Tittel på leksjonen

Kompetansemål:

- utføre arbeid på automatiserte anlegg fagmessig, nøyaktig og i overensstemmelse med krav til helse, miljø og sikkerhet og rutiner for kvalitetssikring og internkontroll
- utføre risikovurdering og vurdere tiltak for ivaretakelse av person- og maskinsikkerhet
- vurdere hvilke regelverk og normer som gjelder for arbeidet som skal utføres og anvende dette
- planlegge, utføre, vurdere kvalitet, sluttkontrollere og dokumentere arbeidet
- planlegge, programmere, montere og idriftsette programmerbare styresystemer
- endre og tilpasse skjermbilder for grensesnitt mellom menneske og maskin
- anvende ulike elektroniske kommunikasjonssystemer i automatiserte anlegg
- vurdere datasikkerhet i automatiserte anlegg
- tegne, lese og forklare instrumenterte prosessflytskjemaer og bruke annen relevant dokumentasjon for automatiserte anlegg
- montere, konfigurere, kalibrere og idriftsettelse digitale og analoge målesystemer
- idriftsette og optimalisere regulatorer basert på prosessbehov
- montere og idriftsette ulike typer pådragsorganer med tilhørende forstillingselementer og hjelpeutstyr
- programmere, idriftsette samt gjøre rede for roboters funksjon og anvendelse i produksjonsanlegg
- måle fysiske størrelser i automatiserte anlegg
- feilsøke og rette feil i automatiserte anlegg
- bruke gjeldende regelverk og normer for elektriske installasjoner på maskiner
- bruke gjeldende regelverk og normer for installasjon av elektroniske kommunikasjonssystemer
- beskrive ulike vedlikeholdssystemer og -rutiner knyttet til automatiserte anlegg, og anvende et av disse
- redegjøre for bedriftens organisasjonsoppbygging og bedriftens verdiskapning i et samfunnsperspektiv
- dokumentere egen opplæring i automatiseringssystemer

Læringsmål

- Kunne
- Kunne

Forkunnskaper

-

Teori

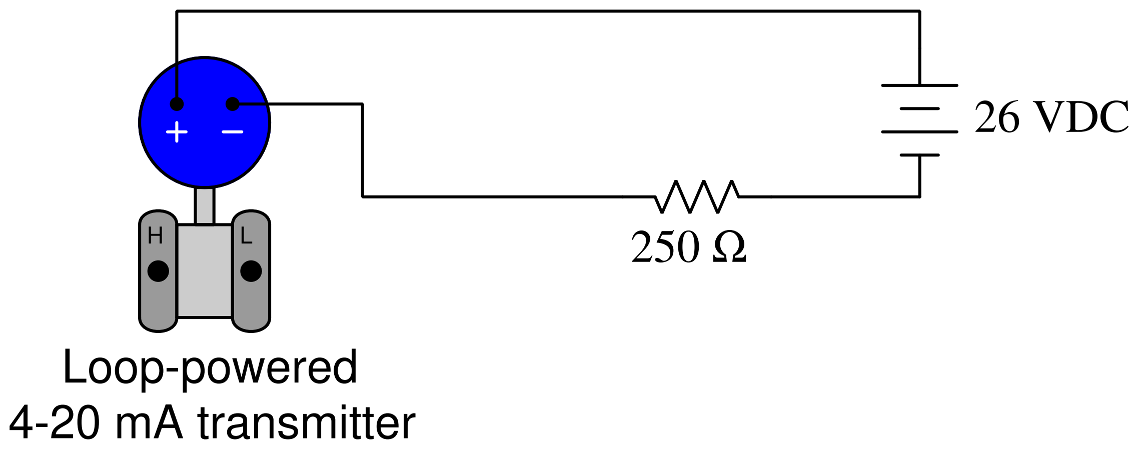
afgv.pdf - Programmerbare Logiske Styringer - Inngangs- og utgangs tilkoblinger (IO-er)

Øvingsoppgaver til leksjon - følger neste side

Innlevering til leksjon - Det er ingen innlevering til leksjonen.

Oppgave 1

Calculate the current and all voltage drops in this loop-powered transmitter circuit, assuming the pressure transmitter is calibrated for a range of 0 to 70 PSI, 4 to 20 mADC. Be sure to show all your work!

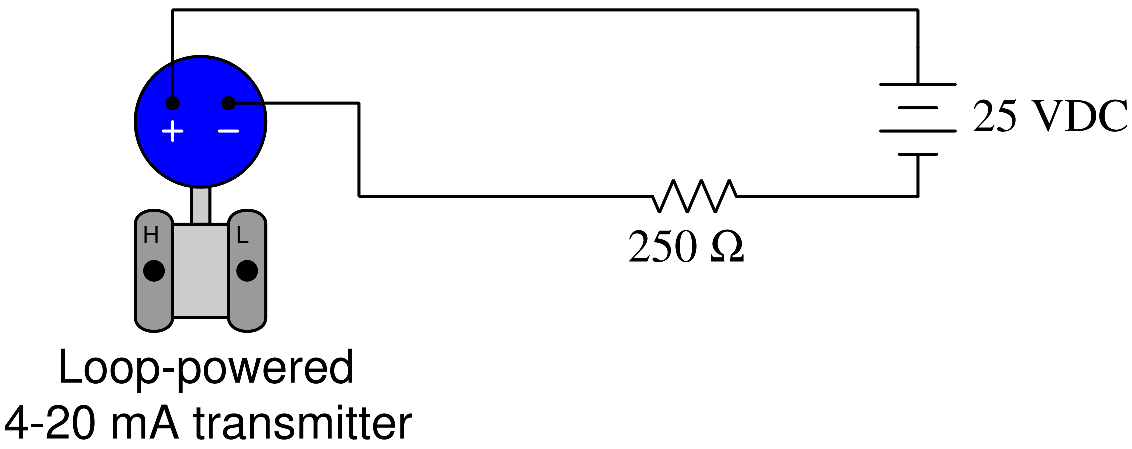


Applied pressure (PSI)	Current (mA)	Transmitter voltage (V)	Resistor voltage (V)
0 PSI			
10 PSI			
20 PSI			
35 PSI			
60 PSI			
70 PSI			

file i02669

Oppgave 2

Calculate the current and all voltage drops in this loop-powered transmitter circuit, assuming the pressure transmitter is calibrated for a range of 0 to 70 PSI, 4 to 20 mADC. Be sure to show all your work!

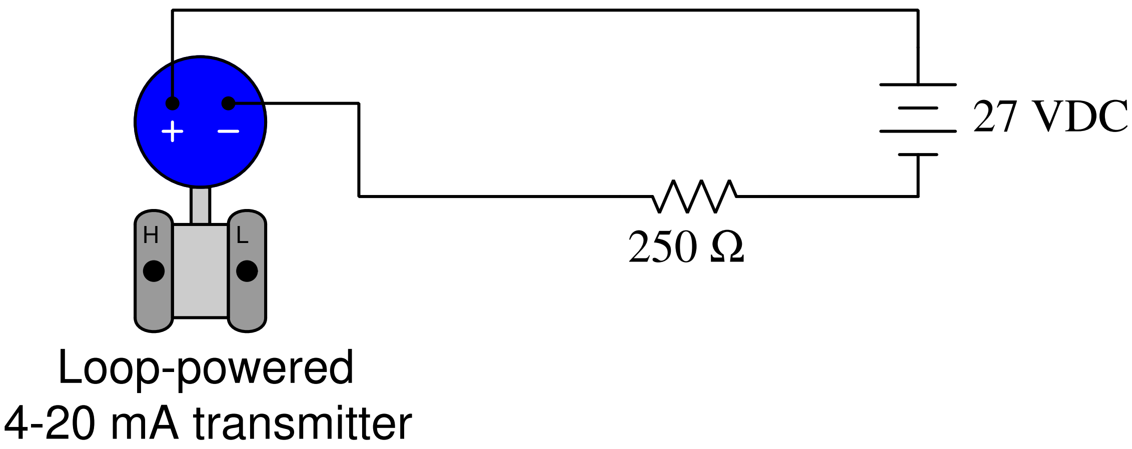


Applied pressure (PSI)	Current (mA)	Transmitter voltage (V)	Resistor voltage (V)
0 PSI			
15 PSI			
20 PSI			
35 PSI			
60 PSI			
70 PSI			

file i03232

Oppgave 3

Calculate the current and all voltage drops in this loop-powered transmitter circuit, assuming the pressure transmitter is calibrated for a range of 50 to 150 PSI, 4 to 20 mADC. Be sure to show all your work!

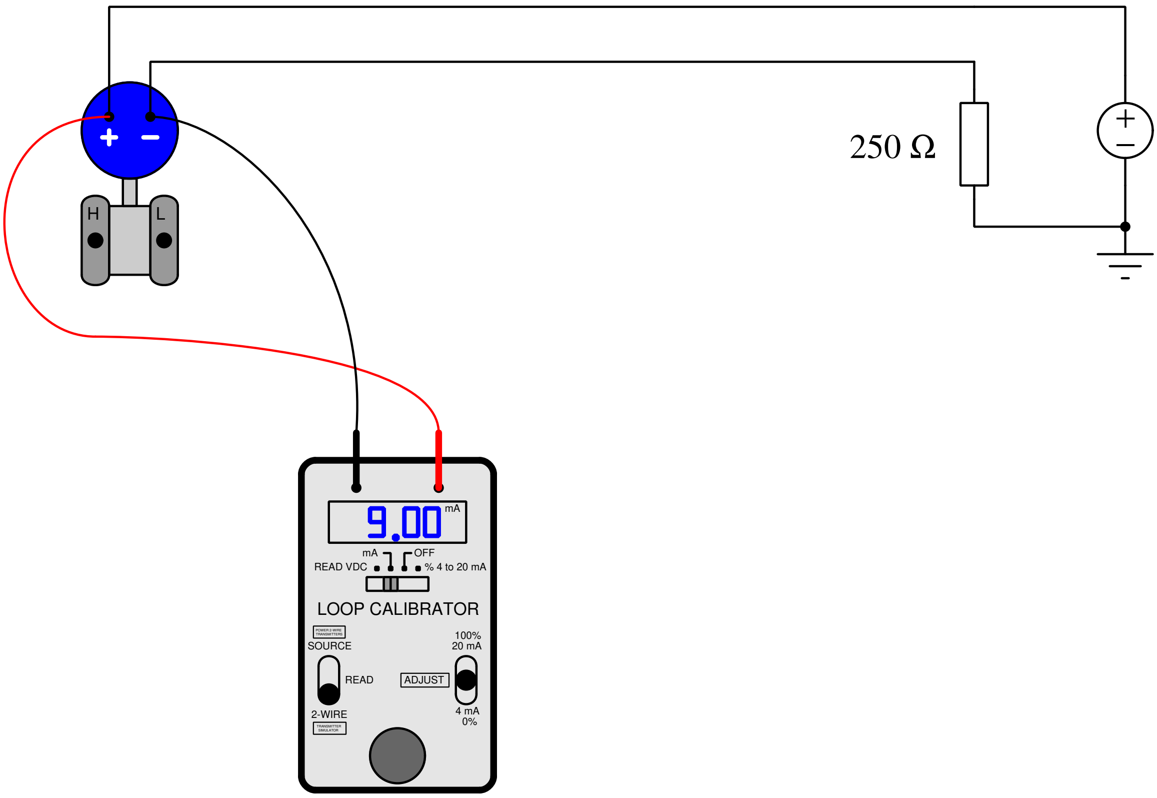


Applied pressure (PSI)	Current (mA)	Transmitter voltage (V)	Resistor voltage (V)
55 PSI			
70 PSI			
82 PSI			
107 PSI			
140 PSI			
150 PSI			

file i03141

Oppgave 4

Anta at en automatikker ønsker å bruke en loop kalibrator til å simulere et 4-20mA signal til en regulator. Han kobler den opp slik bildet viser.

