OFF	OFF	OFF	OFF	Pass
2	ON	OFF	ON	ON	ON	ON	Pass

The results of the tests above can be seen in figures 46 – 56 in the appendix.

6.2.6 Panel / HMI Function Select Test with Conveyor Speed Setting

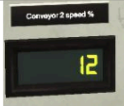
Table 8 - Panel / HMI Function Select Test with Conveyor Speed Setting

Test No	HMI / Panel Function Select	HMI Start	HMI stop	Panel Start	Panel Stop	Panel Speed Set Conveyor 1	Panel Speed Set Conveyor 2	HMI Speed Set Conveyor 1	HMI Speed Set Conveyor 2	Pass / Fail
1	HMI	Active	Active	Active	Active	Inactive	Inactive	Active	Active	Pass
2	Panel	Active	Active	Active	Active	Active	Active	Inactive	Inactive	Pass

The results of the tests above can be seen in figures 46 – 56 in the appendix.

6.2.7 Table of Panel Speed Settings Tested

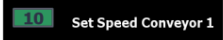
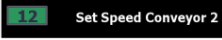
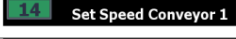
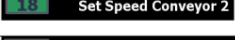
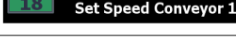
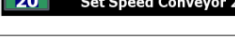
Table 9 - Panel Speed settings tested

Speed Set (%) Conveyor 1	Speed Set (%) Conveyor 2	Image Evidence Conveyor 1	Image Evidence Conveyor 2
10	12		
12	14		
14	16		
16	18		
18	20		

The Panel Speed Settings will override the HMI Settings if switch is in Panel mode. This is to ensure that if operators need to change the speed of the conveyors, they can do it from the panel and don't need to go to the HMI.

6.2.8 Table of HMI Speed Settings Tested

Table 10 - HMI Speed settings Tested

Speed Set (%) Conveyor 1	Speed Set (%) Conveyor 2	Image Conveyor 1	Evidence	Image Evidence Conveyor 2
10	12			
12	14			
14	16			
16	18			
18	20			

By looking at all the modified test tables 3-10 in the report, it's clear it see that the pass rate for all the tests was 100%. The evidence indicates that all simulation test results were successful. These tests show that the function of the system would meet the requirements from the original test plan and maintain a smooth and efficient operating system.

Each pack takes 1 second to transfer to conveyor two, and the stoppers have a 5-second delay that activates after 5 packs have arrived. The Packs Per Minute formula can be used to determine the efficiency of the production line.

The formula can be demonstrated as follows.

$$1 \times 5 = 5 \text{ Seconds}$$

$$5 + 5 = 10 \text{ Seconds}$$

$$\frac{60}{10} = 6$$

$$6 \times 5 = 30 \text{ Packs Per Minute}$$

Therefore, by using the formula, even with the conveyor speeds running at a max of 30% regulation, the system will still produce 30 Packs per minute. This is a significant difference compared to the target of 20 packs per minute. Over a production shift this will make a substantial difference in terms of efficiency rate and reducing the downtime of the line.

7. Evaluation of Project Outcomes

The completion of this independent engineering project has provided a valuable opportunity to combine practical skills with theoretical knowledge, applied within the context of a real-world manufacturing environment. The primary aim of the project was to design, develop, and implement a pack stopper system capable of reducing downtime, improving production efficiency, and lowering waste levels on a food production line. Through careful planning, structured project management, and a flexible approach to unforeseen challenges, the project outcomes reflect both notable successes and some practical limitations.

One of the most significant achievements of the project was the successful simulation and testing of the system's core functionality using Factory IO and Siemens TIA Portal. While the original plan was to implement and test the system physically on-site, unforeseen delays in the delivery of crucial hardware components required a shift in strategy. Rather than allowing this limitation to stall progress, simulation software was integrated to test the system logic and operational sequences in a controlled virtual environment. This proved highly effective, enabling rigorous testing of the pack counting mechanism, conveyor speed regulation, emergency stop functionality, and HMI interface operations. The modified test plans applied within the simulation environment achieved a 100% pass rate, demonstrating that the designed control logic was reliable and performed as expected across all tested scenarios.

Financial management was another key area in which the project excelled. From the outset, a strict budget of £2,000 was established, with a detailed costing spreadsheet used to track expenses and ensure financial control throughout the project's lifecycle. Although the actual labour costs exceeded predictions due to additional programming and adjustments, the overall project expenditure remained within budget, closing at £1,991. This careful oversight of financial resources enabled the project to maintain its intended scope and quality without sacrificing essential components or functionality.

An encouraging aspect of the project's outcomes was the demonstration of increased production efficiency. The system's throughput capability, based on simulation data, showed a significant improvement compared to the original production rate. The newly designed system was able to consistently handle 30 packs per minute, outperforming the original production target of 20 packs per minute. This improvement was achieved while maintaining the system's operational safety and reliability, indicating that the implemented design changes would likely result in considerable production benefits if applied in a practical environment. This outcome supports the project's initial aim of reducing downtime and increasing efficiency on the production line.

Despite these achievements, the project was not without its challenges. The most significant limitation was the inability to complete full physical implementation and testing of the system. Certain aspects of the Functional Design Specification (FDS), such as the manual firing of the pack stoppers and the installation of physical safety guards, could not be tested practically. These gaps were reflected in the original test plan results, where several criteria failed solely due to the lack of hardware testing rather than system design flaws. However, simulation-based validation provided strong evidence to suggest that these functions would perform as intended once physically implemented.

The project timeline also experienced delays, primarily due to component procurement issues and the additional time required to create and run comprehensive simulation tests. While these setbacks extended the project's duration beyond the initial schedule, the proactive use of project management tools, such as a Gantt chart, allowed for effective tracking and adjustment of project milestones. The inclusion of a risk management plan proved particularly useful, ensuring that potential issues were anticipated, and contingency actions were identified early in the project lifecycle.

The late addition of an HMI interface to the project also proved highly beneficial. Originally not part of the project's initial scope, this addition provided improved control options, enhanced operational safety, and allowed for a more comprehensive simulation testing experience. The HMI screens enabled operators to manage conveyor speeds, monitor pack counts, and operate start/stop functions while minimising the risk of operator error. This feature worked well with the overall aim of improving production efficiency and reliability.

8. Conclusions and Recommendations

8.1 Conclusions

In conclusion, the outcomes of this project reflect a well-executed engineering solution that, despite encountering practical constraints, managed to achieve its primary objectives through adaptability, careful planning, and thorough simulation testing. The decision to shift to a simulation-based testing approach ensured that the project could continue progressing in the absence of hardware, providing credible evidence of the system's effectiveness in improving production line efficiency and reducing downtime. Financial control was maintained throughout, and operational performance targets were exceeded.

8.2 Recommendations

Having completed the project and carefully evaluated its outcomes, several recommendations can be made to further improve the system's functionality, address the limitations encountered, and enhance future projects of a similar nature. These recommendations are based both on the lessons learned throughout this project and on the performance, results achieved through simulation testing.

The most immediate recommendation is to proceed with the full physical implementation and commissioning of the system as soon as the remaining hardware components become available. While simulation testing provided comprehensive validation of the system's logic and functionality, certain operational aspects, such as the mechanical performance of the pack stoppers and the physical interaction between hardware components, can only be accurately assessed through hands-on testing in a live production environment. Completing this stage would allow for practical fine-tuning, adjustments for real-world tolerances, and the opportunity to resolve any unforeseen issues that may arise during physical operation.

Another important recommendation concerns the safety features of the system. Although emergency stop functionality was successfully tested within the simulation environment, the physical integration of safety guards around the pack stopper mechanism remains incomplete. This is a critical requirement for any production line modification, especially in a food manufacturing environment where operator safety is needed. It is recommended that safety guards be installed and validated in line with the relevant health and safety regulations before the system is brought into live production. Additionally, integrating an emergency stop condition within the HMI interface, which was identified as a possible future modification in the project report, would further enhance operator safety and system control.

An enhancement to consider for future system iterations would be the addition of adjustable pack count parameters. The current system is hardcoded to stop after every five packs, based

on the original production line requirement. However, giving operators or engineers the ability to adjust this count via the HMI or control panel would provide greater flexibility, allowing the system to be adapted quickly for different product runs or packaging requirements without needing to reprogram the PLC. This feature would improve the versatility and long-term value of the system to the production facility.

In terms of system monitoring and data collection, another recommendation would be to incorporate data logging capabilities into the HMI or PLC program. Logging operational data such as pack counts, downtime incidents, and speed changes could provide valuable insights into system performance over time. This data could then be used for continuous improvement initiatives, helping maintenance teams identify patterns, predict faults, and make data-driven decisions to optimise production efficiency and reduce downtime.

Looking ahead to the management of future projects, it would also be beneficial to consider developing a contingency strategy specifically for hardware delays, as this was one of the main challenges faced during this project. One possible approach would be to build stronger supplier relationships or identify alternative suppliers who can deliver critical components more reliably. Additionally, allocating a small contingency fund within the project budget to accommodate unexpected expenses, such as additional labour costs or last-minute component substitutions, would further strengthen project risk management practices.

Finally, it is recommended to further explore and develop the use of simulation software like Factory IO for both system design and operator training purposes. The project has demonstrated the practical value of simulation tools in validating control logic and system performance when physical testing is limited or delayed. Beyond project development, such tools could be used within the company for operator training, scenario testing, and pre-implementation design validation, ultimately supporting a safer and more efficient production environment.

9. Employer Statement

The employer statement can be seen in figure 57 in the appendix and this was completed by the Site Engineering Manager of the company.

