

2119238

by Kyran Pritchard

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Assignment 2 Integrated Automation System

Name: Kyran Pritchard

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1 - Work Plan for Lifelong Learning and Risk Assessment

To identify and research instrumentation and integrated automation is the purpose of the assignment as well to understand them. These kinds of systems are typically found in modern industry for the application of automatic lines. The system that is the focus of the assignment is in G8 of Coleg Sir Gar, this system will be researched into as well as modified. This particular system is known as a Computer Integrated System (CIM). A variety of HMI's and PLCs are combined to control an array of instrumentation within the system. Modifications will be made both as an individual and as a team to the system. When working as a group all genders, beliefs and ethnicities were respected and understood. Whilst carrying out the assignment new regulations and legislations were come across and understood. A full risk assessment of the overall system has been carried out and a table produced from this, which is placed in the appendix.

A good but not full list

2 – Research

You could improve your writing style here

Gov.uk states 'EC 61508 assigns four software and hardware safety integrity levels (SILs) to required measures of risk reduction' (2023). Based off this guidance is then provided on the configuration of the system, level of fault tolerance and diagnostic coverage. As well as this it also 'provides guidance on qualitative methods for establishing the SIL level required' (Gov, 2023). The second part of the standard places constraints on the hardware of each subsystem by demanding a minimum fault tolerance and diagnostic coverage of each part of the system. Whilst producing an integrated automated system throughout the design, installation, operation, and maintenance the system must demonstrate the level of integrity must be reached (Festo, 2023). A SIL rating is based off the level of severity and the frequency of which it could occur. Perforce states 'There are four SILs — SIL 1, SIL 2, SIL 3, and SIL 4. The higher the SIL, the greater the risk of failure. And the greater the risk of failure, the stricter the safety requirements' (Perforce, 2023). What rating of SIL an integrated automation system would fall under is based off table found in the appendix.

PL stands for performance level regarding machine building Eaton states 'this refers to manageable units on which life safety systems are frequently used. ISO 13849-1T was developed with this context in mind' (2023). The PL standard, from both a quantitative and qualitative point of view, considers the machinery and considers safety functions. There are five performance levels PL (a, b, c, d and e) these represent the average probability of dangerous failure per hour (PFH) (Eaton, 2023). These ratings then compare to a mean probability of a critical outage, the table of this seen in appendix. The performance level rating is then combined with quantitative measures of diagnostic coverage as well as mean time to dangerous failure to produce and overall rating for the automated integrated system (Control, 2022).

A Conformance Européenne (CE) marking can be done by the manufacturer themselves if they prove compliance with the EU health, safety and environmental protection legislation and this shows the systems compliance with the relevant requirement (Gov, 2023). UKCA stands for UK Conformity Assessment, to be sold in the UK market a integrated system must have the UKCA mark affixed to the product at least 5mm big. Not all systems need to be UKCA marked but according to gov.uk 'on the product but you must affix UKCA marking to any work equipment that comes within the scope of the Supply of Machinery (Safety) Regulations 2008 and make sure it meets all of its essential health and safety requirements - even if it is only for your own use and you have no intention of supplying it to other parties' (2023).

A firewall is one type of internet security that could be used, a firewall controls incoming and outgoing traffic on networks. Checkpoint says firewalls block malware and application layer-attacks (CheckPoint, 2023). Checkpoint states that 'Remote access VPN provides remote and secure access to a company network to individual hosts or clients, such as telecommuters, mobile users, and extranet consumers' (2023). A VPN also allows a client to access and control an automated integrated system remotely and safely by connecting to the IP address via the VPN, all data transmitted is encrypted uses a multi-factor authentication. Sandboxing is a commonly used method of protection as it observes files and codes as they are opened and then monitors them for foreign behaviour to prevent threats from accessing the networks of the system (Critics, 2023).

According to Pepperl + Fuchs 'Devices that fall under the machinery directive mostly expose the user to hazards that result from mechanical movement of parts' (2023). This applies to the CIM system in G8 as it has moving robot arms, moving wagons and other moving parts that are not guarded. This CIM system will have to meet the requirements of EN ISO 13849, this can be done by calculating the actual Performance Level (PL) of all safety functions. The CIM system must also abide by the EN standards and the EU directives. As well as these the Electrical Equipment (Safety) Regulations of 2016 and the Pressure Systems Safety Regulations 200 apply to the CIM system.

3 – System Overview and Operation

Below is an overview diagram of the CIM system showing all the substations and how they are interconnected.

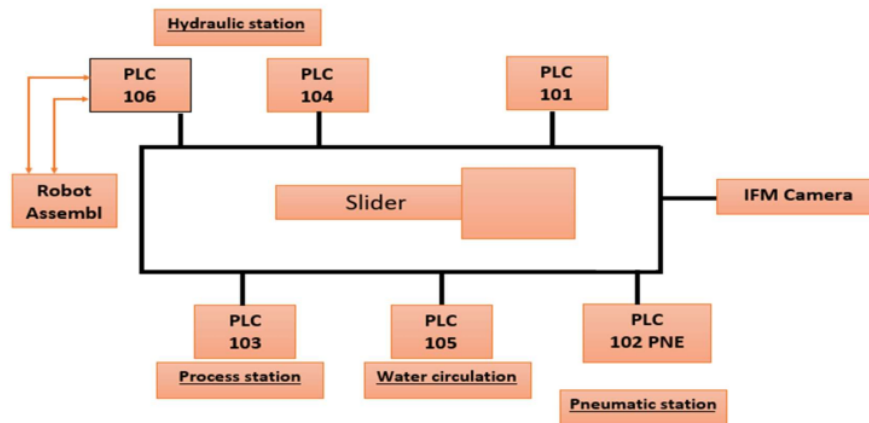


Figure 1 CIM System Diagram

Wagon Tracking System

There are 5 proximity sensors that are used in order to know what station the wagons are located at. Each proxy is used the form binary code through the system. Each wagon has a metal disk at the bottom having its own binary code unique to that wagon, numbering the wagons allows them to be tracked on the HMI. A signal is sent from the proximities to the PLC as in an input (%0.0 - %0.4). Proximity detectors are also used to know whether a wagon is at a station so that the auto sequence can run without wagons colliding. Upon completion of the task at that station there is a proximity to see the wagon has left the station.

PLC and Communication

Grocer's apostrophe

In this system there is a profinet where all 5 master PLC's, the slave PLC and 3 HMI's communicate with each other. The purpose of the lone slave PLC is to store and send data to and from each PLC by means of a data block, as well as a function call for controlling data. A data block is also used with the master PLCs to store data to and from the slave. Put and get are used for the handshaking signals on the profinet, this is within the data block how the data communicates. The master PLCs are what initiate all of the communications throughout the system.

Camera Inspection

The wagon in the camera system uses an IFM OD200 vision sensor to relay the data. The data is communicated on a profinet via the network. The camera is programmed separately with online software with the use of a function block. Whether the part has passed or failed is decided by the camera, based off this is what happens next in the system. The camera knows whether it is a pass or fail off the application it is given, the camera is part of the vision subsystem.