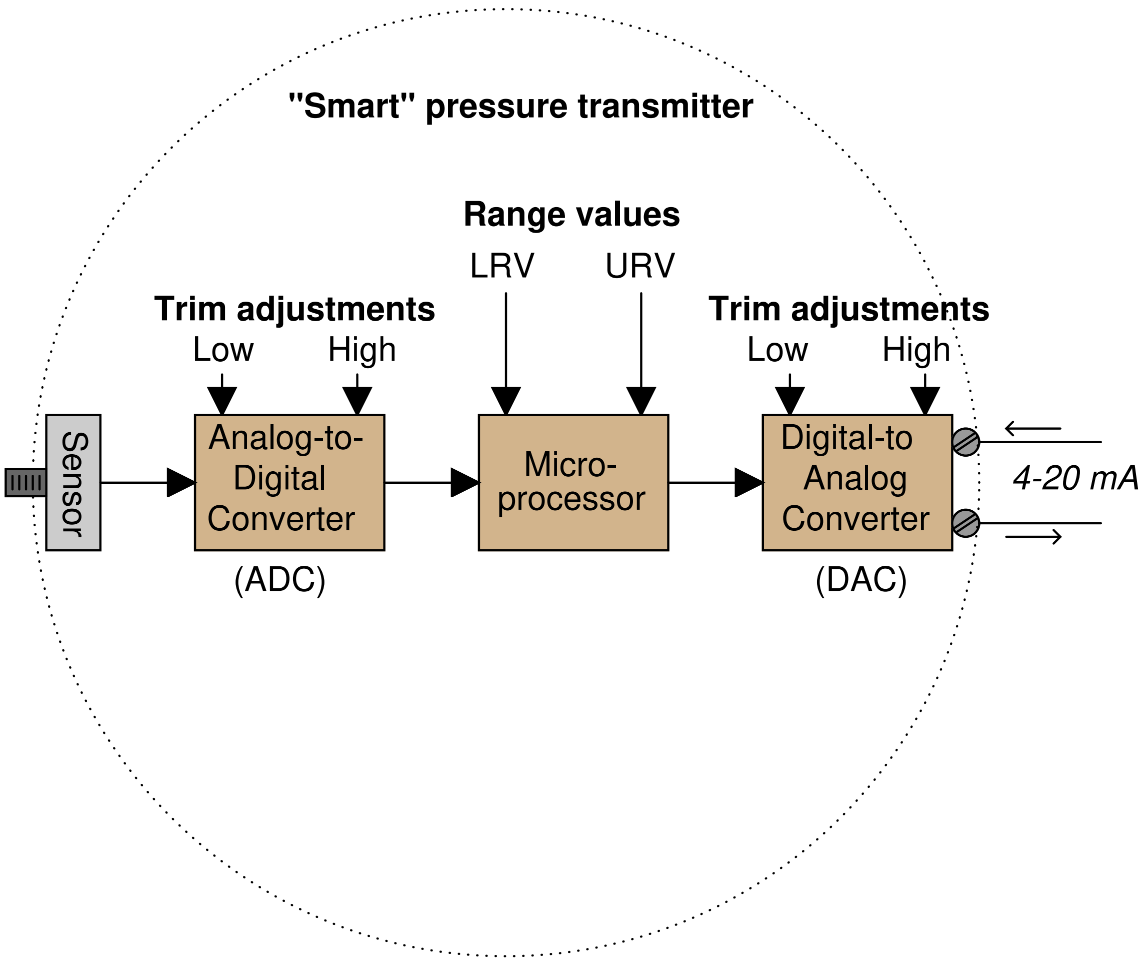


Forklar hvorfor det ikke går å koble en loop kalibrator på denne måten, og hva som vil skje om han prøver på det. Tilslutt skal du vise den korrekte måten en kan bruke en loop kalibrator for å simulere en transmitter.

file i00011

Oppgave 5

Analog electronic process transmitters typically have only two calibration adjustments: one for *zero* and another for *span*. Occasionally you may find an analog electronic transmitter with a third adjustment: one for *linearity*.
Modern "smart" process transmitters have more components in need of adjustment. A block diagram of a typical smart pressure transmitter shows this very clearly:

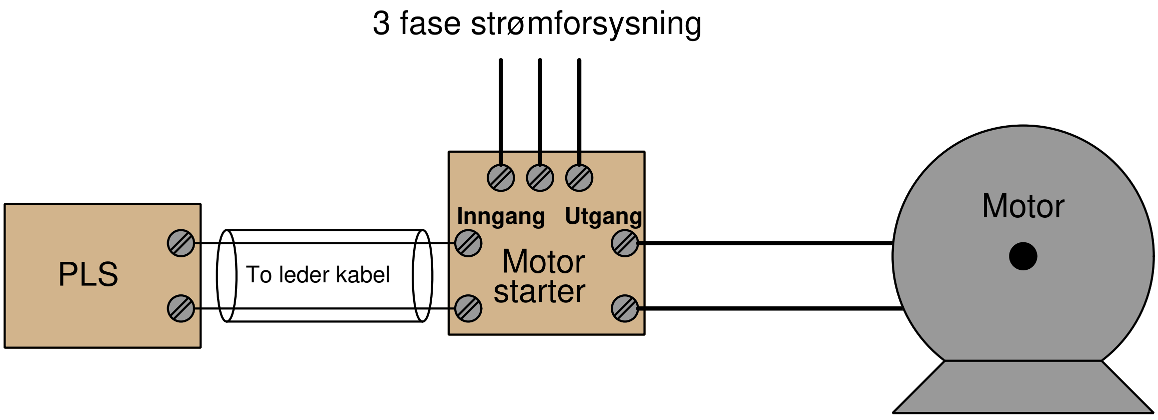


The purpose of the analog-to-digital converter (ADC) is to translate the pressure sensor's electrical output signal into a digital number the microprocessor can understand. Likewise, the purpose of the digital-to-analog converter (DAC) is to translate the digital output of the microprocessor into a 4 to 20 mA DC current signal representing measured pressure. The procedure of calibrating the ADC is called a *sensor trim*, while the process of calibrating the DAC is called an *output trim*.

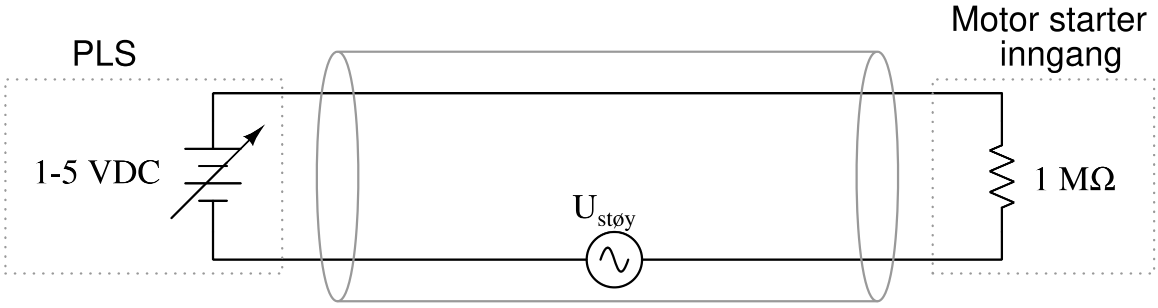
Explain the importance of performing both a sensor trim and an output trim whenever calibrating a "smart" transmitter. In other words, explain why it is not enough to simply program LRV and URV values into the microprocessor (e.g. LRV = 0 PSI ; URV = 30 PSI) and declare the job finished.
Furthermore, explain what external calibration equipment must be connected to the transmitter to complete a sensor trim procedure, and also what external calibration equipment must be connected in order to complete an output trim procedure.
file i00090

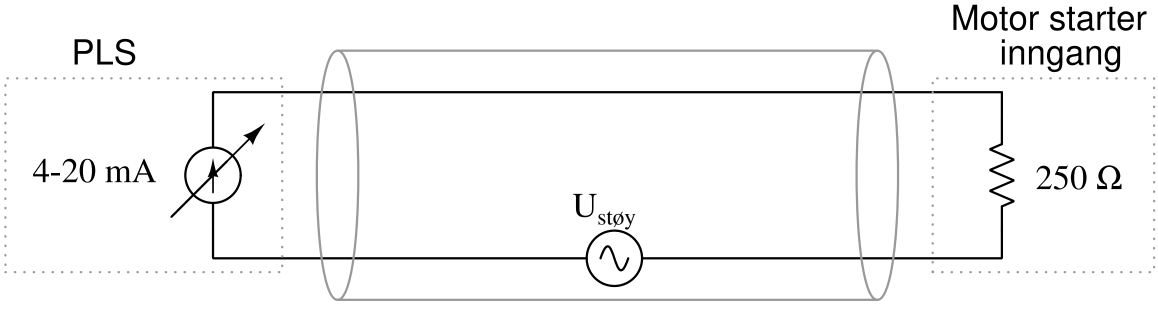
Oppgave 6

Elektriske signaler blir ofte brukt til å overføre informasjon i automatiseringsystemer. Et eksempel på dette kan være at en PLS skal gi informasjon om hvor fort en motor skal rotere.



To vanlige standarder for styresignaler er 1-5V og 4-20mA.
Det kan se ut som valget mellom 1-5V og 4-20mA er et tilfeldig. Men en av disse har mye større tolleranse mot støy på overføringskabelen. Her vises et skjema for de to signalstandardene, komplett med spenningsgenerator for støykildene på kablene.



