

PDSE 4005- Assignment 1-

Daniel Evans

by Daniel Evans

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PDSE 4005-
Programmable Logic
Controllers –
Assignment 1

Daniel Evans

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1. Research

Types of PLC's

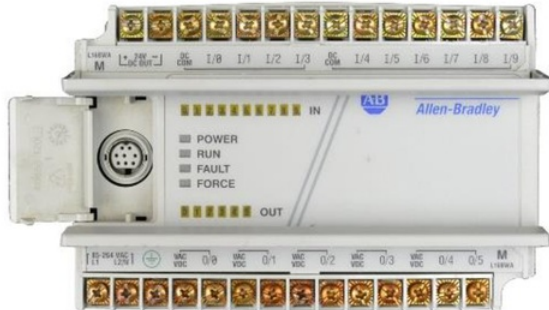


Figure 1- Unitary

The Automation Blog (2017)

According to Techwalla (2017), a unitary PLC is the simplest type of PLC and is typically contained within a single box. This box includes all the components needed for the PLC to operate (i.e the processor, analogue/digital input and outputs, power supply). Typically they can't be expanded and are the cheapest type of PLC. An example of a unitary PLC would be a Micrologix 1000 as shown in figure 1.



Figure 2- Modular

The Automation Blog (2017)

According to Techwalla (2017), A Modular PLC is a made up of a base unit, which would include a power supply, a processor and limited number of integrated I/O. However it can be expanded using several expansion modules in order to achieve the required specification of the PLC (i.e. number of inputs/output). An example of a modular PLC would be a Micrologix 1200 as shown in figure 2.



Figure 3- Rack Mounted

Professional Control Corporation (2017)

According to Techwalla (2017), A Rack mounted PLC is similar to a modular PLC. However it is done differently, the modules are all linked to the base unit in a modular PLC, but in a rack mounted plc, and all modules are networked together and are organised using racks. This allows the PLC to be built for a large application without it becoming cluttered and complicated. All modules can be removed and reinserted easily when and as needed. An example of a rack mounted PLC would be a SLC 500 as shown in figure 3.

Table to compare the 3 different types of PLC's

	Unitary – Micrologix 1000	Modular- Micrologix 1200	Rack mounted- SLC 500
Cost	£189	£380	CPU – 4k word capacity = £1710
Number of Inputs	10	Expands up to 136 I/O points	Up to 30 I/O modules to a single controller
Number of Outputs	6		
Total memory available	1 K EEPROM (approximately 737 instruction words: 437 data words)	6K flash memory: 4K user program, 2K user data	64k of configurable memory
Physical Dimensions	80 x 120 x 73 mm	90 x 110 x 87mm	*Dependant on module type
Example of a typical application	Domestic heating system	Signalling systems	Production plants (e.g Bottle making plants)

Unitary - Allen-Bradley (2017), PLC Hardware (2017)

Modular- Allen-Bradley (2017), PLC Hardware (2017)

Rack mounted- Allen-Bradley (2017), UK RS Online (2017))

IEC programming languages

According to Automation.com. (2017). "The IEC is an organization that prepares and publishes international standards for all electrical, electronic and related technologies, including controllers".

It recognises 5 programming languages. These include:-

- Ladder Diagram (LD)
- Instruction List (IL)
- Function Block Diagram (FBD)
- Structured Text (ST)
- Sequential Function Chart (SFC)

Function Block Diagram

FBD is a graphical language similar to ladder, which also uses the same instructions as ladder. However it shows how each block is connected to each other (similar to a wiring diagram) and therefore is visually easier to understand. However for large programmes with a large number of functions, the amount of screen required makes it very awkward to use. (automation.com, 2017)

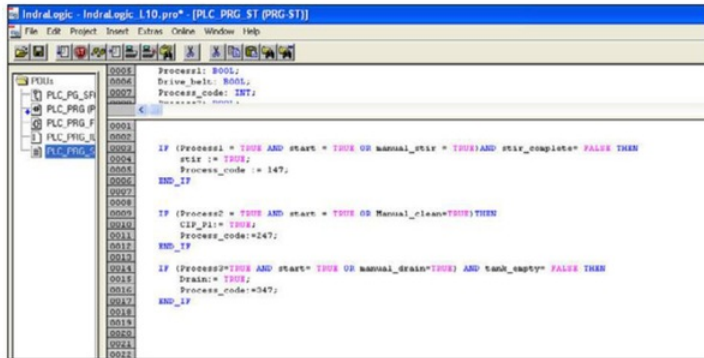


Figure 7- FBD

(automation.com, 2017)

Structured Text

ST resembles a high level computer programming language called 'PASCAL' or 'C'. It is said that data analysis can be applied a lot easier even in a very complex programme. "The variables and function calls are defined by common element". Which therefore means that multiple programming languages can be used within one programme. (B.R. Mehta, 2014, p. 152)

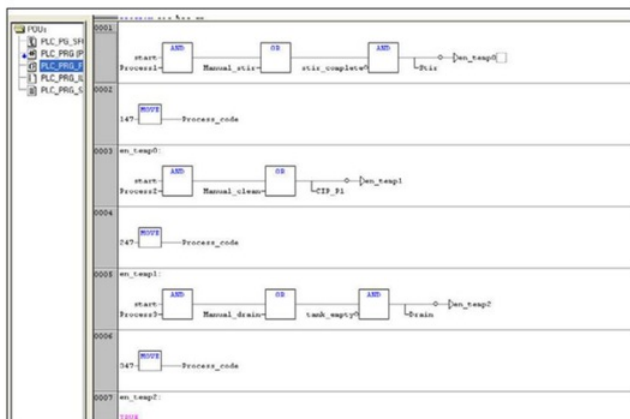


Figure 8- ST

(automation.com, 2017)

Sequential Function Chart

SFC is a graphical language that is similar to a 'flowchart'. A SFC consists of an action/step followed by a transition and an additional step. An action box has a small program inside them and is made up of code using any programming language. This action box is active until the following transition is activated.

