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by Thomas Grennan

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HNC Electrical Electronic Engineering
SGEE4006 Electrical Electronic Engineering
Project
Final Report

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EBS Automation

Established in 1993 as Equipment Building Systems Ltd the company carried out a re-branding exercise in July 2008 and as part of the re-branding, changed it's company name to EBS Automation Ltd. EBS Automation has become a specialist in the design, manufacture and installation of automation systems and special purpose machines for the automotive, pharmaceutical and industrial sectors. Operating from our 12,000 sq. ft facility EBS originally concentrated on the UK market, however the company is now developing a multi-national customer base and has supplied automation systems and special purpose machines to Poland, USA, Spain and Romania.



Figure 1 – EBS Automation Logo

The Original Project

As EBS Automation manufacture automated systems and machines, they also install and commission these machines at customer sites. One of the issues when working on site is that we need to machine or modify mechanical components during commission if a machine isn't running properly, as EBS construct machines all over the UK and Europe it is sometimes not possible to return to EBS HQ in order to modify components. Due to this problem I have been tasked in constructing a small machine which can modify mechanical components which is small enough so it can be taken to customer sites. *Avoid using first person terms.*

The proposed method to eliminate this problem is to manufacture is to create a CNC controlled gantry which will be used to mill and modify mechanical manufactured components when the technicians are working on site.

The CNC router will be created with three moving axis, X, Y and Z. The CNC router will be software controlled by a logic controller or a microcontroller such as an Arduino or Raspberry Pi. The gantry will move by motor control or by electrical actuators. A CNC software package will be created to design the alterations to the material, the G-Codes will then be sent to the Arduino to drive the step and direction of the motor to cut the material, The material will be cut by a router which will have a chuck to enable various drills and cutters to be used.

Two Solutions were chosen, Solution 1 would be controlled by a PLC with an HMI for operator control, Whereas Solution 2 was controlled by an Arduino with JavaSwing to create a graphical user interface for operator control. Solution 2 was then chosen as it is the most cost-effective option, it utilised open source software which requires no licenses, Arduino is relatively straightforward to

learn and understand. JavaSwing has extensive online tutorials, along with Arduino it is reliable for this application. After the solution was chosen a component list was created, these were then ordered. When waiting for delivery the electrical schematic and layout were designed. Upon delivery the components were booked in. The panel was then wired.

During the Christmas shutdown research into Arduino and JavaSwing was undertaken.

After returning to work after shutdown I was informed that due to work commitments and new orders this project had to be changed as the new project was a higher priority.

CONTINGENCY PLAN

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1. Introduction and Background Research

Summary of New Project

EBS have recently won a contract with a local automotive manufacturer, this company manufacture aluminium pipes used in automotive radiator and intercooler systems. Three machines have been ordered with EBS. Machine 1 will punch a hole into the aluminium tube, Machine 2 will pneumatically punch an assembly dimple into the tube and machine 3 will perform a high-pressure leak test on the component.

I have been tasked with designing the control system for Machine 2, This control system will be made up of an electrical control panel including switchgear, power supplies, relays, safety equipment and a controller. This controller will control the machines operation. This machine will punch a dimple on either side of a tube, this will be done through a pneumatic cylinder. The two dimples have to be punched completely parallel to each other. The problem that the customer has is that the current method for “dimpling” the part is not always accurate as an operator uses a foot pedal and has to line the part up by eye which does not always give an accurate finish, therefore out of a 100 parts sometimes up to 25 are wrong, My task is to develop a semi-automated system which produces 100 correct parts out of every 100.

Avoid first person terms

Research was undertaken on the methods of semi-automating a machine process. This can be done by a Programmable Logic Controller (PLC) or a Microcontroller.

A programmable logic controller is an industrial solid-state controller which continuously monitors field sensing devices (Inputs), from the programme written by engineers the PLC will make a decision on which outputs are triggered by certain inputs. (Gonzalez, 2015) Most PLCs today are of the modular type, this means they allow expansion “Cards” to be added onto the PLC for different functions such as analog cards, extra input cards or extra output cards. (Michael, 2018)

Good explanation



Figure 2 – Modular PLC

PLCs are used to monitor and record machine data, runtime data such as temperature, productivity, starting and stopping processes without a human interference. (Boisset, 2018)

Most PLCs have 5 programming languages under the IEC 61131-3 standard, these are Instruction List, Function Block Diagram, Structured Text and Sequential Function Chart.

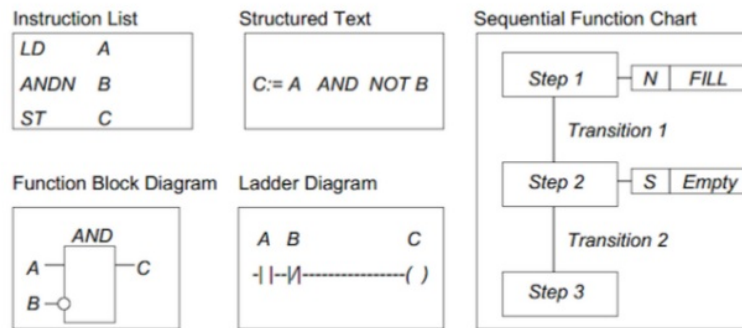


Figure 3 – IEC 61131-3 Programming Languages

The most widely used language for PLCs is Ladder Programming. It is a graphical language which represents logic operations using symbols for Inputs and Outputs. There is 24VDC or 110VAC on the left hand rail and 0VDC/AC Neutral on the right hand rail where the coil is grounded, when all of the required inputs in the rung are “Logic 1” then the output is energised. (LadderLogicWorld, 2017)

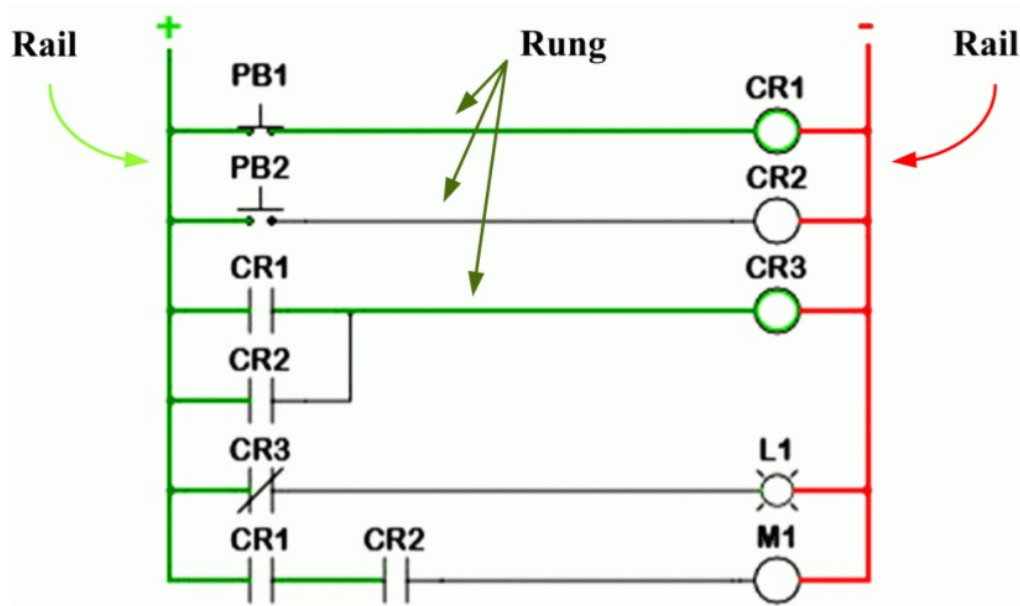


Figure 4 – PLC Ladder Logic Example

A microcontroller is a compact integrated circuit, this circuit is designed to perform a specific operation which has been programmed onto the controller. It controls this operation by interpreting the data received from I/O devices to its central processor. (Rouse, 2019)

This is a good argument for a possible solution



Figure 5 – Integrated Circuit Chip

One of the most popular platforms that have integrated with microcontrollers is an Arduino. An Arduino is an open source platform used for electrical and electronic projects. The microcontroller is utilised in the Arduino by allowing it to be programmed in order for it to execute output commands based upon the logic level of its inputs. (OpenSource, 2019). Figure 6 shows a microcontroller that is integrated into the Arduino.



Figure 6 – Arduino Microcontroller

Arduino is a very popular method of programming; Arduinos do not need a “programmer” to upload code onto the board, this is done simply with a USB cable which also powers the board with 5VDC. Programs are written on the Arduino Integrated Development Environment which utilises a simplified version of C++, which is an easy language to pick up and learn. “Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package” (OpenSource, 2019)

The argument is justified for the Arduino as a possible solution. You could have given an example scenario where this is used.

2. Specification

The main specification for the project is to produce an accurate, reliable and easily maintainable control system which runs the machine to produce accurate and high-quality parts within the customer specified cycle time. This project will consist of Electrical components such as a controller, Relays, MCBs, Power Supply and pneumatic components such as valves, cylinders and pressure switches. If the project can be controlled electrically using a controller then it must, if not the pneumatic circuits will be used.

The end project will consist of an electrical control panel which will be connected to a pneumatic circuit with the use solenoids on valves which will control the dimpling cylinder. A PLC will be programmed to run the machine sequence. In order to meet the specification, all sections in the project outcomes table below must be met. This outcome table will be reviewed at the end to see if it has been met, if so then it is a successful project

Project Outcomes	
Where is the project based?	EBS Automation's Manufacturing unit
How will the reliability of the project be met?	There will be weekly meetings which will monitor the progress.
Operational conditions?	The machine will be created in a clean workshop, Once the customer has signed the project off it will run at their plant.
Budget?	The budget is £5000, this is just the budget for Electrical Components.
Ergonomics, ease of use etc	The wiring and software will be designed as simple as possible to allow for easy maintenance and fault finding. The machine sequence will be designed as simple as possible to reduce operator errors.
Health and Safety Standards (H&S)	As the project is undertaken at EBS Automation, I will follow their H&S standards This project will comply with the Health and Safety at work act, the electricity at work regulations and the IET Wiring regulations. All necessary PPE will be worn when needed.
Environmental Impact?	This project does not use any harmful chemicals or substances that will have an effect on the ecosystem. This project will not be an energy saver; however, it will run as efficient as possible.
Sustainability?	If there are components that EBS have in stock they will be used, all excess material will be reused or recycled.
Time scale?	The project started on 06/01/2020 and will conclude on 21/04/2020
Cycle Time?	The customer has specified that they want a cycle time of under 20 seconds.
Customer needs?	A reliable control system that is easy to operate and maintain. A machine that consistently meets the cycle time whilst producing high quality parts.
Machine Standards?	All British Standards will be followed for the machine's safety, the panel will be wired to the IETs 18 th edition wiring standards. The software will be written to EBS' standards which meets the British standard for programming.
Control Panel?	500mm x 500mm x 300mm, must be IP65 Rated.
Electrical Specification?	The machine has a Single Phase 16amp 230VAC supply, this will be lowered to 24VDC 10amp for the control circuit. All components will be fused appropriately. The wire colours will follow the BS Code.
Earth Bonding?	All extraneous conductive material must be bonded to earth, with a resistance to earth of <0.5ohms.
Operator Controls?	The operator will have a MIMIC (Operators Panel) where there will be buttons to control the machine, and an E-Stop for emergency conditions.

Figure 7 – Project Outcome Table

Good table of expected results to meet specifications

3. Planning

In order to monitor the projects progression and to keep track of the project a Gantt chart was created; this chart illustrates the projects schedule. The top bar of the Gantt chart displays the planned time for tasks to be completed, underneath displays a different colour bar showing the actual schedule. This will be useful for future projects as it gives an accurate representation of how long some tasks take.

The plan is to firstly research about the type of project, after deciding on the project type two possible solutions will be researched. One of these solutions will be chosen, A component list for the chosen solution will be constructed, these components will be ordered. The electrical drawings will be designed, then the panels and field devices will be wired back to the panel. The software will be developed from the start until the end due to the learning curve it entails, it will be integrated into the system and tested. The final machine will be tested and commissioned, the end process will then be evaluated to see if it has met the specification and how it could be improved in the future. (Figure 8)

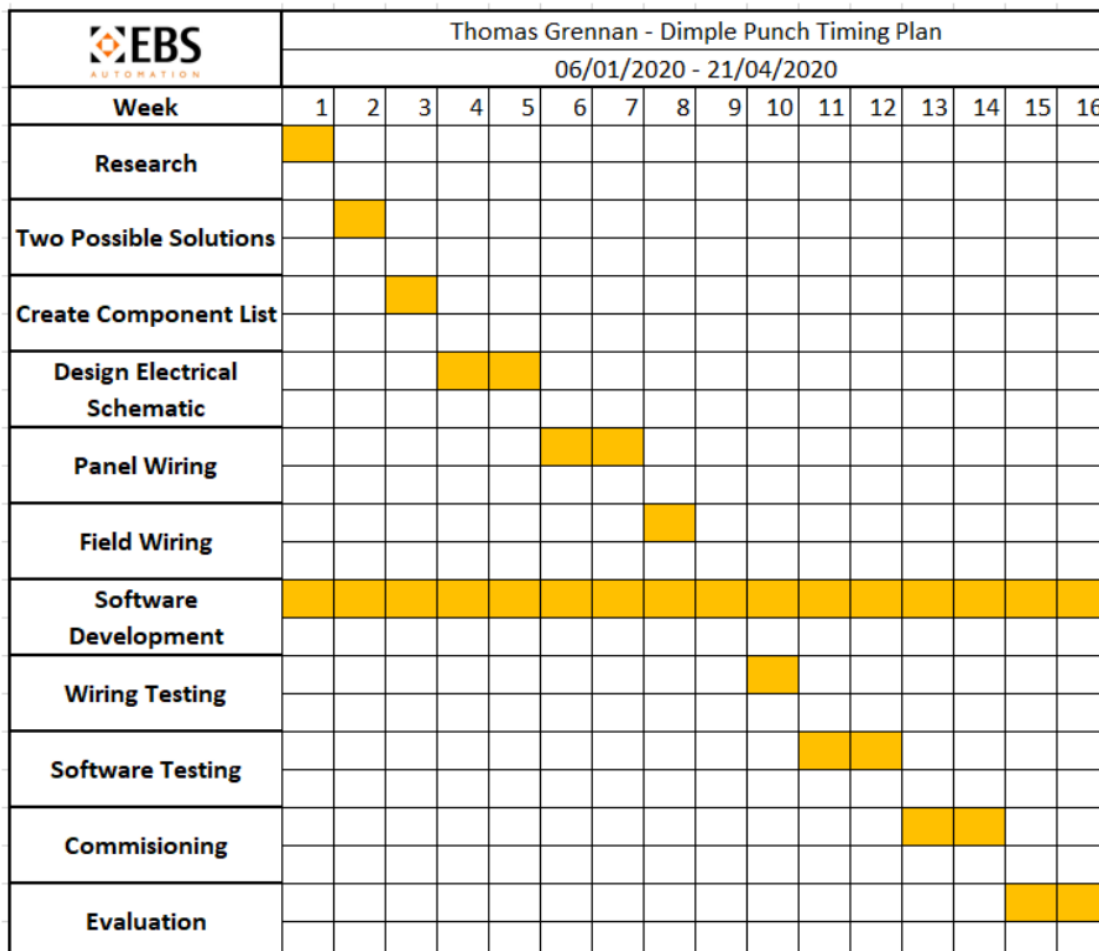


Figure 8 – Gantt Chart

A testing plan was then created in conjunction with the Gantt chart, this plan is for the type of test that needs to be undertaken and the date it needs to be completed on in order for the project to be on time. (Figure 9)

Testing Plan		
Test	Test Description	Planned Date
1. Protective Earth Bonding Tests	Ensure that the resistance between all extraneous conductive material on the machine is less than 0.5ohms to earth.	23/03/2020
2. Wiring Check	Check that all wiring is wired correctly	23/03/2020
3. Safety Function Tests	Ensure that all safety systems are working in the control system correctly.	23/03/2020
4. Input and Output Verification Test	Ensure that the correct sensors and buttons are sending signals to the correct input, ensure that the correct outputs are energising actuators.	30/03/2020
5. Machine Sequence Test	Ensure that the machine is operating the software sequence correctly.	30/03/2020

Figure 9 – Testing Plan

Test
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4. Solutions Considered

Solution 1 – PLC Control

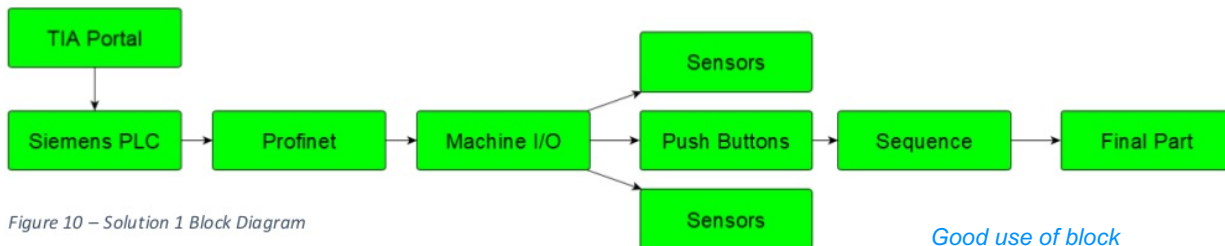


Figure 10 – Solution 1 Block Diagram

Good use of block diagram

Solution 1 is a control system which is controlled by a Siemens PLC, this will be programmed through TIA portal over the Profinet communications protocol. Physical I/O will be addressed in the PLC from the field wiring. A software code will manipulate this I/O into performing a sequence. (Figure 10)

This method would cost £1332.18 which is well within the £5000 budget. This solution will meet not only the project specification but also the customers specification as they use Siemens PLCs.

This solution will conform to BS7671 and 18th edition wiring regulations whilst using a control voltage of 24VDC



Figure 11 – Siemens S71200 Series PLC

Using this PLC will also meet the specification of using an automatic sequence of which the software is easily maintainable, the customer's technicians are familiar with Siemens PLCs.

Siemens PLCs are also well known for their reliability and are highly efficient for manufacturing processes. TIA portal is also highly praised for fault finding as all networks can be monitored to see if a sensor or actuator is faulty. This will be an efficient method of meeting the specification (Figure 11)

A map was created to compare the pros and cons of solution 1, Green sections show the positives, Amber show the negatives (Figure 12).