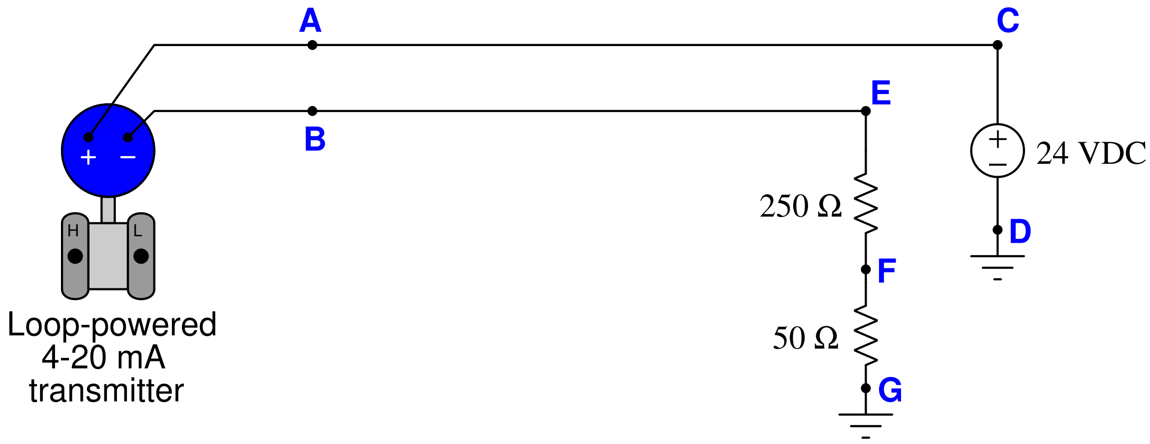


Bruk Kirchhoffs spenningslov til til avgjøre hvilen signalstandard som gir mest spenningsvariasjoner på motorstarterens inngang, og dermed påvirker motorens hastighet mest.

file if001.tex

Oppgave 7

Calculate the voltage drops in this loop-powered 4-20 mA transmitter circuit for the current conditions shown in the table:



Percent of range	Transmitter current	V_{CD}	V_{EF}	V_{FG}	V_{AB}
0 %	4 mA				
25 %	8 mA				
50 %	12 mA				
75 %	16 mA				
100 %	20 mA				

In order for a loop-powered transmitter such as this to function adequately, there must be a minimum DC voltage between its terminals (V_{AB}) at all times. A typical value for this voltage is 12 volts (be aware that this minimum voltage level varies considerably between different manufacturers and models!). Identify what loop condition(s) may jeopardize this minimum supply voltage value, and how you as a technician would ensure the transmitter always received enough voltage to function.

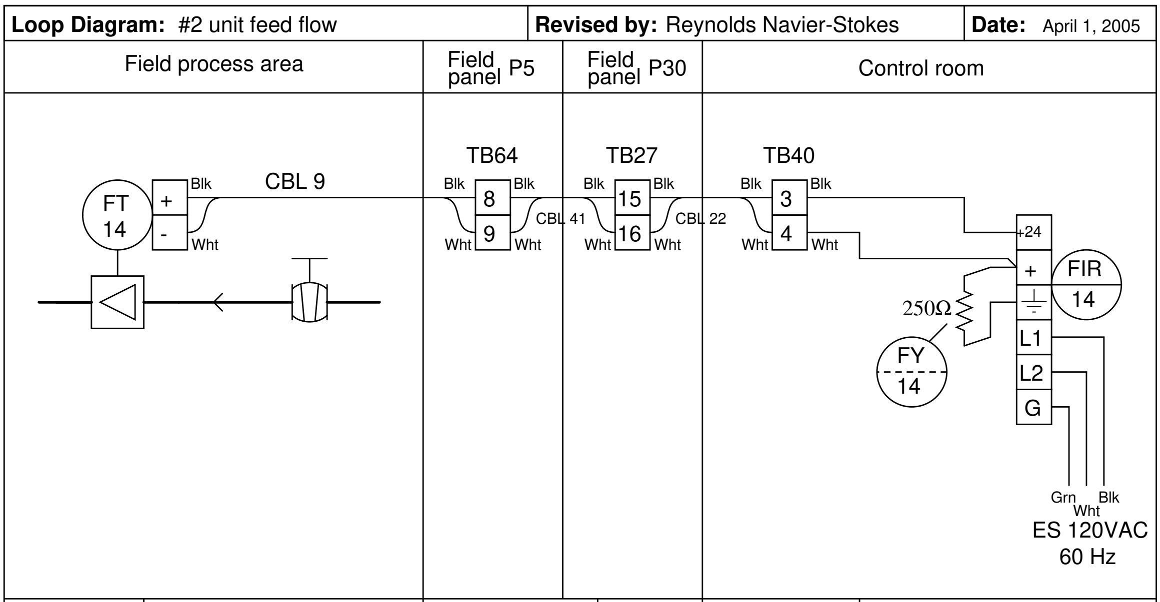
Suggestions for Socratic discussion

- If a technician happened to be measuring transmitter terminal voltage while the pressure applied to the "H" port of the transmitter suddenly increased, would the measured voltage increase or decrease?
- This circuit shows *two* resistors, rather than just one. Identify a practical reason why a 4-20 mA loop circuit might have multiple resistances in it.
- Demonstrate how to *estimate* numerical answers for this problem without using a calculator.

file i00129

Oppgave 8

Examine the following loop diagram:



Tag number	Description	Manufacturer	Model	Calibration	Notes
FT-14	Vortex flow transmitter	Yokogawa		0-250 GPM 4-20 mA	
FY-14	250 Ω resistor	n/a		+/- 0.1 %	
FIR-14	Paper chart recorder	Bristol-Babcock		1-5 VDC	

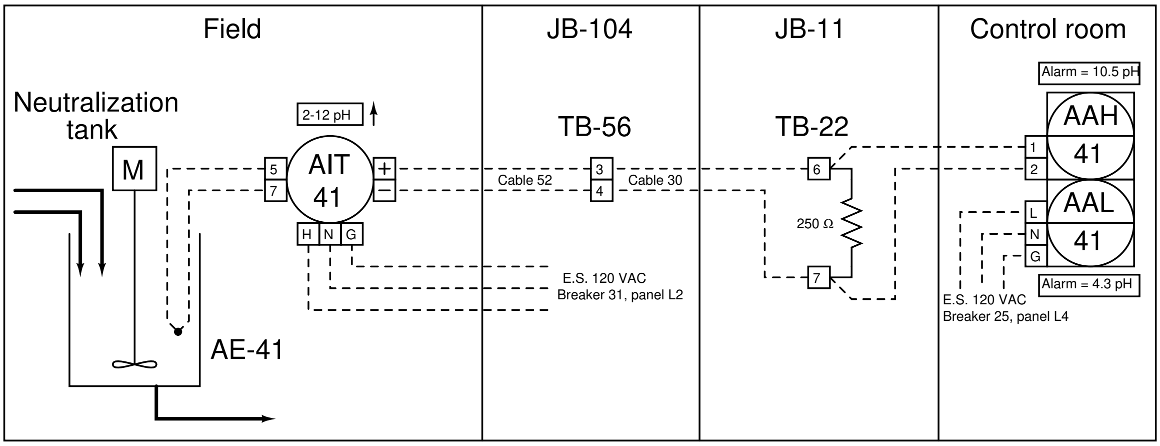
Trace the path of current in the signal wiring, then determine the following voltage drops at the respective flow rates. Assume a power supply voltage of exactly 24 volts DC:

- Voltage across FY-14 resistor = ________ ; Flow rate = 100 GPM
- Voltage between terminals TB40-3 and TB40-4 = ________ ; Flow rate = 200 GPM
- Voltage across FT-14 transmitter terminals = ________ ; Flow rate = 175 GPM
- Voltage between terminals TB64-8 and TB27-15 = ________ ; Flow rate = 200 GPM

file i00136

Oppgave 9

This pH monitoring system triggers an alarm if the pH value of the process water in the neutralization tank drifts past either of two threshold (trip) values:



Answer the following questions about this pH alarm system:

- If a wire breaks loose at TB56-4, creating an "open" fault in the loop circuit, determine what will happen at the alarm unit (AAH, AAL-41) and also where you would expect to measure voltage in the loop circuit and where you would expect to measure *no* voltage in the loop circuit.

- If breaker #25 in panel L4 suddenly trips, what will happen in this system? Will an operator still be able to read the pH value of the water in the neutralization tank?

- If a fire breaks out near the conduit through which cable 52 runs, causing the plastic insulation around the conductors of cable 52 to melt and consequently causing those conductors to *short* together, what will happen in this system? Where would you expect to measure voltage in the loop circuit, and where would you expect to measure *no* voltage in the loop circuit? Where would you expect to measure current in the loop circuit, and where would you expect to measure *no* current in the loop circuit?

- Calculate the loop current value when the pH measures 6.8 inside the neutralization tank.

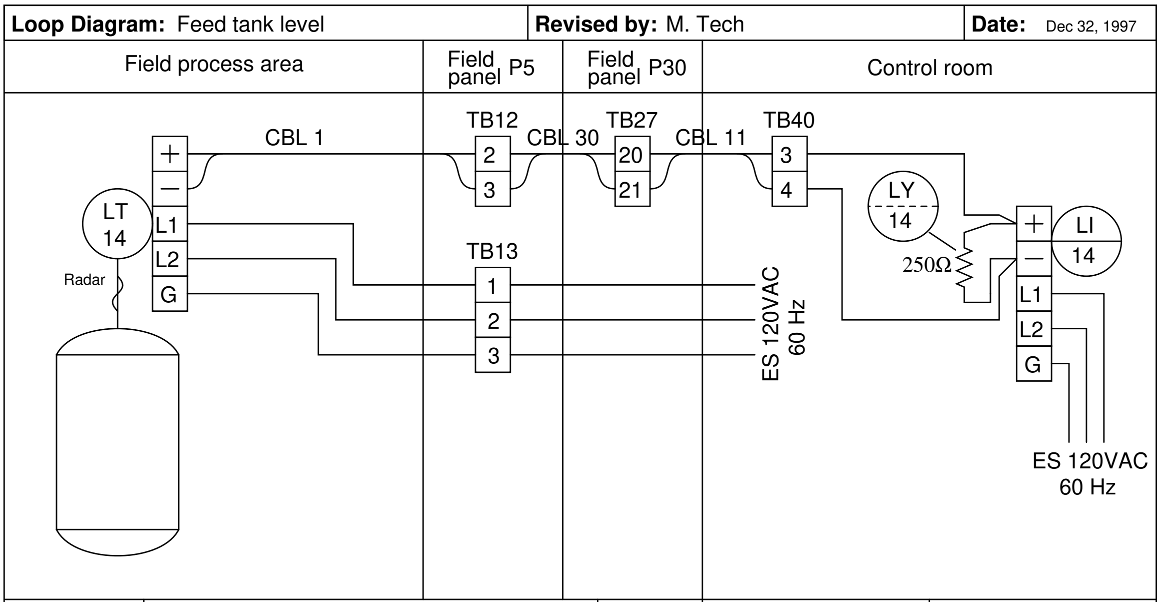
Suggestions for Socratic discussion

- For those who have studied pH measurement, explain why pH "neutralization" is an important control process in industry.
- How can we tell from this diagram whether the 4-20 mA output of transmitter AIT-41 is *active* or *passive* (i.e. *sourcing* or *sinking*)?

file i00239

Oppgave 10

Determine the following voltage drops in this level-sensing circuit when the process level is at a height of 12 feet. Note that this is *not* a loop-powered transmitter, but receives its electrical power through separate power conductors (120 volts AC). Assume negligible (0) voltage drop along the signal conductor lengths:



Tag number	Description	Manufacturer	Model	Calibration	Notes
LT-14	Radar level transmitter	Enraf		0-30 ft ; 4-20 mA	
LY-14	250 Ω resistor			+/- 0.1 %	
LI-14	Panel indicator	Red Lion		1-5 VDC	

- Voltage drop across transmitter signal terminals =
- Voltage drop between TB40-3 and TB27-21 =
- Voltage drop across 250 Ω resistor =
- Voltage drop between TB12-3 and TB27-21 =

Suggestions for Socratic discussion

- Demonstrate how to *estimate* numerical answers for this problem without using a calculator.
- If the voltage drop along the signal wiring length were significant rather than zero, how would the voltage calculations be affected? Would significant loop wire resistance cause a level measurement error? If so, would it result in a *high* error or a *low* error?
- Explain why this particular level transmitter must be self-powered rather than loop-powered as is (more) typical for process transmitters.
- Explain why non-contact radar level transmitters must be used only on metal vessels in order to comply with FCC regulations, while guided-wave radar level transmitters may be used in either metal or non-metal vessels.

