

1910603

by Benjamin Brickle

FILE	17595_BENJAMIN_BRICKLE_1910603_178815_411188687.PDF (1.36M)		
TIME SUBMITTED	01-FEB-2021 09:01PM (UTC+0000)	WORD COUNT	3744
SUBMISSION ID	143966765	CHARACTER COUNT	23440

Course: HNC Electrical and Electronic
Engineering

Module: SGEE4005 Instrumentation and
Integrated Automation Systems

Assignment: 1. Instrumentation for
Automation Systems

Name: Ben Brickle

University number: 1910603

Date submitted: 1/2/2021

Word count: 2714

Contents

Good Structure

1) System Investigation	3
2) Research	6
3) Environmental, Sustainable Development, Commercial Risk and Codes of Practice	8
4) Calibration of Pressure Sensor	9
5) Calibration of Temperature Sensor.....	12
6) Calibration of Level Sensor.....	15
7) Calibration of Flow Sensor	18
8) Design Adaptation for Maintenance and Reliability.....	19
9) Conclusions and Recommendations	23
10) Team Working.....	24
11) Citation List	25
12) Appendix.....	27

Table of Figures

Figure 1- Section 1 P&ID	3
Figure 2- Section 2 P&ID	4
Figure 3- Instrument data	4
Figure 4- Pressure calibration arrangement	9
Figure 5- Pressure calibration results.....	10
Figure 6- Comparing measured values with linear values, pressure calibration	11
Figure 7- ConLAB RTT-2 RTD Signal Conditioner	12
Figure 8- Calibration results temperature.....	12
Figure 9- Comparing measured values and linear values, temperature.....	13
Figure 10- Sight Glass used as reference.....	15
Figure 11- LT-541, Endress and Hauser Cerabar	15
Figure 12- Calibration results for level	16
Figure 13- Comparing measured values with linear values, level	16
Figure 14- Flow calibration graph	18
Figure 15- Flow calibration data	18
Figure 16- Adapted HMI screen for LT-541	19
Figure 17- Adapted screen for TT-511	19
Figure 18- TT-511 SP tag	20
Figure 19- Adapted screen for FT-535, driven by LC	20
Figure 20- FT-353 manually adjusting SP	21
Figure 21- Testing table	22
Figure 22- Druck LPM500 Datasheet.....	27
Figure 23- Endress and Hauser Cerebar PMC 133 datasheet	28
Figure 24- CONLAB RTT-2 Datasheet	28
Figure 25- RS Pro radial flow turbine meter datasheet.....	28
Figure 26- Siemens TH300 temperature puck.....	28

1) System Investigation

The P&ID can be used to analyse all sections of the system.

LT541 is a capacitance pressure transducer, which can be used to determine tank level. Its output feeds into LC-541 to control the level in the cleaning tank. It controls the level with an output to the drain valve (V500), and an output to LY541 which controls the DC pump (P1)

The cleaning tank also has two level switch interlocks, LS-542 and 543. These switches will ensure that there is a safe level before temperature can be increased, whilst LS543 offers protection against overflow, via a data link to DC pump (P1)
software interlock

TT511 is a PT-100 RTD, which is used as a temperature controller, TC-511. This RTD provides temperature feedback to the controller, to control the temperature in the tank. TC-511 controls the temperature by operating the heating element to heat, and by operating the fan below to cool.

FT-535 is used to monitor and control flow into the cleaning tank. The flow into the tank can be passed through the cooling fans or bypassing it straight to the tank, by controlling through V515 and V516. The output from this transducer is fed into FC-535 which controls the flow via LY-541 to control the DC pump.

LS-541 is used in the sump tank. This will become an open circuit if the level drops too low, raising an alarm.

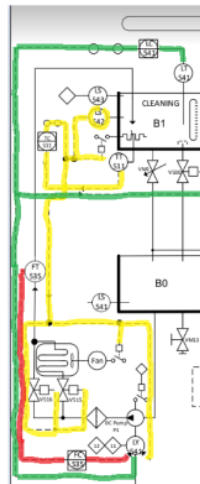


Figure 1- Section 1 P&ID

FT-531 monitors the flow of water into each rinsing chamber. The output from the FT goes to FC-531 which controls the flow via VF531 proportional valve, and via V510/11/12 inlet valves to each chamber.

LS-544 is a level switch which effectively provides on/off control for the AC pump (P2).

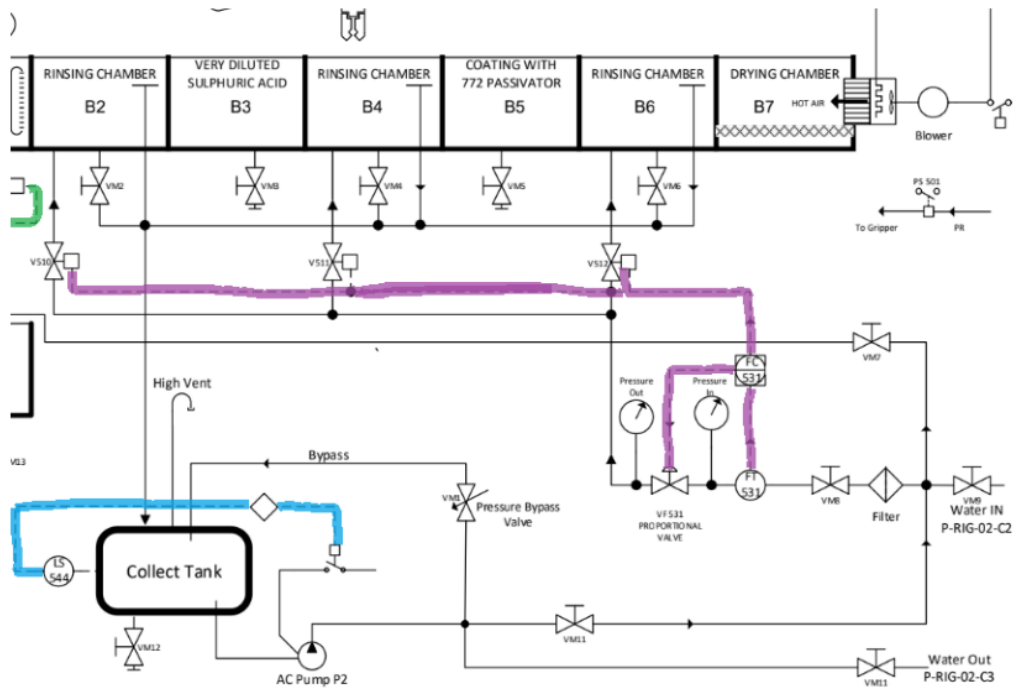


Figure 2- Section 2 P&ID

Tag	Name	Type	Range	Static Sensitivity	Accuracy	Link
LT-514	Endress and Hauser- Cerebar PMCI	Capacitance pressure transmitt	0-10 Bar	±2.5mBar/mA	±0.2%	https://www.uk.endress.com/en/field-instruments-overview/PMC133
LS-541	Flow line level switch	Float switch	-	-	-	-
LS-542	Flow line level switch	Float switch	-	-	-	-
LS-543	Flow line level switch	Float switch	-	-	-	-
FT-353	RS Pro Radial Flow Turbine	Turbine flow meter	0.25-6.5l/min	-	1%	https://uk.rs-online.com/web/p/flow-sensors/0257149/
TT-511	RTD, ConLAB RTT-2 conditioner	PT100 RTD	30-810°C	0.062mA/°C	±0.015%	https://www.exportersindia.com/conlab/temperature-measurement-transmitter-rtt-2-azor-israel-1304399.htm