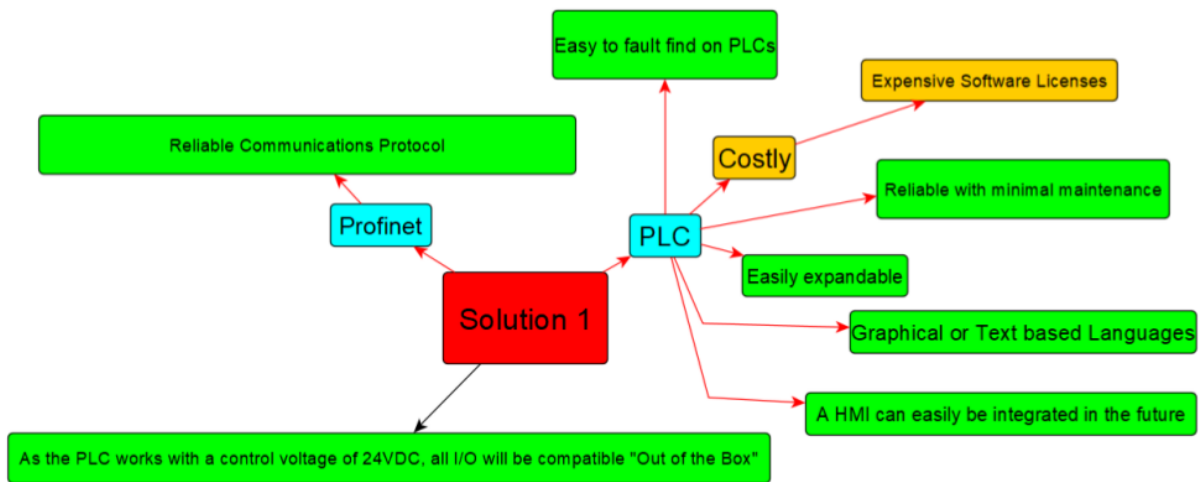
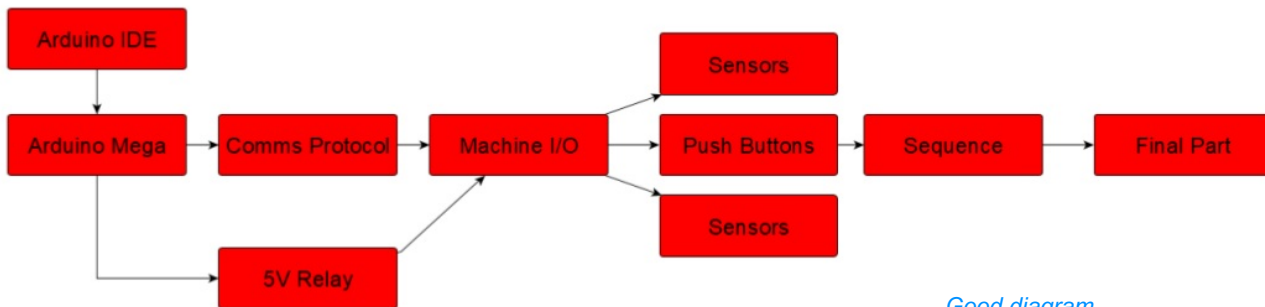


Figure 12 – Pros and Cons of Solution 1

A good idea for showing the comparison

Solution 2 – Arduino Control



Good diagram

Figure 13 – Solution 2 Block Diagram

Solution 2 is a control system which is controlled by an Arduino microcontroller this will be programmed through Arduino IDE over a MODBUS communications protocol. (Figure 13)

Due to the Arduino having a control voltage of 5VDC Physical I/O (24VDC) will have to be wired to relays, the other side of the relay will be sent to the Arduino I/O ports, each port can be addressed as an input or an output, giving the user flexibility. (Figure 14)

All I/O will need an individual relay, 20 in total. This method would cost around £1054 which is well within the £5000 budget. This solution meets the specification, the controller is highly robust, can be used in extreme environments and is easily replaceable if it develops a fault as it takes seconds to upload a programme onto an Arduino.

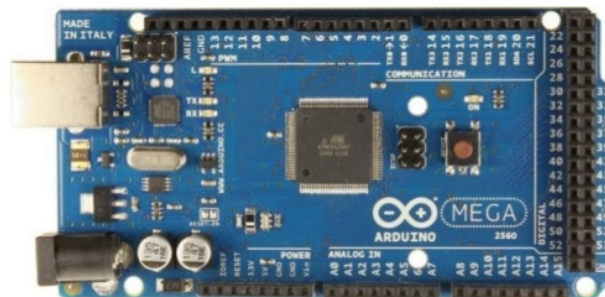


Figure 14 – Arduino Mega Microcontroller

This solution will conform to BS7671 and 18th edition wiring regulations whilst using a control voltage of 24VDC and 5VDC.

Using this Arduino will meet the specification of using an automatic sequence of which the software is easily maintainable and can be edited easily, hardware for the Arduino is also very inexpensive. This will also be an efficient method of meeting the specification, however, it will take longer to complete.

A map was created to compare the pros and cons of solution 2, Blue shows the component, Green shows the pros, orange shows the cons. (Figure 15)



Figure 15 – Pros and Cons of Solution 2

Solution 3 – Siemens SIMATIC IOT2020

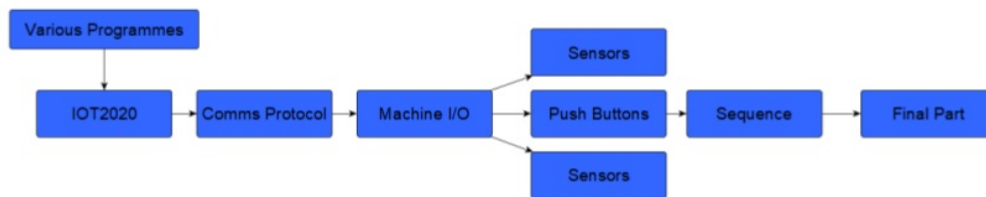


Figure 16 – Solution 3 Block Diagram

Good diagram which shows the system design

Solution 3 is a control system which is controlled by a Siemens SIMATIC IOT2020, this will be programmed through the Arduino IDE and can be connected to various industrial protocols such as Modbus and Profinet. Physical I/O will be addressed in the IOT2020 from the field wiring, third party sensors and actuators will be used, these are 24VDC compatible. A software code will manipulate this I/O into performing a sequence. (Figure 10)

This method would cost £985.18 which is well within the £5000 budget. This solution will meet not only the project specification, this meets the customer specification for using Siemens products but also gives them the aspect of Industry 4.0 which can turn manufacturing facilities into smart factories.

This solution will conform to BS7671 and 18th edition wiring regulations whilst using a control voltage of 24VDC, it is DIN rail mountable which will fit into the panel.



Figure 17 – Siemens IOT2020

This is a good possibility because this controller is designed around the IIOT 4.0 and is a combination of Siemens and Arduino technology which is supported by RS components

A map was created to compare the pros and cons of solution 3, Green sections show the positives, Amber show the negatives (Figure 18).

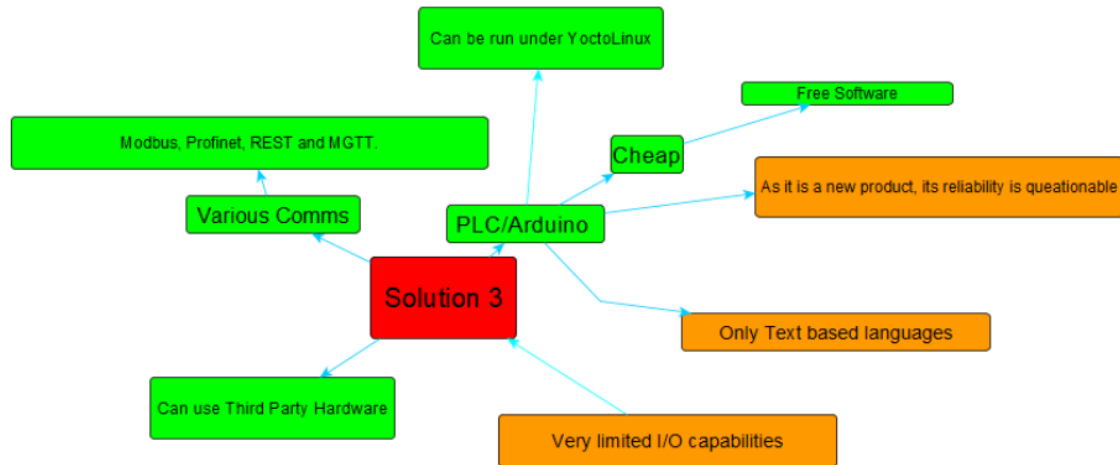


Figure 18 – Solution 3 Pros and Cons

All 3 solutions were then compared to find the strongest two, Due to the very limited I/O capabilities and questionable reliability solution 3 was eliminated as a potential option. Solutions 1 and 2 were then compared in more detail.

4.1 Comparison of Solutions

Category	Solution 1	Solution 2
Cost (£)	£1332.18 (Most Expensive)	£1054 (Least Expensive)
Accessibility (Components & Timeframes)	The components for this solution are easily accessible. However, the PLC and I/O card make this solution cost £278 more than solution 2.	The components for this solution are slightly harder to obtain, the Arduino has a long lead time. £278 cheaper than solution 2.
Simplicity of Design	The circuit for this would be as simple as possible. The machine I/O would wire directly into the PLC and can be used straight away. The PLC is din rail mountable.	This circuit design is more complex than solution 1 due to the 5VDC relays being used, this will take up unneeded space in the cabinet. The Arduino is not din rail mountable.
Size (Smallest/Medium/Largest)	Medium Panel	Medium Panel
Ease of Use	Relatively Easy from an operator's point of view. From the authors point of view this will be easier as the author has experience with Siemens PLCs.	Relatively Easy from an operator's point of view. From the authors point of view this will be harder and take longer as the author has no experience with Arduino programming.
Which Solution fits the customer needs the best?	Solution 1 will fit the customer needs well. It will be a reliable control system; their technicians have experience on Siemens PLCs which will be an advantage during fault finding which will reduce downtime.	Solution 2 does not fit the customer needs as good. It will still be a reliable control system; however, their technicians have no experience with Arduino which will be a disadvantage during fault finding.
Final comment	This solution will be the best option for the project. It is more expensive; however, this will be made back in hours spent on the project as the author has more experience with TIA Portal. Less time will be spent than on solution 2 as the I/O relays are unneeded.	This solution requires components that are hard to obtain and are costly. The circuit does not change, however, due to the authors inexperience with Arduino and due to the extra relays needed which will take up unneeded space.

Figure 19 – Comparison of Solutions

5. Final Solution and Implementation

The final chosen solution for the project is solution 1, the PLC solution. This solution was chosen as it was well within the budget, the customer is familiar with Siemens PLCs and TIA portal as many of their machines have these PLCs therefore machine training and fault finding would be easier due to the familiarity with the system. EBS automation also specify that electrical machine control should be done with a PLC, through the use of a PLC it gives the customer options for future expansion by adding I/O cards. If the Arduino solution was chosen then 20 more relays would be required due to the difference in control voltage, this would have made the panel highly cramped.

A good design argument here

This solution will have an IP65 rated control panel. A supply voltage of 240VAC will be used, this supply will be fused at 16amps, an isolator is also incorporated into the panel. 240VAC is used for the machine light and to supply the 240VAC to 24VDC power supply. The rest of the panel will be powered by 24VDC from the power supply. Wire 24 from the power supply will feed all of the DC circuit breakers, Wire 25 will be 24VDC for the internal panel components, Wire 26 will be 24VDC for field devices and Wire 27 will be 24VDC for safety components, each individual supply will be protected by an MCB rated accordingly, the MCBs controlling field devices and safety devices will have auxiliary contacts which will send a signal to the PLC when the MCB is on.

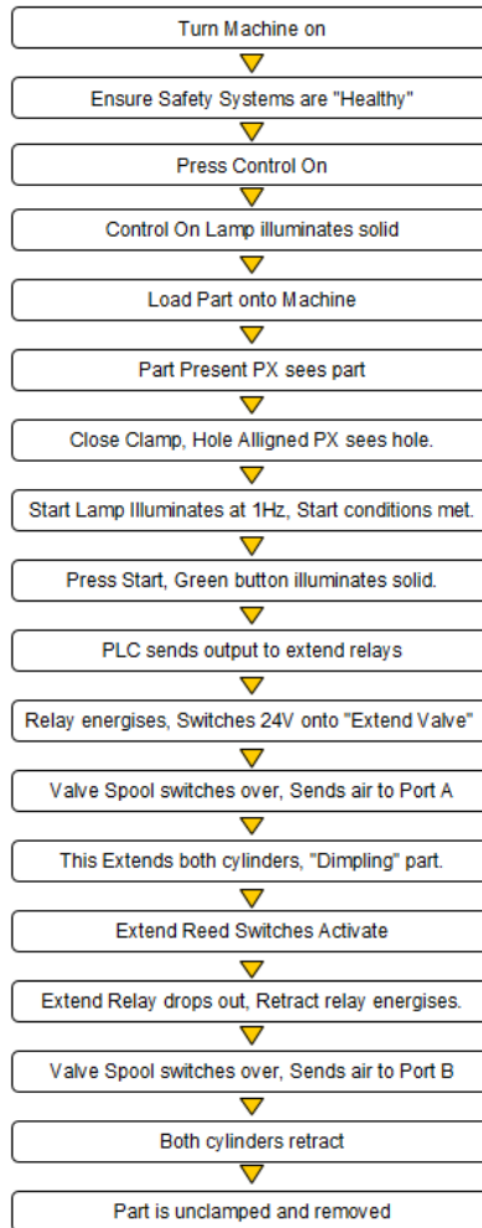
A Siemens S7-1200 1214C DC/DC/DC relay will be used with an extra input card for 16 extra inputs, A PILZ Pnoz s3 Safety Relay will be used to control the air system, this will also control the 24VDC sent to the common side of relays which will operate the valves to switch the spool over to extend or retract the cylinder. The panel will have three relays, one will reset the safety relay, one relay will extend the cylinders and the final relay will retract the cylinders, all relays will be controlled by outputs from the PLC.

The machine will also be pneumatically controlled, a service unit will consist of a main air isolator, a flow control, a digital pressure switch, a dump valve and a manifold with one solenoid operated valve. Two cylinders are on the machine, they will be piped in parallel together, therefore they will extend and retract together, this is to give an equal duple parallel to each other on the part.

Two Proximity sensors will be used, one will sense that the part is present and one sense the hole in the pipe from the previous machine. Four reed switches will also be used for the cylinders, each cylinder will have two each, one to say it has extended and one to say it has retracted.

The machine will be controlled by an operator; therefore, a control unit of pushbuttons and lamps will be wired to the control panel.

The first task for implementing the project is to plan out the machine sequence, using this sequence it helps the design stage easier. (Figure 20)



Sequence table is a good design tool

Figure 20 – Project Sequence

After the machine sequence was created, the electrical control design was started. Firstly, a parts list was created for the panel, the mechanical technician for the job created the mechanical and pneumatic parts list as I have been tasked with the electrical control side. (Figure 21)

Dimple Punch Project Bought Out List						
Component	Supplier	Part No.	Qty	Price Per Unit	Total Price	Electrical Reference
Panel enclosure and Plate	~~Rittal~~	AE1060.500	1	£89	£89	Elec Panel 1
Fuse Holder	R&M	RS20H	1	£9.83	£9.83	10F1
16A Fuse	R&M	NIT16	1	£3.74	£3.74	10F1
3 Pole 16A non fused disconnect, shaft and handle	R&M	1SCA104811R1001	1	£20.83	£20.83	10S0
6A MCB	RS	A9F44106	1	£18.59	£18.59	70F1
2A MCB	RS	A9F44102	4	£22.24	£88.96	10F3, 70F2, 70F3, 70F4
MCB AUX Contact	RS	A9A26924	2	£30.39	£60.78	70F3, 70F4
240v to 24V PSU 10A	RS	6EP13341LB00	1	£101	£101	70T1
Siemens PLC CPU	RS	6ES72141AG400XB0	1	£362	£362	200A0
Siemens 16 Input card	RS	6ES72211BH320XB0	1	£166	£166	220A0
PILZ PNOZ s3	RS	750103	1	£128.47	£128.47	80K0
Omron 6A Slimline Relay	RS	OMR.G2RV-SR700_DC24	2	£9.66	£19.32	KO004, KO005
Omron DPST Relay	RS	OMR.G2R-2-SND-24DC(S)	1	£3.57	£3.57	KO000
PTTB 2.5s Terminals	~~Routeco~~	PXC.3210567	4	£0.50	£2	/
PTTB 1.5s Terminals	~~Routeco~~	PXC.3208511	50	£0.40	£20	/
End Clamp	RS	3022276	10	£0.368	£3.68	/
Trunking	EBS Stock	T1EF60X80G T1EF40X80G	1.5m etres	£18 per metre	£27	/
Din Rail	EBS Stock	TS35	1.5m etres	£11 per metre	£16.5	/
Buttons, Lamps and collars	EBS Stock	XB4 Series	5 off each	£11.63	£58.15	E-Stop, Start, Reset, Control On, Fault.
Tri Rated Cable	EBS Stock	906-2704	100 m	£15.84	£15.84	/
SMC Reed Switch		D-A93	4	£18.03	£72.12	WI204-WI207
IFM PX Sensor		IFS204	2	£22.40	£44.80	WI200, WI201
Total Costing			£1332.18			

Figure 21 – Bought Out List

After creating the parts list, a table of power distribution in the panel was created. Each individual circuit was categorised into type of power, each different supply was given an individual wire number and MCB number to help fault finding, these will be referenced to the electrical drawings. The table below shows what each circuit operates. (Figure 22)

Dimple Punch Project Panel Power Distribution			
Power	Wire Number	MCB	What is it operating?
240VAC Supply		Main Fuse (16 Amp)	Supplies the Panel
240VAC		10F3 (2 Amp)	Machine Light
240VAC	70L1	70F1 (6 Amp)	240VAC to 24VDC Power Supply
AC Neutral	10N	/	Return for Machine Light and PSU.
24VDC	24	/	Supply to 24VDC MCBs
24VDC	25	70F2 (2 Amp)	Internal Component Power
24VDC	26	70F3 (2 Amp)	External Component Power
24VDC	27	70F4 (2 Amp)	Safety Component Power
0VDC	0	/	Return for all DC power
Protective Earth	/	/	Tied to 0VDC, Protects machine from earth faults.

Figure 22 – Power Distribution List

Good use of the table of power distribution

After completing the power distribution, a terminal block list was created. Each terminal block will be used for different components or operations. This will be referenced in the drawings. (Figure 23)

Dimple Punch Project Terminal Assignment		
Terminal Block Number	No. of terminals	What is this block used for?
X1	2 x 2.5 PTTB, 2 x 2.5 PE	240VAC Power for Light
X2	5 x 1.5 PTTB	Internal 24VDC/0VDC
X2.1	10 x 1.5 PTTB	Field 24VDC/0VDC
X3	15 x 1.5 PTTB	PLC Inputs
X4	5 x 1.5 PTTB	PLC Outputs
X6	10 x 1.5 PTTB	Safety (e.g. E-Stop)
X10	2 x PTTB	Solenoid Valve Cables

Figure 23 – Terminal Assignment

Using tables for the design is good practice

A control unit of pushbuttons, pilot lights and an emergency stop will be created for the operator's operation, this includes a Start button with a lamp, a reset button, a control on button with a lamp, a fault lamp and an emergency stop button. (Figure 24)

Dimple Punch Project (Pushbutton and Lamp Operations)	
Pushbutton/Lamp	Operation
Start Button and Lamp	Starts the automatic sequence, When the start conditions are met the button will flash green every second to indicate that the start conditions are met. During operation the Lamp will be illuminated for the full sequence.
Reset Button	Resets the machine if it goes into fault, this resets the machine back into its home position.
Control on Button and Lamp	Control On will enable the machines control, this button will send an Input to the PLC, an output will be fired to a relay which will reset the safety relay which supplies 24VDC to the dump valve and cylinder relay commons. When the machine safety is healthy the control on lamp will be illuminated, when the safety system is healthy but there is no air present the lamp will flash every second to indicate no air present.
Fault Lamp	This Lamp indicates a machine fault, when this lamp illuminates the machine is in a fault condition.
Emergency Stop	The Emergency Stop button is a mushroom head button which controls the safety relay. When it is not pressed the safety relay channels will be connected as needed and the machine will operate. When this emergency stop button is pressed it will drop put the safety relay which will drop out the air supply making the machine safe.

