

2017198

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Assignment 1: Instrumentation for Automation Systems

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A well structured report, good presentation and good evidence of reading from a wide range of sources. However, in your analysis, there are mistakes and in the practical there is no testing table. Good conclusions and good evidenc eof team working.

Contents

1. System Investigation	3
2. Research.....	4
3. Environmental, Sustainable Development, Commercial Risk and Codes of Practice.....	5
4. Calibration of Pressure Sensor	6
5. Calibration of Temperature Sensor.....	8
6. Calibration of Level Sensor	10
7. Calibration of Position Sensors	12
8. Design Adaptation for Maintenance and Reliability	14
9. Conclusions and Recommendations	15
10. Team Working.....	16
11. Works Cited.....	17
12. Appendix	19

Good structure

1. System Investigation

It can be seen that in the control loop FC535 a control variable (CV) flows into LY541, which can be described as a Pump Amplifier. From that it can be said interlocks are required in the form of solenoid valves V515 or V516 to ensure the water recirculating is pumped back into the cleaning with hot water tank B1. Process variables can be determined by FT535, a flow transmitter.

In loop 531 the flow controller (FC531) uses a proportional valve (VF531) to control the water pressure within the recirculating system. It can be determined by a flow transmitter FT531. As a result of this, water can enter each tank through the solenoid valves V510, V511 and V512.

Loop Number	Accuracy	Repeatability	Figure Number
535 & 531	$\pm 3\%$	0.5%	7&8

A temperature control loop TC511 is used to monitor the temperature conditions of tank B1. Temperature Transmitter (TT511) is used to monitor the process variables. The temperature controller (TC511) creates a CV which sends a signal to a solid state relay using PWM to control the tanks heater. An interlock can be found in the form of a limit switch LS542. In order to maintain the required temperature, solenoid valves (V516 and V515), pump amplifier LY541 and a cooling fan add cold water to the circulation process.

Loop Number	Linearity Error	Operating Temperature Range	Figure Number
511	$\pm 0.1\%$	-40°C ... 85°C	6

A level controller (LC541) is used to control the level within tank B1; with assistance of a level transmitter LT541. When the level within the tank is too high a drain solenoid valve (V500) operates to drain the water into the sump tank B0 where it is interlocked with a limit switch LS541. Whilst draining LY541 controls the water flow.

Loop Number	Accuracy	Repeatability	Non-linearity	Figure Number
541	$\pm 0.5\%$	$\pm 0.1\%$	$\pm 0.2\%$	9

you could have mentioned the encoder

2. Research

Industry 4.0 can be described as the way a company improves, manufacture and distribute products with use of technologies like Internet of Things (IoT) and cloud computing. The industries can be then described as smart factories that are equipped with sensors, specialist software and robotics that improve decision making. This can lead onto greater things like better efficiency, reliability, and predictive maintenance (IBM, 2022).

I-O Link can be defined as a point-point communication tool. It is commonly found in automation processes where it is used to communicate with sensors and actuators. A PLC usually acts as the device controller that I-O Link uses to communicate with the instruments (James Jowett, 2022).

Smart sensors are used along side industry 4.0 which can include level, temperature, pressure, infrared and proximity sensors. Level sensors are used to monitor and provide real time information to management and process control systems (see figure 23 and 24). Temperature sensors are used to detect overheating equipment that needs urgent maintenance or to be shut down via the cloud platform it uses. Pressure sensors are used to monitor pipework and detect irregular pressure readings due to leaks that require repairs by alerting a central computer system. Infrared sensors are commonly used to detect heat leaks within buildings and industrial systems. Proximity sensors can be used to detect the flow or distance of industrial settings as shown in figure 27. (RGBSI, 2022).

By using industry 4.0 it would improve the maintenance and reliability by using predictive maintenance. Using the smart sensors, it analyses and identifies patterns in the production data to prevent equipment failure with use of storage facilities within the cloud. As a result of this it reduces maintenance time thus leading to lower costs. (accesa RaRo, 2022) .

In order for the smart sensors mentioned above it can be noticed that in order for industry 4.0 to work it requires the use of I-O Link. This is because industry 4.0 uses I-O Link as the effective, accurate and real time information communication tool it is designed for. From this gathered information it is then used as industry 4.0 requires (Hannaby, 2017).

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

Sustainable development can be defined as development that meets the needs of the present without impacting or compromising the needs of the future (UNESCO, 2021).

The current subsystems both use out of date instruments that need updating. By updating the instruments for new it can benefit the future generations of technicians as the equipment will require less maintenance and improve reliability.

The purpose of codes of practice are to help manage and identify risks to ensure safety. It can further be described as a written regulation that explains how people should behave (Staf writer, 2022).

BSEN 6739 is considered to be the benchmark of regulations that show good practice for instrumentation in process control systems, however there are other types of regulations that come under the code of practices for calibrating analogue sensors such as:

- BSEN 61511 is the regulation for the safety of instrumented systems in the process industry sector.
- BSEN 6282 is the alarm system designed to make operators aware that a process is operating out of normal conditions

(Executive, 2022)

There are numerous commercial risks that could occur when producing the subsystems for a customer which can include construction and completion risks. This could happen due to unrealistic timescales or technical problems, since the equipment on the subsystems are outdated and old. Furthermore, financial costs could impact the production of the new system since the instruments used would need to be sourced new, or higher maintenance costs on the older outdated equipment when a problem arises (Organisation for Economic Co-operation and Development, 2022).

An environmental impact the process station would have upon the environment is within tank B3 which contains diluted sulphuric acid. If this comes in contact with the human hand possible burns could occur; as a result appropriate PPE should be worn.

4. Calibration of Pressure Sensor

It can be seen that with the pressure sensor the full range of values range from 0 Bar to 5 Bar, giving it a total span and FSD of 5 Bar.

Table 1: Pressure sensor calibration results table.

Measured Pressure (Bar)	Output Voltage (Volts)		Linear Value (Volts)	Non-linearity error (Volts)		Hysteresis Error (Volts)
	Rising	Falling		Rising	Falling	
0	0.18	0.24	0	0.18	0.24	0.06
0.5	1.05	1.04	1	0.05	0.04	-0.01
1	2	2	2	0	0	0
1.5	2.98	3	3	-0.02	0	0.02
2	3.97	4	4	-0.03	0	0.03
2.5	4.98	5	5	-0.02	0	0.02
3	5.97	6	6	-0.03	0	0.03
3.5	6.97	7	7	-0.03	0	0.03
4	7.98	7.97	8	-0.02	-0.03	-0.01
4.5	8.98	8.99	9	-0.02	-0.01	0.01
5	10	10	10	0	0	0

The resolution is said to be the smallest change a sensor can measure which can be seen at 4.5 Bar where the output voltage has a difference of 0.01 V meaning it could be between 8.98V or 8.99V.

The accuracy of the sensor can be proven by a formula as shown below:

$$\%Accuracy = \pm \frac{Resolution}{Input Span} \times 100$$

$$\frac{0.01V}{5 Bar} \times 100 = \pm 0.2\%$$

The static sensitivity of the sensor can be calculated using the following formula:

$$Static Sensitivity = \frac{Output range of sensor}{Input range measured} = \frac{10V}{5 Bar} = 2 V / Bar \text{ (see table 1)}$$

Non-linearity error is the difference between the true value and what the linear value is showing (W.Bolton 1991, 1996, 2000).

$$Non - Linearity = Sensor Output - Linear value \text{ (see table 1)}$$

The hysteresis error can be found using the following formula:

$$Falling Output - Rising Output \text{ (see table 1)}$$

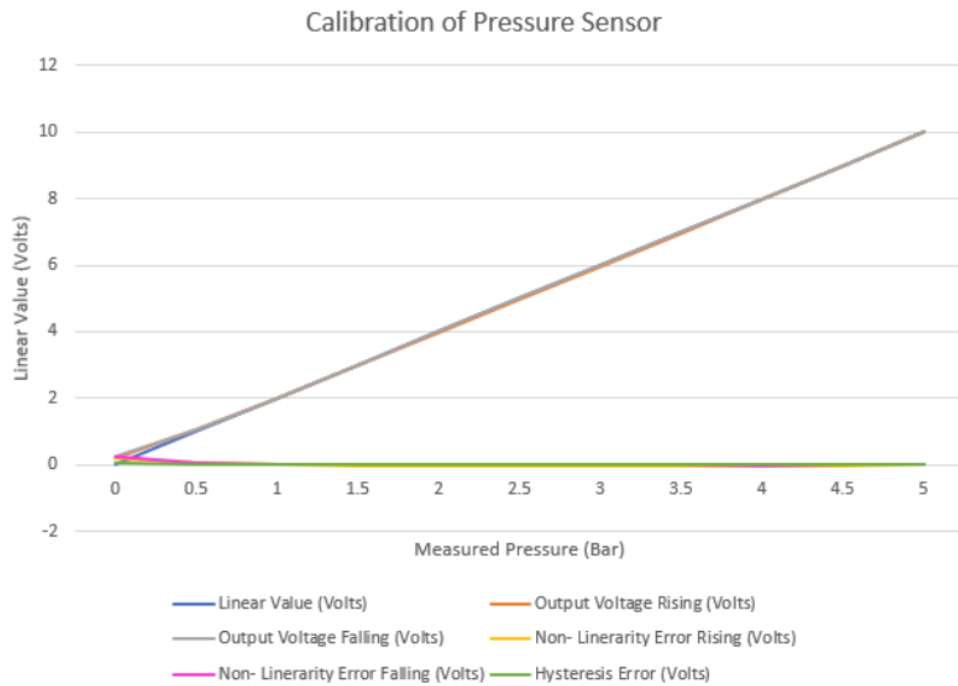


Figure 1: Calibration graph for pressure sensor.