10. Citation List

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10. Appendix

Panel Schematics

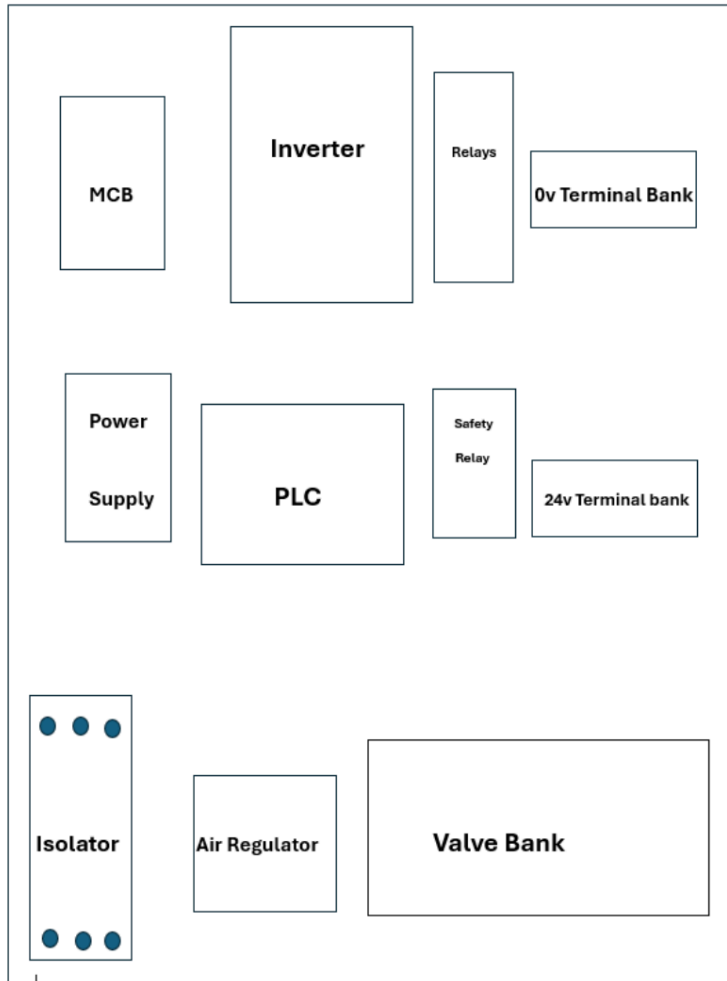


Figure 1 - Inside Panel Layout

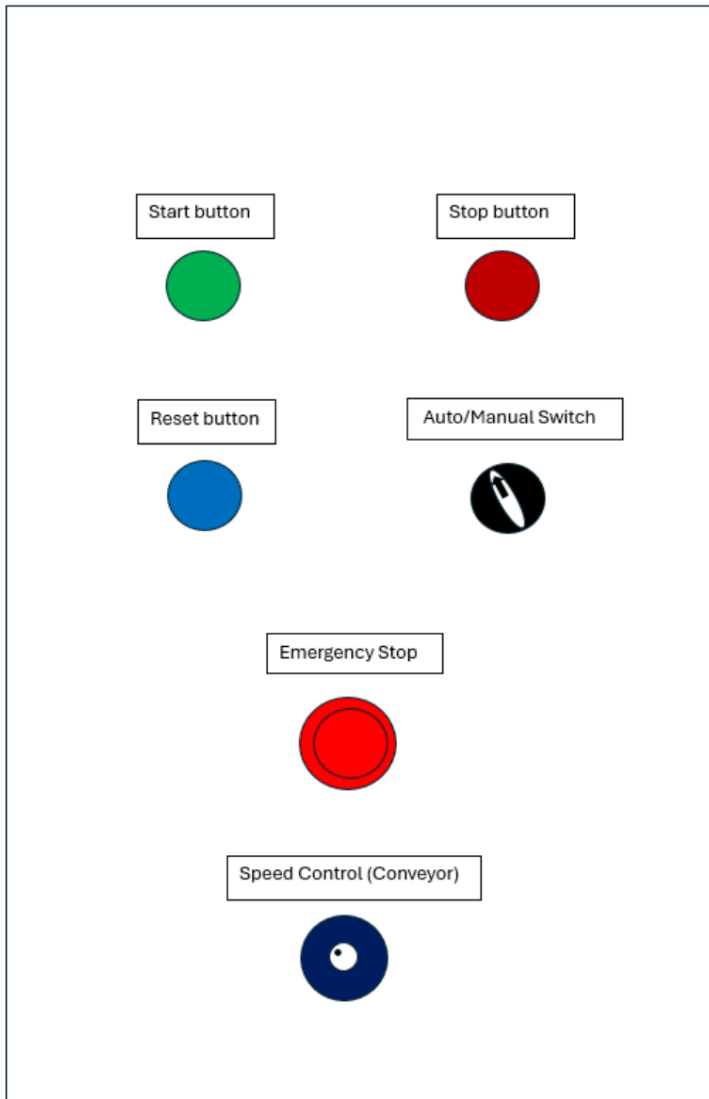
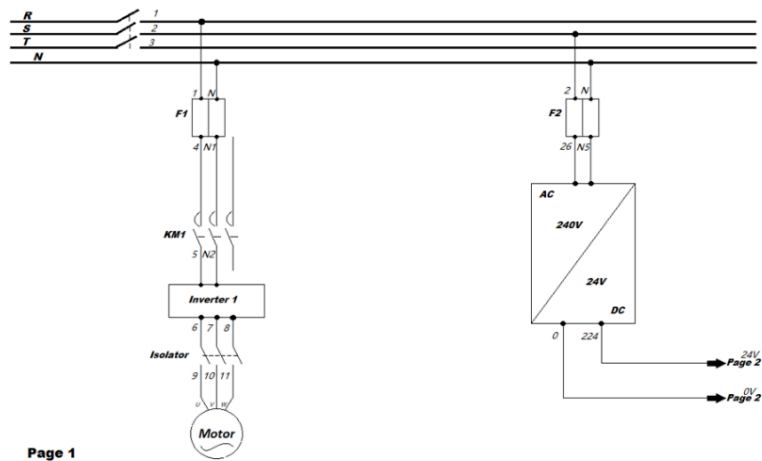


Figure 2 - Front Panel Layout

Power Circuit



Page 1

Figure 3 - Power Circuit

Control Circuit 1

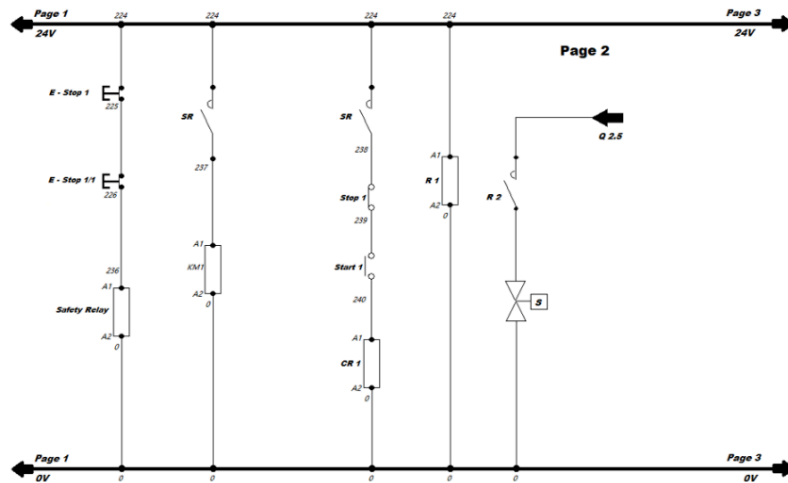


Figure 4 - Control Circuit

Control Circuit 2

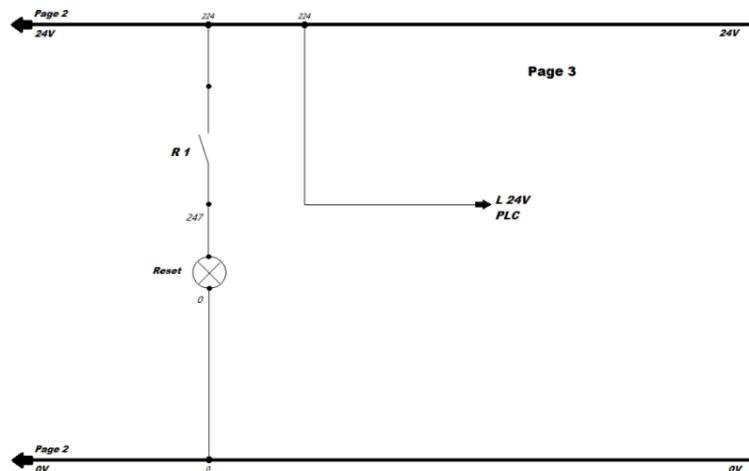
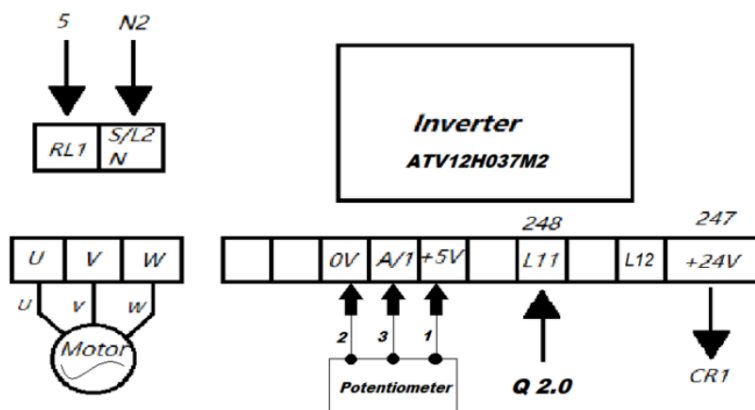


Figure 6 - Control Circuit 2

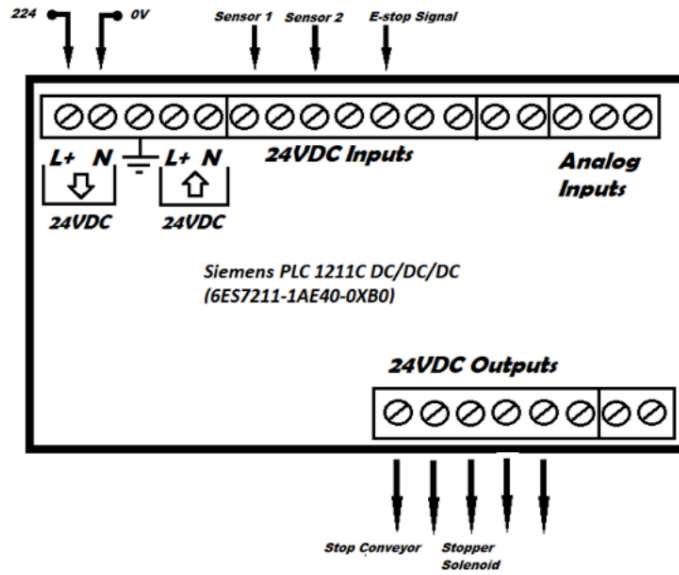
Inverter Wiring



Page 4

Figure 5 - Inverter Wiring

PLC Wiring



Page 5

Figure 7 - PLC Wiring

Pack Stopper Design

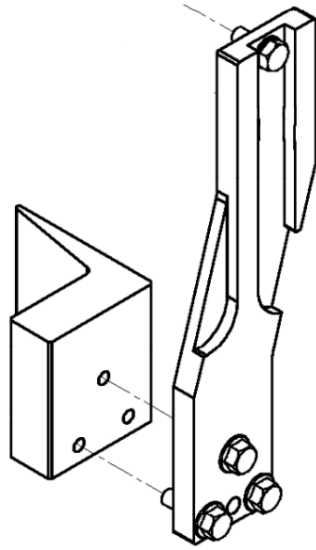


Figure 8 - Pack Stopper Design

1211C PLC (DC/DC/DC)



Figure 9 - 1211C PLC (DC/DC/DC)

