

1909753

by Aaron Rees

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Name: Aaron Rees

University Number: 1909753

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Table of Contents Good Structure

Table of figures/tables	3
1. Research	4
2. System Overview and Operation	5
3. Health and Safety, Maintenance and Reliability Requirements	7
4. System Design Adaptation	9
4a	9
4b	11
4c	12
4d	13
4e	14
4f	15
Table of test results	16
5. Conclusions and Recommendations	17
6. Team Working	18
7. Citation List	19

You have forgotten to switch on page numbering, without this, the table of contents is meaning less.

Table of figures/tables

Table 1.....7

Table 2 16

Figure 1 5

Figure 2.....6

Figure 3.....6

Figure 4.....9

Figure 5.....10

Figure 6.....10

Figure 7 11

Figure 8.....12

Figure 9.....13

Figure 10.....13

Figure 11.....14

Figure 12.....15

1. Research

The current stage of industry has reached the stage of industry 4.0. Industry 4.0 essentially means that industry these days uses newer technology and sensors to create and improve upon automation systems for as much of the industry as possible (BECKHOFF, 2020). This allows more ways to connect physical aspects of machines with the digital side of technology and allow for PLC's and HMIs to control a varied array of physical machines and to attempt to reduce the amount of human interaction with the machine itself, rather just the HMI or the digital side of the process (Control Engineering, 2007). This allows fault finding to become easier as the sensors can detect the problem and display it on the HMI for the use of the engineer for an easier fix (PLC Academy, 2018). This would allow for quicker fixes and less time on the machine which would cause less downtime on the machines making industry safer, easier and more profitable (PLC dev, 2011). Industry 4.0 not only makes controlling machines easier using software, but it also allows for connection between machines to be made allowing for software on multiple machines connect and give information to each other allowing for the machines to work together more effectively. A piece of technology that allows this process of communication to be simple and easy is the IO link (WI Automation, 2020). This piece of equipment is a serial communication protocol, this piece of equipment makes communication to and from sensors and actuators simple and easy (PLC talk, 2017). This gives more configurability to specific control methods and PLCs to have more control over their specific system. This tool improves the current sensors and actuators of a machine by having extra configurability options. This allows the engineer to find faults easier and control the processes of the system much more efficiently (Siemens, 2018).

This part of industry 4.0 which allows for connection between machines has been given the term M2M (Machine to Machine) (I scoop, 2020). As the name suggests this means connections between machines allowing for the exchange of information allowing for a smoother control and processing system. This is a way of creating a network of PLC controlled machines all communication fluidly and efficiently (tech target, 2019). This will help fault finding even further as, when a fault is found in one system all the other systems can be alerted to adapt to the fault by either adjusting setting or stopping the system entirely. This will help prevent damage to the systems from a fault and allow the engineer to find and fix the fault much easier. M2M typically uses profinet to transfer data between all the machines, sensors and actuators within the network (Adaptive Modules, 2020).

2. System Overview and Operation

Figure 1 shows the overview of the CIM system. As can be seen there are 6 separate PLC each with their own small system that they control. Within the whole system there are 5 station around the conveyor belt of the system.

