

2117074-carlo

by Carlo Coppola

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Table of Contents

1. Work Plan for Lifelong Learning and Risk Assessment	3
2. Research	4
Current safety legislation that applies to integrated automation systems including SIL and PL ratings, and UKCA/CE marking requirements.	4
Internet security for industrial interconnected systems	5
3. System Overview and Operation	7
4. Health and Safety and the Environment	8
5 - Maintenance, Reliability and Commercial Risk	9
6. Complex System Design – Individual Modifications	10
7. Complex System Design – Team Modifications	11
8. Environmental, Maintenance and Reliability	12
9. Team working	13
10. Citation list	14
Works Cited	14
11. Appendix	16

1. Work Plan for Lifelong Learning and Risk Assessment

The first steps to take to complete this assignment will be to carry out the appropriate research into current legislation that is relevant to Automated systems including SIL and PL ratings. UKCA/CE marking, legislation requires these markings to be on equipment. When our knowledge has improved with regards to the legislation, we will begin to look at our system to be worked on and reference the legislation in the risk assessments that will be produced before work is carried out. Next steps are to produce an overview of the CIM system showing how the subsystems connect, the system in place is a M2M (Machine to machine) where data is exchanged between devices in the network (Shea, 2019).

Write in the third person

The wagon tracking station, camera inspection station and the robot including the arm and slider will be looked into more detail how they are operated and most importantly what improvements to the system that can be made. The suggestions can include safety requirements, as we are going to be looking at the legislation for the system, we can point out what legislation it doesn't meet, is the system sufficiently guarded? Is it safe to carry out maintenances? Is the machine "Fail safe", these are the questions we are going to be asking ourselves.

The next focus areas are to calculate the expected time our implemented systems will fail, this will be calculated using equations that can be found in the legislation. We will then need to think about how the CIM is going to impact the environment and society and what steps can be made to minimise or eliminate these risks.

Individual work is to be carried out to improve the CIM as well as a teamwork exercise to further improve the system, these improvements are provided. Programme alterations and other changes will be shown in the appendix and explained why the changes have been made in this report to better conform with the regulations, modifications made can be tested by Simulating the PLC with the HMI put into a simulation mode. The group exercise will be improvements on the VoT (View of things) web page. The changes made here will be tested live on the CIM, taking screenshots of the VoT page to gather and represent data to produce our findings. Once all the data is gathered a conclusion and recommendations section will be filled out.

2. Research

Current safety legislation that applies to integrated automation systems including SIL and PL ratings, and UKCA/CE marking requirements.

SIL (Safety integrity level)- A SIL has 4 levels and is the measurement of the functional safety of a given system, its grading where the higher the SIL value a system is given the greater the risk of failure as these references the probability of failure which can be found in ISO 13849-1 (safety of machinery) showing the overlap between PL and SIL.

Table 4 — Relationship between performance level (PL) and safety integrity level (SIL)

PL	SIL (IEC 61508-1, for information) high/continuous mode of operation
a	No correspondence
b	1
c	1
d	2
e	3

Figure 1 PL and SIL overlap (ISO, 2009)

SIL can be referred to mainly in IEC 61508-1 where values are given to represent the risk of failure.

Safety Integrity Level	Probability of Failure on Demand	Risk Reduction Factor
SIL 4	$\geq 10^5$ to $< 10^4$	100,000 to 10,000
SIL 3	$\geq 10^4$ to $< 10^3$	10,000 to 1,000
SIL 2	$\geq 10^3$ to $< 10^2$	1,000 to 100
SIL 1	$\geq 10^2$ to $< 10^1$	100 to 10

Figure 2 SIL table (Bellairs, 2019)

SIL applies to all devices that use an electronic and programmable control system. (Meyer, 2019).

PL (Performance level)- There are 5 levels, they are graded A, B, C, D and E. They are given to equipment to indicate the equipment's average probability of a dangerous failure for that component, per hour. Engineers can use ISO 13849-1 to guide them in designing the safety system through a set process for safety related parts of a control system. PL is very similar to SIL however the application differs where SIL follows IEC 62061 which has no performance requirements for non-electrical safety devices, this includes mechanical devices driven by hydraulics and pneumatics. As they are similar there is a table to show the direct relation between SIL and PL. (Meyer, 2019) Correctly cited

PL	Mean probability of a critical outage [1/h]	SIL
a	$\geq 10^{-5}$ to $< 10^{-4}$	-
b	$\geq 3 \times 10^{-6}$ to $< 10^{-5}$	1
c	$\geq 10^{-6}$ to $< 3 \times 10^{-6}$	1
d	$\geq 10^{-7}$ to $< 10^{-6}$	2
e	$\geq 10^{-8}$ to $< 10^{-7}$	3

*Figure 3 Relation between SIL and PL
(Meyer, 2019)*

This table is only to represent the relationship and should not be used as a conversion between the two as their applications are for separate legislation.

UKCA/CE/UKNI- These markings are to indicate that the product meets all statutory requirements to be sold in the designated region by the manufacturer or representative of the manufacturer. UKCA is new legislation that will be replacing CE, the UKCA is marked on products that meet british statutory requirements for product being sold in the UK, this change has taken place since Britain have left the EU and no longer are required to have CE marking which is for the European market. Further, Northern Ireland has its own unique UKNI marking that had its change in 2021 and was monitored by 3rd party conformity assessment based in the UK. (UK Government, 2020) (UK Government, 2020). Correctly cited

Internet security for industrial interconnected systems

Industrial control systems or ICS is a broad term given to varying types of control systems and instrumentation which includes the devices, network and any process used to automate the industrial process. Common ICS systems include SCADA (Supervisory control and data

acquisition) and DCS (Distributed control systems) a hybrid of the 2 systems can be used for ICS. As the plant process relies on this system to run we need to protect the servers from viruses and other cyber attacks that could cause issue to the process, this can be done with:

Network segmentation- The purpose of network segmentation is to divide the system into separate hierarchy security zones and that include several layers of protection to protect the safety critical parts of the network. This is done by using a firewall.

