

2117076

by Aaron Lupton

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Contents

1. Work Plan for Lifelong Learning and Risk Assessment.....	4
2. System Investigation.....	5
Flow Control Loop –	5
Temperature Control Loop –	5
Level Control Loop -	5
Water Input Flow -	5
1. Calibration of Pressure Sensor	6
3. Calibration of Temperature Sensor.....	7
2. Calibration of Level Sensor	8
6. Calibration of Position Sensors.....	9
7. Research	10
Industry 4.0	10
I-O Links	10
Distance Sensor	11
Flow Sensor.....	11
Temperature Sensor.....	11
Level Sensor.....	12
8. Health and Safety, Environmental, Maintenance and Reliability	13
9. Conclusions and Recommendations	14
10. Team Working	15

11. Citation List 16

Bibliography 16

12. Appendix..... 18

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Table of Figures..... 23

1. Work Plan for Lifelong Learning and Risk Assessment

For this assignment the focus will be the process station and water recirculation sub-systems which is in G8 classroom. Within the system, it contains many PLCs and HMIs built into the stations, which include a range on instrumentation and actuation devices/sensors. The individual components within the system will be researched and the function of each component will be looked at in-depth finding out why the certain sensor is best picked for the task. As part of the team working task, everyone must be respectful to each other, as well as taking part in the role sharing ideas and showing willing to complete the task at a high standard. *This is not a complete plan*

In the appendix (referenced below figure 5) there is a risk assessment created, and how we try to limit the risk ~~we are taking~~ ^{Write in the third person} taking certain precautions when needed. Some risks cannot be eliminated so we take control measures to try and minimize any harm if something did occur. There is also a risk matrix which has been used to measure our risk factor.

2. System Investigation

where is your technical data on each sensor?

Flow Control Loop – The flow controller (FC535) will produce a control variable which is fed into the pump amplifier (LY541). The Process variable will come from the flow transmitter which is FT535. There will also be an interlocked system in place from either V516 or V515 to enable water to be pumped up to the flow tank (B1).

not constant

Temperature Control Loop – TC511 will again produce a constant voltage into SSR (solid state relay) and the heating element using pulse width modulation which will control the heater. The process variable comes from TT511 (temperature transmitter). This control loop also has an interlock mechanism LS542 (Low water level switch). There are a few things in the control loop that will affect the temperature by adding cold water into the system. These components are the cooling fan, solenoid valves (V516 and V515) and the pump amplifier (LY541)

Level Control Loop - The water level in Tank B1 is controlled by the Level controller (LC541) which is then monitored by the level transmitter (LT541). The drain solenoid valve (V500) is fitted to empty the tank if needed, whereas the pump amplifier (LY541) is there to control the water flow. There is also an interlock system fitted with the low water level limit switch (LS541).

Water Input Flow - The flow is controlled by the flow transmitter (FT531). When the water is recirculating, this creates pressure which is controlled by the proportional valve (VF531) and the flow controller (FC531). The water will enter each tank using independent solenoid valves (VF510, VF511 and VF512).

In the appendix there are two images to show the SLD of the subsystems control loops (figure 11 and 12).

1. Calibration of Pressure Sensor

To calibrate the pressure sensor, the pressure was manually increased from 0 Bar to the maximum value of 5 Bar, using incrementation of 0.5 Bar. At the increment, the voltage was listed and recorded onto a table. Once the maximum pressure was reached, we repeated the same procedure for the pressure decreasing, using decrements of 0.5 Bar until 0 Bar was reached. Again, the readings were recorded onto a table. All readings were recorded using a multimeter with the recording measured in Volts. The multimeter was connected in parallel as we were measuring the voltage. The static sensitivity here is $10\text{v}/5\text{bar} = 2\text{v}/\text{bar}$.