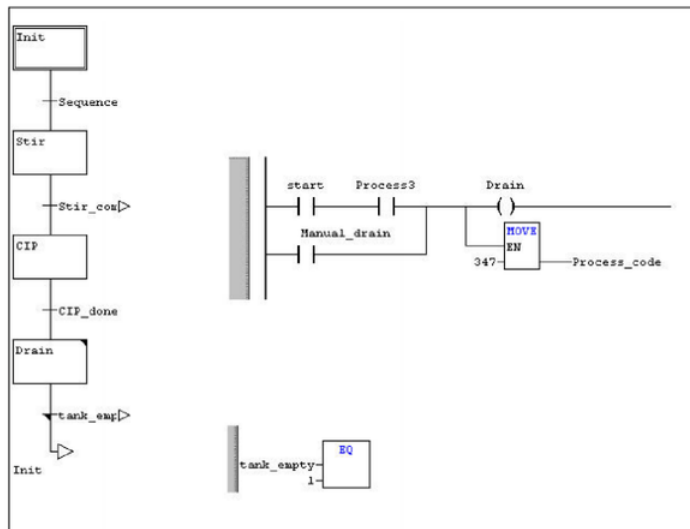


Figure 9-SFC

(automation.com, 2017)

2. Hardware description and I/O list

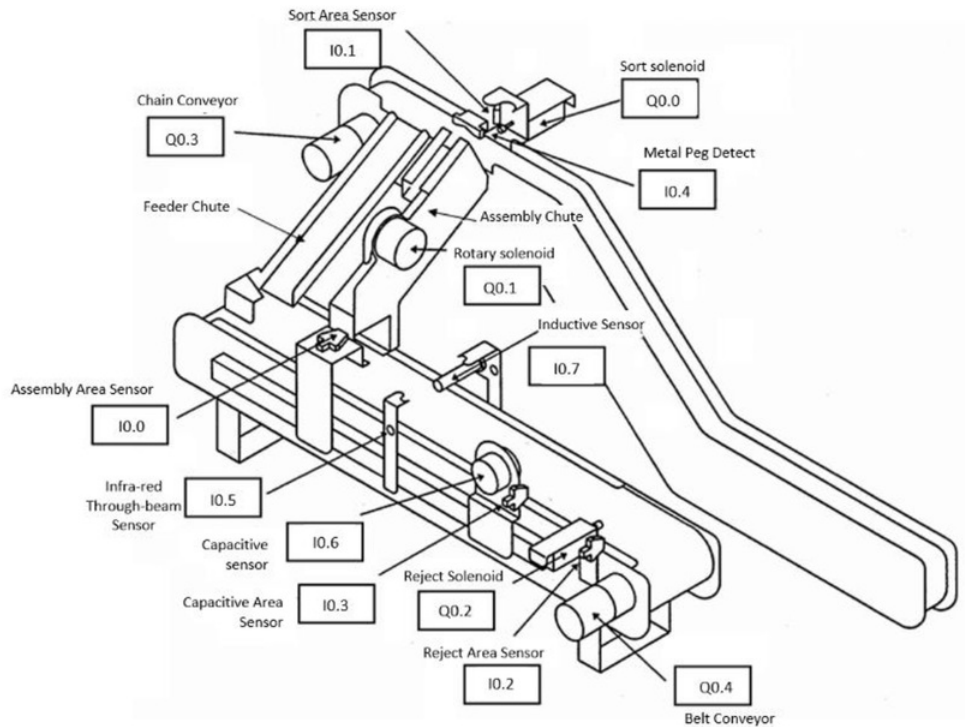


Figure 10- Industrial Control Trainer

On the industrial control trainer, both plastic rings and metal pegs travel up on the chain conveyor, at the top of the chain conveyor there is a 'metal peg detect' and a 'sort area sensor'. The 'sort area sensor' is a capacitive sensor and therefore will detect both the metal pegs and the plastic rings. The 'metal peg detect' is an inductive sensor and therefore only detects the metal peg. The objective is for the sort solenoid to energise only if there's a plastic ring there (i.e. when the sort area sensor has detected but the metal peg detect hasn't) and the assembly chute is not full. All metal pegs and any waste plastic rings (when the chute is full) will go down the feeder chute onto the belt conveyor.

Figure 11 shows the sort solenoid, where it would push the plastic ring down the assembly chute



Figure 11- Sort solenoid

Figure 12 shows the metal pegs and any plastic ring wastage going passed the sort solenoid down the feeder chute

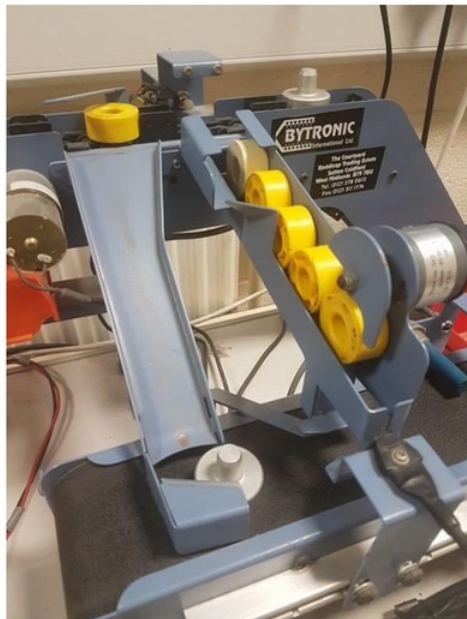


Figure 12- Feeder chute

When on the belt conveyor the objective is that the plastic ring will sit on top of the metal peg, this should then travel down the line and end up in the assembled products area. Any other products on the belt conveyor should be rejected by the reject solenoid. The rotary solenoid will dispense a plastic ring into the assembly area where it will stay until a metal peg receives it. The rotary solenoid must dispense a plastic ring into the assembly area when it's empty. The inductive sensor will then detect that a metal peg is on the assembly line, and a capacitive sensor will detect a plastic peg on top of the peg. The product will then pass the reject area sensor where it will go down the assembled product chute. Any products that fail to energise the inductive sensor and capacitive sensor must be rejected.

Figure 13 shows the metal peg collecting the plastic ring from the assembly area



Figure 13- Assembly area

Figure 14 shows the assembled product on the belt having past the inductive sensor and currently at the inductive sensor and inductive area sensor

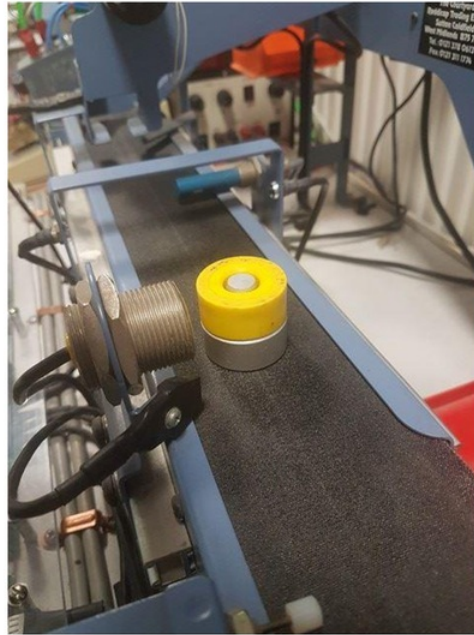


Figure 14- Assembled product on belt

Figure 15 shows the assembled product in the assembled product area and any other products have been pushed out by the reject solenoid

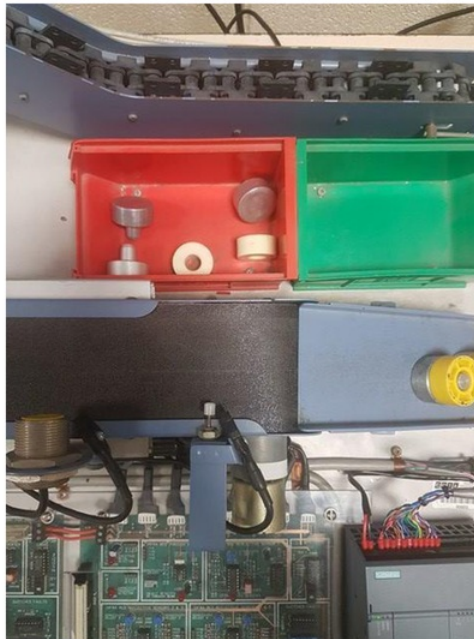


Figure 15- Reject and assembled product area

Figure 16 shows the 'Industrial Control Trainer'