Citation Needed

Remote access- to limit unauthorised access safety software and devices such as Firewalls, Virtual Private Networks (VPN), call back (for dial-up), multi-factor authentication, user access control, and intrusion detection provide Layers of security to keep the system safe from any external attacks and unauthorised leaks of company sensitive documentation.

Patch management- keeping the system updated with patches when weaknesses in the systems safety are found is a basic strategy to keep the system safe.

Citation Needed

Access control- by limiting access to certain networks via passwords and removing unnecessary functions and features, the system is able to stay safe with the limited access by authorised personnel.

System monitoring and protection- Monitoring the networks is required to find minor security risks that can tend to go undetected, after some time this develops critical security risks so monitoring the state of the network is important to maintain the integrity of the network safety.

Citation Needed

Training- Its critical that employees using ICS sensitive systems have the required knowledge to understand their roles in using the systems and allows for an active defence form that employees should they themselves see something wrong with the system that has gone undetected.

Incident planning and response- when a problem in the system occurs a record of the methods for tackling issues when they have happened should be kept so its known how to tackle the issue more efficiently, it can also help to keep a record of how to prevent the issue from occurring entirely as to not jeopardize system integrity. (Huq, 2017)

Correctly cited

3. System Overview and Operation

Write in the third person

As you can see in figure 4 the CIM system connects a master PLC to 5 PLCs which are for executing and are all using the master to transfer data between one another and the HMI which are also directly connected. The devices are all connected via ethernet. PLC 101 which is our master is used to store Data, whereas the other PLC contain function and data blocks which it can send to the master PLC. The function blocks contained are GET and PUT functions for the transferring of data between the PLC master and other sub-PLC. Communication is initiated by the sub-PLC.

The wagons are tracked via proximity devices that are stationed underneath each station on the conveyor, a set of 5 PDs are using Binary coding to keep track of the wagon number, there are magnets on the wagons for the PDs to detect. An example for wagon number 6 would be 0110. This allows the PLC to track the wagon as it journeys around the conveyor to the various stations. The stations can be seen in figure 5 of the appendix.

The wagons are inspected during the manufacturing process, they are inspected at the vision station with an IFM 0D200 vision sensor. This is done to make sure the wagon has the correct pallet and scan it to verify that It has the correct orientation, its also used to check the pallet is completed. If there is any error detected by the vision sensor then the wagons contents are disposed of.

What about the assembly robot?

4. Health and Safety and the Environment

All equipment was checked for proof marking of the UKCA/CE marks. This assures us the manufacturer has adhered to statutory regs.

At the start of the Assignment risk assessments were carried out on the CIM set-up and had been found to not meet a number of legislations, 1 area that was particularly noticeable was a lack of guarding around the conveyor rejection station which had frequent movement of the robot arm. According to the risk assessment we followed and all presented criteria when graded it was found the area to be High risk. As this is unacceptable a design was made to guard against any accidents or injury of students should the conveyor not be appropriately isolated. Maintenance may need to be required on this particular section of the conveyor so it was decided that for safety and maintenance purposes that a PILZ safety relay be introduced with the guarding. A safety gate hinge was found from PILZ called a PSENhinge, this hinge would be Electrically interconnected into the PILZ so that unless the gate is closed the PILZ would prevent the line from running. (PILZ, 2023) due to the introduction of a new electrical safety device, legislation ISO 13849-1 was followed to carry out a functional safety check. See figure 7 for the functional safety of the new device. After the implementation of the new design the risk assessment was revised and found to be a negligible risk. Reliability calculations can be found in the appendix figure 8, 9 and 10.

With the new implementations made it eliminated the risk of injuring a person and limited access to the conveyor to authorised personnel, the system is failed safe so that the line can't run unless the gate is closed. This improves the safety of the system for the individuals carrying out maintenance as they can safely work in the guarding with the door opened and the PILZ will prevent any power going to moving parts preventing accidents.

5 - Maintenance, Reliability and Commercial Risk

Make sure all software is up to date and the correct licences are installed before carrying out any maintenances, regular maintenances/audits need to be carried out on the software to ensure there's no risk to the software. To improve the safety of the software I would include the addition of a VPN network to mask the IP address.

Write in the third person

Reliability of the system can be improved by carrying out regular audits of the software and keeping it updated, software such as TIA Portal. In terms of the integrity of the CIM regular maintenance inspections can be carried out on the moving components such as the robot arm. Due to the nature of the CIM it doesn't need to regularly be maintained as the vast majority of the equipment used is automated, however. The robot seems to be extremely outdated with its coding. It doesn't use a common structure and uses a programme similar to SCL in Siemens but instead runs on a constant loop.

This runs the risk of becoming redundant and requiring more specialised personnel to be called should the robot break down stopping production. It also makes it difficult to maintain when using such out dated coding.

There are hydraulics and pneumatics present on the system but it was observed that there's no safety point to isolate these supplies mechanically. I would suggest putting in a pressure release valve but it's not urgent as it's a low-pressure system.

The reliability of the newly installed safety interlocked gate is in question but as seen in figures 8, 9 and 10. It has sufficient safety ratings with current legislation to be trusted as part of the safety systems and can be relied on when maintenance is required in that guarded area.

Paragraphs should be fully justified text as required in the brief

Line spacing should be 1.5

6. Complex System Design – Individual Modifications

To complete this task, I need to implement changes to the HMI and appropriately simulate to prove those changes has worked. These changes are being made to increase the functionality of the CIM system, these changes are to allow the existing system to comply with industry 4.0. changes that are needed to be implemented are supplied by the lecturer.

1. On HMI 131, add the following features:

a. The Engineer Main CIM screen should display the Profinet counters for each station, together with indicators for the Air OK and the Photobeam.

Refer to figure 5.

b. The Assembly Robot Slider should be animated to move from right to left according to the Linear Drive Distance value in the range 0 to 1320mm.

Refer to figure 13.

c. The Engineer Pneumatic Station screen should show the indicators for the handshaking signals sent to and from PLC 102.

Refer to figure 14.

d. The Engineer Process Station screen should show the indicators for the handshaking signals sent to and from PLC 103.