From looking at the calibration results gathered in table 1 and shown on the graph in figure 2 it can be seen that there is a minor zero error displayed by the hysteresis column. This could be down to the resistance within the test leads used to calibrate the sensor but also human error when recording the results. A zero error can be removed by performing a zero adjustment, where the offset is removed and an accurate zero is displayed.

5. Calibration of Temperature Sensor

Table 2: Table of results for Calibration of Temperature sensor.

Tempurature	mA Falling	mA Rising	Linear Value	Error Rising	Error Falling	Hysterisis
0	4.03	4.02	4	0.02	0.03	0.01
10	5.62	5.62	5.6	0.02	0.02	0
20	7.22	7.21	7.2	0.01	0.02	0.01
30	8.82	8.81	8.8	0.01	0.02	0.01
40	10.42	10.41	10.4	0.01	0.02	0.01
50	12.01	12.01	12	0.01	0.01	0
60	13.61	13.61	13.6	0.01	0.01	0
70	15.21	15.2	15.2	0	0.01	0.01
80	16.81	16.8	16.8	0	0.01	0.01
90	18.4	18.4	18.4	0	0	0
100	19.99	19.99	20	-0.01	-0.01	0

The temperature sensor has a full range of 0-100°C, with a total span and FSD of 100°C. As it is known that the resolution is calculated by the smallest change in sensor measurement, then it can be said at 40°C the current rising and falling have a difference of 0.01, meaning the value could be between 10.42mA and 10.41mA.

The accuracy of the sensor can be proven by a formula as shown below:

$$\%Accuracy = \pm \frac{Resolution}{Input Span} \times 100$$

$$\frac{0.01V^{Amps}}{100^{\circ}C} \times 100 = \pm 0.01\%$$

The static sensitivity of the sensor can be calculated using the following formula:

$$Static Sensitivity = \frac{Output range of sensor}{Input range measured} = \frac{19.99mA^4}{100^{\circ}C} = 0.19mA/^{\circ}C \text{ (see table 2)}$$

0.16mA/deg C

$$Non - Linearity = Sensor Output - Linear value \text{ (see table 2)}$$

The hysteresis error can be found using the following formula:

$$Falling Output - Rising Output \text{ (see table 2)}$$

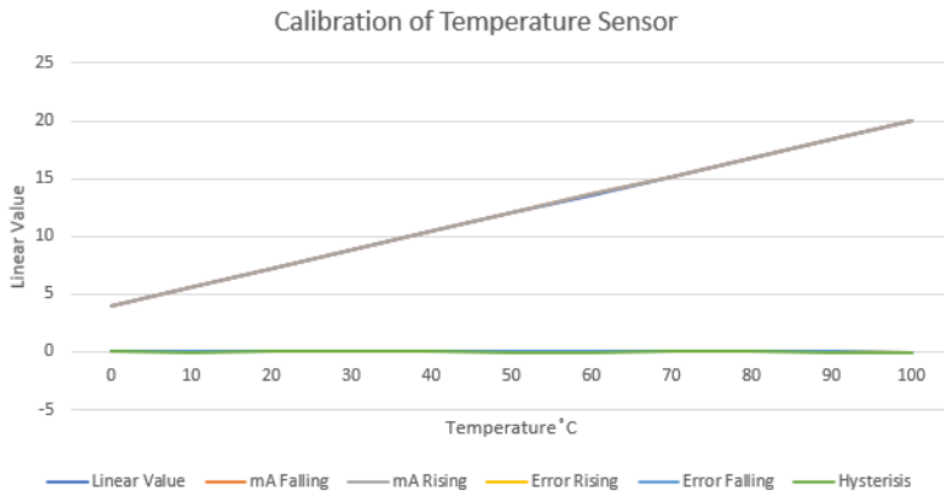


Figure 2: Calibration graph for temperature sensor.

From looking at the graph in figure 2 it can be seen the temperature ^{spelling} sensor has an offset. The offset has occurred due to the ambient temperature being recorded as it wasn't possible to achieve 0°C. However, throughout the calibration range when going through the inputted values, the hysteresis value never went higher than 0.01. From this it can be concluded that the temperature transmitter was within its accuracy calculation of 0.01% and no adjustments were required.

6. Calibration of Level Sensor

Table 3: Table of results for Calibration of Level sensor.

Level (cm)	mA Rising	mA Falling	Linear Value	Error Rising	Error Falling	Hysterisis Error
7	6.08	6.1	6.08	0	-0.02	0.02
8	6.64	6.48	6.48	-0.16	0	-0.16
9	6.97	6.86	6.88	-0.09	0.02	-0.11
10	7.36	7.25	7.28	-0.08	0.03	-0.11
11	7.8	7.63	7.68	-0.12	0.05	-0.17
12	8.2	8.06	8.08	-0.12	0.02	-0.14
13	8.56	8.45	8.48	-0.08	0.03	-0.11
14	9	8.8	8.88	-0.12	0.08	-0.2
15	9.34	9.21	9.28	-0.06	0.07	-0.13
16	9.75	9.59	9.68	-0.07	0.09	-0.16
17	10.19	10	10.08	-0.11	0.08	-0.19
18	10.52	10.39	10.48	-0.04	0.09	-0.13
19	10.9	10.81	10.88	-0.02	0.07	-0.09
20	11.33	11.21	11.28	-0.05	0.07	-0.12
21	11.71	11.68	11.68	-0.03	0	-0.03
22	12.11	11.97	12.08	-0.03	0.11	-0.14
23	12.48	12.48	12.48	0	0	0

The level sensor can be seen to have a range from 7cm³- 23cm³, with a calculated span and FSD of 16cm³. With the resolution said to be the smallest change in measurement then at 14cm³ the current values had a difference between 9mA rising and 8.8mA falling resulting in the reading being consistently within that area.

$$\%Accuracy = \pm \frac{Resolution}{Input Span} \times 100$$

where did this figure come from

$$\frac{0.02}{16cm^3} \times 100 = \pm 0.125\%$$

$$Static Sensitivity = \frac{Output range of sensor}{Input range measured} = \frac{12.48mA}{23cm^3} = 0.54mA/cm^3 \text{ incorrect}$$

$$Non - Linearity = Sensor Output - Linear value \text{ (see table 3)}$$

The hysteresis error can be found using the following formula:

$$Falling Output - Rising Output \text{ (see table 3)}$$

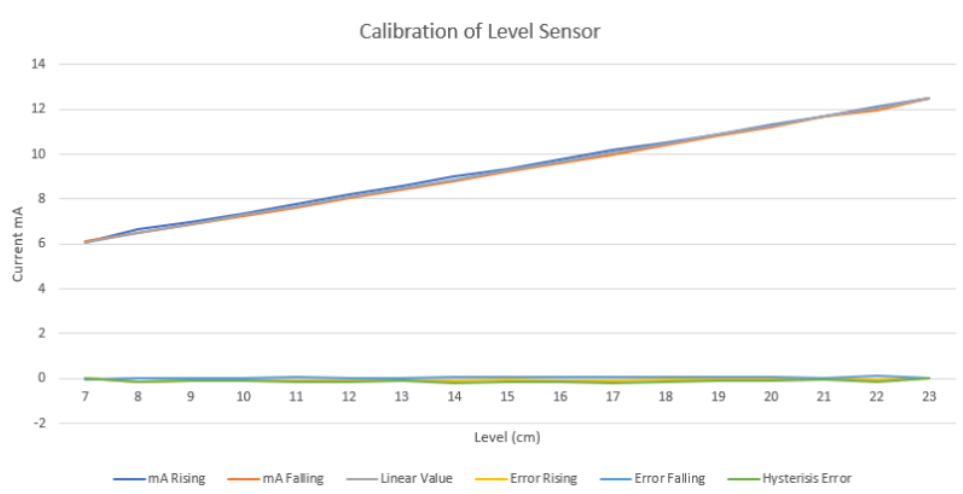


Figure 3: Calibration graph for level sensor.

Again this sensor can be seen to have an offset in figure 3, as this was due to the sensor only being able to display a value starting at 7cm³. This could be down to the sensitivity of the sensor being poor and not at a high enough accuracy level to capture all the necessary data. This is further proven with the hysteresis error which can also be seen to be above the calculated accuracy level. It would be recommended to seek a more accurate level sensor such as a vega.

7. Calibration of Position Sensors

Table 4: Table of results for Calibration of Position sensors.