- As process level increases, will the voltage measured across the transmitter's terminals *increase*, *decrease*, or *remain the same*?

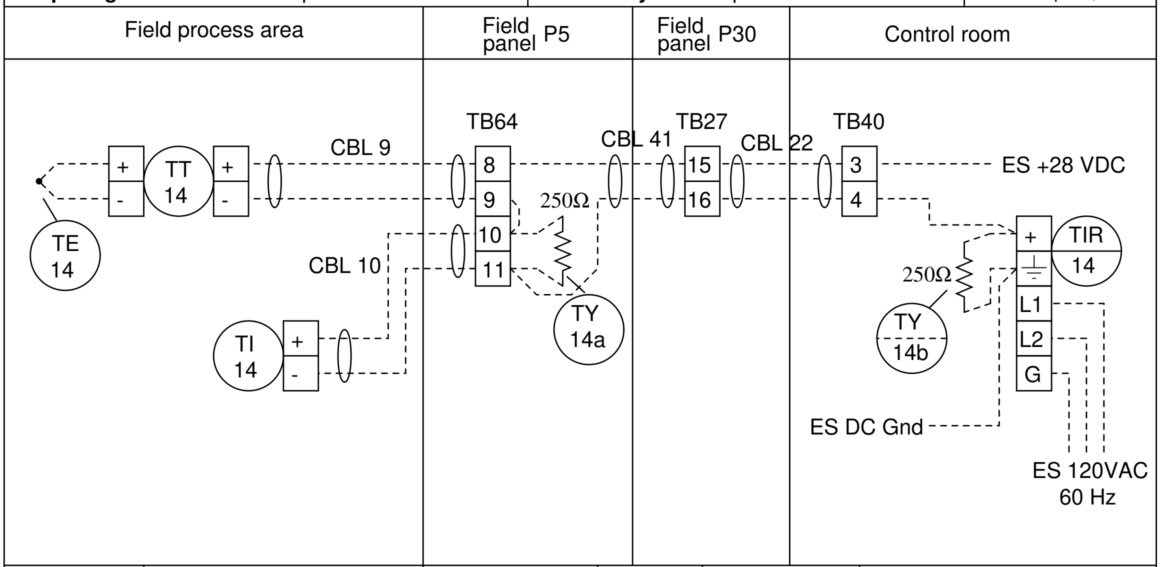
- Suppose this self-powered ("4-wire") level transmitter were replaced be a loop-powered ("2-wire") level transmitter. As process level increases, will the voltage measured across the transmitter's terminals *increase*, *decrease*, or *remain the same*?

file i00293

Oppgave 11

Calculate the following voltage drops in this circuit assuming a thermocouple tip temperature of 718^o F, perfect calibration of all other instruments in the loop (Temp. range = 500 to 1000^o F; current range = 4 to 20 mA), and a DC power supply voltage of exactly 28 volts:

Loop Diagram: #3 retort temperature	**Revised by:** T. Couple	**Date:** April 1, 2002



Tag number	Description	Manufacturer	Model	Calibration	Notes
TE-14	Type K thermocouple	Gordon			Ungrounded tip
TT-14	Temperature transmitter	Rosemount	444	500 - 1000^o F 4-20 mA	Downscale burnout
TI-14	Local indicator			1 - 5 VDC 500 - 1000^o F	
TY-14a,b	250 Ω resistor	n/a		+/- 0.1 %	
TIR-14	Paperless chart recorder	Eurotherm		1-5 VDC	

- Voltage between terminals TB64-8 and TB64-9 =
- Voltage between terminals TB64-10 and TB64-11 =
- Voltage between terminals TB27-15 and TB27-16 =

Also, determine where you could connect a *loop calibrator* device to substitute for the transmitter, and what mode the calibrator should be set to in order to control the loop current.

Suggestions for Socratic discussion

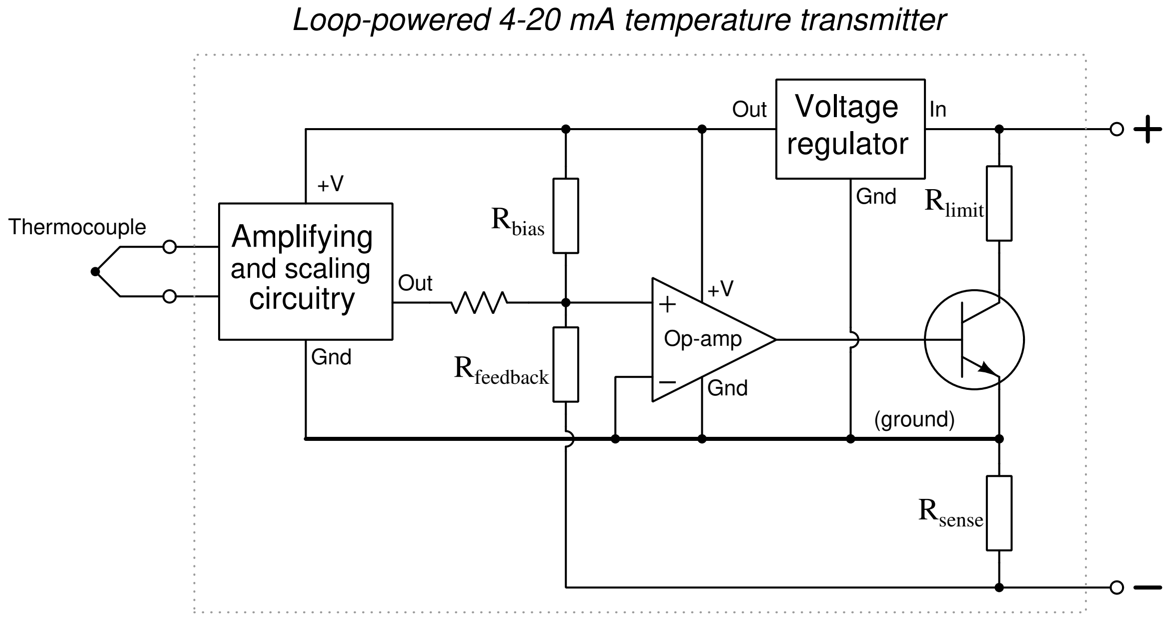
- Demonstrate how to *estimate* numerical answers for this problem without using a calculator.
- Discuss the options we have for thermocouple tip styles, and how this particular thermocouple's tip characteristics compare with others.
- Explain what "downscale burnout" means and why this transmitter configuration might be significant.

- What exactly is a “paperless” chart recorder?
- What would happen in this system if the local indicator (TI-14) were to electrically fail open?

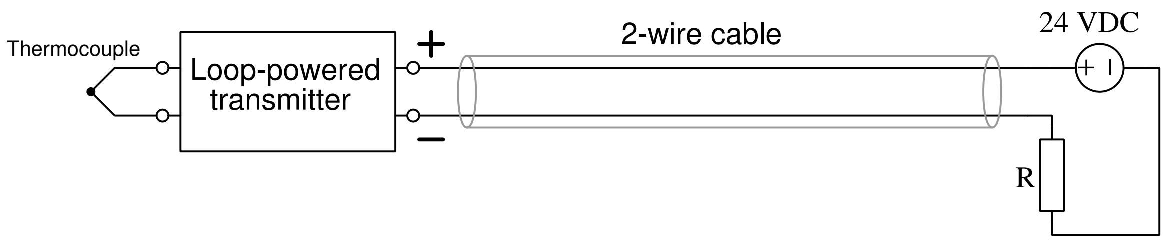
file i00393

Oppgave 12

Kretsen under er for en forenklet 2-leder 4-20mA temperatur transmitter.



Resten av kretsen ser slik ut:



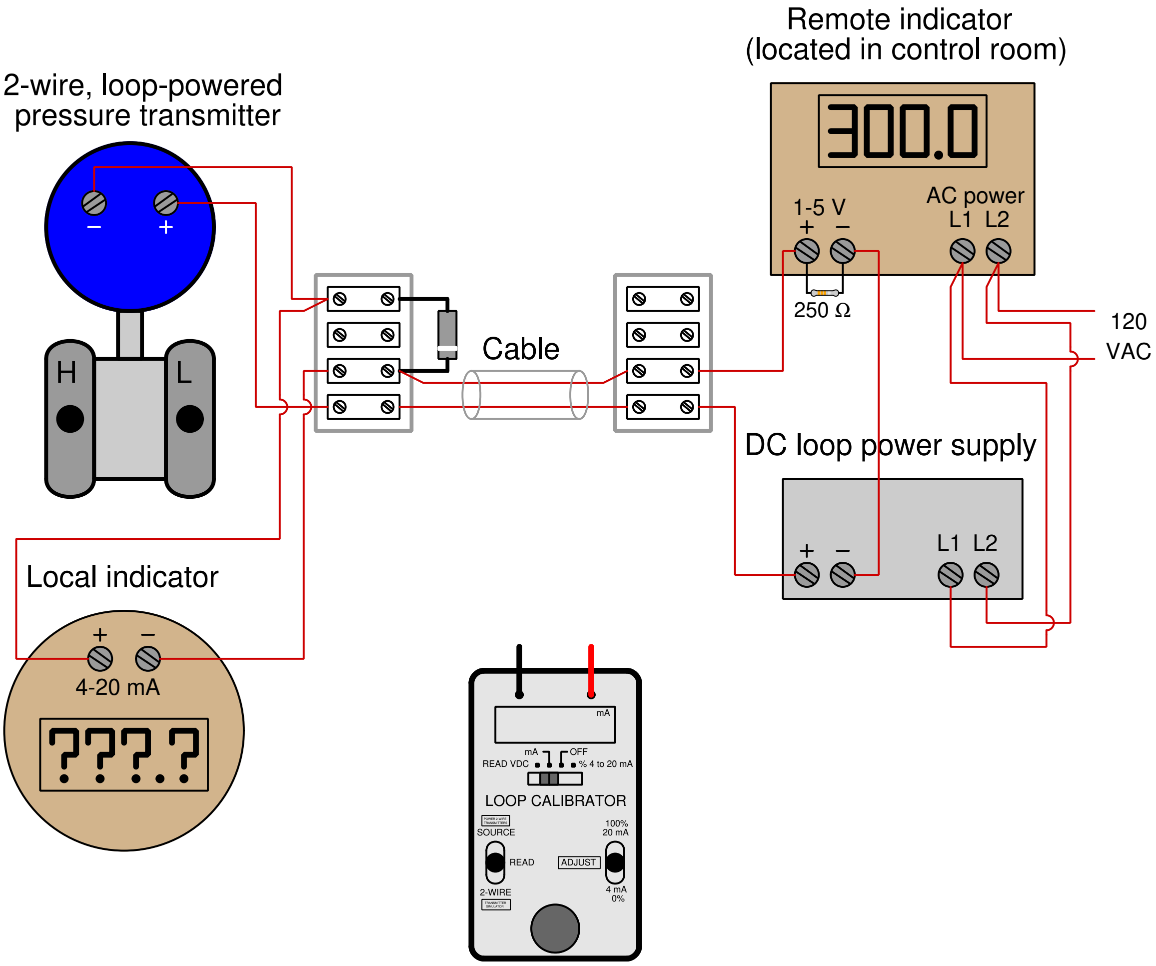
Regn ut strømmen ut fra emitter på transistoren inne i transmitteren, gitt følgende betingelser:

- Måleomtåde = 50 to 250 degrees C
- Temperatur for termoelement = 100 degrees C
- Forsyningsspenning = 24.0 volts
- Sløyferesistans = 250 ohms
- Spenningsregulatorens inngangstrøm = 3.7 mA (konstant)

Tegn også inn strømretning for alle strømmer inne i transmitteren.
file i00397

Oppgave 13

In this circuit, an electronic differential pressure transmitter with a 4-20 mA output signal connects to a local pressure indicator and to a remote pressure indicator. Your task is to figure out how to connect the loop calibrator to force the remote indicator (only) to register a pressure of 300 PSI, without interrupting or otherwise affecting the transmitter's signal to the local indicator:



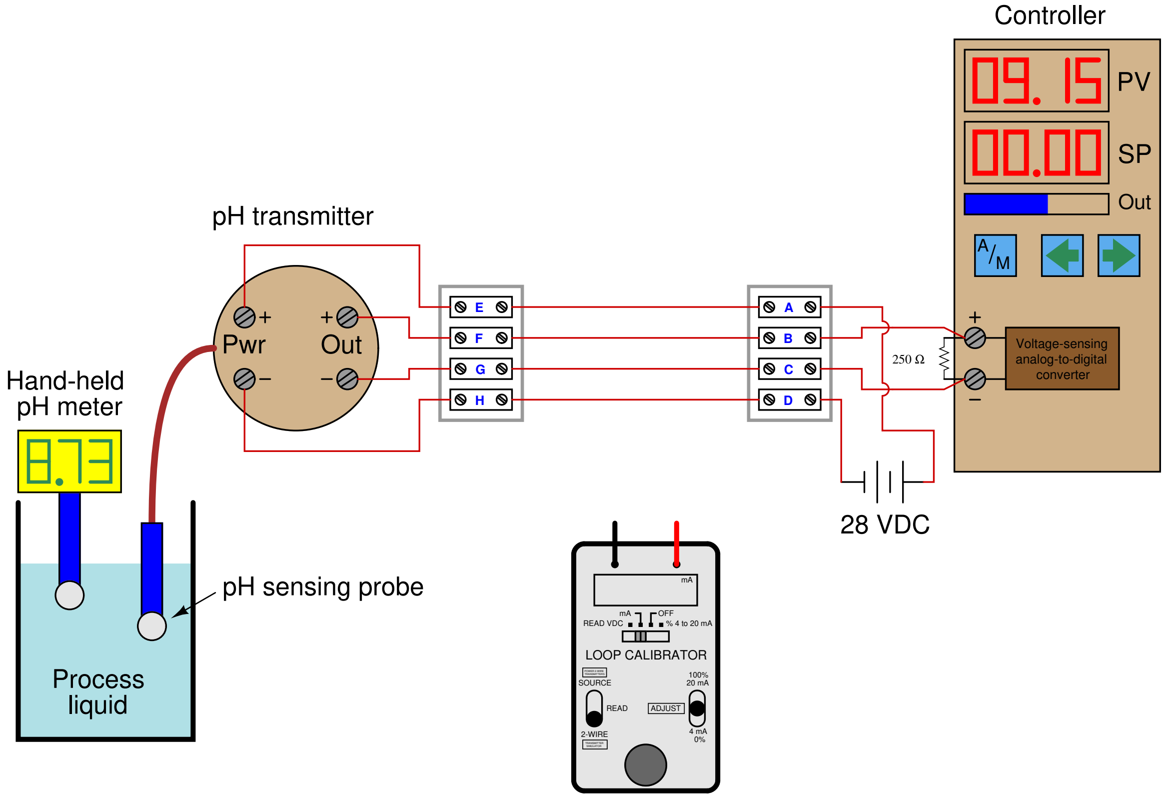
Sketch your solution, showing both the loop calibrator's test lead connections and the mode it must be set to (*source*, *read*, or *simulate*). Assume a transmitter calibration of −10 PSI to +440 PSI.

Note: there is more than one correct answer to this question!

file i00627

Oppgave 14

Et nyinstallert pH målesystem ser ikke ut til å måle rett pH verdi på prosessvæsken. Regulatoren som systemet er tilkoblet viser ikke samme verdi som et håndholdt pH-meter om en operatør holder ned i væsken.



Måleområde til den 4 leder koblede transmitteren skal være 2-12 pH, med et utgangssignal på 4-20mA. En automatiker som har startet feilsøking ved å måle strømmen som transmitteren sender ut med en loopkalibrator. Dette gir et resultat på 15.43 mA.

Ut fra dette skal du finne ut hvor problemet i systemet er. Vis også hvordan du ville koblet loopkalibratoren inn i sløyfen for å gjøre denne målingen.

Suggestions for Socratic discussion

- Review the problem-solving tips listed in Question 0 and apply them to this problem.
- A problem-solving technique useful for making proper connections in pictorial circuit diagrams is to first identify the directions of all DC currents entering and exiting component terminals, as well as the respective voltage polarity marks (+,−) for those terminals, based on your knowledge of each component acting either as an electrical *source* or an electrical *load*. Discuss and compare how these arrows and polarity marks simplify the task of properly connecting wires between components.
- If the technician had no test equipment except for a voltmeter, could a good diagnostic test still be made in this system?
- Identify where you could install a rectifying diode in this circuit to allow convenient measurement of loop current.

file i00976

Oppgave 15

Read Fluke's *Transmitter Calibration with the Fluke 750 Series Documenting Process Calibrator* application note (document 3792201B A-EN-N, August 2011) and answer the following questions:

Identify the four different instrument calibration examples in this application note. Are any of these similar to an instrument calibration you have done?

Explain the advantage of using the "Auto Test" feature of the Fluke DPC to perform an instrument calibration, compared to performing a manual calibration test.

Explain why the fourth calibration example in this application note cannot be done using the "Auto Test" capability of the Fluke DPC.

When manually providing the input values for the instrument under test as is the case in the last calibration example, is it necessary for you to exactly settle at each test point? Explain why or why not.

Suggestions for Socratic discussion

- One of the Auto Test features not mentioned in this application note is the ability to perform an "Up/Down" test. Explain why this feature might be useful for certain calibration procedures, specifically identifying the sort of calibration error it would be intended to detect.
- Explain what would have to be different about the Fluke 750 series DPC in order for it to perform all the calibration tests described in automatic mode. In other words, devise a solution to the "manual-only" test option given in the fourth calibration example.

file i01940

Oppgave 16

Read Fluke's *Calibrating Pressure Switches with a DPC* application note (document 2069058B A-EN-N, July 2011) and answer the following questions:

Define "deadband" as used in this document with reference to a pressure switch, and explain why this is an important parameter for a process switch.

Explain why it is important to tell the DPC whether the setpoint type is "low" or "high".

Explain why a pressure switch calibration check cannot be done using the "Auto Test" capability of the Fluke DPC, but rather must be done using the "Manual Test" feature.