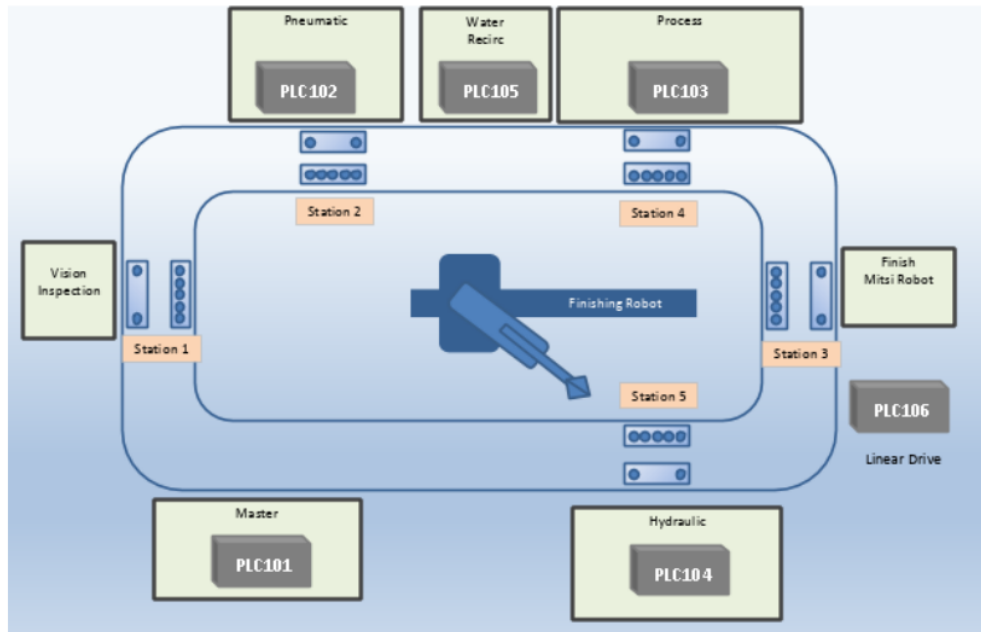


Figure 1

On the CIM systems conveyor belt, there parts which are called wagons. The serve as holders for the components to be moved around the conveyor belt between the stations. Each of these wagons contain a binary code unique to each individual one. These codes are shown on the underside of the wagon. These codes are then read by the sensor on each of the station to identify the wagon and display which station it is currently at. This will be displayed the main HMI screen. There is also a second sensor at each station which tells the PLC when the wagon is at the station to then drive a piston to act as a stop for the wagon.

Figure 2 shows the wagon on the conveyor belt. As can be seen at the top of the wagon the binary code can be seen. The sensor on the bottom left of the wagon detects when the wagon is at the station. The other dot on the bottom right is the actuator which will tell the PLC to release the wagon to move to the next station.

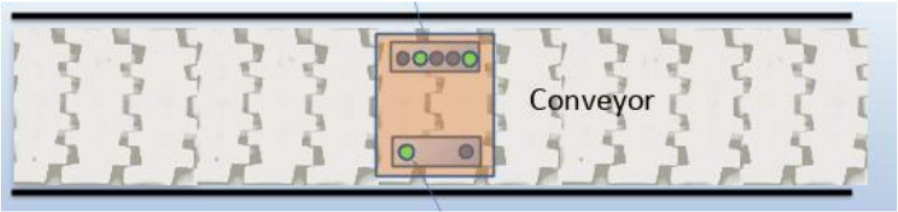


Figure 2

To create the program to control this system, Siemens TIA Portal was used. Which allows for multiple languages to be used to create programs such as LAD, FBD and SCL. To adhere to industry 4.0, all the PLC's are connected using profinet cabling. This network is shown in figure 3. The master PLC in this network which is named PLC 101 has data blocks for all of the slave PLC's which contain the GET and PUT signals. These then get sent to the other PLC's which contain the GET and PUT bits. Certain connections within the system are hardwired whereas some other connections are M2M connected.