Refer to figure 15.

e. The Engineer Hydraulic Station screen should show the indicators for the handshaking signals sent to and from PLC 104.

Refer to figure 16.

f. The Engineer Water Recirculation screen should show the indicators for the handshaking signals sent to and from PLC 105.

Refer to figure 17.

g. The Engineer Assembly Station Slider screen should show the indicators for the handshaking signals sent to and from PLC 106.

Refer to figure 18.

h. The Engineer Vision Station screen should show the indicators for the handshaking signals sent to and from the camera.

Refer to figure 19.

All were checked In simulation mode, you can see the indicators working in all screenshots where required.

Testing table is missing

7. Complex System Design – Team Modifications

Write in the third person

To complete this part of the assignment we split off into groups. The purpose of this group was to implement changes to the VoT website. We collaborated together to test the programme live using VoT on the CIM system. the tests were done in real time and it could be observed that when using the live data page, the changes were happening on the CIM system. in order for this to have worked we needed to adjust the HMI before starting and toggle the web enabler function to enable the remote control on VoT.

The changes that were requested of us were:

1. For the Main CIM page, add the following

Profinet counter for each station as shown on the HMI, Display Process Station manipulator position and animate the Process Station Manipulator from its position in the same way as the Assembly robot.

Refer to figures 20, 21 and 22.

Figure 20 shows the profinet counters working. Figures 21 and 22 shows movement of the process station from 1126.50mm to 517.60mm.

2. For the Process Station Page:

a. Add information about FC535 loop data – SP, PV, Error, Kp, Ki, Kd, CV plus a graphic object for the PV

b. Add information about LC541 loop data – SP, PV, Error, Kp, Ki, Kd, CV plus a graphic object for the PV

c. Add information about TC511 loop data – SP, PV, Error, Kp, Ki, Kd, CV plus a graphic object for the PV

Refer to figure 23

This shows all displays we generated to represent the values required.

8. Conclusions and recommendations

To conclude, the system in place was lacking some requirements in order to meet the new standards of industry 4.0. we achieved reaching the new standards by following legislation for UK and internationally recognised legislation that were broad and specific to automated systems. Recommendations I can think of are to implement a VPN, this would improve the overall security of the software which was lacking after completing research and comparing to what others are doing. The final recommendation I an upgrade for the outdated robot arm as it's a key component of the CIM system which is running on outdated code.

This is a reflection, you should be concluding your findings

9. Team working

For this assignment small groups of 3 people were formed to complete an assignment task together, we were to improve the existing program with instructions on how to improve the programme supplied to us. Everyone in the group treated each other professionally and worked together to get the task done. Communication was important so we effectively communicated together so everyone understood their roles, if 1 person in the group felt overloaded the others would help them, each member had specified roles that were communicated to 1 another, I was to finish half of the indication upgrades for the HMI engineering screen. All assigned roles were completed effectively and when it came to testing the system worked perfectly, this includes the upgrades made to the VoT. This concluded the team working exercise. Emails were shared between everyone so all the data was able to be easily transferred from one another.

Write in the third person

How did you treat each other?

10. Citation list

Good range of sources

Works Cited

Bellairs, R., 2019. *What Is IEC 61508? How To Determine Safety Integrity Levels*. [Online]
Available at: <https://www.perforce.com/blog/qac/what-iec-61508-how-determine-safety-integrity-levels>

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[Accessed 25 April 2023].

Figure 1 PL and SIL overlap (ISO, 2009)	4
Figure 2 SIL table (Bellairs, 2019)	4
Figure 3 Relation between SIL and PL (Meyer, 2019)	5
Figure 4 CIM system network.....	16
Figure 5 Air ok indication and photobeam added	16
Figure 6 Conveyor risk assessment	17
Figure 7 Functional safety for robot arm.....	18
Figure 8 schematic for new gate	19
Figure 9 reliability calculations	19
Figure 10 reliability calculations part 2	20
Figure 11 2nd hazard evaluation.....	21
Figure 12 3rd hazard evaluation.....	22
Figure 13 animation of slider	23
Figure 14 indication for pneumatics station	23
Figure 15 Indication for the process station.....	24
Figure 16 indication for hydraulics station	24
Figure 17 indication for water recirculation.....	25
Figure 18 indication for assembly station slider.....	25
Figure 19 indication for vision station	26
Figure 20 VoT Profinet counters	26
Figure 21 VoT Process station adjustment.....	27
Figure 22 VoT Process station 2nd adjustment.....	27
Figure 23 Process station values displayed	28