Figure 24 – Pushbutton and Lamp Operations

Operation
panel is
clear

The final part of the panel to be planned before the drawings are started is the PLC I/O. (Figure 25)

Input Map		Output Map	
Input	PLC Address	Output	PLC Address
E-Stop Relay Ok	%I0.0	Safety Reset	%Q0.0
Spare	%I0.1	Machine Fault Lamp	%Q0.1
Field 24V MCB	%I0.2	Control on Lamp	%Q0.2
Safety 24V MCB	%I0.3	Start PB Lamp	%Q0.3
Spare	%I0.4	Punch Cylinders In	%Q0.4
Spare	%I0.5	Punch Cylinders Out	%Q0.5
Air Pressure Switch	%I0.6	Spare	%Q0.6
Spare	%I0.7	Spare	%Q0.7
Start PB	%I1.0	Spare	%Q1.0
Reset PB	%I1.1	Spare	%Q1.1
Control On PB	%I1.2		
Emergency Stop PB	%I1.3		
Spare	%I1.4		
Spare	%I1.5		
Spare	%I1.6		
Spare	%I1.7		
Part Present PX	%I2.0		
Hole Aligned PX	%I2.1		
Spare	%I2.2		
Spare	%I2.3		
Front Cylinder Extend	%I2.4		
Front Cylinder Retract	%I2.5		
Back Cylinder Extend	%I2.6		
Back Cylinder Retract	%I2.7		
Spare	%I3.0		
Spare	%I3.1		
Spare	%I3.2		
Spare	%I3.3		
Spare	%I3.4		
Spare	%I3.5		
Spare	%I3.6		
Spare	%I3.7		

Figure 25 – I/O List

The table of IO is useful and part of the design but can be put in an appendix and referenced from the main report.

The electrical control drawings were then drawn. Firstly, they were sketched on paper, after sketching them I showed my project mentor who confirmed that it was correct. I could then draw the electrical control drawings on EPLAN.

The panel layout was firstly designed, then the AC circuits, then DC circuits and finally the PLC circuit. (Figure 26)

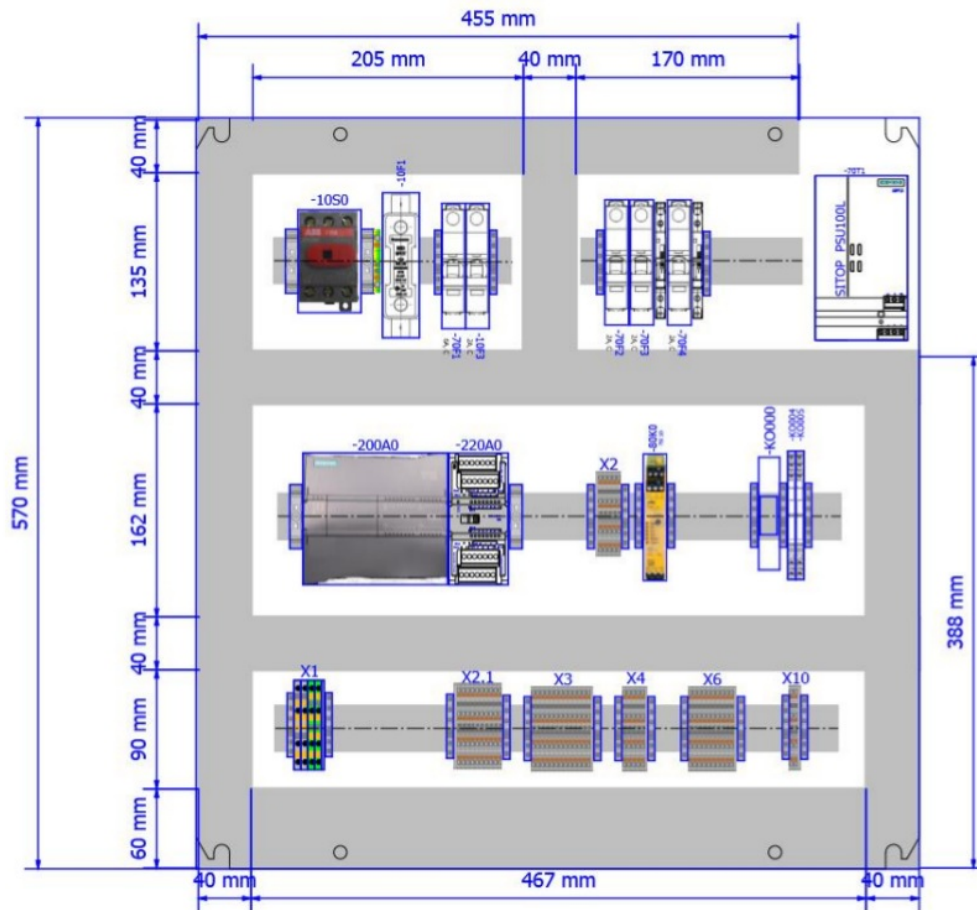


Figure 26 – Electrical Panel Layout

*This could
be in an
appendix*

Wiring Standards		
Circuit Type	Colour	Size (mm ²)
AC POWER (L1/L2/L3)	BLACK (BK)	1.5
AC NEUTRAL	LIGHT BLUE (LT BU)	1.5
AC MOTOR	BLACK (BK)	1.5
AC CONTROL	RED (RD)	1.0
DC POWER	BLUE (BU)	1.0
DC CONTROL	BLUE (BU)	0.75
DC INPUTS	BLUE (BU)	0.5
DC OUTPUTS	BLUE (BU)	0.5
EXTERNAL INTERLOCKS	ORANGE (OR)	1.0
EARTHING	GREEN/YELLOW (GN/YE)	>= PROTECTED CONDUCTOR
EARTH BONDING	GREEN/YELLOW (GN/YE)	6

Earthling	
ALL EARTHINGS TO BE BONDED TO THE EARTH BAR. ALL BONDING POINTS TO BE IDENTIFIED WITH PE SYMBOL	
	

Termination	
ALL CABLES TO BE FERRULED AT BOTH ENDS USE RINGS OR FORKS AS NECESSARY	

Terminal Labelling Standard	
X0 - MAINS INCOMING WIRING	
X1 - MAINS FIELD CONNECTIONS	
X2/X2.a - 24V DC DISTRIBUTION	
X3/X3.a - PLC INPUTS	
X4/X4.a - PLC OUTPUTS	
X5 - VISION	
X6 - SAFETY	
X10 - GENERAL 24V	

COLOUR CODES	
BK - BROWN	
BU - BLUE	
WH - WHITE	
GN - GREEN	
YE - YELLOW	
GY - GREY	
PK - PINK	
RD - RED	
BK - BLACK	
VT - VIOLET	

Figure 27 – Wiring Information



Figure 28 – Incoming Supply and AC Voltage Distribution

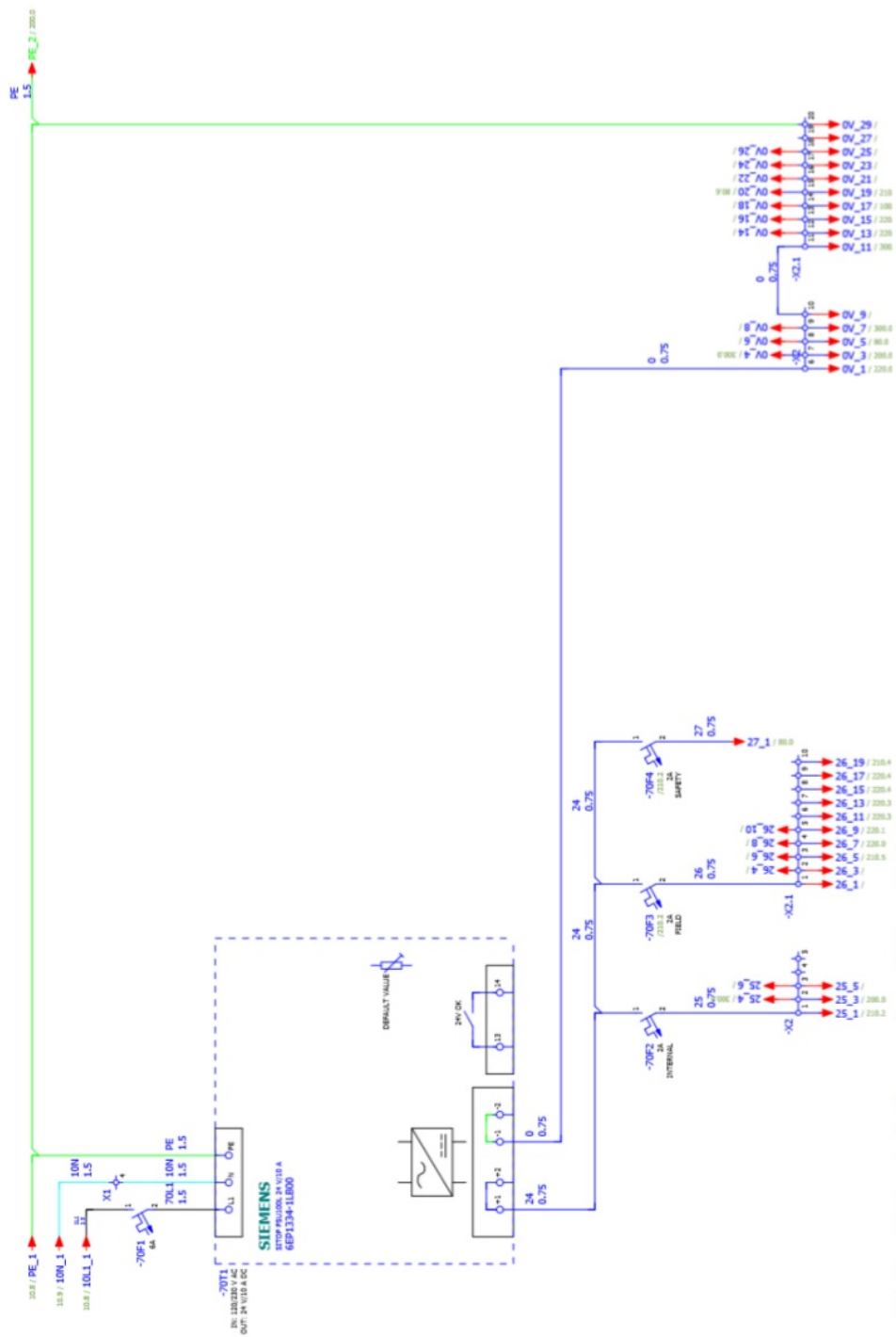


Figure 29 – Supply Voltage to the Power supply and DC Power distribution

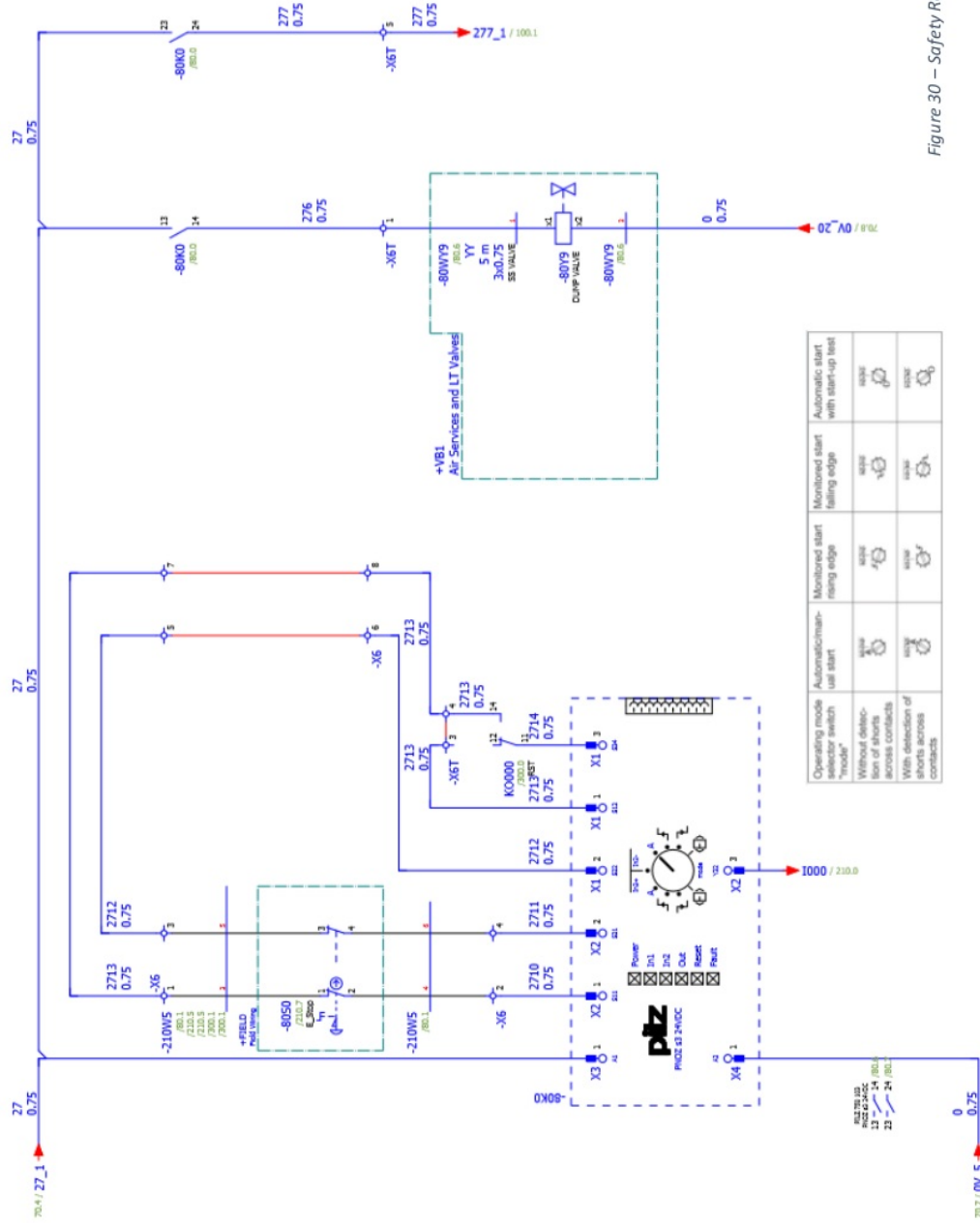


Figure 30 – Safety Relay Circuit

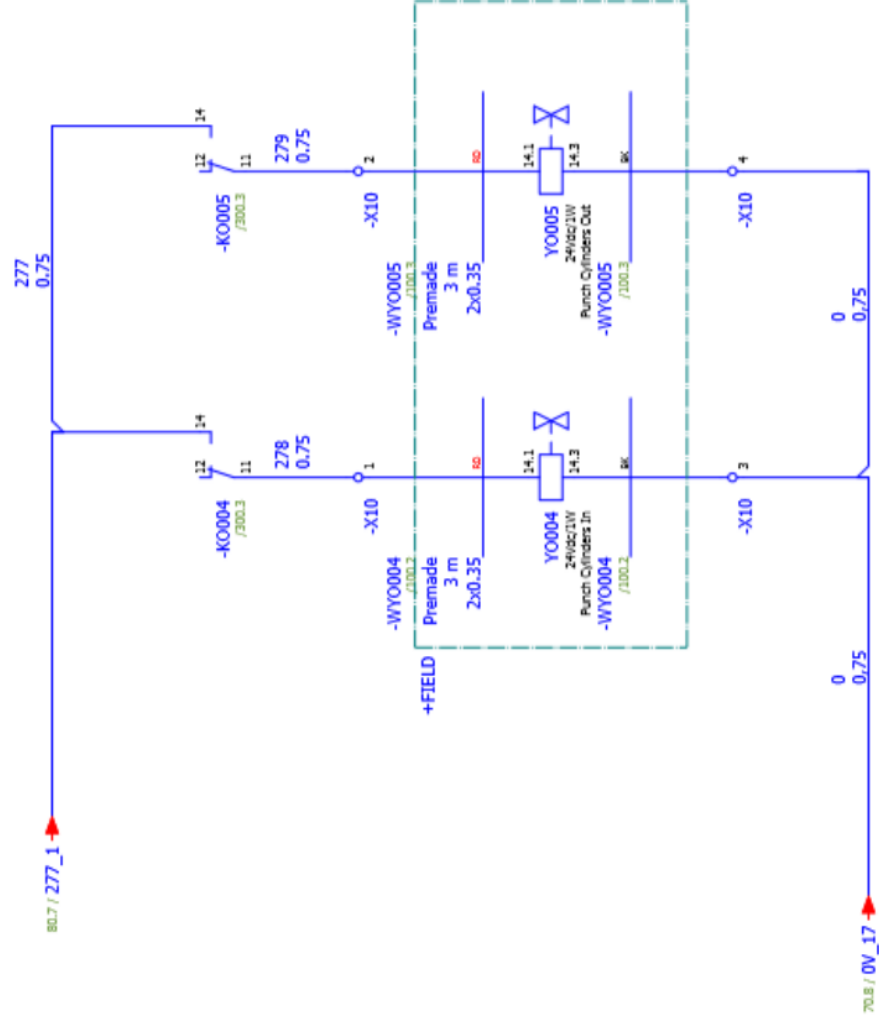


Figure 31 – Valve and Cylinder Wiring

Figure 32 – PLC CPU Power

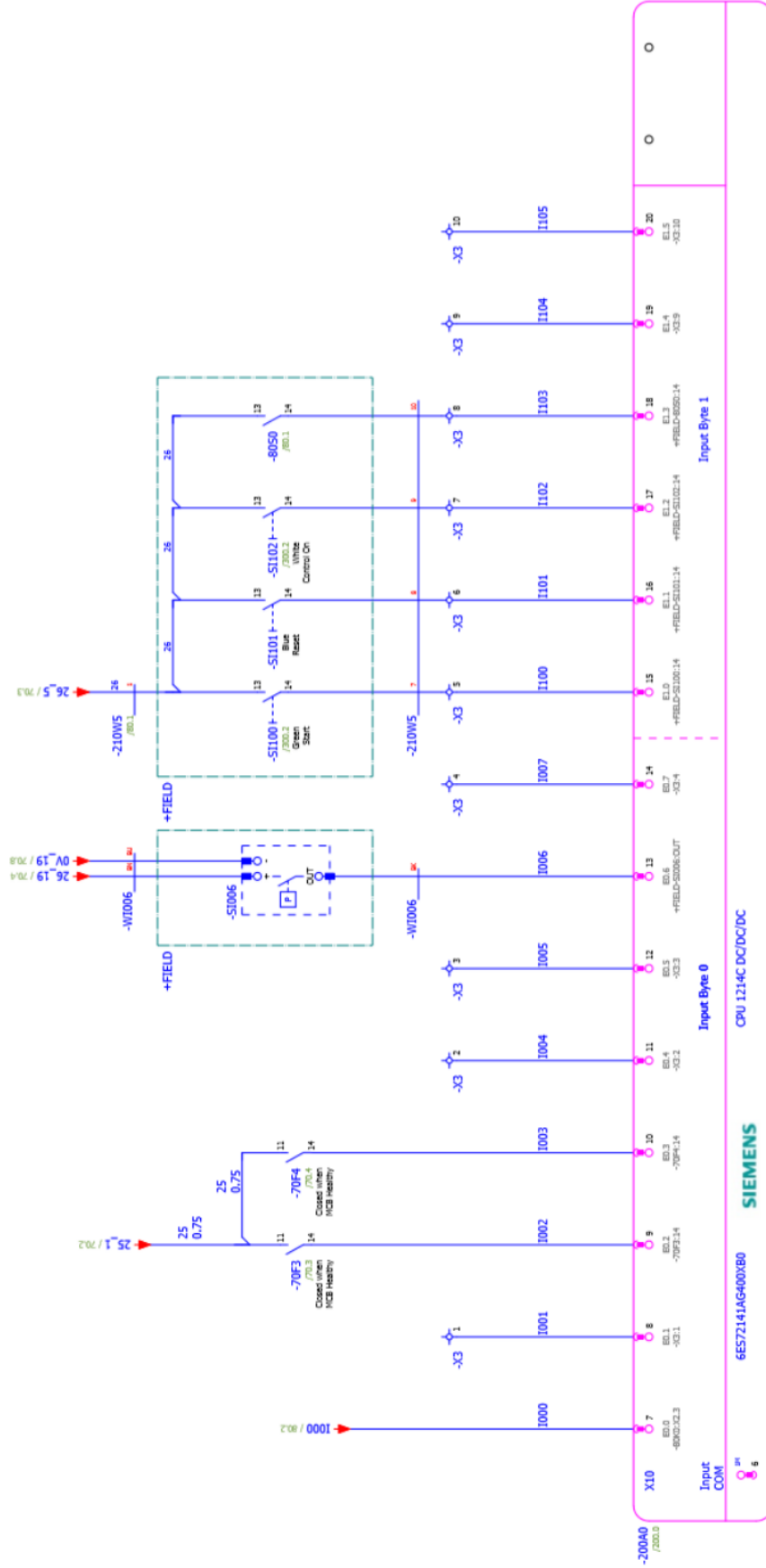


Figure 33 – PLC Inputs (I000-I105)

