

PLC assignment 1 - Bytronic industrial control trainer PSDE 4005 Nicholas Devoy

by Nicholas Devoy

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HNC Electronic Engineering
PSDE 4005

Programmable Logic Controllers

Assignment 1 – Bytronic Industrial Control Trainer

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1. Research

The research that I will be carrying out for this task will be about different types of PLC's that are currently available with their performances and costs from one manufacturer with suitable applications for each. I will also be doing research on the different types of PLC languages available with a preferred choice of language for different applications or processes.

A PLC (Programmable Logic Controller) is an industrial computer system that constantly monitors the state of input devices and makes decisions based upon a custom program to control the state of the output devices. There are a lot of different types of PLC's used in the industry these days but the types of PLC's I am going to do research on are the unitary, modular and rack mounted. There are also a lot of manufacturers in today's industry. For example; Mitsubishi, Alan Bradley and Festo, but the PLC I will be using for this assignment is the Siemens S7. (AMCI, n.d.)

Unitary plc

The unitary PLC is one of the earliest types of PLC's dating back to the 1970s. It has a very simple design and is one of the least expensive PLC types on the market. It contains all the basic features such as the CPU and I/O boards and are normally used for small processes. (An Introduction To The Plc Information Technology, 2015)

These types of PLC are very reliable, however their main disadvantage is that you cannot extend as they have a fixed amount of inputs and outputs on them, so if something needed to be extended or modified you are very limited. (2015)

Overall these types of PLC's are generally the cheapest as they are very limited to what they can do as you are restricted with expanding them. Also, the whole PLC needs to be replaced if any component is damaged within it. They are also relatively slow and have little memory. The advantage of this type of PLC is that it requires a low amount of power and is very small. (An Introduction To The Plc Information Technology, 2015)

If you were to use a unitary PLC you should consider whether it will need more inputs and outputs in the future. If you know you'll have to add on then you should use different type of PLC. Although there is restricted use for the unitary PLC, some will allow you to expand but its limited, the Siemens S7-1211C has room for a plug-in signal board. This component is shown in figure 2.



(Conrad, 2015)

Figure 1: Siemens Unitary PLC

Design and Characteristics

- An input module
- An output module
- A power supply
- A CPU

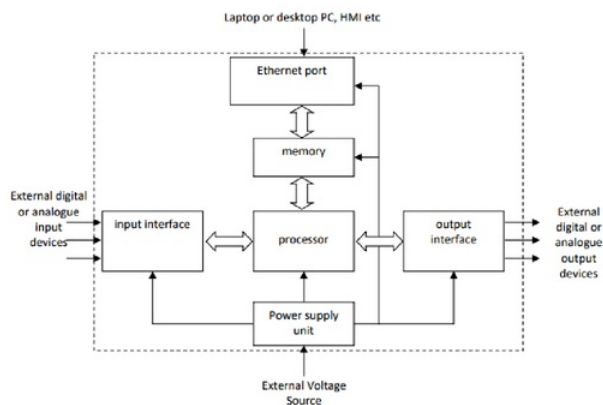
A Siemens Simatic S7-1211C PLC is one example of a unitary type. It has a 1211C CPU which is suitable for how many inputs and outputs there are. It has 6 digital inputs and 4 digital outputs. It also has 2 analogue inputs (0-10V DC). Even though this PLC comes with a power supply, anything that can produce 20.4-28.8V DC is suitable for a power supply for this PLC. This PLC has a memory of 50KB. You can also expand this PLC by using a Siemens signal board. I would use this PLC for any application which doesn't require a lot of inputs and outputs. For example; a car park barrier, this is because it wouldn't need many inputs and outputs. (AG, 2016)

An example of a unitary PLC being used could be for a gate barrier for a car park. This is because they are self-contained units and are very unlikely to be expanded on.



(Reichelt, 2016)

Figure 2: Siemens Signal Board



(Readingrat, 2017)

Figure 3: Unitary PLC Block Diagram

Modular plc

The modular PLC is very similar in size and design to the unitary PLC but is a little more expensive. This type of PLC contains 3 different modules being, the input, output and CPU. The power source is provided separately. This type of PLC would usually be mounted on a DIN rail, this would allow a range of extra modules to put together to expand the system if needed. This type of PLC is normally used for larger operations but with the possibility of expansion if the process was to increase. (Aries, 2016)

These PLC's are very practical depending on the future, whether you need to add on to it. The main disadvantage of this PLC is that the whole module will need replacing if any of the components become damaged, you are also limited when it comes to expanding on to your PLC depending on the brand even though I have stated this as a disadvantage, this can also be an advantage. (Siddiqui, 2014)

Even though there are a few disadvantages to this plc on the other hand it is relatively cheap to buy, ranging from £140-£850 for siemens S7, and the number of input and output terminals can withstand changes to the hardware system. This PLC has a relatively big memory size and has expandable input and outputs. (Aries, 2016)

An example of a modular PLC is the siemens S7-1214C (shown in figure 4). It has a 1214 CPU which is capable of processing at high speeds as this PLC has 14 digital inputs, 10 digital outputs and 2 analogue outputs (0-10V DC). This PLC doesn't come with a power supply, but it needs a supply of 20.4-28.8V DC, this PLC also has 75KB of memory. Modular PLC's slightly more than Unitary PLC's as you can add more inputs and outputs to them, this obviously means that it will need to have a more powerful processor and more memory. (Siemens, n.d.)

A stand-alone machine would be an example of where a modular PLC would be used. This is because it doesn't require too many inputs and outputs, but gives you the option to expand on in the future.



Figure 4: Siemens S7-1214C with expansion modules (modular PLC)

(Oatewell, 2014)

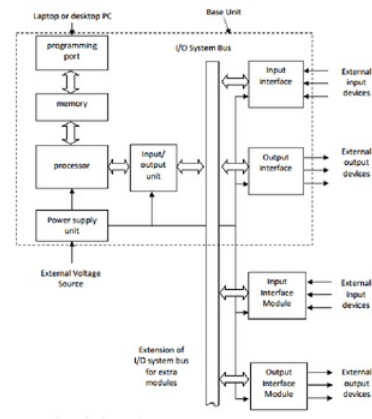


Figure 5: Block diagram of modular PLC

(Mohapatra, 2013)

Rack mounted

The rack mounted PLC is very similar to the modular PLC, but each is implemented differently. For example; the modular PLC connects to the base unit directly whereas the rack mounted PLC keeps each module separate. All the units are connected to the racks and are all kept organised on the racks, this would allow you to build larger systems without anything becoming overly cluttered and complicated. These types of PLC's are suitable for programs with a lot of inputs and outputs as it has a fast processor and large memory. (Aries, 2016)

The rack mounted PLC is more expensive than the unitary and modular PLC and are physically bigger in size due to the rack. The power required depends on the size of the rack and will require more than the unitary and the modular.

The rack mounted PLC has many advantages. For example; it has a large memory, can process at high speeds and has a lot of inputs and outputs, both digital and analogue. The disadvantage of this type of PLC is that it is expensive (Siemens S7 £600- £7000) and is much bigger in size. (Wijesekara, n.d.)

I would use a Rack mounted PLC if I knew that the operation needed a lot of inputs and outputs. This type of PLC is normally used in the manufacturing industry purely because of the number of inputs and outputs that the system possesses and the ability to expand with ease. An example of use of a Rack mounted PLC could be on a large production line where a lot of inputs and outputs are used and will also give you an option to expand in the future.



(Oatewell, 2014)

Figure 6: Rack mounted PLC S7-400

Types of PLC languages

For this part of the assignment I will be carrying out research and explaining each of the IEC PLC languages used and my preferred choice for different applications. There are a lot of different types of languages used in today's industry to program PLC's. Each language possesses many advantages and disadvantages depending on the task you are carrying out. The five main types of PLC language are:

- Function Block
- Instruction list
- Ladder diagram
- Sequential Function Chart
- Function block

Function block

The Function Block (FBD) language is graphical language which has logic gates shown in the form different blocks which will give you an insight of how the program will run. The graphical view makes the program easy to understand and to put together as it way of replacing words in a sense. I wouldn't really use function blocks for a large program as it can become complicated due to how much room they take up on your screen due to the number of blocks used. (Veeramani, 2007)

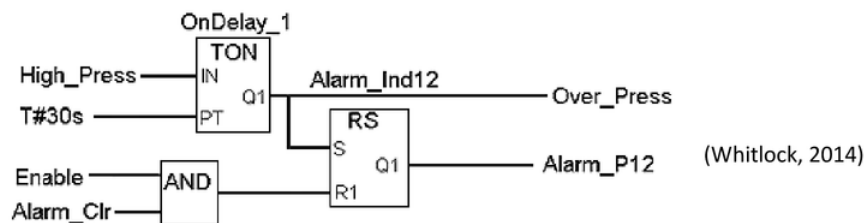


Figure 7: Function block

Instruction List

The instruction list (IL) involves of a sequence of instructions with each instruction beginning a new line. It uses a low language design which is easy to use, understand and remember. I would use this language for small or simple PLC programs as there are much faster ways to insert instructions by using different languages. (Bekhoff, n.d.)