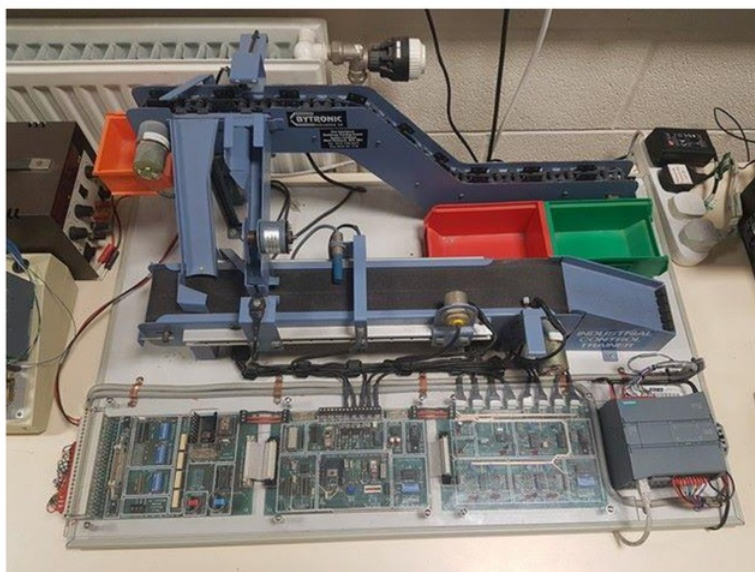


Figure 16- Industrial Control Trainer

I/O list

Input	
Device	Address
Assembly area sensor	I0.0
Soft area sensor	I0.1
Reject area sensor	I0.2
Capacitive area sensor	I0.3
Metal peg detect	I0.4
Infra-red Through-beam sensor	I0.5
Capacitive sensor	I0.6
Inductive Sensor	I0.7

Output	
Device	Address
Sort solenoid	Q0.0
Rotary solenoid	Q0.1
Reject solenoid	Q0.2
Chain conveyor	Q0.3
Belt conveyor	Q0.4

3. Programme Explanation

Figure 17 shows the PLC tag table, this includes the PLC's input, output and memory bits

Assignment 1- Dan, Callum & Josh (2) ▶ PLC_127 Byronic conveyor [CPU 1214C DC/DC/DC] ▶ PLC tags

Tags User constants System constants

PLC tags

	Name	Tag table	Data type	Address	Retain	Access...	Write...	Visibl...	Comment
1	Assembly area sensor	Input tag table	Bool	%I0.0		☒	☒	☒	
2	Sort area sensor	Input tag table	Bool	%I0.1		☒	☒	☒	
3	Reject area sensor	Input tag table	Bool	%I0.2		☒	☒	☒	
4	Capacitive area sensor	Input tag table	Bool	%I0.3		☒	☒	☒	
5	Metal peg detect	Input tag table	Bool	%I0.4		☒	☒	☒	
6	Infra-red Through-beam sensor	Input tag table	Bool	%I0.5		☒	☒	☒	
7	Capacitive sensor	Input tag table	Bool	%I0.6		☒	☒	☒	
8	Inductive Sensor	Input tag table	Bool	%I0.7		☒	☒	☒	
9	Sort solenoid	Output tag table	Bool	%Q0.0		☒	☒	☒	
10	Rotary solenoid	Output tag table	Bool	%Q0.1		☒	☒	☒	
11	Reject solenoid	Output tag table	Bool	%Q0.2		☒	☒	☒	
12	Chain conveyor	Output tag table	Bool	%Q0.3		☒	☒	☒	
13	Belt conveyor	Output tag table	Bool	%Q0.4		☒	☒	☒	
14	Manual sort solenoid test	Memory tag table	Bool	%M0.0		☒	☒	☒	
15	Manual rotary solenoid test	Memory tag table	Bool	%M0.1		☒	☒	☒	
16	Manual reject solenoid test	Memory tag table	Bool	%M0.2		☒	☒	☒	
17	Manual chain conveyor test	Memory tag table	Bool	%M0.3		☒	☒	☒	
18	Manual belt conveyor test	Memory tag table	Bool	%M0.4		☒	☒	☒	
19	Metal peg on belt conv	Input tag table	Bool	%M1.0		☒	☒	☒	
20	Assembled product on belt	Input tag table	Bool	%M1.1		☒	☒	☒	
21	Reject area sensor pulse	Input tag table	Bool	%M1.2		☒	☒	☒	
22	Plastic wastage counter reset	Memory tag table	Bool	%M2.0		☒	☒	☒	
23	Metal peg reject counter reset	Memory tag table	Bool	%M2.1		☒	☒	☒	
24	Plastic peg reject counter reset	Memory tag table	Bool	%M2.2		☒	☒	☒	
25	Assembled product counter res..	Memory tag table	Bool	%M2.3		☒	☒	☒	
26	<Add new>					☒	☒	☒	

Figure 17- PLC tag table

Figure 18 shows network 1 which energises the chain conveyor and belt conveyor, see figure 18 for network comments.

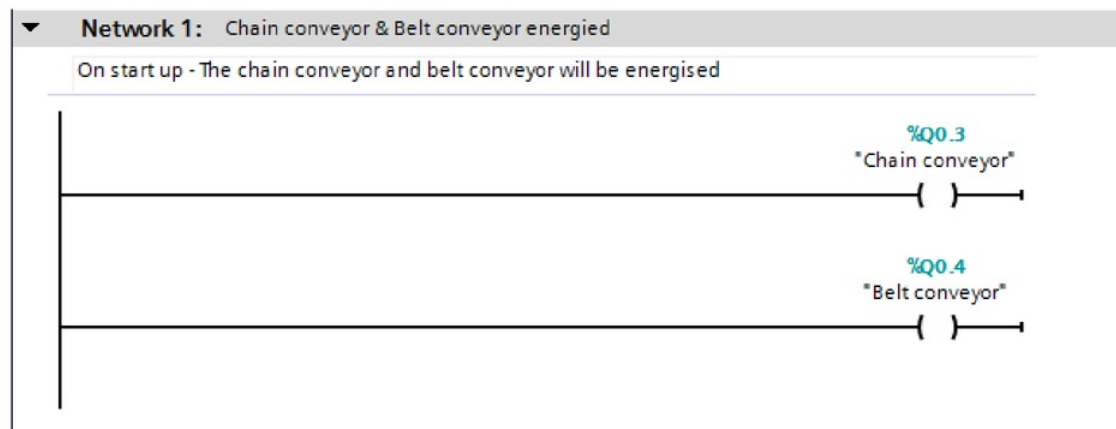


Figure 18- Network 1

Figure 19 shows network 2 which energises the sort solenoid, see figure 19 for network comments.

