

1707739

by Liam Phillips

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This is a very good report, well structured and laid out, covering most aspects required by the brief. Good analysis and conclusions and good evidence of testing.

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1. System Investigation

The CIM system process station cleans, rinses, passivates, and dries parts. This process requires the part to go through a series of tanks i.e., cleaning; rinsing chamber; very diluted sulphuric acid; rinsing chamber; coating with 772 passivator; rinsing chamber; drying chamber. The machine is run by various control loops. The P&ID diagram of the process station is found in appendices 1.

Water from the process rig is fed into the bottom tank of the water recirculation sub-system via water outlet. This water is then pumped to the top tank, and from there, the water is fed into the process rig water inlet. Both tanks have a level transmitter, and the pipe in which the water travels from the bottom tank to the top has a flowrate transmitter. The P&ID diagram of the water recirculation sub-system is found in appendices 2.

1.1. Temperature Control Loop 511

The symbol 'TC511' controls the temperature of water into tank B1. It does this by producing a control variable which is fed into an SSR using PWM. The interlock is provided by 'LS542'. The temperature is affected by the addition of cold water provided by the cooling fan, solenoid valves 'V515' and 'V516', and the pump amplifier 'LY541'.

The symbol 'TT511' is a temperature transmitter (PV) that measures the temperature of the water going into tank B1. This device is a PT100 RTD. Characteristics of this device are shown in table 1.

you should have quoted the singal conditioner details

Minimum Temperature	-50°C
Maximum Temperature	200°C
Accuracy	Class A
Tolerance	±1.5%

Table 1 – CIM system temperature sensor characteristics (RS Components, 2022)

1.2. Flow Control Loop 535

The symbol 'FC535' controls the flow of water into tank B1. It does this by producing a control variable which is fed into the pump amplifier 'LY541'. An interlock is used to ensure that the water pumped is allowed to flow up to tank B1.

The symbol 'FT535' is a flow transmitter (PV) that measures the flowrate of the water going into tank B1. Characteristics of this device are shown in table 2.

Minimum Flowrate	0.25LPM
Maximum Flowrate	6.5LPM
Operating Temperature	-40°C to 70°C

Tolerance	$\pm 1.5\%$
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Table 2 – CIM system flowrate sensor characteristics (RS Components, 2022)

1.3. Level Control Loop 541

The symbol 'LC541' controls the level of water within tank B1. The tank is filled by the pump amplifier 'LY541', and is drained by a solenoid valve. There is an interlock with the low water limit switch 'LS541'.

The symbol 'LT541' is a level transmitter (PV) that measures the level of water within tank B1. Characteristics of this device are shown in table 3.

manufacturer?

Calibration	0 – 40mBar
Max Pressure	10Bar
Output current	4 – 20mA

Table 3 – CIM system level sensor characteristics

1.4. Flow Control Loop 531

The symbol 'FC531' controls the flow of water into all of the tanks. It does this by controlling the proportional valve 'VF531'. The water comes from the recirculating water system and enters each tank via solenoid valves 'V510', 'V511', and 'V512'.

The symbol 'FT531' is the flow transmitter that measures the flow of water going into all of the tanks. This device is the same as the one used in the flow control loop 535.

1.5. Robot Control

The symbol 'XC' controls the position of the robot. The robot's movement is linear, travelling from tank B1 to B7. Additionally, the robot's gripper can move both up and down; these operations are performed to pick and place a part.

The symbol 'XT' measures the position of the robot relative to its home. The device is an encoder and characteristics of it are presented in table 4.

Max Speed	10,000RPM
Max Resolution	6,000 pulses
Accuracy	0.1°
Operating Temperature	-20°C to 100°C

Table 4 – CIM system encoder characteristics (Euro Techsys, 2022)

2. Research

2.1. Industry 4.0

Industry 4.0 is considered to be the fourth revolution that has occurred in manufacturing. The first industrial revolution was the breakthrough of mechanisation through water and steam power; the next being the introduction of assembly lines using oil, gas, and electrical power; the third, often referred to as the “digital revolution”, was the implementation of electronics and computer systems. (Forbes, 2018)

Now, industry 4.0 picks up from the third revolution, with more technological advancements in communication and machine learning, resulting in factories working smarter. Machines can now gather valuable data and communicate and utilise that data in real time. This communication enables enhanced production capabilities while being able to immediately access and analyse data that was not previously available. (IBM, 2022)

2.2. I-O Link

I-O link is essential to the implementation of industry 4.0. It complements existing control systems utilising Ethernet-based fieldbus such as Ethernet/IP. The connections provide a true digital process value that is a lower cost alternative to analogue signals. I-O link also unlocks diagnostic data and helps reduce unplanned downtime. (IFM, 2022)



Figure 1 – IFM I-O link splitter

Implementing I-O link to the CIM system process station would be a great improvement to the machine. So, with regards to upgrading the sensors, they should be I-O link compatible. A particular brand of interest would be IFM.

2.3. CIM System Improvements

2.3.1. Temperature Sensor

IFM offer a high precision, I-O link compatible temperature transmitter in the TA2145. A comparison table between the current sensor on the process station and the suggested upgrade is demonstrated below in table 5.

accuracy should be quoted as %FSD

	Current	Upgrade
Minimum Temperature	-50°C	-50°C
Maximum Temperature	200°C	150°C
Accuracy	Class A	Class A
Tolerance	±1.5%	±0.3%

Table 5 – Temperature sensor characteristics comparison (IFM, 2022)

The TA2145 shows to have a much greater tolerance rating. Although its maximum temperature is lower, it is irrelevant considering that the process station does not reach such a high temperature.

2.3.2. Flowrate Sensor

IFM offer a high precision, I-O link compatible flow sensor in the SBG232 that also has a clearly visible LED display. A comparison table between the current sensor on the process station and the suggested upgrade is demonstrated below in table 6.

	Current	Upgrade
Minimum Flowrate	0.25LPM	0.3LPM
Maximum Flowrate	6.5LPM	15LPM
Operating Temperature	-40°C to 70°C	-10°C to 100°C
Tolerance	±1.5%	±0.5%

Table 6 – Flowrate sensor characteristics comparison (IFM, 2022)

Although it isn't required, the SBG232 has a greater flowrate detection range. But what it does have that is important is a far better tolerance rating in comparison to the sensor on the process station.

2.3.3. Level Sensor

IFM offer a reliable, I-O link compatible level sensor in the LR7000 that also has a clearly visible 4-digit LED display. A comparison table between the current sensor on the process station and the suggested upgrade is demonstrated below in table 7.

	Current	Upgrade
Calibration	0 – 40mBar	-
Max Pressure	10Bar	16Bar
Accuracy	-	±0.7%
Output current	4 – 20mA	I-O link digital signal

Table 7 – Level sensor characteristics comparison (IFM, 2022)

There is not much difference between the two sensors other than the LR7000 being capable of operating at a higher-pressure rating. But the upgrade is I-O link compatible, therefore making it the more favourable choice.

Information could not be found regarding the accuracy of the level sensor currently on the machine.

2.3.4. Position Sensor

IFM offer a reliable detection of rotational speeds, I-O link compatible encoder in the RV3100. A comparison table of the current sensor on the process station and the suggested upgrade is demonstrated below in table 8.

	Current	Upgrade
Max Speed	10,000RPM	12,000RPM
Max Resolution	6,000 pulses	10,000 pulses
Accuracy	0.1°	0.1°
Operating Temperature	-20°C to 100°C	-40°C to 85°C

Table 8 – Encoder characteristics comparison (IFM, 2022)

The RV3100 has far better specs with regards to its speed, operating frequency, and resolution. However, these advantages over the current sensor are insignificant as the robot does not travel near that sort of speed. But the IFM sensor is I-O link compatible, therefore making it the more favourable choice.

3. Environmental, Sustainable Development, Commercial Risk and Codes of Practice

3.1. Environmental and Sustainable Development

The CIM system is environmentally friendly as it reuses the same water via the water recirculation sub-system, and does not produce any waste for landfill sites. Although one of the tanks in the process rig contains sulphuric acid, which is detrimental to the environment, it is in fact very diluted which in turn reduces its harm.

To meet sustainable development standards, a direction to go into is industry 4.0; particularly implementing I-O link. This would result in a reduction in hardware, therefore, less materials being used; replacing the sensors with long-lasting reliable ones which will not require as much maintenance; and being more efficient with its energy consumption.

3.2. Commercial Risk

Producing a new similar system that is compatible with I-O link would cost a lot less in both short-term and long-term. The initial cost of manufacturing the machine would be less in comparison to the current one due to less hardware being used i.e., cables and expansion modules for PLCs. Most IO would be connected to an I-O link splitter, and a single multicore would go back to the PLC.

Long-term wise, the advancements of I-O link require less maintenance, therefore, resulting in less down time on the machine; this will in-turn increase productivity while lowering costs.

3.3. Codes of Practice for the Calibration of Analogue Sensors

The first step in calibrating an analogue sensor is creating a table. The first column is the constant which should increase in reasonable increments e.g., 10, 20, 30 etc. The constant is what the sensor measures e.g., temperature (°C).