The screenshot shows a PLC programming software interface with a tabbed editor. The active tab is 'ILBlock1'. The code in the editor is as follows:

```
IF START OR RUN THEN
  RUN := TRUE;
END_IF;

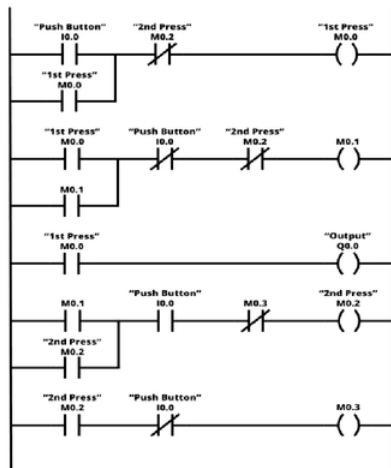
IF STOP THEN
  RUN := FALSE;
END_IF;
```

The text '(Reichelt, 2016)' is located to the right of the code editor.

Figure 8: Instruction List

Ladder Diagram

The ladder diagram () typically flows from left to right. The diagrams can be split up into sections called rungs, typically each rung contains a combination of input instructions which lead to an output instruction, ladder diagrams which contain function blocks may be more complicated. (Walter, 2007) This type of language is beneficial to electricians as it is structured like an electrical drawing due to the contacts, inputs and outputs. The advantage of this language is that it is very easy to use and understand and it makes it easy for you to modify your work. (Rosandich, 2002)

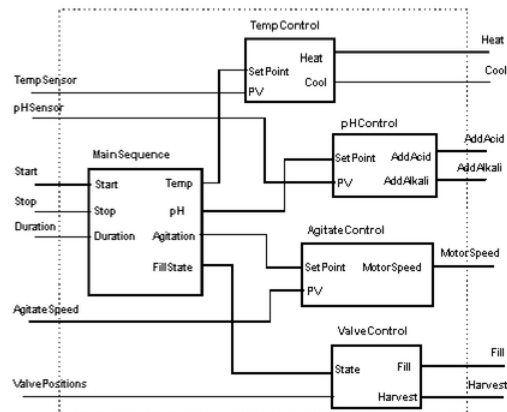


(Peter, 2015)

Figure 9: Ladder diagram

Sequential Function Block

This type of language is a graphical language which has its blocks in chronological order, it is very similar to the Function Block language. This language is very easy to follow and understand but wouldn't be very ideal if you needed to add a lot of boxes to the program. Just like the function block language, each block has a function. (Bekhoff, n.d.)

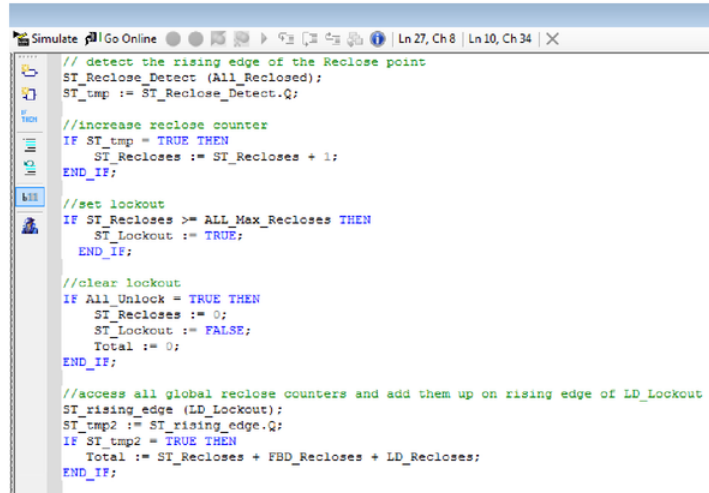


(Wal, 2010)

Figure 10: sequential function block

Structured text

Structured text is a high-level PLC text based language unlike the function block language. At first this language might seem daunting and would prefer to go a graphical language. For example; The Sequential Function Block language, but when it comes to a more complex program I would use this type of language as it takes up less space and the logic will be much easier to understand and read. It is very similar to a computer programming language. People who type with this language tend to use C programming. The only disadvantage to this language is that it is very complexed so if you were just starting out I would not recommend this language. (Peter, 2015)



```
// detect the rising edge of the Reclose point
SI_Reclose_Detect (All_Reclosed);
ST_tmp := SI_Reclose_Detect.Q;

//increase reclose counter
IF ST_tmp = TRUE THEN
    SI_Recloses := SI_Recloses + 1;
END_IF;

//set lockout
IF SI_Recloses >= ALL_Max_Recloses THEN
    SI_Lockout := TRUE;
END_IF;

//clear lockout
IF All_Unlock = TRUE THEN
    SI_Recloses := 0;
    SI_Lockout := FALSE;
    Total := 0;
END_IF;

//access all global reclose counters and add them up on rising edge of LD_Lockout
SI_rising_edge (LD_Lockout);
ST_tmp2 := SI_rising_edge.Q;
IF ST_tmp2 = TRUE THEN
    Total := SI_Recloses + FBD_Recloses + LD_Recloses;
END_IF;
```

(NovaTech, 2017)

Figure 11: Structured text

2. [Hardware description and I/O list](#)