Assembly Robot

The assembly robot had been programmed to load the pallets as they pass by and stop on the conveyor. The robot is controlled via an HMI screen and be controlled remotely on a VPN^{incorrect} or on the physical HMI at the system. The robot is programmed to be controlled in both automatic and manual mode. PLC 106 (s7-1212c) with a digital module and relay slider. The use of bit and bytes are used in this section of program – being 0 and + being 1. Once the robot receives power therefore becoming state 1 it returns to the home position.

4 - Health and Safety, and the Environment

The cabinet, with the gripper robot on located at the rear of the system, can currently be opened when the arm is moving. This cabinet door could be interlocked so that when the arm is moving the door can't be opened. This would therefore comply with the machinery directive as the arm is a moving mechanical part and should not be accessible when moving. Many of the PLCs and terminal banks are not enclosed and are open when live, this could become dangerous to students if cables were to become damaged and cores exposed. These could be placed in cabinets with isolators so they can be separately isolated to be worked on, this then conforming with EN ISO 13849.

During operation, the system has a high energy output due to the many individual moving parts that use electricity. A lot of these parts, especially on the conveyor, are under load therefore needing more energy to move providing a higher energy output usage. Having different parts of the system on different circuits could minimise the energy use as those that are not being used could be isolated separately allowing the rest of the system to run. Isolating the entire system when it is not in use would be beneficial to the environment as it would be using zero energy. As a future upgrade renewable sources of energy could be looked at to power the machine to be more sustainable and eco-friendlier.

You should have referred to your forms in the appendix

5 - Maintenance, Reliability and Commercial Risk

Spelling

The overall reliability of the system is good as it is in a clean environment and not run constantly. This system must be maintained regularly as it an automated system and relies on many components to allow it to run in an auto sequence. The sensors on the system can be cleaned often to ensure reliability and accuracy. Calibration of the sensors on the system should be carried out on a schedule once again to maintain accuracy throughout.

Each screen used to control the system has an engineer's version of the screen. These screens have LEDs representing each command and status in that subsystem. This allows engineers to monitor the running of the system and identify any faults that occur. The View of Things (VoT) is used to access these pages remotely, from this web page the system can also be fully controlled. Through the process page on VoT the flow, level and temperature readings can all be monitored, the SP, PV, errors, Kp, Ki, Kd and CV can be seen for each of these. All readings can be seen on visual displays to allow monitoring.

The system could be made more reliable periodically changing the password that used to access the VoT page. Accessing the system constantly via a VPN would make it more reliable also.

6 – Complex System Design – Individual Modifications

The first mod made to the system was to put LEDs to show the photobeam and airs status within the system. When the LEDs are illuminated green is indicates the status being healthy and OK to progress. Each station had a profinet counter added to it on the main CIM screen to see the status of that station. Also, on the main CIM screen an assembly robot slider animation was added as well as a counter to see its position was added. Using the linear drive distance value, it can be seen where the robot is between the range 0 – 1320mm. A set of LEDs was added to the engineer's pneumatic station to see the status and commands of this station. The LED illuminating represent the handshaking signal being communicated for that action, to and from PLC 102. PLC 103 now receives handshaking signals, which are visual representations of commands and statuses on the process station screen. Hydraulic station (PLC 104) now has LEDs to represent the handshaking signal sent and received, these LEDs can be used to monitor this subsystem and its operations. LEDs have been added to the water recirculation page, once again to monitor commands and statuses in the system. Alarm LEDs were added to this page to indicate any faults in the system so that the system doesn't damage any components and faults can be identified with ease. The handshaking signal for the assembly slider station are sent and received via PLC 106. The indicators for these signals the position direction and mode in which the robot is in. The position is seen on this page based off the encoders feedback. The camera sends handshaking signals to the visual system as it is separately programmed. From these indications it can be seen whether the work pass or failed, whether the camera is online and if it is ready to receive a test piece. All evidence of each station with indicators can be found in the appendix.

Individual Modifications Test Results				
Test Number	Expected Result	Result	Pass/Fail	Figure
1	Profinet counter will be counting, air OK and photobeam LEDs illuminated	Counters were counting and LEDs illuminated	P	12
2	Assembly robot slider to move left to right and linear drive distance displayed	Robot moved and distance displayed	P	6, 7, 8, 9 and 11
3	The Engineer Pneumatic Station screen should show the indicators for the handshaking signals sent	LEDs illuminated showing handshaking signals were received	P	14
4	The Engineer Process Station screen should show the indicators for the handshaking signals sent	LEDs illuminated showing handshaking signals were received	P	15
5	The Engineer Hydraulic Station screen should show the indicators for the handshaking signals sent	LEDs illuminated showing handshaking signals were recieved	P	10
6	The Engineer Water Recirculation screen should show the indicators for the handshaking signals sent	LEDs illuminated showing handshaking signals were recieved	P	21
7	The Engineer Assembly Station Slider screen should show the indicators for the handshaking signals sent	LEDs illuminated showing handshaking signals were recieved	P	11
8	The Engineer Vision Station screen should show the indicators for the handshaking signals sent	LEDs illuminated showing handshaking signals were recieved	P	20

Table 1 Individual Modification Tests

7 – Complex System Design – Team Modifications

The team added a profinet counter to each station and tagged it to the relevant tag. These allow the systems status to be monitored and it holds previous data, these are displayed on the HMI. A visual representation of the manipulator and its position are displayed on the process station with a counter to be able to see the exact position. This tagged to the encoder reading for accuracy and to be able to see the position remotely. For accuracy the manipulator was tested by moving it to 3 positions and the conveyor started on the VoT to make sure each counter is counting. All testing evidence is provided in the appendix.

A separate page for the process station has been produced on VoT to monitor the three data loops in the system FC535 (flow), LC541 (level) and TC511 (temp. The SP, PV, error, Kp, Ki, Kd and CV values are displayed here so that they can be remotely monitored. As well as this for each data loop the Process Value is graphically displayed to monitor as this is the actual value of the flow, temperature, and level within the system. The system was run remotely using VoT to test all data loops were communicating to their counters and the graphic displays were reading correctly, once again all evidence see in the appendix.

Team Modifications Test Results				
Test Number	Expected Result	Result	Pass/Fail	Figure
1	Profinet counter counting on each station as shown on HMI	All counter counting	P	22
2	The process station slider moves to multiple postions displaying the distance	Robot succesfully moved to 3 poitions displaying distance	P	17, 18, 19
3	Data loops displaying all infromation and graphical charts displaying the PV	All infromation displayed for all data loops	P	16

Table 3 Team Modification Test Table

8 – Conclusions and Recommendations

To conclude after carrying out risk assessments on the system and researching current legislation and standards, in terms of safety and compliance the system needs safety upgrades. Safety recommendations include interlocked guarding for mechanical moving parts to conform with recent standards. Another would be to place open components and cables into cabinets with separate isolators. As the system does not run as a production and not often it was found in task 4 it was not very harmful to the environment, however a recommendation would be to investigate further into renewal energy options. The maintenance of the system was found to be minimal therefore making the system very reliable. After the individual modifications were made the overall performance and conformity of the system was improved as it had been modernized with features of industry 4.0 and displays to enhance monitoring of each subsystem. Task 7 then further modernized the system as the team modifications allowed the system to be remotely accessed using the IP address and an VPN. The team modifications also now allow all data loops to be scrutinized more in depth as well as graphically. A further recommendation would be to often change the password used to access the system remotely for security reasons. It was learnt throughout the assignment the importance of modernising the system towards industry 4.0 standards to allow remote control and access from multiple devices.