The next column(s) is the variable. This is either the voltage or current measured via multimeter at the constants value. So, to begin, the constant is increased to measure the rise of the variable; once the constant has reached its peak, the constant is decreased to measure the fall of the variable.

These measurements are recorded in the table and compared with the linear value. The linear value is calculated by using $y=mx+c$ and is the idealistic value of the variable. This value is then subtracted from the rising and falling recordings in order to find the 'non-linearity error'. The difference between these errors is the 'hysteresis error'.

The rising, falling, and linear values can be put into a graph to compare each line to one another.

4. Calibration of Pressure Sensor

Using a multimeter, the output voltage of the pressure sensor was measured when increasing and decreasing the air in increments of 0.5Bar. The results are displayed in table 9.

Measureand pressure (Bar)	Output Voltage (V)		Linear Value	Non-linearity error		Hysteresis Error
	Rising	Falling		Rising	Falling	
0	0	0	0	0	0	0
0.5	1.1	1.04	1	-0.1	-0.04	-0.06
1	2.04	2.01	2	-0.04	-0.01	-0.03
1.5	2.99	3.02	3	0.01	-0.02	0.03
2	3.98	4.01	4	0.02	-0.01	0.03
2.5	4.97	5.01	5	0.03	-0.01	0.04
3	5.99	5.99	6	0.01	0.01	0
3.5	6.97	7.03	7	0.03	-0.03	0.06
4	7.98	8	8	0.02	0	0.02
4.5	8.98	9.01	9	0.02	-0.01	0.03
5	10	10	10	0	0	0

Table 9 – Calibration of pressure sensor results

The graph produced from these results is shown in figure 2.

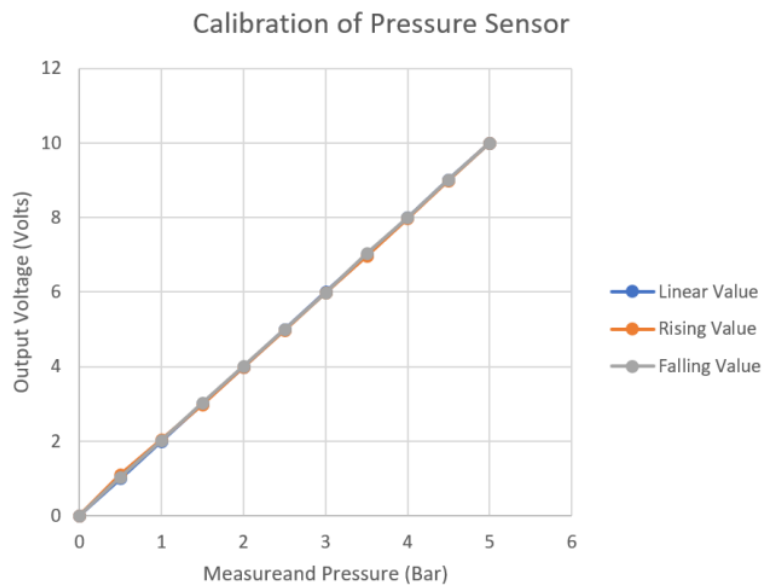


Figure 2 – Calibration of pressure sensor graph

The rising and falling values were extremely close to the linear, with a maximum hysteresis error of 0.6%.

5. Calibration of Temperature Sensor

Using a multimeter, the output current of the temperature sensor was measured when increasing and decreasing the temperature in increments of 10 degrees Celsius. The results are displayed in table 10.

Measureand Temperature (°C)	Output Current (mA)		Linear Value	Non-linearity error		Hysteresis Error
	Rising	Falling		Rising	Falling	
0	4.06	4.06	4	0	0	0
10	5.66	5.66	5.6	-0.06	-0.06	0
20	7.27	7.29	7.2	-0.07	-0.09	0.02
30	8.88	8.89	8.8	-0.08	-0.09	0.01
40	10.5	10.5	10.4	-0.1	-0.1	0
50	12.11	12.11	12	-0.11	-0.11	0
60	13.72	13.72	13.6	-0.12	-0.12	0
70	15.33	15.33	15.2	-0.13	-0.13	0
80	16.94	16.94	16.8	-0.14	-0.14	0
90	18.55	18.55	18.4	-0.15	-0.15	0
100	20.1	20.1	20	-0.1	-0.1	0

Table 10 – Calibration of temperature sensor results

The graph produced from these results is shown in figure 3.

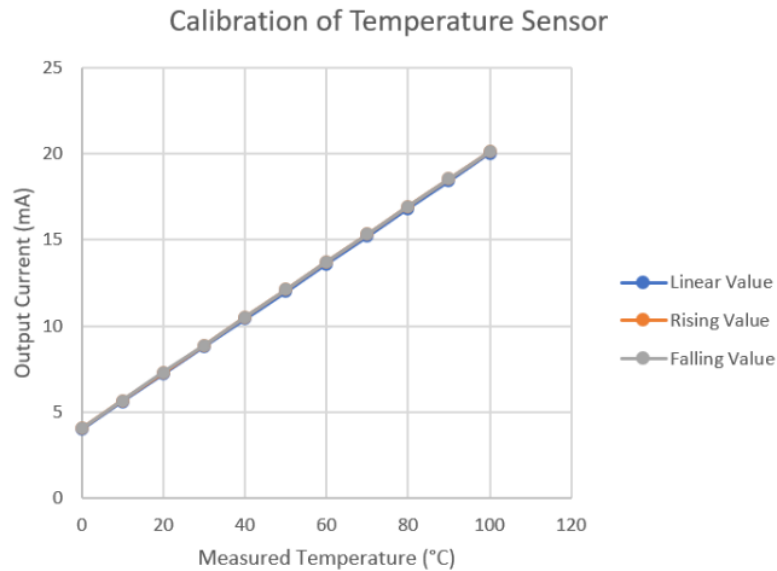


Figure 3 – Calibration of temperature sensor graph

The rising and falling values were extremely close to the linear, with a maximum hysteresis error of 0.2%.

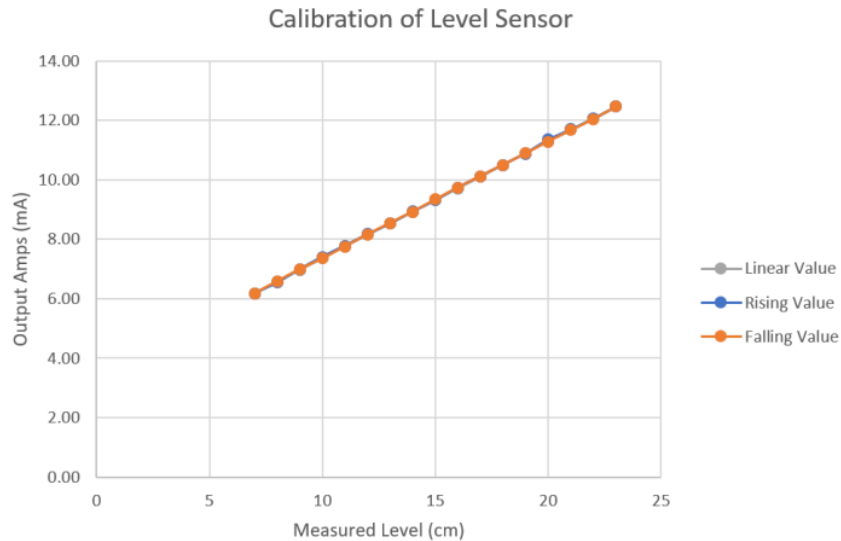
6. Calibration of Level Sensor

Using a multimeter, the output current of the level sensor was measured when increasing and decreasing the level of water in increments of 1cm. The results are displayed in table 11.

Measureand Level (cm)	Output Amps (mA)		Linear Value	Non-linearity error		Hysteresis Error
	Rising	Falling		Rising	Falling	
7	6.18	6.18	6.18	0.00	0.00	0
8	6.55	6.59	6.57	0.02	-0.02	0.04
9	7	6.99	6.97	-0.04	-0.03	-0.01
10	7.4	7.36	7.36	-0.04	0.00	-0.04
11	7.78	7.75	7.75	-0.03	0.00	-0.03
12	8.17	8.16	8.14	-0.03	-0.02	-0.01
13	8.53	8.54	8.54	0.01	0.00	0.01
14	8.94	8.92	8.93	-0.01	0.01	-0.02
15	9.32	9.34	9.32	0.00	-0.02	0.02
16	9.73	9.73	9.71	-0.02	-0.02	0
17	10.11	10.12	10.11	0.00	-0.01	0.01
18	10.49	10.49	10.50	0.01	0.01	0
19	10.88	10.89	10.89	0.01	0.00	0.01
20	11.36	11.28	11.28	-0.08	0.00	-0.08
21	11.7	11.67	11.68	-0.02	0.01	-0.03
22	12.05	12.04	12.07	0.02	0.03	-0.01
23	12.46	12.46	12.46	0.00	0.00	0

Table 11 – Calibration of level sensor results

The graph produced from these results is shown in figure 4.