Industrial control trainer

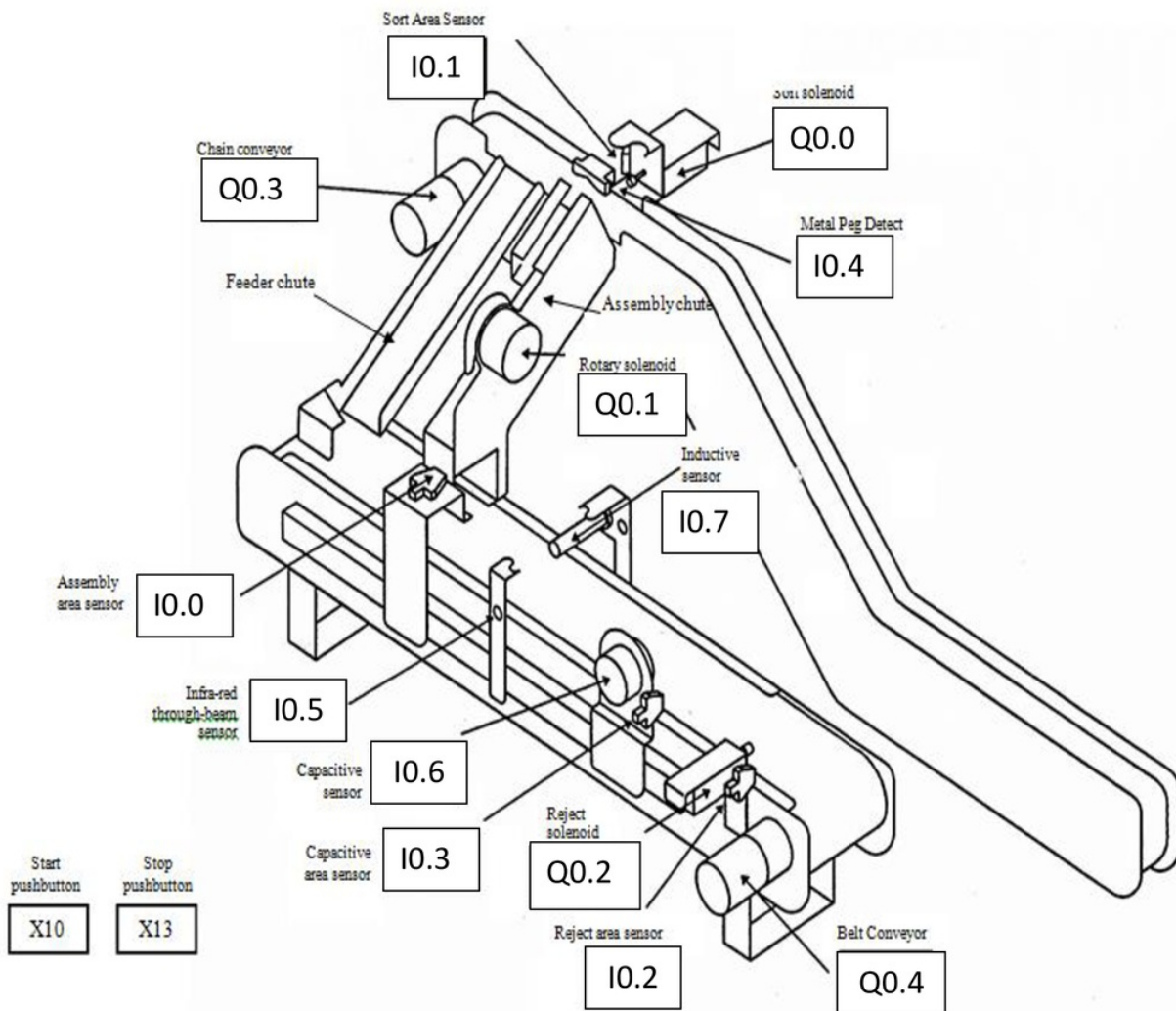


Figure 12: Industrial control trainer

Hardware description

The system that the PLC will be designed on is a belt and chain conveyor where plastic rings and metal pegs will be transported around and sorted by their identities. This system consists of 8 inputs and 5 outputs.

PLC hardware

The programmable logic controller (P.L.C) used is a Siemens S7-1200 and is modular and compact. The PLC also consists of a CPU (central processing unit) which can be programmed and runs the software program. The PLC also consists of digital inputs, digital outputs and analogue I/O. These are used to connect the field wiring to the PLC. More I/O modules can be added to the PLC if required. There are also three communication ports for serial communication or various I/O devices. The PLC also has three L.E.D's on the front to show run/stop, error and maintenance. For this program to work the PLC will need to be in run with no error.

The Industrial control trainer consists of two motors, 8 sensors, 2 push solenoids and rotary solenoid. The both motors are 24-volt D.C. One drives the "chain conveyor" and the other drives the "belt conveyor" The eight input sensors going to the PLC consists of an inductive sensor, capacitive sensor, through beam sensor, metal sensor and area sensors. There are 3 solenoid actuators, two of which are of the push type and the other is a rotary type.



Figure 14: PLC Siemens S7-1200

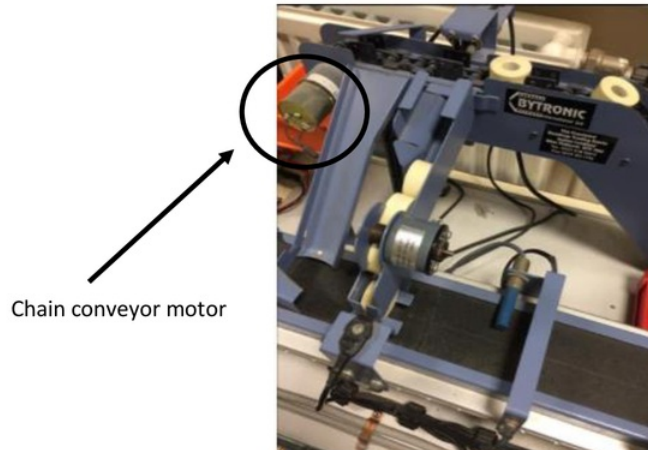


Figure 13: Motor for chain conveyor

Input hardware

The Input "I0.6" tagged "capacitive sensor" is a sensor that will detect an object that is conductive. If a conductive object passes within the sensors range, it will change the state of the switch to the PLC.

The input "I0.5" tagged "infra-red through beam sensor" is made up of two parts, a transmitter and receiver, if an object cuts the beam the receiver changes the state of the switch to the PLC input.



Infra-red through beam sensor

Figure 15: Infra-red through beam sensor

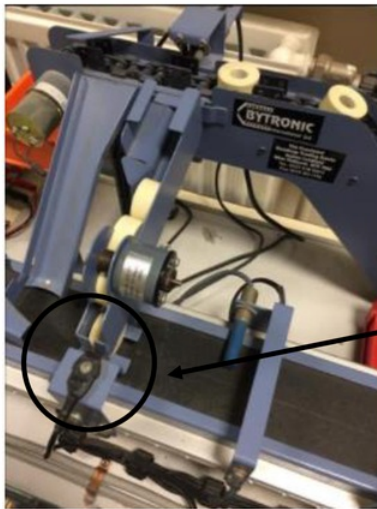
The input "I0.4" tagged "metal peg detect" and Input "I0.7" tagged "inductive sensor" are both sensors that will detect metal objects, such as the metal pegs on the conveyor. If a metal peg passes within the sensors range, it will change the state of the input to the PLC.



Inductive sensor

Figure 16: Inductive sensor

The input "I0.0" tagged "assembly area sensor", input "I0.1" tagged "sort area sensor", input "I0.2" tagged "reject area sensor" and input "I0.3" tagged "capacitive area sensor" are all proximity sensors which can detect nearby objects because it looks for changes in the field or return signal.



Assembly area sensor

Figure 17: Assembly area sensor

Output hardware

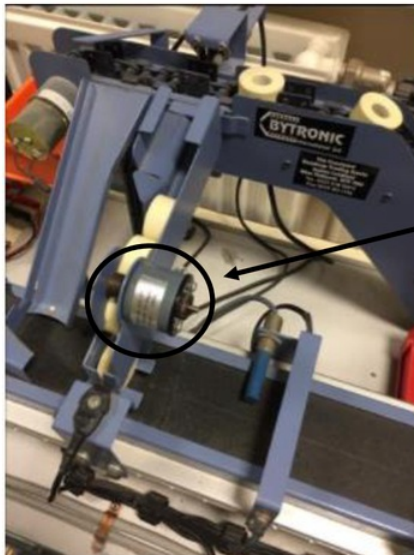
The output "sort solenoid" addressed "Q.00" and output "reject solenoid" addressed "Q.02" are both electro-magnetic solenoids, when the solenoid is energised it creates a magnetic field through the coil. There is an electromagnetic force on the plunger and it moves to eject the product. When the power is de-energised to the solenoid, the plunger returns to its home position with an internal spring to return it.



Sort solenoid

Figure 18: Sort solenoid

The output “rotary solenoid” addressed “Q.01” works in a similar way to the sort solenoid and reject solenoid by creating an electromagnetic field when energised. The difference is that when the solenoid is energised it creates a rotating motion to the shaft, allowing a plastic ring to drop into the assembly area.



Rotary solenoid

Figure 19: Rotary solenoid

I/O Listing

For this section of the assignment, tables of inputs outputs and memory addresses will be shown. All the inputs and outputs shown below will be used in the PLC program I will be designing for the Industrial control conveyor.

With Siemens all the inputs addresses begin with the letter “I”. Every time a different input is added, a byte will also be added to the address. For example; the first input is tagged “assembly area sensor” and has an address of “I0.0”. The second input added is the “sort area sensor” which has the address of “I0.1” and the sixth input added is the “infra-red through- beam sensor” which has the address “I0.5”.

With Siemens all the outputs are given a letter “Q”. The same rule applies to the outputs as it does with inputs. When ever a different output is added, a byte will also be added to the address. For example; the first output tagged “Sort solenoid” has the address of “Q0.0”, the second output added has the tag “Rotary solenoid” and has the address of “Q0.1” and the fourth output tagged “chain conveyor” has the address of “Q0.3”.