Figure 3- Instrument data

Datasheets for each instrument used can be obtained by manufacturer's websites. Calibration data and features such as sensitivity and accuracy can be crucial to choosing the right instrumentation for a task. The accuracy required for the system can be achieved using all instruments provided.

2) Research

Industry 4.0 is a phrase used to describe the fourth industrial revolution, which primarily focuses on automation and use of cyber systems. The phrase was initially used to improve the competitiveness of the German manufacturing industry and has since been adopted to various industries worldwide.

Richards states that: "The vision of Industry 4.0 facilitates "cyber-physical production systems" in which sensor-laden "smart products" tell machines how to go about being processed'- German Academy of Science and Technology (2014, p. 10). The overall goal of industry 4.0 is to convert industry into a fully automatic system, with automatic decision making, monitoring and continuous control. A key component of Industry 4.0 is the Internet of Things (IoT) with features such as cloud storage, artificial intelligence, and new communication techniques (2016). The use of Industry 4.0 can be implemented into Instrument and Control systems. Control systems can be improved using several key factors of Industry 4.0, such as remote access to control systems, improved efficiency through use of robotics and automation and increased cyber security.

Instruments can be replaced with 'smart' equivalents, which communicate via the HART protocol. Instruments using this protocol can communicate with each other, the control system or entirely separately via other methods such as Ethernet (A. Guochen, 2010). Using Smart instruments can make control systems work differently, where they can primarily control, whilst using another system such as PLC's or SCADA for maintenance or acquiring data from the instruments. These smart instruments can be calibrated whilst online and will generally offer a higher level of diagnostics than non-smart equivalents. Features such as failure current outputs or transmitter-based alarm points can be used, which offer a level of redundancy when used alongside a control system alarm point (Perelman, 2019).

Another example of Industry 4.0 is IO-Link, an extension of the IEC 61131 standard for PLC's. IO Link is an alternative to DCS or SCADA and is another option of connecting instrumentation. The standard provides a continuous communication link between instrumentation and controllers, with constant access to all process variables and other factors useful for engineering/maintenance. The system can be implemented on an HMI, providing a visualisation of the system. An IO-Link master is required, with devices configured to communicate with it, in contrast to DCS architecture (Link, 2018).

Pepperl + Fuchs promote the use of IO-Link, and state that: "In any place that a digital or analogue sensor is used, an IO-Link sensor can provide significantly more information, configurability and control" (2017).

According to Pepperl + Fuchs, IO-Link capable instruments can be implemented in their own preventative maintenance strategy, predicting process variables and potential for failure. Continuous diagnostics can be used, which can be of use to any control or ESD system, improving the reliability and functionality of the loop (2017). Correctly cited

Methods that comply to Industry 4.0 can be extremely useful for maintenance purposes. Whilst improving reliability as suggested above, maintenance tasks can be performed much more efficiently, meaning that systems can be repaired much quicker if required which would significantly reduce process downtime. Instruments can be replaced with HART equivalents, such as those in Emerson's Rosemount range, or Siemens's TH300 Grocer's apostrophe temperature puck transmitter, which converts mV signals from thermocouples or resistance values from RTD's into a 4-20mA HART signal, as shown in section of datasheet in appendix (Siemens, 2019). Correctly cited

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

The CIM system uses water and a highly diluted sulphuric acid. Sulphuric acid is one of the materials regulated by Control of Substances Hazardous to Health (COSHH) regulations and therefore must be used following several guidelines. A COSHH assessment should have been made and reviewed regularly. The acid should be stored accordingly, with manufacturer safety data sheets (MSDS) available. The HSE list all expectations for those working with hazardous substances (2020). Improper Citation

The system effectively recycles the water within it, so can be deemed as very sustainable. If the system is properly maintained, there will be no leakages or any water losses whilst in use. All engineering systems should be designed sustainably, using environmentally materials where possible and from approved manufacturers with their own environmentally friendly codes of practice. Where possible, local products should be used to reduce the impact on the environment with the carbon footprint left by shipping activities. If the system is to be left for long periods of time, there are several issues that may arise from stagnant water such as Legionnaires. A risk assessment should be made to ensure the potential for diseases arising from stagnant water and all hazards should be controlled accordingly, using HSE's ACOP for 'controlling legionella bacteria in water systems' (2013). Improper Citation

Electrical components should be maintained regularly to ensure that they are performing efficiently and effectively. If components start to deteriorate, they may consume more energy and reduce the efficiency of the system.

Approved Codes of practice (ACOP) should be written with environmental and sustainable factors considered. Many companies will write their own procedures and standards, which may follow IEC standards. ACOP's regarding analogue instruments involved in safety systems may be written following IEC 61508 or 61511, 61508- Functional Safety standard and 61511-Instrument Safety systems (2010) (2020).

Analogue instruments will be covered in the Electricity at Work Regulations 1989, and ACOP's should also be written to accommodate requirements stated in the HSE regulations (1989).

If a firm choose to implement this system on a larger scale, several considerations should be made. All legislation stated must be followed and adhered to, of which the consequences of error may be significantly higher due to the increased scale. Considerations should be made for all environmental factors, including replacing acid at regular intervals. This may incur higher costs as it would need to be removed correctly using a suitable waste disposal point.

4) Calibration of Pressure Sensor

Datasheets for all instruments are attached in Appendix.

A calibration was performed on the Druck LPM5380 pressure transducer. The sensor has an input range of 0-5 bar, with an output of 0-10V. This would show that there is a static sensitivity of 2V/Bar. If the sensor performed perfectly linear, at 0 Bar, the output would be 0V. At full range (5 Bar), the output should be 10V.



Figure 4- Pressure calibration arrangement

0-10V is a standard signal voltage for instrumentation. It could be argued that other signals are more useful, such as the 4-20mA as there is no signal loss across long distances, and the elevated zero can suggest the difference between 0% input and a signal failure.