The rising and falling values were extremely close to the linear, with a maximum hysteresis error of 0.8%.

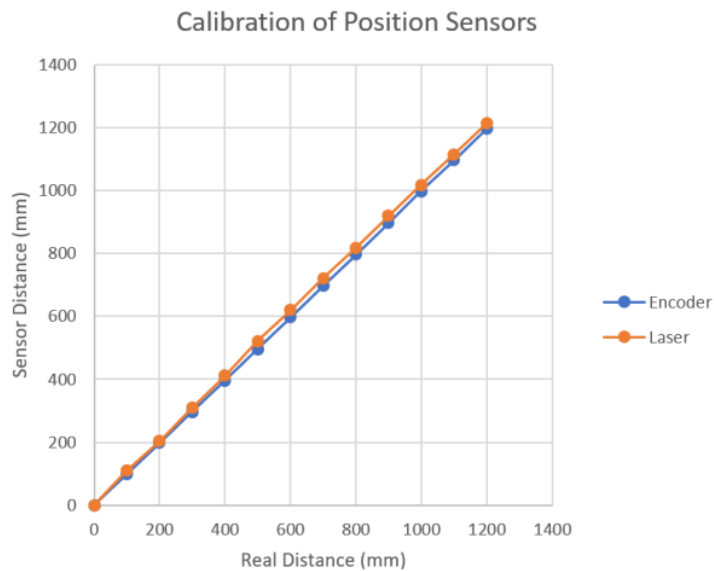
7. Calibration of Position Sensor

The position of the gripper was measured using three different methods; tape measure, an encoder, and a laser. Measurements were taken from the encoder and laser every time the tape measurement increased by 100mm. The results are displayed in table 12.

Distance (mm)		Encoder (mm)		Laser (mm)		Error
Actual	From 0	Actual	From 0	Actual	From 0	
201	0	80.4	0	269.76	0	0
301	100	178.6	98.2	380.46	110.7	12.5
401	200	278.6	198.2	474.08	204.32	6.12
500	299	377.6	297.2	579.57	309.81	12.61
600	399	476.3	395.9	681.43	411.67	15.77
700	499	576.5	496.1	791.29	521.53	25.43
801	600	677.3	596.9	889.26	619.5	22.6
901	700	777.3	696.9	991.02	721.26	24.36
1001	800	877.3	796.9	1088.24	818.48	21.58
1100	899	976.9	896.5	1189.53	919.77	23.27
1200	999	1077.7	997.3	1287.35	1017.59	20.29
1300	1099	1176.2	1095.8	1384.7	1114.94	19.14
1400	1199	1276.9	1196.5	1482.06	1212.3	15.8

Table 12 – Calibration of position sensors results

The graph produced from these results is shown in figure 5.



you could have plotted the laser against the encoder as the encoder is better than the eye
Figure 5 – Calibration of position sensors graph

Due to the tape measure readings not being as accurate as the encoder, possibly due to human error, the encoder results were subtracted from the laser values to find the laser error. The laser error reached a value of 25.43mm; a very inaccurate reading of the distance.

8. Design Adaptation for Maintenance and Reliability

8.1. Auto Sequence Screen

Start and stop buttons were added to the screen to control DC pump P1 and AC pump P2. Additionally, status lamps were included for each pump to indicate whether the pump is on or off.

The auto sequence screen is shown in appendices 12.3.

8.2. TT511 Temperature Instrument Screen

PID parameters (Kp, Ki, Kd), a PID graph, and buttons controlling the heater, along with a status lamp, were added to the TT511 temperature instrument screen.

This screen is shown in appendices 12.4.

8.3. LT541 Level Instrument Screen

PID parameters (Kp, Ki, Kd), a PID graph, and buttons controlling the cycle pump, along with a status lamp, were added to the LT541 level instrument screen.

This screen is shown in appendices 12.5.

8.4. FT535 Flowrate Instrument Screen

PID parameters (Kp, Ki, Kd), a PID graph, and buttons controlling the cycle pump, along with a status lamp, were added to the FT535 flowrate instrument screen.

This screen is shown in appendices 12.6.

8.5. FT531 Flowrate Instrument Screen

A PID graph and percentage values for the scale, multiplier, divisor, and offset were added to the FT531 flowrate instrument screen.

This screen is shown in appendices 12.7.

8.6. Robot Manual Control Screen

The laser position textbox was substituted for encoder position. This involved creating new tags and designing a new network block in order to convert the real input value from the encoder, into an integer value to display the position in mm. Evidence of this is shown in appendices 12.8 and 12.9.

A block was added to the screen to represent the position of the gripper. The block moves simultaneously with the gripper to indicate its position relative to the tank numbers.

This screen is shown in appendices 12.10.

8.7. Design Adaptation Testing

The system was downloaded to the HMI; results of the tests are tabulated in table 13.

Description of Test	Expected Results	Actual Results	Pass or Fail Decision	Reference to evidence in appendix
The TT511 screen allows the engineer to control the heater via on/off buttons, as well as display the PID status of the temperature (°C) on a graph.	When the heater is turned on, the setpoint value is set to 50°C (blue line). The control variable (green line) should increase, followed by the process variable (red line) increasing to meet the setpoint.	The heater was turned on by pressing the 'on' button. The SP was set to 50°C and the CV increased drastically, thus resulting in the PV to increase to meet the SP. The photo taken of the screen shows that the scaled value is at 42.91°C; closing to 50°C.	Pass	Appendices 12.11.
The LT541 screen allows the engineer to control the cycle pump via start/stop buttons, as well as display the PID status of the level (cm) on a graph.	With the setpoint being at 20cm, the process variable should be near that value.	The setpoint was at 20cm and the process variable was scaled at 23.1cm.	Pass	Appendices 12.12.
The FT535 screen allows the engineer to control the cycle pump via start/stop buttons, as well as display the PID status	When the flow of water is enabled via pressing the 'start' button, the setpoint value is set to 50LPM (blue line). The process variable (red	On pressing the 'start' button, the SP was set to 50LPM and the PV alternated to meet the allowed flowrate.	Pass	Appendices 12.13.

of the flowrate (LPM) on a graph.	line) alternates to meet the setpoint.			
The FT531 screen allows the engineer to see the percentage values for the scale, multiplier, divisor, and offset. Additionally, the screen displays a flowrate (LPM) graph.	When manually opening the valve 'VF531', the flowrate should be recorded on the graph.	The valve was manually opened and the graph recorded the scaled value of the flowrate.	Pass	Appendices 12.14.
The robot manual control screen allows the engineer to manually move the robot from tank to tank, as well as dropping the gripper at tank 3. On moving the robot, the encoder position presents the distance of the robot from its home.	When at tank 1, the box labelled 1 should be yellow indicating the location of the robot. The encoder position should be near 0.	The box labelled 1 was highlighted in yellow and the encoder position was 1.	Pass	Appendices 12.15.
	When at tank 2, the box labelled 2 should be yellow indicating the location of the robot. The encoder position should be near 200.	The box labelled 2 was highlighted in yellow and the encoder position was 238.	Pass	Appendices 12.16.
	When at tank 3, the box labelled 3 should be yellow indicating the location of the robot. The encoder position should be near 400.	The box labelled 3 was highlighted in yellow and the encoder position was 428.	Pass	Appendices 12.17.

	When at tank 4, the box labelled 4 should be yellow indicating the location of the robot. The encoder position should be near 600.	The box labelled 4 was highlighted in yellow and the encoder position was 642.	Pass	12.18.
	When at tank 7, the box labelled 7 should be yellow indicating the location of the robot. The encoder position should be near 1300.	The box labelled 7 was highlighted in yellow and the encoder position was 1318.	Pass	12.19.
	When at tank 3, pressing the 'move down' button should drop the gripper and the box labelled C should turn yellow.	The box labelled C turned yellow when the gripper moved down.	Pass	12.20.

Table 13 - Design adaptation tests

excellent testing table

9. Conclusions and Recommendations

The results gathered from calibrating each of the analogue sensors proved that they were in a very good condition with the exception of the laser. Excluding the laser, no hysteresis error was greater than $\pm 0.8\%$ which demonstrates that they are very accurate. As expected, the rising and falling outputs were immensely close due to the measurements being taken at the same constant; in some cases, they were exactly the same.

the laser is not fit for purpose, that's why the encoder was added

The lasers error readings seemed to be very inconsistent, ranging from 6.12mm to 25.43mm. This highlights the need for calibrating devices to ensure that they are still in working order.

HMI screens that included the level sensor, flow sensors, and encoder were modified to present the PID controls of each device. This was to monitor the sensors input in relation to the setpoint. Buttons were also added to the control screens to operate their respective valves.

The updated software was downloaded to the HMI and a series of tests were performed to ensure that the modifications were working as intended. Most tests included manually opening and closing valves to visualise the graphs pattern altering to meet the setpoint. The remaining tests involved operating the robot and monitoring its position on the screen. All tests were successful.

