

2017197

by Aeron Smitham

Submission date: 26-Apr-2022 09:52PM (UTC+0100)

Submission ID: 177402561

File name: 16679_Aeron_Smitham_2017197_179606_1265873995.pdf (1.49M)

Word count: 3263

Character count: 20567

Course: HNC Electrical and Electronic Engineering
Module: SGEE4005 Instrumentation and Integrated Automation Systems
Assignment: 2. Integrated Automation System
Name: Aeron Smitham
University number: 2017197
Date submitted: 26/04/2022
Word count: 2513

Table of Contents

Table of Figures..... 3

1. Research 4

2. System Overview and Operation..... 6

3. Health and Safety, Maintenance and Reliability Requirements 8

4. System Design Adaptation..... 10

5. Conclusions and Recommendations 11

6. Team Working 13

7. References 14

8. Appendix..... 16

Table of Figures

Figure 1..... 6

Figure 2 (Wyllie, 2011) 16

Figure 3..... 16

Figure 4..... 17

Figure 5 (Keyence, 2022) 17

Figure 6..... 18

Figure 7..... 18

Figure 8..... 19

Figure 9..... 19

Figure 10..... 20

Figure 11..... 20

Figure 12..... 21

Figure 13..... 21

Figure 14..... 22

Figure 15..... 22

Figure 16..... 23

Figure 17..... 23

Figure 18..... 24

Figure 19..... 25

Figure 20..... 25

Figure 21..... 26

Figure 22..... 27

Figure 23..... 27

1. Research

Computer Integrated Manufacturing (CIM) systems are used to control entire production processes with minimal human interaction. Each individual process communicates with each other with real-time data from sensors which monitor and control how the system functions (Bolton, 2015). This sharing of data allows several individual processes to become one single integrated system.

Some pros of a CIM system are:

- Measuring the Overall Equipment Effectiveness (OEE) through machine utilisation and machine efficiency.
- Real-time data collection to be used for monitoring the process (YingZhen & Wenlan, 2021).
- Real-time process control and ability to intelligently respond to machine failures.
- Information sharing between machines via M2M communications. Processes can automatically react to information received from a previous machine (Yanlan, et al., 2011).
- Improved maintenance capabilities via condition-based monitoring. Industry 4.0 ready sensors can feedback their condition and operating characteristics in real-time for the maintenance team to react to issues more reliably and efficiently (Gilchrist, 2016).

Some cons of a CIM system are:

- Integration of several different technologies into one system can be difficult, with various technologies such as: PLC controlled machinery, Robotics, and CNCs.
- Automated processes require high levels of data integrity to successfully control a process; a small issue such as a faulty sensor can cause a process to come to a halt, as the automatic cycle has its sequence interrupted (Jack, 2010).
- High levels of automation reduce the amount of amount of manual labour required, but also increases the complexity of the system – meaning experts in the field of automation are required to maintain the system (Groover, 2016).

In the era of Industry 4.0, cyber-physical systems are used to power modern smart factories, with technologies such as wireless sensors that can communicate with PLCs which can then be used to communicate with other controllers in the same network or to feedback to a central server through the OPC-UA standard (Shapournia, 2020). Advancements in wired sensors have also been made with technologies such as IO-Link, where data and diagnostic information can be stored in the sensor and then collected at intervals to be analysed (IO-Link, 2022). Another emerging technology is the View of Things (VOT) in Siemens TIA Portal V17.

The VOT can be set up as a web server which can be accessed anywhere in the world to monitor and control a process (Siemens, 2022). An engineer can sign into the web server and monitor a process from a remote location, rather than having to be onsite to interrogate the system.

A typical Cyber-physical system is made up of: a physical layer – which connects sensors on the production line to the PLC, a gateway – which connects the PLC to the Cloud via communications protocols such as Profibus, Profinet, or Modbus, and the Cloud computing layer which can be used for data storage or diagnostic interrogation (Prist, et al., 2019).

Profinet – a type of industrial ethernet – is leading the way as the preferred communication protocol for Industry 4.0 applications. Modbus, Profibus, and other serial forms of communication are being replaced by Profinet for its ease of use, device and network diagnostics, flexible topologies, and fast, efficient data transmission (Siemens, 2022). Profinet has the fastest transmission times, and also has the ability to transmit and receive data at the same time due to its full-duplex transmission (Pigan & Metter, 2008).

Characteristics	Profinet	Profibus
Transmission Speed	Ultra-fast transmission	Fast transmission
Cycle Times	Adjustable, fast cycle times	Fixed, fast cycle times
Transmission Modes	Full duplex. Can transmit and receive at the same time.	Half duplex. Can also transmit or receive at a time.
Protocol	Ethernet	Serial
Topology	Any topology is possible, with Star the most used.	Star & Daisy Chain, but most commonly Daisy Chain which causes the network to be fault sensitive if one of the nodes becomes faulty.

Table 1 (Procentec, 2022)

2. System Overview and Operation

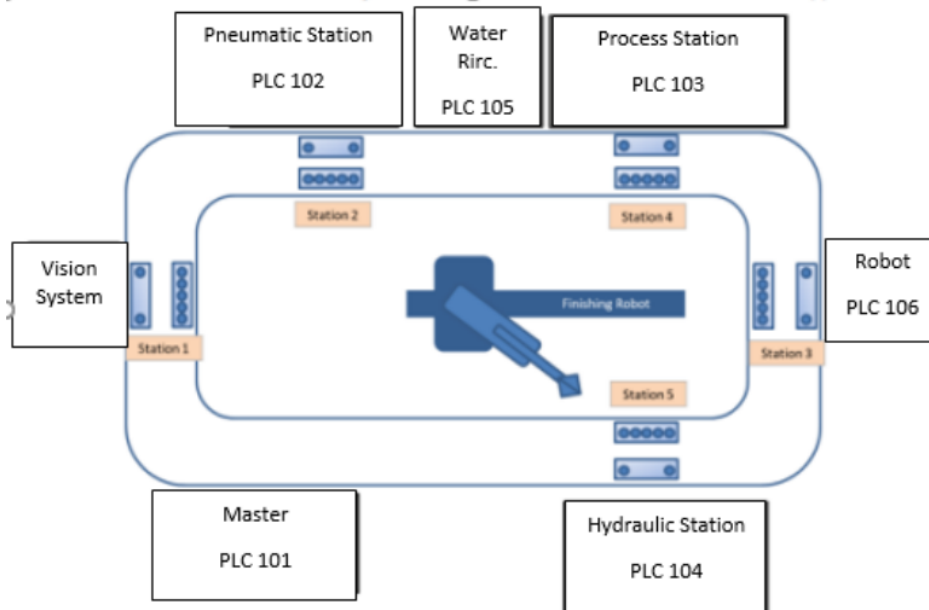


Figure 1

Figures 3 and 4 in the appendix show an overview of CIM system and the complete network connection.