Input

Address	Tag Name
I0.0	Assembly area sensor
I0.1	Sort area sensor
I0.2	Reject area sensor
I0.3	Capacitive area sensor
I0.4	Metal peg detect
I0.5	Infra-red through-beam sensor
I0.6	Capacitive sensor
I0.7	Inductive sensor

Output

Address	Tag Name
Q0.0	Sort solenoid
Q0.1	Rotary solenoid
Q.02	Reject solenoid
Q.03	Chain conveyor
Q.04	Belt conveyor

Memory bit addresses

14	Manual Sort Solenoid Test	Default tag table	Bool	%M0.0	☐	☒	☒	☒
15	Manual Rotary Solenoid Test	Default tag table	Bool	%M0.1	☐	☒	☒	☒
16	Manual Reject Solenoid Test	Default tag table	Bool	%M0.2	☐	☒	☒	☒
17	Manual Chain Conveyor Test	Default tag table	Bool	%M0.3	☐	☒	☒	☒
18	Manual Belt Conveyor Test	Default tag table	Bool	%M0.4	☐	☒	☒	☒
19	metal peg on belt conv	Default tag table	Bool	%M0.5	☐	☒	☒	☒
20	assembled product on belt conv	Default tag table	Bool	%M0.6	☐	☒	☒	☒
21	Reject area sensor pulse	Default tag table	Bool	%M0.7	☐	☒	☒	☒
22	rejected plastic ring (sort area)	Default tag table	Bool	%M1.0	☐	☒	☒	☒
23	rejected metal pegs reset	Default tag table	Bool	%M1.1	☐	☒	☒	☒
24	rejected plastic rings (assembly	Default tag table	Bool	%M1.2	☐	☒	☒	☒
25	assembled products Reset	Default tag table	Bool	%M1.3	☐	☒	☒	☒
26	Reject solenoid counting pulse	Default tag table	Bool	%M1.4	☐	☒	☒	☒
27	Sort area sensor counter pulse	Default tag table	Bool	%M1.5	☐	☒	☒	☒
28	reject solenoid pulse 2	Default tag table	Bool	%M1.6	☐	☒	☒	☒

Figure 20: Memory bit addresses

3. Program Explanation

Main organisation

Network 1

Shown below is the first step of the main operation of the conveyor system. These lines of networks will control the chain conveyor and the belt conveyor. As soon as the switch is turned on, power goes to the PLC which energises the both output coils, which will then start the both conveyors. Each output coil has been tagged with the correct tag names and both have the required addresses.

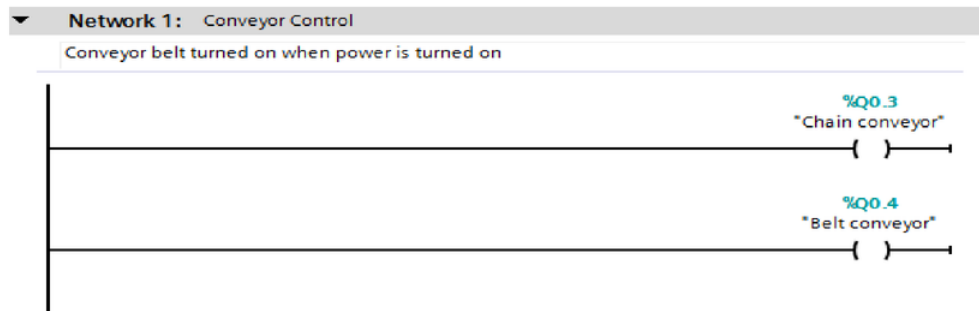


Figure 21: Network 1

Network 2

Shown below is the second step of the main operation in ladder logic. This line of network will control the "sort solenoid" Q0.0 automatically and manually. Each input and output have been giving the right name tags with all the required addresses. When the "sort area sensor" I0.1 is made and providing the 3 normally closed contacts are closed the "sort solenoid" Q0.0 output coil will energise and latch. When the "metal peg detect" I0.4 or the "sort solenoid timer" is made, it will unlatch the sort solenoid retaining contact. This will continue to run in this way until the "queue counter" is energised. This indicates that the assembly chute is full so inhibiting the "sort solenoid" Q0.0 to work. This line of network also has a "manual sort solenoid test" button on the HMI screen which will enable the user to test the sort solenoid. This again will only work providing that the "queue counter", "metal peg detect" and "sort solenoid" are de-energised.

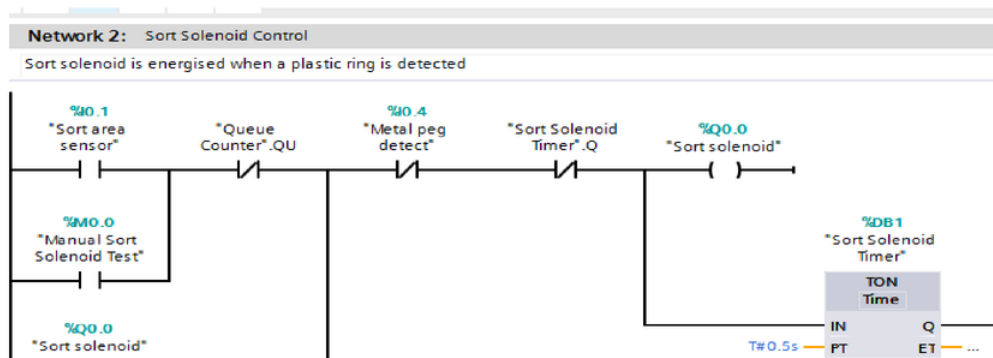


Figure 22: Network 2

Network 3

Shown below is the Plastic ring queue counter line network. This network will play a part in controlling the sort solenoid. Whenever the "sort solenoid" Q0.0 is energised, the "queue counter" will increment by 1, this will only happen until it reaches the maximum which is 5 rings. Once there are 5 rings in the assembly chute the queue counter output will energise inhibiting the "sort solenoid" Q0.0 to work. Whenever the "rotary solenoid" Q0.1 is energised, one of the plastic rings gets released from the queue, the counter then decreases by 1.

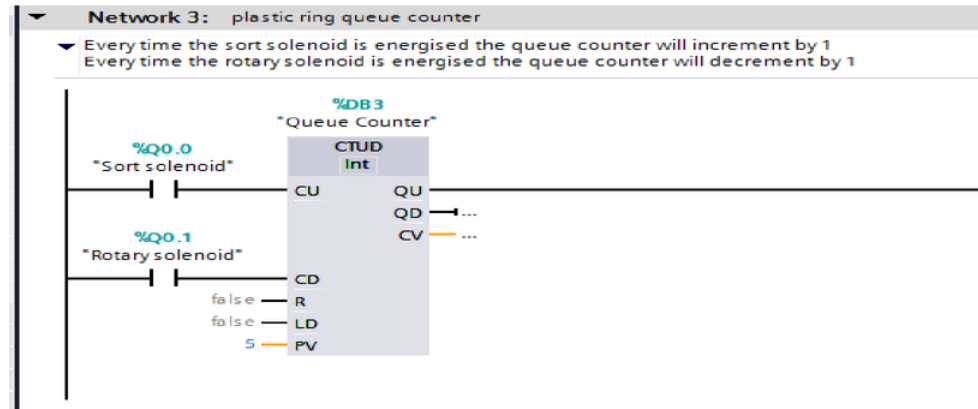


Figure 23: Network 3

Network 4

Below is network 4 which is called "rotary ring dispense solenoid control". This line of control will control the "rotary solenoid" Q0.1 automatically and manually. Each input and output have been giving the right name tags with all the required addresses. This networks states that if the "assembly area sensor" I0.0 is clear and there is at least 1 plastic ring in the assembly chute for 2 seconds the timer will energise for the "rotary solenoid" Q0.1 to work, this then releases a plastic ring into the assembly area. The "rotary solenoid" Q0.1 is latched for 0.5 seconds before being unlatched by its own timer. There is also a manual rotary solenoid test button if there is a need to operate the "rotary solenoid" Q0.1 manually.

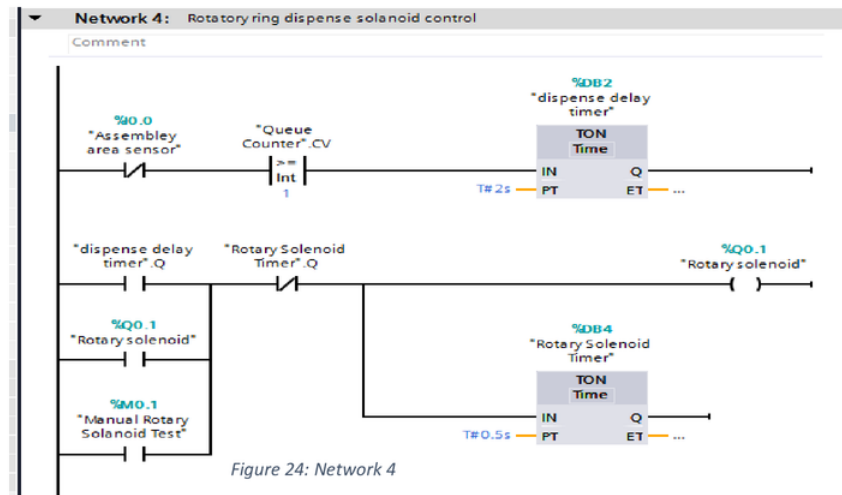


Figure 24: Network 4

Network 5

Shown in figure 25 is the “product selection set bit” line of network. Each input and output have been giving the right name tags with all the required addresses. Network 5 tells me that when the “inductive sensor” I0.7 detects a metal peg, it sets the internal coil M0.5 “Metal peg on belt conveyor” and it stays energised as is an “s” coil. Then as the product travels further down the belt, if the “capacitive area sensor” I0.3 and the “capacitive sensor” I0.6 are energised that means there is a plastic ring detected, which then in turn goes on to set the “assembled product on the belt”. If M0.6 internal coil is set, it means a fully assembled product has been produced.