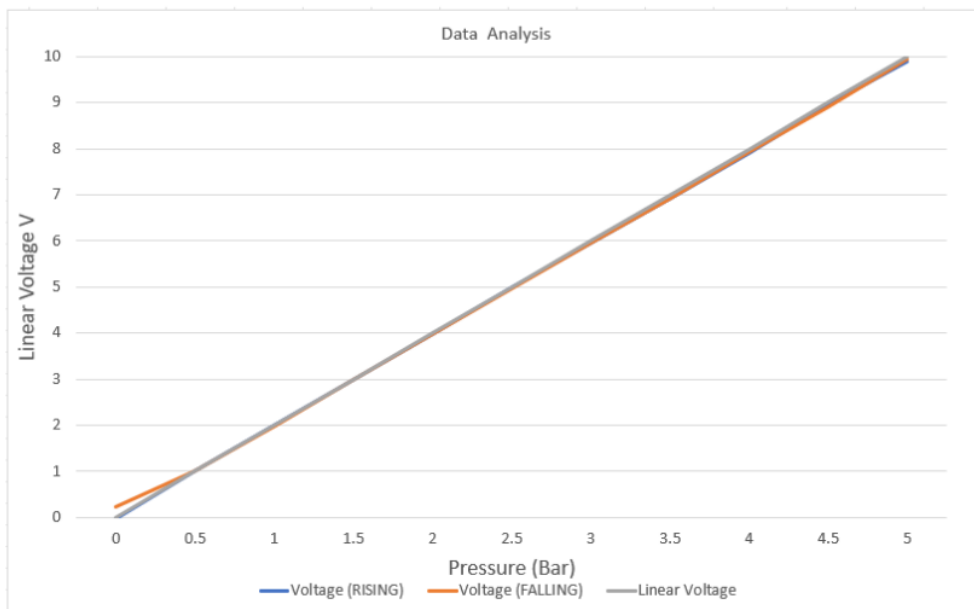


Figure 1 Comparison with voltage rising and falling against the linear value.

- figure the table of results.

The sensor used is a piezo electric transducer. Looking at the graph, it shows that the highest nonlinearity is 0.03v and then you can see that the rest of the recordings are linear. As found online, this typical sensor has a tolerance of $\pm 0.3\%$. As the voltage here is peaking at 10v, this shows that the sensor has an error of 0.3% which is just in range.

3. Calibration of Temperature Sensor

Write in the third person

To calibrate the temperature sensor, we used increments and decrements of 10 degrees Celsius at a time and measured the current for the rising and falling temperatures. All readings were recorded using a multimeter with the recording measured in mA. The multimeter was connected in series as we were measuring the current. During the procedure, we have a slight error within the calibration, this is due to the temperature at 0 degrees Celsius, the current was 4 mA, giving us an offset of 4mA. (Figure 10 in the appendix to see the table of results).

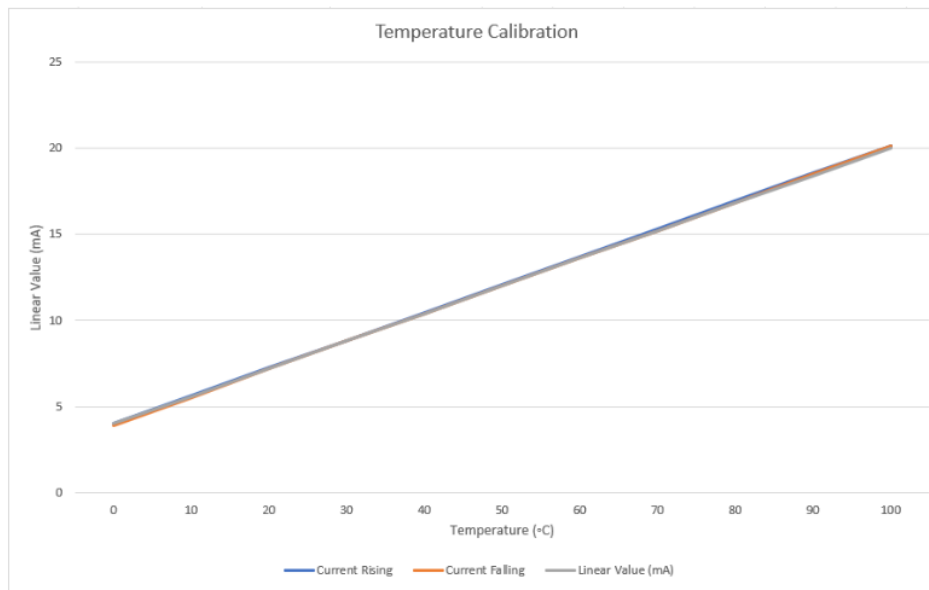


Figure 5 Graph to show the results of the temperature sensor being calibrated.