The Druck datasheet states that the sensor has an accuracy of $\pm 0.25\%$. The maximum non-linearity error and maximum hysteresis error is 0.6% of full scale. This therefore shows that this pressure sensor is no longer operating as manufactured and should either undergo a full overhaul from manufacturer or replacement. The datasheet states that there is a long-term stability error of $\pm 0.3\%$ per year, which may suggest why the sensor has started to drift from linear values (Druck, 2008).

Correctly cited

These errors are assuming that air regulator gauges and digital multi-meters are calibrated regularly and within date.

Pressure (Bar)	Vout (Volts)		Linear Voltage	Non-Linearity Error		Hysteresis Error	Pressure				
	Rising	Falling		Voltage	Voltage						
0	0.01	0.02	0	0.01	0.02	0.3					
0.5	1.02	1.02	1	0.02	0.02	0.4	Static sensitivity	2V/Bar			
1	2.06	2	2	0.06	0	0.6	Y=1.005 x + 0.01				
1.5	3.04	2.97	3	0.04	-0.03	0.1					
2	4.02	4.01	4	0.02	0.01	0.3					
2.5	5.02	5	5	0.02	0	0.2	M=	1.005	C=	0.01	
3	6.02	6	6	0.02	0	0.2					
3.5	7.01	7	7	0.01	0	0.1					
4	8.02	8	8	0.02	0	0.2	Max Non Linearity error % of full scale	0.6			
4.5	9.05	9.01	9	0.05	0.01	0.6	Max Hysteresis Error %	0.6			
5	10.06	10.06	10	0.06	0.06	1.2					

Figure 5- Pressure calibration results

$$y = mx + c$$

$$M = \frac{(10.06 - 0.01)}{10} = 1.005$$

$$C = 0.01 - (1.005 \times 0) = 0.01$$

$$y = 1.005x + 0.01$$

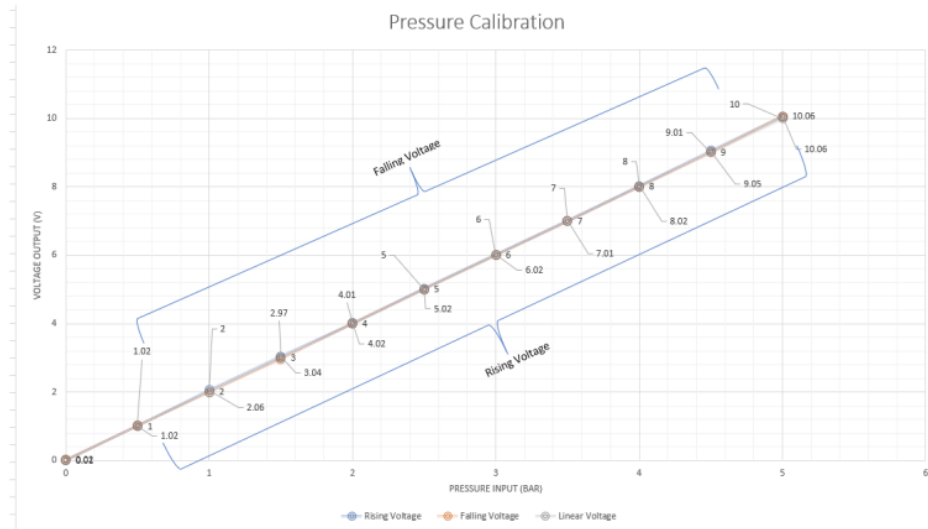


Figure 6- Comparing measured values with linear values, pressure calibration

The data gathered shows a zero error of 0.01V rising, and 0.02V falling, or 0.3% of range. The errors throughout the calibration are relatively linear, suggesting that adjusting the zero of this instruments will have reduced the error throughout the rest of the range. The highest error exists at 100% of its range, or at 5 Bar. This suggests that a span adjustment should have also been made. If both adjustments had been made, several retests would have been performed, adjusting throughout to achieve a higher standard of calibration of the instrument, likely making the instrument within its tolerance as per datasheet.

This is a good analysis

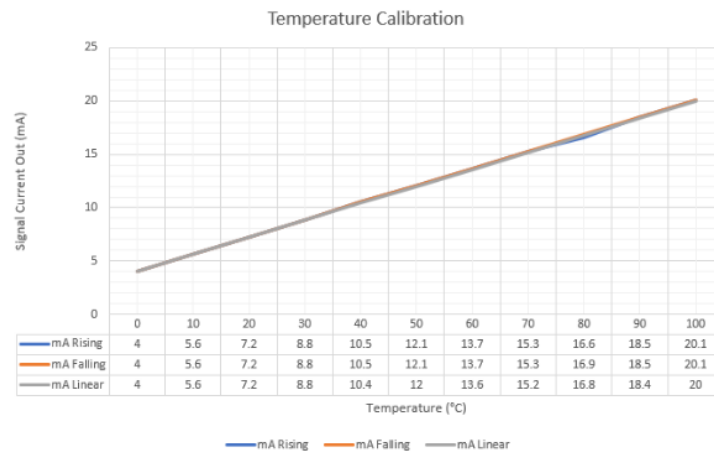


Figure 9- Comparing measured values and linear values, temperature

$$y = mx + c$$

$$M = \frac{(20.1 - 4)}{16} = 1.00625$$

$$C = 4 - (1.00625 \times 0) = 4$$

$$y = 1.00625 x + 4$$

The results gathered can be placed into a graph to provide a visual representation of findings. RTD's are often chosen as they are extremely linear, and a PT100 is expected to increase 38.5Ω per $^{\circ}\text{C}$ (TC, 2008). From this, it would be expected that the RTD will provide a linear output, which can be seen by the very low hysteresis errors. It is likely that any errors, will be due to the signal conditioning device (ConLAB RTT-2). The datasheet for this conditioning device states that its accuracy is $\pm 0.1\%$, which it generally is. As can be seen from the results, the significant error arose with an input of 80°C , which provided a hysteresis error of 1.875% . It can be argued that this result is an anomaly, and the test should be reperformed several times to determine whether this is an anomaly, or a genuine drift. The datasheet does also state that the results may differ by $\pm 0.05^{\circ}\text{C}/10\Omega$ due to electrical resistance in leads, although this was not seen during the calibration. The conditioner also provides excellent stability, with $\pm 0.015\%$ of its range/ 1°K .

Correctly cited

After 40°C , an error of 0.1mA can be seen, rising and falling. As this error is generally linear, it may suggest that the span may need a slight adjustment by adjusting the 's' screw on the conditioner. Apart from the anomaly at 80°C , this 0.1mA error still falls within calibration as per manufacturer's datasheet, so should be repeated to determine whether anomaly occurs again, replacing if so (2015).

Another good analysis

6) Calibration of Level Sensor

A calibration was performed on an Endress and Hauser PMC 133 Pressure Transmitter, which has been used as a form of level measurement. With a range of 7-23cm, and an output of 6-12.2mA, this instrument has a static sensitivity of 0.3875mA/cm. With a set specific gravity, an increase in pressure will indicate an increased level.