11. Appendix

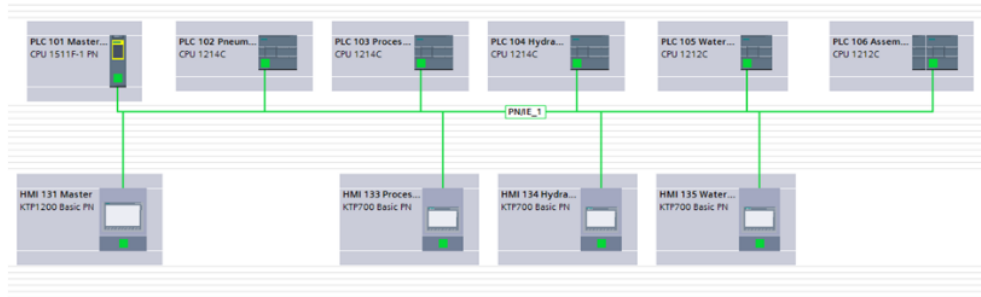


Figure 4 CIM system network

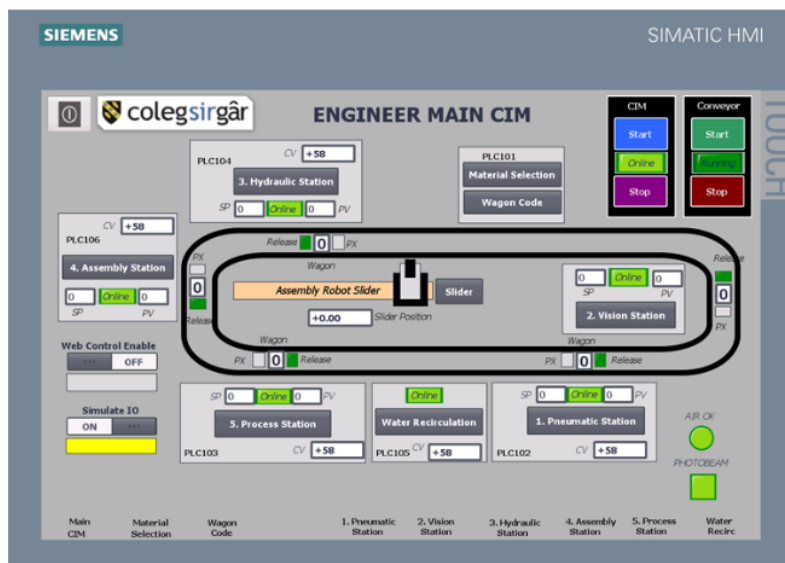


Figure 5 Air ok indication and photobeam added

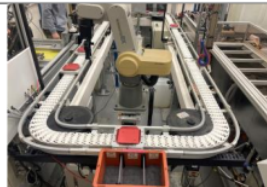
Hazard Evaluation 1			
Hazard Title	Mechanical		
Description	Conveyor/Moving Elements		
	Robot Arm Movement		
	Stored Energy		
	Rotating Elements		
	Approach of a Moving Element		
HR – Risk Estimation & Evaluation			
Degree of Possible Harm	3	Possibility of Occurrence	6
Possibility of Avoidance	2.5	Frequency of Exposure	4
Hazard Rating Number	180	Summary Level	HIGH RISK
HRN = DPH x PA x PO x FE			
Hazard Mitigation			
Risk Reduction Description	Interlocking Guarding		
	Signage		
Applied Standards	PUWER Reg 23: Markings	PUWER Reg 11: Dangerous Parts of Machinery	PUWER Reg 24: Warnings
	PUWER Reg 22: Maintenance Operations	BS EN 14119	BS EN 14120
HR – Risk Mitigation Evaluation			
Degree of Possible Harm	3	Possibility of Occurrence	0.05
Possibility of Avoidance	0.75	Frequency of Exposure	4
Hazard Rating Number	0.45	Summary Level	NEGLIGIBLE RISK
HR – Possible Residual Risk & Mitigation	PPE, Training, Signage, Work Safe Practices		

Figure 6 Conveyor risk assessment

Functional Safety							
Hazard Title		Mechanical					
Description		Mechanical Robot Arm					
Risk Reduction Description		Interlocking Guarding					
Applied Standards		BS EN ISO 12100		BS EN ISO 10228-1&2		BS EN 13849-1&2	
		BS EN 14 120		BS EN 14 119		BS EN ISO 14118	
HR – Risk Mitigation Evaluation							
Degree of Possible Harm		3		Possibility of Occurrence		0.05	
Possibility of Avoidance		0.75		Frequency of Exposure		4	
Hazard Rating Number		0.45		Summary Level		NEGLIGIBLE	
Functional Safety Calculations							
Required Performance Level PLr	C	S	S1	F	F2	P	P2
Define The Safety Function		Detail					
Activation		Two channel guard switches					
Behavior		Machinery Safety Stop Cat 0 IEC 60204-1					
Condition To Be Observed		Doesn't Restart					
Restart		Press Push Button					

Figure 7 Functional safety for robot arm

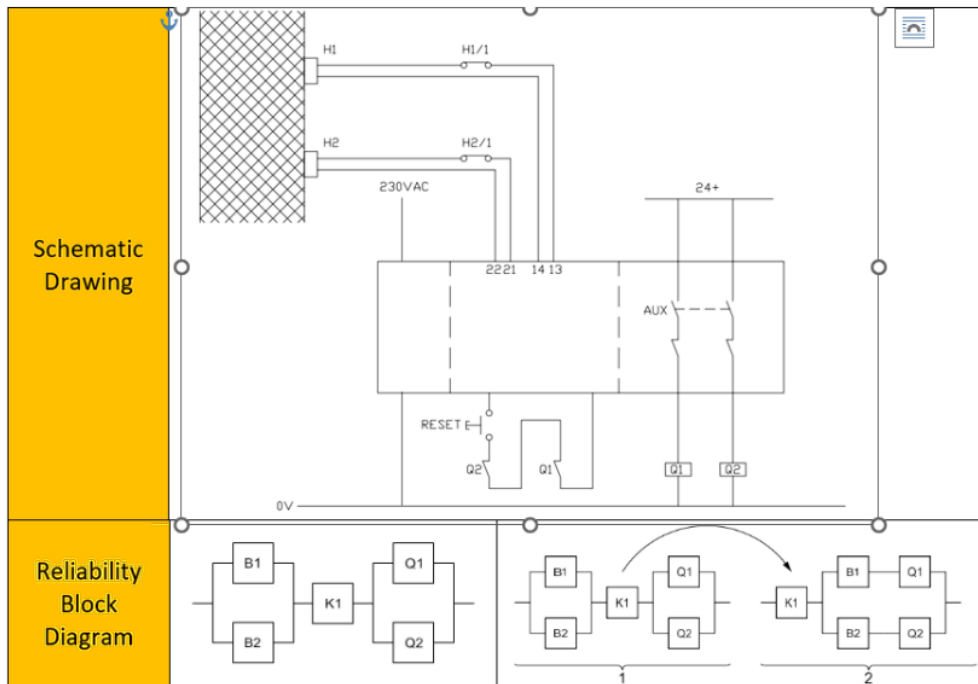


Figure 8 schematic for new gate

Reliability Calculations			
NOP – Number of Operations Per Year	Day	313	NOP
	Hours	24	7,512 cycles per year
	Cycle Time (Seconds)	3600(1hr)	
Input			
MTTFd.b1	B10d	2,000,000	MTTFd.b1
	NOP	7,512	2662 years (capped at 100 years)
T10d,b2	B10d	2,000,000	Mission Time
	NOP	7,512	266 years