%FSD linearity and hysteresis?

There is minimal errors showing that the calibration device and the temperature sensor used in the subsystem are accurate and within tolerance. In the subsystem the temperature sensor used is a 3 wire RTD sensor, tolerances for these types of sensors are $\pm 0.3\%$ showing us that our sensor is in range.

2. Calibration of Level Sensor

The level was increased in small increments of 1cm at a time, from 7 to 23cm using a DC Pump. Each step was repeated back from 23cm down to 7 completing the same process. To calibrate the level sensor the level of the tank was manually raised, and reading were taking at each cm increase/decrease. All reading were recorded using a multimeter with the recording measured in mA. The multimeter was connected in series as we were measuring the current. Once the max level was reached, we repeated the same process started with the tank being full (23cm) and ended with the tank level low (7cm) - decrements of 1cm). There is an offset of 6mA, the equation used is.

$$offset = y2 = \frac{multiplier}{divisor} x2 = \frac{12.49 - 6}{23 - 0} x2 = 6mA$$

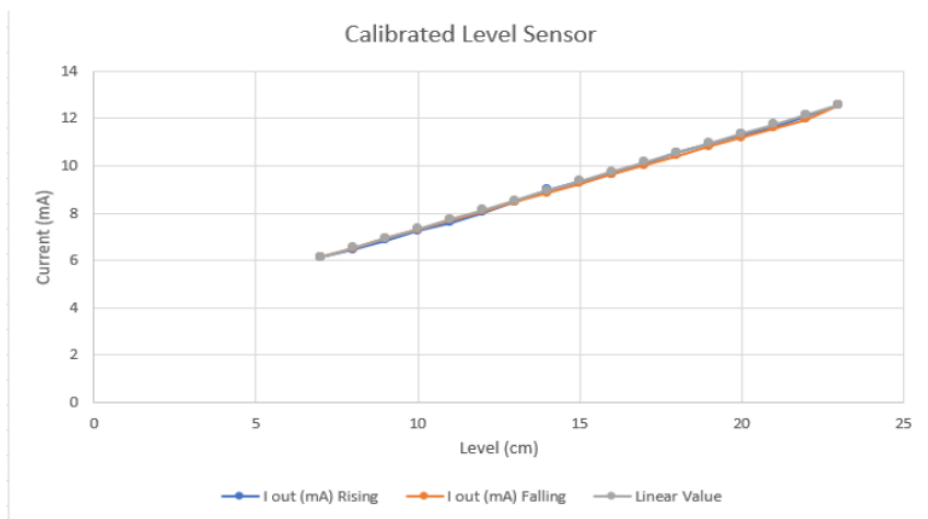


Figure 9 Calibrated level sensor graph.

- figure 8 in the appendix to find the table of results.

As we can see from the graph above, there is very low errors with the highest being roughly 0.04. The sensor here will have an analogue input using 4-20mA feedback which then will be converted into a readable result showing the level in the tank. The error here could be to do with the overshoot when filling the tank, this could be controlled by installing a pump to the system which can then slow the speed of the tank filling when it's close to the desired level.

6. Calibration of Position Sensors

The position sensor (laser) was increased in increments of approximately 10cm (100mm) at a time. This process was carried out twice, one moving the laser from right to left and then the other from the left to the right by installing dc motors on the x axis. Each step was to calibrate the position sensor, and then recording any errors that occurred in the calibration. During the calibration test, errors can be seen which accumulated along the way. This is due to the laser not being accurate compared to the encoder as the encoder will count in increments of 0.1mm. The laser is repeatable and consistent throughout.