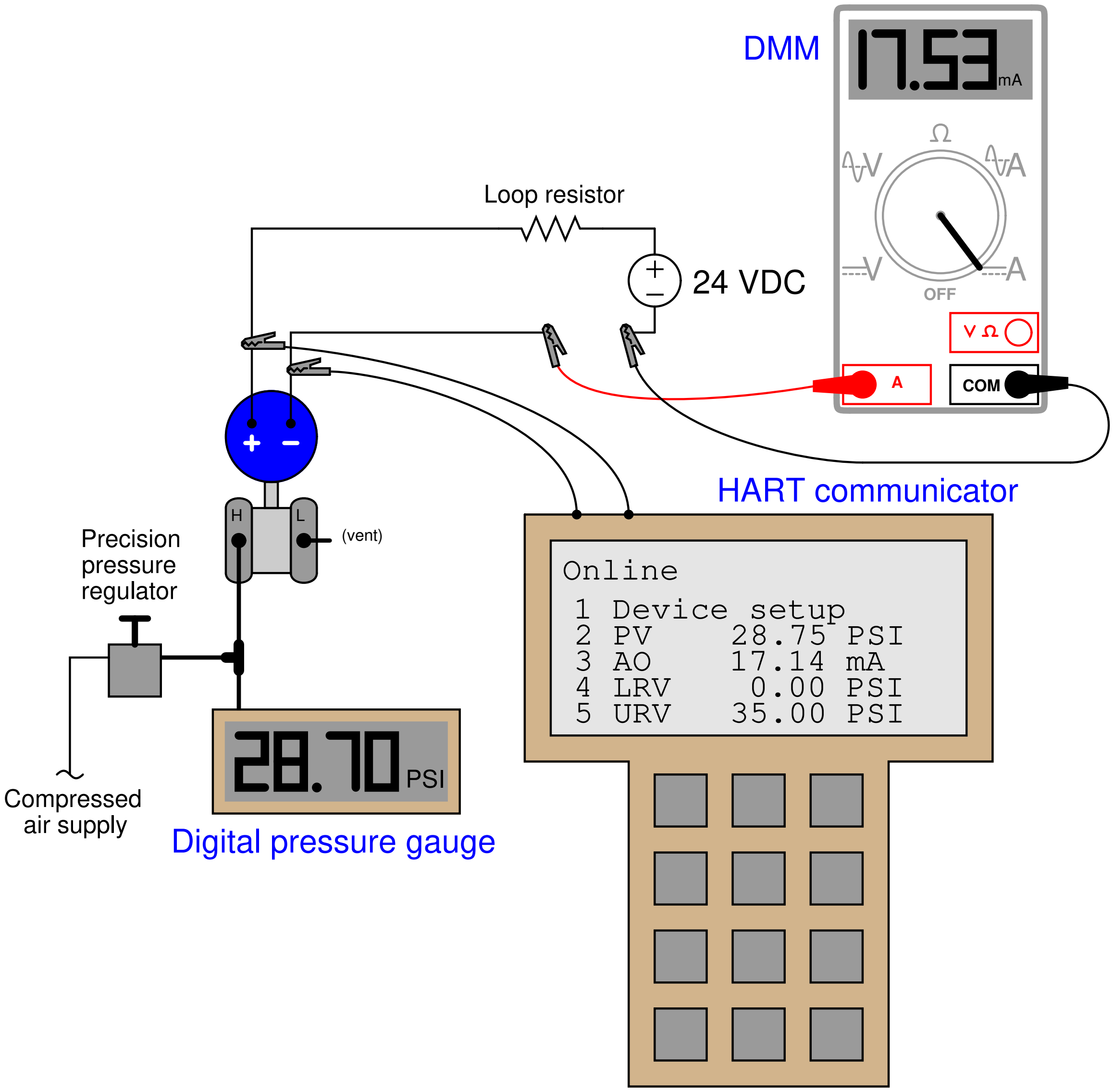
Suggestions for Socratic discussion

- Explain why this document advises you to repeatedly cycle the test pressure past the set and reset switch states, instead of traversing those values just once.
- At the conclusion of the described test, the Fluke DPC displays both *setpoint error* and *deadband error* figures. Explain the meaning of each.
- Explain what would have to be different about the Fluke 750 series DPC in order for it to perform all the calibration tests described in automatic mode. In other words, devise a solution to the "manual-only" test option given in the fourth calibration example.

file i01941

Oppgave 17

A "smart" (digital) DP pressure transmitter is removed from service and taken to a calibration bench for testing. A technician connects a precision pressure gauge and air source to the transmitter's high port while monitoring the 4-20 mA output signal using a DMM:



Calculate the amount of *sensor trim* error as well as the amount of *output trim* error, both expressed in percent of span. Also, explain why the HART communicator is necessary to be able to separately calculate these error values.

Suggestions for Socratic discussion

- What other possible sources of error besides the transmitter could account for these discrepancies?
- Suppose another instrument technician suggests to you that a problem within the precision air pressure regulator might account for some (or all!) of the calibration error seen in the data, and that we should replace the regulator with another. How would you respond to this suggestion?

- Suppose another instrument technician suggests to you that a problem within the loop resistor might account for some (or all!) of the calibration error seen in the data, and that we should replace the resistor with another. How would you respond to this suggestion?

- Does the HART communicator need to be NIST traceable? Why or why not?

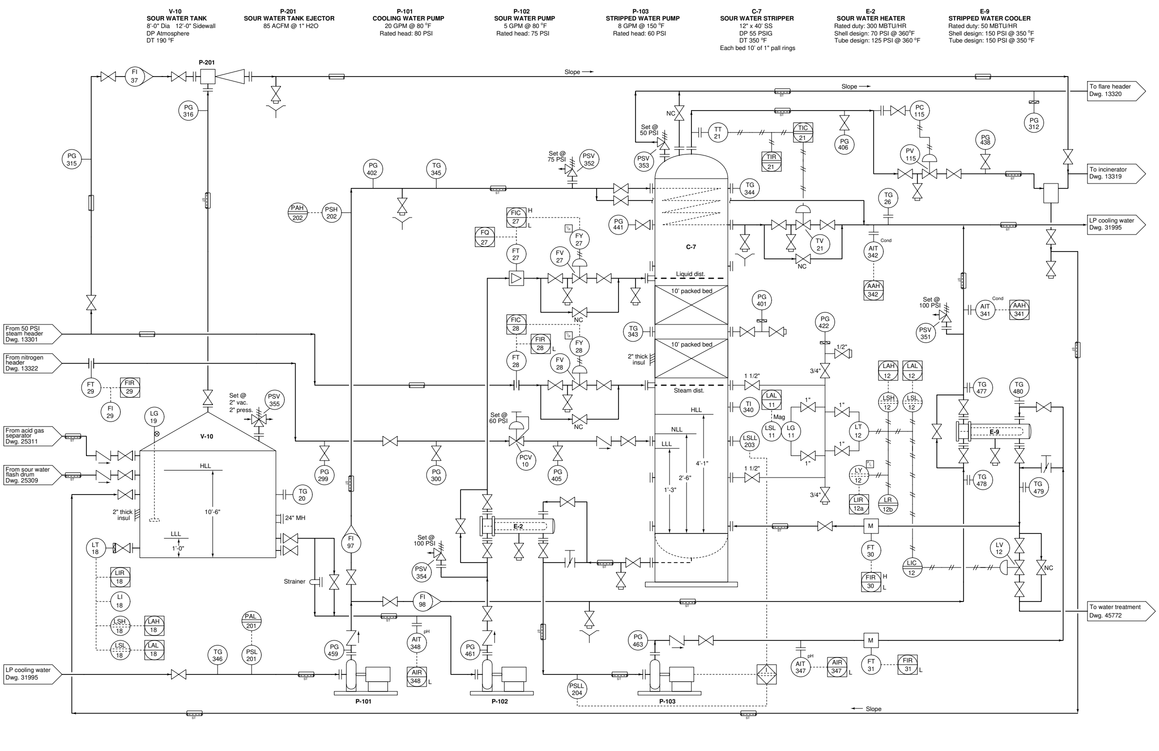
file i02033

Oppgave 18

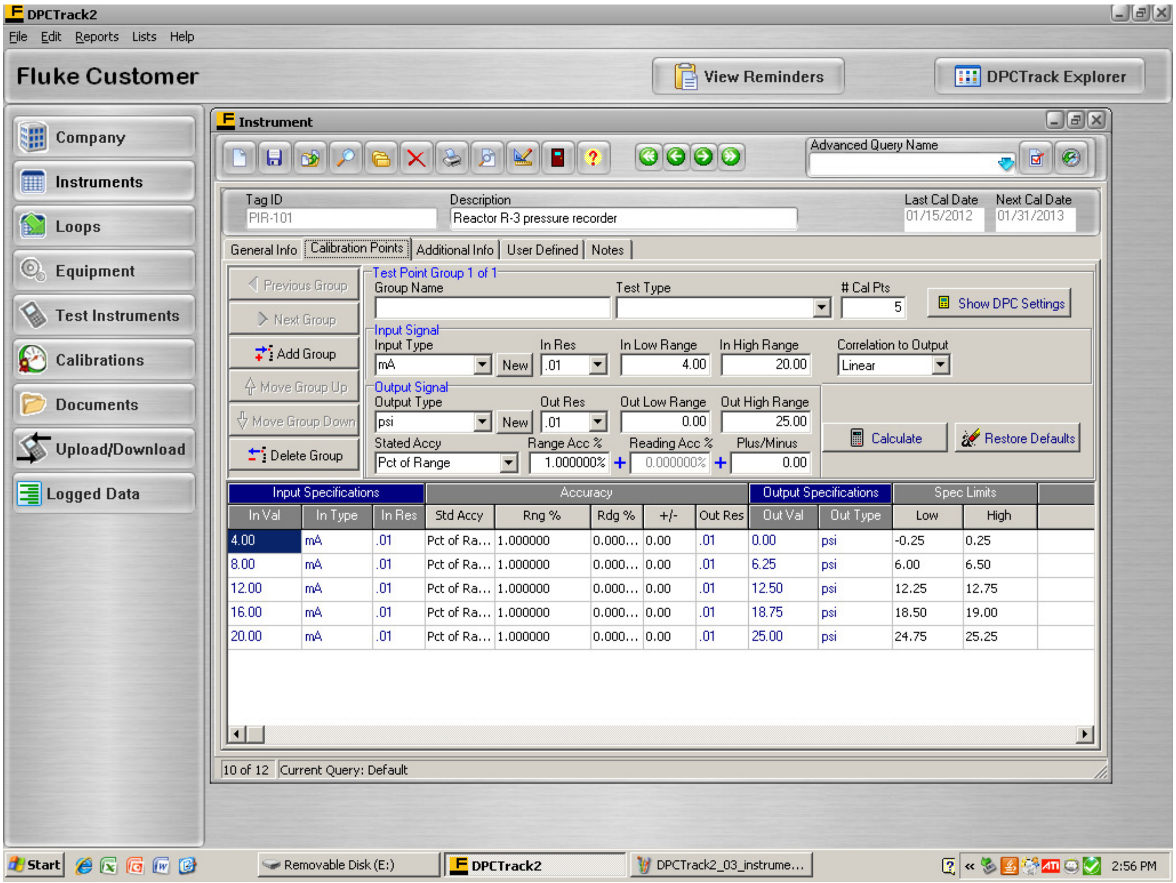
The Fluke corporation sells a software product called *DPCTrack2* that may be downloaded and run for a free trial basis. Locate this software on the Fluke website (`http://www.fluke.com`) and download it to your PC so that you may experiment with it in class.

DPCTrack2 is used to upload calibration specifications to a process calibrator (e.g. the Fluke model 754) prior to instrument technicians performing a field or a bench calibration. After the calibration(s) have been completed, the calibrator is re-connected to the personal computer so the As-Found and As-Left calibration results may be downloaded to DPCTrack2 for archival. Thus, DPCTrack2 is useful for calibration *workload* management: ensuring all technicians have the information necessary to properly complete mission-critical field instrument calibrations, and ensuring all the calibration data gets properly archived.