The CIM system is split up into various processes:

- Pneumatic Station – Loads handles and stamps to wagons for transportation.
- Vision System – Inspects stamp, handle, and finished product.
- Process Station – Processes the handle.
- Assembly Robot and Press – Assembles the stamp and handle into the finished product. Assembly robot also removes defective parts after inspection at the Vision System.
- Hydraulic Station – Stores finished product.

Each wagon is individual numbered, with detectable bits on the underneath of the wagon which proximity sensors pick up at each station. This ensures that the system knows where each wagon is, or what wagon is at each station. There are 5 possible detectable bits on the wagons, with a binary value of 1, 2, 4, 8, and 16. If the first and last proximity at a station detects the wagon then it means the wagon at the station is wagon 17. There is also a proximity to detect if a wagon is present at each station, and a piston that is actuated to release the wagon from the station when ready.

A 4-point register is used to check the current state of the wagons in circulation on the system. The first digit describes what the wagon is carrying, from an empty pallet to a finished product. The second digit is to feedback if a part needs to be inspected, with a different number for the stamp and each handle. The third digit is whether either of the handles requires processing. While the fourth digit details the result of the inspection and what part has passed or failed.

This works by a setpoint (SP) value being entered into the system and then the register adds up until the PV matches the SP and the product is finished. If a certain part of the sequence fails inspection, then the part will be removed as the PV will never match up with the required SP.

There was much more that could have been explained in this section

3. Health and Safety, Maintenance and Reliability Requirements

Hazard	Persons at risk	Severity (0-5)	Likelihood (0-5)	Total (S x L)	Control Measures	Additional Control Measures	Severity (0-5)	Likelihood (0-5)	Total (S x L)
Moving Parts	Persons in the area of machine	4	4	16	Unauthorised persons not allowed to operate machinery.	Install guarding around machinery in accordance with BS EN ISO 13857 & BS EN ISO 14120. As per the above the fixed guarding shall be yellow in colour, with black perforate material which enhances the process under observation.	4	1	4
Electricity	Persons operating machine	5	3	15	Unauthorised persons not allowed in area and made aware of hazards.	All electrical enclosures to be padlocked.	5	1	5
Trip Hazards	Persons in the area of machine	3	3	9	Cables run in conduit and other containment.	All cables to be run overhead to eliminate trip hazards.	3	1	3
Scalding	Persons operating machine	4	3	12	Heating elements interlocked and inaccessible.	Max temperature to be set in software to ensure water cannot be heated to a high temperature.	4	1	4

Using a risk rating matrix, as can be seen in figure 2 of the appendix, it can be seen that 2 of the hazards warrant urgent action to be taken with scores of 16 and 15, while the other hazards have a score of 9 and 12 which requires action to be taken. With the stated additional control measures, these scores could be reduced to 4, 5, 3, and 4, respectively, meaning they have been reduced to an acceptable or desirable level.

The biggest hazard is that of the moving parts of the CIM system that can still be accessed. All moving parts should be guarded, interlocked, or protected via a light curtain. The guarding installed to mitigate against the hazard should be installed to BS EN ISO 14120:2015 Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards.

An industry standard for designing safety systems is to use Performance Level (PL) and required Performance Level (PLr). A safety system will have a PLr to meet the minimum level of safety, and the PL is the verified level after the safety system has been designed. The PL must be equal or greater than the PLr (PILZ, 2022). Using figure 5 in the appendix, the CIM system has a PL of 'c', made up of a S1, F2, and P2, meaning slight injury, frequent exposure, and scarcely possible to avoid hazard.

With the installation of guarding around the machine and interlocks on the guards to ensure the moving parts of the system stop when the guards are opened, the PL would be reduced to an 'a'. The PL parameters now being S1, F1, and P1 – slight injury, infrequent exposure and possible to avoid hazard.

To ensure the process is performing reliably, the instruments in the system should be calibrated regularly. Without the calibration of the instruments, a true and accurate reading may not be given by the system. In some industrial processes it is paramount that instruments are calibrated and give an accurate reading, otherwise they run the risk of catastrophic failures or loss of profits.

Another way of ensuring the CIM system performs reliably is to develop a maintenance program for the several different parts in the system. The maintenance programs could be split up into: mechanical parts, pneumatic fittings, fluid tanks and fittings, motors, and electrical components. Regular checks and maintenance – when required – ensures the optimum performance of the machine, with decreased downtime due to faults.

4. System Design Adaptation

Several modifications were made to the CIM system such as analogue values for level and flow taken from PLC 103 and mapped to PLC 101, as can be seen in figures 18 – 23. Profinet handshaking signals between the PLCs were added to the Engineer Main CIM screen of HMI 131, as can be seen in figure 6, while indicators for wagon position and online status were added to the same screen.

A remote monitoring and control webpage was also created on View of Things (VOT) for the CIM system, which acts as a mimic of the Engineer Main CIM HMI screen. This feature greatly improves the CIM system in meeting the needs of Industry 4.0 with the ability for an engineer to remote in from anywhere to check the performance of the machine and even control it.

Test	Expected result	Actual Result	Pass/Fail	Figures
Setpoint (SP) value to show on HMI & VoT	SP to show in each box with no '#' and can be changed.	SP showed in each box and were able to change.	Pass	14 – 17
Process Variable (PV) value to show on HMI & VoT	PV to show in each box with no '#'.	PVs showed in each box.	Pass	14 – 17
Wagon number value to show on HMI & VoT	Wagon numbers to show on different stations	Stations showed various wagon numbers	Pass	14 – 17
Profinet counter value to show on HMI & VoT	Profinet counters to count up showing successful handshaking	Profinet counters continually counted up.	Pass	14 – 17
Indicators to show on HMI & VoT	Indicators to light up when wagon at station and wagon released from station	Indicators lit up when wagons were at stations.	Pass	14 – 17

5. Conclusions and Recommendations

In this report, several tasks were completed to develop the understanding of the Computer Integrated Manufacturing (CIM) system. The report has two distinct sections, with one being the research into M2M communications and their associated protocols and how integrated systems are becoming the norm in the era of Industry 4.0, with whole factories becoming interconnected together to make one process. The second section consists of software modifications to the PLC, HMI, and View of Things web server, which all improve the integration of the CIM system and its M2M communications.

The various communication protocols were investigated, such as: Profibus, Modbus, Industrial Ethernet, and Profinet, with particular interest paid to Profinet as it is the protocol used in the CIM system. As shown in the research section, the Profinet protocol will all but replace serial communications such as RS-232, Profibus, and RS-485, as Industrial Ethernet becomes the industry standard. With Industry 4.0 ever-growing, more and more electrical components are becoming Profinet capable, such as the obvious PLCs, HMIs, Variable Speed Drives, and then newer technologies such as encoders and sensors.

The modifications made to the software were to improve the communications between PLC 101 and PLC 103, with the other 4 PLCs in the system already set up. PLC 101 is the master PLC, but as is required in Profinet, PLC 101 had to be set up as the slave PLC with each of the other PLCs – meaning PLC 103 was the master, as it was putting (PUT) data to PLC 101 and getting (GET) data from it. This master/slave setup was used for all other PLCs with PLC 101, with all the REAL analogue values from the Profinet masters PUT to PLC 101.