Recommendations include adapting the CIM system to industry 4.0 via I-O link. Research found that IFM were a leading brand in this field due to their technology in transferring data digitally via IO splitters. Implementing this type of technology to the system would be more sustainable and cost effective.

10. Team Working

The calibration exercises were performed by a group of individuals including myself. Each individual had a different role in participation of conducting the experiments. These roles were adjusting the variable; reading the measurement; and logging the data into a table to create a graph. My involvement in these experiments was the latter.

The design adaptation to the systems screens also required groupwork. Each member of the group contributed their own recommendations for improving the HMI screens. The group came to the conclusion of adding PID displays and a PID graph to all of the sensor screens. Also, a decision was made to add a position status to the robot control screen.

My contribution to this task was downloading the software to the HMI and conducting the experiments.

11. Citation List

Euro Techsys, 2022. *Incremental Encoder*. [Online]

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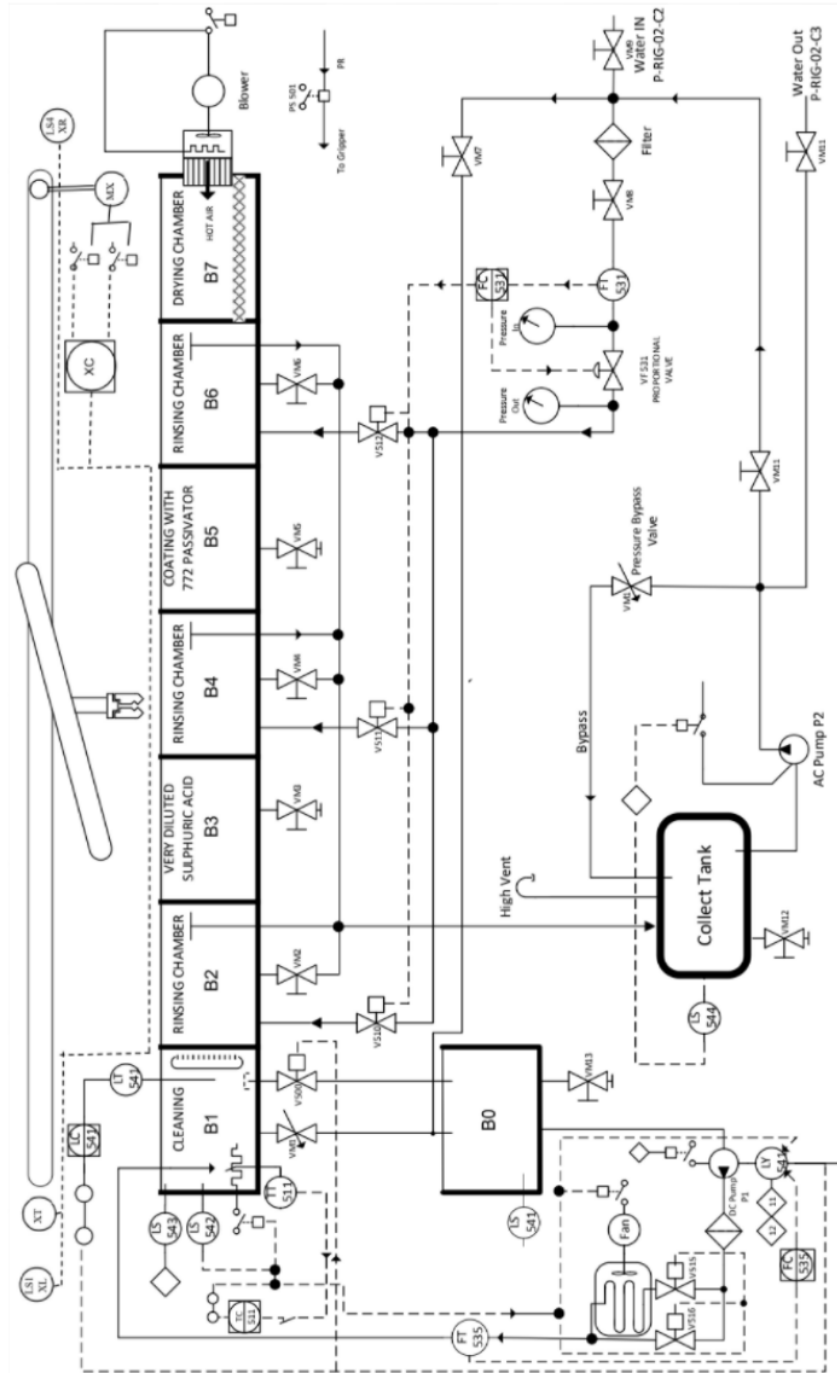
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[Accessed 20 01 2022].