Figure 9 reliability calculations

MTTFd.b2	B10d	2,000,000	MTTFd.b2
	NOP	7,512	2662 years (capped at 100 years)
Output			
B10 =		B10d = B10 x2	
MTTFd.q1	B10d	10,000,000	MTTFd.Q1
	NOP	7,512	13,312 years (capped at 100 years)
T10d,q1	B10d	10,000,000	Mission Time
	NOP	7,512	1331 years
MTTFd.q2	B10d	10,000,000	MTTFd.Q1
	NOP	7,512	13,312 years (capped at 100 years)
T10d,q2	B10d	10,000,000	Mission Time
	NOP	7,512	1331 years
Logic Unit K1			
Probability of dangerous failure per hour		2.31 x 10 ⁻⁹ per hour	

Figure 10 reliability calculations part 2

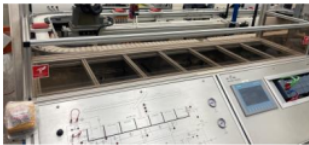
Hazard Evaluation 2			
Hazard Title	Chemical		
Description	Acid Tank		
	Dust/Fumes from Fluid		
			
HR – Risk Estimation & Evaluation			
Degree of Possible Harm	65	Possibility of Occurrence	1.25
Possibility of Avoidance	2.5	Frequency of Exposure	3
Hazard Rating Number	609.375	Summary Level	VERY HIGH RISK
HRN = DPH x PA x PO x FE			
Hazard Mitigation			
Risk Reduction Description	Ventilation		
	Interlocking Guarding		
	Air Circulation		
Applied Standards	PUWER Regs 12: Specific Hazards	PUWER Reg 23: Markings	COSHH
HR – Risk Mitigation Evaluation			
Degree of Possible Harm	65	Possibility of Occurrence	0.05
Possibility of Avoidance	0.75	Frequency of Exposure	3
Hazard Rating Number	7.3125	Summary Level	NEGLIGIBLE RISK
HR – Possible Residual Risk & Mitigation	PPE, Training, Signage, Work Safe Practices		

Figure 11 2nd hazard evaluation

Hazard Evaluation 3			
Hazard Title	Electrical		
Description	Live Parts		
	Thermal Radiation		
			
HR – Risk Estimation & Evaluation			
Degree of Possible Harm	8	Possibility of Occurrence	2.5
Possibility of Avoidance	5	Frequency of Exposure	3
Hazard Rating Number	400	Summary Level	HIGH RISK

$$HRN = DPH \times PA \times PO \times FE$$

Hazard Mitigation			
Risk Reduction Description	Isolations		
	Signage		
	Electrical house keeping		
Applied Standards	PUWER Reg 8: Information & Instructions	PUWER Reg 16: Emergency Stop Controls	PUWER 18: Control Systems
	PUWER Reg 23: Markings	PUWER 24: Warnings	
HR – Risk Mitigation Evaluation			
Degree of Possible Harm	8	Possibility of Occurrence	0.05
Possibility of Avoidance	0.75	Frequency of Exposure	4
Hazard Rating Number	1.2	Summary Level	NEGLIGIBLE RISK
HR – Possible Residual Risk & Mitigation	PPE, Training, Signage, Work Safe Practices		