As:

$$\text{Pressure} = \text{height} \times \text{specific gravity}$$

Or

$$\text{Pressure} = \text{height} \times \text{density} \times \text{gravity}$$

$$P = h \times \rho \times g$$

The level in the tank increased, causing the level transmitter (LT) to increase its current output. A sight glass was used as reference against the LT.



Figure 11- LT-541, Endress and Hauser Cerabar



Figure 10- Sight Glass used as reference

The results from calibration can be seen below:

Level (cm)	Current (mA)		Linear Current (mA)	Non-Linearity Error		Hysteresis Error	LEVEL		
	Rising	Falling		Rising Current (mA)	Falling Current (mA)				
7	6.1	6.1	6	0.1	0.1	3.225806452	y=Max+c 0.40625 Y= 0.040625 x + 3.256	C	
8	6.6	6.5	6.3875	0.2125	0.1125	5.241935484			
9	7	6.9	6.775	0.225	0.125	5.64516129			
10	7.4	7.3	7.1625	0.2375	0.1375	6.048387097			
11	7.8	7.7	7.55	0.25	0.15	6.451612903			
12	8.2	8.1	7.9375	0.2625	0.1625	6.85483871			
13	8.6	8.5	8.325	0.275	0.175	7.258064516			
14	9	8.9	8.7125	0.2875	0.1875	7.661290323			
15	9.4	9.3	9.1	0.3	0.2	8.064516129			
16	9.8	9.7	9.4875	0.3125	0.2125	8.467741935			
17	10.2	10.1	9.875	0.325	0.225	8.870967742			
18	10.6	10.5	10.2625	0.3375	0.2375	9.274193548			
19	11	10.9	10.65	0.35	0.25	9.677419355			
20	11.4	11.3	11.0375	0.3625	0.2625	10.08064516			
21	11.8	11.7	11.425	0.375	0.275	10.48387097			
22	12.2	12	11.8125	0.3875	0.1875	9.274193548			
23	12.6	12.6	12.2	0.4	0.4	12.90322581			
							0.3875 mA/cm		
							Max Linearity Error=	6.25 %	
							Max Hysteresis Error=	10.48 %	

Figure 12- Calibration results for level

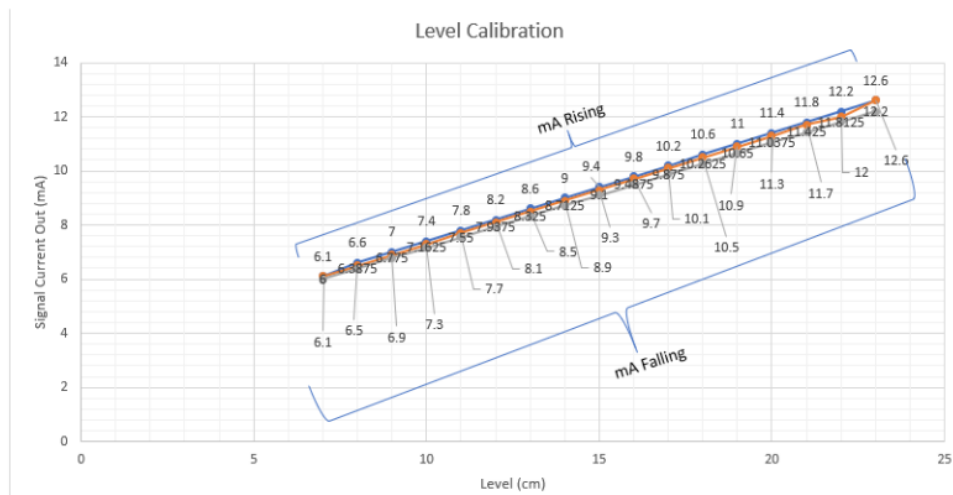


Figure 13- Comparing measured values with linear values, level

$$y = mx + c$$

$$M = \frac{(12.6 - 6.1)}{16} = 0.40625$$

$$C = 6.1 - (0.40625 \times 7) = 3.25625$$

$$y = 0.40625 x + 3.25625$$

Errors can be seen throughout the calibration. A zero error exists on this transmitter, showing 0.1mA away from its linear current output. When no level is in the tank, this transmitter should be zero'd, to assist with the rest of the calibration. The error appears to gradually grow through its range, suggesting that there is also a span error. At its worst, a linearity error of 6.25% can be seen, and a hysteresis error of 10.48%. These errors may be exaggerated due to its poor zero and span adjustment. A zero check and span check should be performed, to ensure 6mA at 0%, and 12.2mA at 100% before checking the instrument through its whole range. The datasheet states that there is a $\pm 0.2\%$ linearity error and a $\pm 0.01\%$ hysteresis error of its full range. The values gathered exceed the guidelines from manufacturer and should therefore undergo a full rehaul/calibration or replacement.

The calibration method posed several potential risks to the quality of calibration. Using a sight glass as a reference point is questionable, and can be subject to a difference of opinion, parallax error etc. It may be more useful to perform this calibration by increasing pressure to this instrument using a pressure calibrator. This will check the instruments response to a pressure input as designed and can be measured accurately against its mA output. This will eliminate the likelihood of error using a poor reference, and a calibrated input device (pressure calibrator) can be compared critically against a calibrated output measuring device (digital multimeter), to provide a higher quality calibration. (2015)

Improper Citation

7) Calibration of Flow Sensor

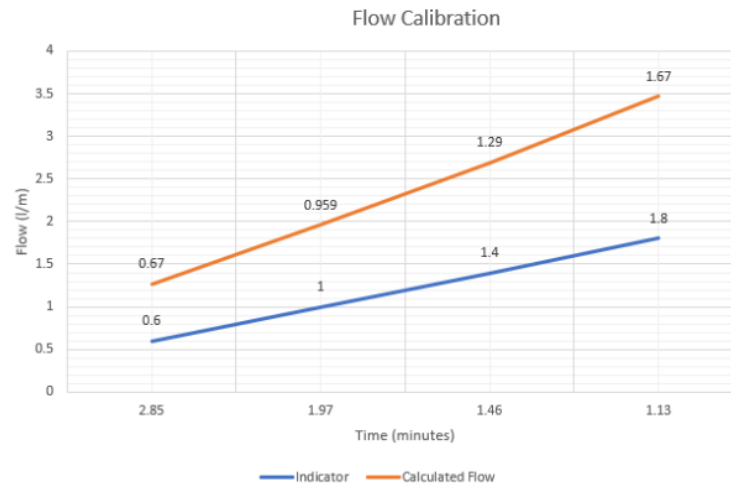


Figure 14- Flow calibration graph

Flow Indication	Time (min)	Calculated flow (l/m)	Error %		FLOW
0.6	2.85	0.67	7		
1	1.97	0.959	-4.1		
1.4	1.46	1.29	-11		
1.8	1.13	1.67	-13		

Figure 15- Flow calibration data

Whilst performing this calibration, there was lots of potential for human error. It would have been useful to have a good reference point, which can be used consistently. The values given differ greatly from the values expected from calculations. As stated, there was potential for human error in calculation, but it still appears that this measurement is still not accurate and fit for purpose.