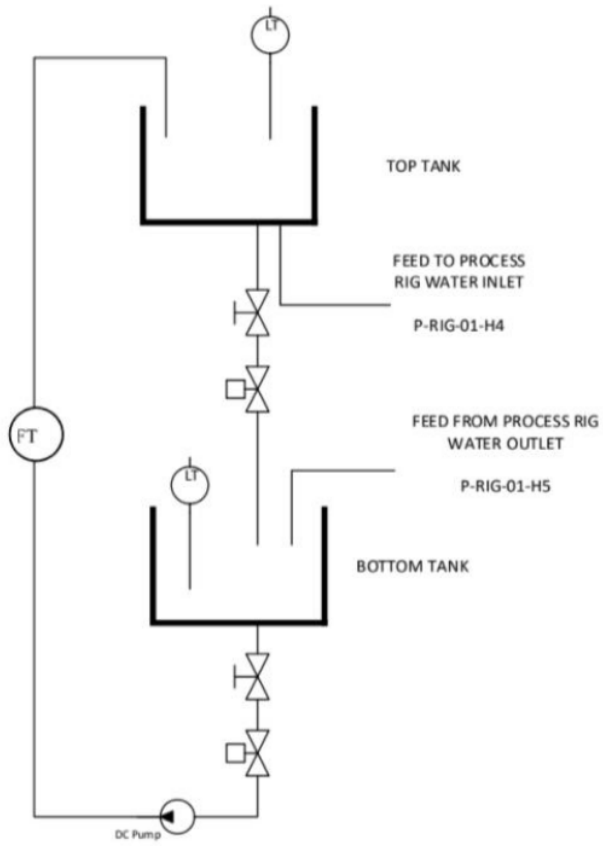
good range of sources

12. Appendix

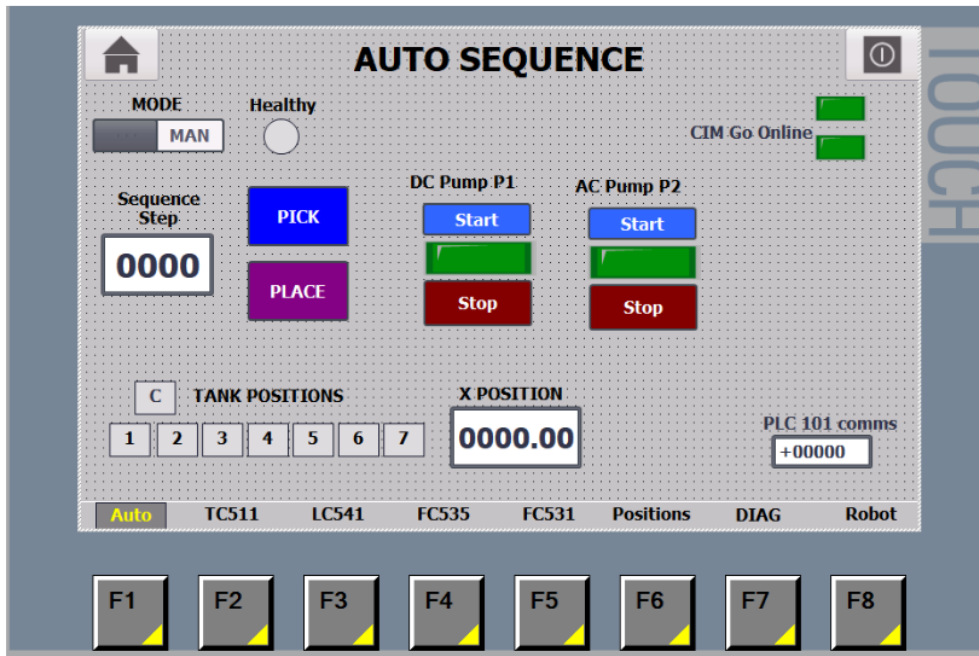
12.1. CIM System Process Station



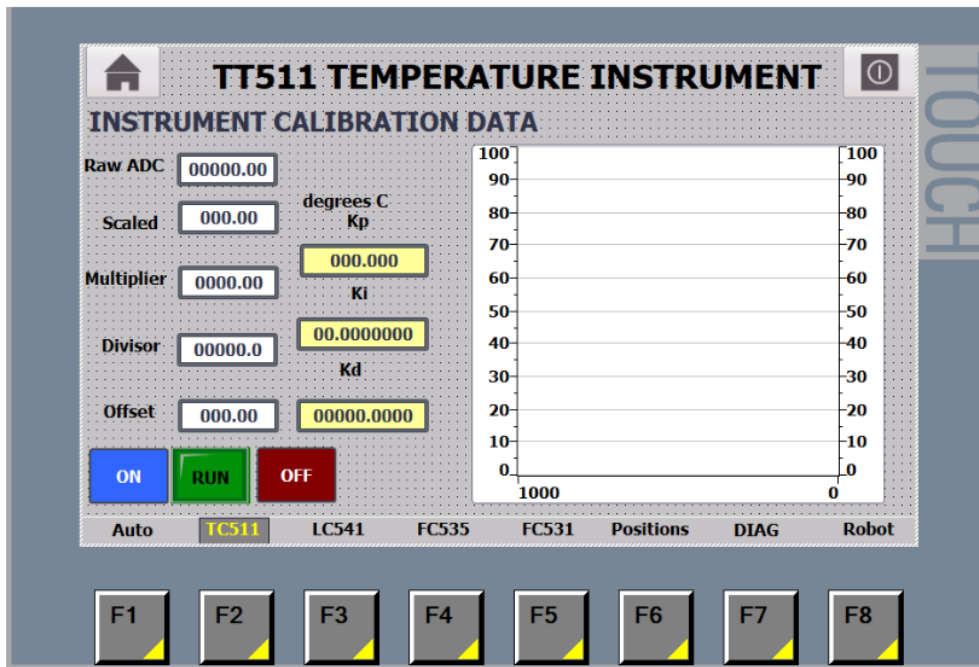
12.2. CIM System Water Recirculation



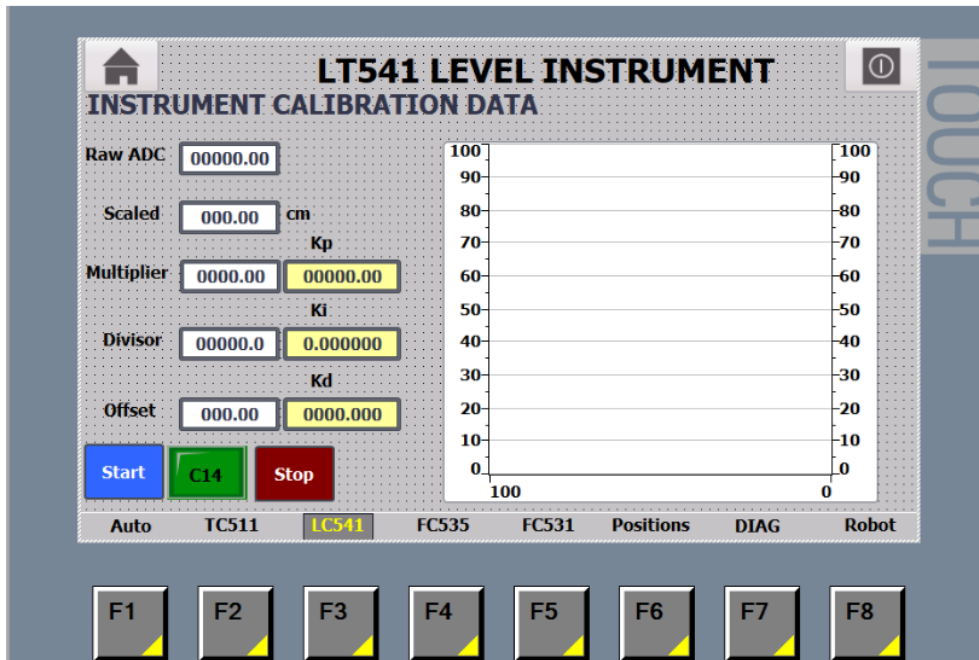
12.3. Auto Sequence Screen



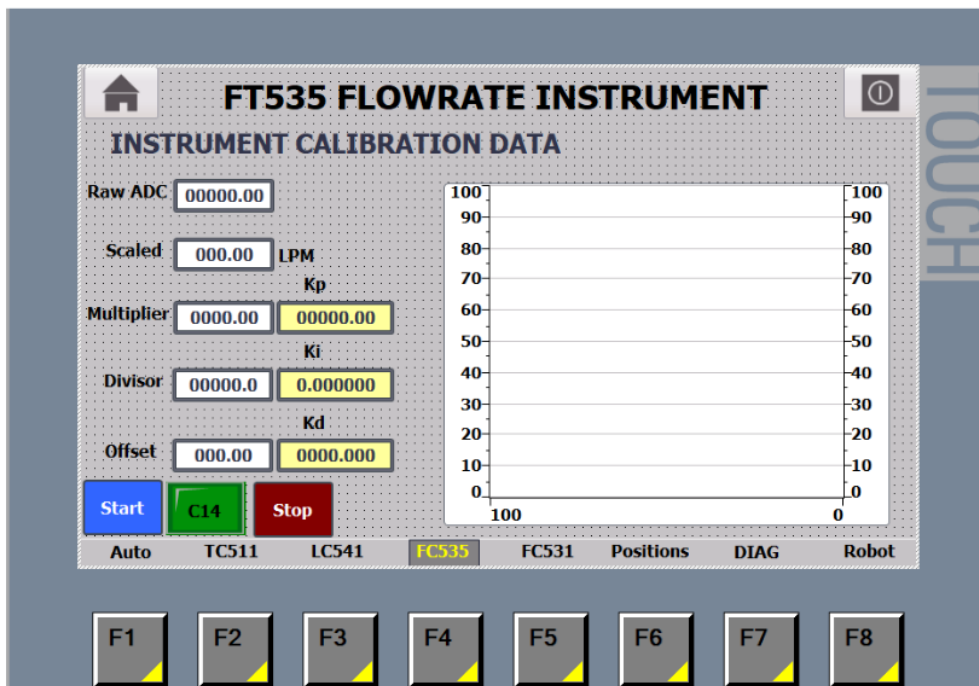
12.4. TT511 Temperature Instrument Screen