In this exercise, you will enter data for a few instruments as they appear on the following P&ID. Choose any instruments you wish from the P&ID (choosing a few within the same control loop would be best, because that would allow you to define a "Loop" in the DPCTrack software as well as the instruments themselves), giving yourself license to invent realistic calibration ranges for each of them:



Your assignment – at minimum – is to enter multiple instruments into the DPCTrack2 database, complete with one or more "Test Point Groups" specifying calibration parameters for those instruments. An example of this is shown here:



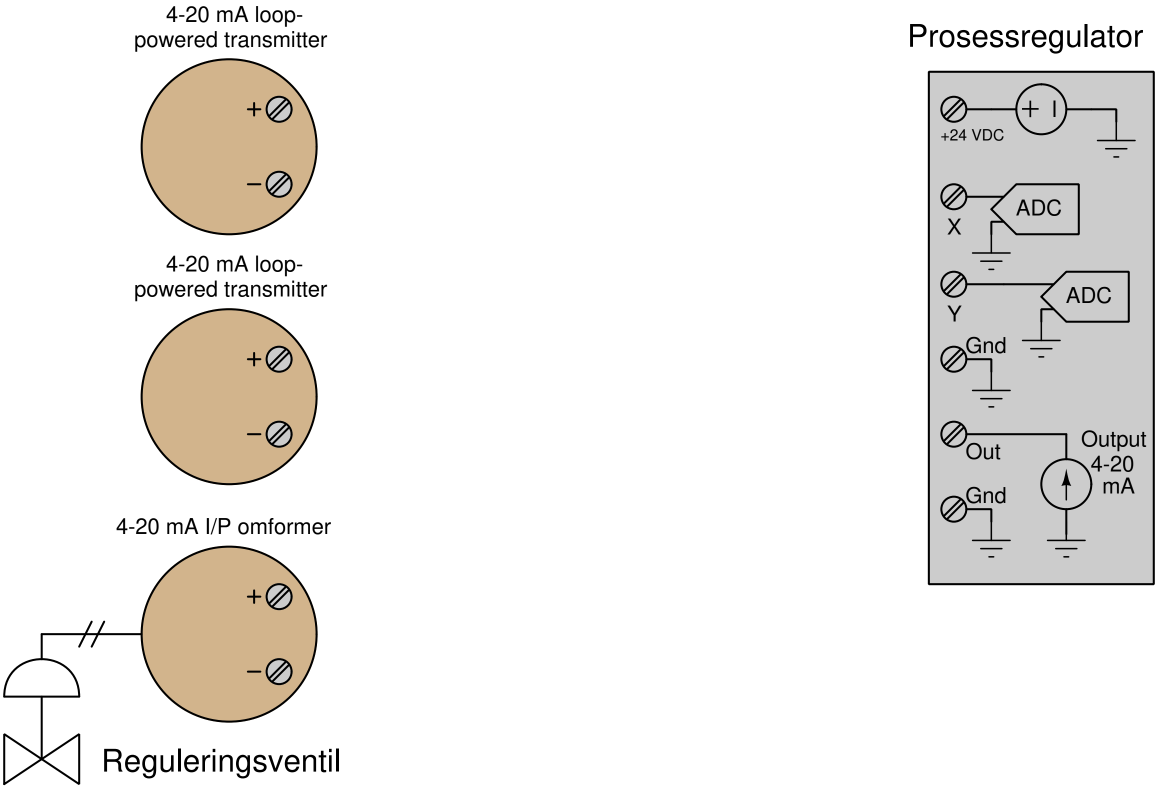
Beyond that, feel free to experiment with entering more data into the DPCTrack2 database:

- Equipment data (assigning individual instruments to a piece of equipment)
- Loop data (assigning individual instruments to a loop)
- Location data (assigning equipment to certain buildings or other physical locations)
- Technician information
- User's manuals or other instructional documents linked to loops or instruments

file i02034

Oppgave 19

Her vises to transmittere som er koblet til en regulator med to innganger. Transmitterene får forsysningspenning fra strømsløyfen(4-20mA). Til utgangen på regulatoren er det koblet en I/P konverter som brukes til å styre en pneumatisk reguleringsventil. Inngangen på regulatoren har et område på 1-5V, ikke 4-20mA.

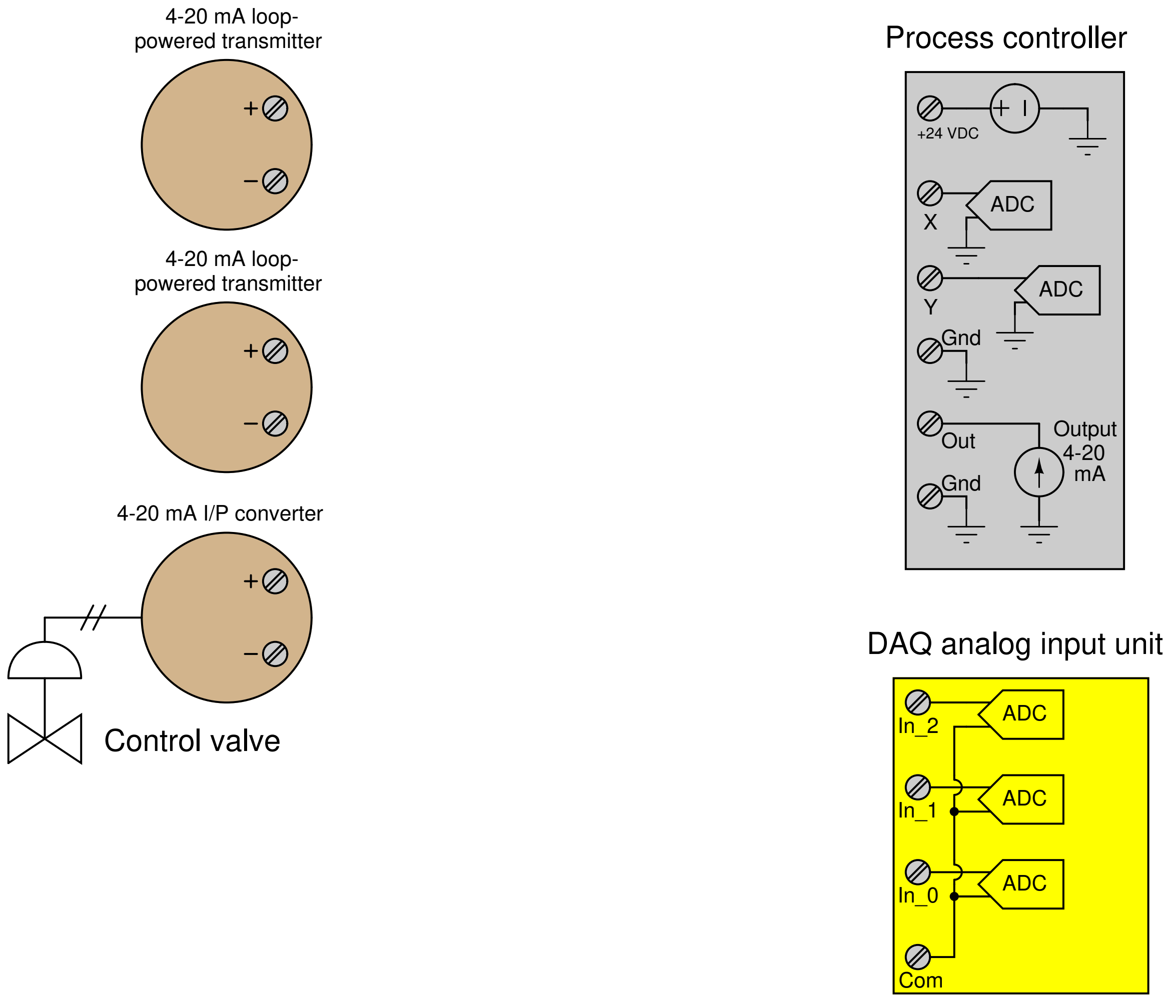


Vis hvordan feltutstyret skal kobles til regulatoren, inkluder plassering av motstander for konvertere strømsignal til spenningssignal som regulatorens ADC kan lese. Bruk skjermet kabel og vis hvordan denne skal jordes.

file i02273

Oppgave 20

Shown here is a pair of loop-powered 4-20 mA process transmitters, a process controller with dual measurement inputs, a 4-20 mA I/P (current-to-pressure) converter used to drive a pneumatically-actuated control valve, and a DAQ (data acquisition) unit for interfacing to a computer. Both the process controller and DAQ unit inputs are ranged from 1 to 5 volts DC, not 4-20 mA:



Show how all three field devices would properly connect to the controller and to the DAQ unit at the same time, including the placement of resistors to convert the current signals into voltage signals that both the controller and the DAQ may interpret.

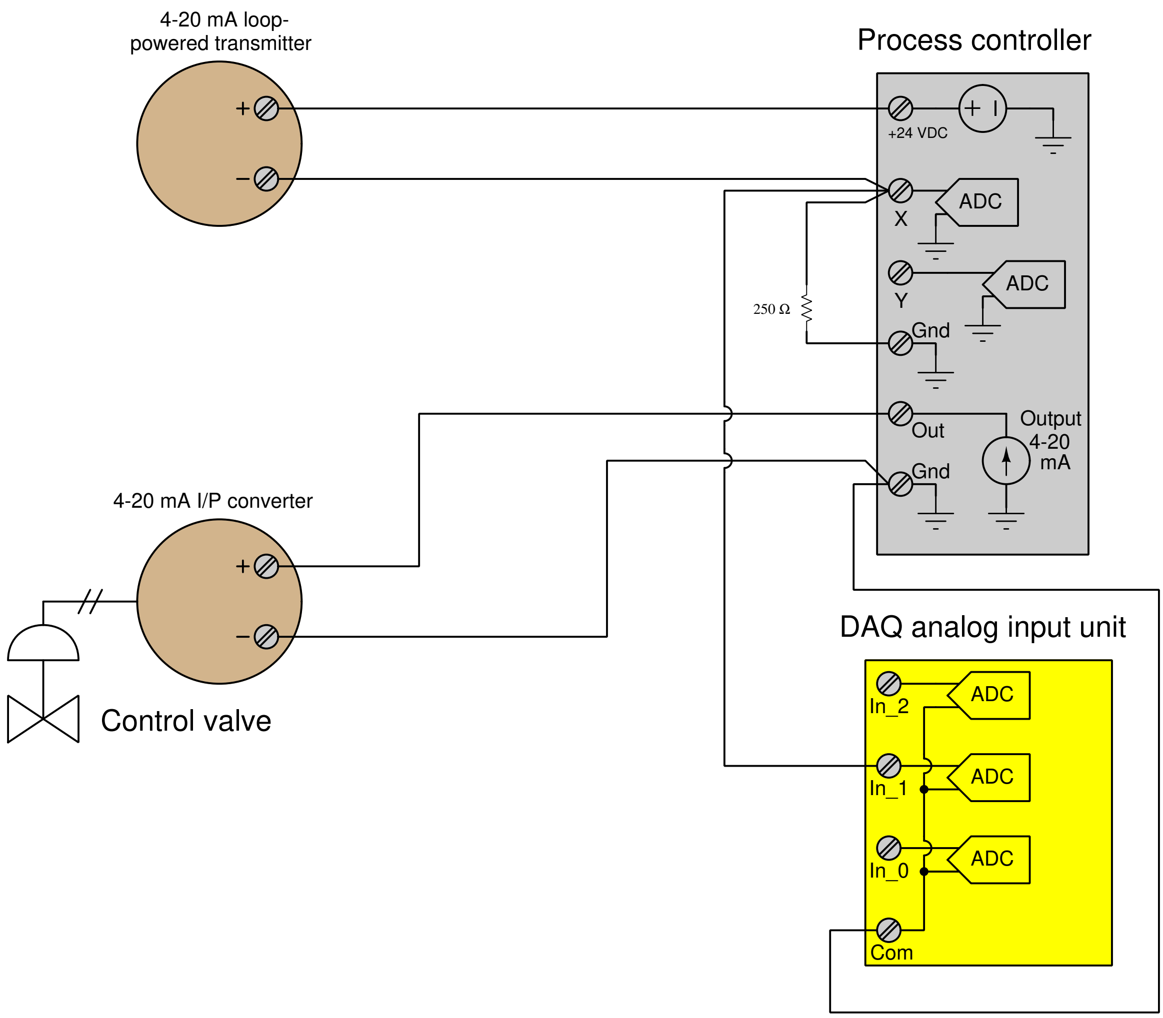
Suggestions for Socratic discussion

- A problem-solving technique useful for making proper connections in pictorial circuit diagrams is to first identify the directions of all DC currents entering and exiting component terminals, as well as the respective voltage polarity marks (+,−) for those terminals, based on your knowledge of each component acting either as an electrical *source* or an electrical *load*. Discuss and compare how these arrows and polarity marks simplify the task of properly connecting wires between components.
- After you have sketched your circuit, evaluate the effects of various components failing either open or shorted, one at a time.