A standard turbine flow meter with a similar range (0-10l/m), provide a linear error of $\pm 1\%$. RS Pros' radial turbine flow meter is a good example of this. The calibration data falls significantly outside this tolerance, and therefore should be repaired or replaced. The high zero and span errors should be red

Datasheet of RS PRO radial turbine flow meter included in appendix.

8) Design Adaptation for Maintenance and Reliability

Several changes have been made to improve the functionality of the CIM system. Each controller has its own screen, showing maintenance technicians SP's, raw and scaled values, offset etc. Relevant buttons have been added to overcome any interlocks required to adjust controller. Each controller can be seen working independently, but FC-535 can work alongside LC-541.

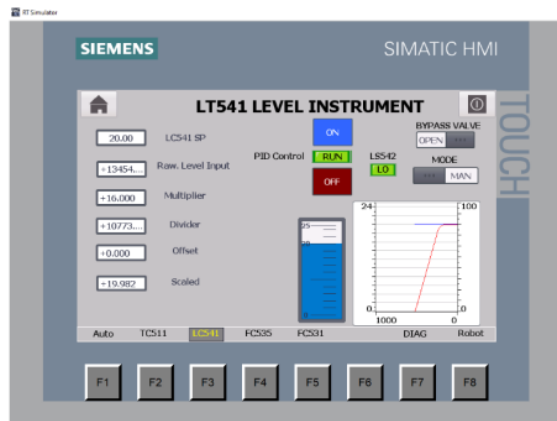


Figure 16- Adapted HMI screen for LT-541

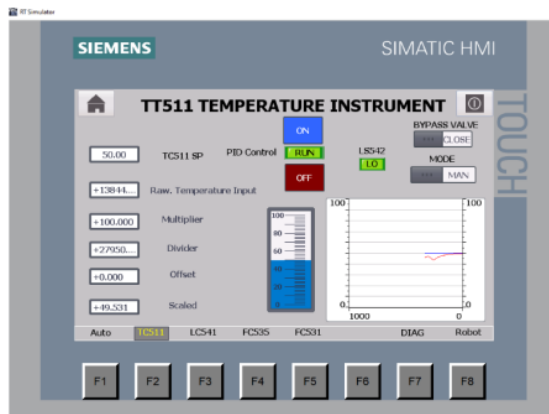


Figure 17- Adapted screen for TT-511

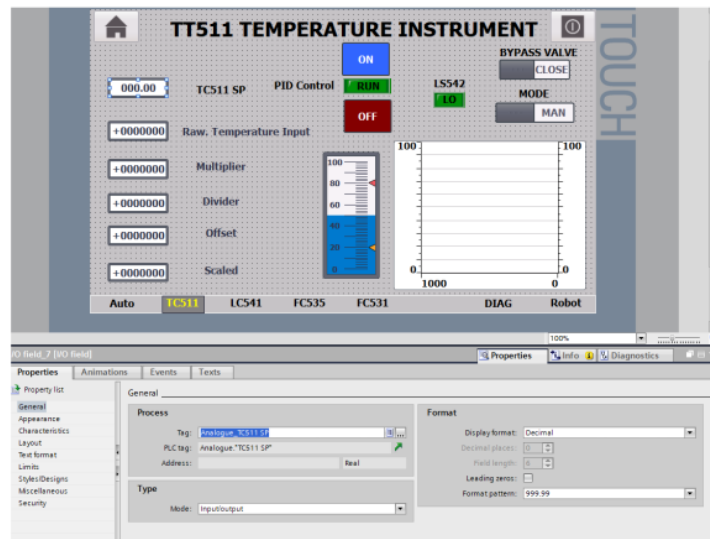


Figure 18- TT-511 SP tag

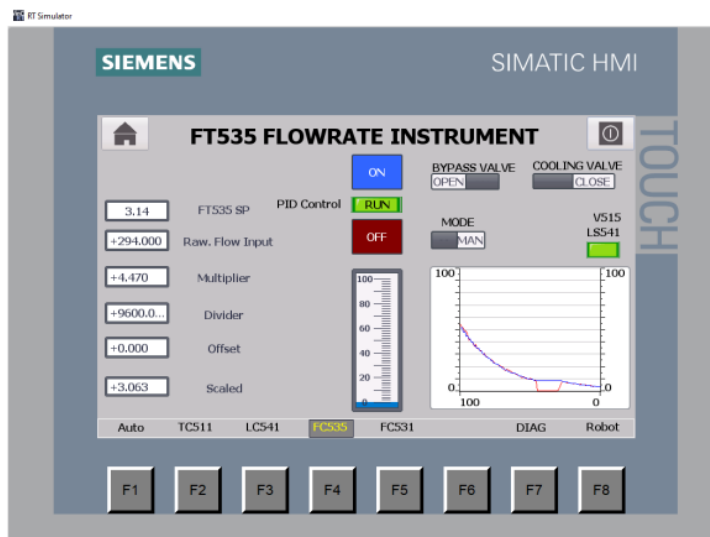


Figure 19- Adapted screen for FT-535, driven by LC

Each button was labelled accordingly, as shown in fig. 22. Each screen was simulated several times to prove functionality and reliability, and each performed correctly, before being tested on the CIM system. The program was downloaded to the system via a VPN, to function test the screens alongside the hardware. A table of results was made, shown in fig. 21.