These analogue values, along with Profinet counters, were then displayed on HMI 131 and the View of Things screen. Profinet counter values for the Pneumatic station, Process station, Hydraulic station, Water Recirculation, and Assembly station were tagged to the Engineer Main CIM screens to show the communications were healthy. Proximities and release indicators were also added to both screens to show where the Wagon was in the system. These indicators were retagged as a PLC 101 data item.

A recommendation for this system would be to improve the safety of the machinery in the CIM system. As stated in Section 3, the moving parts of the system can easily be accessed and could cause serious harm to someone in the vicinity of the machine. The required Performance Level (PLr) of the machine was determined to be a 'c' in its current state, but with the installation of an interlocked safety guard that inhibits movement while the guard is opened, the new PL would be an 'a' as there would be no exposure to moving parts and would be possible to avoid harm so the F and P parameter of the PL would be reduced.

This system could be further improved through the use of a solenoid-trapped mechanically interlocked key, that would only be released for use when there is no movement inside the system. Standstill relays could be used to check that the motors had stopped moving and come to a stop, along with safety dump valves used to dump all the hydraulic and pneumatic pressure in the system before a Fail-Safe Siemens S7-1500 PLC output actuates the solenoid to release the key, which then is used to open the guard. This would be an improvement on a system that just has a guard interlock that is free to open and stops the supply to the machinery, as in this case there could still be moving parts active as the motors ramp down to stop, or if pressure remains in a hydraulic or pneumatic system.

6. Team Working

A group of 4 was put together to complete the modifications to the CIM system PLC software and HMI screens. For the task, the team was split up into different roles. The roles were as follows:

- PLC Modifications
- HMI Modifications
- VoT (View of Things) Screen Creation
- Operating and Testing

The operator controlled and tested all the modifications made by the other team members to ensure they were functioning correctly. The PLC modifications were made to ensure the communications between all the different PLCs were all healthy, with GET and PUT functions used to transfer the Profinet count of each PLC. HMI modifications were made to visualise the system status signals and also the command signals for that PLCs functions – such as the Process Station pick and place command signals being shown. A View of Things screen was created on a web server that was a mimic of the HMI screen already created showing the Engineering Main CIM screen. The HMI screen was used as a base, and then value boxes and light indicators were used to show the process. This setup provided successful results as everyone was familiar with their role, allowing the team to succeed in finishing the task promptly.

7. References

- Bolton, W., 2015. *Instrumentation and Control Systems*. 2nd ed. Oxford: Newnes.
- Gilchrist, A., 2016. *Industry 4.0: the industrial internet of things*. 1st ed. s.l.:Apress.
- Groover, M., 2016. *Automation, Production Systems, and Computer-Integrated Manufacturing*. 4th ed. Essex: Pearson.
- IO-Link, 2022. *IO-Link Advantages*. [Online]
Available at: <https://io-link.com/en/Advantages/Maintenance.php?thisID=109>
[Accessed 19 01 2022].
- Jack, H., 2010. *Automating manufacturing systems with PLCs*. 7th ed. United States: s.n.
- Keyence, 2022. *PLr and PL (From ISO 13849-1:2006)*. [Online]
Available at:
<https://www.keyence.com/ss/products/safetyknowledge/performance/level/#:~:text=The%20performance%20level%20%28PL%29%20is%20a%20value%20used,the%20required%20risk%20reduction%20for%20each%20safety%20of%20function.>
[Accessed 21 04 2022].
- Pigan, R. & Metter, M., 2008. *Automating with PROFINET*. 2nd ed. s.l.:Publicis.
- PILZ, 2022. *EN ISO 13849-1: Performance Level (PL)*. [Online]
Available at: <https://www.pilz.com/en-GB/support/knowhow/law-standards-norms/functional-safety/en-iso-13849-1>
[Accessed 21 04 2022].
- Prist, M. et al., 2019. *Cyber-Physical Manufacturing Systems for Industry 4.0: Architectural Approach and Pilot Case*. Naples, Workshop on Metrology for Industry 4.0 and IoT (MetroInd4.0&IoT).
- Procentec, 2022. *Profibus vs Profinet*. [Online]
Available at: <https://procentec.com/content/profibus-vs-profinet-what-are-the-main-differences/>
[Accessed 12 04 2022].
- Shapournia, S., 2020. *WiFi vs Industrial Wireless*. [Online]
Available at: <https://realpars.com/wifi-vs-industrial-wireless/>
[Accessed 20 04 2022].
- Siemens, 2022. *Advantages of Profinet*. [Online]
Available at: <https://new.siemens.com/uk/en/products/automation/industrial-communication/profinet/advantage.html>
[Accessed 11 04 2022].
- Siemens, 2022. *View of Things*. [Online]
Available at: <https://new.siemens.com/global/en/products/automation/simatic-hmi/wincc-unified/view-of-things-web-hmi.html>
[Accessed 19 04 2022].
- Wyllie, G., 2011. *Risk Managment with Gordon Wyllie*. [Online]
Available at: <http://blog.mindgenius.com/2011/04/risk-management-with-gordon-wyllie.html>
[Accessed 18 04 2022].

Yanlan, Y., Hua, Y. & Shumin, F., 2011. *Design of communication interface for M2M-based positioning and monitoring system*. Ningbo, China, International Conference on Electronics, Communications and Control (ICECC).

YingZhen, Y. & Wenlan, X., 2021. *Composition and Communication Analysis of M2M System in Internet of Things*. Guangzhou, China, International Conference on Artificial Intelligence and Electromechanical Automation (AIEA).

8. Appendix

Risk Rating = Likelihood x Severity



Figure 2 (Wyllie, 2011)