9 – Team Working

Working as part of a team allowed everyone's ideas to be shared creating an overall better understanding of what modifications to make. Within the team everyone's genders, beliefs and sexualities were respected to create a comfortable and happier working environment for all. All ideas were welcomed and listened to, so the team had an overall better understanding of the task. Responsibilities were agreed and shared evenly so that the workload was even. All of these points benefitted the group, and everyone was involved, happy and had a clear direction of what to achieve therefore the work was efficiently carried out.

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[levels#:~:text=SIL%20is%20a%20relative%20level,SIL%203%2C%20and%20SIL%204.](https://www.perforce.com/blog/qac/what-iec-61508-how-determine-safety-integrity-levels#:~:text=SIL%20is%20a%20relative%20level,SIL%203%2C%20and%20SIL%204.)

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11 – Appendix

Risk Assessment				
Risk	Person at Risk	Risk Rating	Precautions	New risk Rating
Acid Burn	Student	Medium	Avoid any contact with the acid and wear PPE if required	Low
Overhead Gantree	Student	High	Stay clear whilst it is moving and locate E-stops before use incase of emergency	Medium
Electric Shock	Student	Medium	Isolate as needed and test for dead	Low
Compressed Air	Student	Low	Be aware of where it is located and use PPE as required	Low
Trip Hazards	Student	Medium	Before starting clean area removing trip hazards, cables already covered with mats	Low
Moving Conveyor	Student	Medium	Conveyor is currently interlocked by a lightbeam, be aware of light beam failure	Low
Hydraulic Robot and Press Movement in Operation	Student	Low	Be aware of where it is located and it's movments when operating, stay clear and locate E-stops beforew use	Low
Pneumatic Robots for Loading Parts Misfiring or Failing	Student	Low	As system uses compressed air for loading stay clear when machine is in operation and locate E-stops prior to use	Low
Handle Manipulator Robot Moving in Operation	Student	Low	Be aware of where it is located and it's movments when operating, stay clear and locate E-stops beforew use	Low

Figure 2 Risk Assessment

		Impact		
		Low	Medium	High
Probability	High	Low	Medium	High
	Medium	Low	Medium	Medium
	Low	Low	Low	Low

Figure 3 Risk Rating Table

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 4 SIL Rating Table

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

Figure 5 PL Rating Table

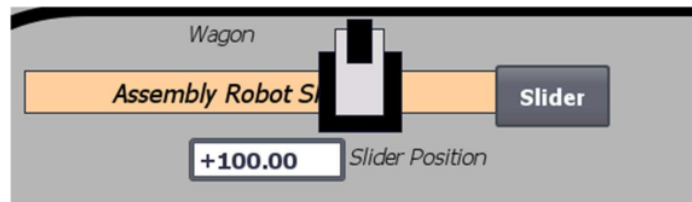


Figure 6 Assembly Robot Slider Position 1 Test

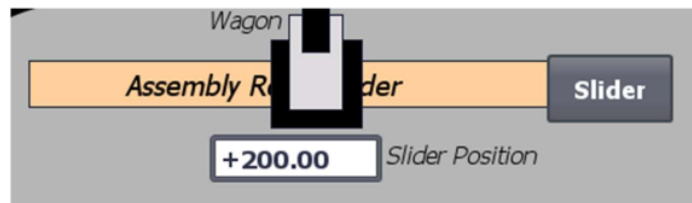


Figure 7 Assembly Robot Slider Position 2 Test

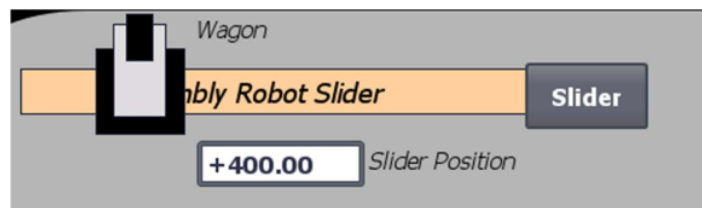


Figure 8 Assembly Robot Slider Position 3 Test

PLC 106											
	Name	Data type	Offset	Start value	Monitor value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Su
43	Assembly Robot Slider Input 3 - Right Limi...	Bool	33.2	false	FALSE	☐	☒	☒	☒	☐	
44	Assembly Robot Slider Input 4 - Slider Co...	Bool	33.3	false	FALSE	☐	☒	☒	☒	☐	
45	Assembly Robot Slider Input 5 - Slider Co...	Bool	33.4	false	FALSE	☐	☒	☒	☒	☐	
46	Assembly Robot Slider Input 6 - Slider Co...	Bool	33.5	false	FALSE	☐	☒	☒	☒	☐	
47	Assembly Robot Slider Input 7 - Slider Mo...	Bool	33.6	false	FALSE	☐	☒	☒	☒	☐	
48	Assembly Robot Slider Output 0 - Move Ri...	Bool	33.7	false	FALSE	☐	☒	☒	☒	☐	
49	Assembly Robot Slider Output 1 - Move Le...	Bool	34.0	false	FALSE	☐	☒	☒	☒	☐	
50	Assembly Robot Slider Output 2 - Speed R...	Bool	34.1	false	FALSE	☐	☒	☒	☒	☐	
51	Assembly Robot Slider Output 3	Bool	34.2	false	FALSE	☐	☒	☒	☒	☐	
52	Assembly Robot Slider Output 4 - In Positi...	Bool	34.3	false	FALSE	☐	☒	☒	☒	☐	
53	Put Bit 20	Bool	34.4	false	FALSE	☐	☒	☒	☒	☐	
54	Put Bit 21	Bool	34.5	false	FALSE	☐	☒	☒	☒	☐	
55	Put Bit 22	Bool	34.6	false	FALSE	☐	☒	☒	☒	☐	
56	Put Bit 23	Bool	34.7	false	FALSE	☐	☒	☒	☒	☐	
57	Put Bit 24	Bool	35.0	false	FALSE	☐	☒	☒	☒	☐	
58	Put Bit 25	Bool	35.1	false	FALSE	☐	☒	☒	☒	☐	
59	Put Bit 26	Bool	35.2	false	FALSE	☐	☒	☒	☒	☐	
60	Put Bit 27	Bool	35.3	false	FALSE	☐	☒	☒	☒	☐	
61	Put Bit 28	Bool	35.4	false	FALSE	☐	☒	☒	☒	☐	
62	Put Bit 29	Bool	35.5	false	FALSE	☐	☒	☒	☒	☐	
63	Put Bit 30	Bool	35.6	false	FALSE	☐	☒	☒	☒	☐	
64	Put Bit 31	Bool	35.7	false	FALSE	☐	☒	☒	☒	☐	
65	Assembly Robot Slider Teach Position	Word	36.0	16#0	16#0000	☐	☒	☒	☒	☐	
66	Put Word 3	Word	38.0	16#0	16#0000	☐	☒	☒	☒	☐	
67	Put Word 4	Word	40.0	16#0	16#0000	☐	☒	☒	☒	☐	
68	Put Word 5	Word	42.0	16#0	16#0000	☐	☒	☒	☒	☐	
69	Put Word 6	Word	44.0	16#0	16#0000	☐	☒	☒	☒	☐	
70	Assembly Robot Slider Distance Int	Word	46.0	16#0	16#0400	☐	☒	☒	☒	☐	
71	Assembly Robot Slider Distance	Real	48.0	0.0	400.0	☐	☒	☒	☒	☐	