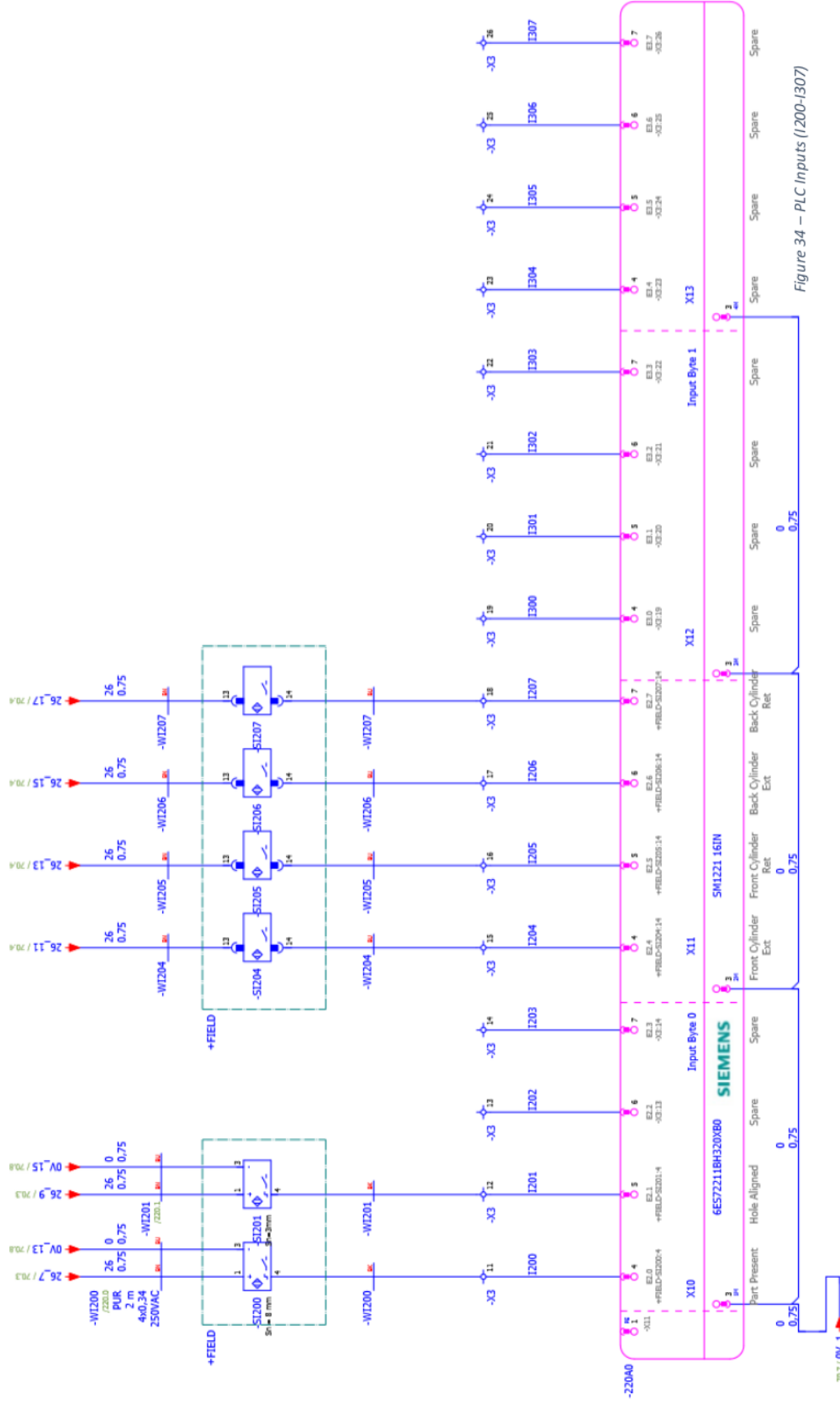
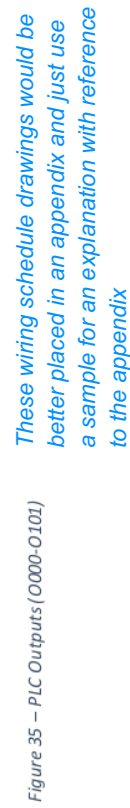


Figure 34 – PLC Inputs (I200-I307)



35

After completing the drawings, the panel was constructed. The panel and components were collected from the stores. Trunking, Din rail and cable was also collected. All components were laid out onto the panel and inspected for any damage, after inspection the din rail and trunking were mounted onto the panel. (Figure 36)



Figure 36 – Panel Trunking Layout

All components were then mounted onto the din rail and labelled. (Figure 37)

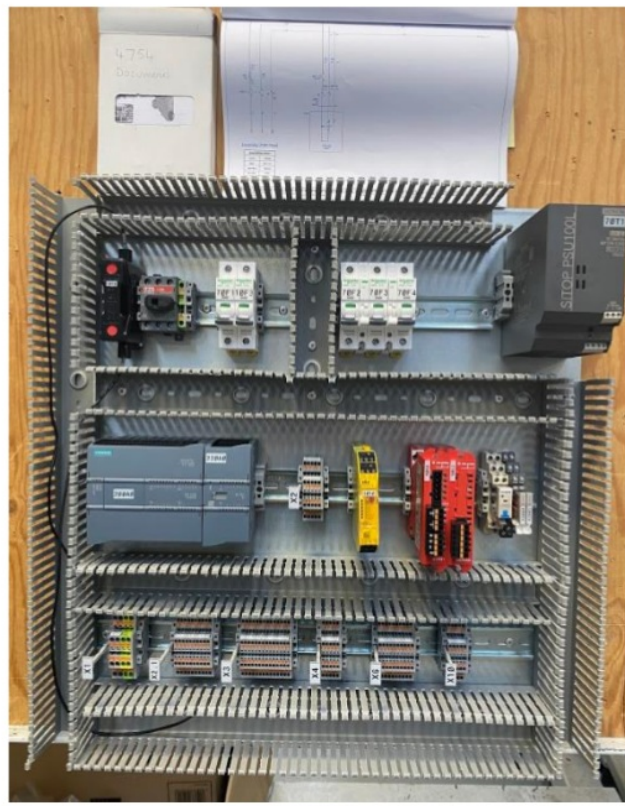


Figure 37 – Control Panel with Components

The panel was then wired, AC Components were wired first. (Figure 38/39)

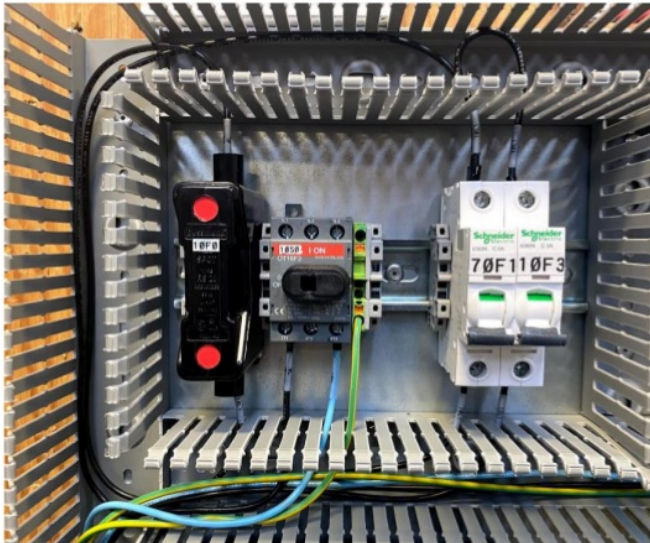


Figure 39 – Main Fuse, Isolator and AC MCB Wiring



Figure 38 – PSU Wiring

The DC Components such as the PLC were then wired. (Figure 40/41)



Figure 40 – PLC Wiring



Figure 41 – PLC Inputs to X3 Terminal Block

It is EBS Automations standard to label every wire with an individual ID label, these IDs are referenced to the drawings. This is for good practice and helps with fault finding. (Figure 42/43)

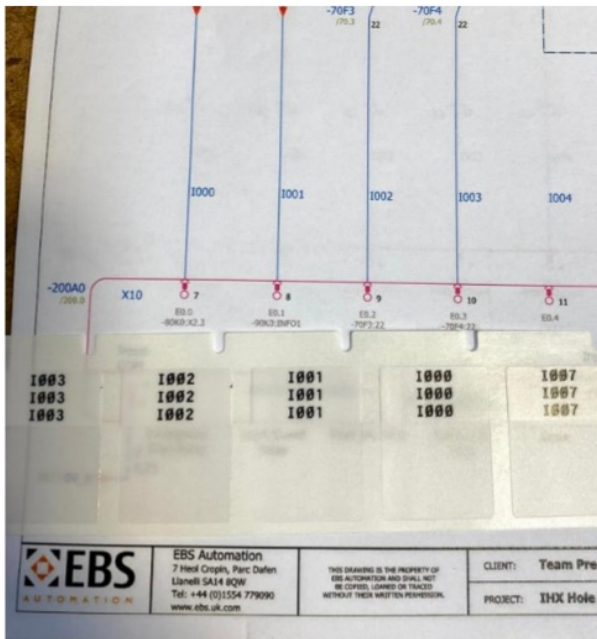


Figure 42 – Input Labels



Figure 43 – Label Printer

All wires are then labelled. (Figure 44/45)



Figure 44 – Input Wires Labelled





Figure 47 – Electromechanical Relays Wired

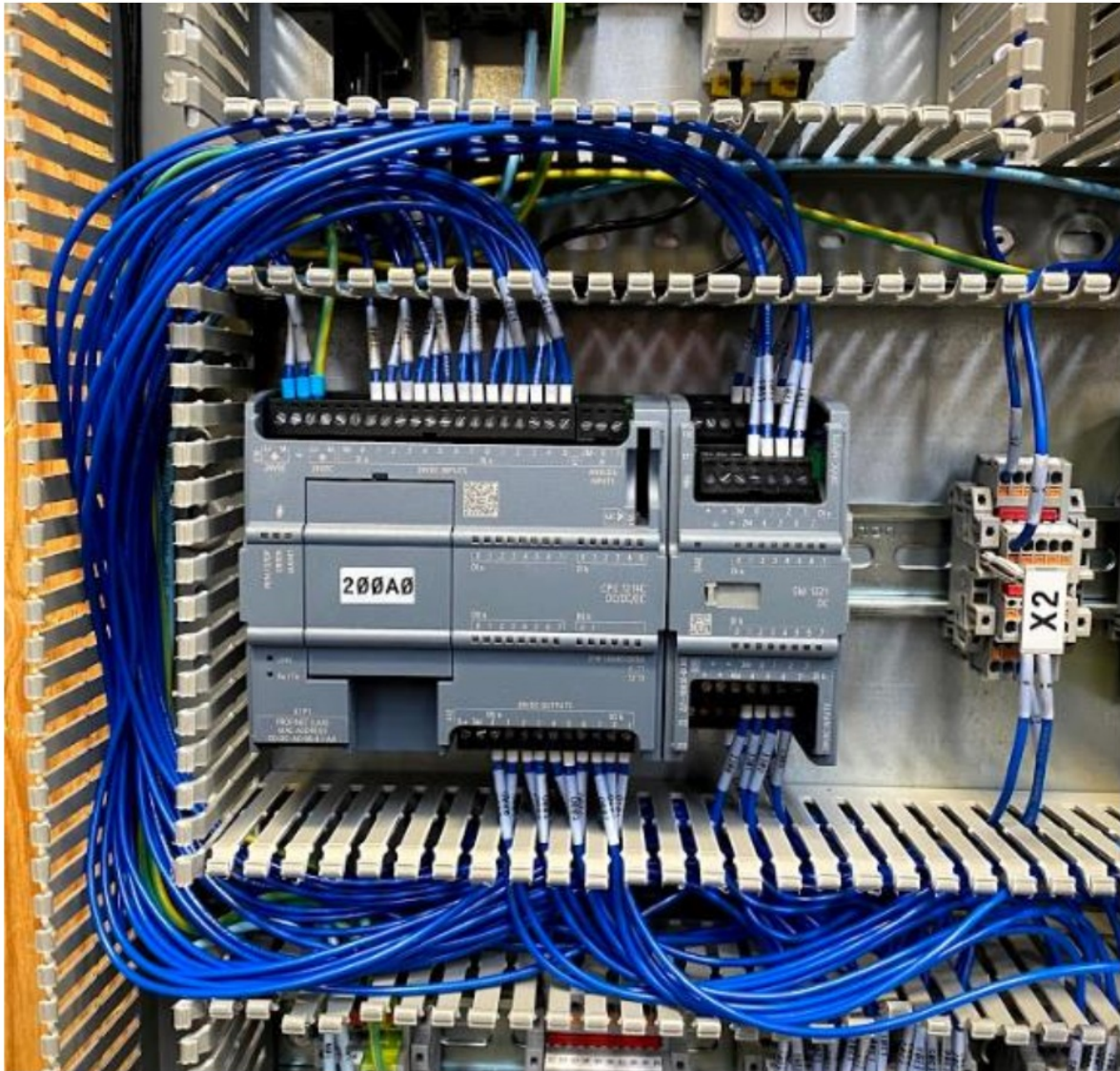


Figure 48 – PLC Wired

All trunking lids were then cut and fitted onto the panel. The panel was then mounted into the enclosure on the machine frame, ready to be tested. However, firstly the field cables such as sensors and the operator control unit were wired, the cables from the service unit were also wired (Figure 49)



Figure 49 – Control Panel inserted into Cabinet

Implementation images are good

Firstly, the service unit was wired. This includes the pressure switch, dump valve and the solenoid valve lead. (Figure 51)



Figure 51 – Air Service Unit

The operator control unit was then wired, these are buttons where the operator will control the machines sequence. The buttons are sent as inputs to the PLC, the lamps are outputs from the PLC. The emergency stop controls the safety relay. (Figure 50/52)

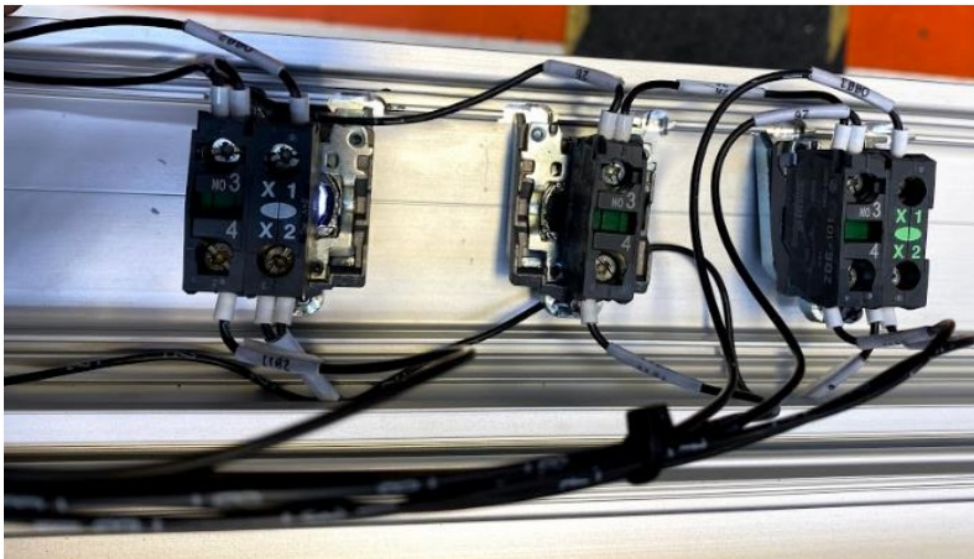


Figure 50 – Wiring of Operator buttons



Figure 52 – Operators Control Station

Good image of the operators
panel

The machine sensors were then wired, this includes 2 reed switches per cylinder and 2 proximity sensors.