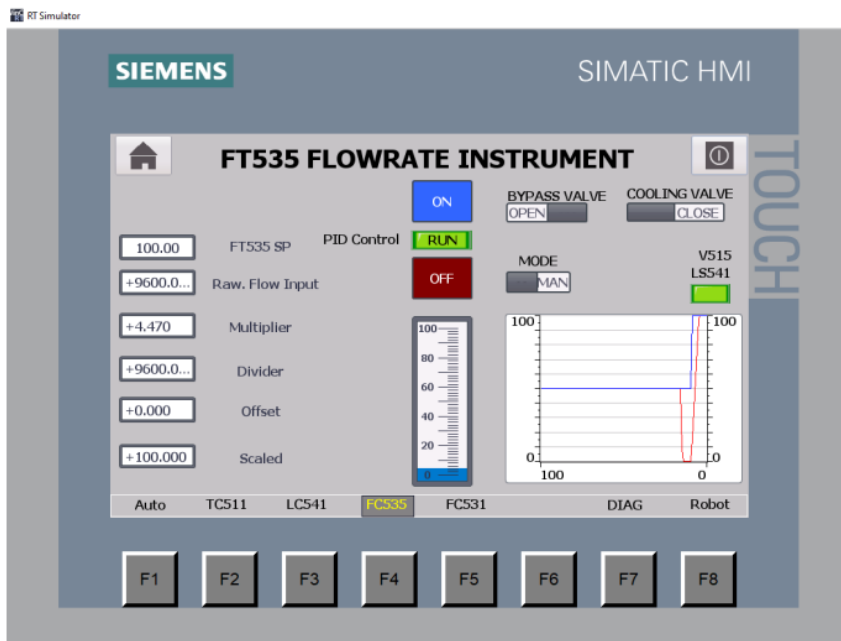


Figure 20- FT-353 manually adjusting SP

Test	TIA Simulation	Download through VPN
Control HMI's and move between them	Y	Y
Adjust SP through HMI	Y	Y
Monitor trends	Y	Y
Control valves through HMI	Y	Y
PID Control	Y	Y
Scaled, multiplier, raw values on each screen	Y	Y
Level Control	Y	Y
		N-Level switch interlock faulty. Retest required once switch replaced.
Temperature Control	Y	
Flow Control	Y	Y

Figure 21- Testing table

9) Conclusions and Recommendations

Calibrations were performed and HMI screens were adapted to improve functionality of the CIM system. Comments have been made in each section with regards to the quality and possible improvements of each instrument. Procedures could be written to ensure that calibration tasks are performed to the same standard every time, to improve likelihood of good maintenance taking place. This will also assist with record keeping if any adjustments are made. Calibration records could be kept, to assist with noting any patterns which may suggest instrument drift or potential failure.

The CIM system could be developed further. Features such as logins to screens to prevent unauthorised access, promoting a cyber security aware workforce, or to reduce likelihood of unauthorised personnel making poor adjustments to the system.

To improve the accuracy, temperature measurements could be taken, which will compensate for any fluctuations having an affect on pressure, therefore affecting level measurement LT-541.

Good evidence of analysis

10) Team Working

All members took an active role in calibrating and recording data, rotating to ensure each member achieved a similar standard of calibration. Each task was discussed thoroughly prior to performing, so each member fully understood their roles for the task. The plan determined that all members had the same objectives and desired outcomes, with clearly defined methods on how they will be achieved.

All members discussed the HMI screens, and how they could be improved. Group meetings were held, and the author implemented all changes the group discussed. Each member continually monitored progress, to identify any mistakes which arose so they could be quickly amended. A group call was held to test each screen after changes, with all sharing standards and expectations of the screens, discussing where further improvements could be made.

11) Citation List

Good range of

sources used

A. Guochen, M. Z. M. H. S. B., 2010. *Design of Intelligent Transmitter Based on HART Protocol*. Changsha, IEEE.

Anon., 2016. *I-Scoop*. [Online]

Available at: <https://www.i-scoop.eu/industry-4-0/>

[Accessed 28 November 2020].

ConLAB, 2015. *ConLAB RTT-2 PT100*. [Online]

Available at: <http://files5.design-editor.com/90/9008485/UploadedFiles/1609d612-8248-4ae8-beca-09fc4f7869e6.pdf>

[Accessed 7 December 2020].

Druck, 2008. *Druck LPM/LPX 5000 Series*. [Online]

Available at: http://www.ic72.com/pdf_file/l/549963.pdf

[Accessed 7 December 2020].

E-Functional Safety, 2020. *IEC 61511*. [Online]

Available at: <https://efunctionalsafety.com/iec-61511-guide/>

[Accessed 20 December 2020].

Emerson, 2020. *Rosemount 2051 Datasheet*. [Online]

Available at: <https://www.emerson.com/documents/automation/product-data-sheet-rosemount-2051-pressure-products-en-73206.pdf>

[Accessed 7 December 2020].

Endress and Hauser, 2015. *Endress and Hauser Cerabar PMC133*. [Online]

Available at: <https://portal.endress.com/wa001/dla/5000000/1746/000/00/KA004PA3.PDF>

[Accessed 7 December 2020].

HSE, 1989. *Electricity at Work Regulations*. s.l.:HSE.

HSE, 2013. *Legionnaire's Disease*. Four ed. s.l.:Crown.

HSE, 2020. *COSHH*. [Online]

Available at: <https://www.hse.gov.uk/coshh/basics/substance.htm>

[Accessed 20 December 2020].

IEC, 2010. 61508. 2 ed. s.l.:IEC.

Link, I., 2018. *IO-Link Community*. [Online]

Available at: https://io-link.com/share/Downloads/At-a-glance/IO-Link_System_Description_eng_2018.pdf

[Accessed 28 November 2020].

Pepperl and Fuchs, 2017. *Control-Pepperl and Fuchs*. [Online]

Available at: <https://comtrol.com/io-link-master-gateways/what-is-io-link>

[Accessed 28 November 2020].

Perelman, C., 2019. *Control Engineering*. [Online]

Available at: <https://www.controleng.com/articles/five-factors-to-smart-instrumentation-in-industry-4-0/>

[Accessed 28 November 2020].

Richards, H., 2014. *Intelligent HQ*. [Online]

Available at: <https://www.intelligenthq.com/5-reasons-why-industry-4-0-is-a-game-changer/>

[Accessed 27 November 2020].

Siemens, 2019. *Siemens*. [Online]

Available at: <https://new.siemens.com/global/en/products/automation/process-instrumentation/temperature-measurement/sitrams-th300.html>

[Accessed 7 December 2020].

TC, 2008. *TC*. [Online]

Available at: <https://www.tc.co.uk/rtd-pt100-information/what-is-pt100-sensor.html>

[Accessed 7 December 2020].

12) Appendix

STANDARD SPECIFICATION

Operating Pressure Ranges

in H₂O (inH₂O)
0.2(0.4), 0.4(0.8), 0.8(1.5), 2(4), 4(8),
20(40), 40(80), 80(160)

Operating Pressure Ranges

PSI
7.5, 30, 75, 150

Overpressure

The rated range can be exceeded by the following multiples without negligible calibration change:

20x Ranges 0.4 to 8 inches H₂O

5x Ranges 20 to 80 inches H₂O

3x Ranges 7.5 to 150 psi

Static (line) Pressure

Vacuum to 380 psig, all ranges

Static Pressure Effect

<2mV, 5.7/1000 PSI, effects may be zeroed out at operating line pressure

Process Media

Fluids/Gases compatible with Anodized Aluminum (Al₂O₃), beryllium copper, brazing solder (Pb/Sn)

Relative Humidity

0 to 100%

Transduction Principal

Variable Inductance

Excitation Voltage

10-30 Vdc 2-wire, 4-20 mA, 12±8mA
18-30 Vdc 4-wire, 0-10 Vdc
±12 Vdc 4-wire, 0-5 Vdc