Figure 9 Assembly Robot Slider Movement

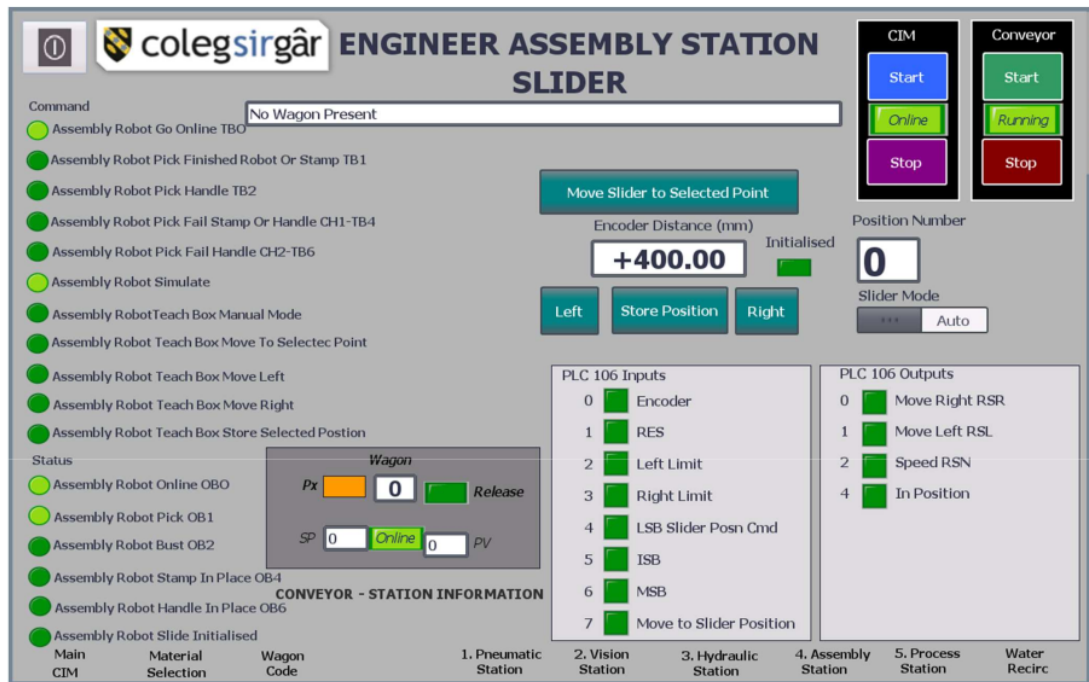


Figure 11 Engineers Assembly Station Slider Page Test

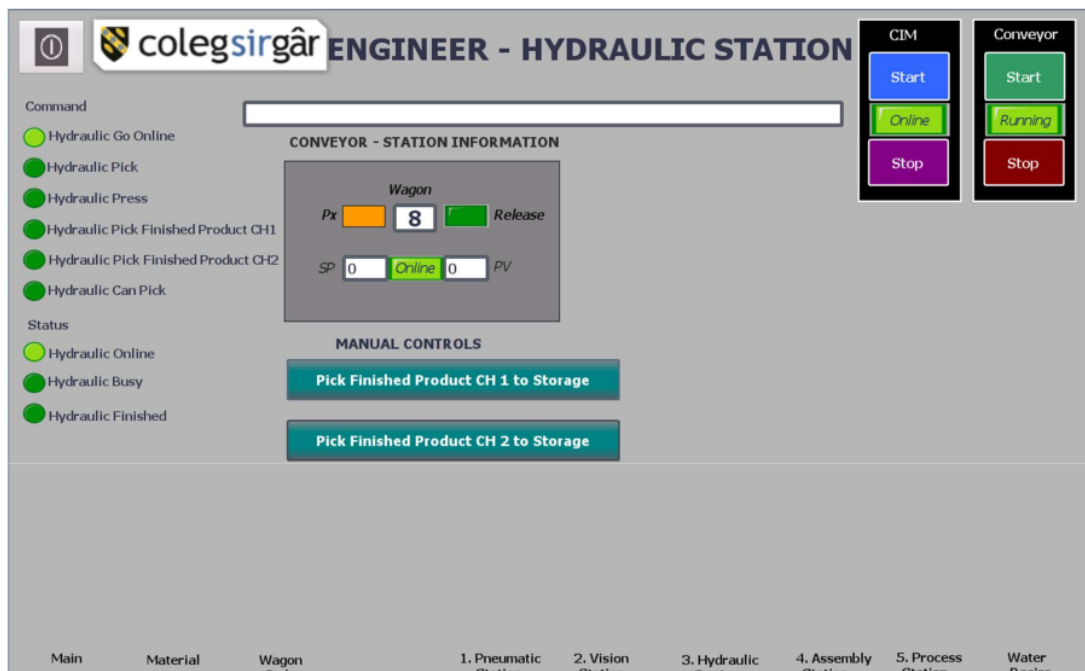


Figure 10 Engineers Hydraulic Station Page Test

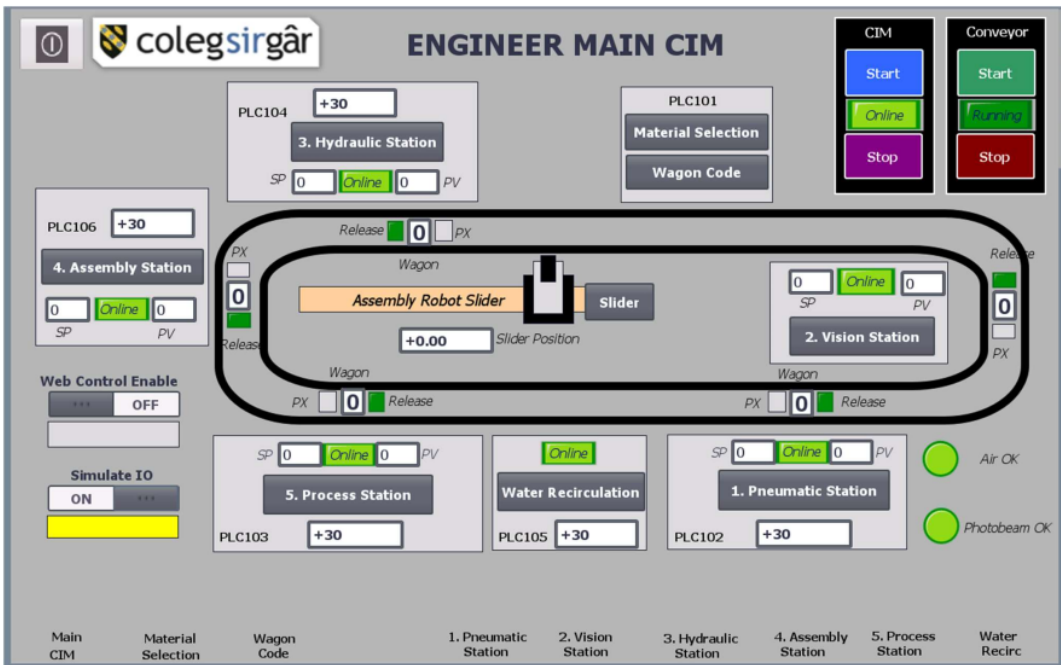


Figure 12 Engineer Main CIM Page Test



Figure 13 PLC Simulating

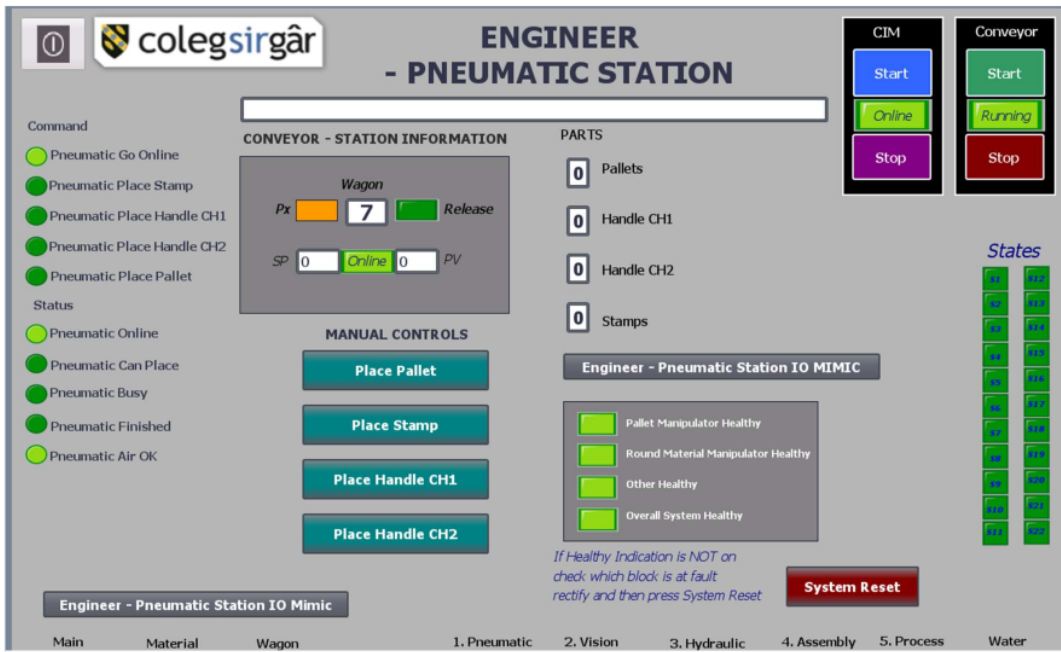


Figure 14 Engineer Pneumatic Station Page Test

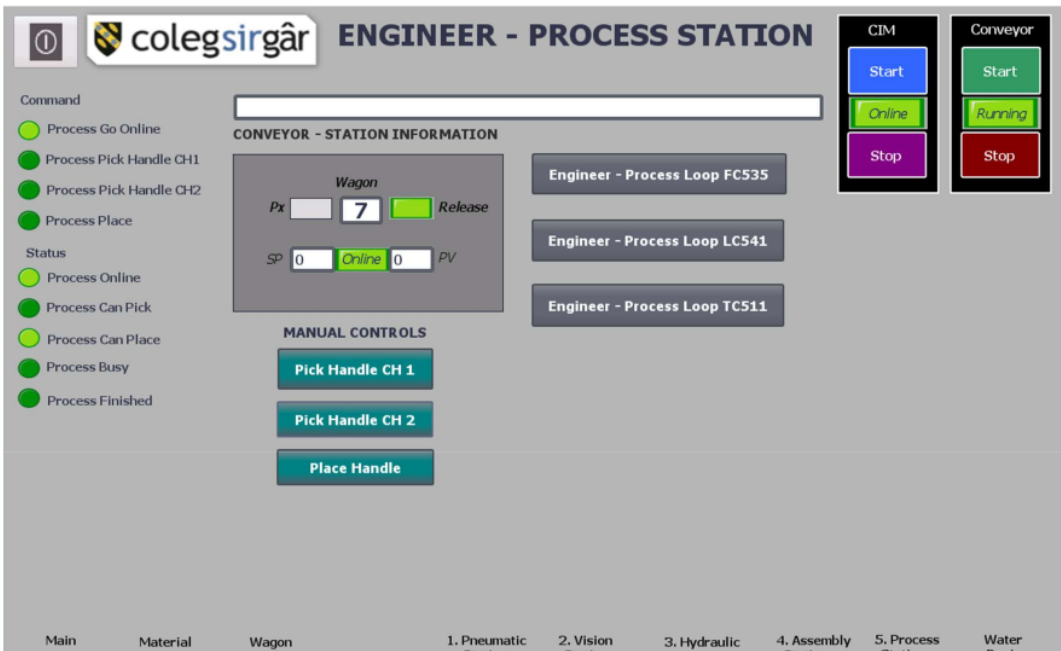


Figure 15 Engineer Process Station Page Test

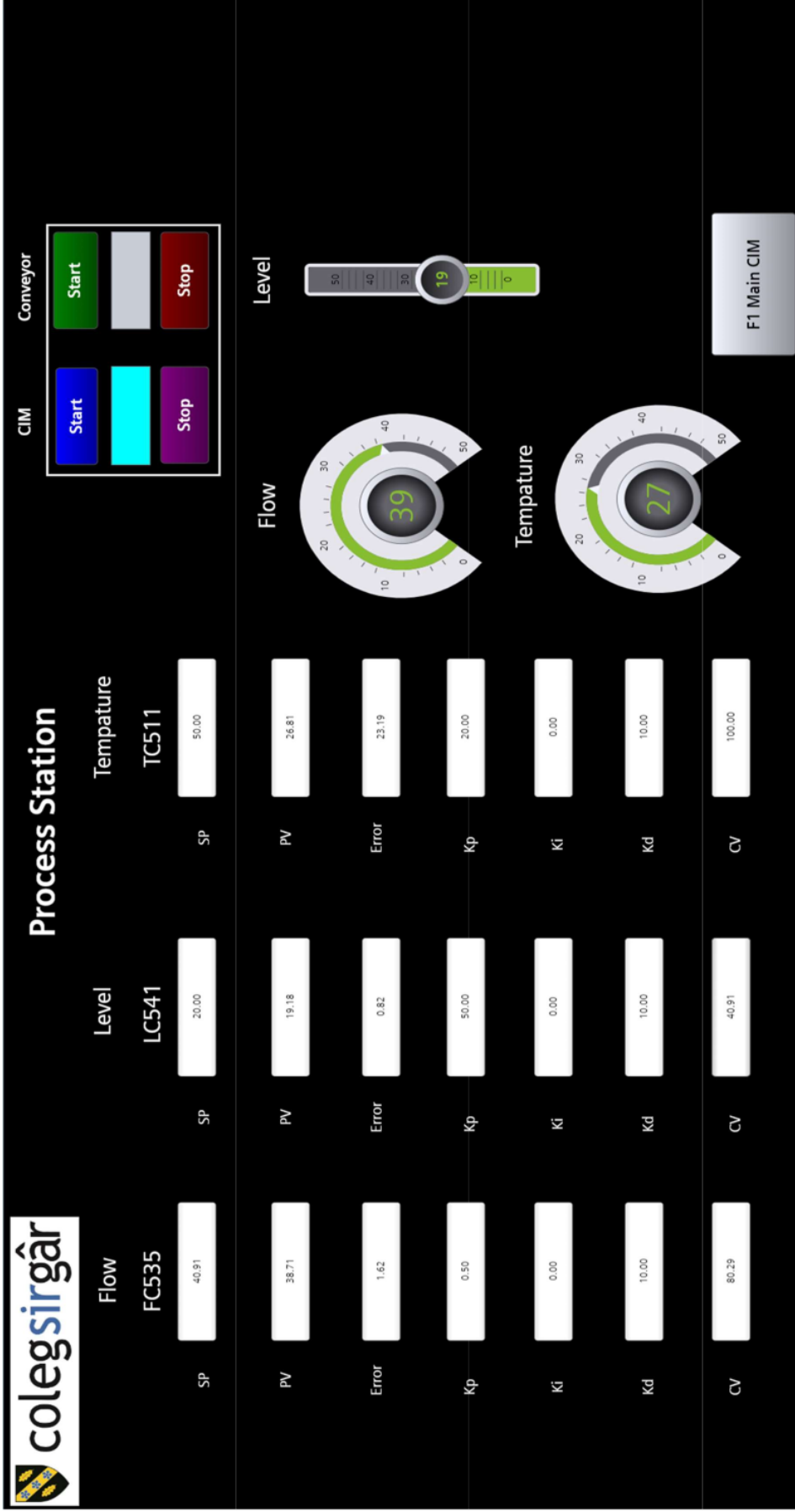


Figure 16 Process Station VoT Running

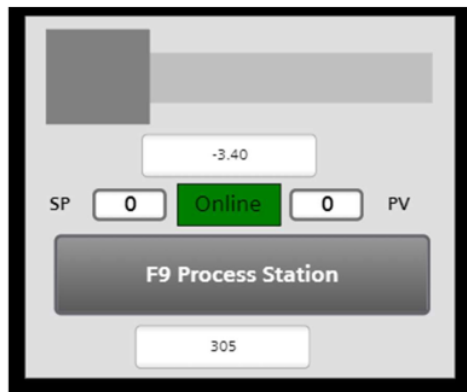


Figure 17 Process Robot Start Test - Start