Firstly, the reed switches were wired. These monitor the position of the cylinder, if the cylinder is extended, the extend reed switch is activated. If the cylinder is retracted, the retract reed switch is activated. This is common to both cylinders. (Figure 53/54)



Figure 53 – Left hand side Cylinder Reed



Figure 54 – Right hand side Cylinder Reed

The machine proximity sensors were then wired. Firstly, the part present sensor is wired, this sensor will detect when a part is loaded onto the machine, this sensor will send a signal to the PLC to say there is a part ready. (Figure 55)



Figure 55 – Part Present Sensor

The final sensor to be wired is the “Hole Aligned” sensor, this sensor detects that the hole in the part lines up with a clamp. This is to ensure that the dimples are always accurate to the position of the hole, this makes all parts the same with no errors as the hole is essentially a datum, all dimples are referenced off the hole. The clamp can only be shut when the hole is in the part. (Figure 56)



Figure 56 – Hole Aligned Sensor

All cables were entered into the left-hand side of the panel through an Icotek Gland with appropriate grommet inserts. (Figure 57)



Figure 57 – Cable Entry

The isolator was then installed on the panel along with warning labels. (Figure 58)



Figure 58 – Control Panel with Isolator and Warning labels

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After the machine wiring was finished the software development stage started, as this is a Siemens PLC, the software used for the project is Siemens TIA Portal V1.5.1, Firstly, the necessary program blocks were added in the software, this consisted of the Main organization block where all function calls will be “called”, Function calls were created for the activations, auto sequence and I/O Mapping. (Figure 59)

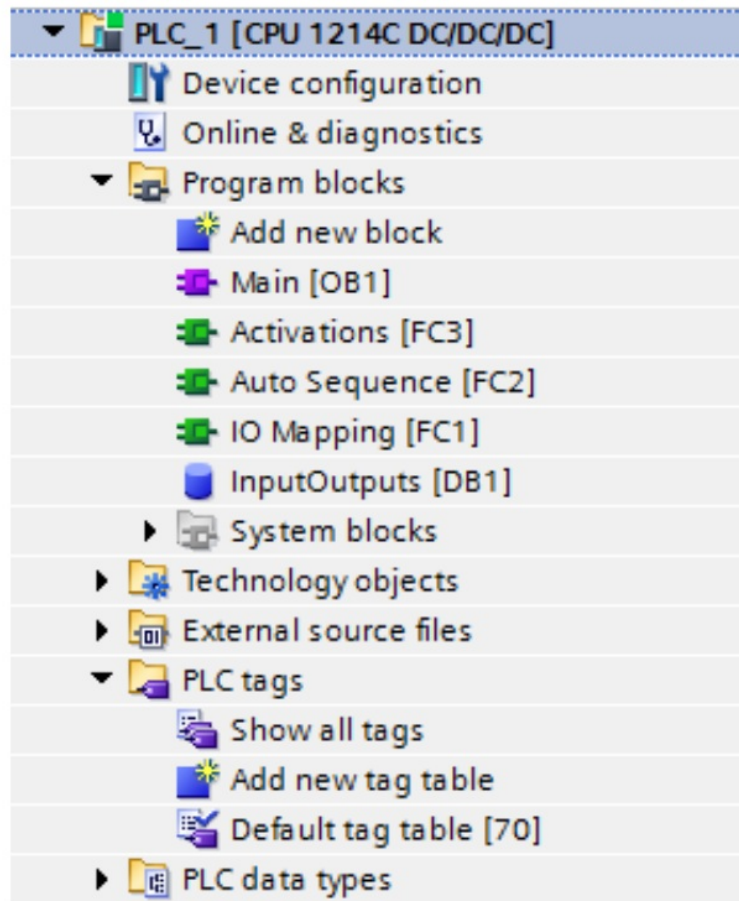


Figure 59 – PLC Software Information

All of the IO was then added into the PLC tags, this was done with the help of the previously created IO table. (Figure 60)

	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...
1	Estop Relay Ok	Bool	%I0.0	☐	☒	☒	☒
2	Field 24v Mcb	Bool	%I0.2	☐	☒	☒	☒
3	Safety 24v Mcb	Bool	%I0.3	☐	☒	☒	☒
4	L_Spare1	Bool	%I0.1	☐	☒	☒	☒
5	L_Spare2	Bool	%I0.4	☐	☒	☒	☒
6	L_Spare3	Bool	%I0.5	☐	☒	☒	☒
7	Air Pressure Sw	Bool	%I0.6	☐	☒	☒	☒
8	L_Spare4	Bool	%I0.7	☐	☒	☒	☒
9	Start PB	Bool	%I1.0	☐	☒	☒	☒
10	Reset PB	Bool	%I1.1	☐	☒	☒	☒
11	Control On PB	Bool	%I1.2	☐	☒	☒	☒
12	Estop PB	Bool	%I1.3	☐	☒	☒	☒
13	L_Spare5	Bool	%I1.4	☐	☒	☒	☒
14	L_Spare6	Bool	%I1.5	☐	☒	☒	☒
15	Part Present	Bool	%I2.0	☐	☒	☒	☒
16	Hole Aligned	Bool	%I2.1	☐	☒	☒	☒
17	L_Spare7	Bool	%I2.2	☐	☒	☒	☒
18	L_Spare8	Bool	%I2.3	☐	☒	☒	☒
19	Front Cyl Extended	Bool	%I2.4	☐	☒	☒	☒
20	Front Cyl Retracted	Bool	%I2.5	☐	☒	☒	☒
21	Back Cyl Extended	Bool	%I2.6	☐	☒	☒	☒
22	Back Cyl Retracted	Bool	%I2.7	☐	☒	☒	☒
23	Safety Reset	Bool	%Q0.0	☐	☒	☒	☒
24	Fault Lamp	Bool	%Q0.1	☐	☒	☒	☒
25	Control On Lamp	Bool	%Q0.2	☐	☒	☒	☒
26	Start PB Lamp	Bool	%Q0.3	☐	☒	☒	☒
27	Punch Cyl In	Bool	%Q0.4	☐	☒	☒	☒
28	Punch Cyl Out	Bool	%Q0.5	☐	☒	☒	☒
29	Start Conditions Ok	Bool	%M100.0	☐	☒	☒	☒
30	ControlOn	Bool	%M10.0	☐	☒	☒	☒
31	Tag_1	Bool	%M1.0	☐	☒	☒	☒
32	Tag_2	Bool	%M1.1	☐	☒	☒	☒
33	Tag_3	Bool	%M1.2	☐	☒	☒	☒
34	Tag_4	Bool	%M1.3	☐	☒	☒	☒
35	Seq Reset	Bool	%M2.0	☐	☒	☒	☒
36	Cylinders Didnt Extend	Bool	%M60.0	☐	☒	☒	☒
37	Cylinders Didnt Retract	Bool	%M60.1	☐	☒	☒	☒
38	MachineFault	Bool	%M70.0	☐	☒	☒	☒
39	AirPressureFault	Bool	%M70.1	☐	☒	☒	☒
40	SeqNo	Int	%MW80	☐	☒	☒	☒
41	SeqNoNext	Int	%MW82	☐	☒	☒	☒

Figure 60 – Field I/O Addressed in the PLC

These Inputs and Outputs were then added into an IO data block. In the network rungs, the IO will be called from this data block. (Figure 61)

4755 ▶ PLC_1 [CPU 1214C DC/DC/DC] ▶ Program blocks ▶ InputOutputs [DB1]

Keep actual values Snapshot Copy snapshots to start values Load start values as actual values

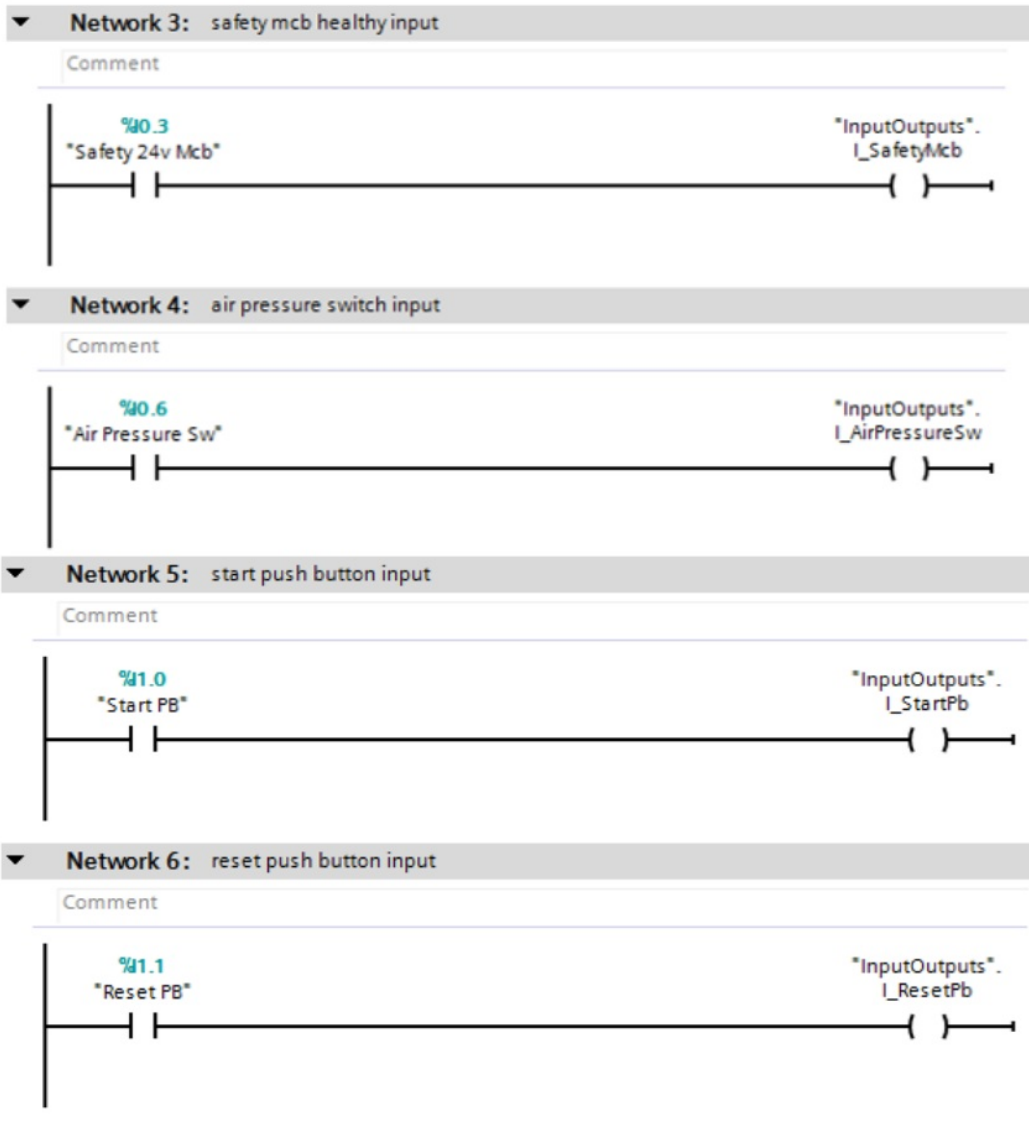
InputOutputs (snapshot created: 2/28/2020 2:23:31 PM)

	Name	Data type	Start value	Retain	Accessible f...	Write...	Visible in ...	Setpoint	Comment
1	Static								
2	I_EstopRelay	Bool	false		☒	☒	☒	☐	
3	I_FieldMcb	Bool	false		☒	☒	☒	☐	
4	I_SafetyMcb	Bool	false		☒	☒	☒	☐	
5	I_AirPressureSw	Bool	false		☒	☒	☒	☐	
6	I_StartPb	Bool	false		☒	☒	☒	☐	
7	I_ResetPb	Bool	false		☒	☒	☒	☐	
8	I_ControlOnPb	Bool	false		☒	☒	☒	☐	
9	I_EstopPb	Bool	false		☒	☒	☒	☐	
10	I_PartPresent	Bool	false		☒	☒	☒	☐	
11	I_HoleAligned	Bool	false		☒	☒	☒	☐	
12	I_FrontCylExtended	Bool	false		☒	☒	☒	☐	
13	I_FrontCylRetracted	Bool	false		☒	☒	☒	☐	
14	I_BackCylExtended	Bool	false		☒	☒	☒	☐	
15	I_BackCylRetracted	Bool	false		☒	☒	☒	☐	
16	Q_SafetyReset	Bool	false		☒	☒	☒	☐	
17	Q_FaultLamp	Bool	false		☒	☒	☒	☐	
18	Q_ControlOnLamp	Bool	false		☒	☒	☒	☐	
19	Q_StartPbLamp	Bool	false		☒	☒	☒	☐	
20	Q_PunchCyl IN	Bool	false		☒	☒	☒	☐	
21	Q_PunchCyl OUT	Bool	false		☒	☒	☒	☐	

Figure 61 – PLC I/O Data block

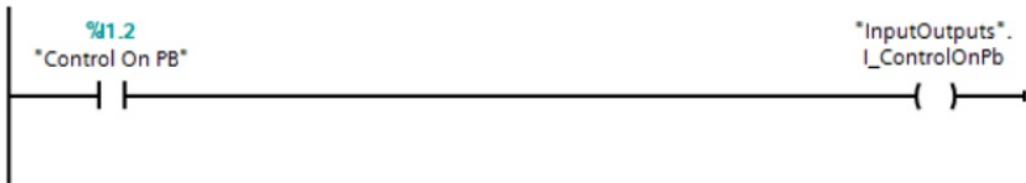
An I/O mapping network was created in order for the hard-wired physical I/O will control the I/O in the InputOutputs data block where the network rungs will be tagged to. This is the software standard of EBS. (Figure 62)





▼ **Network 7:** control on push button input

Comment



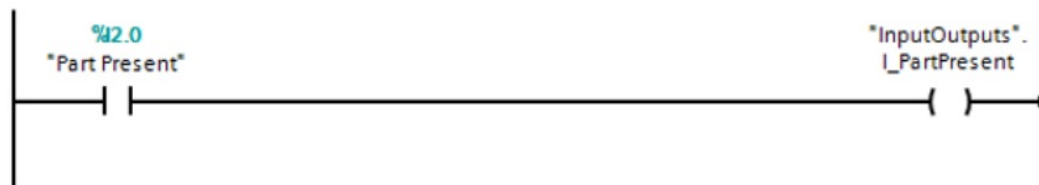
▼ **Network 8:** estop push button input