Type	Type Actual	Encoder 1	Encoder Actual 1	Encoder 2	Encoder Actual 2	Laser 1	Laser Actual 1	Laser 2	Laser Actual 2	Encoder Error	Encoder Error 2	Laser Error	Laser Error 2
120	0	0.3	0	0.1	0	230	0	230.3	0	0	0	0	0
200	80	78.3	78	78.7	78.6	269.7	39.7	269.2	38.9	-2	-1.4	-40.3	-41.1
300	180	177.8	177.5	178.1	178	373.5	143.5	373.1	142.8	-2.5	-2	-36.5	-37.2
400	280	277.7	277.4	278.2	278.1	477.8	247.8	473.2	242.9	-2.6	-1.9	-32.2	-37.1
500	380	377.3	377	377.1	377	579.5	349.5	579.3	349	-3	-3	-30.5	-31
600	480	477.1	476.8	478	477.9	658.7	428.7	658.7	428.4	-3.2	-2.1	-51.3	-51.6
700	580	576.9	576.6	576.5	576.4	792.9	562.9	791.9	561.6	-3.4	-3.6	-17.1	-18.4
800	680	676.7	676.4	677.3	677.2	890.5	660.5	889.2	658.9	-3.6	-2.8	-19.5	-21.1
900	780	777.3	777	777.4	777.3	991.5	761.5	991	760.7	-3	-2.7	-18.5	-19.3
1000	880	877.6	877.3	876.9	876.8	1089.4	859.4	1088.2	857.9	-2.7	-3.2	-20.6	-22.1
1100	980	977.5	977.2	976.4	976.3	1189.2	959.2	1189.9	959.6	-2.8	-3.7	-20.8	-20.4
1200	1080	1077.4	1077.1	1076.6	1076.5	1287.3	1057.3	1287.4	1057.1	-2.9	-3.5	-22.7	-22.9
1300	1180	1176.7	1176.4	1176.1	1176	1386.1	1156.1	1384.7	1154.4	-3.6	-4	-23.9	-25.6
1400	1280	1277.4	1277.1	1276.9	1276.8	1482.7	1252.7	1482.8	1252.5	-2.9	-3.2	-27.3	-27.5

The position sensor is said to have a range from 0-1280cm as shown in table 4, with a span and FSD of 1280cm.

The accuracy of the sensors can be proven by a formula as shown below:

$$\%Accuracy = \pm \frac{Resolution}{Input Span} \times 100$$

$$Encoder 1 = \frac{-2}{1280} \times 100 = \pm 0.15\%$$

$$Laser 1 = \frac{-17.1}{1280} \times 100 = \pm 1.33\%$$

$$Encoder 2 = \frac{-2}{1280} \times 100 = \pm 0.15\%$$

$$Laser 2 = \frac{-18.4}{1280} \times 100 = \pm 1.43\%$$

The static sensitivity of the sensor can be calculated using the following formula:

$$Static Sensitivity = \frac{Output range of sensor}{Input range measured} = \frac{1400}{1280} = 1.09cm \text{ (see table 4)}$$

$$Non - Linearity = Sensor Output - Linear value \text{ (see table 4)}$$

The hysteresis error can be found using the following formula:

$$Falling Output - Rising Output \text{ (see table 4)}$$

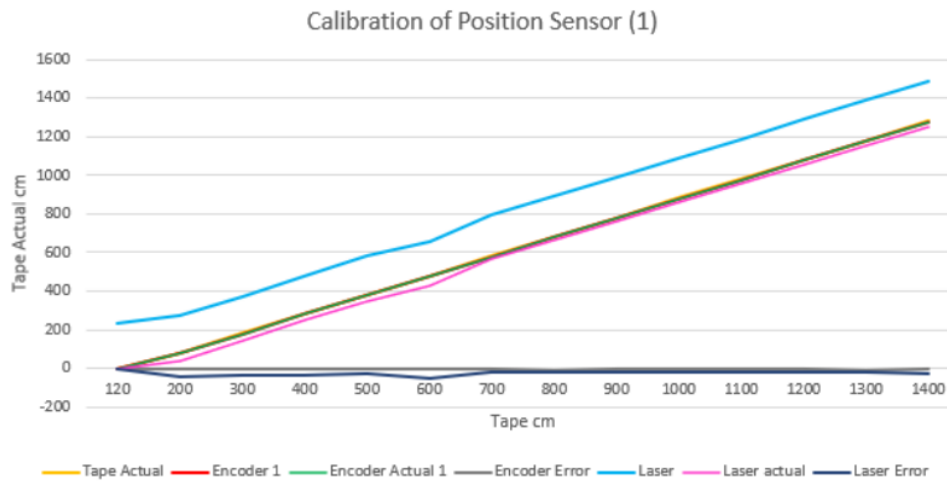


Figure 4: Calibration graph for position sensor 1.

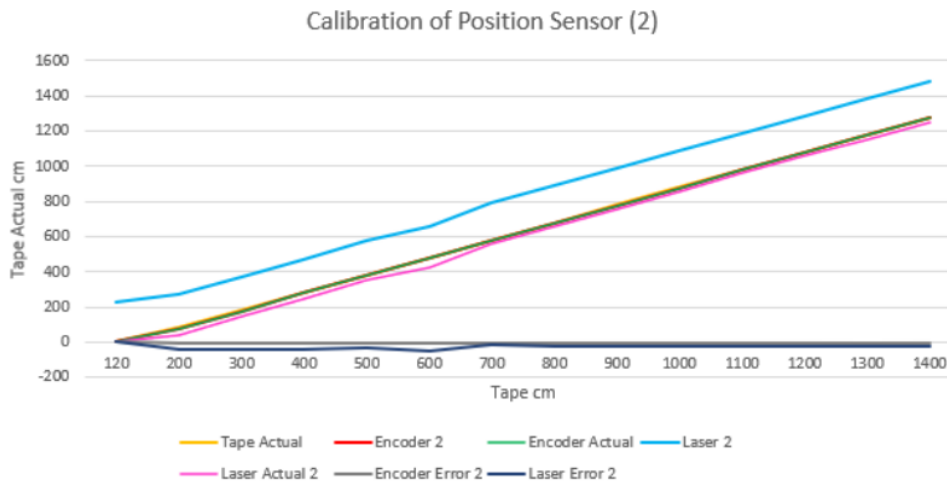


Figure 5: Calibration graph for position sensor 2.

An encoder can be described as a sensing device used to deliver feedback to a PLC by converting motion detection into an electrical signal (Encoder Products Company, 2021). The data sheet for the encoder can be found in the appendix in figure 28.

The graphs in figures 4 and 5 indicate that the encoder was more accurate than what the laser was detecting, as the encoders were able to read the zero value. It can be further seen when looking at the errors developed in table 4. However, from looking at the overall calibration it can be said that both the encoder and laser were out of calibration. By performing a span adjustment, it would be possible to get the results similar as the gain would change.

8. Design Adaptation for Maintenance and Reliability

After examining the programs, it was noticed that there no trend graphs on the control loop screens were present. Therefore, it was essential that trend graphs were added to each of the HMI control loop screens (TT511, LT541, FT535 & FT531) as this would ensure visual results being shown and also help aid any issues that arose by seeing them develop.

Another recommendation would be to add PID controls to the control loop screens as this would enable control of the process variables being used and would also be seen to be working via the trend graphs already recommended to be installed (figures 9-13).

Further adaptations were recommended to be made by adding manual start and stop buttons to TT511 for the heater controls and also for the DC pump on LT541. These adaptations were recommended as they could be manually operated if required when witnessing the state of the trend on the control loop.

Upon inspection of the robot screen, it could be seen that it wasn't very visual, so it was recommended that the screen became brighter, more clearly labelled, and also supplied with bigger functions (figure 14). A further issue was noticed with regards to the robot screen as it didn't have a mimic for the laser movement as well as what station it was in. By having the mimic, it would allow the technician to see where the laser encoder was at a given station as shown in figure 15.

The changes suggested above were made and tested thoroughly as shown in figures 18-22. Within the PLC program, design adaptations had to be made for the laser movement mimic as shown in figures 16 and 17. The laser movement mimic required an adaption to network 34 as the real value of the encoder position had to be converted into an integer value for the robot arm movement.

where is your testing table?

9. Conclusions and Recommendations

It is possible to conclude that with the adaptations made to the HMI screen in figure 17, the original issues stated have disappeared. Furthermore, it can be said that by having trend graphs on the control loop HMI screens it has aided technicians when carrying out fault diagnosis and also helped when witnessing the control loop work and also when operated with PID controls.

A further conclusion to be made is that control loops FT535, LT541 and TT511 (figures 10-12) are closed loop systems, whereas FT531 is an open loop system. FT531 can be explained as open loop because it does not rely on the PV to control its actions, as the loop is purely designed to monitor the level of the tank by controlling the flow. The other 3 loops are considered closed loops as they compare the PV with the setpoint target and then determine the control action by use of PID control hence on the HMI screens FT531 didn't have the PID control option (figure 13).