Supply Sensitivity

<0.5 x 10⁻⁶ V/F, 5.7Vdc

Insulation Resistance

>100 megOhms @ 50V

Output-Unidirectional

LPM 5000 4-wire, 0-10Vdc
LPM 5000 2-wire, 4-20mA

Output-Bidirectional

LPM 5000 4-wire, 0-±5Vdc
LPM 5000 2-wire, 12±8mA

Load Impedance

LPM: 0.05 (V_{max}-10) Kohms max
LPM: 1Kohms min

Resolution

Infinite

Combined Non-Linearity, Hysteresis

and Repeatability
±0.25% F.S. @ 5.7Vdc, all ranges

Long Term Stability

±0.2% F.S. over ± stabilized temperature

Zero Offset Adjustment

-15% to +100% of FSPR

Span Setting Adjustment

-25% to +50% of FSPR

Operating Temperature Range

-20°F to +180°F

Compensated Temperature Range

-4°F to +180°F
22 to 122°F

Temperature Effects

Zero: ±0.01% F.S./°F
Span: ±0.01% F.S./°F

Response Time

10 msecs to 500 msecs, adjustable by switches accessible under the cover

Vibration

50g up to 2 KHz

Dead Volume

6±0.1m³ at all ranges

Weight

2.1 pounds

Mounting Position Effect

Effect on zero only, can be adjusted out with zero potentiometer.

Sensor body

Black Anodized Aluminum (Al₂O₃)

Electric Cover

Black Anodized Aluminum (Al₂O₃)

Measuring Diaphragm

Beryllium Copper

Environmental Rating

NEMA 4 (IP66)
Electrical connection:
Cable gland with screw terminal block accessible under housing cover

Pressure Connection:

1/8" NPTF, no adapter; supplied with nylon flared pressure port for 1/8" internal diameter tubing.

OPTIONS

Square Root Extractor (LPM only)

Mounting Bracket

ORDERING INFORMATION

(1) Select model number

Code	Model
LPM	Current output
VPM	Voltage output
Code	
0	Base Model
Code	Diaphragm Material
0	Beryllium Copper
Code	Electrical Connector
0	Cable gland, P&J
Code	Temp. Comp.
0	22 to 122°F
1	4 to 180°F

LPM 5 4 0 0 = Typical model no.

(2) State pressure range

(3) State output required.

Figure 22- Druck LPM500 Datasheet

Operating instructions

Pressure Transmitter Cerabar PMC 133

Technical Data

see also TI 105P/00/e

Construction, Materials

Housing: synthetic (POM) or cast aluminium
Protection: IP 65 (DIN 40050)

Wetted Materials

Process connection: 2.0401 brass or 1.4581 stainless steel (1.4571 stainless steel with high pressure measuring cell)
Ceramic diaphragm up to 60 bar: aluminium oxide ceramic 96 %
Process seal gasket up to 60 bar: e.g. Viton, EPDM, Kalrez, etc.
Above 100 bar: 1.4401 special steel diaphragm.

Permissible Temperatures

Operating limits:
Housing: -20 °C ... +70 °C
Diaphragm: -20 °C ... +80 °C
(up to +130 °C for short periods)
Storage: -40 °C ... +85 °C

Accuracy

- Ceramic measuring cell
Linearity: $\pm 0.2\%$ or $\pm 0.5\%$ of adjusted range
Hysteresis: better than 0.01% of full scale
Installation: any orientation
Temperature variation typical $\pm 0.15\%/10\text{ °C}$ of full scale, of the measuring cell (see Table).
- High Pressure Measuring Cell
Linearity: $\pm 0.5\%$ of full scale
Hysteresis/Reproducibility: $\leq 0.1\%$ of full scale

Temperature effects of maximum measuring span	0...50 °C	-20...0 °C +50...75 °C
TK zero point	0.2 %/10K	0.3 %/10K
TK span	0.2 %/10K	0.3 %/10K

Technical Data
Measuring cells

Type of Mes. cell	Max. perm. overload	T _s	Type of pressure G gauge/A absolute
-0.2 ... +0.2 bar	10 bar	$\pm 0.6\text{ mbar}/10\text{ K}$	G
-1 ... +1 bar	10 bar	$\pm 3.0\text{ mbar}/10\text{ K}$	G
-1 ... +3 bar	25 bar	$\pm 6.0\text{ mbar}/10\text{ K}$	G
-1 ... +9 bar	40 bar	$\pm 15\text{ mbar}/10\text{ K}$	G
0 ... 0.2 bar	10 bar	$\pm 0.6\text{ mbar}/10\text{ K}$	G
0 ... 0.4 bar	10 bar	$\pm 0.6\text{ mbar}/10\text{ K}$	G
0 ... 1 bar	10 bar	$\pm 1.5\text{ mbar}/10\text{ K}$	G or A
0 ... 2 bar	25 bar	$\pm 3.0\text{ mbar}/10\text{ K}$	G or A
0 ... 4 bar	25 bar	$\pm 6.0\text{ mbar}/10\text{ K}$	G or A
0 ... 10 bar	40 bar	$\pm 15\text{ mbar}/10\text{ K}$	G or A
0 ... 20 bar	40 bar	$\pm 30\text{ mbar}/10\text{ K}$	G or A
0 ... 40 bar	60 bar	$\pm 60\text{ mbar}/10\text{ K}$	G or A
0 ... 60 bar	90 bar	$\pm 180\text{ mbar}/10\text{ K}$	G or A
0...100 bar*	400 bar	$\pm 200\text{...}\pm 300\text{ mbar}/10\text{ K}$	G or A
0...250 bar*	600 bar	$\pm 500\text{...}\pm 750\text{ mbar}/10\text{ K}$	G or A
0...400 bar*	600 bar	$\pm 800\text{...}\pm 1600\text{ mbar}/10\text{ K}$	G or A

* polysilicone sensor for high pressure

Figure 23- Endress and Hauser Cerabar PMC 133 datasheet

SPECIFICATIONS

RTT-2

INPUT:
3-wire Pt-100 according to BS 1904
and DIN 43760 characteristics.
Option: Pt-50, 500, Cu-10, Ni-120

INPUT SPAN CHANGE: 30 to 610°C

INPUT ZERO CHANGE: -55 to +202°C

CALIBRATION:
Three "Zero" DIP switches,
Three "Span" DIP switches
and two fine-tuning potentiometers

SENSOR LEAD RESISTANCE: < 50Ω (two ways)