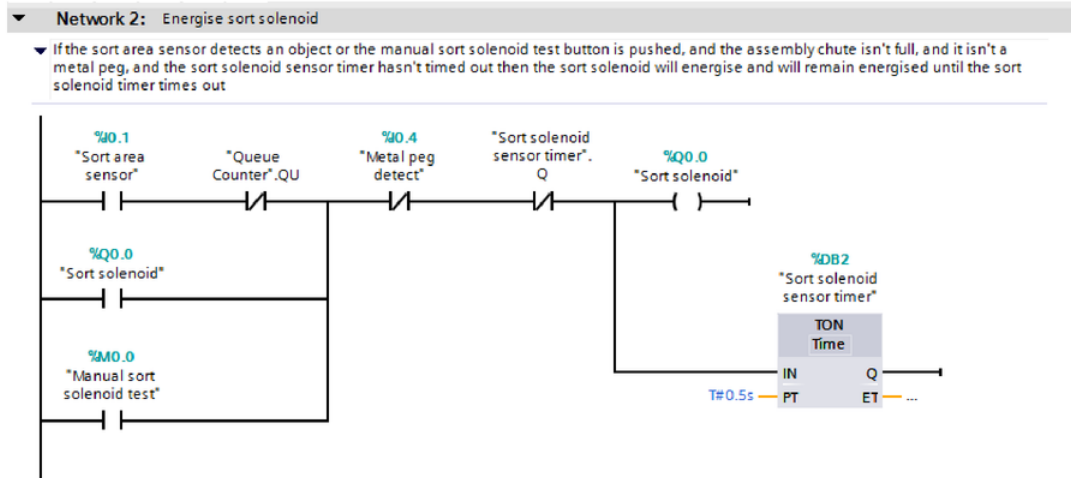


Figure 19- Network 2

Figure 20 shows network 3 which counts the number of plastic rings in the assembly chute, see figure 20 for network comments.

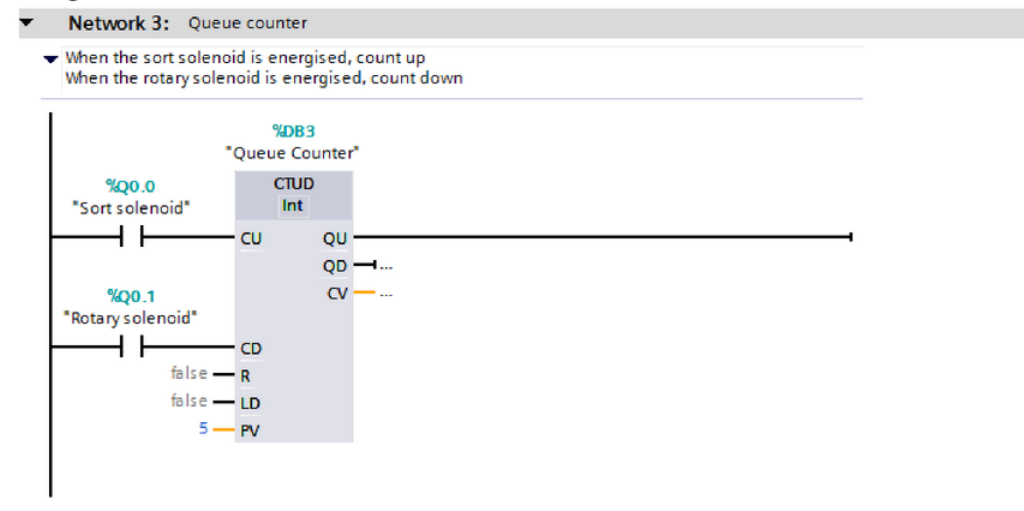


Figure 20- Network 3

Figure 21 shows network 4 which energises the rotary solenoid, see figure 21 for network comments.

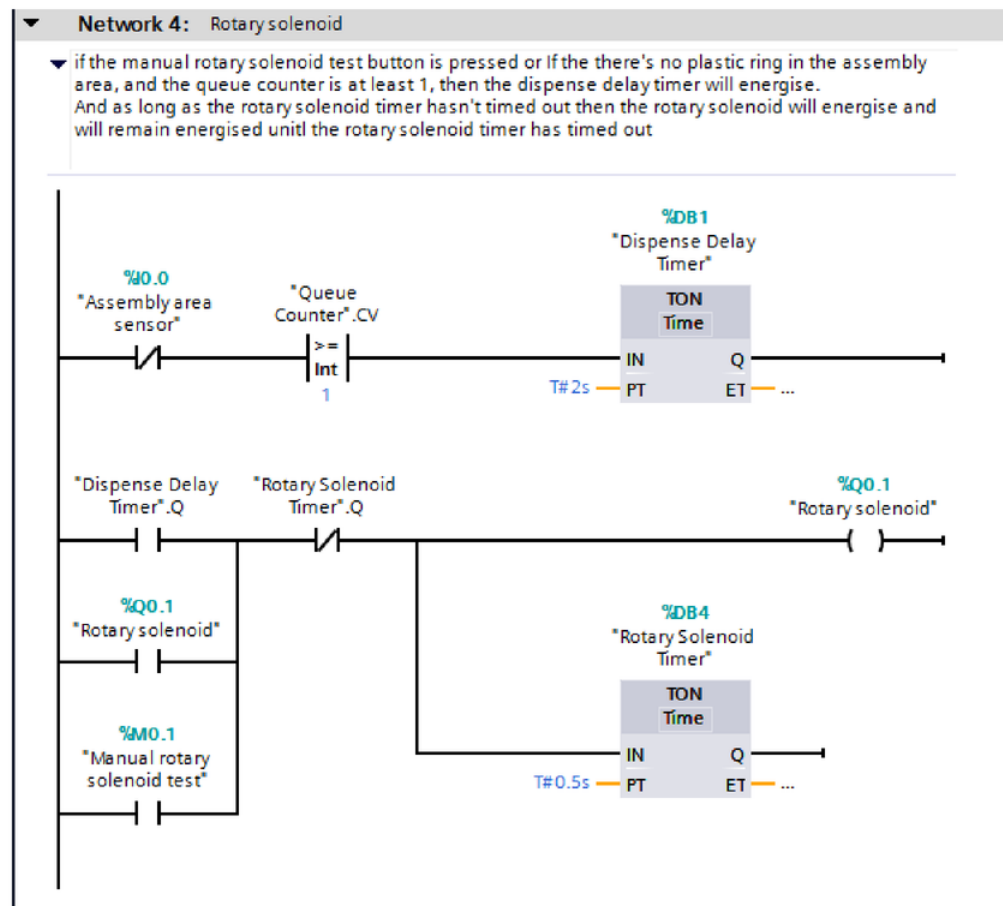


Figure 21- Network 4

Figure 22 shows network 5 which energises and sets memory bits 'Metal peg on belt conv' and 'Assembled product on belt', see figure 22 for network comments.