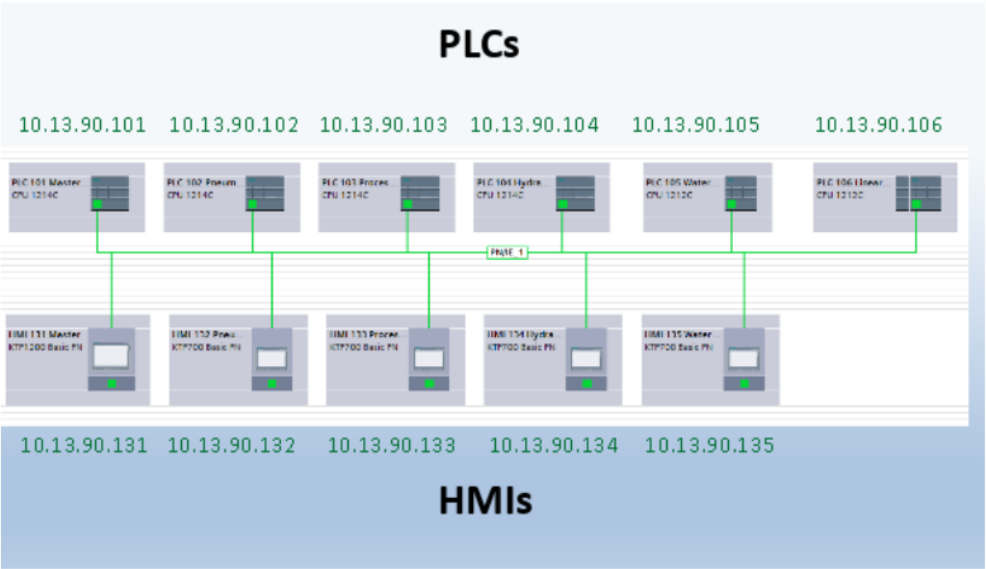


Figure 3

3. Health and Safety, Maintenance and Reliability Requirements

Table 1 in this section shows the results of the risk assessment carried out by the author on the CIM system.

Hazard	Person at risk	Seriousness (0-5)	Likelihood (0-5)	Combined score (Multiplied)	Current control method	Recommended control method	Seriousness (0-5)	Likelihood (0-5)	Combined score (Multiplied)
Electricity	Anyone within the area of the CIM system	5	1	5	Warning signs around the machine, interlocked handles on panel doors.	Only authorised personnel to have keys to the panel	5	1	5
Trip hazards	Anyone within the area of the CIM system	2	3	6	Signage, trunking and cable covers	Regular cleaning to ensure tidiness around the machine	2	2	4
Moving parts	Anyone within the area of the CIM system	4	3	12	Some shielding and only authorised personnel allowed in the room	More shielding, and the addition of laser guards	4	1	4
High air pressure /Hydraulics	Anyone within the area of the CIM system	3	1	3	only authorised personnel allowed in the room	Regular maintenance on the hydraulic	3	1	3

Table 1

For maintenance purposes of the CIM systems there are several ways to ensure maintenance is easy for the engineer. This is done by having several diagnostic and maintenance screens on every HMI to allow the engineer to see how each section is operating and if it is operating to the correct standard. There are several things on this machine that needs regular maintenance in order to ensure quality and safety. Some of these aspects were explored in the risk assessment such as the hydraulic and pneumatic systems. These can cause harm or damage if not maintained properly.

4. System Design Adaptation

This section shows the modifications made to the existing CIM system.

4a

In order to allow for connection and control between all the PLCs in the network. Certain inputs and outputs must be created in the tag list for each plc. These were named GET and PUT inputs. The purpose of these inputs is to take the physical data into digital data which can be stored in a data block which can be accessed by all the PLCs. This is done by adding a could in parallel with a physical output or input and tagging it to relate to an overall data block which can be accessed by all PLCs. Once that is done then the Master PLC must be programmed to bring all the other PLCs online when the CIM system starts up. As can be seen in figure 4-6, when the CIM run is activated then all other station and PLCs receive a signal to go online to start communicating with PLC 101.