From figure 6 and 7 in the appendix, it shows us from the calibration test that the highest error is 87.06mm comparing the laser to the encoder. The encoder has a tolerance of $\pm 0.01\text{mm}$ making it very accurate. The accuracy tolerance for a laser between 0mm - 2000mm is $\pm 5.5\text{mm}$ (Electronics, 2023). Having this information shows that the laser that is used on the subsystem is out of range. *it is within range but not accurate enough for this task*

7. Research

Industry 4.0

“Industry 4.0 refers to a new phase in the Industrial Revolution that focuses heavily on interconnectivity, automation, machine learning, and real-time data. Industry 4.0, which encompasses IIoT (Industrial Internet of Things) and smart manufacturing, marries physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better connected ecosystem for companies that focus on manufacturing and supply chain management”. The main advantage for the industry 4.0 is that it allows for a lot more remote access to systems from online and grants any authorised person to monitor Write in the third person / given location. (Epicor, 2022) Industry 4.0 technology will help you manage all your manufacturing processes and the supply chain. It will also give you real time data which will ultimately boost the efficiency of the overall system in the workplace. Industry 4.0 is made up from 9 pillars which are cloud computing, autonomous and robotic systems, big data analytics, augmented reality, cyber security, simulation, systems, integration, and additive manufacturing. (Technology, 2019) Correctly cited

I-O Links

“IO-Link is a powerful standard, an increasingly deployed point-to-point serial communication protocol used to communicate with sensors and/or actuators. Extending the globally recognized PLC standard IEC 61131, it allows three types of data to be exchanged – Process data, service data, and events.” Correctly cited (Pepperl+Fuchs, 2021). Process data is the exchange between the IO Link master and the IO Link slave (for example a type of sensor or actuator). Correctly cited (Insight, 2020). Event data is an update from the IO Link device when the condition it is monitoring has changed. The event data is usually labelled as a warning or an error depending on the change within the component. Event data is usually monitored in three different categories, which are notification type, warning type and an error type. (Harmon, 2019)

Correctly cited

Distance Sensor

Write in the third person

Write in the third person

Now, we have a distance sensor in the system. I think to improve this, we will change the distance sensor to an ultrasonic sensor. Using an ultrasonic sensor, it has a much faster response time of 64ms. Ultrasonic sensors work by sending ultra-sonic waves out to the product its measuring and then receive a signal back. It will then calculate the signals response time; the longer it takes for the signal to return to the sensor, the further away the object is. Once we know the products level in a vessel, we can then determine the volume, or the percentage of the vessel is filled. Another advantage of this, is that the sensor does not need to touch the product so it does not matter how corrosive or abrasive the product is as nothing will touch the sensor. (Intelligence, 2018). *manufacturrer and part number?*

Correctly cited

Flow Sensor

The sensor that I will look to upgrade is the flow sensor. Water flow sensors consist of a water body and a water rotor. When the water flows through the rotor, the rotor speeds changes depending on the rate of flow. It then has a hall—effect sensor within the body which then sends the correct signal back to a controller. The flow sensor that I have found is the SA5020 Flow sensor. This measures the flow and temperature at the same time with a clear indication on the sensor with green and red screen display of the acceptable range. This flow sensor is compatible with the industry 4.0 as well as switching output, analogue signalling, and I-O Links. The connection can be rotated for correct alignment. (Itf, 2022) *who makes it?*

Temperature Sensor

Temperature sensors work by providing readings in electrical signals. Sensors are composed of two metals that will generate an electrical voltage or resistance when the temperature changes this then alters the voltage/resistance across the diode terminals, which then will send a signal to a controller. The most common temperature sensors are RTDs (Resistance temperature detector). An RTD is a variable resistor that changes its electrical resistance in proportion with the temperature. The hotter the fluid is, the higher the resistance will be and vice versa. The resistance will be measured across the diode a then converted into readable units of temperature. The temperature sensor is TR2432 (Serial Number TR-KDBR12-MFRKG/US/IV). This has a wide temperate range of -40 degrees Celsius to 300 degrees

who makes it?