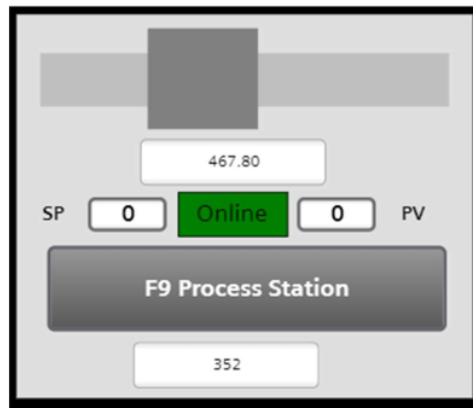


Figure 18 Process Robot Start Test - Middle

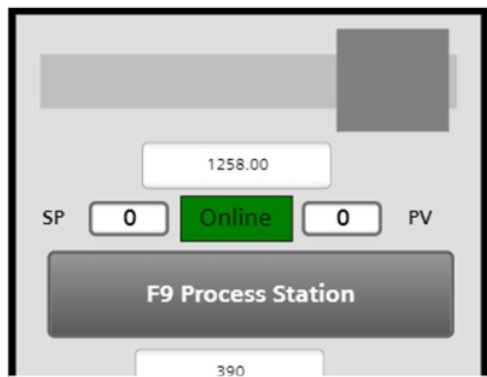


Figure 19 Process Robot Start Test - End

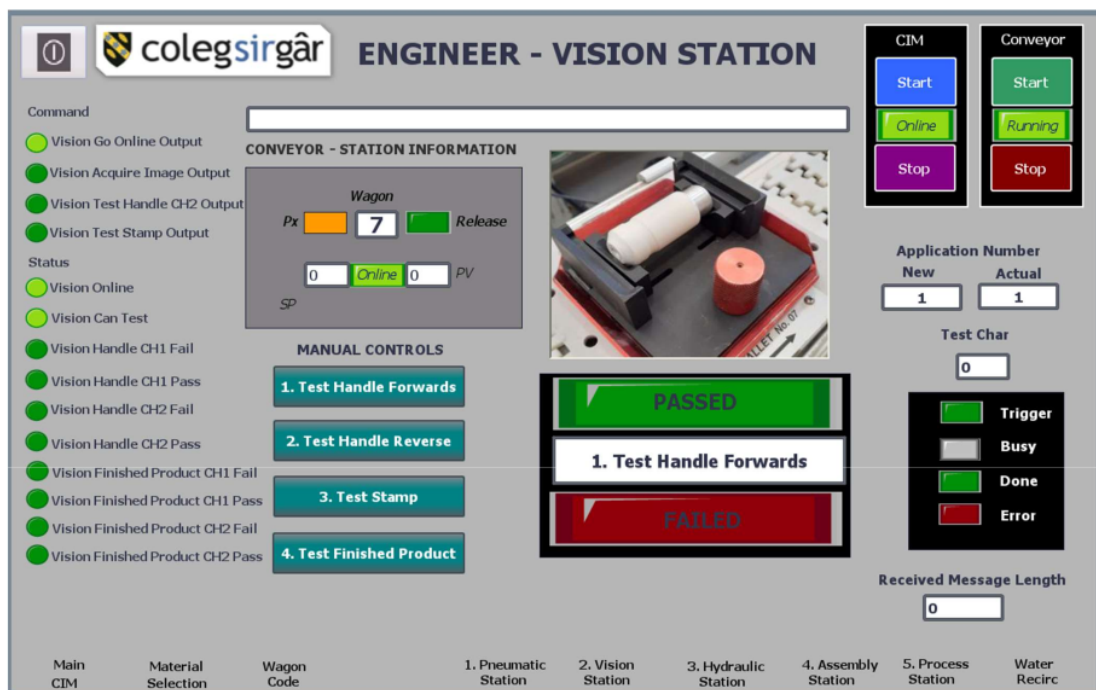


Figure 20 Engineer Vision Station Page Test

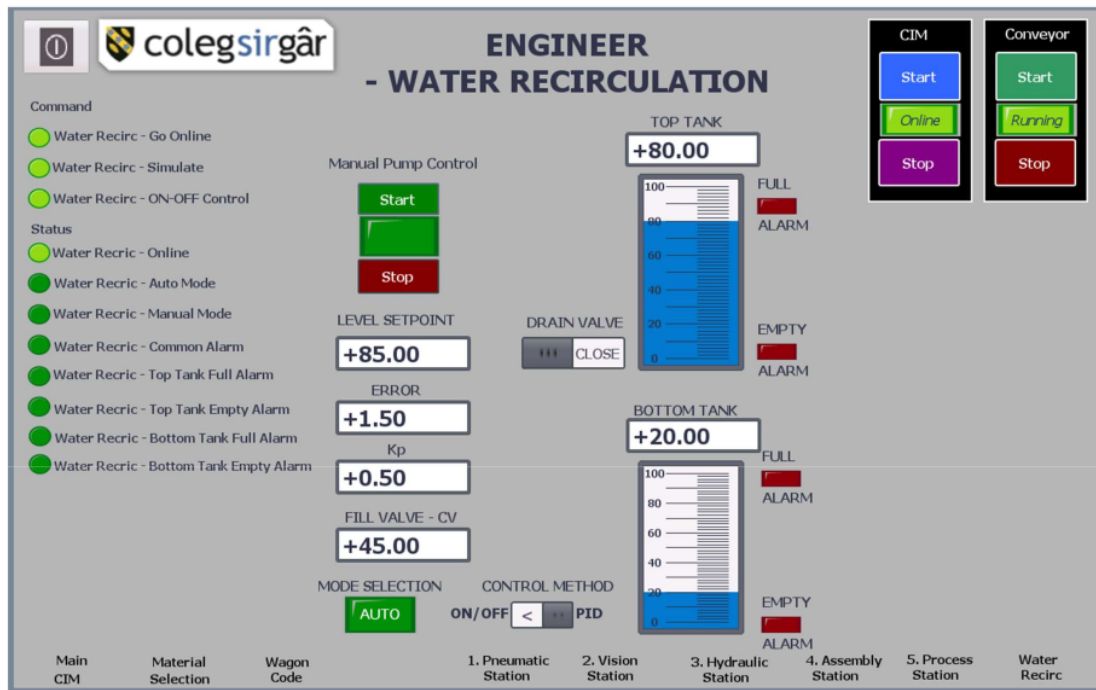


Figure 21 Engineer Water Recirculation Page Test

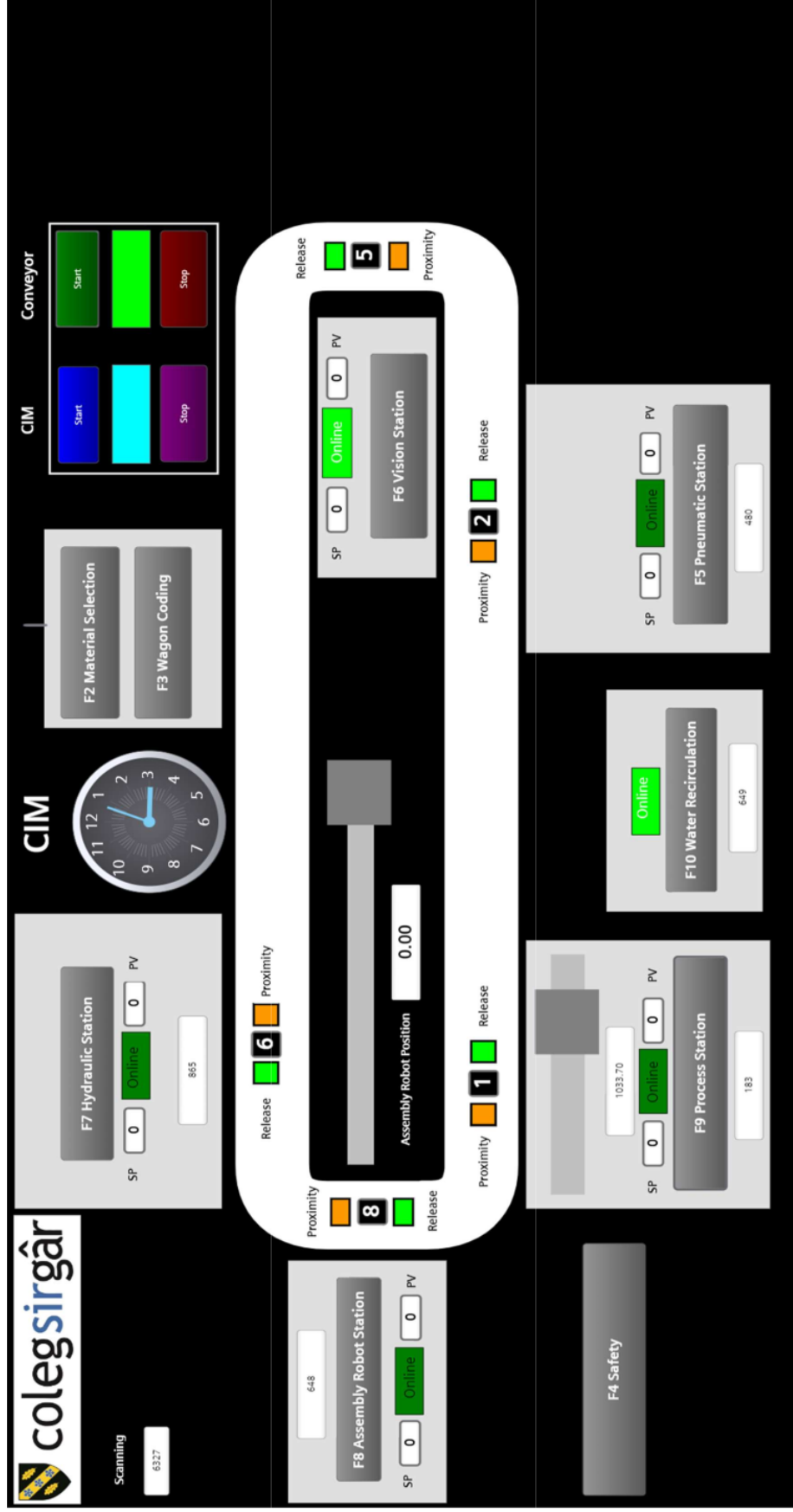


Figure 22 Main CIM VoT Running

Hazard Evaluation			
Hazard Title	Mechanical – High Pressure		
Description	High pressure hydraulics, guarded but not interlocked		
			
HR – Risk Estimation & Evaluation			
Degree of Possible Harm	11	Possibility of Occurrence	1.25