Comment



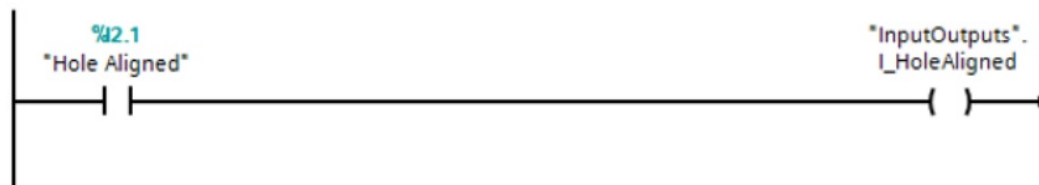
▼ **Network 9:** part present input

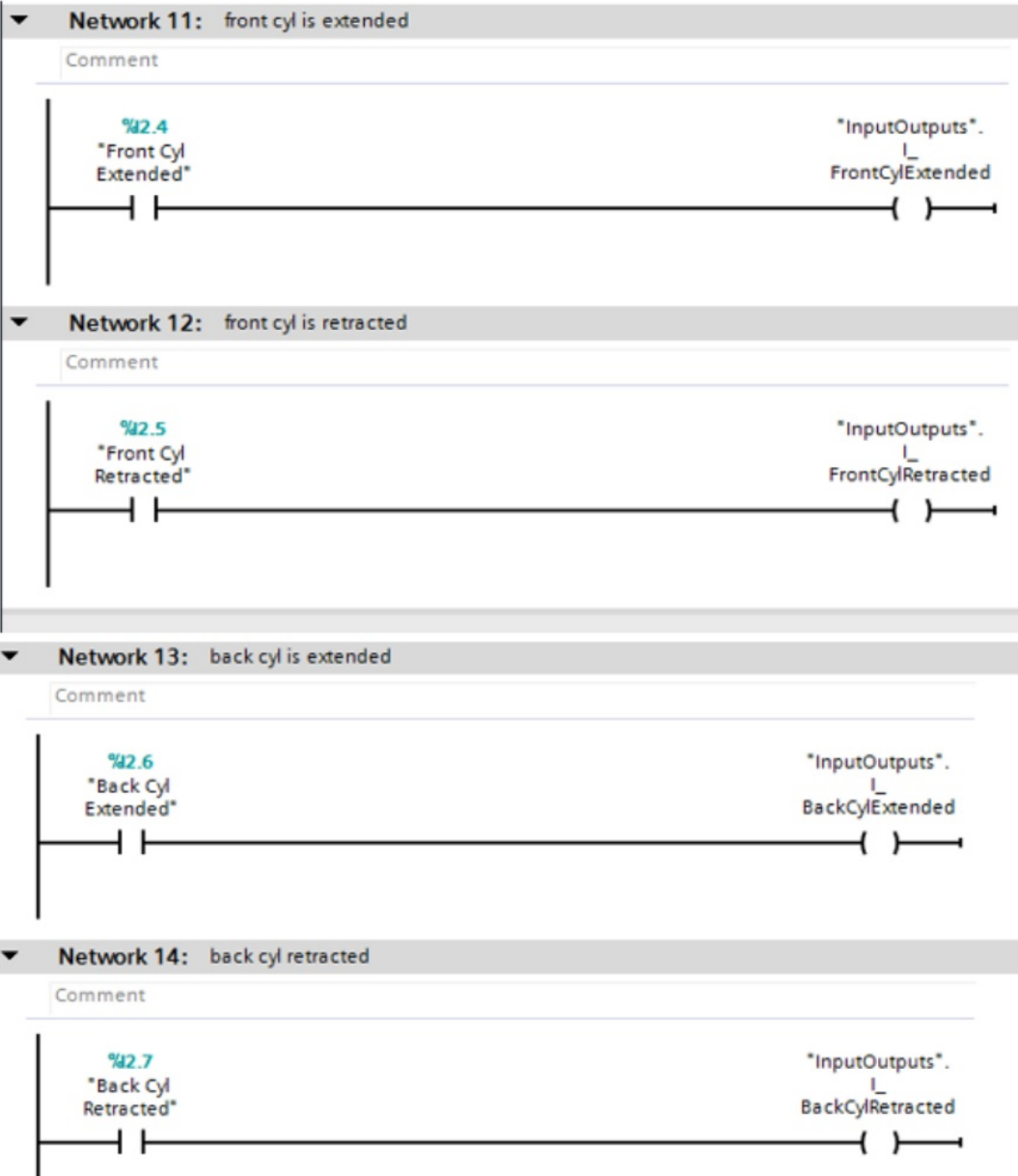
Comment

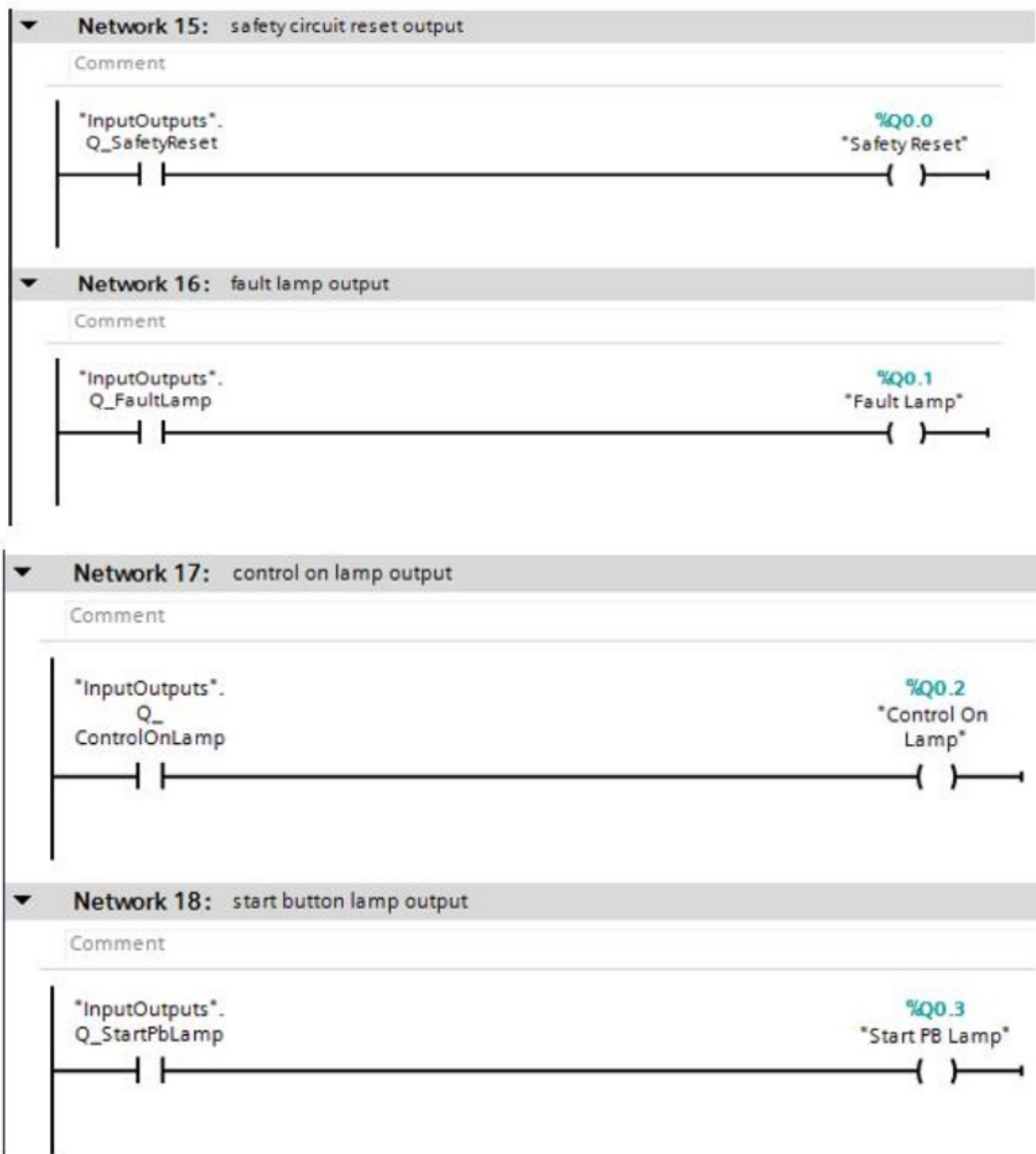


▼ **Network 10:** hole is aligned input

Comment







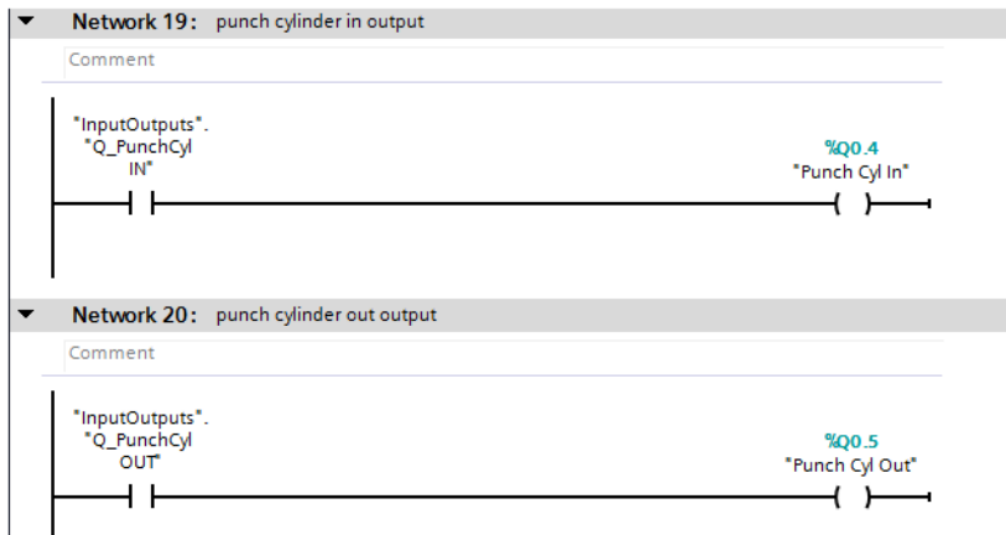
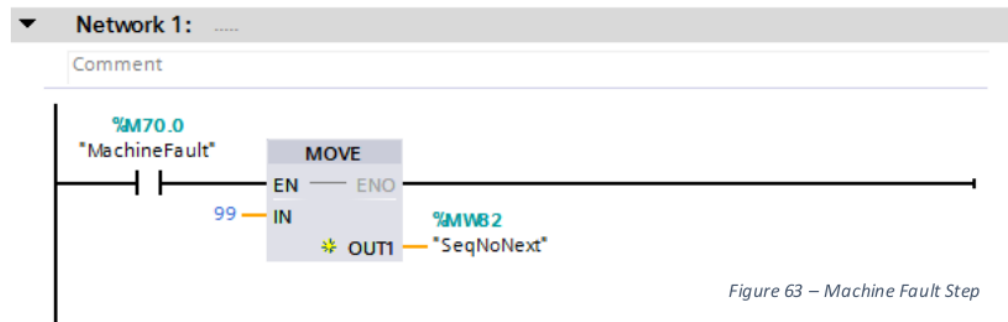


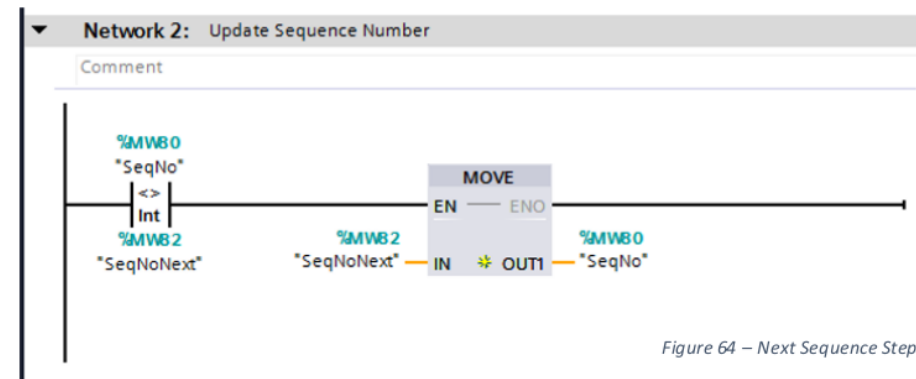
Figure 62 – IO Mapping

The program is very relevant but should be in an appendix. Only an example is necessary to go with an explanation and reference the appendix for the rest of the program.

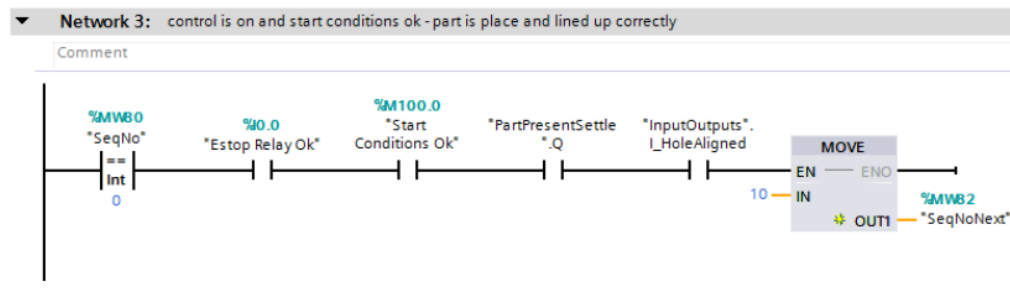
The machine sequence was then created. The first network shows that if the machine is in fault, it stays in step 99 and the sequence cannot progress until the fault is cleared. (Figure 63)



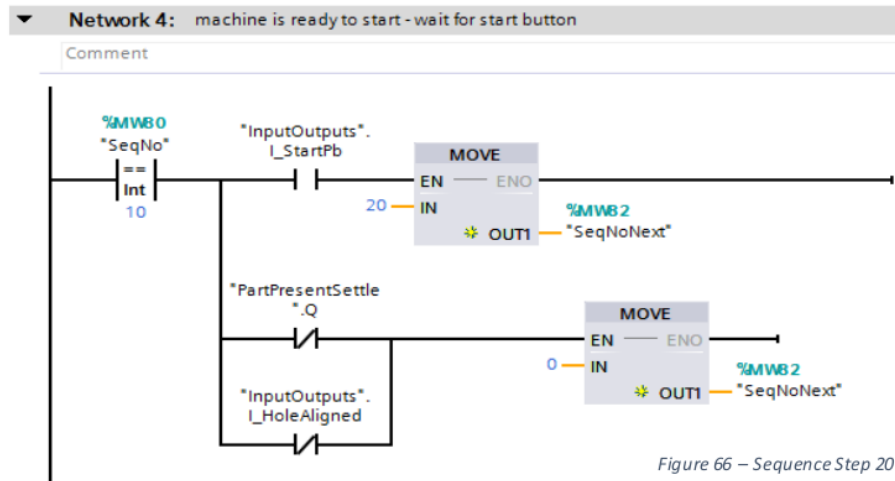
Network 2 shows the rung for updating the sequence number. (Figure 64)



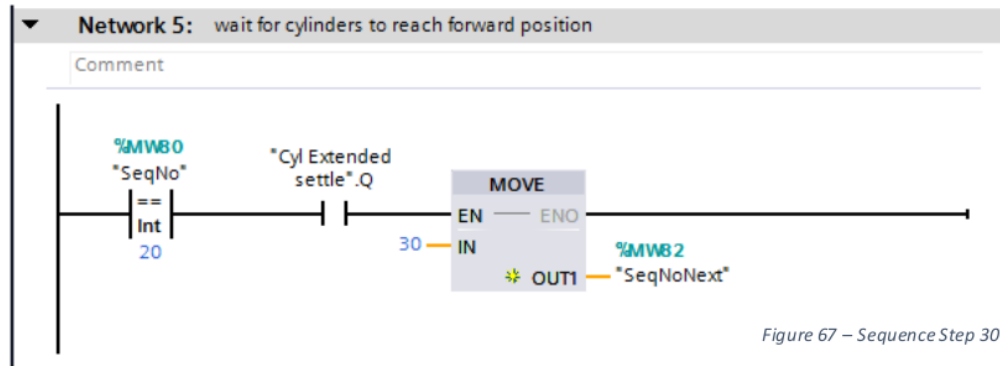
Network 3 shows Step 0, This is the start condition rung. When the E-Stop relay is healthy, the part is present and hole is aligned the start conditions are met the PLC can move to the next step. (Fig 65)



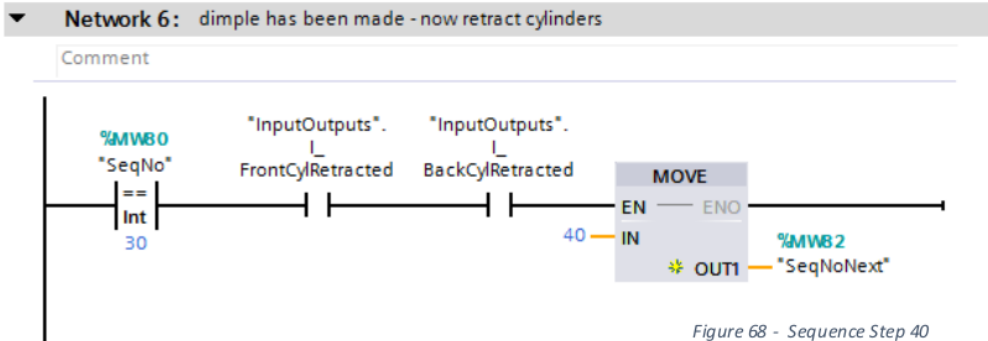
Network 4 is the network for the start button. When the sequence is in step 10 and the start button is pressed the sequence will jump to step 20. If either sensor is lost and is not seeing the part then the sequence will move back to step 0. (Figure 66)



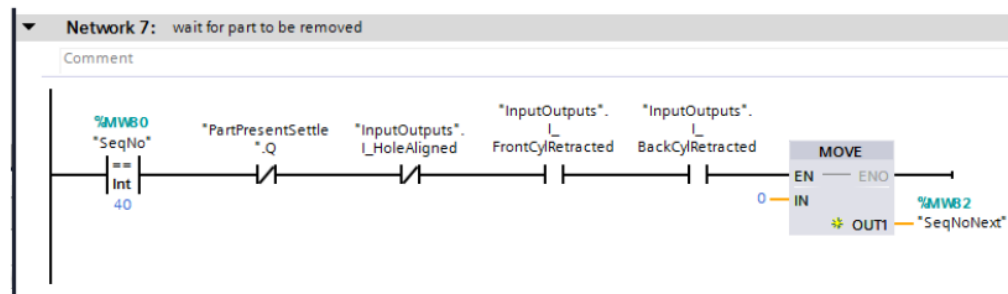
Network 5 is the step for dimpling the part, When the machine is in step 20 it extends the cylinders which dimples the part. When the cylinder extends it moves the sequence to step 30. (Figure 67)



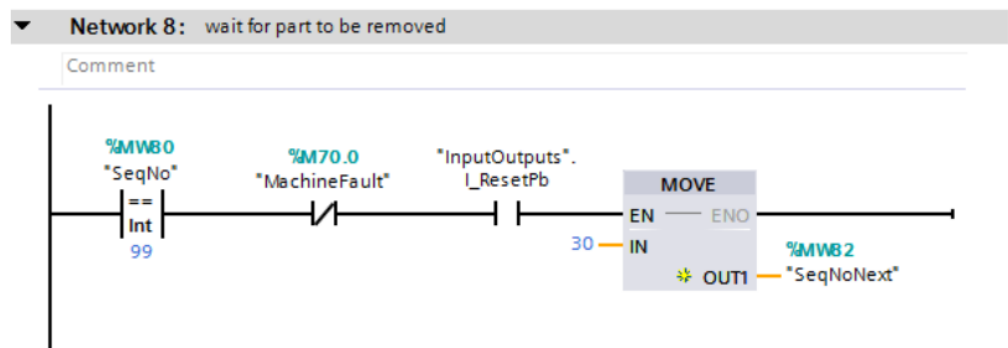
Network 6 is the step for after the dimple has been made, both cylinders retract reed switches will energise when cylinder is home. When it has fully retracted the sequence moves to step 40. (Figure 68)



Network 7 is the step for the removal of the part. When the cylinders are retracted the hole aligned clamp can be removed and the part is removed. The sequence will reset to step 0 for the next part. (Figure 69)



Network 8 is the step for removing the part under fault condition if the cylinders are extended and won't retract. The reset pushbutton will jump the programme to step 30 which retracts the cylinders. (Figure 70)



Network 9 is the network for resetting the sequence. This is done by the reset button or when the E-Stop is pressed. (Figure 71)



Figure 71 – Step Sequence Reset

6. Testing and Results

Following the testing plan from task 3. The machine and control system were put through a series of tests to ensure that the specification was met.

Testing Plan		
Test	Test Description	Planned Date
1. Protective Earth Bonding Tests	Ensure that the resistance between all extraneous conductive material on the machine is less than 0.5ohms to earth.	23/03/2020
2. Wiring Check	Check that all wiring is wired correctly	23/03/2020
3. Safety Function Tests	Ensure that all safety systems are working in the control system correctly.	23/03/2020
4. Input and Output Verification Test	Ensure that the correct sensors and buttons are sending signals to the correct input, ensure that the correct outputs are energising actuators.	30/03/2020
5. Machine Sequence Test	Ensure that the machine is operating the software sequence correctly.	30/03/2020
6. Specification Test	Ensure that the machine meets the original specification. Does the machine meet the projected outcome?	06/04/2020

Figure 72 – Testing Plan Completed

The first test that was undertaken after the implementation was the protective earth bonding checks, this is to ensure that all conductive material on the machine is bonded to earth with a resistance of less than 0.50hm, this is to ensure any leakage of current has a safe path back to earth which will prevent electric shocks.

The wiring of the machine was then tested, this was done with a calibrated multimeter. Resistance between AC and DC was checked to ensure there were no short circuits. Live and Neutral, 24VDC and 0VDC and all power were tested to earth. The only wire which had low resistance to earth was 0VDC which was expected. As all wiring was ok, the panel can be powered up for the remaining tests.



Figure 73 – Fluke Multimeter used for testing

This is a simple but underrated test and good to see this implemented in this section

Before the machine can be run the safety, tests must be undertaken, this is to ensure that the emergency stop is working as intended under certain conditions. This Emergency stop will disable the Dump Valve and Cylinder relays; therefore, it is vital that it works correctly. (Figure 74)

Safety Tests	
1. Ensure all safety systems are healthy	
Check that:	Pass or Fail
80K0 is healthy (Safety Relay)	PASS
80Y0 is healthy (Dump Valve)	PASS
KO004 and KO005 Commons have 24VDC (Cylinder Relays)	PASS

Safety Tests	
2. Press Emergency Stop	
Check that:	Pass or Fail
80K0 is off (Safety Relay)	PASS
80Y0 is off (Dump Valve)	PASS
KO004 and KO005 Commons have 0VDC (Cylinder Relays)	PASS

Safety Tests	
3. Release Emergency Stop	
Check that:	Pass or Fail
80K0 is off (Safety Relay)	PASS
80Y0 is off (Dump Valve)	PASS
KO004 and KO005 Commons have 0VDC (Cylinder Relays)	PASS

Safety Tests	
4. Press Control On	
Check that:	Pass or Fail
80K0 is healthy (Safety Relay)	PASS
80Y0 is healthy (Dump Valve)	PASS
KO004 and KO005 Commons have 24VDC (Cylinder Relays)	PASS

Figure 74 – Safety Tests Completed

The I/O verification was then tested, this is to ensure all I/O is wired correctly. First each I/O was checked to ensure it was wired in the correct terminal. It was then forced on to ensure the correct PLC LED is illuminated. (Figure 75)

Input and Outputs Verification Test			
I/O Reference	I/O Description	Wired to correct terminal?	Is the correct PLC LED lit?
I000	Emergency Stop Relay Ok	YES	YES
I001	Spare	X	X
I002	70F2 MCB Ok	YES	YES
I003	70F3 MCB Ok	YES	YES
I004	Spare	X	X
I005	Spare	X	X
I006	Air Pressure Switch Ok	YES	YES
I007	Spare	YES	YES
I100	Start PB	YES	YES
I101	Reset PB	YES	YES
I102	Control On PB	YES	YES
I103	Emergency Stop PB	YES	YES
I104	Spare	YES	YES
I105	Spare	YES	YES
I200	Part Present PX	YES	YES
I201	Hole Aligned PX	YES	YES
I202	Spare	X	X
I203	Spare	X	X
I204	Front Cylinder Extend	YES	YES
I205	Front Cylinder Retract	YES	YES
I206	Back Cylinder Extend	YES	YES
I207	Back Cylinder Retract	YES	YES
O000	Safety Reset	YES	YES
O001	Machine Fault Lamp	YES	YES
O002	Control On Lamp	YES	YES
O003	Start PB Lamp	YES	YES
O004	Punch Cylinders In	YES	YES
O005	Punch Cylinders Out	YES	YES
O006	Spare	X	X
O007	Spare	X	X

Figure 75 – I/O Verification Test



Figure 76 – PLC I/O Illuminated during testing

Figure 76 shows the LEDs illuminated on the PLC, each input and output has its own LED which illuminates when their I/O is in logic 1 state.

A good test method for PLC's

The next test was the software testing combined with part of the commissioning. The machine was started up, it was then checked that all systems reset as they should. The part was then loaded onto the machine and it was tested to ensure the machine was operating the correct sequence. The software testing is seen in the appendix.