Since closed loop systems maintain setpoints by opening and closing solenoid valves frequently, it would be seen that they would deteriorate at a faster rate than those used in an open loop system.

spelling

A found in the research section of the assignment it was noticed that most industrial industries use manufacturing systems linked with Industry 4.0. This is because of their use of what is known as smart sensors. Smart sensors are used to improve the reliability of sensors but also maintenance as it uses predictive maintenance. This is said to store information in the cloud and detect when maintenance is required on a specific sensor for example calibration or if it needs replacing. It would be recommended upgrading the sensors used on the process station to similar sensors used by this. Another alternative to this option would be I-O Link which is a communication tool used to help calibrate instrumentation and control loops via a PLC.

A much cheaper alternative to than those above would be to upgrade the sensors software to Hart. This is a software that is widely used to communicate with process instruments and also used to help calibrate, configure, and provide diagnostics on required instruments. A further option would be to use Vega for the sensors. This type of equipment is commonly used in pressure and level control loops. An example of this type of communication can be seen in figure 25 and 26. From looking at these options it can be conclude that sensors would have an increased reliability and accuracy, thus leading to lower maintenance costs in the future.

10. Team Working

In various tasks of this assignment group work was required to achieve the tasks. In order to complete the calibration tasks, it was essential that a high level of communication was maintained at all times in order to obtain the calibration results accurately. Within the group calibration tasks it was essential that everyone maintained their role throughout the calibration of each sensor as this would reduce the factor of human error, reduce confusion when noting results and also improve reliability. The way the group worked efficiently and accurately was due to the splitting up of roles, for example one member was operating the equipment to obtain the results, another was witnessing the results and the calibration occur, with the final member of the group was noting down the results in a results table and designing calibration graphs to suit.

Task 8 required an adaptation to the HMI program controlling the subsystems. Within the group it was noticed upon completing the calibrations how certain aspects could be improved and these adaptations were implemented. Upon completion of redesigning the control loop screens it again required a testing stage. This again was carried out by dividing the roles amongst the group as one person operated the PLC, another witnessed the operation to ensure it worked accurately whilst the final member took pictures for evidence to support the adaptations made.

good range of sources

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Educational and Professional Publishing Ltd, p. 9.

12. Appendix

no datasheet please

Technical Data

Input:	Pt100, 2/3-wire circuit
Measuring current:	<1mA*
Zero:	-200..830°C
Span:	> 20°C
Linearity error:	< 0.1%
Supply voltage:	15..35V DC, polarity - safe
Output:	0 .. 10V
Probe break:	>10V
Short circuit:	0V
Reaction time:	<0.1s
TC:	<100ppm/°C
Operating temp. range:	-40..85°C
Storage temp. range:	-40..120°C
Humidity:	<95%
Type of terminals:	screw terminals
Clamping range:	0.2..2.5mm²
Housing:	Polycarbonate 75x25x53mm
Weight:	approx. 60g
Vibration:	5g/10..200Hz
Warranty:	2 years

(GmbH, 2022)

Figure 6: Data sheet for TT511.

Specifications

Wetted Materials	
Body	Nylon 12
Turbine	Nylon 12 Composite
Bearings	PTFE/15% Graphite
Operating Pressure	200 PSIG (13.7 bar)
Burst Pressure	2500 PSIG (172 bar)
Operating Temperature	-4°F to 212°F (-20°C to 100°C)
Viscosity	32 to 81 SSU (.8 to 16 Centistokes)
Filter	<50 Microns
Input Power	5 to 24 VDC @ 8mA
Output (Hz)	NPN Sinking Open Collector @ 20mA Maximum Leakage Current 10µA (Pull-Up Resistor Required)
Accuracy	±3% of Reading
Repeatability	0.5% of Full Scale
Electrical Connection	DIN 9.4mm Spacing* 24 AWG 3 ft. Cable
Inlet/Outlet Ports	3/8" NPT Male G3/8 Male 17mm Tube O-Ring

(controls, 11)

Figure 7: Flow sensor for FT535 & FT531.

Flow Range		Pulses per		Frequency Output
GPM	Liters/m	Gallon	Liter	
.13-1.3	.5-5	26200	6900	58-575 Hz
.13-2	.5-7.5	17800	4700	39-588 Hz
.26-2.6	1-10	12500	3300	55-550 Hz
.26-4	1-15	8300	2200	37-550 Hz
.26-6.6	1-25	3800	1000	16.7-416 Hz
.53-9.2	2-35	2840	750	25-438 Hz

(controls, 11)

Figure 8: Data sheet for flow sensor FT535 & FT531.

(Intelligence,

2018)

Features

Medium	Liquid, gaseous
Pressure type	Gauge pressure
Measuring range	0 bar ... 0.25 bar
Process temperature	-30 °C ... +100 °C
Output signal	4 mA ... 20 mA, 2-wire

Performance

Non-linearity	≤ ± 0.2 %, of span (Best Fit Straight Line, BFSL) according to IEC 61298-2
Accuracy	≤ ± 0.5 % of the span
Non-repeatability	≤ ± 0.1 % of the span
Response time (10 % ... 90 %)	≤ 1 ms ≤ 10 ms at medium temperatures below < -30 °C for pressure ranges up to 25 bar or with flush-mounted membrane
Long-term drift/one-year stability	≤ ± 0.2 % of span (at reference conditions)
Temperature coefficient in rated temperature range	Mean TC of zero: ≤ 0.2 % of span / 10 K (< 0.4 % for pressure ranges ≤ 0.25 bar), Mean TC of span ≤ 0.2 % of span / 10 K
Rated temperature range	0 °C ... +80 °C
Service life	Minimum 10 Mio. life cycles

Mechanics/electronics

Wetted parts	Flush-mounted membrane: Stainless steel 1.4571 with NBR O-ring or FKM O-ring (FKM with integrated cooling element)
Internal transmission fluid	Synthetic oil (Not available for version with standard membrane for pressure ranges > 25 bar)
Pressure port	Front-flush membrane
Housing material	Stainless steel 1.4571
Connection type	Round connector M12 x 1, 4-pin, IP67
Supply voltage	10 V DC ... 30 V DC 14 V DC ... 30 V DC with output signal 0 V ... 10 V
Electrical safety	Overvoltage protection: 36 V DC Short-circuit protection: Q _A towards M Reverse polarity protection: L ⁺ to M Protection class: III

Figure 9: Datasheet for LT541.

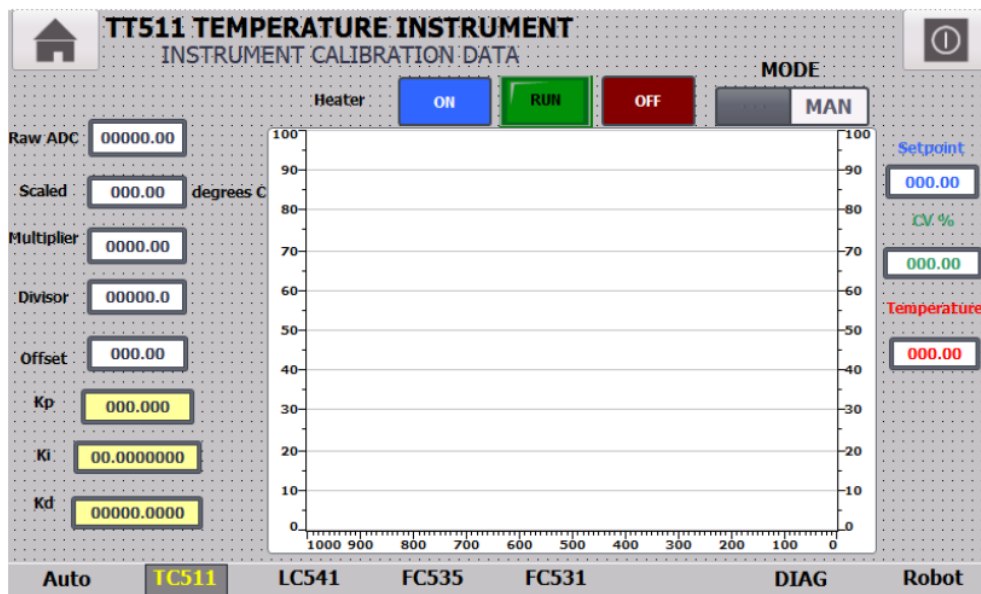


Figure 10: HMI screen for control loop TT511.