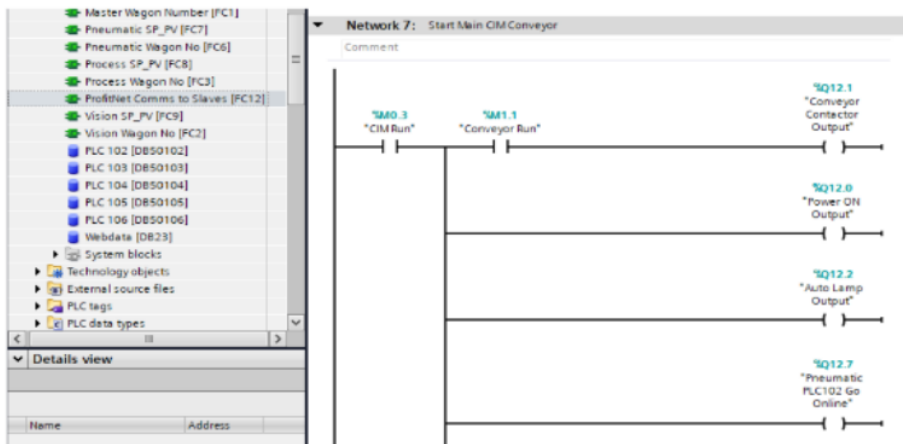


Figure 4

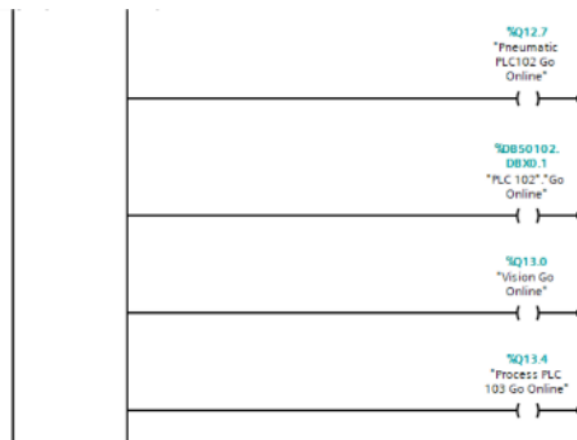


Figure 5

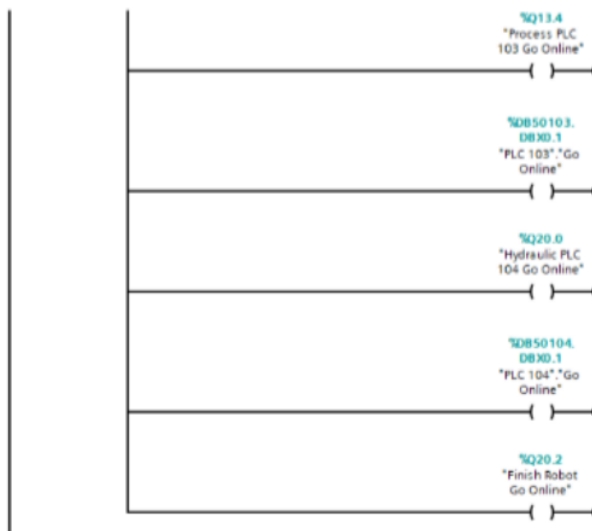


Figure 6

4b

To allow for the main PLC to control the linear drive in PLC 106, the real value of the linear drive need to be converted into an integer. This was achieved by placing a 'real to int' converter into the program. This can be seen in network 12 shown in figure 7. As can be seen the input from the linear drive is labelled as 'Encoder Scaled Distance' which then gets converted into an integer and the named 'Linear Drive Distance Unit' which is part of PLC 101s tag list.