Machine Sequence Test	
Test	Tick to Confirm
Turn on Electrical Panel	✓
Ensure all E-Stops are released	✓
Press Control On PB	✓
Press Reset PB	✓
Ensure all safety systems are healthy and reset	✓
Ensure there are no system faults	✓
Ensure Cylinders are fully retracted	✓
Ensure the part present PX is off	✓
Ensure the Hole Aligned PX is off	✓
After Checking the above	
Load Part onto Machine (Part Present PX energises)	✓
Lower clamp in order for the pin to locate the hole (Hole aligned PX energises)	✓
Press Start	✓
Pneumatic Cylinders Extend, Dimpling the part. (Extend Reed Switches activate)	✓
Pneumatic Cylinders Retract. (Retract Reed Switches activate)	✓
Unclamp Tube (Hole aligned PX is off)	✓
Remove part from machine (Part present PX is off)	✓

Figure 77 – Machine Sequence Test

The machine sequence test also included testing 15 parts to ensure that they met the customers tolerances. (Figure 78)

Testing of 20 Parts	
Part Number	Did the part pass or fail?
1	Pass
2	Pass
3	Pass
4	Pass
5	Pass
6	Pass
7	Pass
8	Pass
9	Pass
10	Pass
11	Pass
12	Pass
13	Pass
14	Pass
15	Pass

Figure 78 – Parts testing table

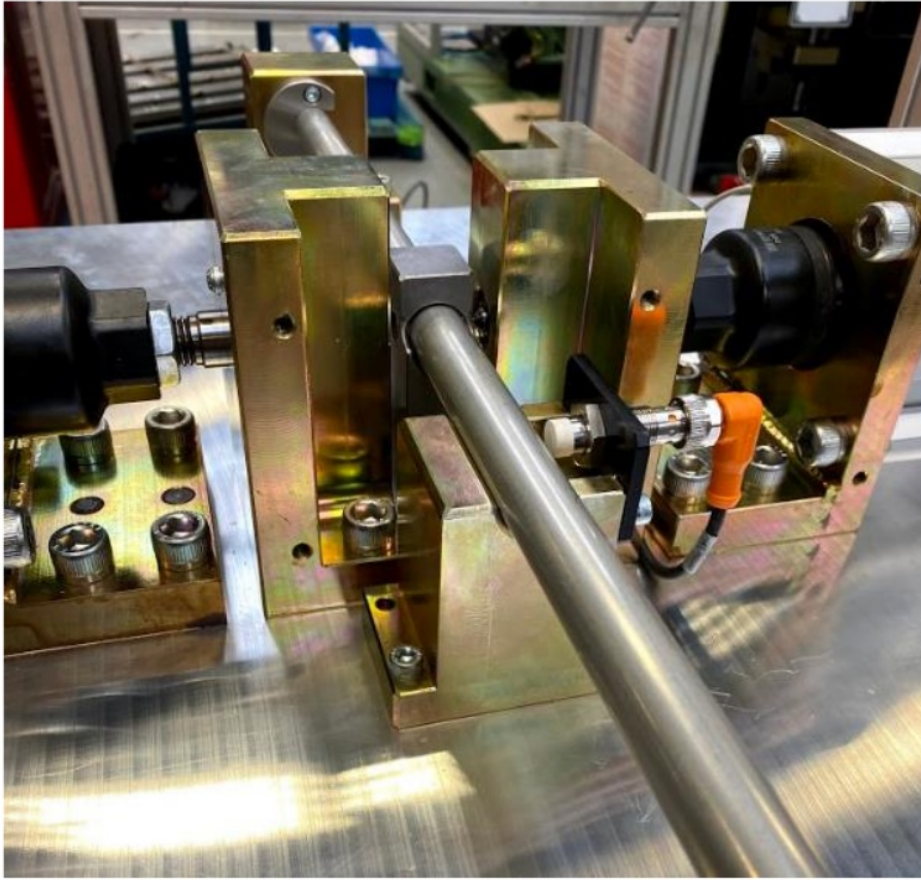


Figure 79 – Part loaded onto mandrel

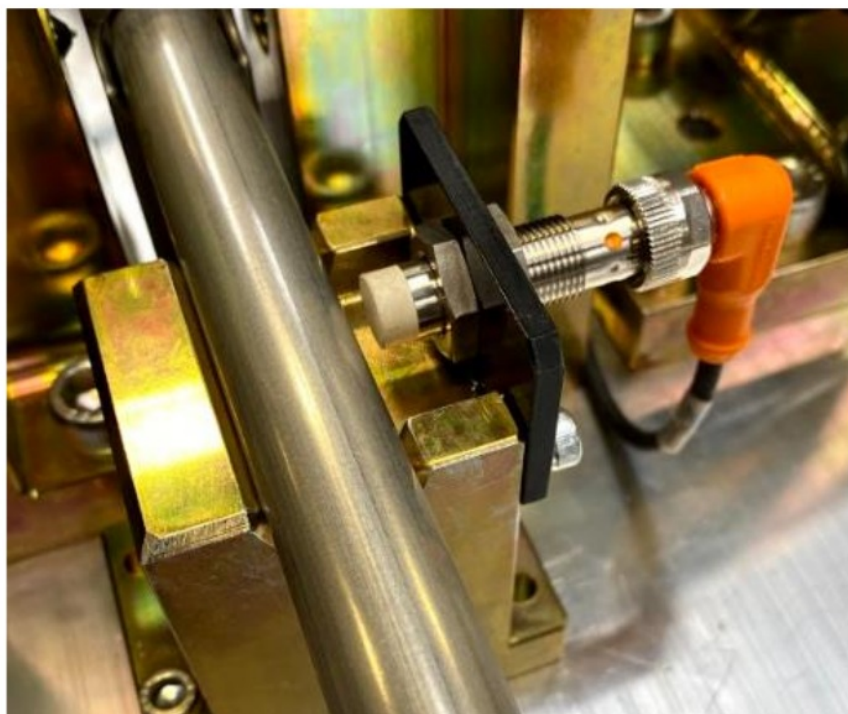


Figure 81 – Part Present Sensor sensing part



Figure 80 – Hole that the "Hole Aligned" Sensor will see

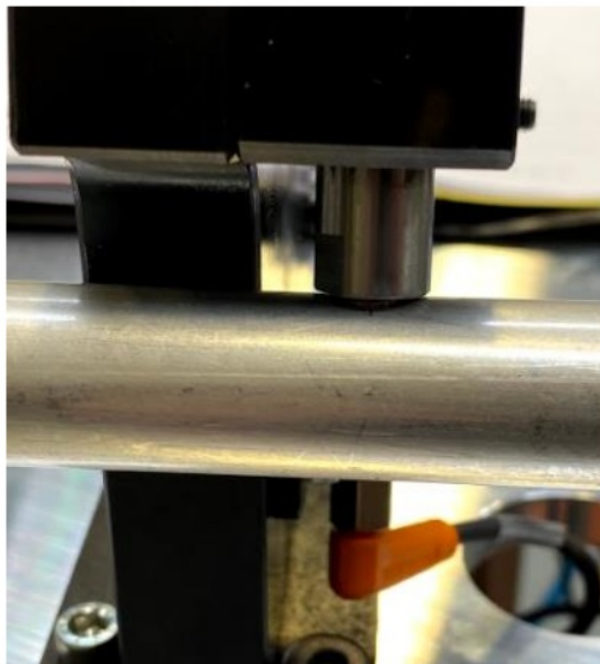
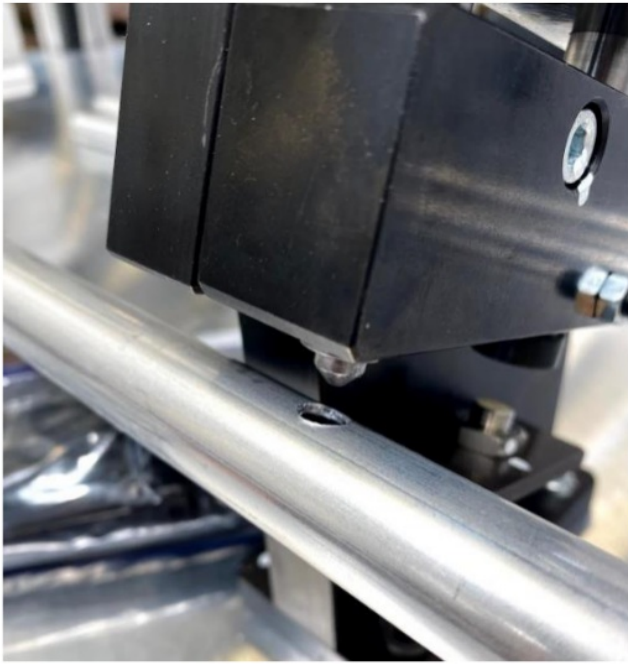


Figure 83 – Hole Aligned Sensor



Figure 82 – Dimpling Cylinders with Reed Switches



Figure 84 – Hole Aligned sensor on

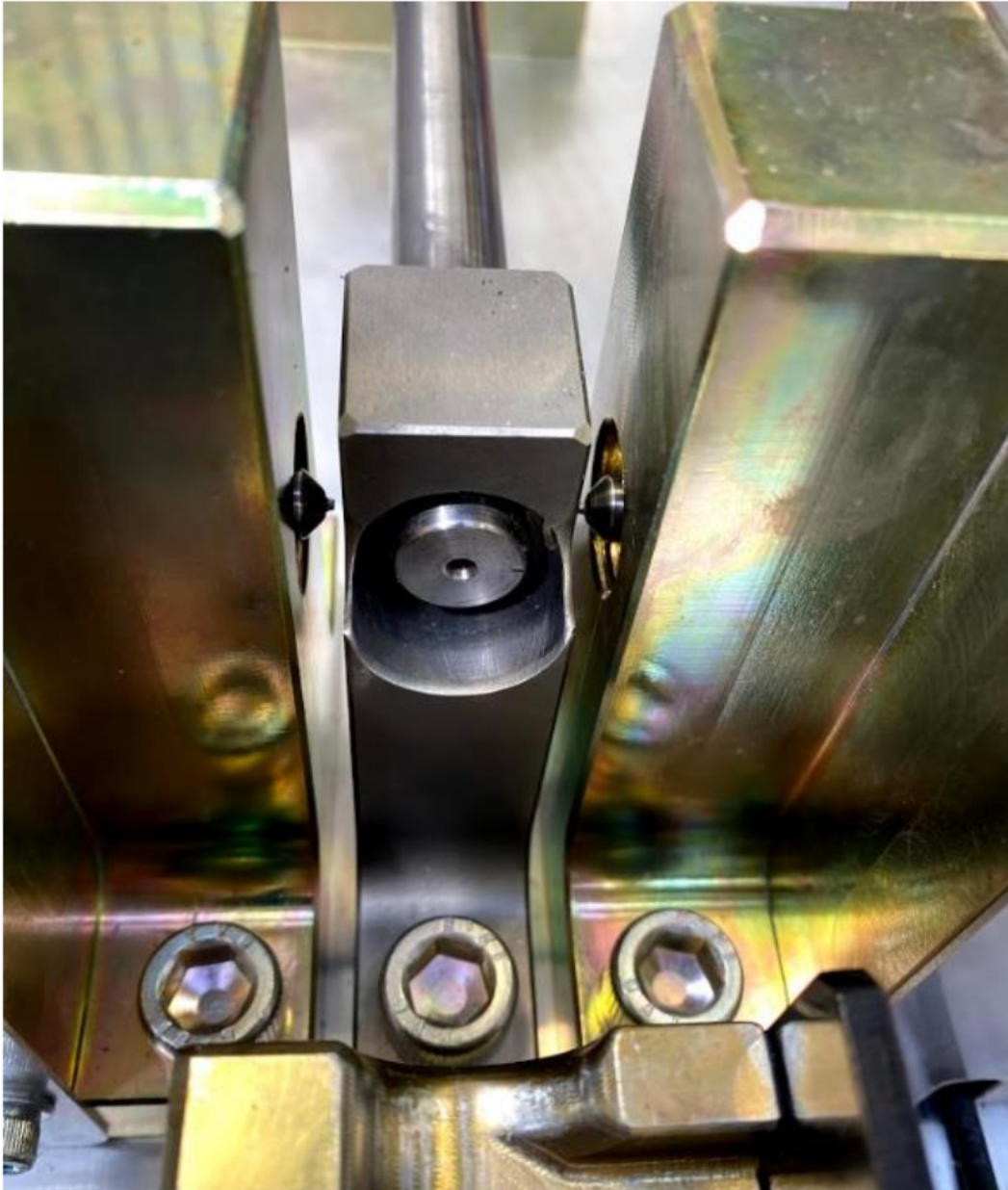


Figure 85 – Image of Mandrel, showing where the dimplers meet the part



Figure 86 – Dimpled Part

Good images of the actual procedure

7. Discussion, Conclusions and Recommendations

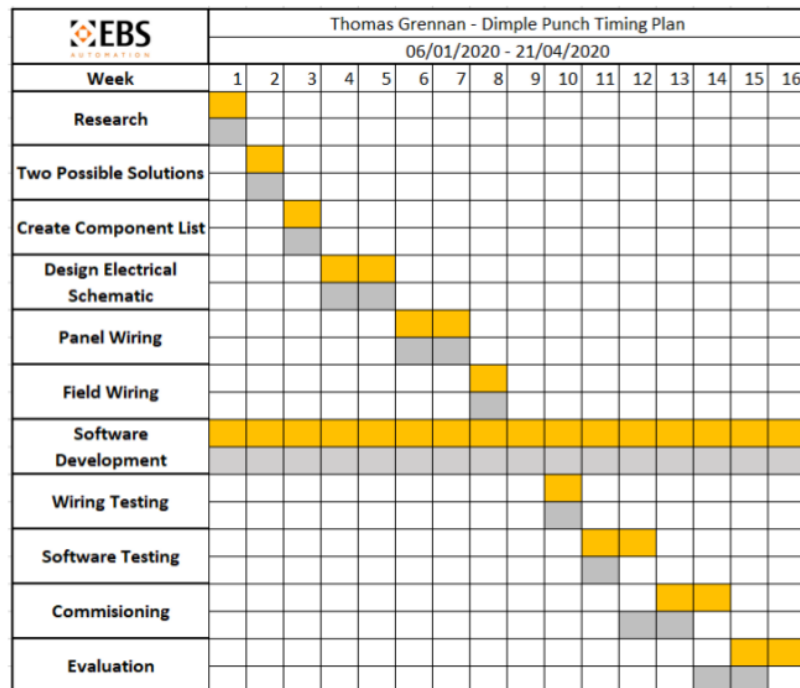
A table was created (Figure 87) to look at the comparisons between the original predicted outcome and the actual outcome.

	Did the final project meet the original outcome?	Did it meet the outcome?
Where is the project based?	EBS Automation's Manufacturing unit	Yes, the project was manufactured at EBS.
How will the reliability of the project be met?	There will be weekly meetings which will monitor the progress.	Yes, the project was monitored through weekly meetings
Operational conditions?	The machine will be created in a clean workshop. Once the customer has signed the project off it will run at their plant.	Yes, the machine was built in a clean environment.
Budget?	The budget is £5000, this is just the budget for Electrical Components.	Yes, the final project cost £1332.18.
Ergonomics, ease of use etc	The wiring and software will be designed as simple as possible to allow for easy maintenance and fault finding. The machine sequence will be designed as simple as possible to reduce operator errors.	Yes, the system was designed as simple and straight forward as possible.
Health and Safety Standards (H&S)	As the project is undertaken at EBS Automation, I will follow their H&S standards. This project will comply with the Health and Safety at work act, the electricity at work regulations and the IET Wiring regulations. All necessary PPE will be worn when needed.	Yes, All H&S standards were abided by.
Environmental Impact?	This project does not use any harmful chemicals or substances that will have an effect on the ecosystem. This project will not be an energy saver; however, it will run as efficient as possible.	Yes, the project will have no effects on the environment.
Sustainability?	If there are components that EBS have in stock they will be used, all excess material will be reused or recycled.	Yes, all material was recycled correctly.
Time scale?	The project started on 06/01/2020 and will conclude on 21/04/2020	Yes, the project finished early on 14/04/2020
Cycle Time?	The customer has specified that they want a cycle time of under 20 seconds.	Yes, the cycle time was 16 seconds.
Customer needs?	A reliable control system that is easy to operate and maintain. A machine that consistently meets the cycle time whilst producing high quality parts.	Yes, the machine met all of the customer's needs.
Machine Standards?	All British Standards will be followed for the machine's safety, the panel will be wired to the IETs 18 th edition wiring standards. The software will be written to EBS' standards which meets the British standard for programming.	Yes, all British Standards were followed.
Control Panel?	500mm x 500mm x 300mm, must be IP65 Rated.	Yes, the panel met the original specification.
Electrical Specification?	The machine has a Single Phase 16amp 230VAC supply, this will be lowered to 24VDC 10amp for the control circuit. All components will be fused appropriately. The wire colours will follow the BS Code.	Yes, all specifications were met.
Earth Bonding?	All extraneous conductive material must be bonded to earth, with a resistance to earth of <0.5ohms.	Yes
Operator Controls?	The operator will have a MIMIC (Operators Panel) where there will be buttons to control the machine, and an E-Stop for emergency conditions.	Yes, the operator has a control button panel.

Figure 87 – Specification vs Actual Project

A different method of conclusion but it makes the point clear.

From looking at the table above it is clear to see that the project met all of the original expected outcomes, proving that the planning and implementation of the project was successful. The project was a huge success, especially considering the time constraints due to time lost from the first project. As seen in figure 88 the project was finished one week early due to the software testing only taking 1 week.



Good Gantt chart for comparison.

Figure 88 – Gantt chart showing actual times compared to expected times

All components were ordered correctly with no problems, all materials and consumables were readily available therefore there were no problems during the construction of the control system. Due to how much planning had gone into the project, this made the software integration straight forward as there was a clear plan which needed to be followed.

By using the Gantt chart as a project schedule planner, it allowed the project to have a solid time plan to adhere to, therefore it was easy to follow and understand what milestone had to be completed before the coming week.

One of the key aspects for any project is the budget, the project was also well under the budget of £5000, the final cost for the electrical control system was at £1332.18 which is £3668.82 under budget.

After performing all of the testing it can be concluded that the system is fit for purpose, it meets the original specification, accurately and consistently dimples the parts to the correct tolerances in the correct area of the part. From a maintenance standpoint the project will be easily maintainable as the drawings created are clear, the customer is familiar with all of the components, especially the Siemens PLC. The machine was also proved reliable as during the part testing it achieved a cycle time of under 17 seconds for each part, this is 3 seconds lower than the specified time, therefore each shift more parts will be produced than expected. The PLC software was written in a clear and concise

way to allow the customer to have a good understanding of the machines process, a clear machine sequence was written to help operators understand the sequence too.

The project has met the set standards of sustainability and environmental protection. The machine will be highly sustainable as the production plant where the machine will be used generate their electricity from solar panels, therefore the machine will run on renewable energy. As long as all scrap material is disposed of by the customer then the machine will meet its environmental standards.

As a further recommendation, I would add an HMI which would display an operator's screen, a manual and automatic screen for engineers and also an I/O screen which will display what I/O is currently active. I would also modify the machine to be able to dimple different diameter pipes as it is currently only able to dimple one diameter part. An IFM I/O splitter could have been mounted onto the machine bed, this way the I/O could be wired directly to the splitter which will reduce downtime when changing sensors if they develop faults. An energy saving relay could be added to make the machine more environmentally friendly, this relay will drop out electricity and air if the machine hasn't been used for 5 minutes, this would work well when operators are on breaks.

*The conclusion is
good and the
arguments for
recommendations
are valid*

8. Works Cited

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Good
sources
used.

9. Appendix

Network Testing of Sequence.