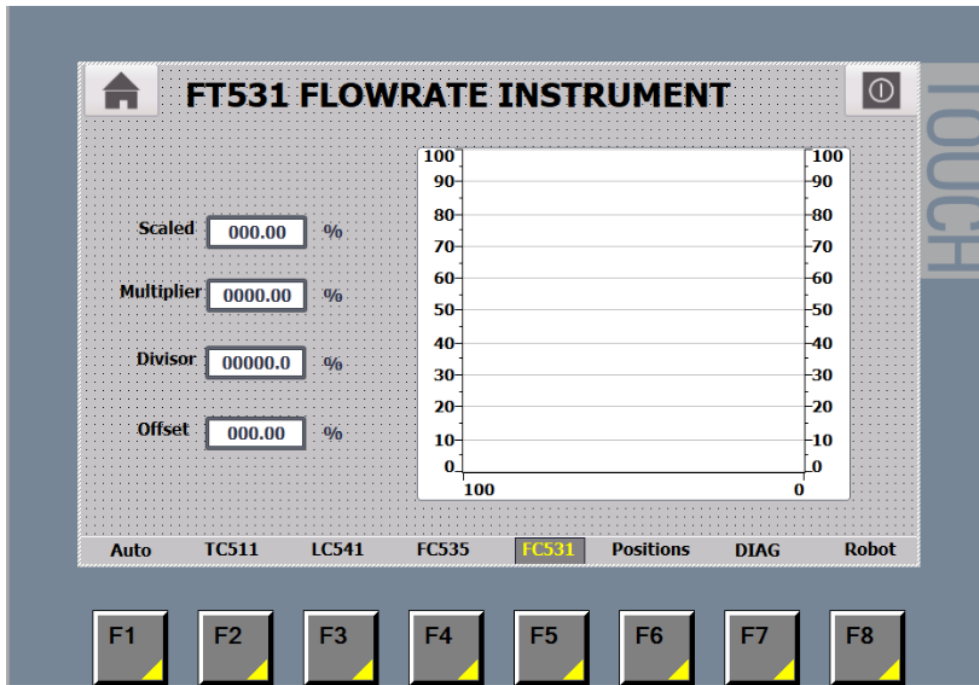
12.5. LT541 Level Instrument Screen



12.6. FT535 Flowrate Instrument Screen



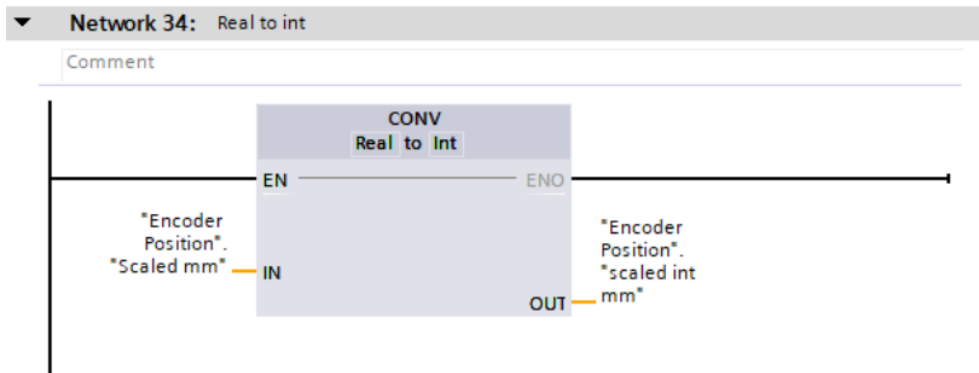
12.7. FT531 Flowrate Instrument Screen



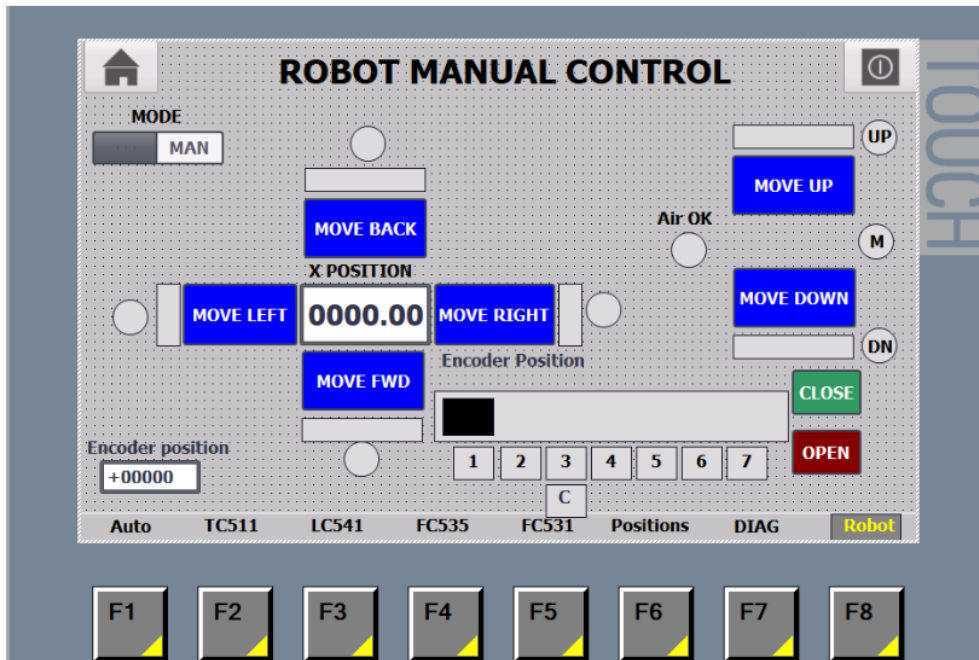
12.8. Robot Manual Control Additional PLC Tags

Encoder Position								
	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint
1	Static			☐	☐	☐	☐	☐
2	Raw count	Real	0.0	☐	☒	☒	☒	☐
3	Offset	Real	0.0	☐	☒	☒	☒	☐
4	Count	Real	0.0	☐	☒	☒	☒	☐
5	Scaled mm	Real	0.0	☐	☒	☒	☒	☐
6	scaled int mm	Int	0	☐	☒	☒	☒	☐

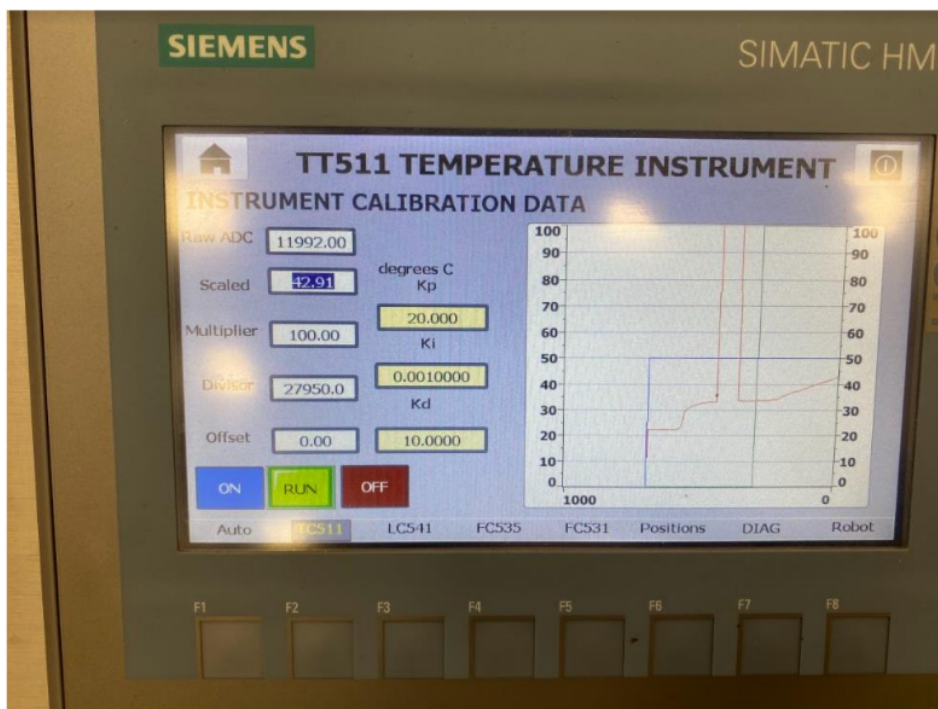
12.9. Robot Manual Control Additional Network Block



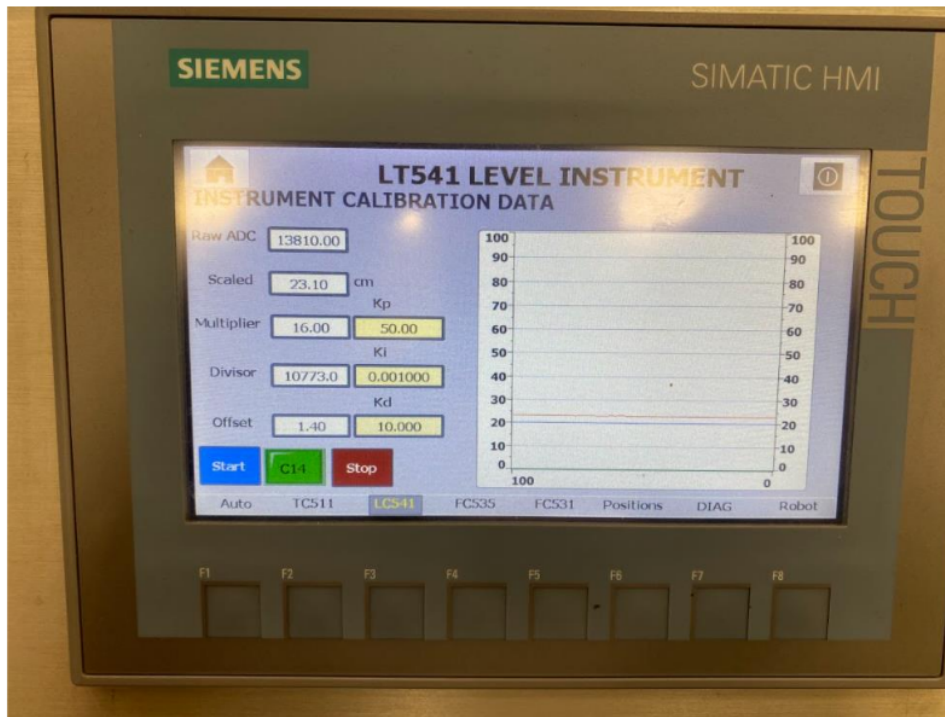
12.10. Robot Manual Control Screen



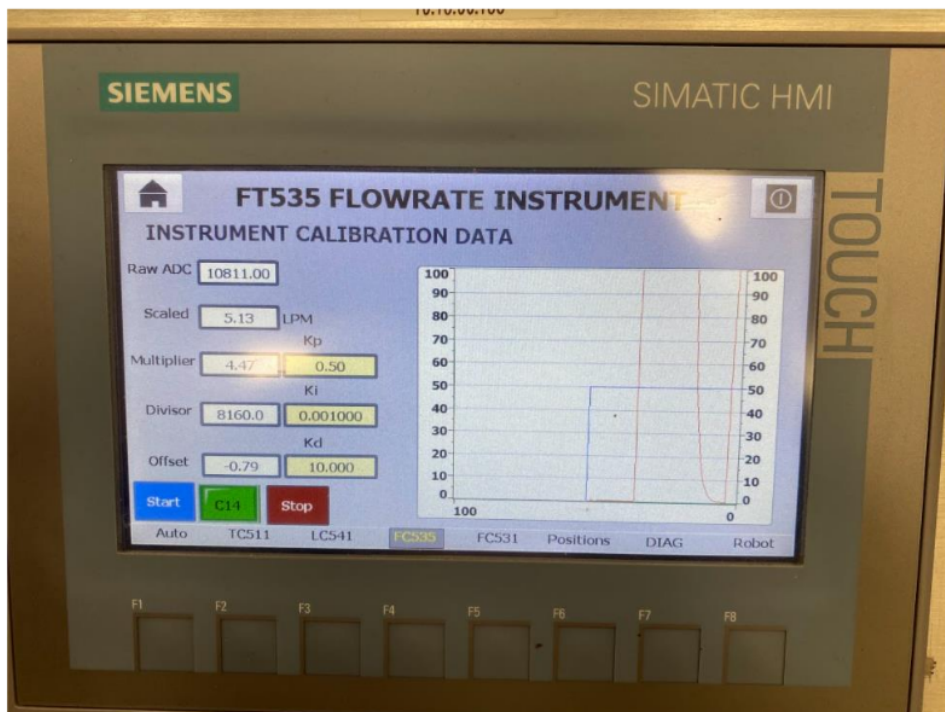
12.11. TT511 Temperature Instrument Screen Test