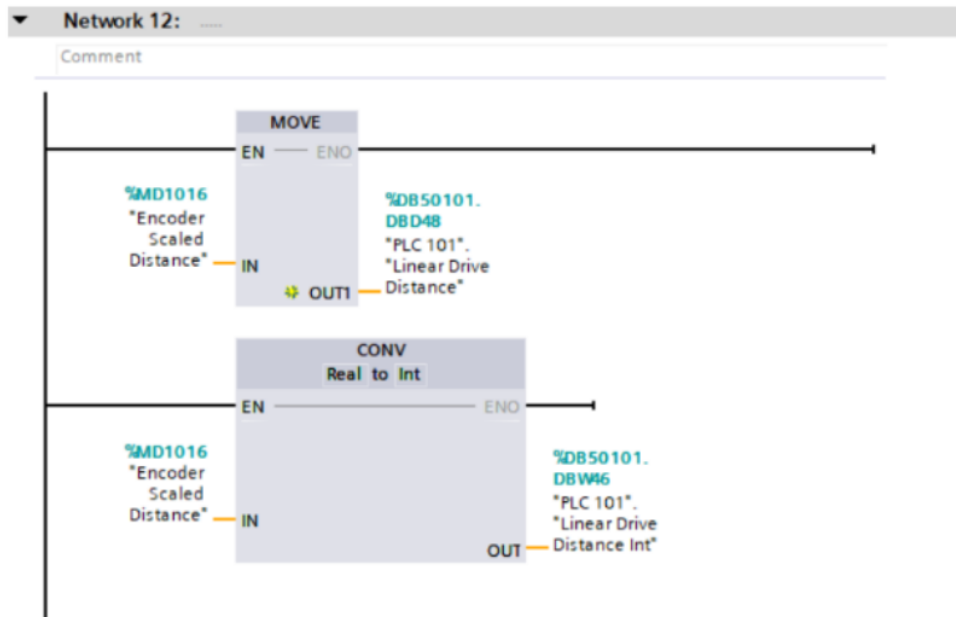


Figure 7

4c

In this section of task 4 the HMI screen showing the overview of the CIM system was modified to show the current location of the Mitsubishi robot. Figure 8 shows the improved version of the HMI. This was modified by removing the old image of the robot for this new image. This new image depicts a long blue box which is the track the robot moves along, and then the gripper can be seen on the left which will move along the track as the robot does. This was done by creating a movement command to the properties of the gripper section which limits applied. The limits were taken from the finishing distance of the encoder value. This was then tagged 'Linear Encoder Distance'.

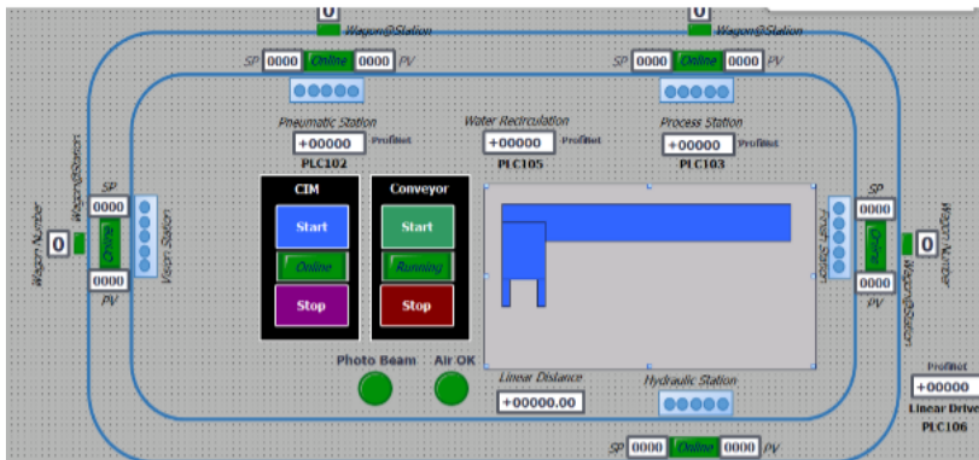


Figure 8

4d

For better ease of use of the CIM system, 2 additional HMI screens were created for diagnostic purposes. The screen shown in figure 9 is used to monitor and control the process station from the main HMI131. For this to be controlled from the main HMI, GET and PUT bits had to be input into the PLC tags on both the main PLC 101 tag list and the slave PLC 102 tag list. These both must be changed to be the same to allow for this to work.