Figure 12 3rd hazard evaluation

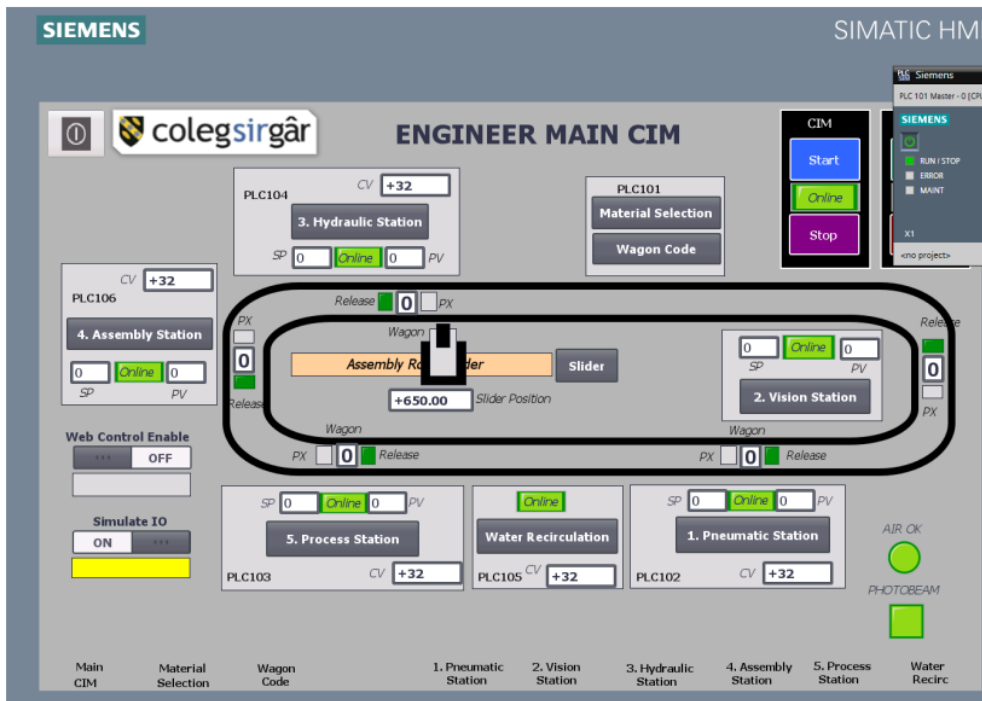


Figure 13 animation of slider

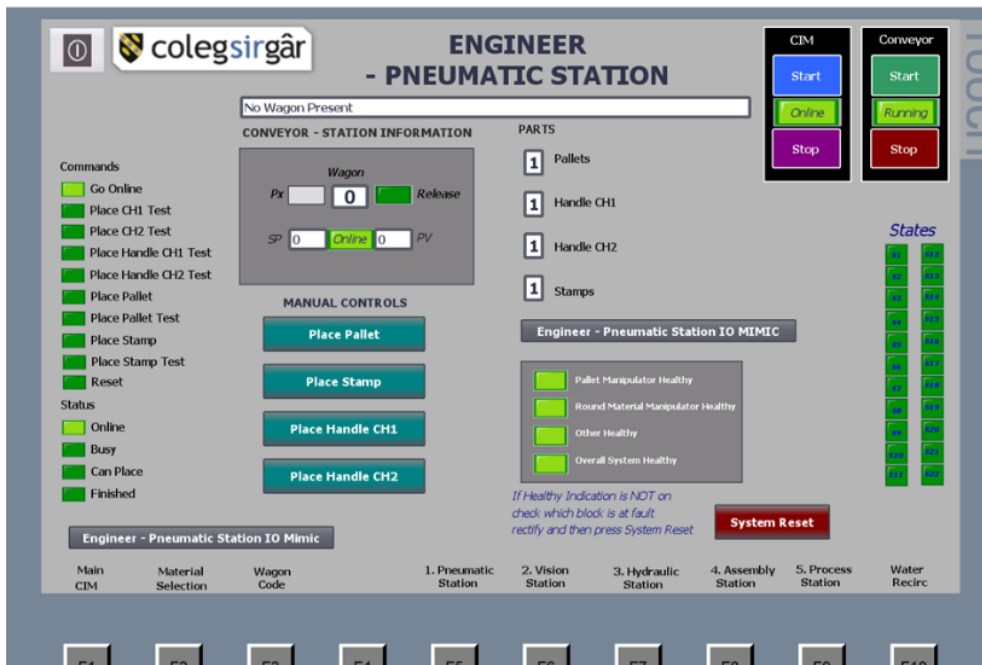


Figure 14 indication for pneumatics station

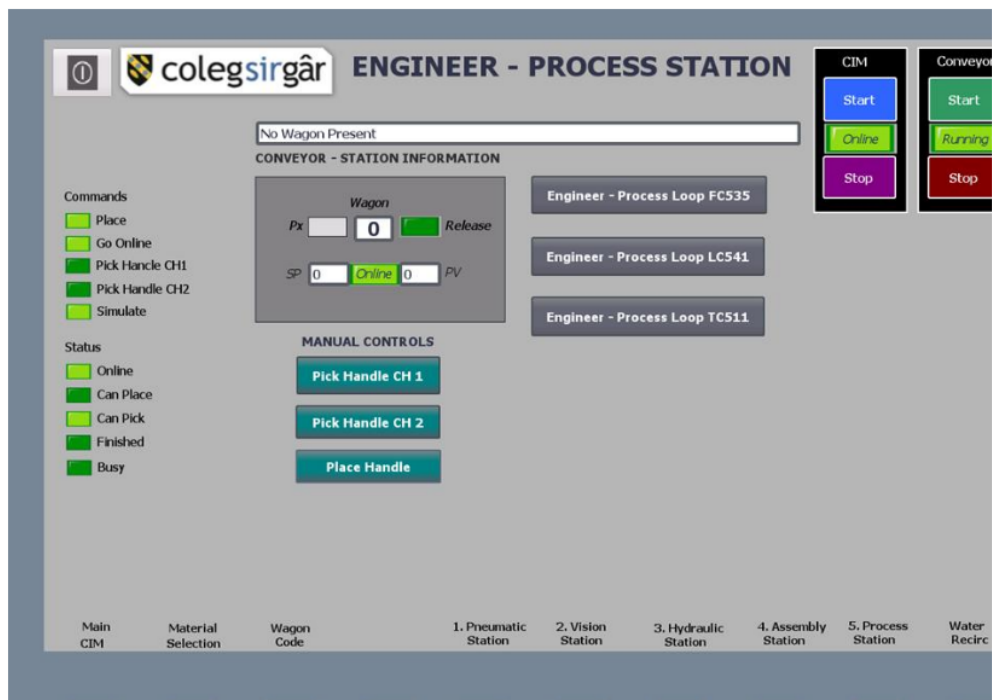


Figure 15 Indication for the process station

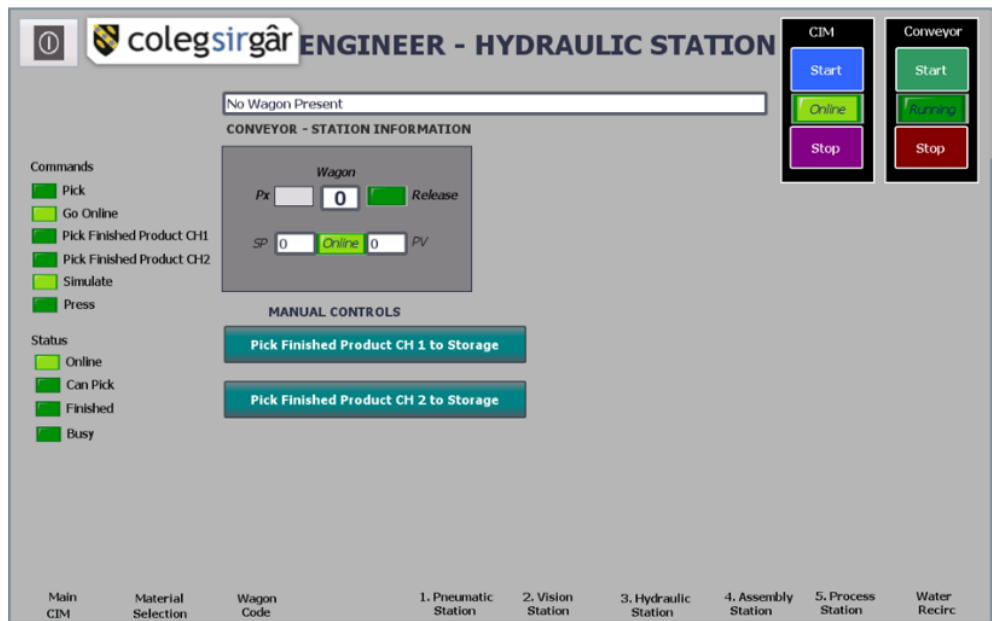


Figure 16 indication for hydraulics station

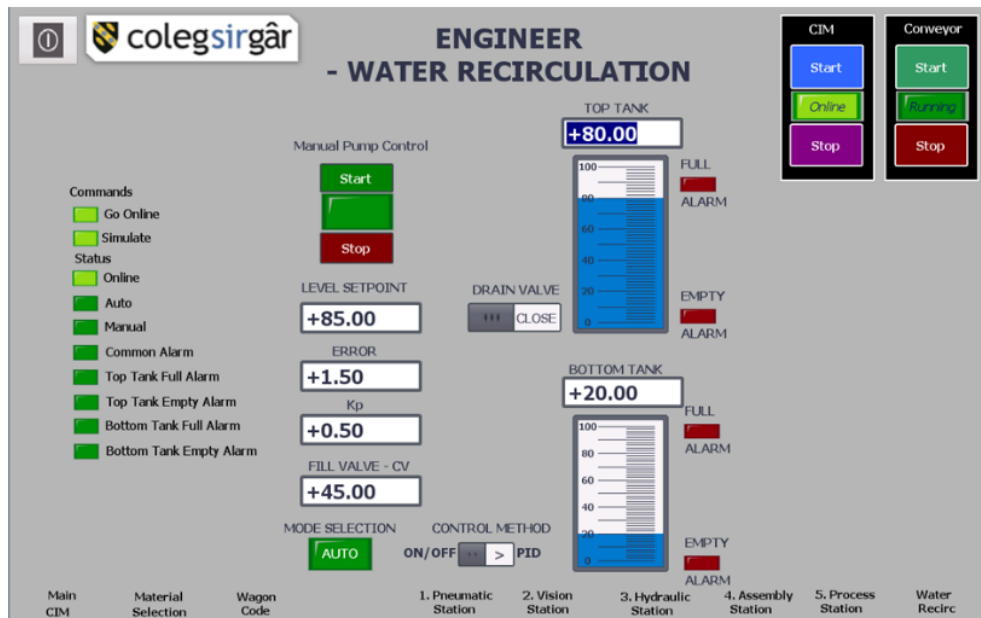


Figure 17 indication for water recirculation

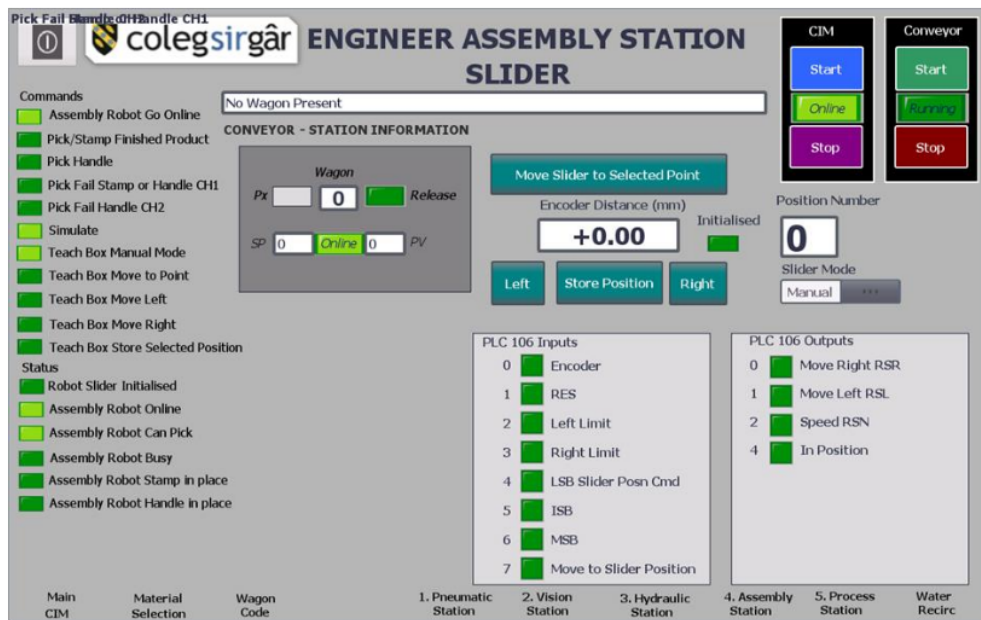


Figure 18 indication for assembly station slider



Figure 19 indication for vision station

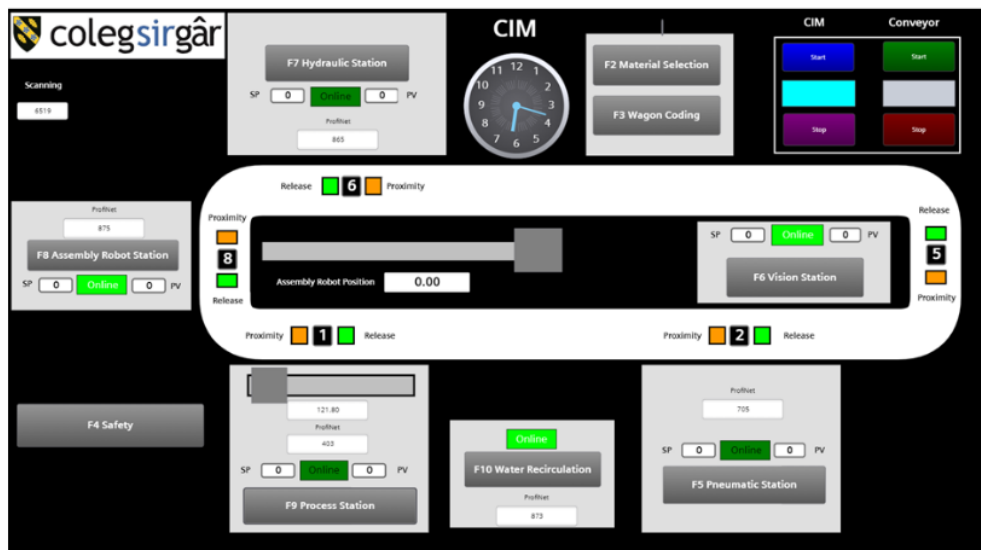


Figure 20 VoT Profinet counters



Figure 21 VoT Process station adjustment

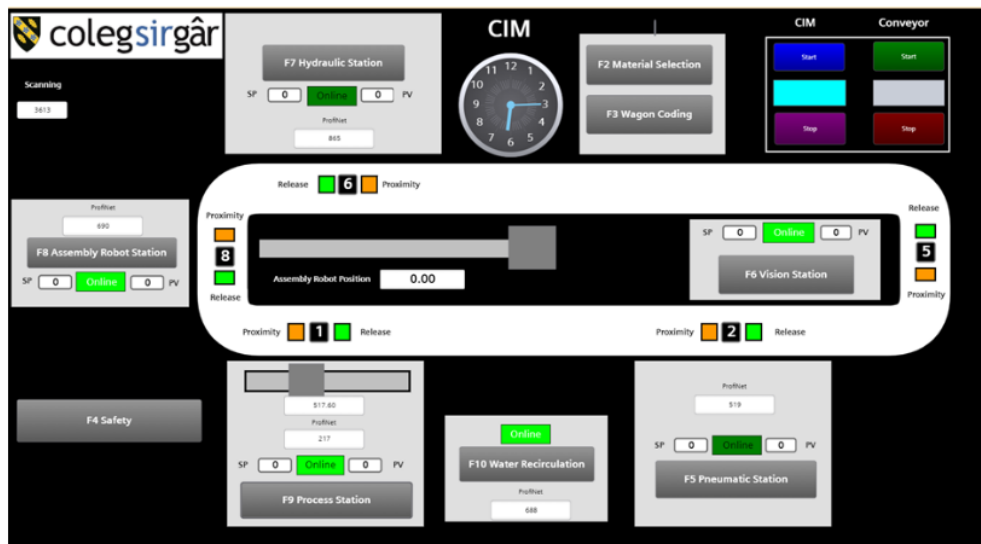


Figure 22 VoT Process station 2nd adjustment

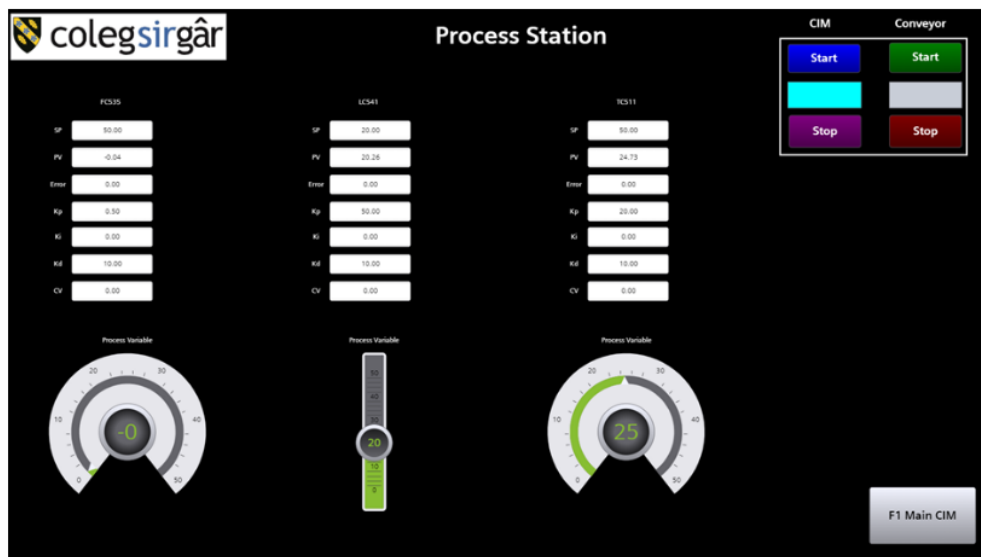


Figure 23 Process station values displayed

FINAL GRADE

GENERAL COMMENTS

Instructor

67 /100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

QM

Write in the third person

Don't refer to your self as I, me, my or others as you etc. Avoid personal references. If absolutely necessary, refer to self as "the author".

PAGE 4

PAGE 5

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 6