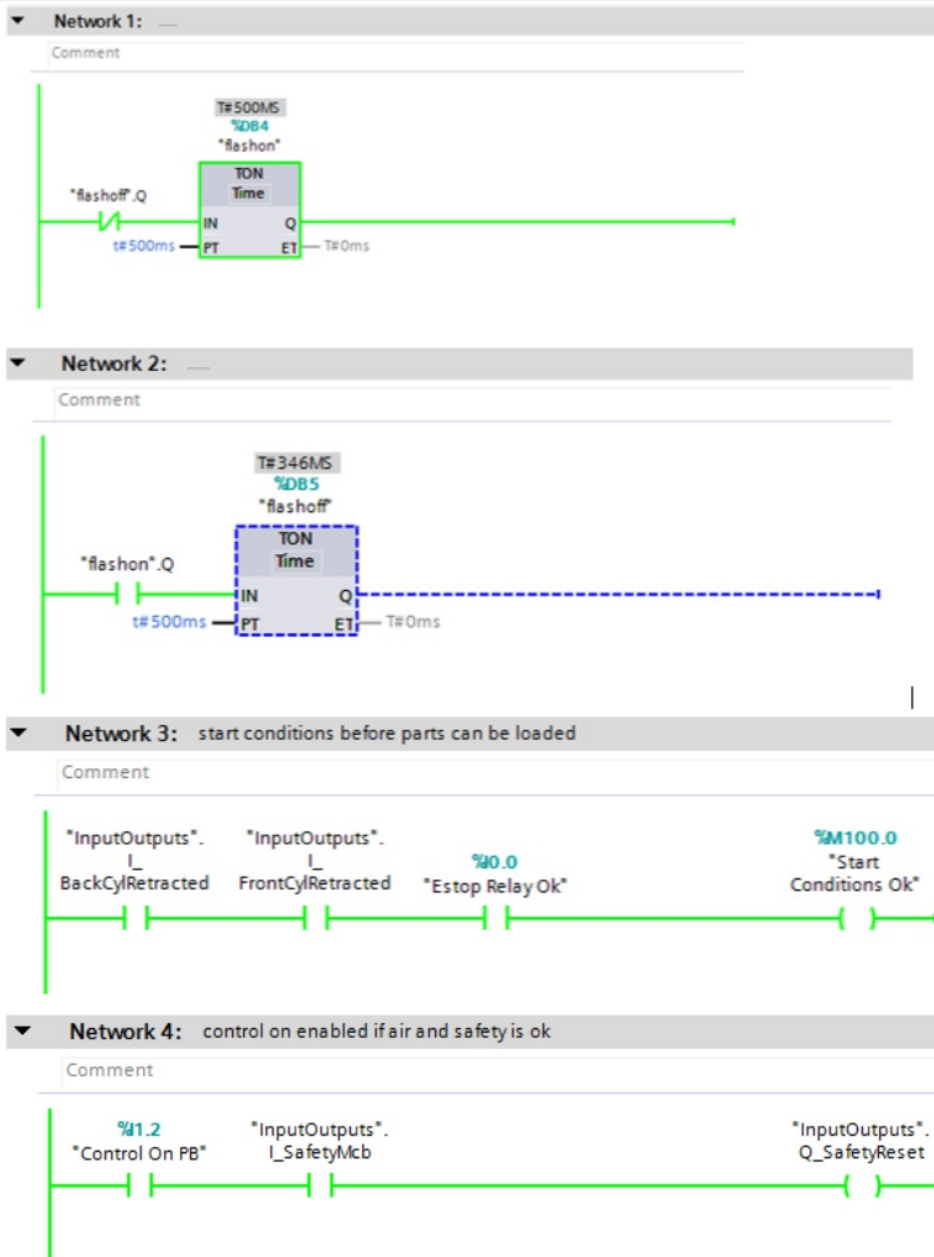


Figure 89 – Networks 1-4 tested through monitoring

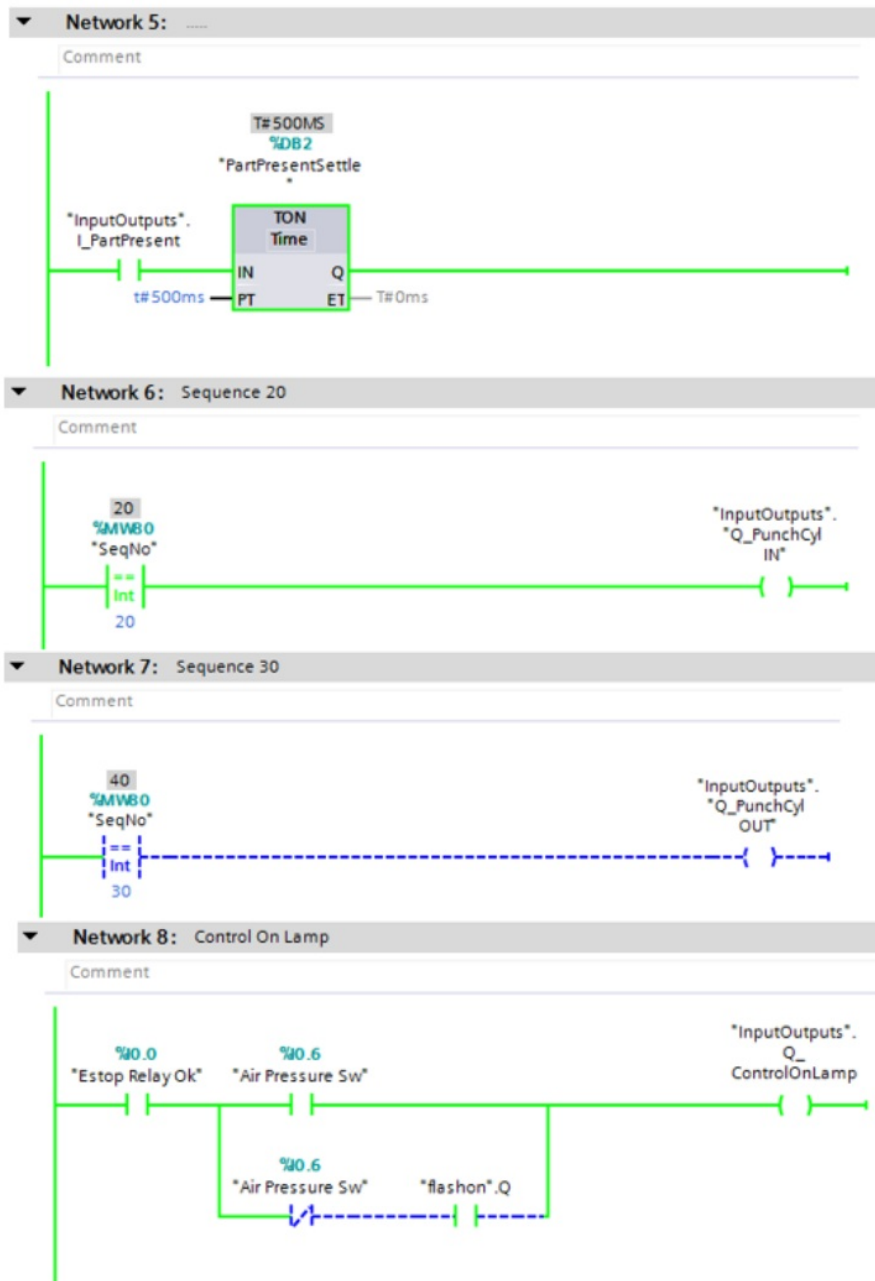
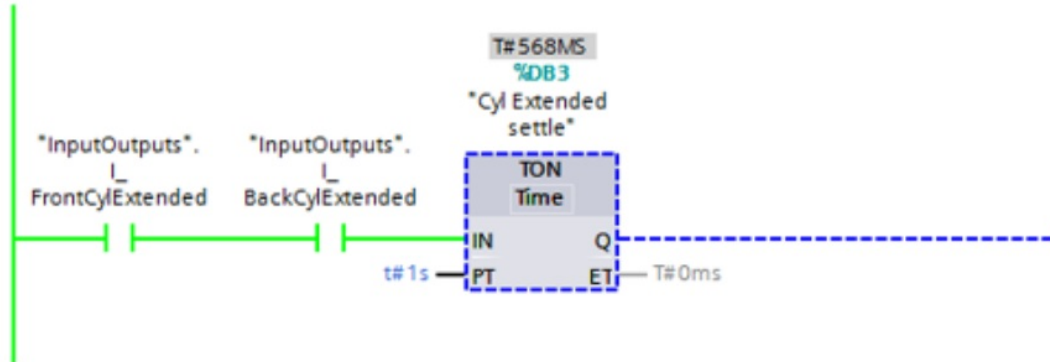


Figure 90 – Networks 5-8 tested through monitoring

Network 9: cylinders forward settle

Comment



Network 10: start button flashes when ready to start / solid when running auto cycle

Comment

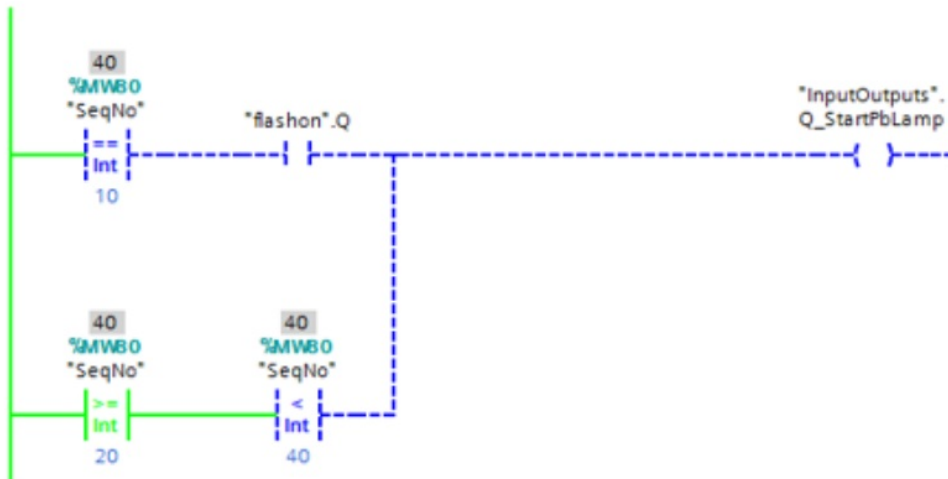


Figure 91 – Networks 9-10 tested through monitoring

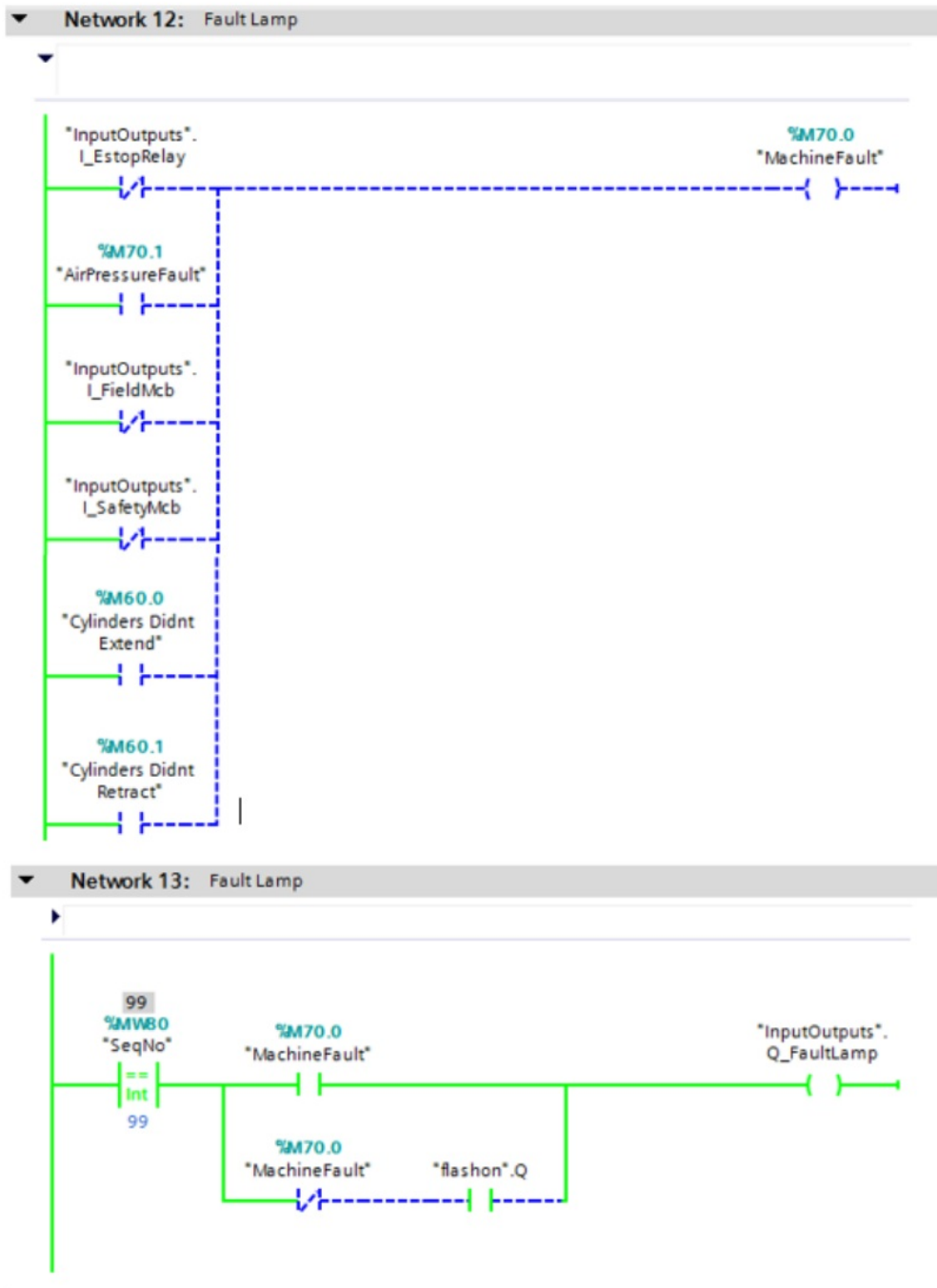


Figure 92 – Network 12-13 tested through monitoring

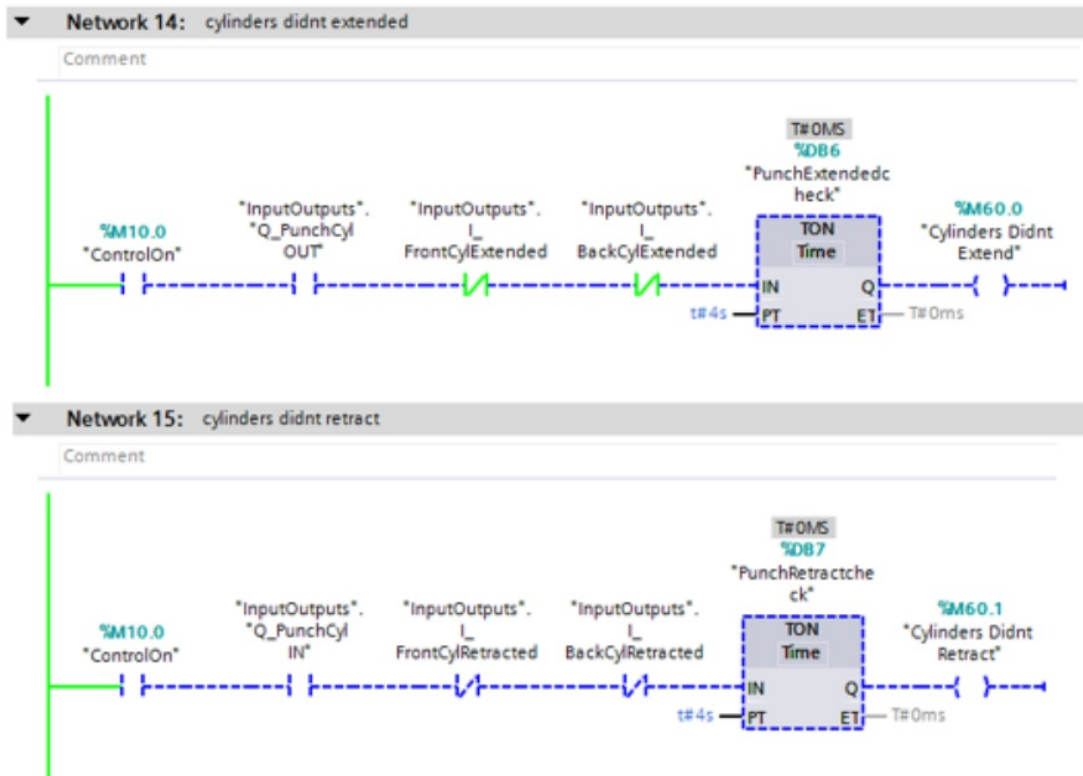


Figure 93 – Network 14-15 tested through monitoring

Good use of the appendix. More of the program could have been contained here which would limit the main report.

10. Log Books

1809799

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

79/100

PAGE 1

PAGE 2

Text Comment. Table of contents could be further sub divided to give more detail of content

PAGE 3

PAGE 4

Text Comment. A good extensive table of figures

PAGE 5

Text Comment. Avoid using first person terms.

PAGE 6

Text Comment. Break of project and implement the contingency plan for the new project which assigned by the employer

PAGE 7

Text Comment. Avoid first person terms

Text Comment. Good explanation

PAGE 8

Text Comment. This is a good argument for a possible solution

PAGE 9

Text Comment. The argument is justified for the Arduino as a possible solution. You could have given an example scenario where this is used.

PAGE 10

Text Comment. Good table of expected results to meet specifications

PAGE 11

Text Comment. The initial Gantt chart shows the predicted timeline for the project schedule.

PAGE 12

Text Comment. Test plan is clear and shows test sequence

PAGE 13

Text Comment. Good use of block diagram

PAGE 14

Text Comment. A good idea for showing the comparison

PAGE 15

Text Comment. Good diagram

PAGE 16

PAGE 17

Text Comment. Good diagram which shows the system design

Text Comment. This is a good possibility because this controller is designed around the IIOT 4.0 and is a combination of Siemens and Arduino technology which is supported by RS components

PAGE 18

PAGE 19

Text Comment. Avery good comparison table

PAGE 20

Text Comment. A good design argument here

PAGE 21

Text Comment. Sequence table is a good design tool

PAGE 22

Text Comment. This list should be in an appendix

PAGE 23

Text Comment. Good use of the table of power distribution

Text Comment. Using tables for the design is good practice

PAGE 24

Text Comment. Operation panel is clear

PAGE 25

Text Comment. The table of IO is useful and part of the design but can be put in an appendix and referenced from the main report.

PAGE 26

Text Comment. This could be in an appendix

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

Text Comment. These wiring schedule drawings would be better placed in an appendix and just use a sample for an explanation with reference to the appendix

Text Comment. Good images of construction

Text Comment. Implementation images are good

Text Comment. Images are very informative and clearly show the implementation stages.

Text Comment. Good image of the operators panel

Text Comment. A good safety feature

PAGE 52

PAGE 53

PAGE 54

PAGE 55

Text Comment. The program is very relevant but should be in an appendix. Only an example is necessary to go with an explanation and reference the appendix for the rest of the program.

PAGE 56

PAGE 57

PAGE 58

PAGE 59

Text Comment. A good detailed explanation of the sequence

PAGE 60

Text Comment. This is a simple but underrated test and good to see this implemented in this section

PAGE 61

Text Comment. Test tables are good and an easy method for acceptance test

PAGE 62

Text Comment. A good test method for PLC's

PAGE 63

Text Comment. Final testing tables show the system successfully meets the specification

PAGE 64

PAGE 65

PAGE 66

PAGE 67

PAGE 68

PAGE 69

Text Comment. Good images of the actual procedure

PAGE 70

Text Comment. A different method of conclusion but it makes the point clear.

PAGE 71

Text Comment. Good Gantt chart for comparison.

PAGE 72

Text Comment. The conclusion is good and the arguments for recommendations are valid

PAGE 73

Text Comment. Good sources used.

PAGE 74

PAGE 75

PAGE 76

PAGE 77

PAGE 78

Text Comment. Good use of the appendix. More of the program could have been contained here which would limit the main report.

PAGE 79

GRADING FORM: CSG-RUBIC

THOMAS GRENNAN

0

RESEARCH-INFORMED LITERATURE



The research carried out is of a good quality and appropriate number of relevant sources used. 7.5/10
Good relevant sources used 7.5/10

15/20

KNOWLEDGE AND UNDERSTANDING



Specification is clear with budget breakdown and good use of diagram. 8/10 The solutions considered are the final solution which is good and in depth. You have also carried out good relevant research on the alternative solutions. 8/10

16/20

ANALYSIS



Testing and results are good and clearly explained and presented in a professional manner. There is sufficient detail in this section. 8.5/10 Conclusion and recommendations make a relevant point and well thought out. 8.5/10

17/20

PRACTICAL APPLICATION AND DEP.



Planning with the use of a Gantt chart and a comparison chart is clear and the project seems to have run to the plan. 3.5/5 Final solution considered and the relevant alternative solutions are very good with research into new methods being developed. 8/10 Implementation is explained very well with

20/25

supporting images as evidence. 8.5/10

SKILLS FOR PROFESSIONAL PRAC.



A very professional report. There are some minor grammatical errors 11/15

11/15