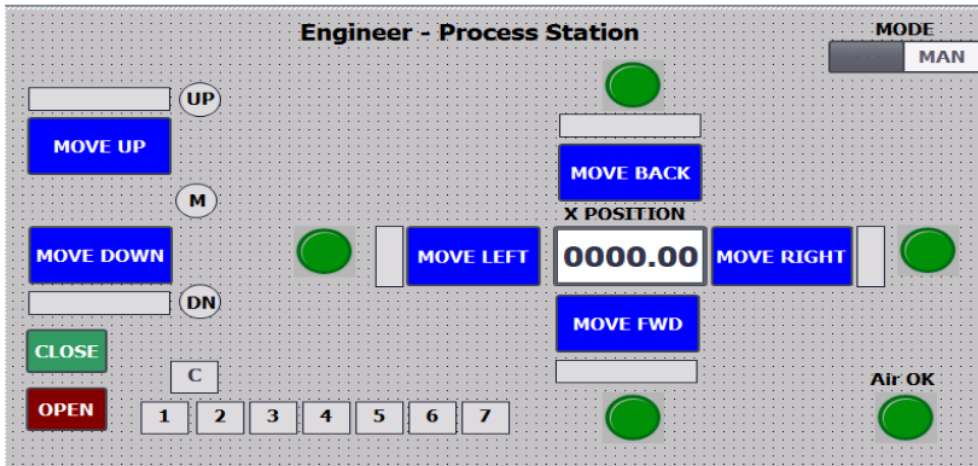


Figure 9

Figure 10 shows the second HMI diagnostic screen used to monitor and control the linear drive and the pump as part of the hydraulic station. The same had to be done with the PLC tag lists for both PLC's. This had to be done for PLC 101 and PLC 104

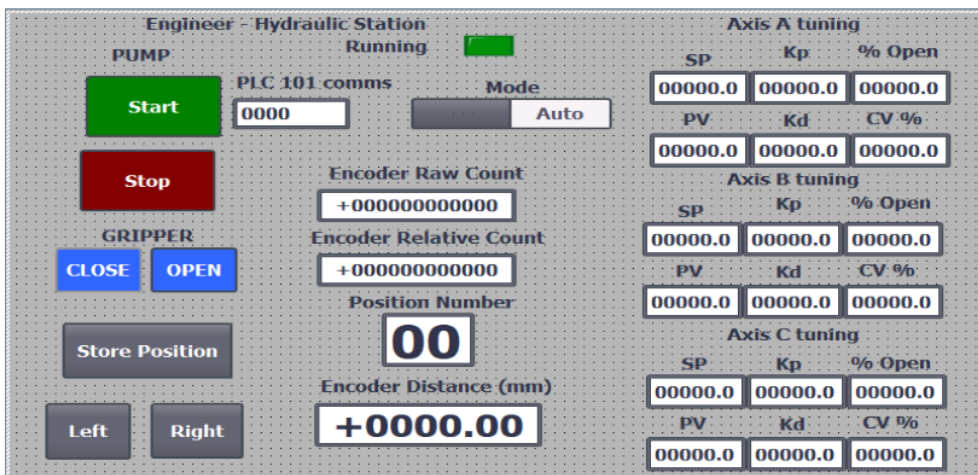


Figure 10

*You have included controls for PLC106
also without you knowing it.*

4e

For task 4e an interlock was added into the code to prevent the conveyor belt from running if the air pressure was not above a certain level. This was done by creating a PLC tag named 'Air Ok' which was placed in the PLC 102 tag list. This tag is then placed as a normally open contact on the conveyor run network on PLC 101. This would only allow for the conveyor to move when the air pressure is high enough allowing for the contact to close. This is an example of one PLC connecting with another PLC as part of industry 4.0. Figure 11 shows the network coded in LAD.