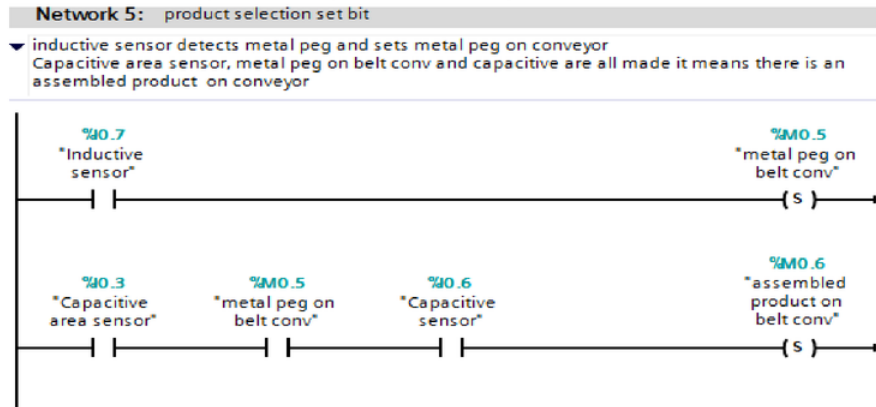


Figure 25: Network 5

Network 6

Below is network 6 called the reject area solenoid control. Each input and output have been giving the right name tags with all the required addresses. This network states that when a product is detected in the reject area with sensor I0.2, it checks to see if the product is fully assembled. If it is fully assembled with the metal peg and plastic ring, then the M0.6 internal coil will be energised stopping the “reject solenoid” Q0.2 from working. If, however the internal coil M0.6 has not been set then the output coil Q0.2 will energise and reject the incomplete product. The output coil Q0.2 will retain for 0.5 seconds before unlatching itself on its own timer. In this network there is also a manual test button to test the “reject solenoid” Q0.2.

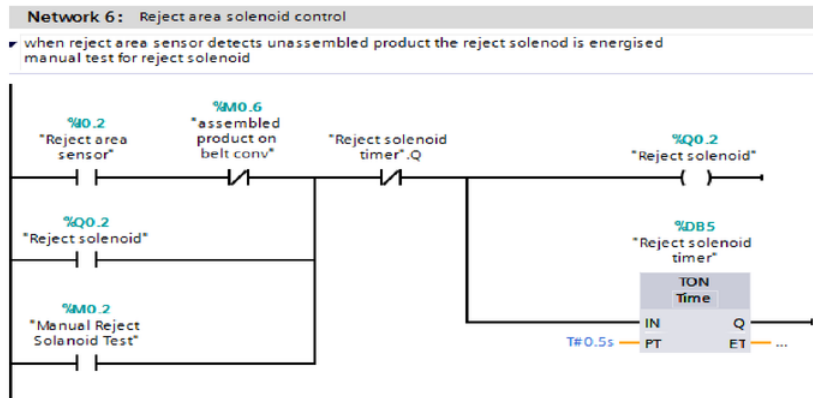


Figure 26: Network 6

Network 7

In network 7 you can see that when a product is detected in the reject area by sensor I0.2 it will reset the internal set coils M0.5 and M0.6. The reset bit is set when the sensor goes from high to low, this resets the detection system ready for the next product piece. Each input and output have been giving the right name tags with all the required addresses.

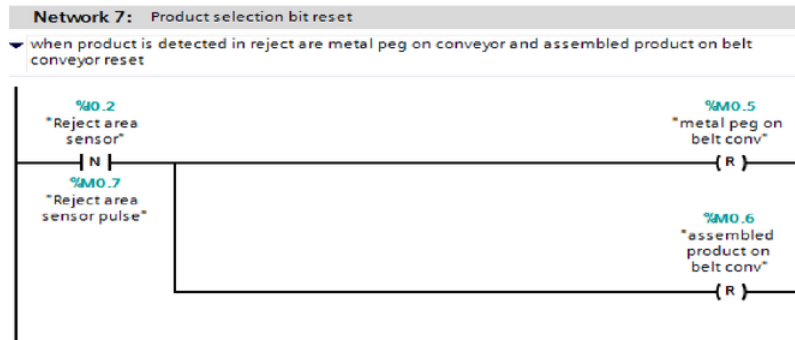


Figure 27: Network 7

Network 8

Below is network 8 called “plastic rings rejected from sort area”. Each input and output have been giving the right name tags with all the required addresses. In this network, if the queue counter is full of plastic rings and the “sort area sensor” I0.1 detects an object and providing its not a metal peg, the counter will increment by 1. When the counter reaches the process variable (PV) value of 10, the counter outputs a signal to say that the plastic ring reject area is full.

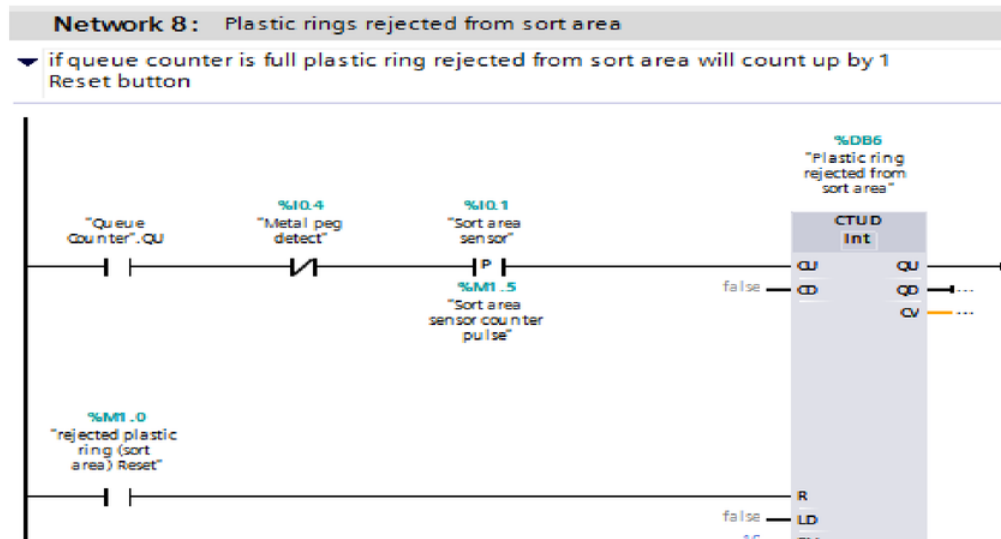


Figure 28: Network 8

Network 9

Network 9 called “rejected metal pegs” counts the number of rejected metal pegs. If the internal coil M0.5 “metal peg on conveyor” is set and the output to the reject solenoid Q0.2 is energised, then this increments the counter by 1. When the process variable (PV) value reaches 10, it outputs a signal to say the basket is full of metal pegs. Each input and output have been giving the right name tags with all the required addresses.

Network 9: Rejected metal pegs

when metal peg on conveyor is set and reject solenoid is energised the counter counts up by 1...