Profinet Address

Set IP address in the project

IP address: 10 . 13 . 90 . 230

Subnet mask: 255 . 0 . 0 . 0

Figure 10 - Profinet Address

Default Tag Table

	Name	Data type	Address	Retain	Access...	Write...	Visibl...
1	Start process	Bool	%I2.0	☐	☒	☒	☒
2	Stop process	Bool	%I2.2	☐	☒	☒	☒
3	Emergency Stop	Bool	%I2.1	☐	☒	☒	☒
4	Lower sensor	Bool	%I2.5	☐	☒	☒	☒
5	Upper sensor	Bool	%I2.6	☐	☒	☒	☒
6	Conveyor	Real	%QD38	☐	☒	☒	☒
7	Process running Indicator	Bool	%Q2.2	☐	☒	☒	☒
8	Process stopped Indicator	Bool	%Q2.6	☐	☒	☒	☒
9	Box PE upper	Bool	%M0.0	☐	☒	☒	☒
10	BS NE	Bool	%M0.2	☐	☒	☒	☒
11	Box count display	DInt	%QD30	☐	☒	☒	☒
12	CV count	DInt	%MD100	☐	☒	☒	☒
13	Conveyor 2	Real	%QD46	☐	☒	☒	☒
14	Stop blade	Bool	%Q2.5	☐	☒	☒	☒
15	Box PE lower	Bool	%M0.3	☐	☒	☒	☒
16	End counter display	DInt	%QD34	☐	☒	☒	☒
17	reset box count display	Bool	%M0.4	☐	☒	☒	☒
18	VFD_Control 1	Real	%ID30	☐	☒	☒	☒
19	Norm_Tag	Real	%MD30	☐	☒	☒	☒
20	VFD_Scaled_Value	Real	%MD34	☐	☒	☒	☒
21	Conveyor 1_control	Bool	%M0.5	☐	☒	☒	☒
22	Conveyor 1 speed %	DInt	%QD42	☐	☒	☒	☒
23	Conveyor 2_control	Bool	%M0.6	☐	☒	☒	☒
24	Conveyor 2 speed %	DInt	%QD50	☐	☒	☒	☒
25	Norm 2 tag	Real	%MD38	☐	☒	☒	☒
26	VFD_Scaled_Value2	Real	%MD42	☐	☒	☒	☒
27	VFD_Control 2	Real	%ID34	☐	☒	☒	☒
28	Retroreflective sensor	Bool	%I2.7	☐	☒	☒	☒
29	CV count 2	DInt	%MD46	☐	☒	☒	☒
30	Counter 2 coil	Bool	%M8.0	☐	☒	☒	☒
31	Conveyor 2 counter reset	Bool	%M8.1	☐	☒	☒	☒
32	Retroreflective sensor 2	Bool	%I2.4	☐	☒	☒	☒
33	Belt conveyor bool 2m	Bool	%Q2.0	☐	☒	☒	☒
34	Curved belt conveyor	Bool	%Q2.1	☐	☒	☒	☒
35	Remover	Bool	%Q2.3	☐	☒	☒	☒
36	Retro sensor MB	Bool	%M8.3	☐	☒	☒	☒
37	CV count 3	DInt	%MD52	☐	☒	☒	☒
38	Total count sensor Mbit	Bool	%M0.7	☐	☒	☒	☒
39	<Add new>			☐	☒	☒	☒

Figure 11 - Default Tag Table

HMI Control Tag Table

29		CV count 2	Dint	%MD46	☐	☒	☒	☒
30		Counter 2 coil	Bool	%M3.0	☐	☒	☒	☒
31		Conveyor 2 counter reset	Bool	%M3.1	☐	☒	☒	☒
32		Retroreflective sensor 2	Bool	%I2.4	☐	☒	☒	☒
33		Belt conveyor bool 2m	Bool	%Q2.0	☐	☒	☒	☒
34		Curved belt conveyor	Bool	%Q2.1	☐	☒	☒	☒
35		Remover	Bool	%Q2.3	☐	☒	☒	☒
36		Retro sensor MB	Bool	%M3.3	☐	☒	☒	☒
37		CV count 3	Dint	%MD52	☐	☒	☒	☒
38		Total count sensor Mbit	Bool	%MD.7	☐	☒	☒	☒
39		<Add new>			☐	☒	☒	☒

Figure 12 - HMI Control Tag List

Main function block

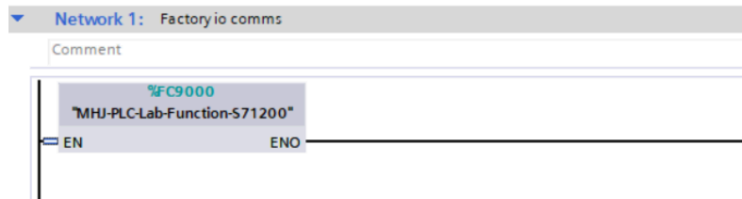


Figure 13 - Main Function Block

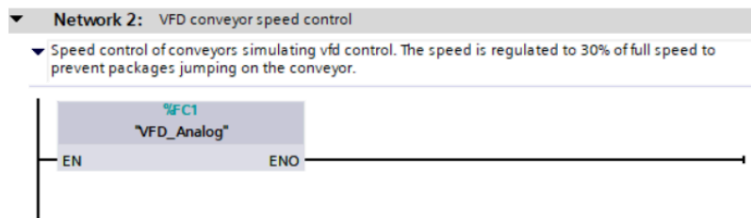


Figure 14 - Network 2 VFD Analog

▼ **Network 3:** Start with ESTOP and set and reset conditions for indicators and conveyors

- ▼ Start using push button on panel or HMI and set all conveyors running at the set speeds. The ESTOP must be reset as a condition.
The Stop using pushbutton is reversed logic and resets the conveyors and indicators using logic conditions.

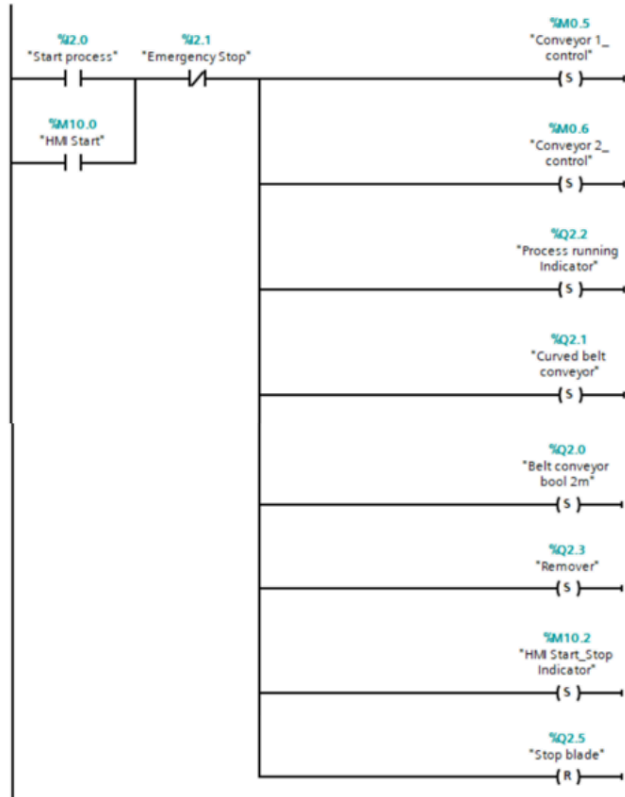


Figure 15 - Network 3 (Start and E-stop Process)

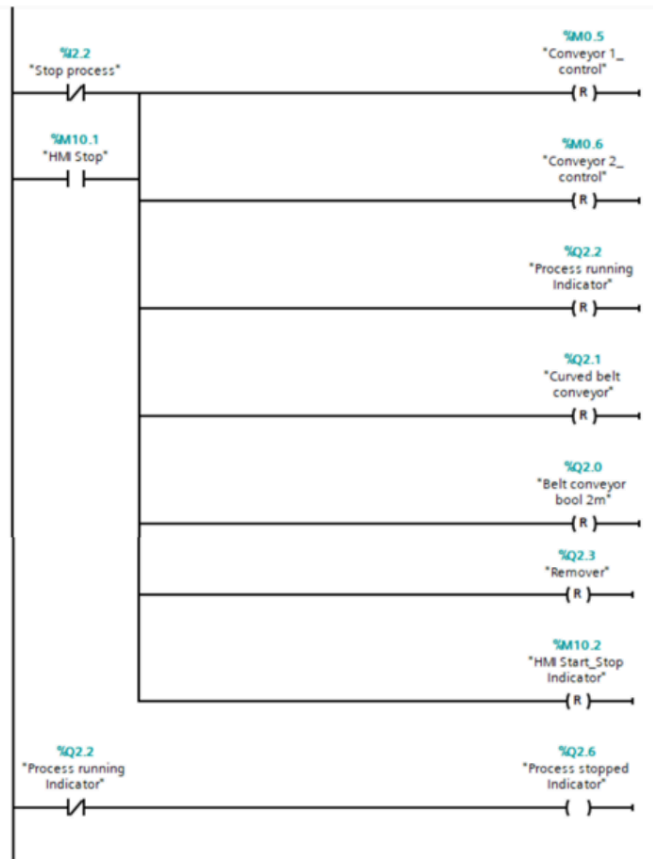


Figure 16 - Network 3 (Part 2)

▼ **Network 4:** Counter using retro sensor positive edge detection and display values.

- ▼ Detecting packages using low retroreflective sensors to increase counters and move value to display on panel and HMI. Counter is reset using stop condition and conveyor control condition.