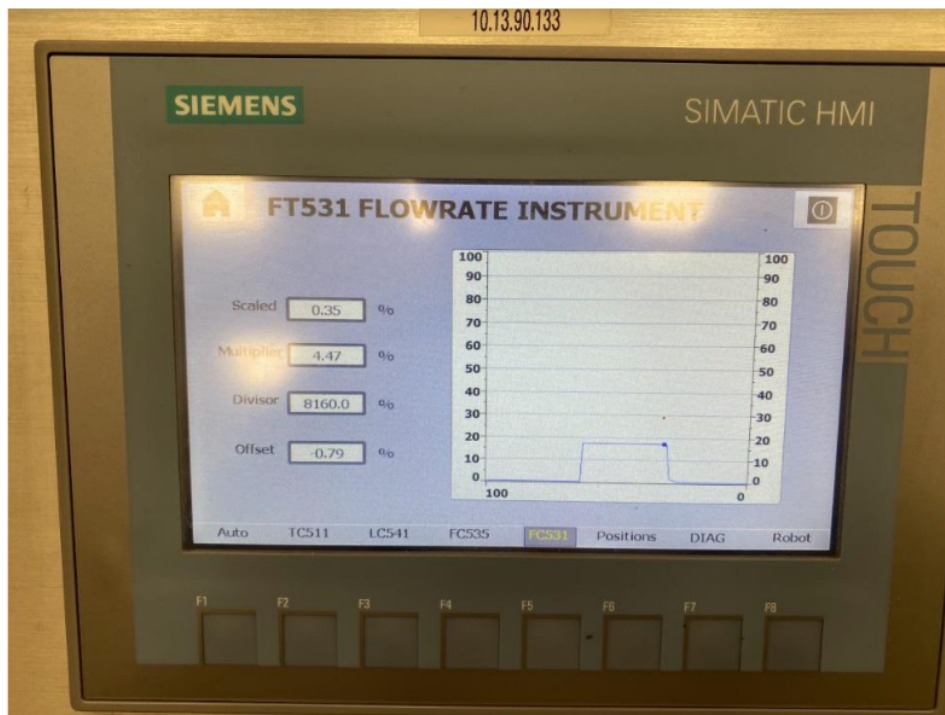
12.12. LT541 Level Instrument Screen Test



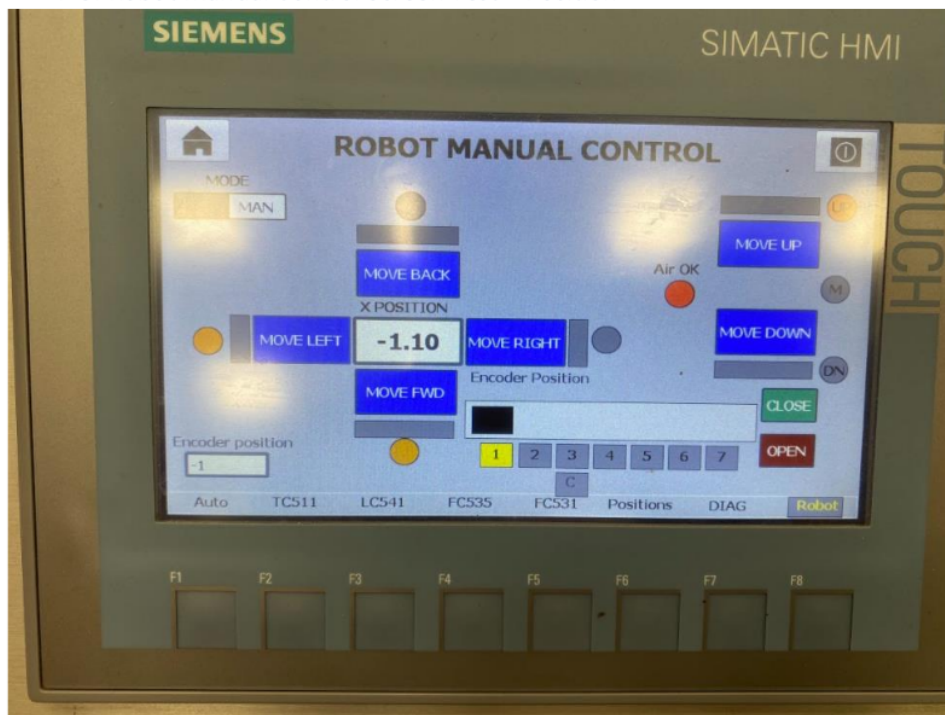
12.13. FT535 Flowrate Instrument Screen Test



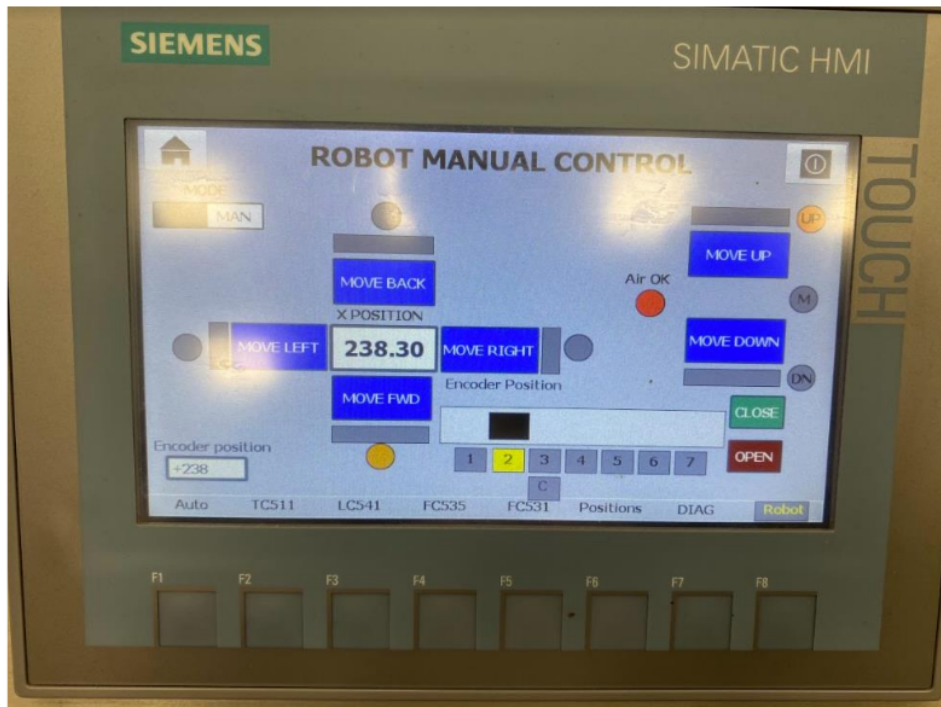
12.14. FT531 Flowrate Instrument Screen Test



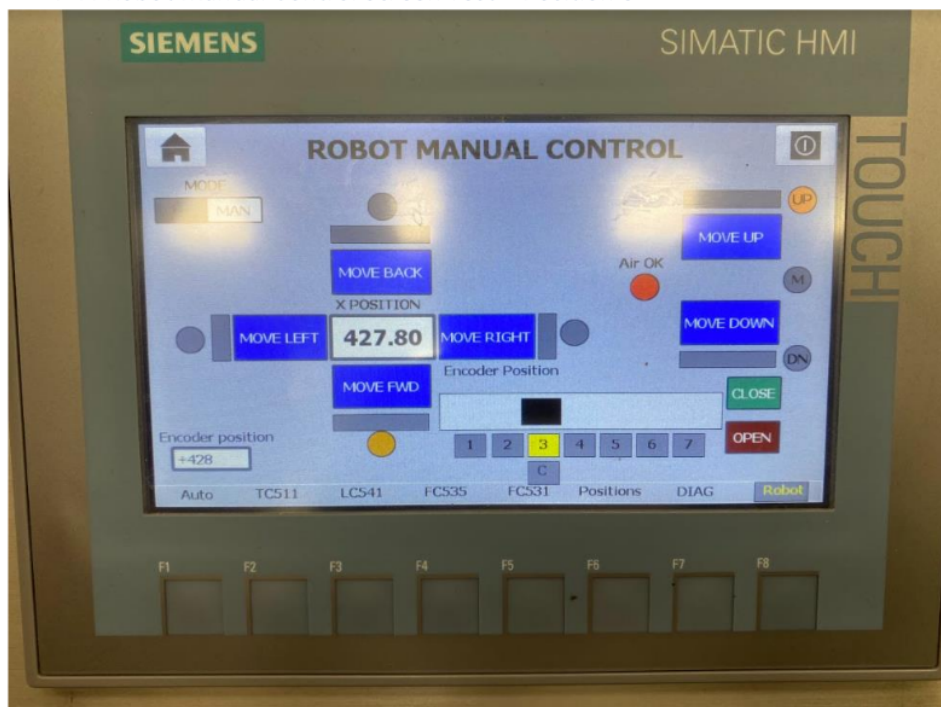
12.15. Robot Manual Control Screen Test – Position 1