QM

Citation Needed

Cite Source:

Please use the link below to find links to information regarding specific citation styles:

QM

Citation Needed

Cite Source:

Please use the link below to find links to information regarding specific citation styles:

http://www.plagiarism.org/plag_article_citation_styles.html

QM

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QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 7

QM

Write in the third person

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Text Comment. What about the assembly robot?

PAGE 8

PAGE 9

QM

Write in the third person

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QM

Paragraphs should be fully justified text as required in the brief

QM

Line spacing should be 1.5

This allows the marker to put comments in between your lines

PAGE 10

Text Comment. Testing table is missing

PAGE 11

QM

Write in the third person

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PAGE 12

Text Comment. This is a reflection, you should be concluding your findings

PAGE 13

QM

Write in the third person

Don't refer to your self as I, me, my or others as you etc. Avoid personal references. If absolutely necessary, refer to self as "the author".

Text Comment. How did you treat each other?

PAGE 14

QM

Correct method of listing.

You have listed your sources correctly according to the Harvard method.

Text Comment. Good range of sources

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

GRADING FORM: NEW CSG-RUBRIC

CARLO COPPOLA**67****1. ENGAGEMENT WITH LITERATURE** There is good evidence of reading from a range of sources cited and listed correctly. 15/20**15****2. KNOWLEDGE AND UNDERSTANDING** Good knowledge and understanding demonstrated in all report sections and particularly sections 3, 4 and 5. 14/20**14****3. COGNITIVE AND INTELLECTUAL** Good evidence of analysis through testing with a good testing table for results, with good conclusions and recommendations. 12/20**12****4. PRACTICAL APPLICATION** Good evidence of practical work both with individual system modifications with simulation and with t**14**

eam work on VoT web server mods. 14/20

5. TRANSFERABLE SKILLS



A good work plan but no risk assessment. Good explanation of team working. Report is well structured but not always correctly presented. Good clear diagrams. Word count not exceeded. However, you must learn to write in the third person. 12/20

12