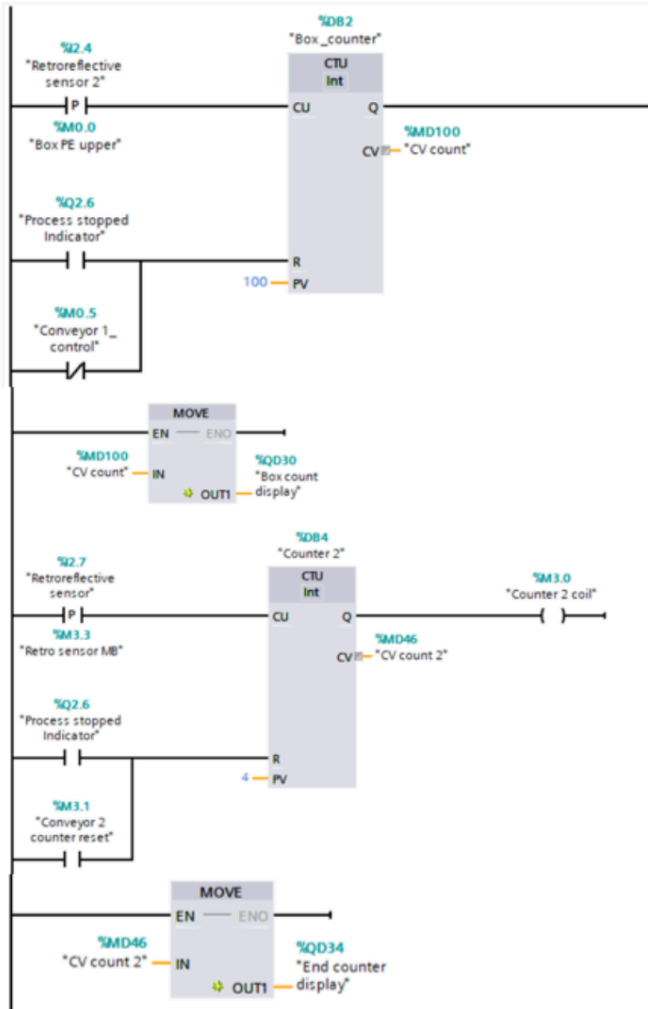


Figure 17 - Network 4

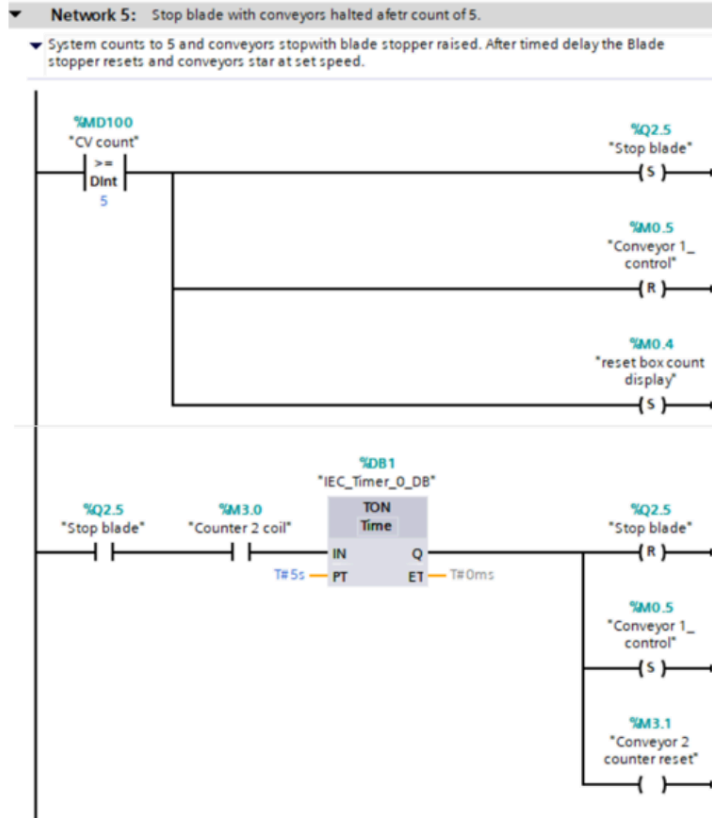


Figure 18 - Network 5

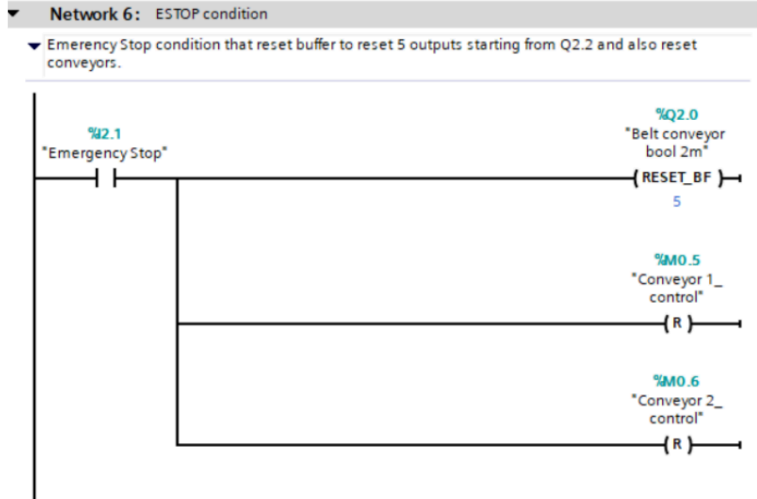


Figure 19 - Network 6 (E-stop Condition)

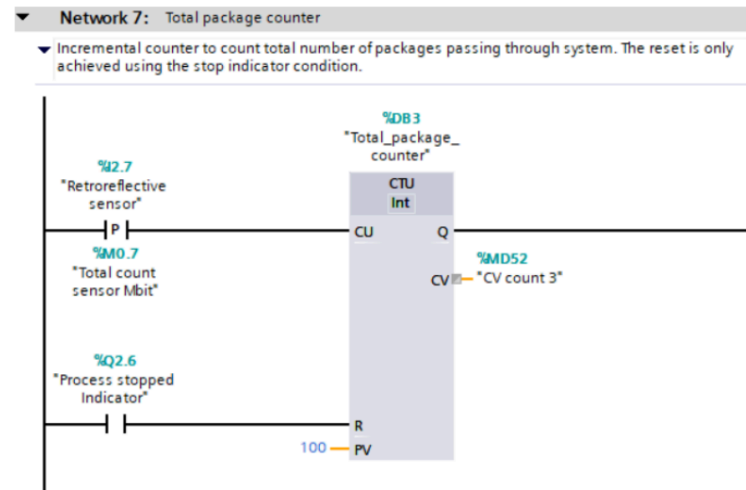


Figure 20 - Network 7 (Total Pack Counter)

VFD Analogue Function Blocks

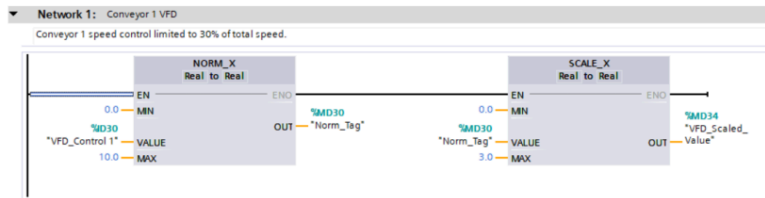


Figure 21 - Network 1 (Conveyor 1 VFD)

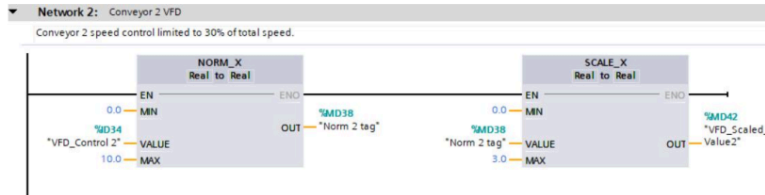


Figure 22 - Network 2 (Conveyor 2 VFD)

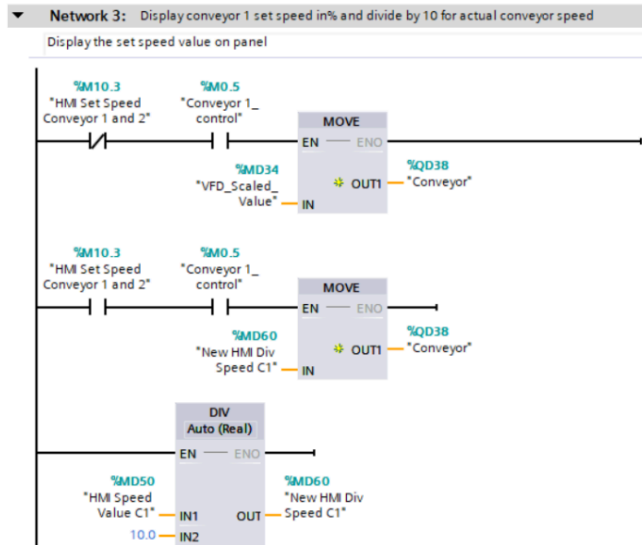


Figure 23 - Network 3 (Conveyor 1 Display)



Figure 24 - Network 4 (Display Value Reset)

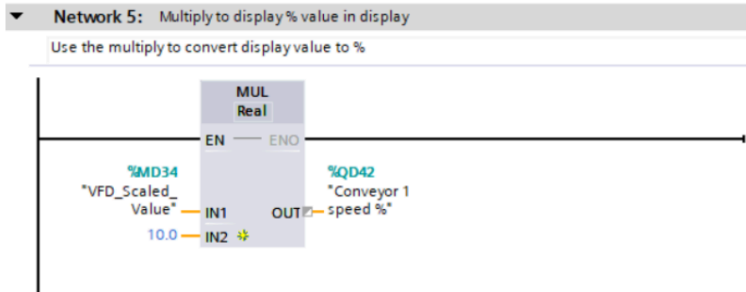


Figure 25 - Network 5 (%Value in Display)

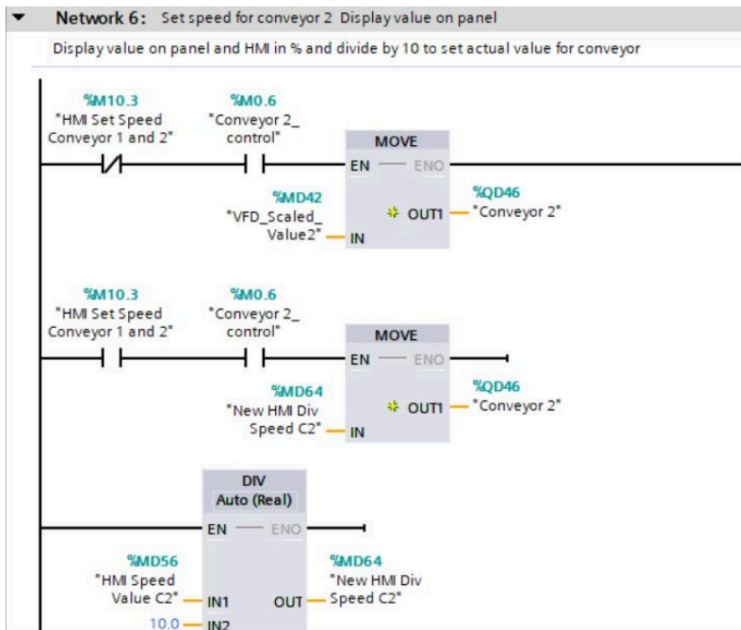


Figure 26 - Network 6 (Conveyor 2 Display Value)

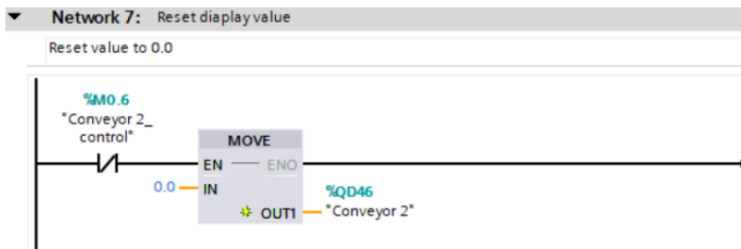


Figure 27 - Network 7 (Reset Display value)