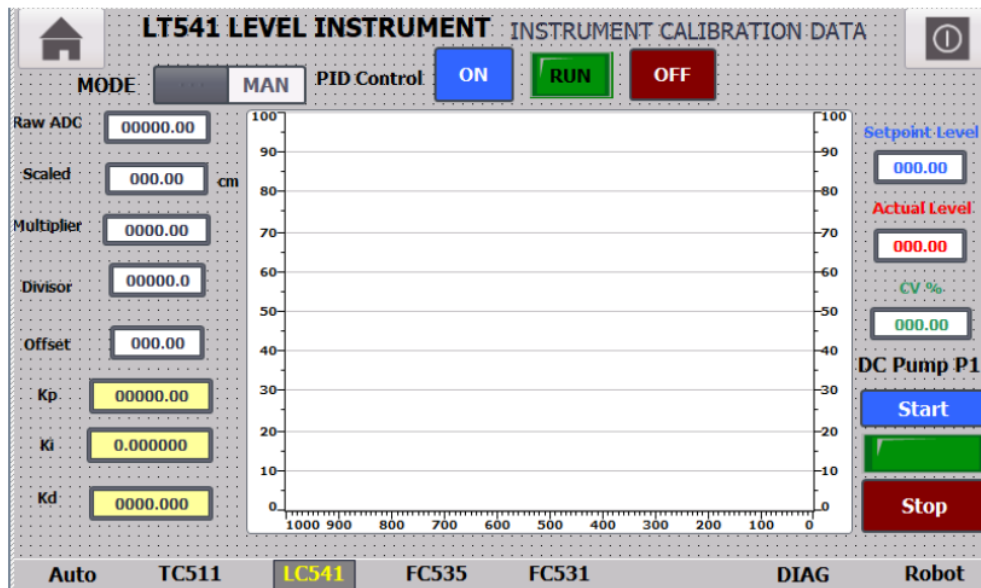


Figure 11: HMI screen for control loop LT541.

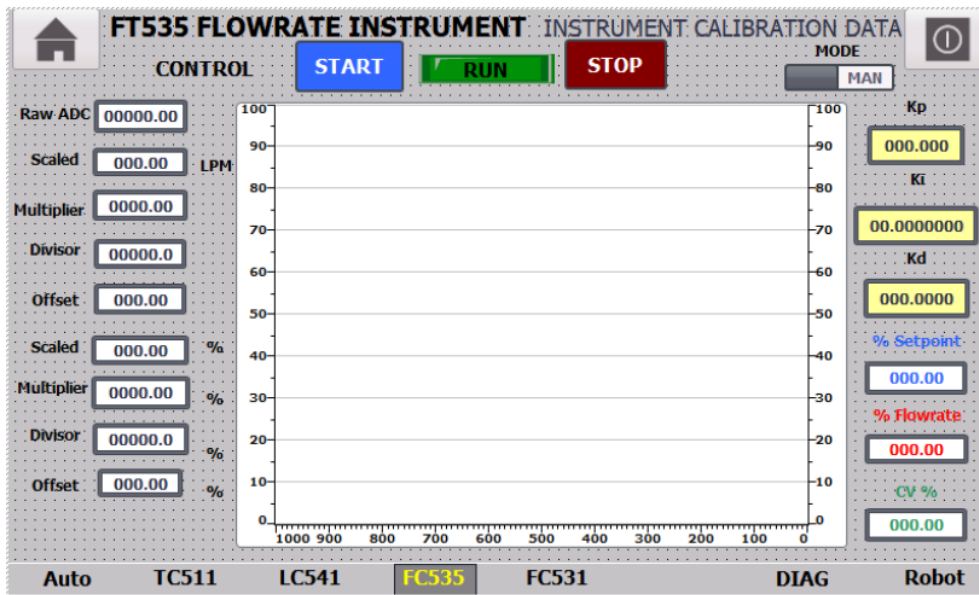


Figure 12:HMI screen for control loop FT535.

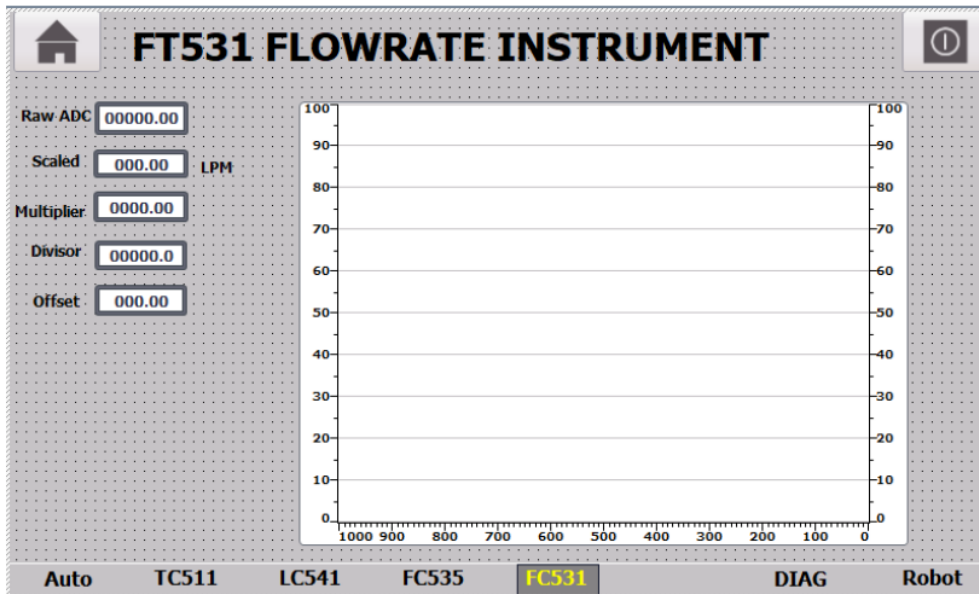


Figure 13:HMI screen for control loop FT531.

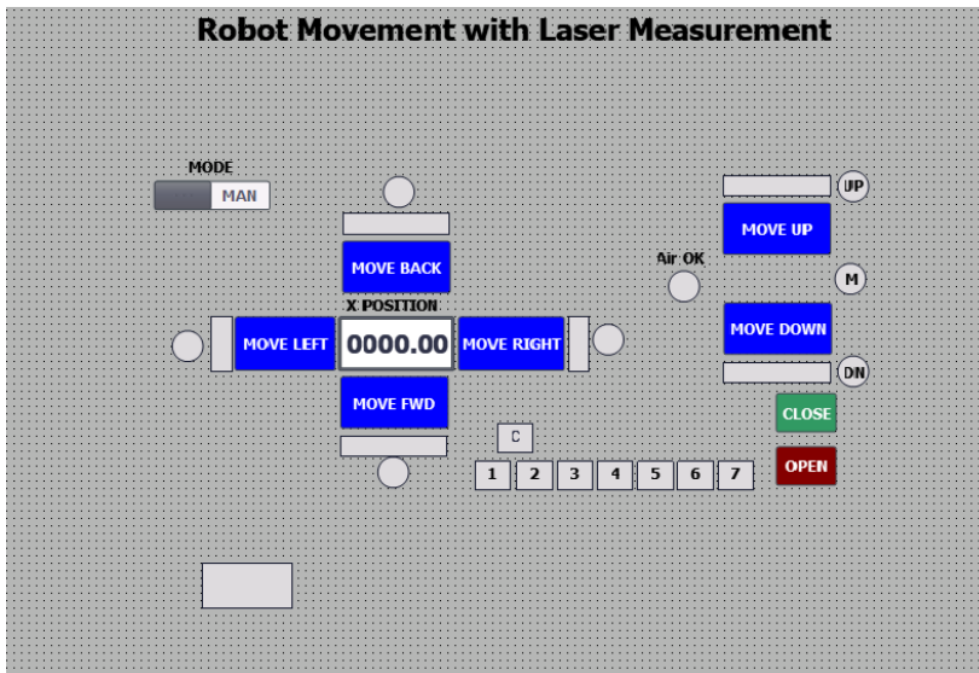


Figure 14: Old HMI screen for robot movement with laser measurement.

Encoder Position									
	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	C
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	junk	Real	0.0	☐	☒	☒	☒	☐	
7	HMI arm position	Int	0	☐	☒	☒	☒	☐	
8	world name			☐	☐	☐	☐	☐	

Figure 15: Software modification for HMI arm position.

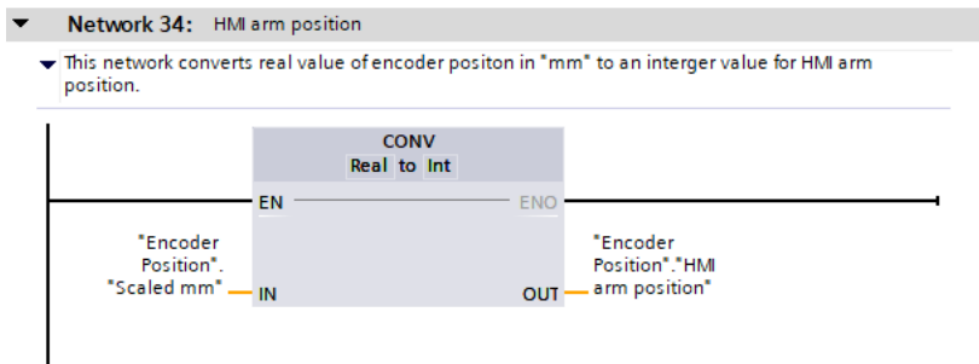


Figure 16: Network 34 HMI arm position adaptation.