Celsius. It has programmable switching outputs and scalable analogue outputs as well as a local display of the current temperature value. (Electronics, 2022)

Level Sensor

A level sensor is a device that is used to monitor, maintain, and measure liquid levels. When the liquid level is detected, the sensor will then convert the data into an electrical signal, sending it back to a controller. The sensor that I have found which will be beneficial to the system is the LMC100 Point level detection sensor. This sensor is reliable for level control in tanks and containers. It is also compatible to the industry 4.0 with two programmable switching outputs with one of them having an IO-Link communication interface (serial number LMFCE-B12E-QSKG-0/US) (IFM-electronics, 2022)

8. Health and Safety, Environmental, Maintenance and Reliability

Within the system, there will be some hazardous chemicals that could be detrimental to the environment if not stored and used correctly, to prevent anything effecting the environment there can be ventilation systems in place to remove and dispose of any hazardous chemicals ^{fumes} that are used or produced when operating. Also, a gas monitor/system could be installed to the apparatus to locate any gases if there was an exposure. Both systems could be interlinked, and an alarm could be raised if there is a chemical or gas leak. In tank B3 there will be sulphuric acid, so removal and disposal of this acid must be done properly and following the COSHH regulations ensuring that you are wearing the correct PPE to avoid any skin exposure as it could be harmful to the skin and eyes. A first aid station located nearby for any accidents. Maintenance on the system will need to be completed on a regular basis which will undertake testing the valves to ensure that they are functioning correctly. Motors will need to be tested and balanced to ensure that the pumps are working as they should, and a visual inspection should be carried out. A thorough check of all the tanks need to be considered to ensure that there is no leaks or damage. As the system is located indoors in a debris free and clean environment, this should prolong the lifespan of the system.

What about existing diagnostics

9. Conclusions and Recommendations

On completion of the assignment, it has improved the knowledge in the instrumentation and integrated automation systems. It has also helped get a better understanding of how each sensor works and how it needs to be calibrated correctly as well as how to choose a sensor that is able to match the specification of its purpose (ensuring that the sensor is able to withstand a certain temperature etc). By completing these tasks, it will help with tasks that involve calibration of sensors. Also, it shows how solenoid valves and relays work. One of the recommendations that would increase the reliability of the subsystem, is to change the photoelectric sensor (laser) for an ultrasonic sensor as the laser compared to the encoder isn't accurate (but is repeatable, it is consistent). The ultrasonic sensor is a lot more accurate and would minimise any errors in the positioning of the gripper arm and will increase the reliability of the subsystem. *a good suggestion*

Another recommendation that would be hugely beneficial and future proof would be to introduce the IO-Link to the subsystem with an IO Link transducer coupled with an IO link master, this will also make it more compatible with the industry. This would also help as all the information would then be stored to the network. The advantages to installing this is that it helps with the fault finding and maintenance of the subsystem. Going a step further to this addition, you could also make it connectable with Bluetooth tethering, as this would then let the trained personnel to access and control the system from an electronic device. By using these methods information can be stored a lot easier and will be used to compare the data further down the line, making it easier to acknowledge any differences as the components wear due to usage. This could help with preventing any permanent damages to the system and will make it easier for the personnel to organise planned maintenance which will increase the lifespan of the subsystem.

Good recommendations

10. Team Working

Write in the third person

During the task, we carried out lone working and team working. Within the teamwork tasks it was beneficial to make sure that the results that we recorded were accurate and precise. To do this, one of the team members would be situated at the computer listing the results onto the spreadsheet that was created previously, with the second team member calling out the results. The third member in the team would then be at the HMI screen operating the machine to suit the calibration of each sensor. At each step of the calibration, all team members would be in constant communication ensuring that everyone is on the same part of the task and that the team moves onto the next stage together. The benefit of carrying out this task in a team is that the workload is shared between the group and that the task was carried out much more efficiently than if the task was to be completed solo. At each different task, the team rotated roles so that everyone had an opportunity to experience the different stations. Within the team, everyone's religious beliefs and gender choices were accepted and respected.

11. Citation List

Good range of sources

Correct method of listing.