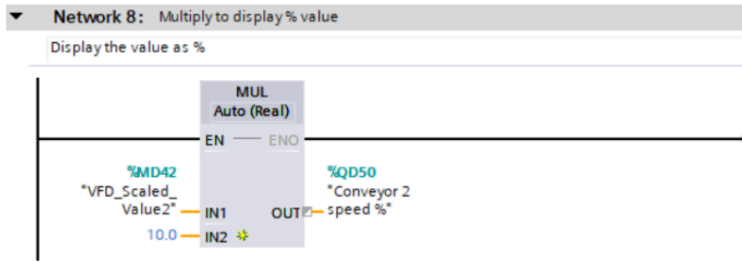


Figure 28 - Network 8 (Display % Value)

HMI Operator screen

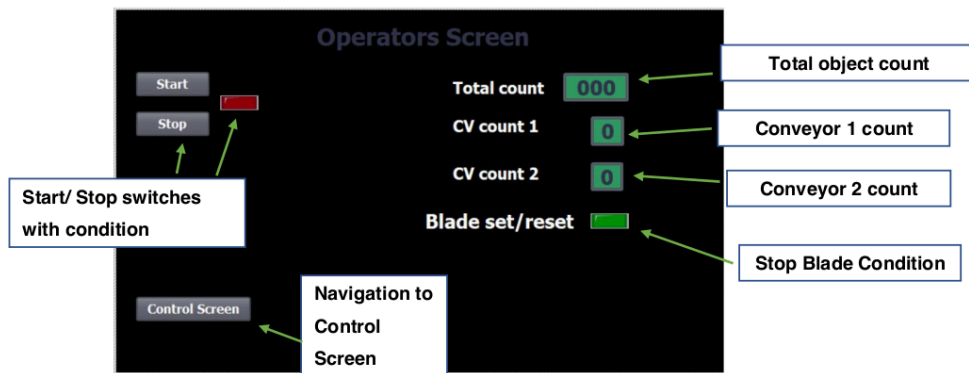


Figure 29 - HMI Operator screen

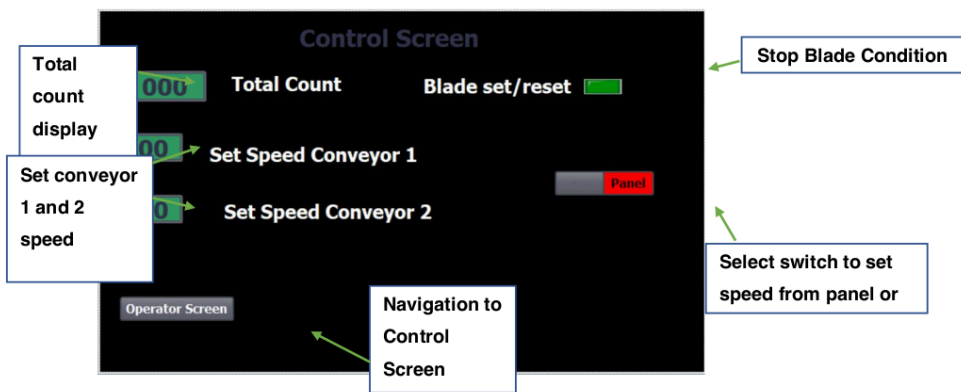


Figure 30 - HMI Control Screen

Conveyor Scene

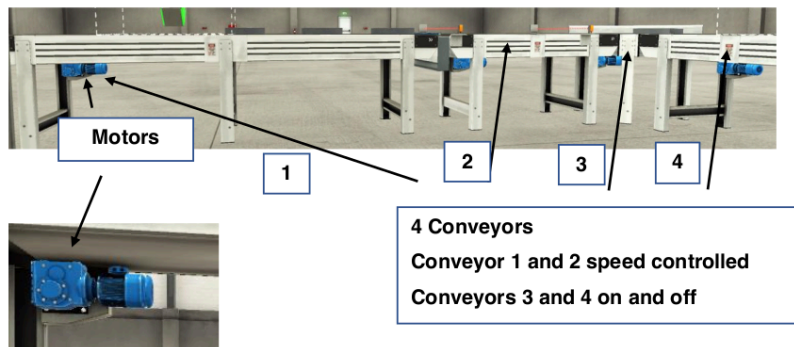


Figure 31 - Conveyor Scene Factory I/O

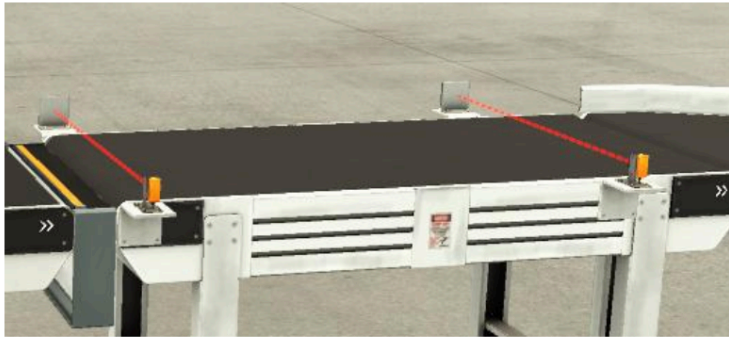


Figure 32 - 2 Retroreflective Sensors

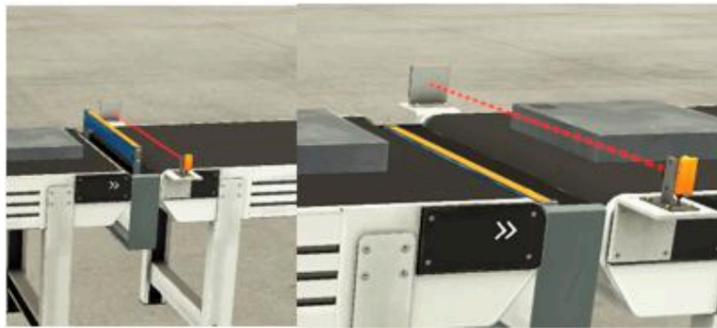


Figure 33 - Pack Stopper (Stop Blade)

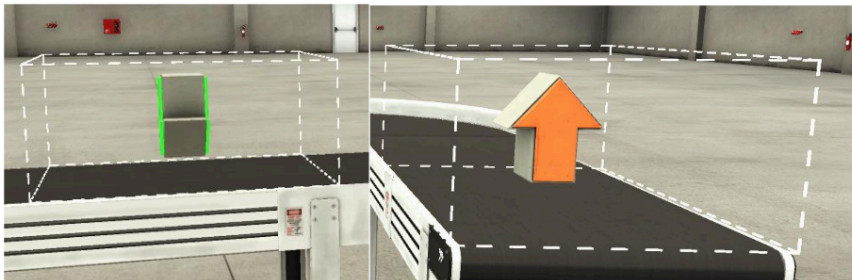


Figure 34 - Emitter and Remover

The Control Panel Instruments



Figure 35 - The Control Panel (Factory IO)

Factory IO PLC configuration

Start process	%I2.0	%Q2.0	Belt Conveyor (2m) 2
Emergency Stop 1	%I2.1	%Q2.1	Curved Belt Conveyor 1 CW
Stop process	%I2.2	%Q2.2	Start Button 1 (Light)
	%I2.3	%Q2.3	Object remover
Retroreflective Sensor 2	%I2.4	%Q2.4	
	%I2.5	%Q2.5	Stop Blade 1
	%I2.6	%Q2.6	Stop Button 1 (Light)
Retroreflective Sensor 1	%I2.7	%Q2.7	
VFD Control conveyor 1	%ID30 (REAL)	(DINT) %QD30	Counter 1
VFD Control conveyor 2	%ID34 (REAL)	(DINT) %QD34	Counter 2
		(REAL) %QD38	Belt Conveyor (4m) 1 (V)
		(DINT) %QD42	Conveyor 1 speed %
		(REAL) %QD46	Belt Conveyor (2m) 1 (V)
		(DINT) %QD50	Conveyor 2 speed %

Figure 36 - Factory IO PLC Configuration

Factory IO Setup Configuration

PLC

☐ Auto connect

Model

S7-1200

I/O Config

Numerical Data Type

DWORD

I/O Points

	Offset	Count
Bool Inputs	2	8
Bool Outputs	2	8
DWORD Inputs	30	2
DWORD Outputs	30	6

Figure 37 - Factory IO Setup Configuration

■

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Gantt Chart (Project Plan)

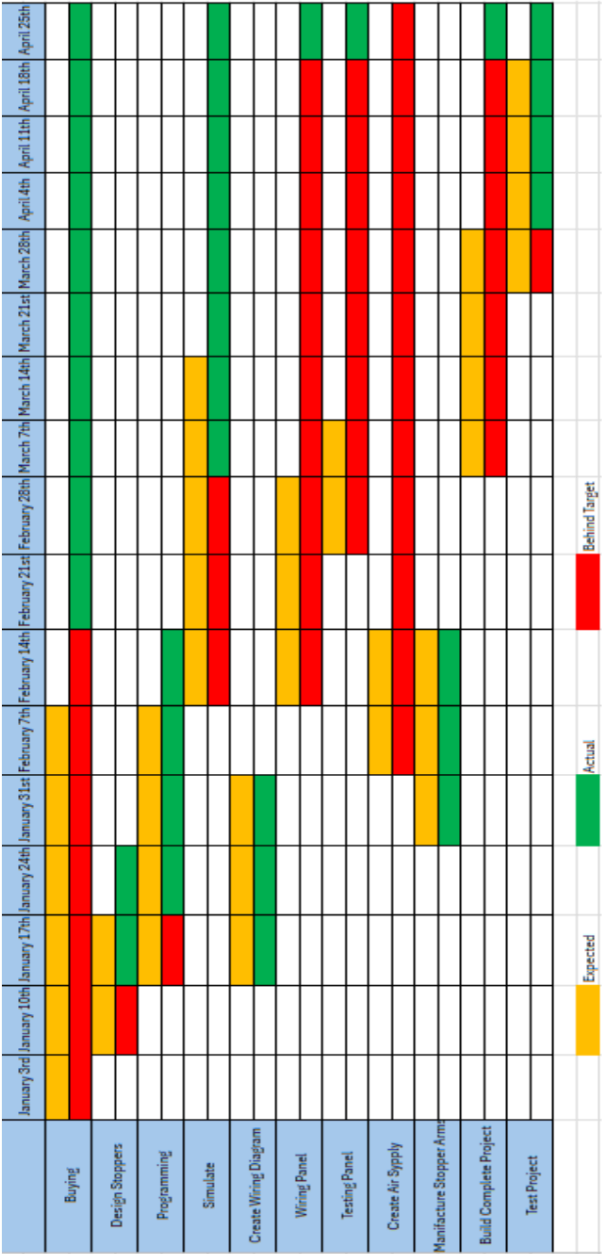


Figure 39 - Gantt Chart

Parameter List of ATV12

Code	Description	Value	page
<i>b F r</i>	Standard motor frequency	50 Hz	44
<i>U n S</i>	Rated motor voltage	230 V	55
<i>A C C</i>	Acceleration	3 seconds	62
<i>d E C</i>	Deceleration	3 seconds	62
<i>L S P</i>	Low speed	0 Hz	44 75
<i>H S P</i>	High speed	50 Hz	76
<i>C t t</i>	Motor control type	Standard U/F law	55
<i>U F r</i>	IR compensation (law U/F)	100%	56
<i>I t h</i>	Motor thermal current	equal to nominal motor current (value determined by drive rating)	80
<i>S d C I</i>	Automatic DC injection current	0.7 x nominal drive current, for 0.5 seconds.	65
<i>S F r</i>	Switching frequency	4 kHz	57