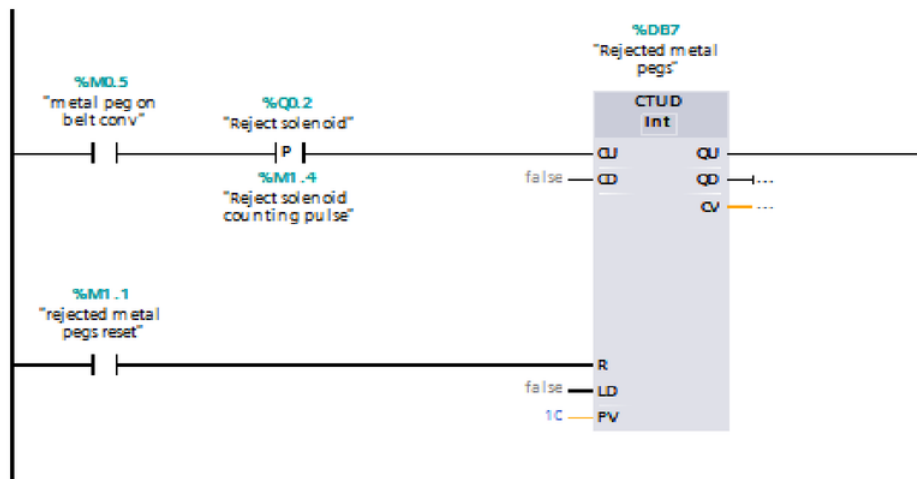


Figure 29: Network 9

Network 10

In network 10 if there is no metal peg detected and the “reject solenoid” Q0.2 is energised then the counter will increment by 1. When the counter reaches the process variable (PV) value of 10 it will output a signal to say that 10 plastic rings are in the reject area. Each input and output have been giving the right name tags with all the required addresses.

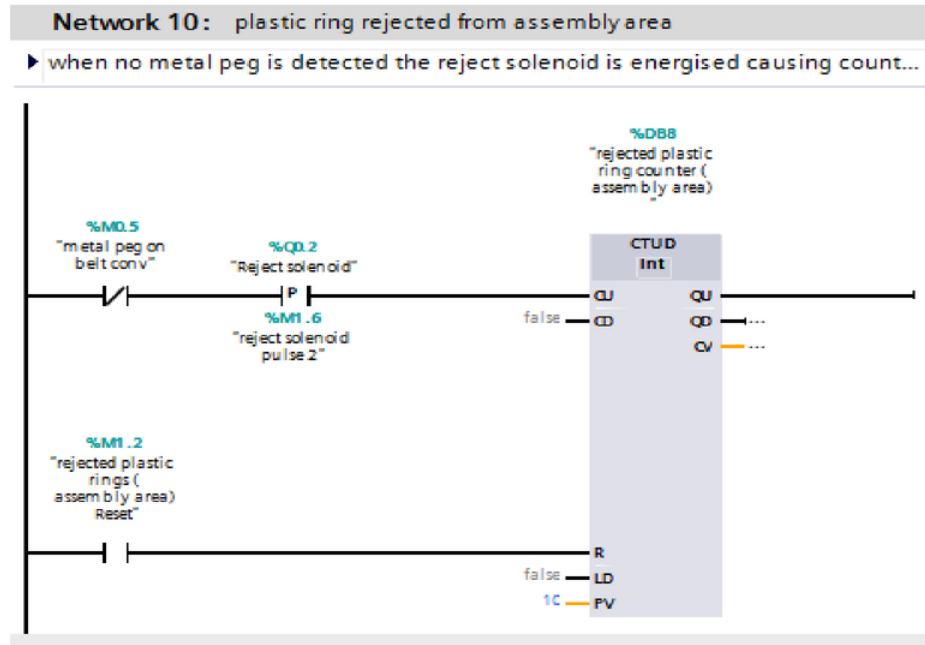


Figure 30: Network 10

Network 11

The last network (network 11) called Assembled product counter counts how many products have been assembled and produced. When a fully assembled product is detected, and it is not rejected, then the counter increments by 1. When the number of assembled products reaches the process variable (PV) value of 10 an output signal from the counter alarms to say that the assembly area is full of assembled products. When the assembled products have been removed, the counter can be manually reset. Each input and output have been giving the right name tags with all the required addresses.

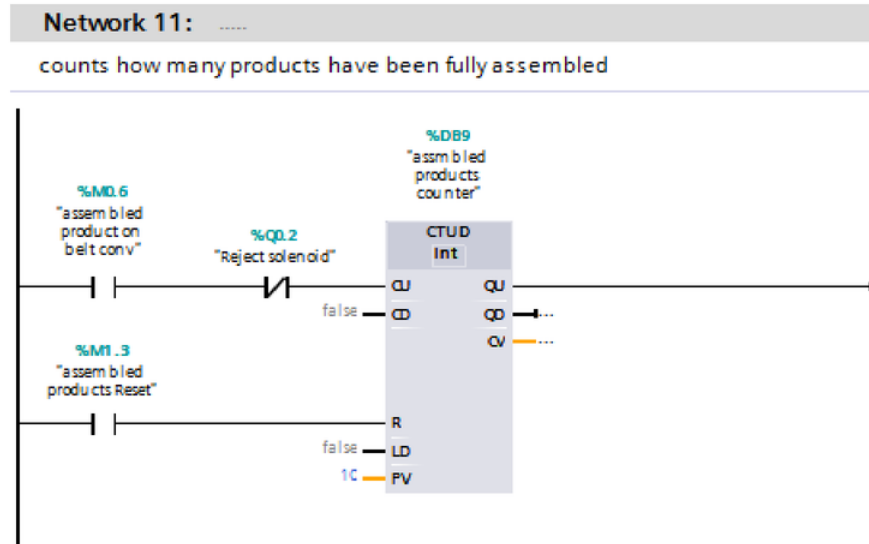


Figure 31: Network 11

[HMI Screen](#)

Apart from designing the program, a HMI screen also had to be designed to help control the conveyor, carry out tests and to help assist the operator/engineer. Below is the operator HMI screen that was used which includes 5 counters, a queue counter with a light that goes red when full next to it, a rejected plastic ring sort area counter, rejected plastic rings assembly area counter, rejected metal pegs counter, assembled products counter and a light that will turn on if there is a ring in the assembly area. The operator screen also shows at the top left corner two lights which will shine green if the chain conveyor and belt conveyor are running.

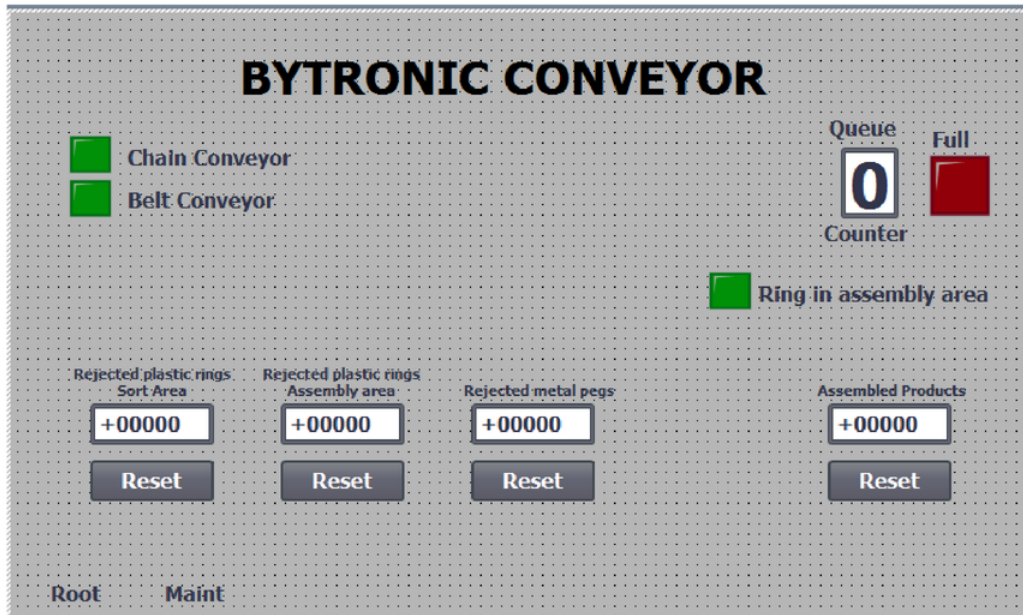


Figure 32: Operator HMI screen

Below is the maintenance screen that was also used for the operation. In a real-life situation this screen would only be accessed by an engineer. On the left-hand side of the screen there is a list of inputs that will light up every time the contacts are energised. At the centre of the screen is a list of outputs that again will light up every time the output contacts energise. On the right-hand side of the screen are three test buttons to manually test all three solenoids, the sort solenoid, rotary solenoid and the reject solenoid.