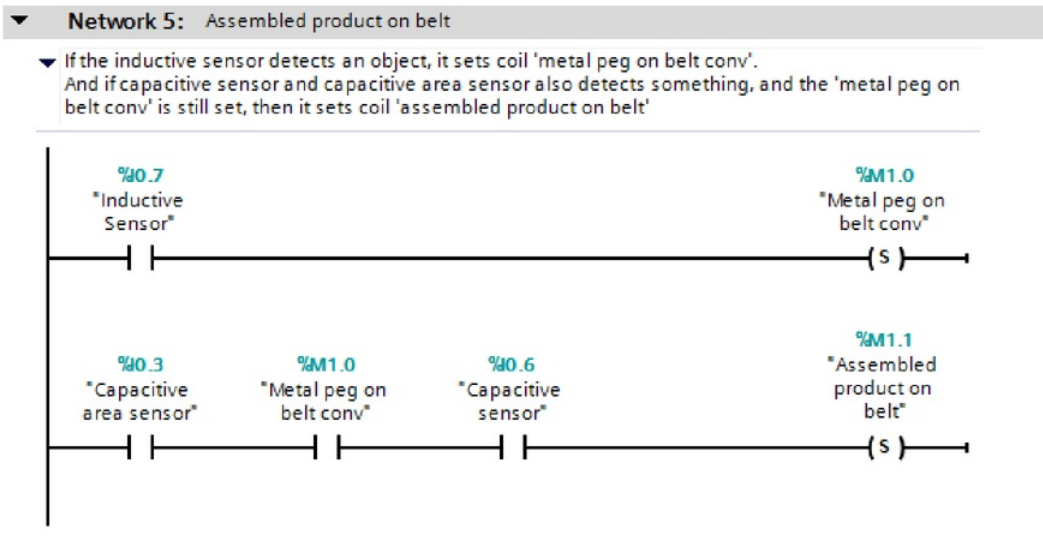


Figure 22- Network 5

Figure 23 shows network 6 which energises the reject solenoid, see figure 23 for network comments.

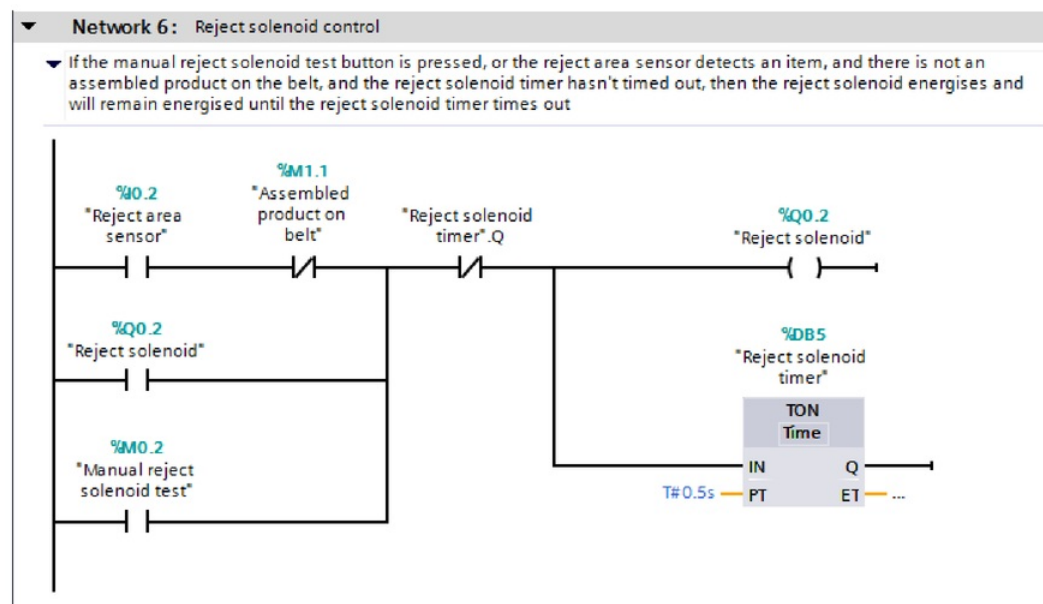


Figure 23- Network 6

Figure 24 shows network 7 which resets memory bits 'Metal peg on belt conv' and 'Assembled product on belt', see figure 24 for network comments.

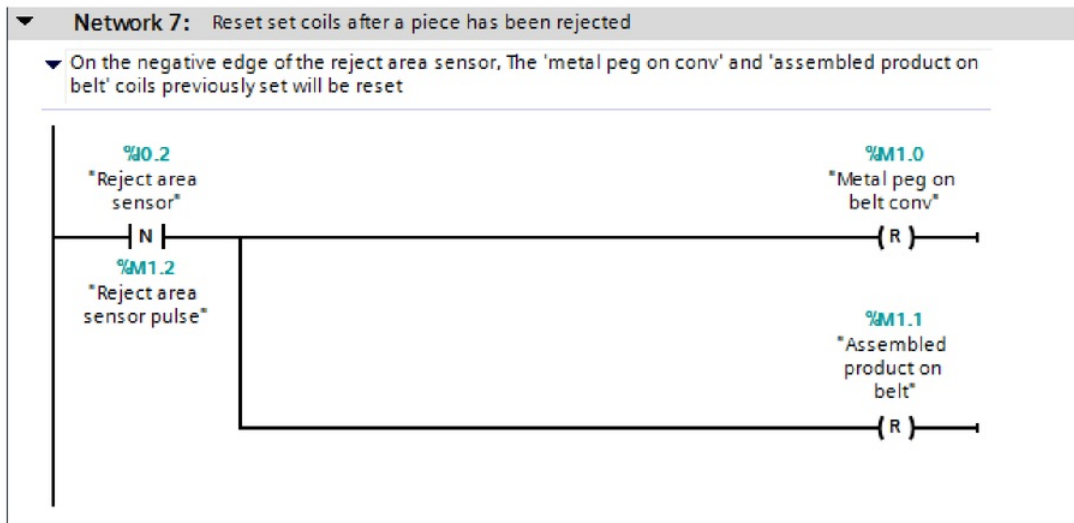


Figure 24- Network 7

Figure 25 shows network 8 which counts the number of plastic rings in the assembly chute, see figure 25 for network comments