Figure 41 - Parameter List

Characteristics and functions of power terminals

Terminal	Function	For ATV12
+	Ground terminal	All ratings
R/L1 - S/L2/N	Power supply	1-phase 100...120 V
R/L1 - S/L2/N		1-phase 200...240 V
R/L1 - S/L2 - T/L3		3-phase 200...240 V
PA/+	+ output (dc) to the braking module DC Bus (divisible part on wiring trap)	All ratings
PC/-	- output (dc) to the braking module DC Bus (divisible part on wiring trap)	All ratings
PO	Not used	
U/T1 - V/T2 - W/T3	Outputs to the motor	All ratings

Figure 40 - Characteristics and functions

LSP Setpoint



Figure 42 - LSP setpoint

Inverter Wiring



Figure 43 - Wiring Inverter ATV12

Pack Stopper Build



Figure 44 - Pack Stoppers

Prototype Factory IO

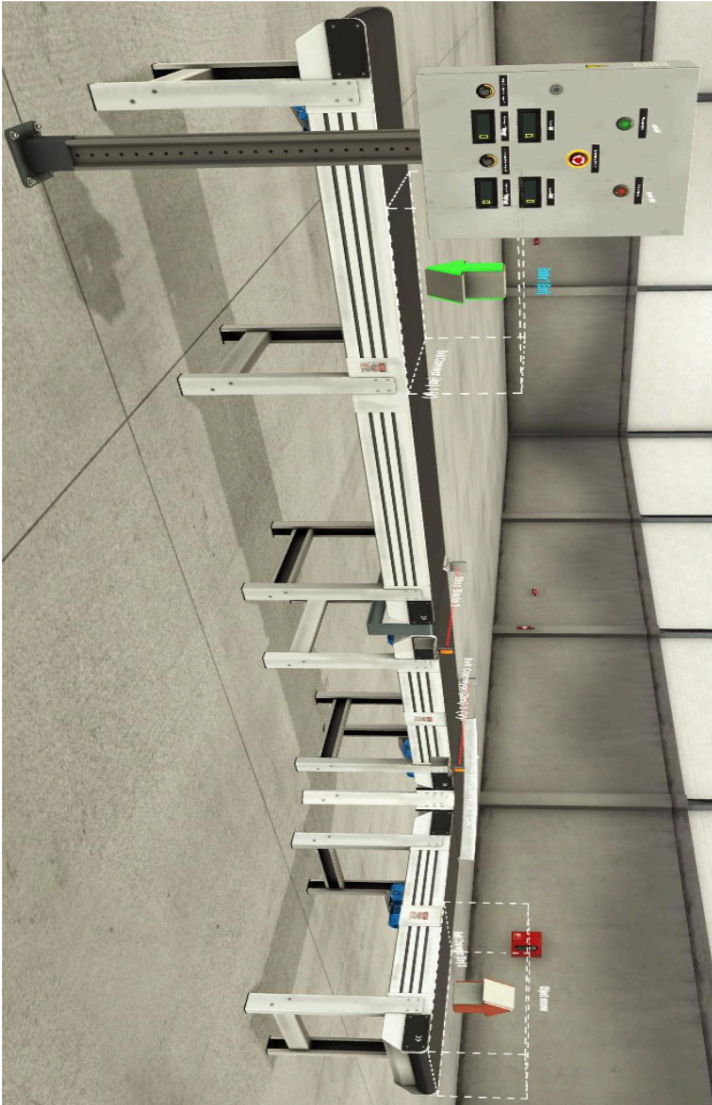


Figure 45 - Factory IO Prototype

Test Evidence

Stop Condition



Figure 46 - Stop Condition

No Speed set for conveyor 1 or conveyor 2, ESTOP active and both conveyors deactivated.

Start Process with no Conveyor



Figure 47 - Start Process with no Conveyor

Start switch pressed system started with no speed settings for conveyors 1 and 2. Both conveyors at standstill with 0% speed set.

Panel Speed Set at 10 and 12 for Conveyors 1 and 2



Figure 48 - Panel Speed Set at 10 and 12 for Conveyors 1 and 2

Counter 1 Resets on Negative Edge of 5th Count on First Sensor



Figure 49 - Counter 1 and 2 Displays

Counter 2 Resets on Negative Edge of 5th Count on second Sensor with time delay of 5s.



Figure 50 - Counter 1 Reset

Panel Control for Conveyors Reset with Stop Blade Activated after Count of 5

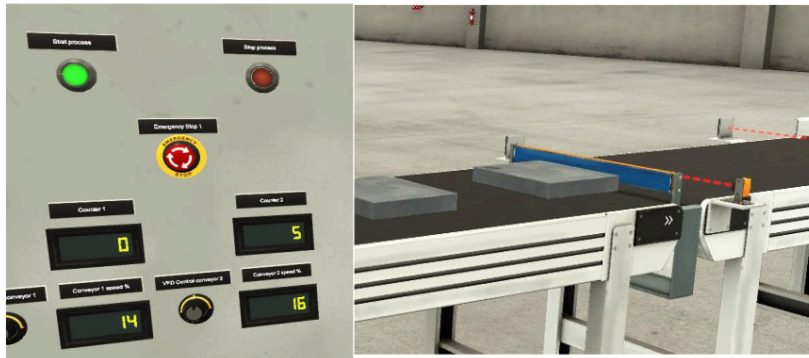


Figure 51 - Stopper Activated

Panel Control for Conveyors Set with Stop Blade Deactivated after Second Count of 5 and Time Delay 5s

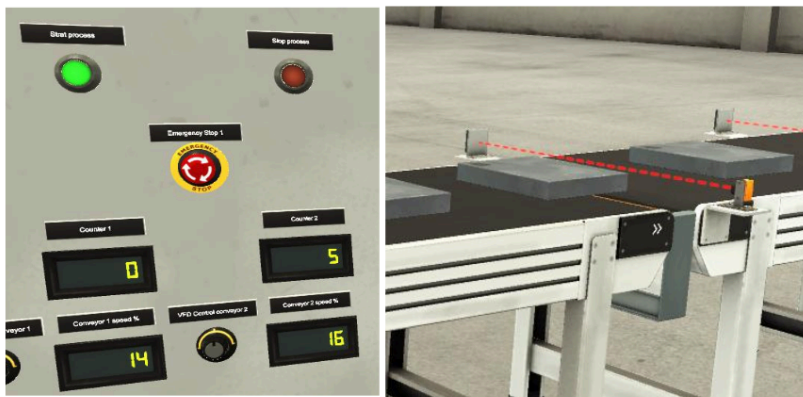


Figure 52 - Stopper Deactivated

HMI Control for Conveyors Reset with Stop Blade Activated after Count of 5

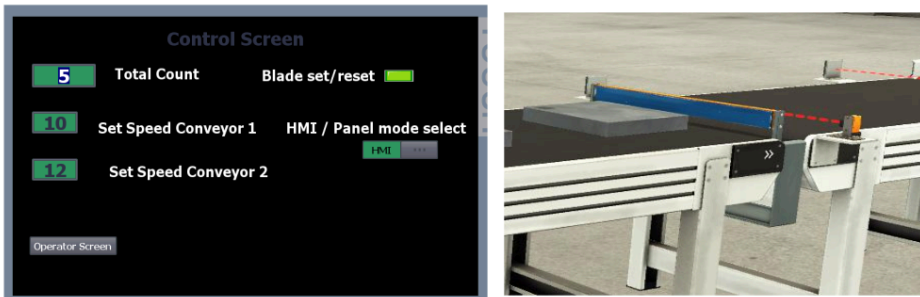


Figure 53 - HMI Control for conveyors reset

Conveyors 1 and 2 are reset with blade stop activated and the Blade Stop indicator shows blade is set. Total count will continue until stop or ESTOP is activated

HMI Operator Panel Start Process

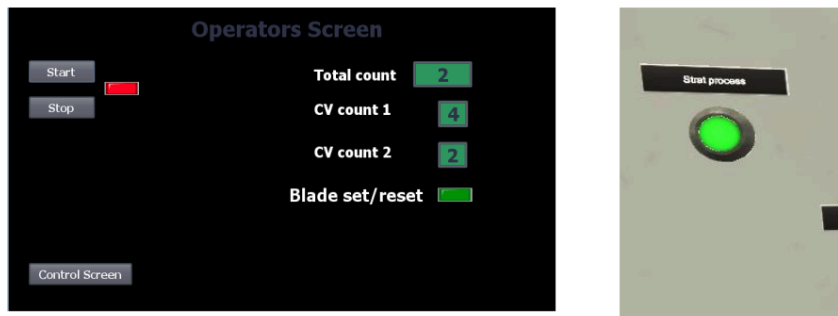


Figure 54 - HMI Operator Panel Start Process

Start / Stop indicator in 'on' state and also the start indicator on panel in 'on' state and the Conveyor counters and total count is on this screen as well as Engineer screen.

HMI Operator Panel Stop Process

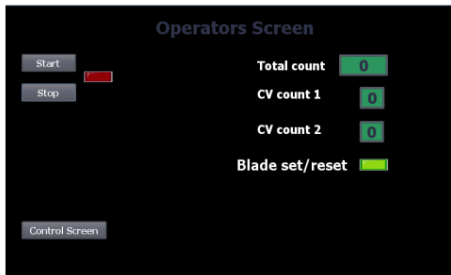


Figure 55 - HMI Operator Panel Stop Process

Start / Stop indicator in 'off' state and also the stop indicator on panel in 'on' state, Conveyor counters and total count is on this screen as well as Engineer screen and indicate counts are reset to zero.

Start switch activated and Stop Blade Resets

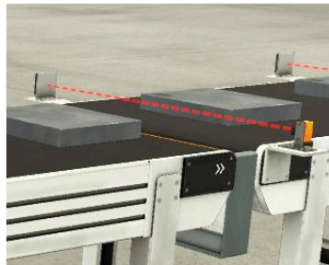
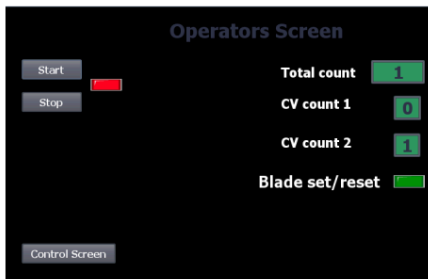


Figure 56 - Start switch activated and Stop Blade Resets

Stop blade indicator in 'off' state with stop blade reset by start function

Employers Statement

Employers Statement

Dylan Jones

Fri 02/05

Employer statement

The project was built by Jack under our supervision. Jack had demonstrated great knowledge and dedication to complete the project in the given timescale. Although there were setbacks, his skill set to then adapt and overcome these obstacles had exceeded our standards.