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(Itf, 2022)

12. Appendix

Risk Assessment			
Risks	Severity	Precautions	Person Affected
Electrical Shock	4	Test for dead/Isolate	Student
Acid Burns	2	Avoid any Contact/Wear correct PPE	Student
Moving Machinery	3	Keep distance when in operation	Student
Compressed Air	4	Wear Correct PPE	Student

Figure 13 Risk assessment Matrix

		Severity/Consequence		
		Slightly harmful (1)	Harmful (2)	Extremely harmful (3)
Likelihood	Highly unlikely (1)	Trivial risk (Score 1)	Tolerable risk (Score 2)	Moderate risk (Score 3)
	Unlikely (2)	Tolerable risk (Score 2)	Moderate risk (Score 4)	Substantial risk (Score 6)
	Likely (3)	Moderate risk (Score 3)	Substantial risk (Score 6)	Intolerable risk (Score 9)

Figure 17 Risk assessment Matrix

Encoder	Laser right	Encoder - Offset	Laser - Offset	Error
7.2	207.9	0	0	0
107.9	300.74	100.7	92.84	-7.86
207.7	403.2	200.5	195.3	-5.2
305.5	508.67	298.3	300.77	2.47
409.4	614.96	402.2	407.06	4.86
505.4	716.72	498.2	508.82	10.62
605.8	821.19	598.6	613.29	14.69
705.1	920.84	697.9	712.94	15.04
805	1017.46	797.8	809.56	11.76
905.4	1019.04	898.2	811.14	-87.06
1007.1	1220.9	999.9	1013	13.1
1106.3	1318.33	1099.1	1110.43	11.33
1205.5	1414.35	1198.3	1206.45	8.15
1308.7	1521.85	1301.5	1313.95	12.45

Figure 21 Table of results to show the encoder moving right.

Encoder	Laser left	Encoder - Offset	Laser - Offset	Error
1308.7	1521.85	0	0	0
1208.1	1419.38	100.6	102.47	-1.87
1107.8	1319.67	200.9	202.18	-1.28
1006.7	1218.2	302	303.65	-1.65
906.16	1118.21	402.54	403.64	-1.1
808	1019.74	500.7	502.11	-1.41
709.8	923.38	598.9	598.47	0.43
608.2	818.48	700.5	703.37	-2.87
510.2	716.57	798.5	805.28	-6.78
409.8	608.21	898.9	913.64	-14.74
308	505.96	1000.7	1015.89	-15.19
207.7	411.44	1101	1110.41	-9.41
107.3	303.26	1201.4	1218.59	-17.19
7.2	207.79	1301.5	1314.06	-12.56

Figure 25 Table of results to show the encoder moving left.

Level (cm)	I out (mA) Rising	I out (mA) Falling	Linear Value	Error Rising	Error Falling	Hysterisis Error
0	4.02	4.02	0	4.02	4.02	0
7	6.12	6.12	6.12	0	0	0
8	6.46	6.5	6.521875	-0.061875	-0.021875	-0.04
9	6.84	6.93	6.92375	-0.08375	0.00625	-0.09
10	7.24	7.29	7.325625	-0.085625	-0.035625	-0.05
11	7.6	7.69	7.7275	-0.1275	-0.0375	-0.09
12	8.02	8.07	8.129375	-0.109375	-0.059375	-0.05
13	8.47	8.48	8.53125	-0.06125	-0.05125	-0.01
14	8.98	8.83	8.933125	0.046875	-0.103125	0.15
15	9.32	9.23	9.335	-0.015	-0.105	0.09
16	9.65	9.63	9.736875	-0.086875	-0.106875	0.02
17	10.06	10.02	10.13875	-0.07875	-0.11875	0.04
18	10.54	10.4	10.540625	-0.000625	-0.140625	0.14
19	10.9	10.8	10.9425	-0.0425	-0.1425	0.1
20	11.3	11.18	11.344375	-0.044375	-0.164375	0.12
21	11.64	11.58	11.74625	-0.10625	-0.16625	0.06
22	12.1	11.96	12.148125	-0.048125	-0.188125	0.14
23	12.55	12.55	12.55	0	0	0

Figure 8 Table of results to show the calibration of the level sensor.