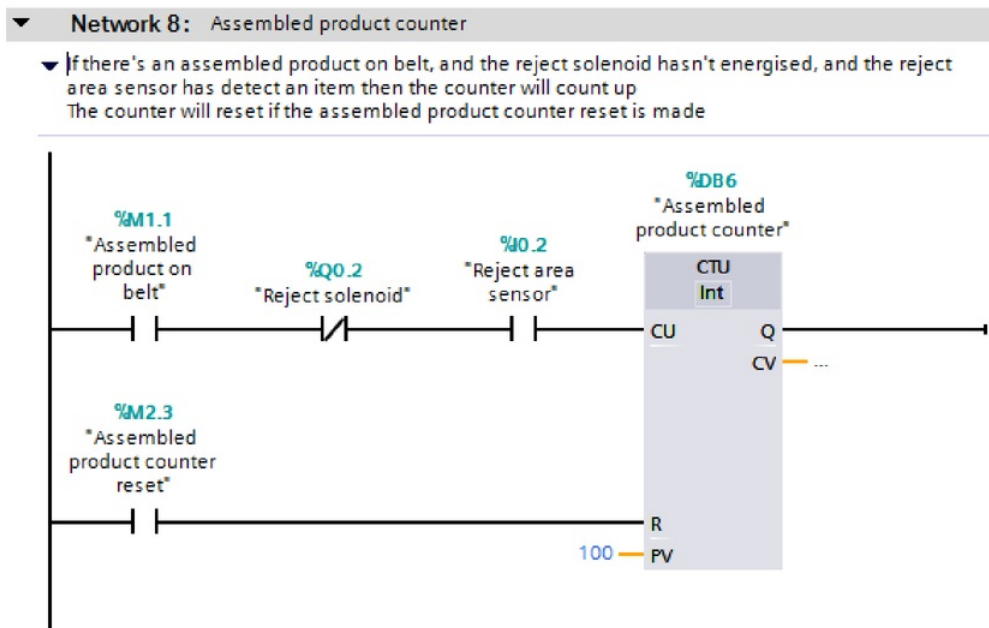


Figure 25- Network 8

Figure 26 shows network 9 which counts the number of plastic rings wasted, see figure 26 for network comments.

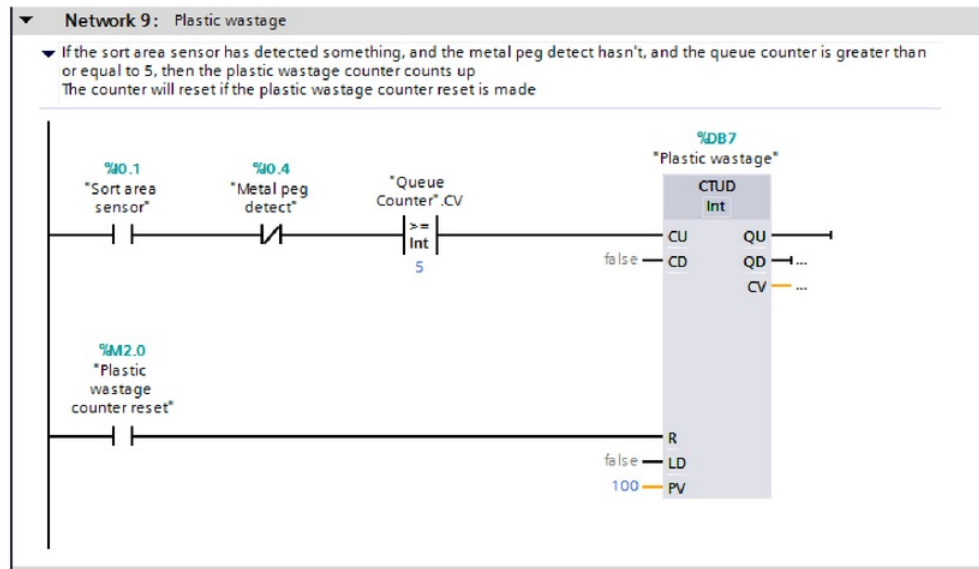


Figure 26- Network 9

Figure 27 shows network 10 which counts the number of rejected metal pegs, see figure 27 for network comments.

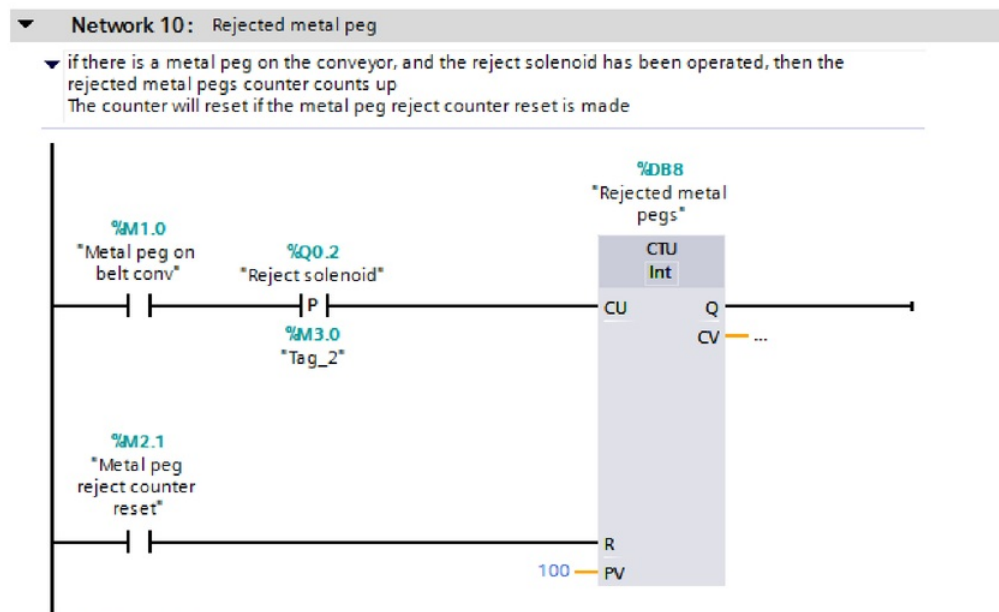


Figure 27- Network 10

Figure 28 shows network 11 which counts the number of rejected plastic rings, see figure 28 for network comments.

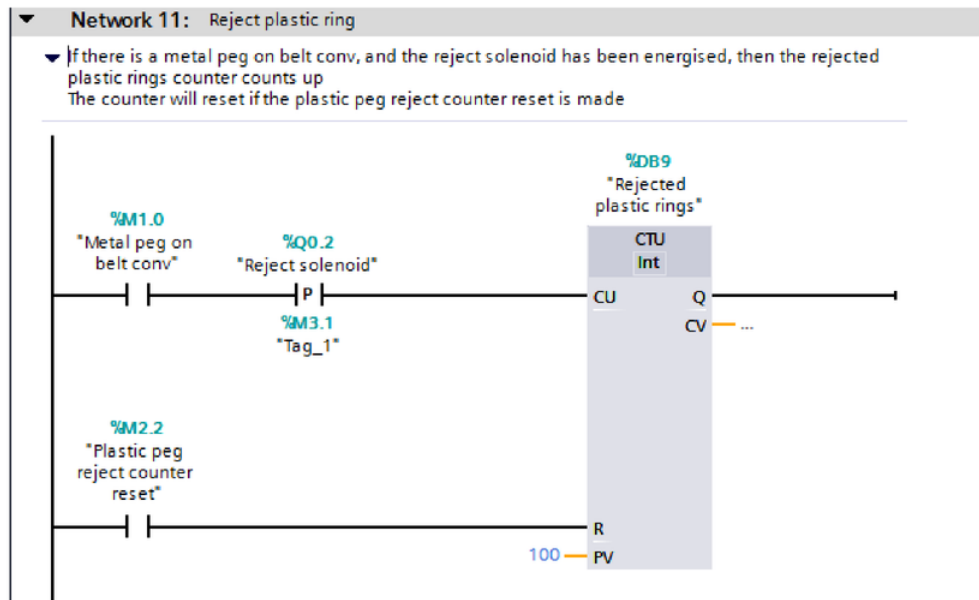


Figure 28- Network 11

Figure 29 shows the operator screen being displayed on the HMI, This screen allows the operator to see if the assembly chute is full, and how many plastic rings have been wasted, how many assembled products have been made, and how many metal pegs and plastic rings have been rejected. This screen also allows the all the counters except the chute queue to be reset via the HMI