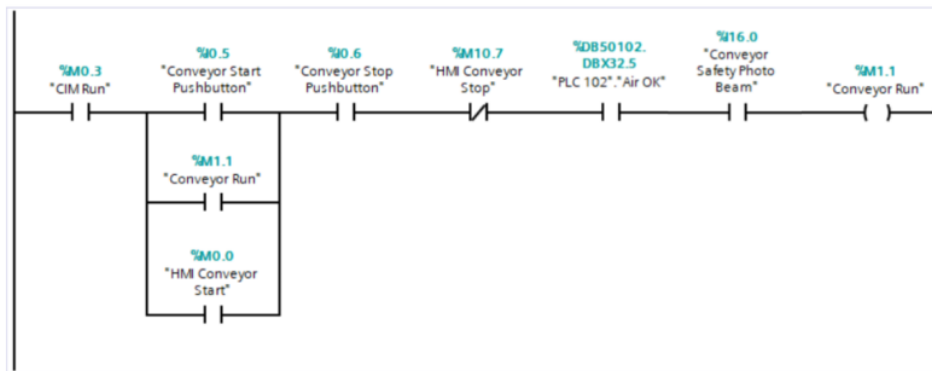


Figure 11

4f

For task 4f, the water recirculation screen was improved to contain more information on the master HMI. As opposed to the original screen this screen shows the comms between the master PLC 101 and PLC 105. A switch was also added to control the mode of the flow. A display was added to show the value of the PWM duty cycle. Figure 12 shows the Water recirculation diagnostic screen on the Master HMI.

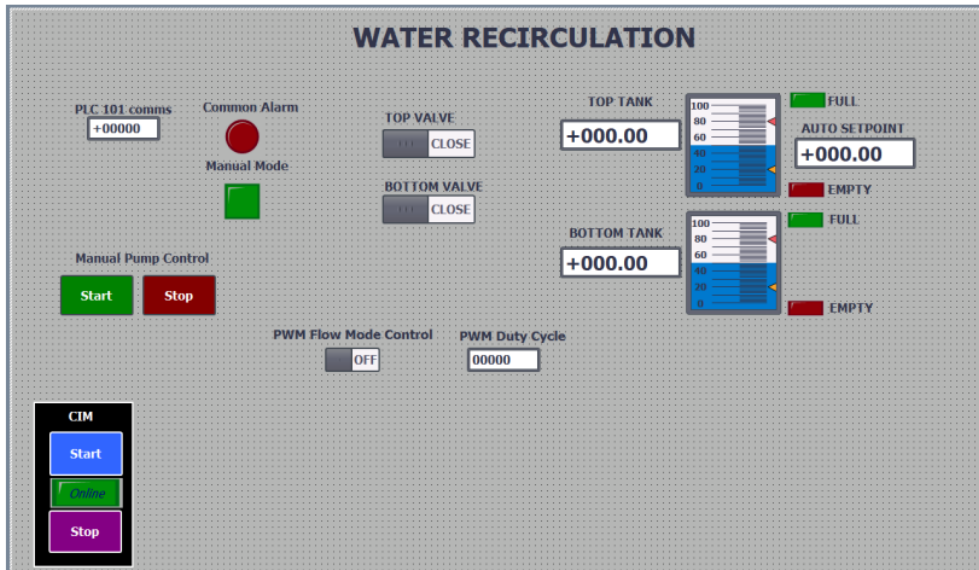


Figure 12

Table of test results

Table 2 shows the results of the tests carried out on the CIM system after the modifications were made to the system. As can be seen the tests were successful as they all were passes.

This means that the changes made to the CIM system worked effectively.

Test	Desired result	Actual result	P/F
Air pressure acceptable	The lamp should light up when the air pressure is acceptable.	The lamp illuminated when the air was okay and turned off when the air was low.	P
Air pressure conveyor interlock	The conveyor should not move when the air pressure is not high enough.	The conveyor would not move until the air pressure was ok.	P
Mitsubishi robot animation	The animation on the HMI should mimic the actual movement of the robot.	The HMI animation displayed the correct movements that robot did.	P
Linear drive counter	The counter should start counting correctly.	The counter began counting correctly.	P