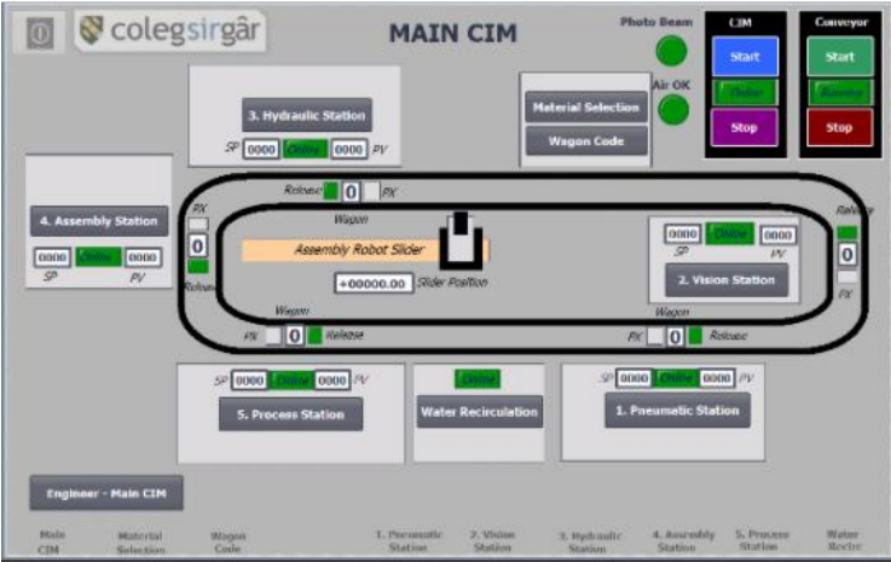


Figure 3



Figure 4

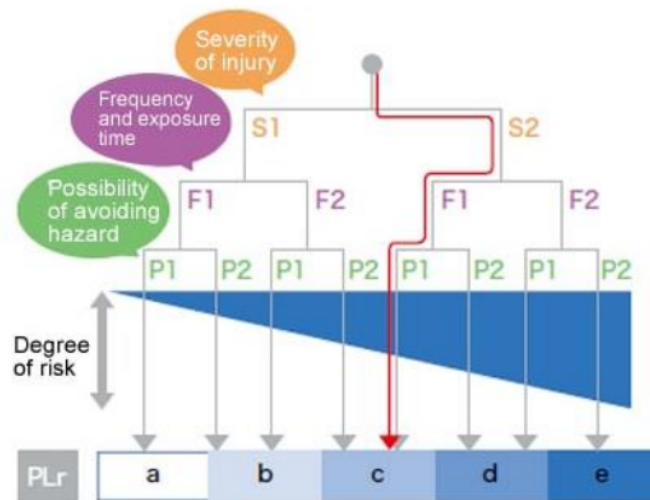


Figure 5 (Keyence, 2022)