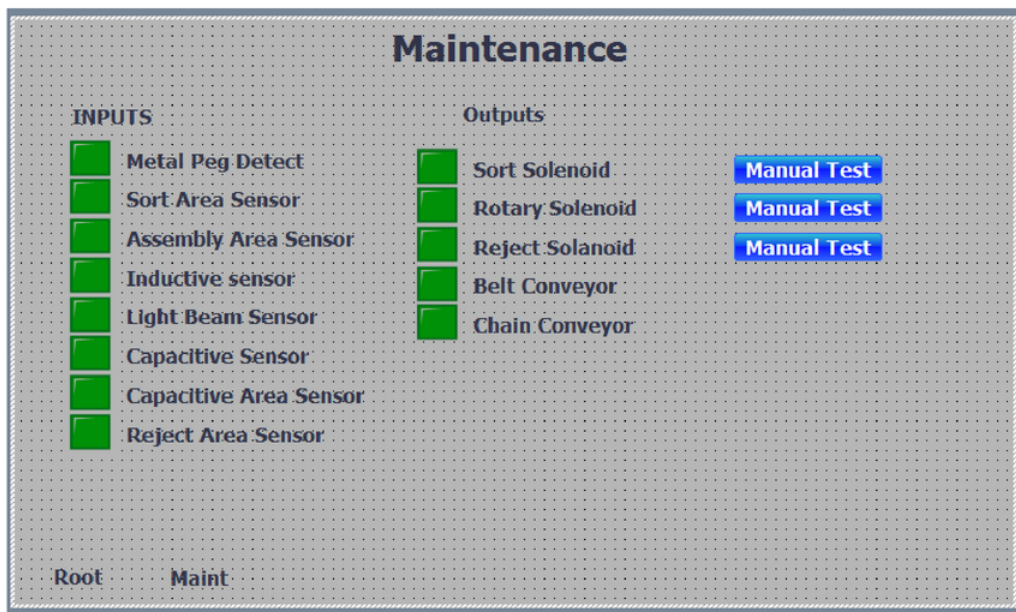


Figure 33: Maintenance HMI screen

4. System Testing and Evaluation

Table of Testing with results

Before anything could be considered complete, the system and program would need to be function tested. Testing is important as part of the design process. Whilst working with Adam and John we carried out tests through out and individually came up with a table of results which is shown below.

Number	Description	Expected result	Actual result
#1	Switch on	Both conveyors should start	Both conveyors came on
#2	Place ring on chain conveyor	Push down chute	Plastic ring has been pushed down the chute
#3	Metal peg on chain conveyor	Not pushed down chute	Metal peg has not been pushed down the chute
#4	Queue counter	Only 5 should be pushed down	Only 5 plastic rings have been pushed down the chute
#5	Place ring on chain conveyor	Rotary solenoid should drop into assembly area	Rotary solenoid drops into assembly area
#6	Plastic ring on belt conveyor	Plastic ring gets rejected	Plastic ring is rejected
#7	Metal peg on belt conveyor	Metal peg gets rejected	Metal peg is rejected
#8	Inverted assembled product on belt conveyor	Inverted assembled product gets rejected	Inverted assembly is rejected
#9	Correctly assembled product	Corrected assembled product doesn't get rejected and goes to assembled product area	Correctly assembled product passes into assembled product area
#10	Reject counter for sort area	Count up by 1 if plastic ring is rejected	Counted up by 1 on HMI screen
#11	Reject counter for plastic ring	Count up by 1 if plastic ring is rejected	Counted up by 1 on the HMI screen
#12	Reject counter for metal peg	Count up by 1 if metal peg is rejected	Counted up on HMI screen by 1
#13	Assembled product counter	Count up by 1 if assembled product passes reject solenoid	Assembled product was counted up by 1

The image below shows the HMI screen that was designed in the Siemens come to real life as a digital display. You can see that the “chain conveyor” and “belt conveyor” are both running correctly as the two lights have come on green. If the lights don’t come on, then that would indicate that both conveyors are not running.

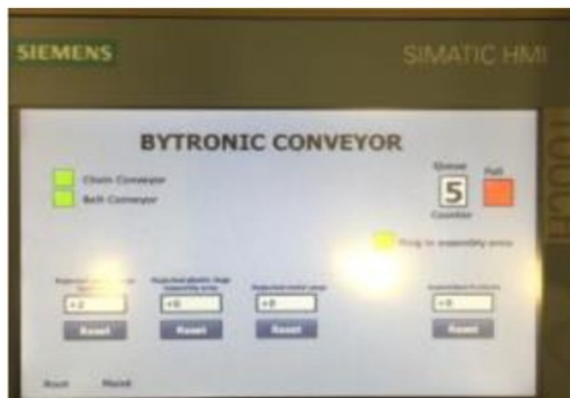


Figure 34: Test chain and belt conveyor

In the image below (figure 35), you can see that the assembly chute is full as the queue counter states that there are 5 plastic rings ready. The light next to the counter has also come on to indicate that the assembly chute is full.

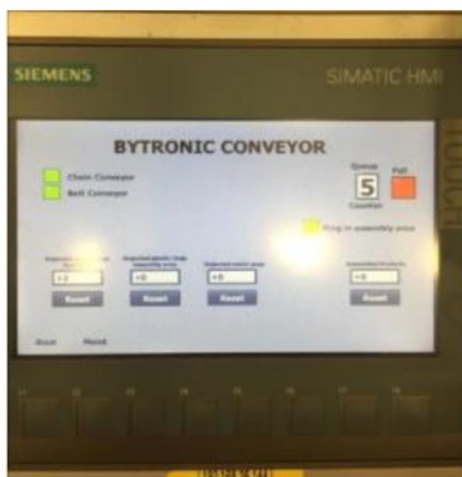


Figure 35: Queue counter HMI screen



Figure 36: Assembly chute full

In the image below (figure 37), you can see that underneath the queue counter there is a green light, this green light tells the operator that there is a plastic ring in the assembly area.

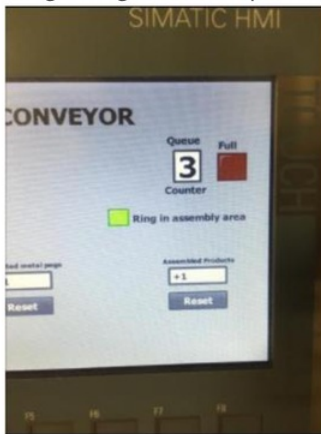


Figure 37: Plastic ring light on HMI test



Figure 38: Plastic ring in assembly area

From the image below (figure 40), you can see that there is 1 rejected plastic ring in the sort area, 0 rejected plastic rings in the assembly area, 2 rejected metal pegs and 0 assembled products.

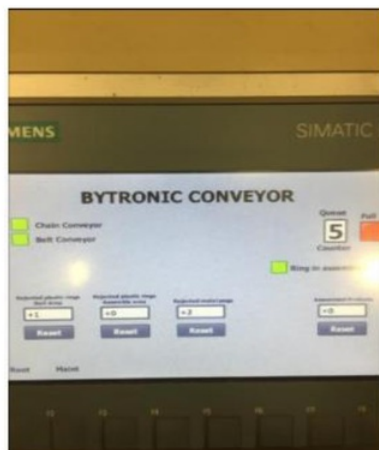


Figure 40: Test HMI screen



Figure 39: Rejected metal pegs

In the image below (figure 42), you can see that the counter tells us that there is one assembled product in the assembly area.

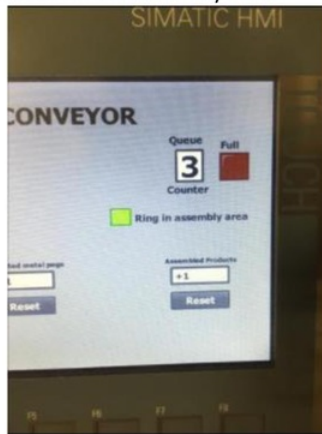


Figure 42: Assembled product counter HMI test



Figure 41: Assembled product in assembled product area

5. Conclusions and Recommendations

Overall the practical objectives proved to be successful as the program was able to carry out all the lab works set when tested. The two HMI screens proved to be very effective also, as it was easy to operate and control all the outputs with ease including the manual testing buttons. I found the research we had to carry out helped me a lot when it came to design the program which was a on siemens S7.