Table 2

You could have added a 5th column for evidence to support your test results

Photographic evidence is needed to see the screens in action

5. Conclusions and Recommendations

Through this assignment the author learned more about industry 4.0 and how M2M is implemented and used, and why it is used. Also, the benefits of using these new advancements in technology improve different aspects of industry and automation. Using the research, industry4.0 was put into practise by adapting the CIM system to suit industry 4.0. This was done by connected multiple PLC's and HMIs in a network and allowing them to work off each other using signals such as the GET and PUT signals. The assignment also improved the authors risk assessment skills by allowing the author to assess the CIM system for hazards and think of suitable and effective ways to reduce the risks. This also allowed the author to further understand how the CIM systems operates. By looking at each PLC's code and how the sensors and actuators are laid out and coded.

In task 4, modifications to the program and HMI screens were made to better suit industry 4.0 and to improve the whole operation of the system. The table in the results section of task 4 shows that the improvements were successful in their goal to improve the overall performance of the system.

In terms of recommendations for the CIM system. A safety screen could be added to master HMI which could display all the safety features currently ongoing withing the machines such as the safety sensors and E-stop placed around the system. This screen would manage the safety system of the system as it could pinpoint were a safety breach happened and would log the breach. This would allow the engineer to find the problem with ease and fix it. This would also allow the engineer to see common safety failures by looking at the log showing all safety failures that there have been. This could then be used to think of ways to minimise the amount of safety failures and improve the overall safety of the CIM system.

6. Team Working

As part of the assignment, it was necessary to work as part of a team to complete certain sections of the assignment. The team that was put together included the author, Jason Sanger, Josh Rees and Ethan Joel. In this group the author had the role of changing and improving the HMI screens. Josh's role was to add the program changes for the CIM systems. Ethan's role was to test the operation of the system whereas Jason's role was to test the safety features of the system such as the interlock.

7. Citation List

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Instructor

59

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PAGE 1

PAGE 2

QM

Good Structure

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Text Comment. You have forgotten to switch on page numbering, without this, the table of contents is meaning less.

PAGE 3

PAGE 4

QM

Repetition

Already stated elsewhere, repeating information is considered boring by your reader

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Repetition

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QM

Grocer's apostrophe

If you meant this as a plural word, don't use an apostrophe. This also applies to acronyms and initialisms such as PLCs

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PAGE 5

QM

Spelling

Spelling error

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Punctuation Error

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Repetition

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PAGE 6

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PAGE 10

PAGE 11

PAGE 12

PAGE 13

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PAGE 14

PAGE 15

PAGE 16

Text Comment. You could have added a 5th column for evidence to support your test results

Text Comment. Photographic evidence is needed to see the screens in action

PAGE 17

QM

Grocer's apostrophe

If you meant this as a plural word, don't use an apostrophe. This also applies to acronyms and initialisms such as PLCs

QM

Punctuation Error

Punctuation error

PAGE 18

PAGE 19

GRADING FORM: NEW CSG-RUBRIC

AARON REES

59

1. ENGAGEMENT WITH LITERATURE



Engagement with a wide range of literature, including sources retrieved independently. Selection of relevant and credible sources. Generally sound referencing, with no/very few inaccuracies or inconsistencies. (13/20)

13

2. KNOWLEDGE AND UNDERSTANDING



Competent knowledge of the basic underlying concepts and principles. Exhibits very good

13

understanding. (13/20)

3. COGNITIVE AND INTELLECTUAL

 Good evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data, with minor errors. An emerging ability to use evidence to support the argument. Mostly valid arguments and logical judgements. A good testing table but no evidence of testing to support it. (11/20)

11

4. PRACTICAL APPLICATION

 A very good application of a range of basic methods, materials, tools and/or techniques. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions. (12/20)

12

5. TRANSFERABLE SKILLS

 Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed. Can work effectively independently and/or as part of a team, with clear contribution to group activities. Demonstrates the skills for employment requiring the exercise of some personal responsibility, with some areas of strength and some of minor weakness. Report

10

contain spelling, punctuation errors and some repetition. No paging numbering ! (10/20)