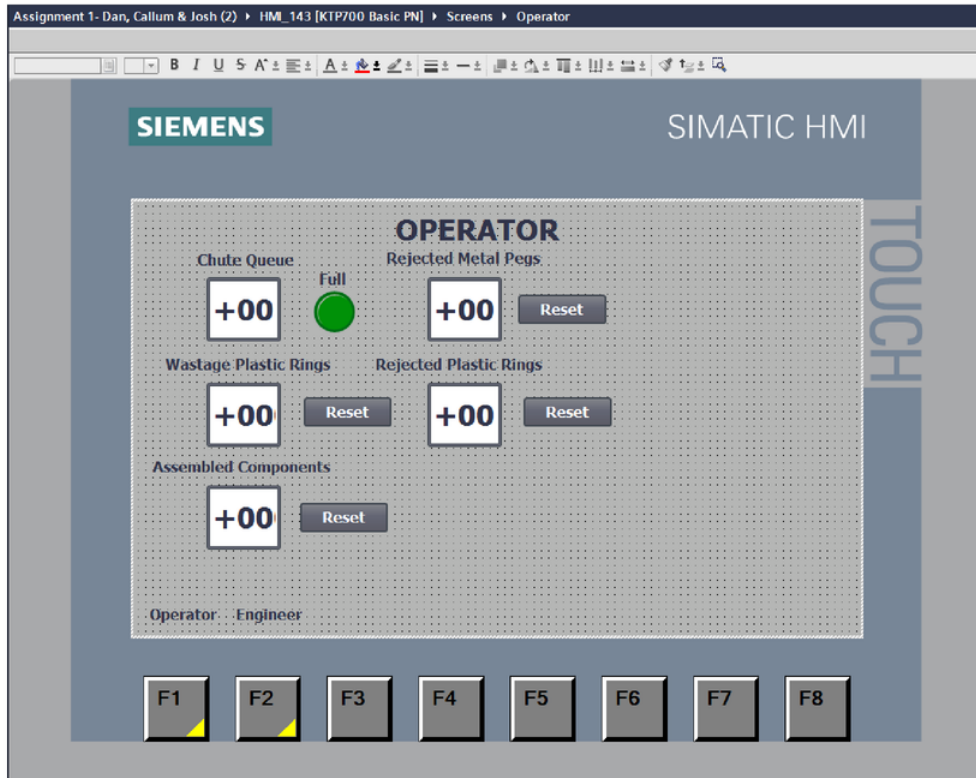


Figure 29- Operator screen

Figure 30 is the engineers screen, this screen can also be accessed via the HMI, and this screen allows you to visually see what inputs and outputs are being energised. This screen also allows you to manually test the outputs.

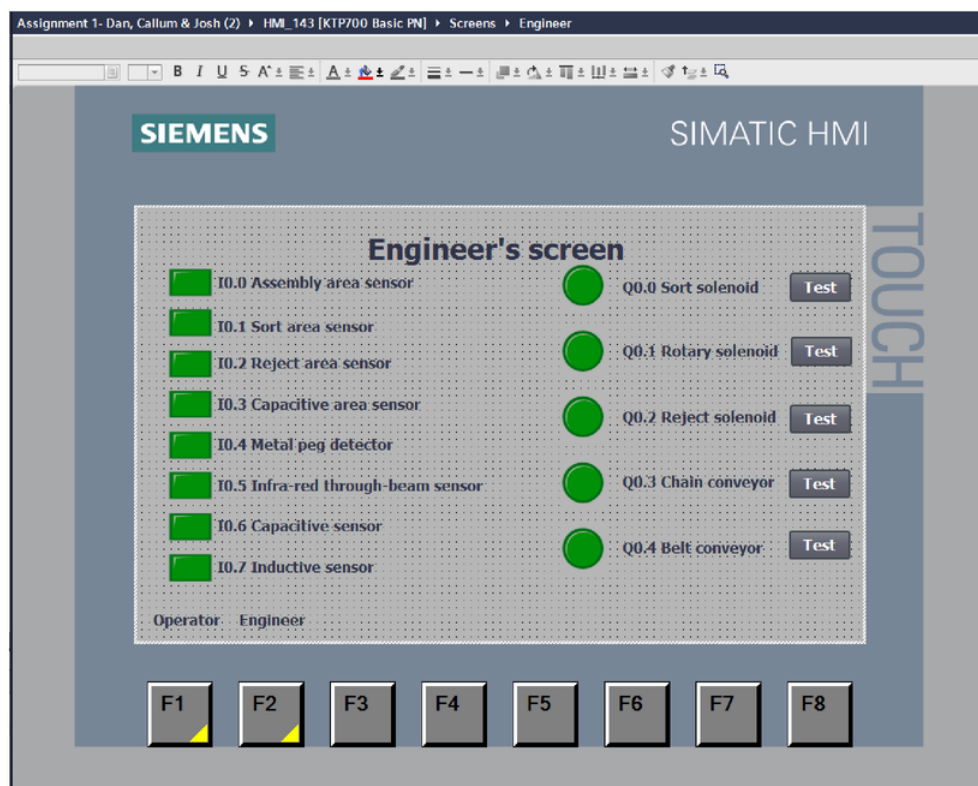


Figure 30- Engineer's screen

4. System Testing and Evaluation

Testing Table				
Number	Description	Expected result	Actual result	Test success
#1	Turn on switch	The chain conveyor and belt conveyor should start	Both the chain and belt conveyor worked as expected	Pass
#2	Place plastic ring on chain conveyor.	Sort solenoid should energise and push it down the assembly chute	'Metal peg detect' didn't energise but the 'sort area sensor' did pushing it down the assembly chute	Pass
#3	Place a metal peg on the chain conveyor.	Metal peg should travel along the chain conveyor and allow it to go down the feeder chute	'Metal peg detect' and the 'sort area sensor' detected the metal peg allowing it pass the assembly chute and down the feeder chute	Pass
#4	Place 8 plastic rings consecutively on the chain conveyor.	The first 5 of the plastic rings should be pushed down the assembly chute and the last 3 should go down the feeder chute	The first 5 energised the sort solenoid pushing them down the assembly chute. The following 3 continued on the chain conveyor until they were pushed down the feeder chute	Pass
#5	Place plastic ring on chain conveyor.	Rotary solenoid should drop 1 plastic ring into assembly area once it is empty as long as there's at least 1 plastic ring in the assembly chute.	The metal peg was pushed down the feeder chute. A plastic ring was placed on the metal peg, the sort solenoid energised allowing a plastic ring to be dispensed into the assembly area	Pass
#6	Place plastic ring onto the belt conveyor.	As it's not an assembled product then it should be rejected by the reject solenoid	The reject solenoid energised rejecting the component	Pass
#7	Place another plastic ring onto the belt conveyor.	As it's not an assembled product then it should be rejected by the reject solenoid	All of the relevant component detection memory was reset and the ring was rejected by the reject solenoid	Pass