Even though the program was successful, there are still some improvements and recommendations that could be added to it, for example:

- A simple start/stop circuit with a push buttons or through the HMI screen to start and stop the conveyors, instead of switching on and off the power to the PLC.
- An emergency stop push button could have been installed as a safety consideration, this would be in case something went wrong. This could be a jam up of objects or a person's piece of clothing getting jammed in the conveyors.
- If no metal peg is detected on I0.4 for a certain length of time, the bottom belt conveyor could have been stopped, saving money and energy. As the top chain conveyor needs to run continuously, when a metal peg is detected it would start the bottom belt conveyor in readiness for the metal peg coming down the feeder chute.
- When the assembly chute is full, any more plastic rings will go into the overflow basket. A return conveyor could have been designed to feed the plastic rings back onto the infeed of the chain conveyor, thus making the system more efficient.

6. Collaboration

Collaborating and working as a team meant that the work load was shared out, tasks and objectives were completed much faster with a better standard. We proved this as we had no problems with our program what so ever and managed to finish all the practical objectives and tests within the time we were given. For this assignment I collaborated with Adam and John, we all took it in turns to do something different. For example; Adam would start the program and carry out the tests on the conveyor, myself would constantly be checking the HMI screen to see if all the counters, reset and test buttons were working correctly and making sure the correct data was being shown, and John would write out the results of the test. We would change this around every time we added something new to the program. Myself, Adam and John would take it in turn to design parts of the program with each other's help and guidance.

7. Citation list

References

AG, 2016. Basic Controller Simatic S7-1200. *Central proceedings units*, pp. 1-5.

AMCI, n.d. *What is a PLC*. [Online]

Available at: <https://www.amci.com/industrial-automation-resources/plc-automation-tutorials/what-plc/>

[Accessed 23 10 2017].

An Introduction To The Plc Information Technology, 2015. *An Introduction To The Plc Information Technology Essay*. [Online]

Available at: <https://www.ukessays.com/essays/information-technology/an-introduction-to-the-plc-information-technology-essay.php>

[Accessed 14 10 2017].

Aries, B., 2016. *The types og PLC's*. [Online]

Available at: <https://www.techwalla.com/articles/the-types-of-plcs>

Bekhoff, n.d. <https://infosys.beckhoff.com>. [Online]

Available at:

https://infosys.beckhoff.com/english.php?content=../content/1033/tcplccontrol/html/TcPlcCtrl_Languages%20IL.htm

[Accessed 21 11 2017].

Conrad, 2015. *Conrad.com*. [Online]

Available at: [https://www.conrad.com/ce/en/product/197335/PLC-controller-Siemens-CPU-1211C-DCDCDC-6ES7211-1AE31-0XB0-24-](https://www.conrad.com/ce/en/product/197335/PLC-controller-Siemens-CPU-1211C-DCDCDC-6ES7211-1AE31-0XB0-24-Vdc;jsessionid=0AE876B2A8D50A5E5B902DC48DC11359.ASTPCEN19)

[Vdc;jsessionid=0AE876B2A8D50A5E5B902DC48DC11359.ASTPCEN19](https://www.conrad.com/ce/en/product/197335/PLC-controller-Siemens-CPU-1211C-DCDCDC-6ES7211-1AE31-0XB0-24-Vdc;jsessionid=0AE876B2A8D50A5E5B902DC48DC11359.ASTPCEN19)

[Accessed 23 11 2017].

Mohapatra, D., 2013. *Instremuntation Devices and systems*. [Online]

Available at: <http://debashish.info/e-learning/ids/plc.html>

[Accessed 27 11 2017].

NovaTech, 2017. *www.Novatech.com*. [Online]

Available at: <https://www.novatechweb.com/substation-automation/math-and-logic/>

[Accessed 15 11 2017].

Oatewell, 2014. *Oatewell.com*. [Online]

Available at: <http://www.aotewell.com/siemens-plc-simatic-plc-siemens-controller>

[Accessed 2 12 2017].

Peter, 2015. *Ladder logic example and PLC programming examples*. [Online]

Available at: <http://www.plcademy.com/ladder-logic-examples/>

[Accessed 23 11 2017].

Peter, 2015. *PLC Programming & Automation Online*. [Online]

Available at: <http://www.plcademy.com/structured-text-tutorial/#what-is>

[Accessed 21 11 2017].

- Readingrat, 2017. *readingrat.net*. [Online]
Available at: <http://readingrat.net/plc-block-diagram/plc-solutions-block-diagram-of-plc-4/>
[Accessed 25 11 2017].
- Reichelt, 2016. *Reichelt.com*. [Online]
Available at: <https://www.reichelt.com/de/en/SIMATIC-Extension-Modules/SB-1221-24V/3/index.html?ACTION=3&GROUPID=7639&ARTICLE=116629>
[Accessed 25 11 2017].
- Rosandich, R. G., 2002. *EC&M*. [Online]
Available at: <http://www.ecmweb.com/content/what-know-about-plc-ladder-diagram-programming>
[Accessed 21 11 2017].
- Siddiqui, K., 2014. *bayt*. [Online]
Available at: <https://www.bayt.com/en/specialties/q/71985/what-are-the-difference-between-fixed-modular-rack-plcs/>
[Accessed 3 11 2017].
- Siemens , n.d. *www.siemens.com*. [Online]
Available at: https://w3.siemens.com/mcms/programmable-logic-controller/en/advanced-controller/Pages/Default_alt.aspx
[Accessed 1 11 2017].
- Veeramani, A., 2007. *www.controleng.com*. [Online]
Available at: <https://www.controleng.com/single-article/function-block-diagrams/ca572fcc91f7fe98f033fe57cff822b2.html>
[Accessed 21 11 2017].
- Wal, E. V. D., 2010. *PLCopen*. [Online]
Available at: http://www.plcopen.org/pages/benefits/program_development/
[Accessed 18 11 2017].
- Walter, T., 2007. *Control Engineering*. [Online]
Available at: <https://www.controleng.com/single-article/ladder-logic-strengths-weaknesses/ec6693edddc35cc540de3f395f5416a5.html>
[Accessed 21 11 2017].
- Whitlock, S., 2014. *Contact and coil*. [Online]
Available at: <http://www.contactandcoil.com/automation/industrial-automation/good-function-blocks-bad-function-blocks/>
[Accessed 16 11 2017].
- Wijesekara, N. T., n.d. *Scribd*. [Online]
Available at: <https://www.scribd.com/document/321054829/What-Are-the-Advantages-and-Disadvantages-of-PLCs-Over-Micro>
[Accessed 6 11 2017].

PLC assignment 1 - Bytronic industrial control trainer PSDE

4005 Nicholas Devoy

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

72/100

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GRADING FORM: CSG-RUBIC

NICHOLAS DEVOY

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RESEARCH-INFORMED LITERATURE



Section 1: Your research - Evidence of research for PLCs and languages. Further marks were available for more details of performance data from manufacturers and machine applications for PLCs together with a more accurate description of languages and details of their applications. (9/15)

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Section 8: Your use of Harvard for citing and listing
- Good range of sources listed. Further marks were available for more accurate use of Harvard method of listing and citing of credible sources without the inclusion of course notes. (3/5)

KNOWLEDGE AND UNDERSTANDING

 Section 2: Hardware Description and I/O list - A good overview diagram linked to a good I/O list with helpful photos of each device and area of the machine with some good descriptions. Further marks were available for a more description of all devices in the system and information about the HMI. (7/10) Section 3: Program Explanation – Detailed explanations given for each network and HMI screen. (8/10)

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ANALYSIS

 Section 4: System Testing and Evaluation - A good number of tests carried out with supporting photos. Further marks could have been awarded for linking evidence to each test number and an overall evaluation in this section. (6/10) Section 5: Conclusions and Recommendations - Some good conclusions and recommendations given. However, these should have been limited to software recommendations which could have included a tracking system to allow more than one assembled product to pass along the belt at a time. (7/10)

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PRACTICAL APPLICATION AND DEP.

 Section 3: Program Design and Network Comments
- A well designed program with helpful features for

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maintenance and operation with some detailed in-program comments. (8/10) Section 3: HMI Screen Designs – Excellent screen designs that are easy to read. (10/10) Section 4: Presentation of Test Results - Results are well presented in a table with helpful photos. However, these could have been linked to each test number. (7/10)

SKILLS FOR PROFESSIONAL PRAC.



All sections - Very good structure with a helpful list of figures. Further marks were available for a better writing style with the avoidance of personal references except for the collaboration section. (4/5) Section 6: Team working - A good explanation given but further detail would have gained extra marks. (3/5)

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