Task3

Measuredeand Pressure (Bar)	Output Voltage (Volts)		Linear Value (Volts)	Non-linearity error (Volts)		Hysteresis Error (Volts)
	Rising	Falling		Rising	Falling	
0	-0.03	0.22	0	-0.03	0.22	-0.25
0.5	1.02	1.01	1	0.02	0.01	0.01
1	2	1.98	2	0	-0.02	0.02
1.5	2.98	2.98	3	-0.02	-0.02	0
2	3.97	3.99	4	-0.03	-0.01	-0.02
2.5	4.99	4.98	5	-0.01	-0.02	0.01
3	5.95	5.97	6	-0.05	-0.03	-0.02
3.5	6.93	6.93	7	-0.07	-0.07	0
4	7.91	7.94	8	-0.09	-0.06	-0.03
4.5	8.95	8.91	9	-0.05	-0.09	0.04
5	9.9	9.95	10	-0.1	-0.05	-0.05

Figure 9 Recordings for the pressure sensor calibration procedure.

Task 4

Measured and Temperature (°C)	Output Current (mA)		Linear Value (mA)	Non-linearity error (mA)		Hysteresis Error (Volts)
	Rising	Falling				
0	4	3.9	4	0	-0.1	0.1
10	5.62	5.5	5.6	0.02	-0.1	0.12
20	7.24	7.2	7.2	0.04	0	0.04
30	8.85	8.8	8.8	0.05	0	0.05
40	10.47	10.4	10.4	0.07	0	0.07
50	12.09	12	12	0.09	0	0.09
60	13.71	13.6	13.6	0.11	0	0.11
70	15.33	15.2	15.2	0.13	0	0.13
80	16.95	16.8	16.8	0.15	0	0.15
90	18.56	18.5	18.4	0.16	0.1	0.06
100	20.1	20.1	20	0.1	0.1	0

Figure 10 Table to show the results of the temperature calibration.

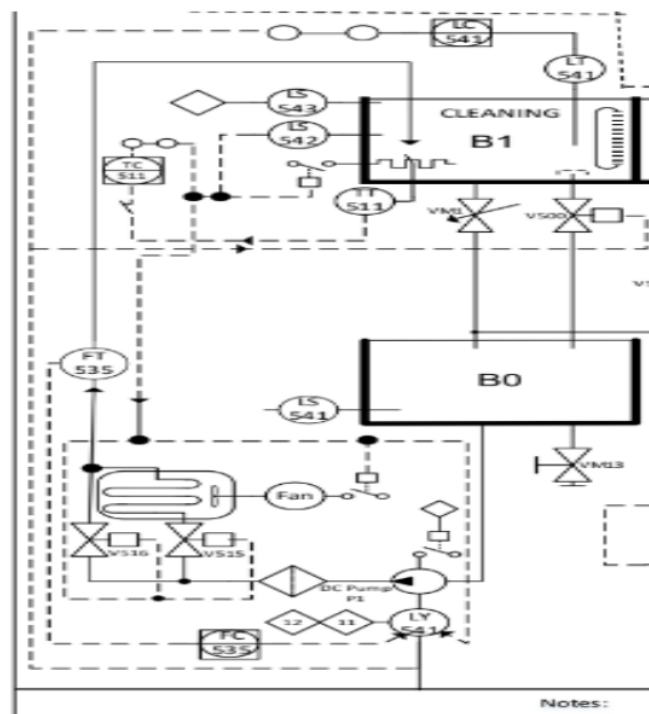


Figure 11 SLD of the Systems investigations loop diagram of the subsystem.