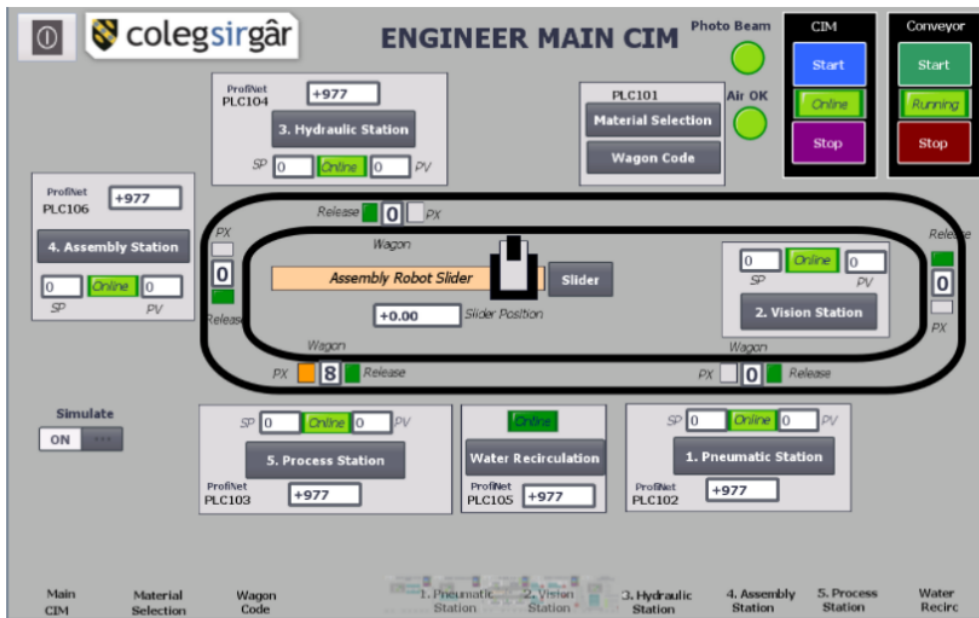


Figure 6

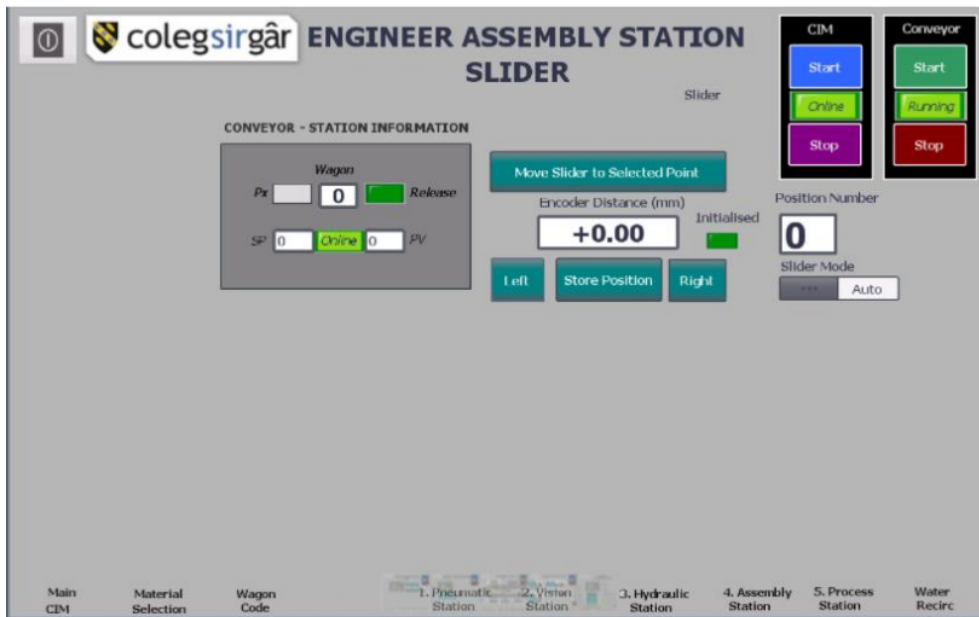


Figure 7

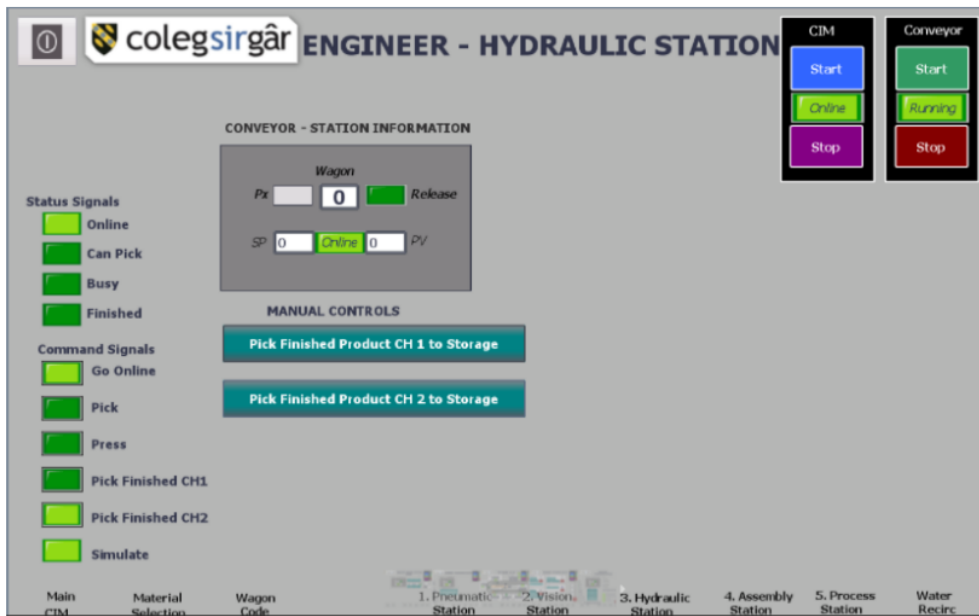


Figure 8

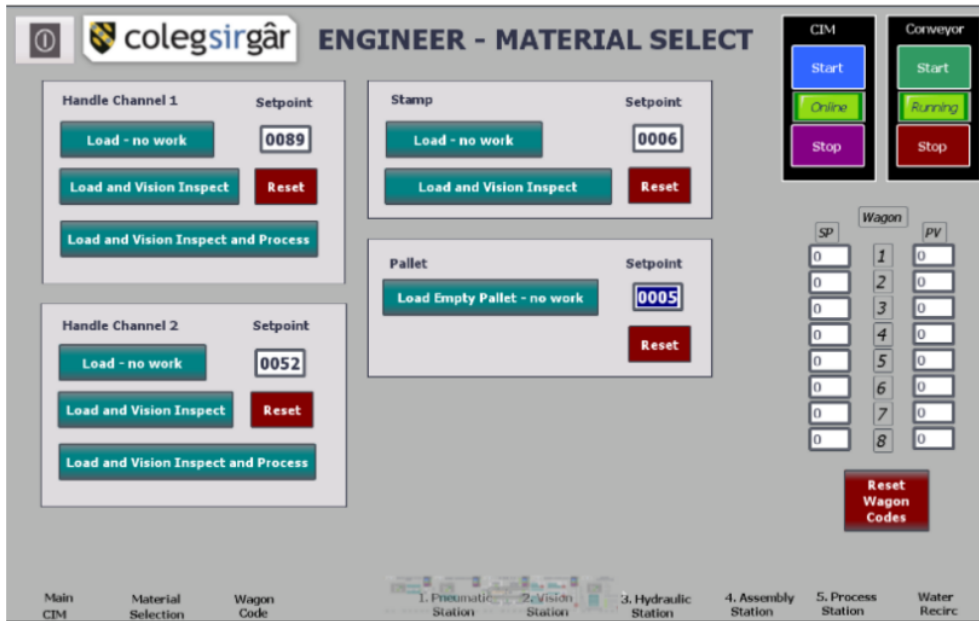


Figure 9

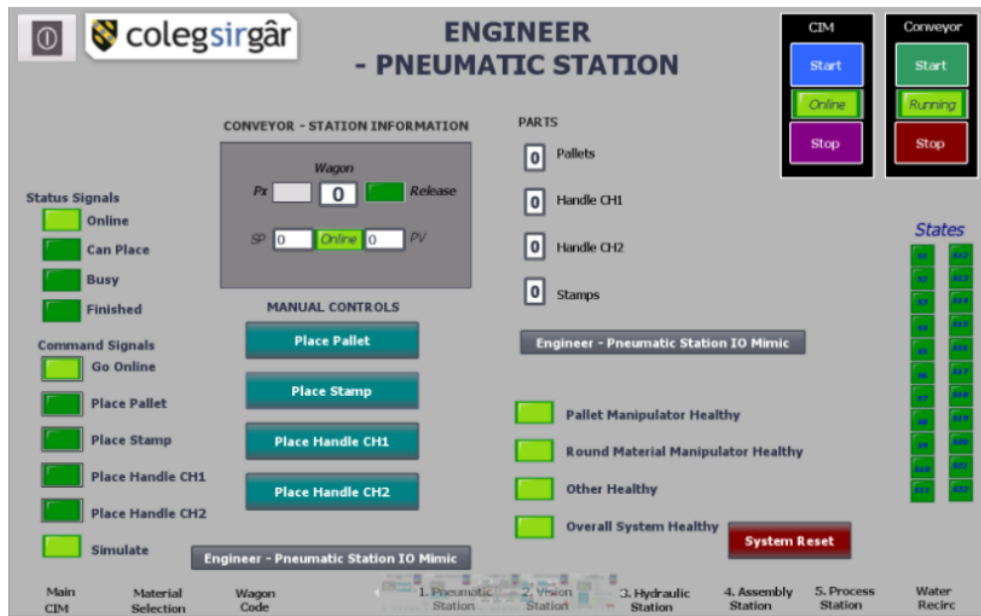


Figure 10

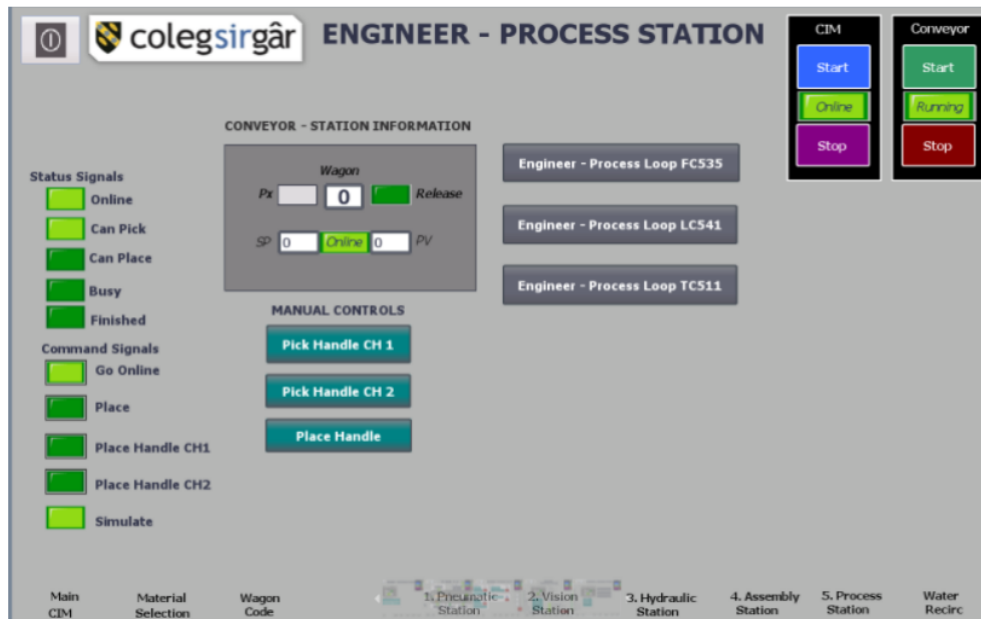


Figure 11

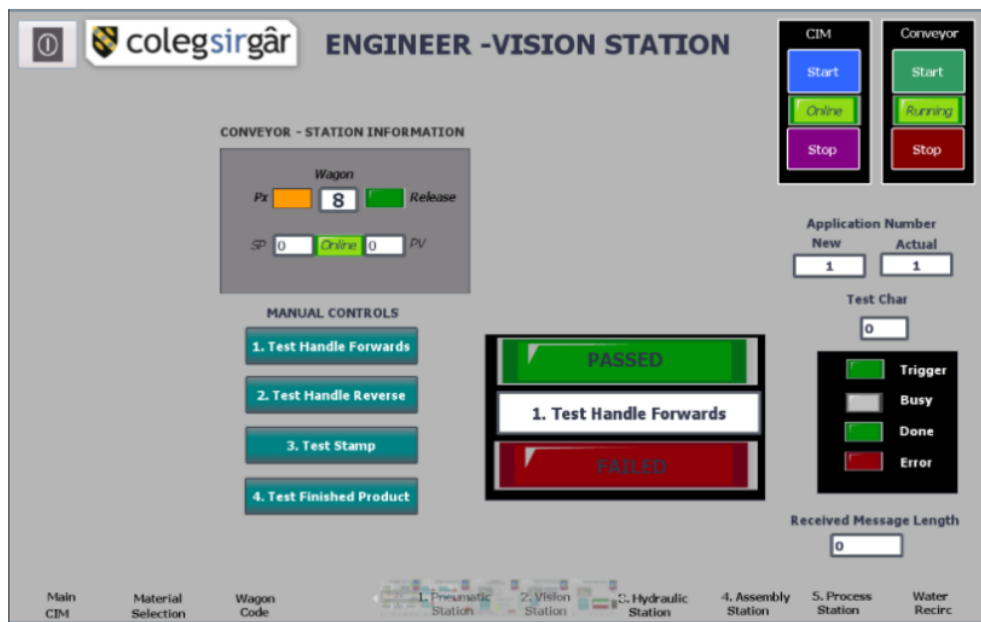


Figure 12

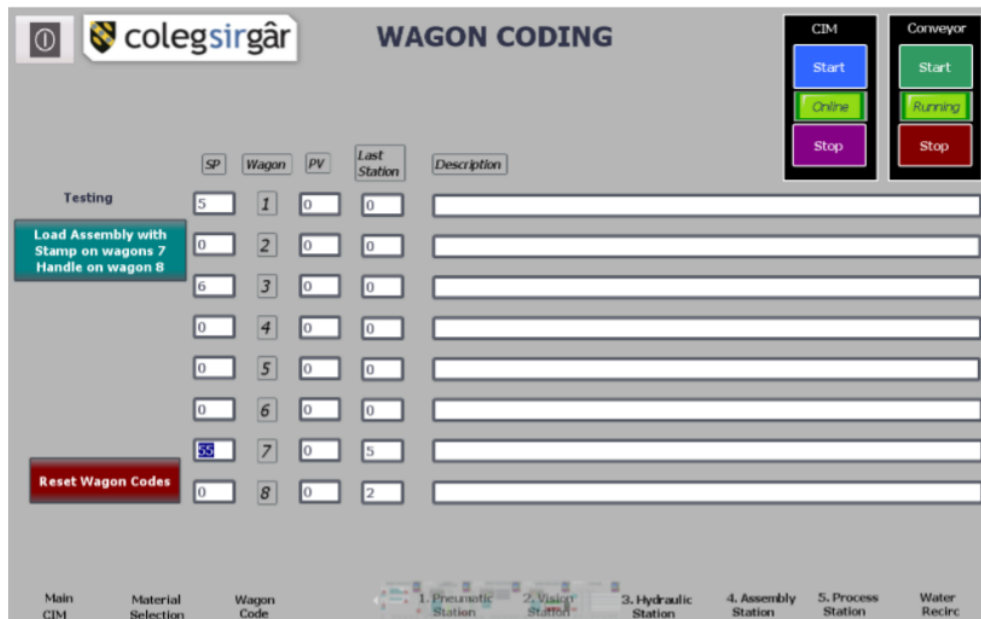


Figure 13

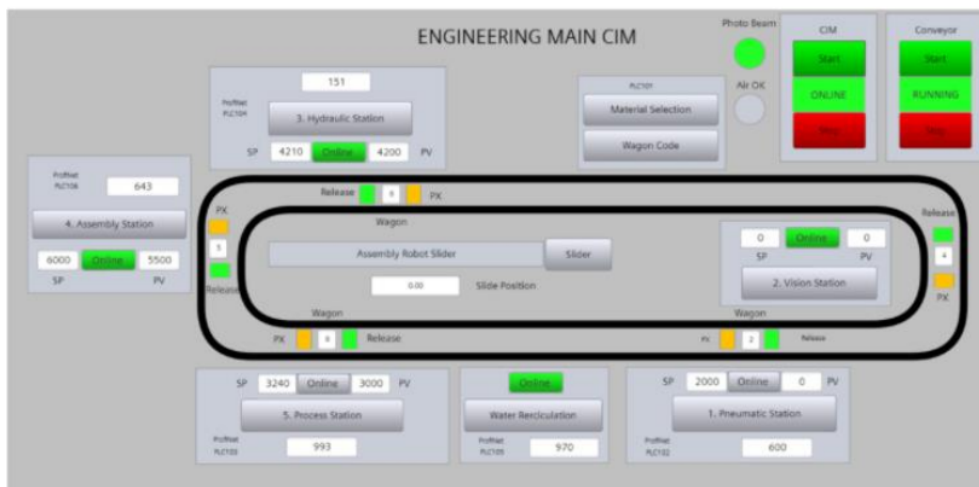


Figure 14

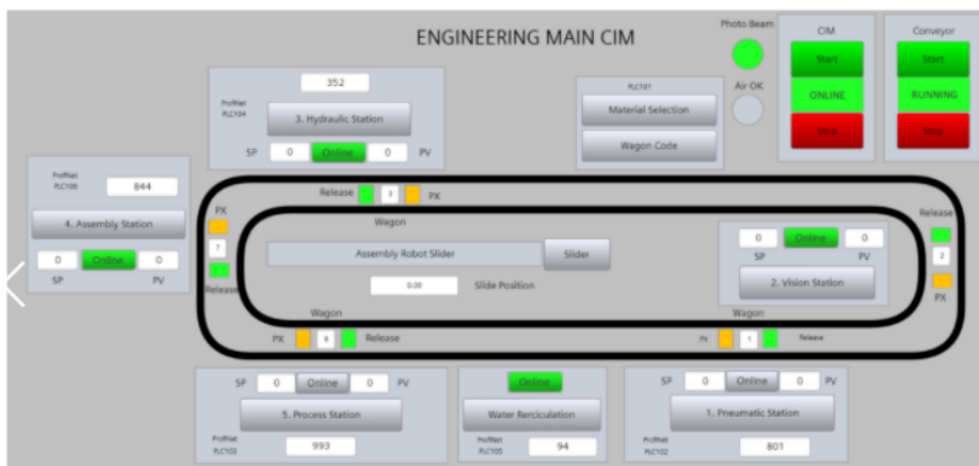


Figure 15