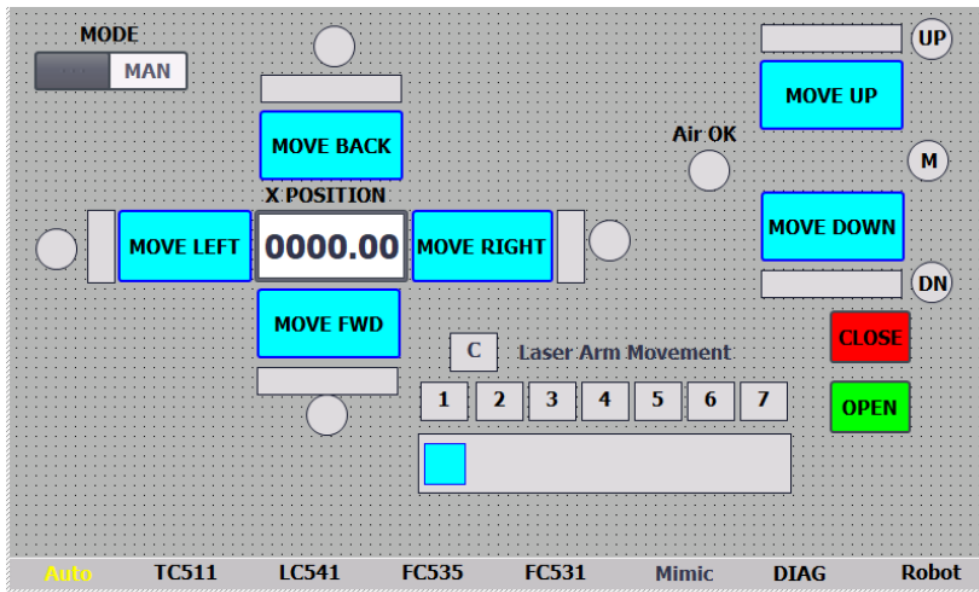


Figure 17: New HMI screen for robot with laser movement.

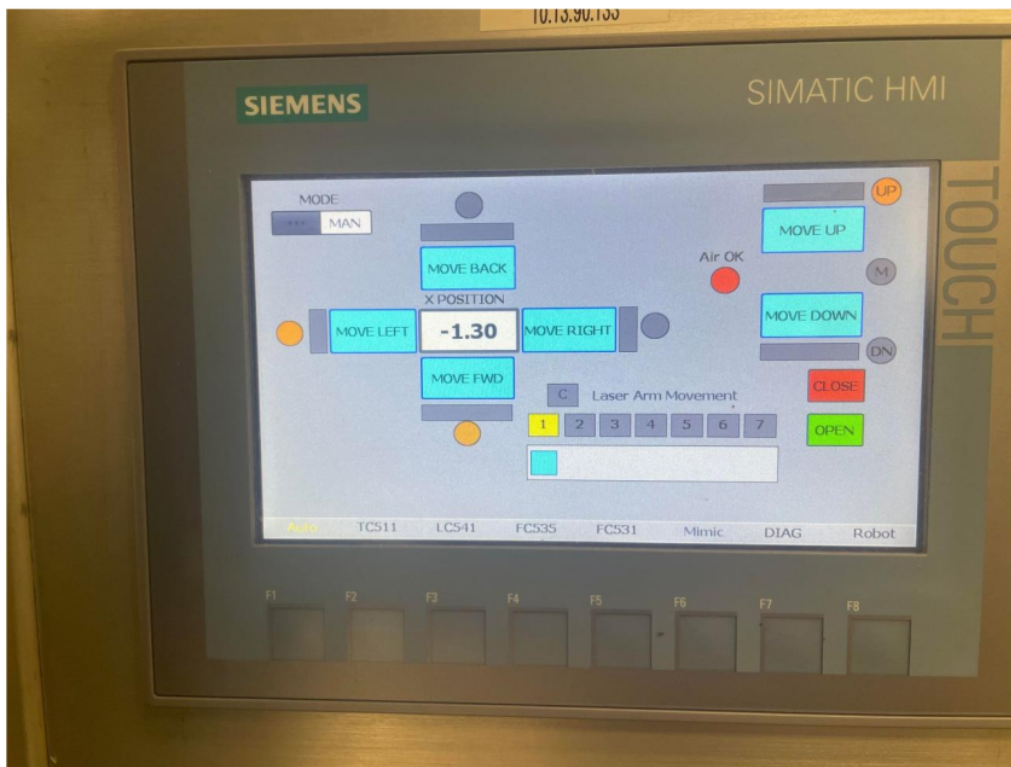


Figure 18: Testing new HMI screen in tank B1.

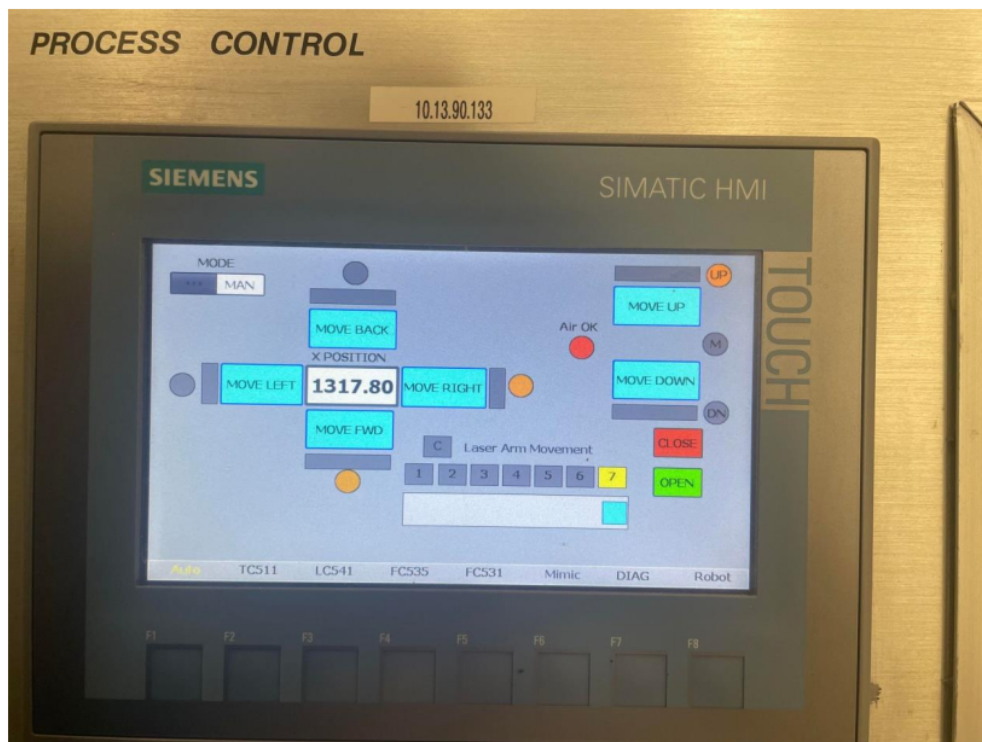


Figure 19: Testing new HMI screen in tank B7.

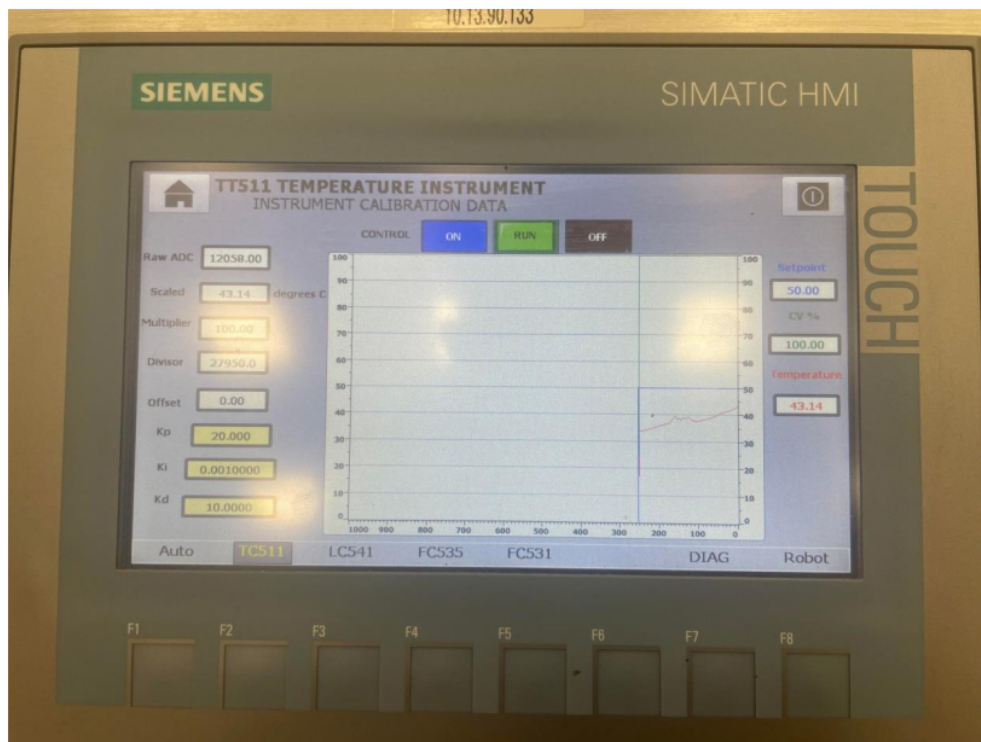


Figure 20: Testing PID controls on TTS11.