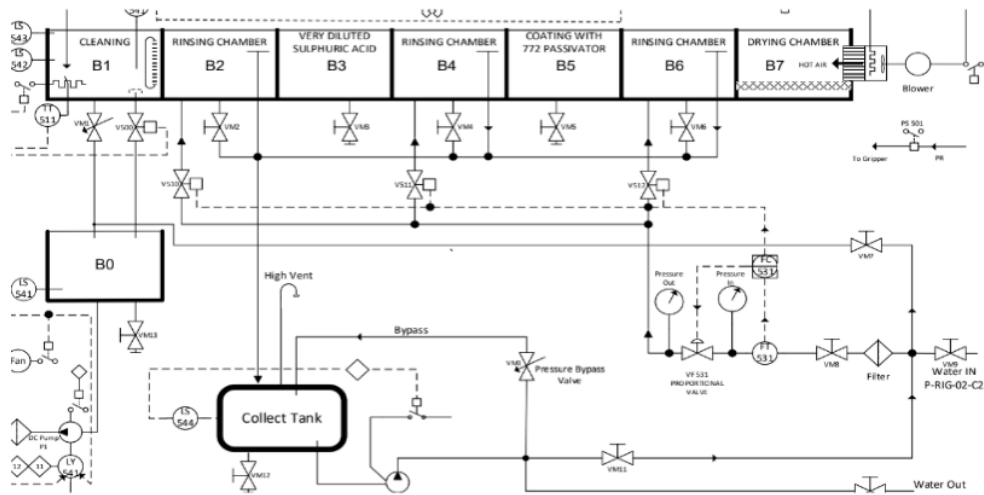


Figure 12 SLD of the subsystems water input control flow loop.

Table of Figures

Figure 1 Comparison with voltage rising and falling against the linear value.**Error! Bookmark not defined.**

Figure 2 Risk Assessment **Error! Bookmark not defined.**

Figure 3 Risk Assessment Matrix **Error! Bookmark not defined.**

Figure 4 Ultrasonic Detection Device..... **Error! Bookmark not defined.**

Figure 5 Encoder moving right. **Error! Bookmark not defined.**

Figure 6 Encoder moving left. **Error! Bookmark not defined.**

Figure 7 Level Sensor Calibration results table..... **Error! Bookmark not defined.**

Figure 8 Graph to show the temperature calibration readings. **Error! Bookmark not defined.**

Figure 9 Recordings for the Pressure Sensor Calibration **Error! Bookmark not defined.**

Figure 10 Systems Investigation Loop diagram of the subsystem..... **Error! Bookmark not defined.**

Figure 11 - Diagram of the subsystem to show the water input control flow loop..... 22

FINAL GRADE

GENERAL COMMENTS

Instructor

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PAGE 1

PAGE 2

PAGE 3

Text Comment. check this next time

PAGE 4

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Text Comment. This is not a complete plan



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 5

Text Comment. where is your technical data on each sensor?

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PAGE 6

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. "the same procedure was repeated"

Text Comment. when the voltage was measured

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".

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

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 7

QM

Write in the third person

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Text Comment. %FSD linearity and hysteresis?

PAGE 8

PAGE 9

Text Comment. it is within range but not accuracte enough for this task

PAGE 10

QM

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QM

Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 11



Write in the third person

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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. manufacturrer and part number?



Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. who makes it?

Text Comment. who makes it?

PAGE 12

PAGE 13

Text Comment. fumes

Text Comment. What about existing diagnostics

PAGE 14

Text Comment. a good suggestion

Text Comment. Good recommendations

PAGE 15

QM

Write in the third person

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PAGE 16

QM

Good range of sources

You have demonstrated reading from a good range of sources shown by your list below

QM

Correct method of listing.

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

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

GRADING FORM: NEW CSG-RUBRIC

AARON LUPTON

59

1. ENGAGEMENT WITH LITERATURE

	A good research section with some evidence of reading from a range of sources cited and listed correctly using the Harvard method. 12/20	12
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2. KNOWLEDGE AND UNDERSTANDING

	Some knowledge demonstrated in your system investigation, explanation of calibration procedure and environment/maintenance section. 10/20	10
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3. COGNITIVE AND INTELLECTUAL

	Some analysis of results and good conclusions/recommendation presented 12/20	12
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4. PRACTICAL APPLICATION

	Good use of calibration equipment and recording/graphing of results 14/20	14
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5. TRANSFERABLE SKILLS

	A brief work plan, good risk assessment and good explanation of team working. Report is well structured and presented with clear diagrams. Word count not exceeded. However, you must learn to write in the third person and improve your grammar, punctuation and spelling 11/20	11
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