Possibility of Avoidance	0.75	Frequency of Exposure	1
Hazard Rating Number	10.3	Summary Level	Very low risk
HRN = DPH x PA x PO x FE			
Hazard Mitigation			
Risk Reduction Description	Interlock guarding using safety PLC, so that they can not be accessed		
Applied Standards			
HR – Risk Mitigation Evaluation			
Degree of Possible Harm	8	Possibility of Occurrence	0.05
Possibility of Avoidance	0.75	Frequency of Exposure	2
Hazard Rating Number	0.6	Summary Level	Negligible
HR – Possible Residual Risk & Mitigation	Put up warning signs		

Figure 23 Hazard Evaluation #1

Hazard Evaluation			
Hazard Title	No Interlock on Robot Cabinet – Machine Mobility		
Description	The robot arm can still move when the door is open due to having no		
	interlock		
			
HR – Risk Estimation & Evaluation			
Degree of Possible Harm	8	Possibility of Occurrence	2.5
Possibility of Avoidance	2.5	Frequency of Exposure	2
Hazard Rating Number	100	Summary Level	Significant

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

Hazard Mitigation			
Risk Reduction Description	Interlock the door with the movement of the robot		
Applied Standards			
HR – Risk Mitigation Evaluation			
Degree of Possible Harm	8	Possibility of Occurrence	0.05
Possibility of Avoidance	0.75	Frequency of Exposure	2
Hazard Rating Number	0.6	Summary Level	Negligible
HR – Possible Residual Risk & Mitigation			