#8	Place metal peg onto the belt conveyor.	As it's not an assembled product then it should be rejected by the reject solenoid	The reject solenoid energised rejecting the component	Pass
#9	Place another metal peg onto the belt conveyor.	As it's not an assembled product then it should be rejected by the reject solenoid	All of the relevant component detection memory was reset and the metal peg was rejected by the reject solenoid	Pass
#10	Place a metal peg on top of a plastic ring	As it's not an assembled product then it should be rejected by the reject solenoid	The reject solenoid energised rejecting the component	Pass
#11	Place another metal peg on top of a plastic ring	As it's not an assembled product then it should be rejected by the reject solenoid	All of the relevant component detection memory was reset and the product was rejected by the reject solenoid	Pass
#12	Place a correctly assembled component onto the belt conveyor.	As it's an assembled product then it should not be rejected by the reject solenoid and therefore travel all the way along the belt conveyor	When the correctly assembled component was detected by both the inductive sensor and the capacitive sensor. This means that the product has been correctly assembled which means the reject solenoid did not energise	Pass
#13	Place six plastic rings on to the chain conveyor. (HMI assembly chute counter test)	The first 5 of the plastic rings should be pushed down the assembly chute and the last 1 should go down the feeder chute. The full light on the HMI should come on	The first 5 of the plastic rings were pushed down the assembly chute by the sort solenoid and the last 1 went down the feeder chute. The full light on the HMI turned on.	Pass
#14	Place an extra two plastic rings onto the chain conveyor. (HMI plastic wastage test)	Every plastic ring that passes the sort solenoid and goes down the feeder chute should increase the counter by 1	The counter increased by a varying amount when the a plastic ring passed the sort solenoid	Fail

#15	Place assembled components onto the belt conveyor. (HMI assembled components counter test)	Every assembled product that passes the reject solenoid and into the assembled product area should increase the counter by 1	The counter increased by a varying amount when the assembled product went into the assembled product area	Fail
#16	Place metal pegs onto the belt conveyor. (HMI rejected metal pegs counter test)	Every metal peg that is rejected by the reject solenoid and into the reject area will increase the counter by 1	The counter increased by a varying amount when a metal peg was rejected	Fail
#17	Place plastic rings onto the belt conveyor. (HMI rejected plastic rings counter test)	Every plastic ring that is rejected by the reject solenoid and into the reject area will increase the counter by 1	The counter increased by 1 every time a plastic ring entered the rejected product area	Pass
#18	Press each of the 'reset' buttons on the operators screen on the HMI	Once each of the 'reset' buttons are pressed their corresponding counters should reset to zero.	Once each of the 'reset' buttons were pressed their corresponding counters reset to zero	Pass

5. Conclusions and Recommendations

The requirements of this task have been achieved, meaning that we have successfully designed, developed and tested a programme to do what our specification required us to do. A suitable HMI was developed however we had a few issues with it that couldn't be resolved within the time given.

The main recommendation would be to fix the issue with the counters on the HMI, as all the problems were counters on the HMI, This may indicate that they may have a common problem that could easily be resolved. If there was time we would have begun to diagnose the fault. One person would be watching the PLC programme in monitor mode, another person would be watching the HMI screen and another person would watch the 'Industrial Control Trainer'. In order to fault diagnose, all three would keep in contact during testing in order to diagnose the problem.

Another recommendation would be a physical change on the 'Industrial Control Trainer', which would mean that any plastic ring wastage wouldn't be sent down the feeder chute and would somehow would continue to go round on the chain conveyor until there was room in the feeder chute. This would eliminate any plastic ring wastage however would need the 'Industrial Control Trainer' to be redesigned and may cost a lot of money in order to implement this change.

6. Collaboration

I was working within a team of three in order to achieve the objectives of this task. We all gave our thoughts on how it should be designed in order to achieve the specification. Then I and Josh started by making an I/O list whilst Callum started by making the testing table. Myself and Josh then started to create the programme using TIA portal. Following completing the programme we then went through the programme with Callum ensuring that it would do what the specification required. When testing the programme. I sat at the computer monitoring the programme in watch mode, whilst Josh watched the HMI and Callum watched the programme. Callum used the testing table in order to ensure that the programme did what the specification required.

7. Citation list

- Techwalla. 2017. The Types of PLCs | Techwalla.com. [ONLINE] Available at: <https://www.techwalla.com/articles/the-types-of-plcs>. [Accessed 26 November 2017].
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PDSE 4005- Assignment 1- Daniel Evans

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

69/100

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GRADING FORM: CSG-RUBIC

DANIEL EVANS**69****RESEARCH-INFORMED LITERATURE**

Section 1: Your research -Good evidence of background reading to support arguments presented. (11/15) Section 8: Your use of Harvard for citing and listing - Wide range of sources listed correctly. Further marks were available for more accurate citing of source in the report. (3/5)

14**KNOWLEDGE AND UNDERSTANDING**

Section 2: Hardware Description and I/O list - This sections contains a useful description of the operation of each part of the machine with photos and a helpful overview diagram and I/O list. Further marks were available for accurate details of each device type including the PLC and HMI. (5/10)
Section 3: Program Explanation – A good tag list

10

and brief description of each network and HMI screen. Further marks were available for a more detailed explanation of each network. (5/10)

ANALYSIS



Section 4: System Testing and Evaluation - Very good evidence of testing. Further marks were available for photographic evidence and an overall evaluation on the success of the testing. (5/10)
Section 5: Conclusions and Recommendations - Brief conclusion offered with some useful recommendations. (6/10)

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PRACTICAL APPLICATION AND DEP.



Section 3: Program Design and Network Comments - Well designed with additional features to help the operator and engineer. Good program comments included. (10/10) Section 3: HMI Screen Designs – Very good screen designs. (10/10) Section 4: Presentation of Test Results - Well presented in table format. Further marks were available for photographic evidence. (5/10)

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SKILLS FOR PROFESSIONAL PRAC.



All sections - Generally well written and presented with excellent structure including a list of figures at the beginning. (5/5) Section 6: Team working - A good explanation given (4/5)

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