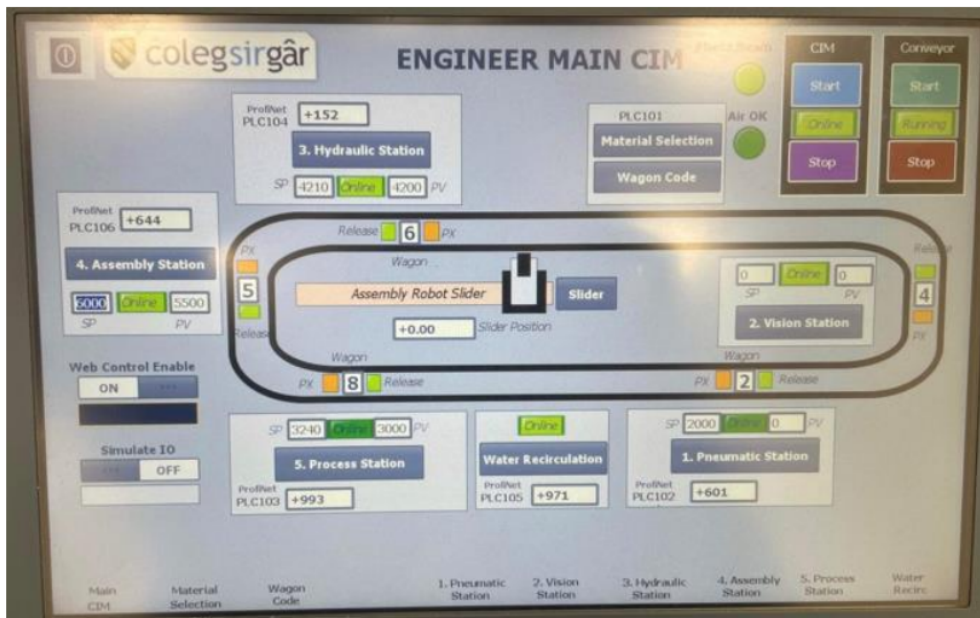


Figure 16

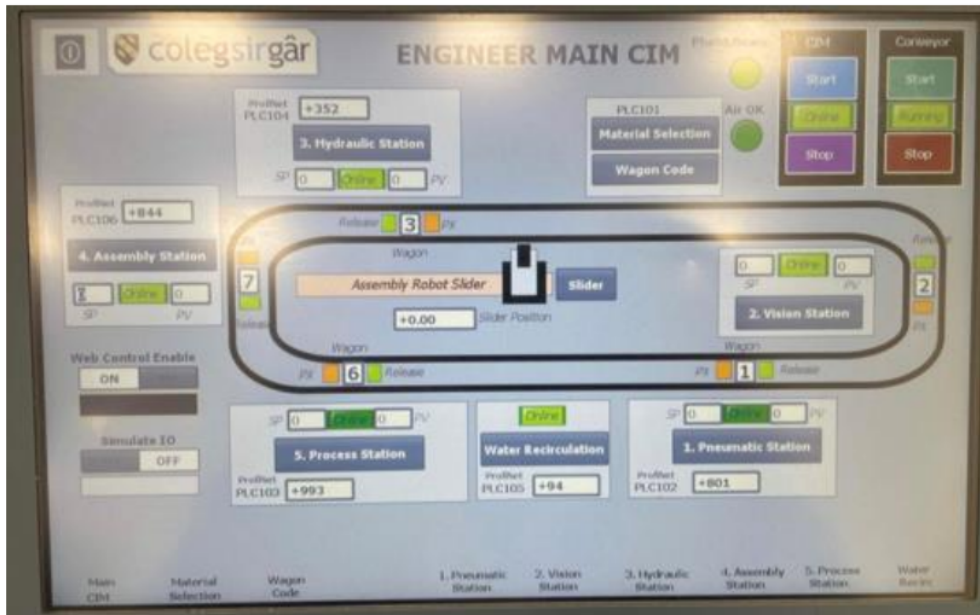


Figure 17

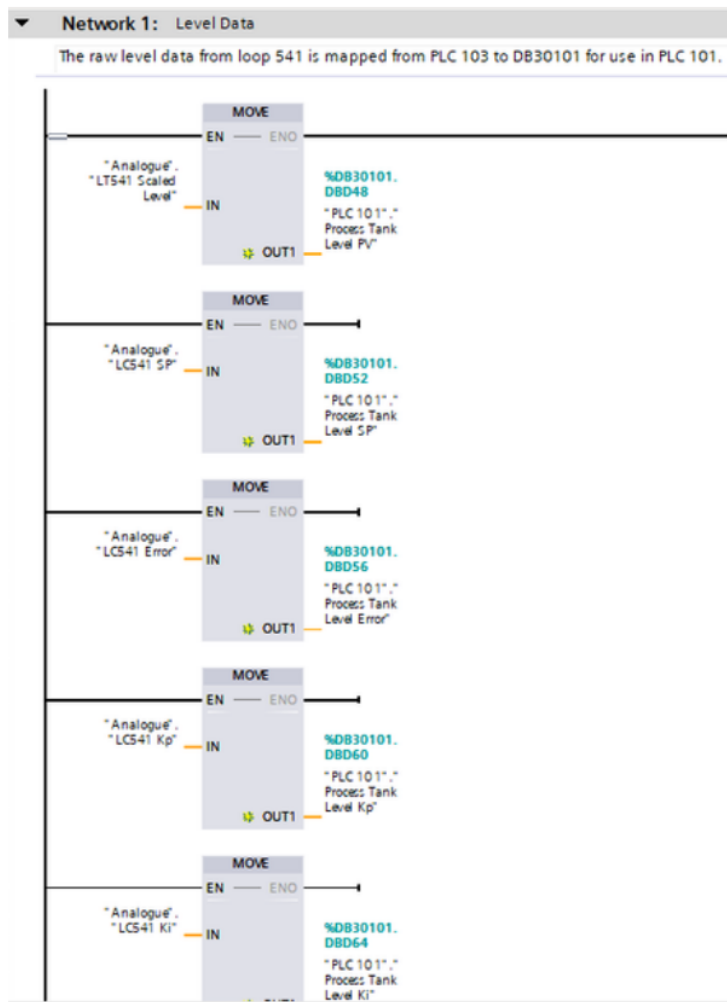


Figure 18

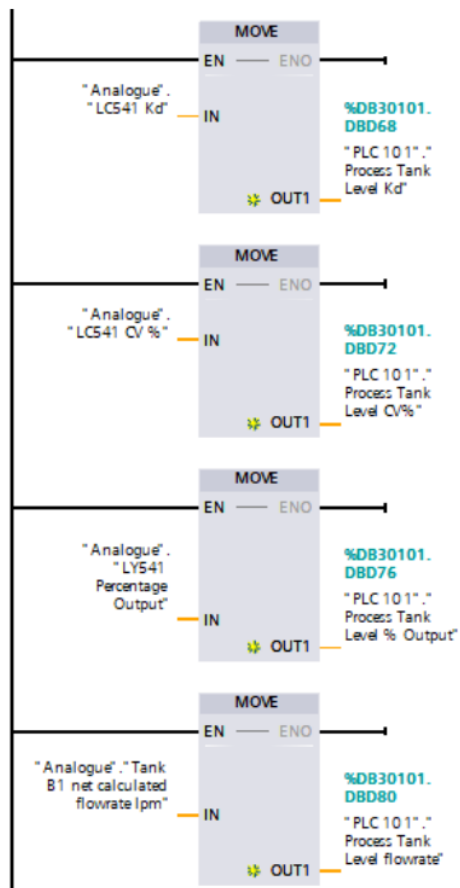


Figure 19

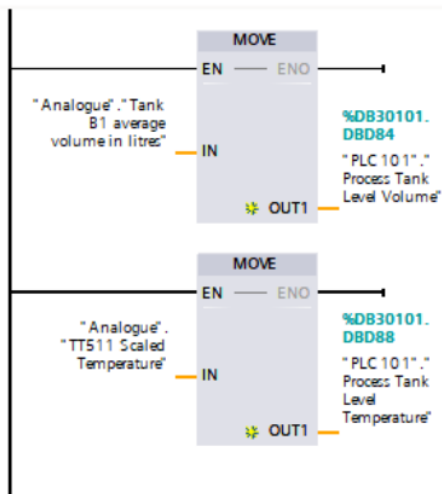


Figure 20

Network 2: Flow Data

The raw flow data from loop 535 is mapped from PLC 103 to DB30101 for use in PLC 101.

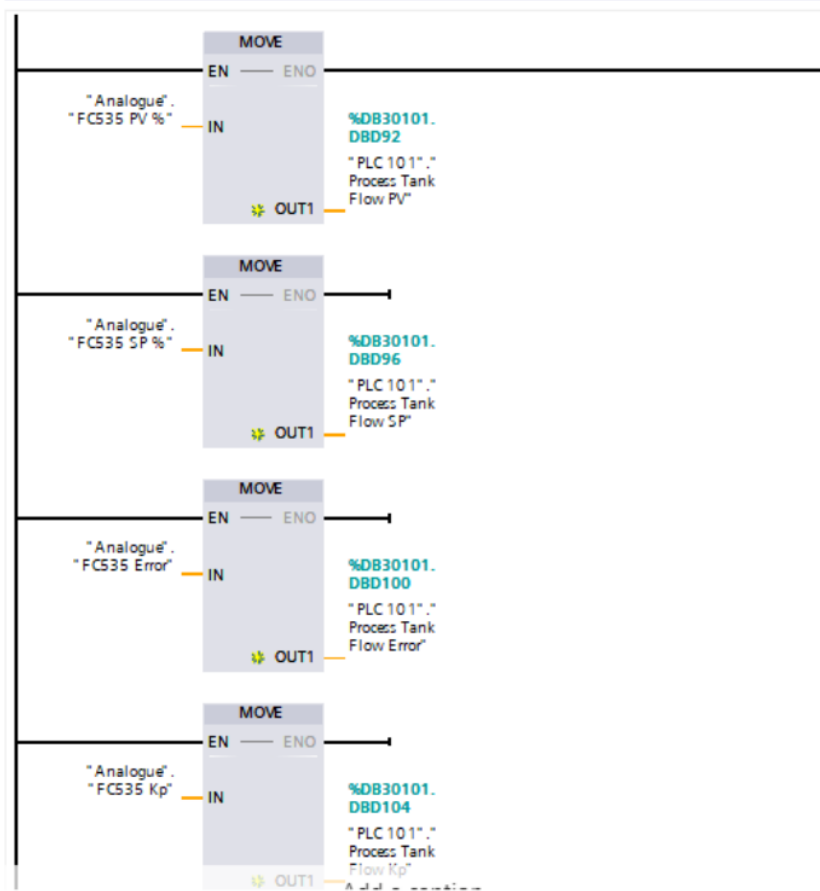


Figure 21

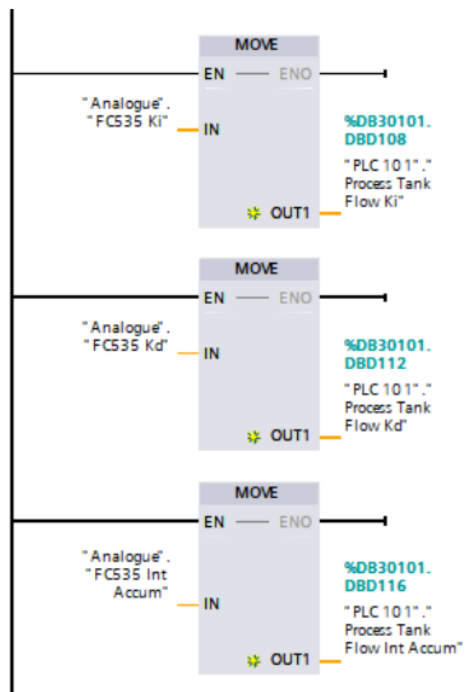


Figure 22

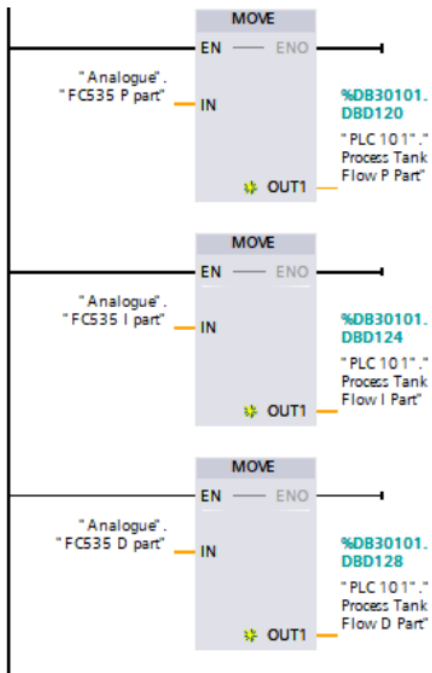


Figure 23

FINAL GRADE

GENERAL COMMENTS

Instructor

84/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

Text Comment. There was much more that could have been explained in this section

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

Text Comment. Wide range of sources correctly listed

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

AERON SMITHAM

84

1. ENGAGEMENT WITH LITERATURE



Excellent evidence of research from a wide range of sources, correctly cited and listed throughout the report. 18/20

18

2. KNOWLEDGE AND UNDERSTANDING



Very good knowledge and understanding also seen throughout the report. However, explanation given of the system's hardware and software is rather brief. 12/20

12

3. COGNITIVE AND INTELLECTUAL



Excellent assessment of risk in section 3, with clear evidence of testing and analysis of results and conclusions and recommendation given. 18/20

18

4. PRACTICAL APPLICATION



Excellent practical work with well presented results and evidence. 18/20

18

5. TRANSFERABLE SKILLS



Excellent report, well presented, formatted and written with clear evidence of team working. 18/20

18