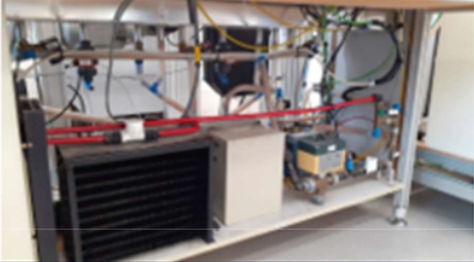
Figure 24 Hazard Evaluation #2

Hazard Evaluation			
Hazard Title	Hazards associated with the environment which the machine has used		
Description	Stagnant water, not temperature controlled when isolated		
			
HR – Risk Estimation & Evaluation			
Degree of Possible Harm	5	Possibility of Occurrence	1.25
Possibility of Avoidance	2.3	Frequency of Exposure	5
Hazard Rating Number	78.125	Summary Level	Significant

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

Hazard Mitigation			
Risk Reduction Description	Temperature treat the water and stir water		
Applied Standards			
HR – Risk Mitigation Evaluation			
Degree of Possible Harm	5	Possibility of Occurrence	0.05
Possibility of Avoidance	0.75	Frequency of Exposure	5
Hazard Rating Number	1	Summary Level	Negligible
HR – Possible Residual Risk & Mitigation			

Figure 25 Hazard Evaluation #3

Hazard Evaluation			
Hazard Title	No Isolator Cleaning Chamber Pump		
Description	Risk of electric shock as it cannot be individually isolated to work on		
	or if there was a problem with it.		
			
HR – Risk Estimation & Evaluation			
Degree of Possible Harm	40	Possibility of Occurrence	2.5
Possibility of Avoidance	2.5	Frequency of Exposure	1
Hazard Rating Number	250	Summary Level	High Risk

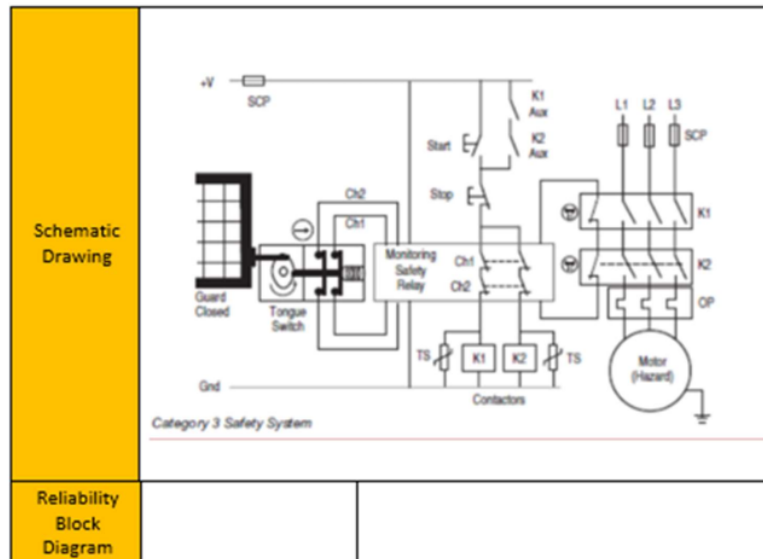
$$HRN = DPH \times PA \times PO \times FE$$

Hazard Mitigation			
Risk Reduction Description	Add an isolator close by the pump		
Applied Standards			
HR – Risk Mitigation Evaluation			
Degree of Possible Harm	40	Possibility of Occurrence	0.05
Possibility of Avoidance	0.75	Frequency of Exposure	1
Hazard Rating Number	1.5	Summary Level	Negligible
HR – Possible Residual Risk & Mitigation			

Figure 26 Hazard Evaluation #4

Functional Safety			
Hazard Title	Mechanical hazard (moving element Hydraulic Robotic arm)		
Description	There is a possibility of Crushing/ impact/ shearing. Due to access within the working area during normal operations. During machine operation it accessed every hour.		
Risk Reduction Description	Interlocking guards with a suitable control safety system. BS ESO ISO 13849 and requires PL=d with structure Cat 3. BS EN ISO 10228-1:2011		
Applied Standards	BS EN ISO 12100	BS EN ISO 10228 - 1 & 2	BS ESO ISO 13849
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
Functional Safety Calculations			
Required Performance Level PLr	1	S	S2
		F	F1
		P	P1
Define The Safety Function	Example		
Activation	Guard switch		
Behavior	Machinery Safety Stop Cat 0 IEC 60204-1		
Condition To Be Observed	Doesn't Restart		
Restart	Press Push Button		

Figure 27 Functional Safety Sheet #1



Reliability Calculations			
NOP – Number of Operations Per Year	Day	365	NOP
	Hours	4	8760 cycles per year
	Cycle Time (Seconds)	600	
Input			
MTTFd.b1	B10d	1000000	MTTFd.b1
	NOP	8760	1141 years (capped at 100years)
T10d_b2	B10d	1000000	Mission Time

Figure 28 Functional Safety Sheet #2

	NOP	8760	114.1 <u>years</u> (capped at 100years)
MTTFd.b2	B10d	500000	MTTFd.b2
	NOP	8760	570 years (capped at 100years)
Output			
B10 = 1,000,000		B10d = B10 x2	2,000,000
MTTFd.q1	B10d	2,000,000	MTTFd.Q1
	NOP	8760	2283 years (capped at 100years)
T10d _{q1}	B10d	2,000,000	Mission Time
	NOP	8760	228 years (capped at 100years)
MTTFd.q2	B10d	2,000,000	MTTFd.Q1
	NOP	8760	228 (capped at 100years)
T10d _{q2}	B10d	2,000,000	Mission Time
	NOP	8760	228 (capped at 100years)
Logic Unit K1			
Probability of dangerous failure per hour		1.01 x 10 ⁻⁷ per hour.	

Figure 29 Functional Safety Sheet #3

FINAL GRADE

GENERAL COMMENTS

Instructor

71 /100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

PAGE 4

Text Comment. A good but not full list

PAGE 5

Text Comment. You could improve your writing style here

Text Comment. on

PAGE 6

PAGE 7

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

PAGE 8

Text Comment. incorrect

PAGE 9

Text Comment. You should have referred to your forms in the appendix

PAGE 10

QM

Spelling

Spelling error

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

QM

Wide Range of Sources

You have shown good evidence of reading from a wide range of sources.

QM

Correct method of listing.

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

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GRADING FORM: NEW CSG-RUBRIC

KYRAN PRITCHARD

71

1. ENGAGEMENT WITH LITERATURE



A good research section with evidence of reading from a wide range of sources listed but not always cited correctly using the Harvard method as seen in sections 2 and 10. 12/20

12

2. KNOWLEDGE AND UNDERSTANDING



Good knowledge and understanding demonstrated in all report sections and particularly sections 3, 4 and 5. 13/20

13

3. COGNITIVE AND INTELLECTUAL

-  Excellent evidence of analysis through testing with a good testing table for results, with good conclusions and recommendations. 16/20
- 16

4. PRACTICAL APPLICATION

-  Excellent evidence of practical work both with individual system modifications with simulation and with team work on VoT web server mods. 16/20
- 16

5. TRANSFERABLE SKILLS

-  A good work plan and risk assessment. Good explanation of team working. Report is well structured, mostly well written and correctly presented. Good clear diagrams. Word count not exceeded. 14/20
- 14