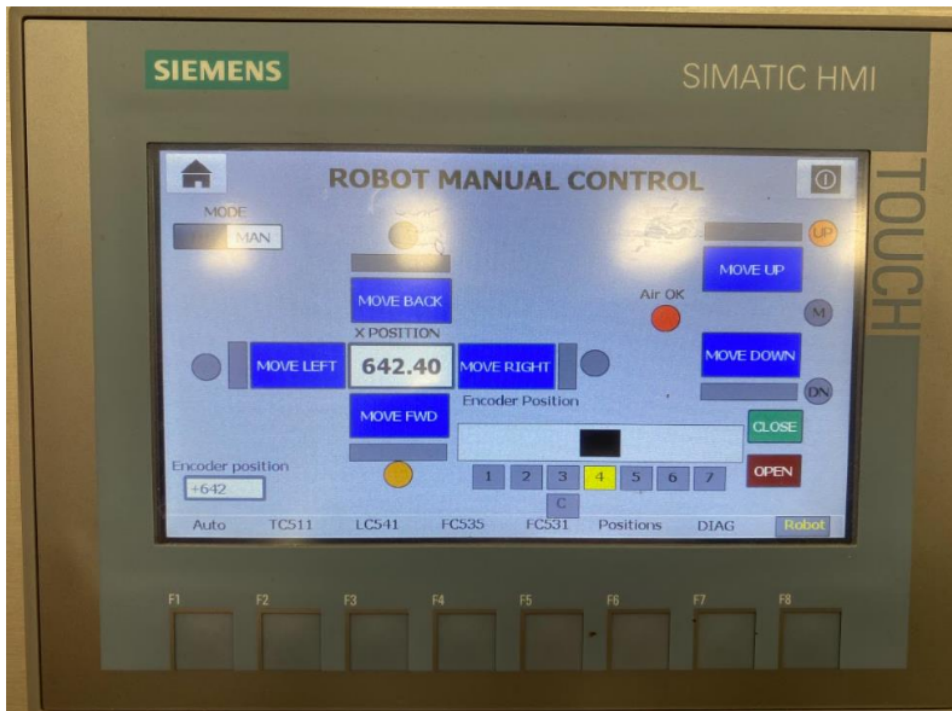
12.16. Robot Manual Control Screen Test – Position 2



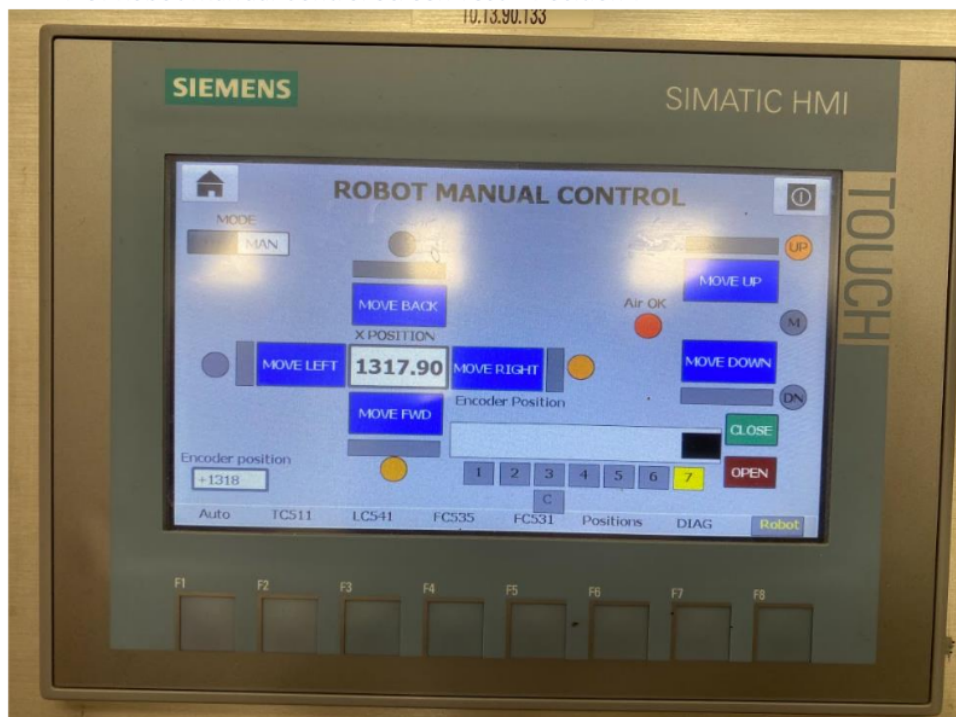
12.17. Robot Manual Control Screen Test – Position 3



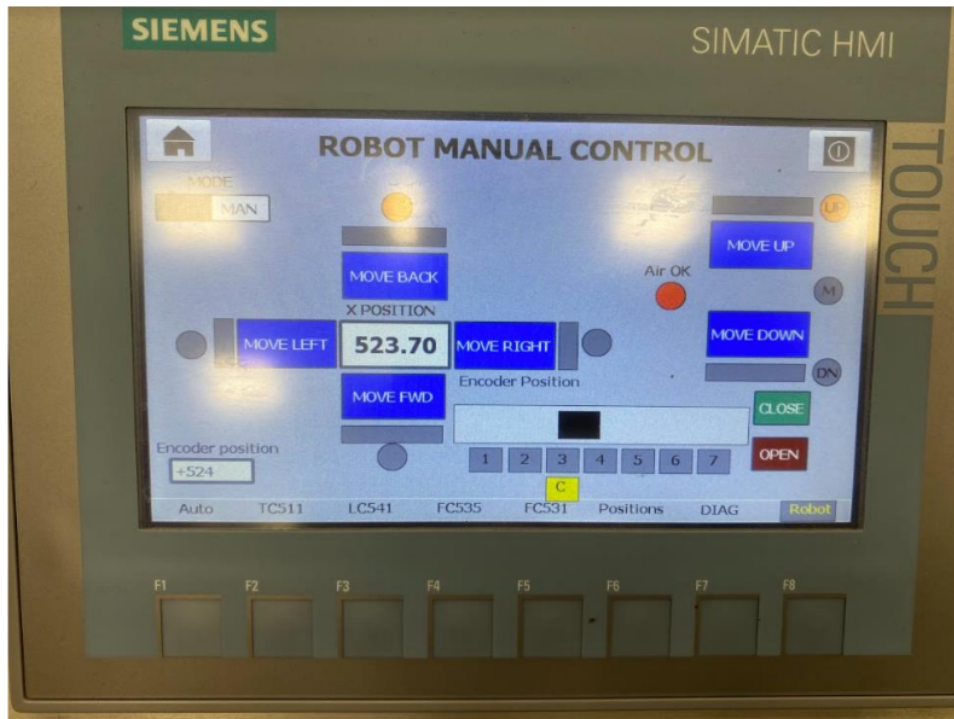
12.18. Robot Manual Control Screen Test – Position 4



12.19. Robot Manual Control Screen Test – Position 7



12.20. Robot Manual Control Screen Test – Position C



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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

72/100

PAGE 1

Text Comment. This is a very good report, well structured and laid out, covering most aspects required by the brief. Good analysis and conclusions and good evidence of testing.

PAGE 2

PAGE 3

PAGE 4

PAGE 5

Text Comment. you should have quoted the singal conditioner details

PAGE 6

Text Comment. manufacturer?

PAGE 7

PAGE 8

Text Comment. accuracy should be quoted as %FSD

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

Text Comment. you could have plotted the laser against the encoder as the encoder is better than the eye

PAGE 15

PAGE 16

PAGE 17

PAGE 18

Text Comment. excellent testing table

PAGE 19

Text Comment. the laser is not fit for purpose, that's why the encoder was added

PAGE 20

PAGE 21

Text Comment. good range of sources

PAGE 22

PAGE 23

PAGE 24

PAGE 25

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PAGE 27

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GRADING FORM: NEW CSG-RUBRIC

LIAM PHILLIPS**72****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**

Excellent knowledge and understanding of the basic underlying concepts and principles of the subject. (15/20)

15**3. COGNITIVE AND INTELLECTUAL**

Excellent evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately and with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements.

15

4. PRACTICAL APPLICATION



An advanced application of a range of taught, basic methods, materials, tools and/or techniques. The context of the application is well considered, and insightful. Excellent evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions. (14/20)

14

5. TRANSFERABLE SKILLS



Work is coherent, very fluent and is presented professionally. Can work effectively independently and/or as part of a team, with an excellent contribution to group activities. Demonstrates excellent skills for employment requiring the exercise of some personal responsibility with an appetite for further development. (15/20)

15