Regards
Dylan Jones

Figure 57 - Employers Statement

SGEL6000

Independent Project

Log Book

Jack Rogers

Pack Stopper Upgrade

2024-2025

Summary of Entries

Log Entry	Date	Brief Description of Activity	Duration (hrs)	Accumulated time (hrs)
1	20/09/24	Discussion with my Manager	2 Hours	2 Hours
2	27/09/24	Discussion with My Lecture about Proposal	4 Hours	6 Hours
3	04/10/24	Created a project proposal	10 Hours	16 Hours
4	11/10/24	Signed off the project proposal	10 Hours	26 Hours
5	18/10/24	Background research into the company	10 Hours	36 Hours
6	25/10/24	Background Research into the machine	10 Hours	46 Hours
7	01/11/24	Look into the problem definition	10 Hours	56 Hours
8	08/11/24	Look at the sustainability and Legal side of the project	10 Hours	66 Hours
9	15/11/24	Look into the company standards	10 Hours	76 Hours
10	22/11/24	Research about delivering an FDS	10 Hours	86 Hours
11	29/11/24	Creating an FDS and Test plan	10 Hours	96 Hours
12	06/12/24	Researching 3 solutions and writing a literature review	10 Hours	106 Hours
13	13/12/24	Comparing 3 solutions	10 Hours	116 Hours
14	19/12/24	Created a Project plan and WBS	10 Hours	126 Hours
15	10/01/25	Creating a parts list and creating a presentation	10 Hours	136 Hours
16	17/01/25	Presentation	4 Hours	140 Hours
17	24/01/25	Purchasing parts	10 Hours	150 Hours
18	31/01/25	Downloading software for programming	10 Hours	160 Hours
19	07/02/25	Started programming - Tag list	10 Hours	170 Hours
20	14/02/25	Completed Tag list and created main function block	10 Hours	180 Hours
21	21/02/25	Designed Pack Stoppers	10 Hours	190 Hours
22	28/02/25	Designed panel schematics	10 Hours	200 Hours
23	07/03/25	Designed electrical drawings	20 Hours	220 Hours
24	14/03/25	Created VFD Function blocks	20 Hours	240 Hours
25	21/03/25	Included a HMI to simulate project as parts not arrived	20 Hours	260 Hours
26	28/03/25	Downloaded Simulation software and created simulation using the program made.	20 Hours	280 Hours
27	04/04/25	Tested simulation and created test result tables	20 Hours	300 Hours
28	11/04/25	Wired up inverter and tested speed control with motor	20 Hours	320 Hours
29	18/04/25	Started assignment 2 and created a project report	60 Hours	380 Hours
30	25/04/25	Completed assignment 2	20 Hours	400 Hours

Log Entry Sheet

Log Number	1
Date	20/09/24
Duration (hrs)	2 Hours
Accumulated time (hrs)	2 Hours

Record of activities and achievements

This week I had a discussion with my manager about a continuous issue we have on one of our production lines. The issue we've been having is that the tray sealer keeps going into error with 'Cycle not done', this error is caused when there are too many packs coming into the tray sealer from a standard conveyor. With this error the machine stops quite frequently, and it causes a lot of downtime for the line and affects the costs of profit for the company.

In this discussion I briefly mentioned how we could solve the issues with a few different solutions. These solutions will be discussed with my lecturer in my next log entry.

Plans for next week

Discuss with my lecturer about the problem and come up with a project proposal.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	2
Date	27/09/24
Duration (hrs)	4 Hours
Accumulated time (hrs)	6 Hours

Record of activities and achievements

This week I discussed with my lecturer about the problem I was having that was mentioned in Log entry 1.

Following this conversation, we discussed about making a project proposal which will need to include the following:

- Where is the project based?
- Why is the project needed?
- Who will be involved with the project?
- What budget is available?
- When it must be completed by?

Plans for next week

Create a project proposal on an A4 sheet of paper and give to my manager and lecturer.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	3
Date	04/10/24
Duration (hrs)	10 Hours
Accumulated time (hrs)	16 Hours

Record of activities and achievements

This week a project proposal was made after having a further conversation with my manager about the project and what would be needed to make it happen such as costs, time frame etc.

In this proposal the location was suggested that it would be done in the local meat factory in the engineering workshop.

The reason was stated that the project was needed to improve production downtime and save company money.

The people that will be involved in the project will be my manager, my lecturer and myself.

The budget was not confirmed as my manager was going to let me know by next log entry.

The project must be simultaneous working by early 2025.

Plans for next week

Further conversation and agree on budget with manager, get feedback from lecturer and manager with project proposal.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	4
Date	11/10/2024
Duration (hrs)	10 Hours
Accumulated time (hrs)	26 Hours

Record of activities and achievements

Confirmed the budget with the manager and gave him the project proposal to sign.
Researched into the background of the machine and company.

Plans for next week

Write up about the background of the machine and company.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	5
Date	18/10/2024
Duration (hrs)	10 Hours
Accumulated time (hrs)	36 Hours

Record of activities and achievements

This week the background of the company and the machine were described going into great detail on how the machine works. The problem definition was researched further.

Plans for next week

The plan for next week's log entry will be to investigate how the machine works physically and re-search its manuals on how to operate it.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	6
Date	25/10/2024
Duration (hrs)	10 Hours
Accumulated time (hrs)	46 Hours

Record of activities and achievements

This week a lot of research was conducted on what the machine is and how it operates. This research was a crucial part of the project because a clear understanding of how the machine works and operates is a key factor when trying to diagnose its faults and highlight its issues. The research covered the basic operation all the way to the design and electrical manual.

Plans for next week

The plan for next week's log entry will be to look into the problem definition that is highlighted by the machine, this will give a better understanding on what is causing downtime and be easier to find a solution for.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	7
Date	01/11/24
Duration (hrs)	10
Accumulated time (hrs)	56

Record of activities and achievements

The problem that is at hand is that when the infeed conveyor transfers the pack into the machine it can only cope with 5 packs at a time and when the cycle has completed the next 5 packs will follow creating the next cycle. The issue is when the infeed gets overcrowded with packs and the operator tries to infeed the machine before the cycle has completed, the machine will go into error with cycle not done. As this is a very common issue at hand, although it is a simple one to reset the amount of times this issues occurs this creates a lot of downtime for the line which leads to shortages of production and therefore a loss of profit and potentially loss of customers.

Plans for next week

Next week's plan for the log entry will be to look into the sustainability and Legal/ commercial side of the project.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	8
Date	08/11/24
Duration (hrs)	10
Accumulated time (hrs)	66

Record of activities and achievements

Research was done looking at the different standards that were relevant to the project and describing how they were relevant.

The standards researched were the following :

- Health and safety work Act 1974
- The Electricity at work regulations 1989
- Use of work equipment regulations 1998 (PUWER)
- The Food Safety Act 1990
- Supply of Machinery (Safety) Regulations (2008)

Plans for next week

Next week's plan will be to look into the company standards.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	9
Date	15/11/24
Duration (hrs)	10
Accumulated time (hrs)	76

Record of activities and achievements

This week's log entry was to research the standards of the company as it is a meat processing factory there are a number of different types of food safety regulations that need to be considered.

Plans for next week

Next week's log entry will be to research about delivering an Functional Design Specification.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	10
Date	22/11/24
Duration (hrs)	10
Accumulated time (hrs)	86

Record of activities and achievements

In this week's log entry research was carried out into delivering a Functional Design Specification. This document should be a table full of requirements so that when the project is being implemented the FDS is used as a guideline to follow to make sure that it meets the correct specifications.

Plans for next week

Next week's log entry will be creating the FDS and a test plan for the project.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	11
Date	29/11/24
Duration (hrs)	10
Accumulated time (hrs)	96

Record of activities and achievements

In this week's log entry a FDS was created containing all the custom requirements that the project will need to include. After creating the FDS the test plan could then be created as a test function for each step of the FDS was used.

Plans for next week

Next week's log entry will be to research 3 solutions to implement the project and write a literature review for the project.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	12
Date	06/12/24
Duration (hrs)	10
Accumulated time (hrs)	106

Record of activities and achievements

This week's log entry was to research 3 different solutions for the project and a literature review was written.

The 3 solutions that were researched were:

- Relay logic
- PLC interface
- Arduino Microcontroller

Plans for next week

In next week's log entry the 3 solutions will be compared.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	13
Date	13/12/24
Duration (hrs)	10
Accumulated time (hrs)	116

Record of activities and achievements

In this week's log Entry the 3 solutions were compared by looking at the advantages and disadvantages and creating a radar chart in order to find the best solution for the project.

After careful consideration the obvious choice was solution 2 with the PLC interface.

Plans for next week

Next week's log entry will be to create a Gantt Chart for the project plan.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	14
Date	19/12/24
Duration (hrs)	10
Accumulated time (hrs)	126

Record of activities and achievements

In this week's log entry a Gantt Chart was creating using Excel.

Each task that will need to be done was recorded and an estimated due date for each task was given.

Plans for next week

Next week's log entry will be to look at buying the components needed.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	15
Date	10/01/25
Duration (hrs)	10 Hours
Accumulated time (hrs)	136 Hours

Record of activities and achievements

In this weeks log entry a preparation was needed in order to create a power point for a project presentation.

The power point will be around 15 slides and carry on for no longer than 7 minutes. The presentation will include:

Also, a parts list was created and an excel costing spreadsheet was created to look at the expected cost and actual cost of the equipment needed.

This will be to ensure that the budget is met and no overspending is happening.

Plans for next week

Next week's log entry will be to complete the power point and deliver the presentation.

Signed *J. Rogers* Signed *R. Davies*

Log Entry Sheet

Log Number	16
Date	17/01/25
Duration (hrs)	4 Hours
Accumulated time (hrs)	140 Hours

Record of activities and achievements

This weeks log entry was to complete the power point for the presentation which was done, then the presentation was delivered although 7 minutes was cutting it close, the audience for the presentation clearly understood what the project was.

Plans for next week

Next weeks log entry will be to order the parts required.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	17
Date	24/01/25
Duration (hrs)	10 Hours
Accumulated time (hrs)	150 Hours

Record of activities and achievements

In this weeks log entry the parts list that was created will begin to be purchased and put on order but due to the high demand of parts required by the company there might be a slight delay to when the parts come in. In the meantime the software and simulation side of the project can begin.

Plans for next week

Next week's log entry will be to download the software required for programming the PLC.