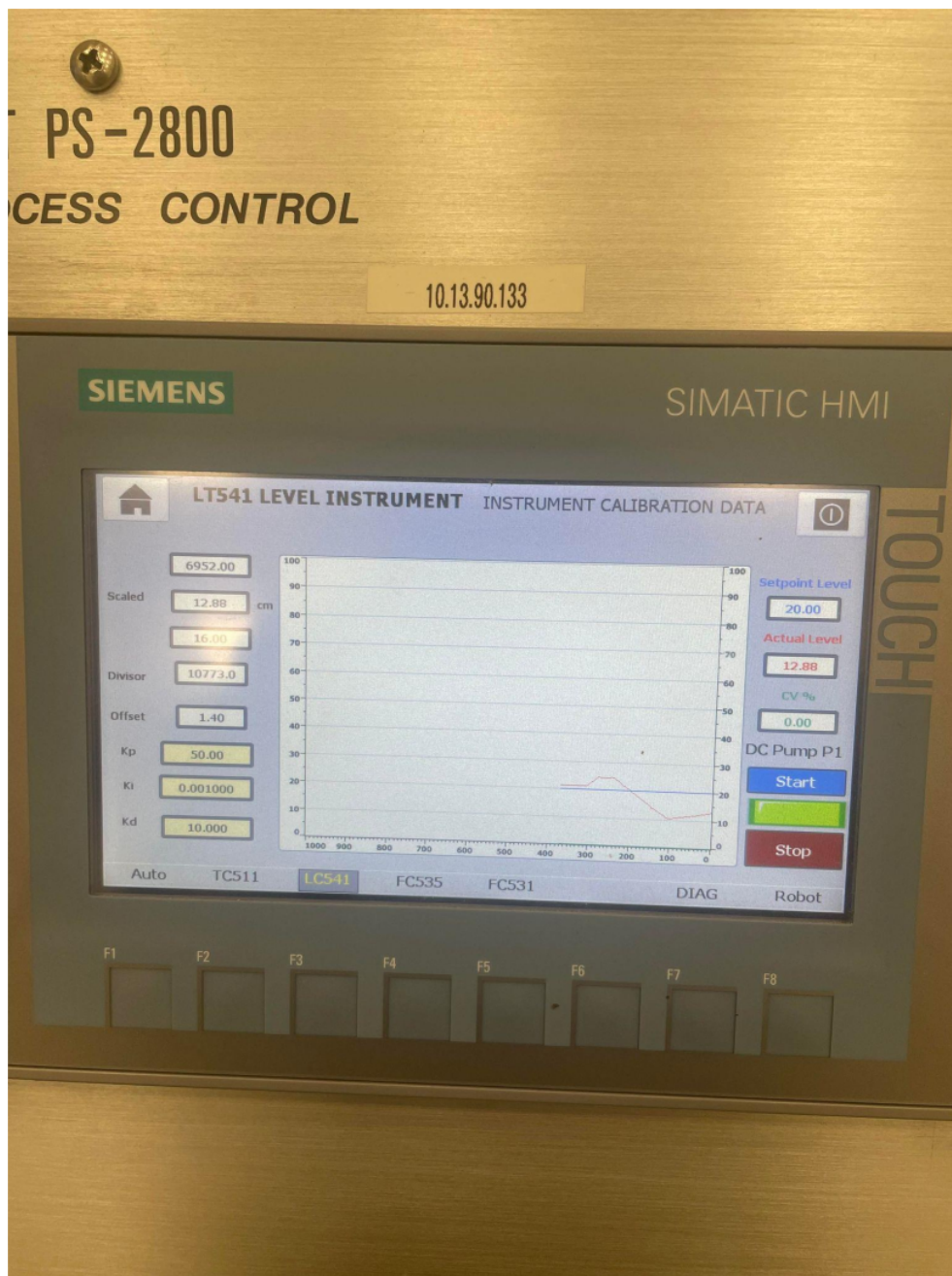


Figure 21: Testing PID controls on LT541.

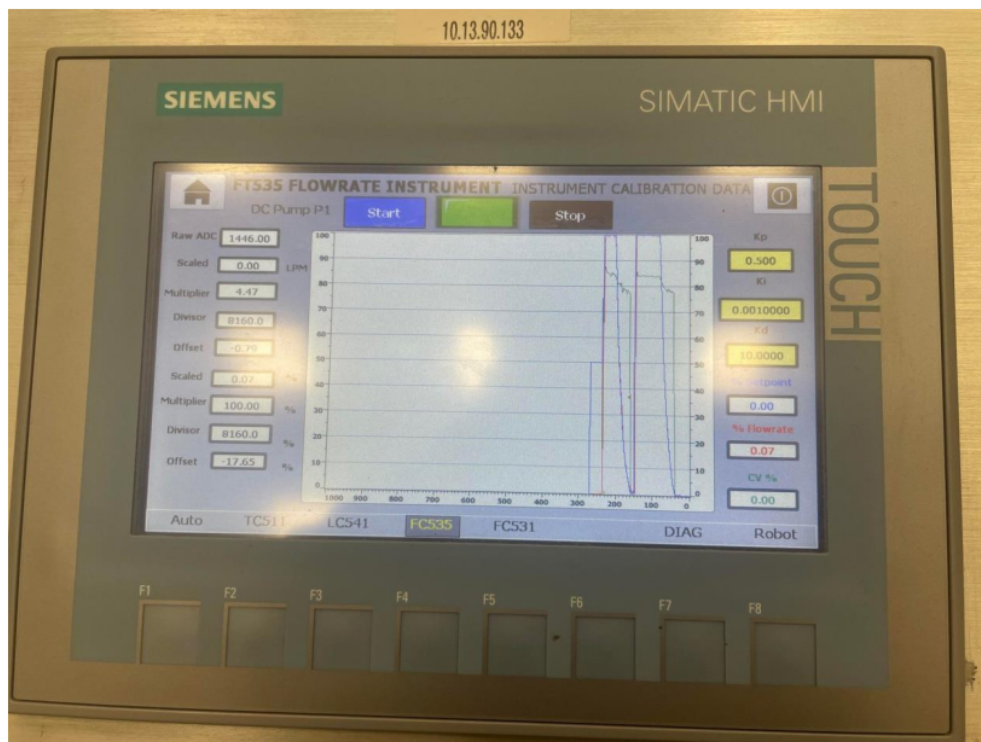


Figure 22: Testing PID controls on FT535.

LFP0500-A4NMB | LFP Cubic

LEVEL SENSORS



Ordering information

Type	Part no.
LFP0500-A4NMB	1057076

Other models and accessories → www.ick.com/LFP_Cubic

Illustration may differ



Detailed technical data

Features

Medium	Fluids
Measurement	Switch, Continuous
Design	Standard
Probe type	Rod probe
Probe length	500 mm
Process pressure	-1 bar ... 10 bar
Process temperature	-20 °C ... +100 °C
RoHS certificate	✓
IO-Link	✓
ULus certificate	✓

Performance

Accuracy of sensor element	± 5 mm ¹⁾
Reproducibility	± 2 mm
Resolution	< 2 mm
Response time	< 400 ms
Dielectricity constant	± 5 for rod probe / cable probe ± 1.8 with coaxial tube
Conductivity	No limitation
Maximum level change	± 500 mm/s
Deactivated area at process connection	25 mm ²⁾

¹⁾ with water under reference conditions.

²⁾ with parameterised container with water under reference conditions, otherwise 40 mm.

Figure 23: Data sheet for level transmitter using I-O Link.

LFP0500-A4NMB | LFP Cubic
LEVEL SENSORS

Deactivated area at end of probe	± 50 mm ¹⁾
MTTF	194.3 years (EN ISO 13849-1)

¹⁾ with water under reference conditions.
²⁾ with parameterized container with water under reference conditions, otherwise 40 mm.

Electronics

Supply voltage	12 V DC ... 30 V DC ¹⁾
Power consumption	± 100 mA at 24 V DC without output load
Initialization time	± 5 s
Protection class	II
Connection type	Round connector M12 x 1, 5 pin
Output signal	4 mA ... 20 mA, 0 V ... 10 V automatic switching depending on the load, 1 PNP transistor output (Q1) and 1 PNP / NPN transistor output (Q2) switchable 1 x PNP = 1 x PNP/NPN = 4 mA ... 20 mA / 0 V ... 10 V
Output load	4 mA ... 20 mA < 500 Ohm at U _v > 15 V, 4 mA ... 20 mA < 250 Ohm at U _v > 12 V, 0 V ... 10 V > 750 Ohm at U _v ≤ 14 V
Hysteresis	Min. 2 mm, free adjustable
Signal voltage HIGH	U _v - 2 V
Signal voltage LOW	± 2 V
Output current	< 100 mA
Inductive load	< 1 H
Capacitive load	100 nF
Enclosure rating	IP67: EN 60529
Temperature drift	< 0.1 mm/K
Lower signal level	2.8 mA ... 4 mA
Upper signal level	20 mA ... 20.5 mA
EMC	EN 61326-2-3, 2014/26/EC

¹⁾ all connections are polarity protected. All outputs are overload and short-circuit protected.