LEAD COMPENSATION ERROR:
≤ ±0.05°C/10Ω lead resistance

SUPPLY VARIATION EFFECT:
≤ ±0.02% of span for full change

ACCURACY (including linearity, hysteresis and repeatability):
≤ ±0.1% of span

LOAD RESISTANCE: $R_{max} (\Omega) = (V_{supply} - 10) / 0.2$

TEMPERATURE STABILITY: < ±0.015% of span/°K

OPERATING TEMPERATURE:
-20 to 70°C
Option: -30 to +85°C
Storage: -40 to +90°C

HUMIDITY: 5 - 95% relative, non condensed

MOUNTING: Standard 35mm DIN rail

Figure 24- CONLAB RTT-2 Datasheet



ENGLISH

Diode

Absolute Maximum Ratings

Reverse voltage @ 25°C low air temperature	3.0V
Continuous forward current at (or below) 25°C low air temperature	60mA
Recommended current	10mA
Operating free air temperature range	-40°C to +70°C
Storage temperature range	-40°C to +70°C
Lead temperature 1.6mm from case for 5 sec.	260°C
Power dissipation	100mW

Photodiode

(Typical)

Max. dissipation	250mW @ 25°C
Operating supply voltage	4.5 to 16V d.c. supply (V _{cc})
Output low	5mA
Supply current	7mA
Output high	6.5mA
Supply current	5mA
Output voltage low	0.2V
Output voltage high	V _{cc}
Rise time	60ns
Fall time	6ns

Note: At the maximum continuous operating temperature (70°C) the power dissipation of the detector output stage is 2.5mW. Care must therefore be taken not to overload the output.

The pulses from the sensor when viewed on an oscilloscope should look like the central drawing in Figure 2. If the LED current is too high, an increase in ambient light levels could cause the signal to stay high. A 10:50 mark space ratio is not possible as the diodes are thinner than the spaces.

Figures 3 and 4 show results of flowtransducers calibrated on a gravimetric flow rig. The differential pressure is not using a rising mercury manometer. Water temperature 10°C

Colour Code	Grey Body	Blue Body
Flow Range	0.001 to 0.1 m/s	0.001 to 0.1 m/s
Linearity @	±1.0%	±1.0%
Repeatability Full Scale	±1.0%	±1.0%
At Full Scale	±0.5%	±0.5%
Response	400 pulses/litre	100 pulses/litre

Standard materials of construction

- Body - Acetal copolymer
- Retaining Cap - Acetal copolymer
- Flange - Acetal copolymer
- Flange housing - Clear nylon
- Spindle - Stainless steel
- Bearings - Sapphire
- O' Ring - Nitrile rubber

Standard connections

15mm Cu x 15mm Cu (compression fittings)

Operation pressure

Max. 300bar/435 psi

Dimensions mm

Length	89 (over fittings)
Height	51
Breadth	37

RS Components shall not be liable for any liability or loss of any nature whatsoever caused or suffered as not due to RS Components negligence which may result from the use of any information provided in RS technical literature.

Figure 25- RS Pro radial flow turbine meter datasheet

Overview**Robust and durable HART - the universal SITRANS TH300 transmitter**

- 2-wire device for 4 to 20 mA, HART
- Mounting in the connection head of the temperature sensor
- Universal input for virtually any type of temperature sensor
- Configurable over HART

Benefits

- Compact design
- Flexible mounting and center hole allow you to select your preferred type of installation
- Galvanic isolation
- Test sockets for multimeters
- Diagnostics LED (green/red)
- Sensor monitoring open circuits and short-circuits
- Self-monitoring
- Configuration status stored in EEPROM
- SIL2 (with order note C20), SIL2/3 (with C23)
- Expanded diagnostic functions, such as slave pointer, operating hours counter, etc.
- Special characteristic
- Electromagnetic compatibility to EN 61326 and NE21

Application

SITRANS TH300 transmitters can be used in all industrial sectors. Its compact size means that it can be installed in connection heads of type B or larger. The following sensors/signal sources can be connected over their universal input module:

- Resistance thermometer (2, 3, 4-wire connection)
- Thermocouples
- Resistance-based sensors and DC voltage sources

The output signal is a load-independent direct current of 4 to 20 mA corresponding to the sensor characteristic overlaid by the digital HART signal.

Transmitters of the "intrinsically safe" type of protection can be installed within potentially explosive atmospheres. The devices meet the directive 2014/54/EU (ATEX) as well as the FM and CSA requirements.

Function

The SITRANS TH300 is configured over HART. This can be done using a handheld communicator or even more conveniently with a HART modem and the SIMATIC PDM parameterization software. The configuration data are then permanently stored in the non-volatile memory (EEPROM).

Once the sensors and power supply have been correctly connected, the transmitter outputs a temperature-linear output signal and the diagnostics LED displays a green light. In the case of a sensor break, the LED flashes red, an internal device fault is indicated by a steady red light.

The test socket can be used to connect an ammeter at any time for monitoring purposes and plausibility checks. The output current can be read without any interruption, or even without opening the current loop.

Figure 26- Siemens TH300 temperature puck

FINAL GRADE

GENERAL COMMENTS

78/100

Instructor

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

PAGE 4

Text Comment. software interlock

PAGE 5

PAGE 6

PAGE 7

QM

Improper Citation

Improper citation:

Improperly cited material. Please use the link below to find links to information regarding specific citation styles: http://www.plagiarism.org/plag_article_citation_styles.html

Text Comment. surname only

QM

Grocer's apostrophe

If you meant this as a plural word, don't use an apostrophe. This also applies to acronyms and initialisms such as PLCs

QM

Correctly cited

Citation method conforms to Harvard standard, well done

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 8

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Grocer's apostrophe

If you meant this as a plural word, don't use an apostrophe. This also applies to acronyms and initialisms such as PLCs

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 9

QM

Improper Citation

Improper citation:

Improperly cited material. Please use the link below to find links to information regarding specific citation styles: http://www.plagiarism.org/plag_article_citation_styles.html

QM

Improper Citation

Improper citation:

Improperly cited material. Please use the link below to find links to information regarding specific citation styles: http://www.plagiarism.org/plag_article_citation_styles.html

PAGE 10

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 11

PAGE 12

Text Comment. This is a good analysis

PAGE 13

PAGE 14

PAGE 15

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. Another good analysis

PAGE 16

PAGE 17

PAGE 18

QM

Improper Citation

Improper citation:

Improperly cited material. Please use the link below to find links to information regarding specific citation styles: http://www.plagiarism.org/plag_article_citation_styles.html

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

Text Comment. Good evidence of analysis

PAGE 25

PAGE 26

QM

Good range of sources

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

PAGE 27

PAGE 28

GRADING FORM: NEW CSG-RUBRIC

**BENJAMIN
BRICKLE**

78

1. ENGAGEMENT WITH LITERATURE



Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing with a few mistakes where source name has been left out. (14/20)

14

2. KNOWLEDGE AND UNDERSTANDING



Excellent knowledge and understanding of the basic underlying concepts and principles of the subject. (16/20)

16

3. COGNITIVE AND INTELLECTUAL



Excellent evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative

16

data accurately and with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements. (16/20)

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. (16/20)

16

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. (16/20)

16