Signed *J. Rogers* Signed *R. Davies*

Log Entry Sheet

Log Number	18
Date	31/01/25
Duration (hrs)	10 Hours
Accumulated time (hrs)	160 Hours

Record of activities and achievements

In this week's log entry a license for TIA portal was purchased and the software was downloaded, a tutorial for the software was viewed in order to ensure the correct use of the program.

Plans for next week

Next week's log entry will be to start the programming using the TIA Portal software..

Signed *J. Rogers*

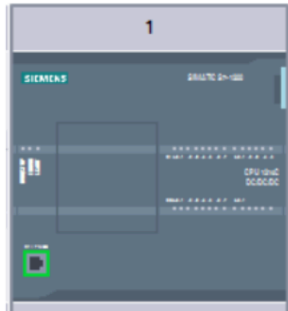
Signed *R. Davies*

Log Entry Sheet

Log Number	19
Date	07/02/25
Duration (hrs)	10 Hours
Accumulated time (hrs)	170 Hours

Record of activities and achievements

In this week's log entry the programming for the project had begun and a tag list was started after the PLC was chosen. The PLC that was chosen was a S7-1200 series. Below is an image of the selected PLC.



Plans for next week

Next week's log entry will be to chase up on delivery for rest of the parts and continue with programming.

Signed *J. Rogers*

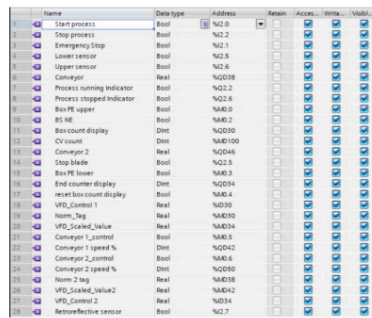
Signed *R. Davies*

Log Entry Sheet

Log Number	20
Date	14/02/2025
Duration (hrs)	10
Accumulated time (hrs)	180

Record of activities and achievements

Completed Tag list and created main function block.



Name	Data type	Address	Retain	Access	Write	Visible
Start process	Bool	NA2.0				
Stop process	Bool	NA2.2				
Emergency Stop	Bool	NA2.1				
Lower sensor	Bool	NA2.5				
Upper sensor	Bool	NA2.6				
Comveyor	Real	NAQ018				
Process running indicator	Bool	NAQ2.2				
Process stopped indicator	Bool	NAQ2.6				
Box ME upper	Bool	NA40.0				
BT ME	Bool	NA40.2				
Box count display	Dint	NAQ030				
CV count	Dint	NA40100				
Comveyor 2	Real	NAQ046				
Stop blade	Bool	NAQ2.5				
Box ME lower	Bool	NA40.3				
End counter display	Dint	NAQ034				
reset box count display	Bool	NA40.4				
VFD_Control 1	Real	NAQ030				
Home_Tag	Real	NA4030				
VFD_Scaled_Value	Real	NA4034				
Comveyor 1_control	Bool	NA40.5				
Comveyor 1 speed %	Dint	NAQ042				
Comveyor 2_control	Bool	NA40.6				
Comveyor 2 speed %	Dint	NAQ050				
Home 2 tag	Real	NA4038				
VFD_Scaled_Value2	Real	NA4042				
VFD_Control 2	Real	NAQ034				
Retractive sensor	Bool	NAQ2.7				

The tag list can be seen by the image shown, this is just a partial list of the full tag list required to build the system.

Plans for next week

Design Pack stoppers

Signed *J. Rogers*

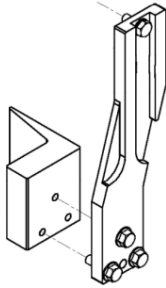
Signed *R. Davies*

Log Entry Sheet

Log Number	21
Date	21/02/2025
Duration (hrs)	10
Accumulated time (hrs)	190

Record of activities and achievements

In this week's log entry the designed pack stoppers have been created by using the software AutoCAD. Below is an image of the completed design.



Plans for next week

Design panel schematics

Signed *J. Rogers*

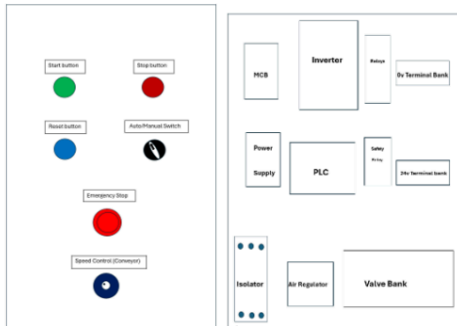
Signed *R. Davies*

Log Entry Sheet

Log Number	22
Date	28/02/2025
Duration (hrs)	20
Accumulated time (hrs)	200

Record of activities and achievements

This week's log entry was to complete the design of the panel schematics. Below is the image of the completed design that was used in Word Microsoft.



Plans for next week

Design electrical drawings

Signed *J. Rogers*

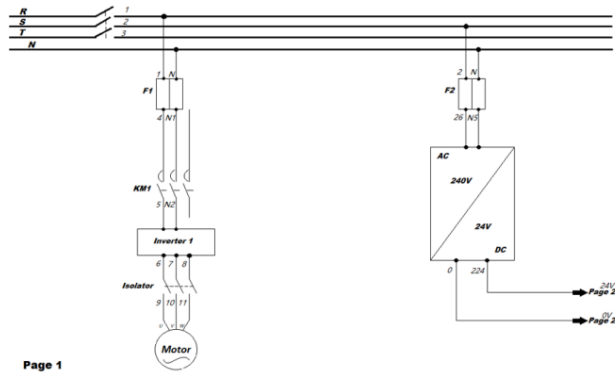
Signed *R. Davies*

Log Entry Sheet

Log Number	23
Date	07/03/2025
Duration (hrs)	20
Accumulated time (hrs)	220

Record of activities and achievements

This week's log entry was to design the electrical drawings for the new panel. The image below shows the power circuit of the panel used by the software Circuit Diagram.



Plans for next week

Create VFD function block

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	24
Date	14/03/2025
Duration (hrs)	20
Accumulated time (hrs)	240

Record of activities and achievements

In this week's log entry the VFD Function block was created, this was done by researching online how to create this function block to get a good understanding on how it works and why it needs to be implemented in the project.

Plans for next week

Chase up parts and make decisions on how to test projects without the arrival of parts.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	25
Date	21/03/2025
Duration (hrs)	20
Accumulated time (hrs)	260

Record of activities and achievements

In this week's log entry a HMI was included to simulate project as parts not arrived some alterations had to be made so that the simulated part of the project can be upgraded to prove the working function of the project as it cannot be physically built.

Plans for next week

Download the Simulation software and create simulation using the program made.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	26
Date	28/03/2025
Duration (hrs)	20
Accumulated time (hrs)	280

Record of activities and achievements

Downloaded Simulation software and created simulation using the program made. The software that was used was Factory IO. This was chosen as it would give the viewer of the project a physically simulated conveyor scene so that they can see the system function by watching the run process and not only by testing the PLC program on TIA Portal.

Plans for next week

Start testing and create results table

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	27
Date	04//04/25
Duration (hrs)	20
Accumulated time (hrs)	300

Record of activities and achievements

This week's log entry was to tested the simulation and create new test result tables.
The new test result tables was created to prove the successfulness of the modified simulated system.
All test tables were created by giving a pass/fail marking scheme and an evidence section to prove the results.

Plans for next week

Inverter has arrived, will need to wire up to the potentiometer and motor to prove speed control working.

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	28
Date	11/04/25
Duration (hrs)	20
Accumulated time (hrs)	320

Record of activities and achievements

This week's log entry was to wire up inverter and test the speed control and to program the inverter. Below is an image to show the wired up inverter and the programmed setting.



Plans for next week

Start assignment 2 by creating a project report

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	29
Date	18/04/25
Duration (hrs)	60
Accumulated time (hrs)	380

Record of activities and achievements

Started assignment 2 and created a project report including the design, implementation and testing phases.

Plans for next week

Continue with assignment 2

Signed *J. Rogers*

Signed *R. Davies*

Log Entry Sheet

Log Number	30
Date	25/04/25
Duration (hrs)	20
Accumulated time (hrs)	400

Record of activities and achievements

Completed assignment 2.

Plans for next week

Chase up parts again.

Signed *J. Rogers*

Signed *R. Davies*

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/100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

Text Comment. This is a good summary that provides and honest and straight forward explanation of all that was done

PAGE 9

Text Comment. A very good introduction that outlines the objectives and contents of the report (with a few improvements suggested)

Text Comment. revised

Text Comment. ^

Text Comment. in order to achieve

Text Comment. ^

Text Comment. simulated

Text Comment. ^

Text Comment. WBS not needed in this report

Text Comment. names should be included

Text Comment. this could have been achieved

Text Comment. to

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

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Correctly cited

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QM

Spelling

Spelling error

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Spelling

Spelling error



Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. modified

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GRADING FORM: NEW CSG-RUBRIC

JACK ROGERS

64

1. ENGAGEMENT WITH LITERATURE



Section 3: Judicial use and critical evaluation of technical literature in the design of the project. There is some evidence of reading and evaluation of sources. (2/5)
Section 8: Extent of reading, range of credible sources and use of Harvard method.

4

A small range of sources have been considered and the method of citing is correct (2/5)

4/10

2. KNOWLEDGE AND UNDERSTANDING



Sections 3 and 4: Advanced knowledge and critical understanding demonstrated in the design and implementation of the project.

There is good evidence of knowledge and understanding throughout the report (6/10)

6

3. COGNITIVE AND INTELLECTUAL



Section 5: Testing and analysis of results.
Excellent evidence of testing and analysis of results (7/10)

Section 5: Critical evaluation of the project outcomes.

Very good evaluation and comparison between the updated FDS and the simulated results. (7/10)

Section 6: Conclusions and recommendations.
A good set of conclusions though briefly stated (4/10)

18

18/30

4. PRACTICAL APPLICATION



Section 4: Deployment method, use of material, tools, equipment and techniques in the construction of the project.

The design section is very good, standard methods of design employed. Good use of Factory IO software to simulate the machine and use of Siemens TIA Portal in the design and testing of the PLC program. (7/10)

Section 4: Quality of the final product or system.
The simulated end product is of a high standard. (7/10)

Sections 5, 6 and appendix: Management of the design process including use of plans, costing

20

spreadsheet and log book.

There is good evidence of deployment of project management processes but the decision to simulate came late in the project cycle. This should have been seen sooner. Log books is good in parts but brief in others. (6/10)

20/30

5. TRANSFERABLE SKILLS



Section 1: Acknowledgements, executive summary and introduction.

A very good summary that explains the project clearly. The acknowledgments should contain the actual names of the people who helped you. The introduction sets out the aims and objectives of the report. (4/5)

All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page and section numbering etc..

Generally, very good quality (4/5)

All Sections: Quality of the writing style, use of punctuation and grammar.

Generally well written with few mistakes (3/5)

Word count limit not exceeded (5/5)

16

16/20