Mechanics

Wetted parts	1.4404, PTFE
Process connection	G 1/4
Housing material	Plastic PBT
Max. probe load	± 6 Nm

Ambient data

Ambient operating temperature	-20 °C ... +60 °C
Ambient storage temperature	-40 °C ... +80 °C

Classifications

ECClass 5.0	273718-13
ECClass 5.1.4	273718-13
ECClass 6.0	273718-13
ECClass 6.2	273718-13
ECClass 7.0	273718-13

Figure 24: Data sheet for Level transmitter using I-O Link.

Specification sheet

VEGAPULS C 21

Two-wire 4 ... 20 mA/HART

Radar sensor for continuous level measurement



Application area

The VEGAPULS C 21 is the ideal radar sensor for non-contact level measurement with high accuracy requirements in all standard applications where a high degree of protection is required.

It is particularly suitable for level measurement in water treatment, in pumping stations and rain overflow basins, for flow measurement in open channels, for level monitoring and for many other industrial areas. The sensor is suitable both for measuring liquids and for use on small bulk solids silos or bulk solids containers.

Your benefit

- Maintenance-free operation due to non-contact 80 GHz radar technology
- Exact measuring results independent of product, process and ambient conditions
- High plant availability because wear and maintenance-free. Exact measurement results independent of medium, process and ambient conditions

Function

The sensor emits a continuous radar signal through the antenna. The emitted signal is reflected by the medium and received as an echo by the antenna.

The frequency difference between the emitted and received signal is proportional to the distance and depends on the filling height. The determined filling height is converted into a respective output signal and output as measured value.

Technical data

Measuring range up to	15 m (49.21 ft)
Deviation	≤ 2 mm
Beam angle	8°
Measuring frequency	W-band (80 GHz technology)
Output signal	4 ... 20 mA/HART
Process fitting	Thread G1½, 1½ NPT, R1½
Mounting connection	Thread G1, 1 NPT, R1
Process pressure	-1 ... +3 bar (-100 ... +300 kPa/-14.5 ... +43.51 psig)
Process temperature	-40 ... +80 °C (-40 ... +176 °F)
Ambient temperature	-40 ... +80 °C (-40 ... +176 °F)
Bluetooth standard	Bluetooth 5.0 (downward compatible to Bluetooth 4.0 LE)
Effective range Bluetooth	25 m (82 ft)
Operating voltage	12 ... 35 V DC
Protection rating	IP66/IP68 (3 bar) acc. to IEC 60529, Type 6P acc. to UL 50

Materials

The wetted parts of the instrument are made of PVDF. The process seal is made of FKM. The connection cable is PUR insulated.

A complete overview of the available materials and seals can be found on our homepage under "Products" and "Configure & Order".

Housing versions

The housing is optimized for applications in the water/waste water industry and manufactured of PVDF. Due to the encapsulated cable gland, protection rating IP66/IP68 (3 bar) is achieved.

Electronics versions

The instruments are available in different electronics versions. Apart from the two-wire electronics with 4 ... 20 mA/HART, two digital versions with SDI-12 and Modbus/Levelmaster protocol are possible.

Approvals

Worldwide approvals are available for VEGA instruments, e.g. for use in hazardous areas, on ships or in hygienic applications.

The technical data in the respective safety instructions are valid for approved instruments (e.g. with Ex approval). In some cases, these data can differ from the data listed herein.

You can find detailed information on the existing approvals with the appropriate product on our homepage.

Figure 25: Data sheet of level transmitter using Hart interface.



Adjustment

Adjustment via the signal cable

The adjustment of the instrument is carried out via the interface adapter VEGACONNECT and a PC with the adjustment software PACTune and corresponding OTM.

Wireless adjustment via Bluetooth

The Bluetooth version of the device enables wireless connection to smartphones/tablets (iOS/Android) or Windows PCs.



Wireless connection to standard operating device.

Operation is via a free app from the "Apple App Store", the "Google Play Store" or the "Baidu Store". Alternatively adjustment can also be carried out via PACTune/OTM and a Windows PC.



Adjustment via PACTune or app

Adjustment via remote systems

Further adjustment options are possible via a HART Communicator as well as manufacturer-specific programs such as AMS1 or PDM.

Electrical connection

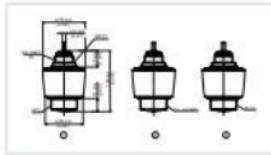


Wire assignment in permanently connected connection cable

1. Brown (+) to voltage supply or to the processing system
2. Blue (-) to voltage supply or to the processing system
3. Shielding

You can find details on electrical connection in the instrument operating instructions at www.vega.com/leveltrans

Dimensions



Dimensions VEGAPULS C 21

1. Thread G 1/4
2. Thread 1/2 NPT
3. Thread R 1/2

Mounting accessories

For the VEGAPULS C 21 the suitable mounting accessories for ceiling or wall mounting is available.



Mounting strap with adjustable sensor holder for sensors with axial cable outlet - that mounting strap is not included.

You can find further information on the mounting accessory on our homepage.

Information

You can find further information on the VEGA product line on our homepage.

In the download section on our homepage you'll find operating instructions, product information, brochures, approval documents, instrument drawings and much, much more.

Software accessories such as the current device software and the appropriate operating software are also available there.

Instrument selection

On our homepage under "Products" you can select the suitable measuring principle and instrument for your application.

There you will also find detailed information on the available device versions.

Contact

You can find your personal contact person at VEGA on our homepage under "Contact".

Figure 26: Data sheet for Level transmitter using Hart interface.



UC4000-30CM-2EP-10-V15

Features

- IO-link interface process data

- ### Diagrams

Characteristic response curve



General specifications

[illegible]

33

(Baumer,

2018)

Technical data - electrical ratings		Technical data - mechanical design	
Voltage supply	5 VDC $\pm$ 10 % 4.75...30 VDC 10...30 VDC	Size (flange)	$\varnothing$ 58 mm
Reverse polarity protection	Yes (4.75...30 VDC)	Admitted shaft load	$\leq$ 20 N axial $\leq$ 40 N radial
Consumption w/o load	$\leq$ 30 mA (24 VDC) $\leq$ 60 mA (5 VDC)	Protection DIN EN 60529	IP 54 (without shaft seal), IP 65 (with shaft seal)
Pulses per revolution	5...6000	Operating speed	$\leq$ 10000 rpm
Reference signal	Zero pulse, width 90°	Starting torque	$\leq$ 0.015 Nm (+25 °C, IP 54) $\leq$ 0.03 Nm (+25 °C, IP 65)
Sensing method	Optical	Rotor moment of inertia	14.5 gcm ²
Output frequency	$\leq$ 150 kHz	Materials	Housing: aluminium Flange: aluminium
Output signals	A 90° B, N + inverted	Operating temperature	-25...+100 °C (5 VDC) -25...+85 °C (24 VDC) -40...+85 °C (optional)
Output stages	Linedriver/RS422 Push-pull short-circuit proof	Relative humidity	95 % non-condensing
Interference immunity	DIN EN 61000-6-2	Resistance	DIN EN 60068-2-6 Vibration 10 g, 16-2000 Hz DIN EN 60068-2-27 Shock 200 g, 6 ms
Emitted interference	DIN EN 61000-6-4	Connection	Connector M23, 12-pin Cable 1 m
Approval	UL approval / E63076	Weight approx.	250 g
		GI355	
		Shaft type	$\varnothing$ 10 mm solid shaft
		Flange	Clamping flange
		GI356	
		Shaft type	$\varnothing$ 6 mm solid shaft
		Flange	Synchro flange

Figure 28: Datasheet of encoder.

FINAL GRADE

GENERAL COMMENTS

Instructor

62/100

PAGE 1

Text Comment. A well structured report, good presentation and good evidence of reading from a wide range of sources. However, in your analysis, there are mistakes and in the practical there is no testing table. Good conclusions and good evidence of team working.

PAGE 2

Text Comment. Good structure

PAGE 3

Text Comment. you could have mentioned the encoder

PAGE 4

Text Comment. link master

PAGE 5

PAGE 6

PAGE 7

PAGE 8

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PAGE 10

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PAGE 12

PAGE 13

PAGE 14

Text Comment. spelling

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PAGE 15

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PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

GRADING FORM: NEW CSG-RUBRIC

RYAN JAMES

62

1. ENGAGEMENT WITH LITERATURE



Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing 14/20

14

2. KNOWLEDGE AND UNDERSTANDING



Knowledge of the basic underlying concepts and principles is accurate with a good understanding of the field of study but lacks depth and/or breadth. 11/20

11

3. COGNITIVE AND INTELLECTUAL



Sound evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately. Ability to devise arguments using evidence to make mostly appropriate and valid judgements. 12/20

12

4. PRACTICAL APPLICATION



A good and appropriate application of basic methods, materials, tools and/or techniques. Clear appreciation of the context of the application. Good evidence of different approaches to problem-solving in particular contexts and proposes mostly appropriate solutions. 11/20

11

5. TRANSFERABLE SKILLS



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. 14/20

14