file i02274

Oppgave 21

In this system a loop controller receives a process variable signal from a 2-wire (loop-powered) transmitter, and sends its own 4-20 mA control signal to operate a control valve. A data acquisition unit (DAQ) performs the auxiliary function of monitoring the process variable signal (voltage dropped across the loop resistor) and reporting it over a digital network where it is recorded on the hard drive of a personal computer. If it helps, you may think of a DAQ as being nothing more than a multi-channel voltmeter, sensing voltage between each of its input terminals (`In_1`, `In_2`) and its "common" (`Com`) terminal:



Unfortunately, the DAQ not only registers the DC signal value, but also any HART pulses present in the transmitter circuit whenever a technician connects a HART communicator to the transmitter to do any maintenance work. The operators are annoyed by the misleading "noise" on the DAQ-recorded signal whenever a technician does routine work on that transmitter, and so they come to you asking for a solution.

Devise a simple modification to this circuit that will eliminiate (or at least minimize) the "HART noise" seen by the DAQ without impeding its ability to record normal process variable signal values.

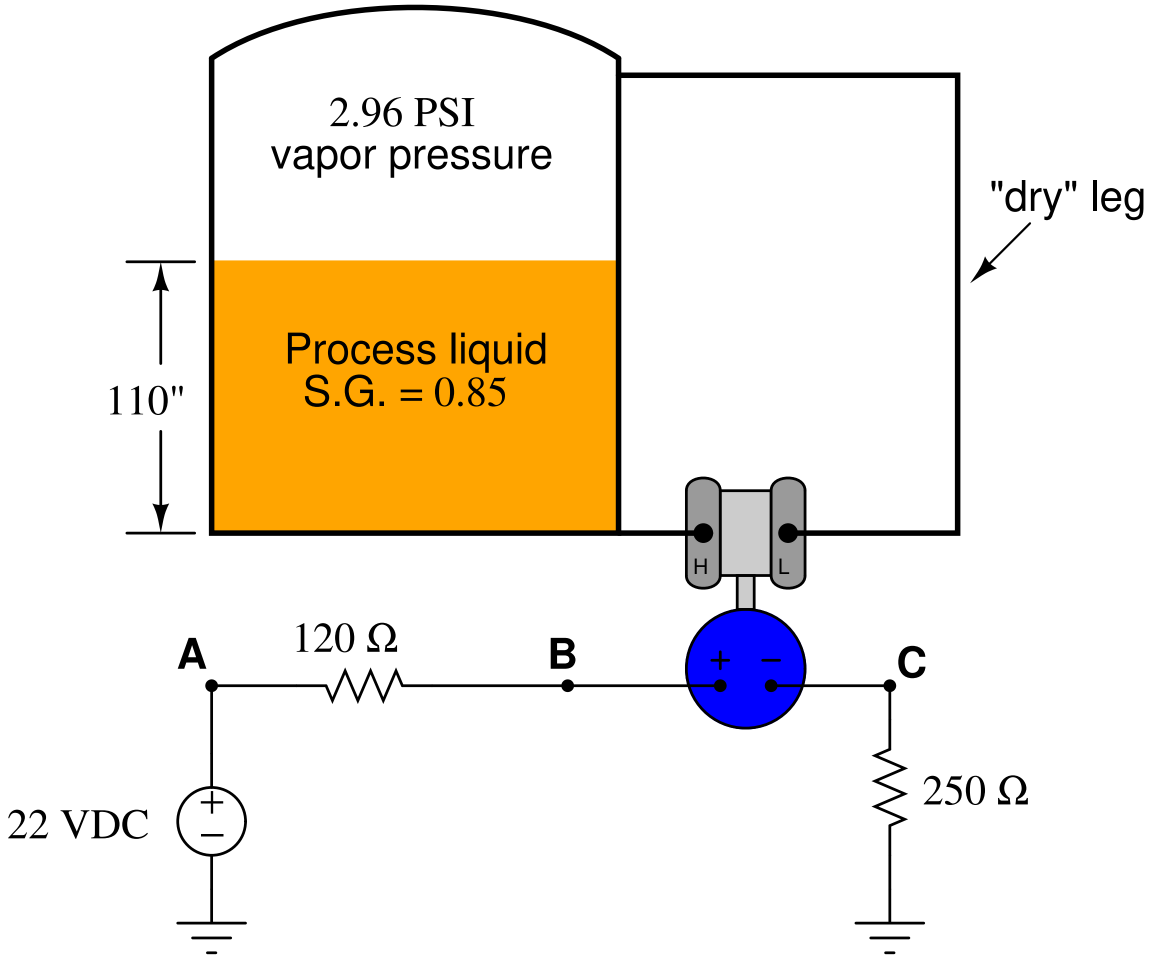
Suggestions for Socratic discussion

- A useful problem-solving technique is to sketch a simple diagram of the system you are asked to analyze. This is useful even when you already have some graphical representation of the problem given to you, as a simple sketch often reduces the complexity of the problem so that you can solve it more easily. Draw your own sketch showing how the given information in this problem inter-relates, and use this sketch to explain your solution.
- A useful analytical technique for any DC electric circuit is to identify all electrical sources and loads in the circuit, annotate the diagram with arrowheads showing the directions of all currents, and also with "+" and "−" symbols (and/or curved arrows) showing the polarities of all component voltages. Show how this helps you analyze the circuit shown in this question.

file i02557

Oppgave 22

Calculate the following circuit parameters, assuming the transmitter has been calibrated to a range of 25 to 150 inches of water column (direct-acting, 4 to 20 mA output). Be sure to show all your calculations!

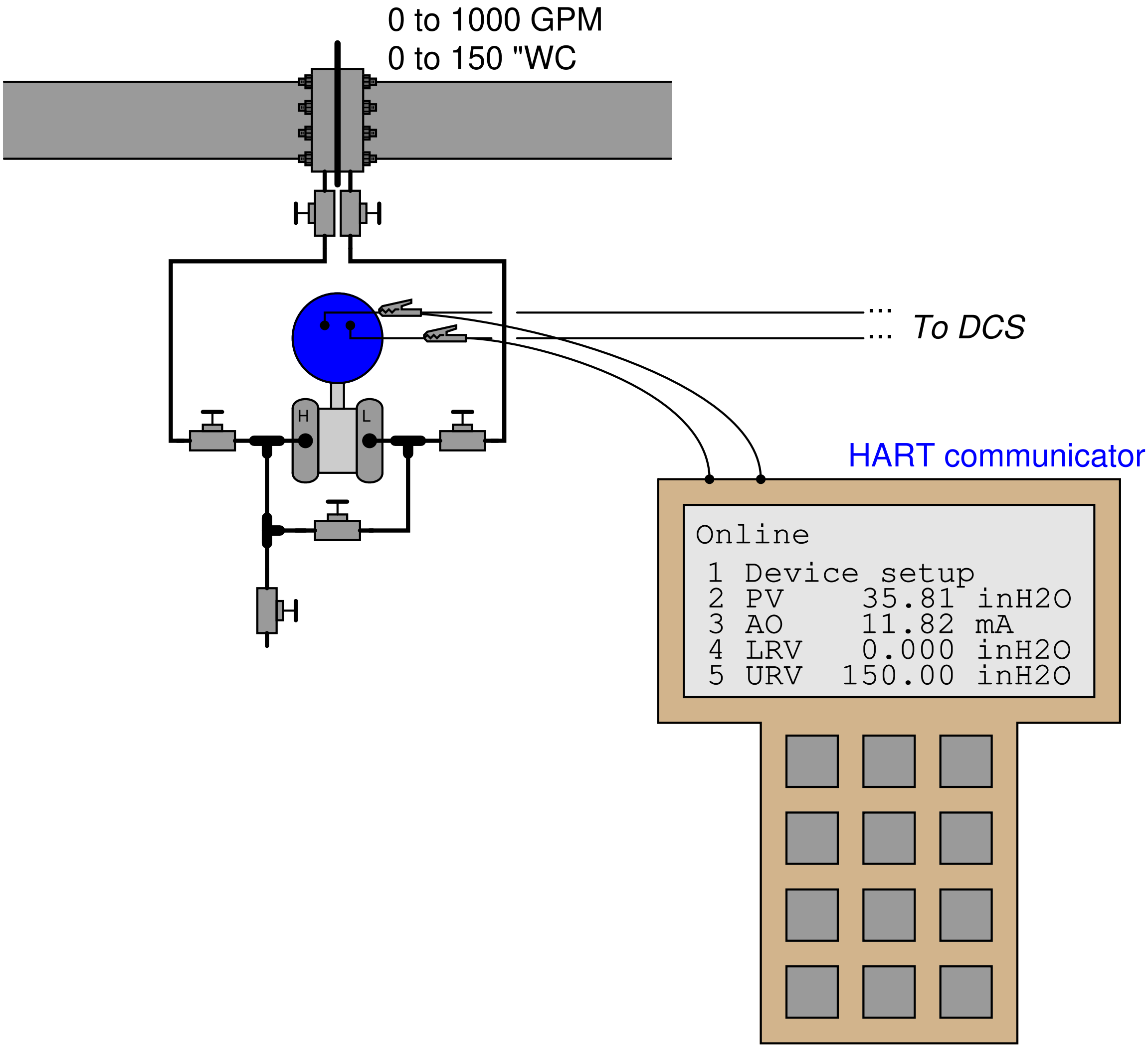


- $I =$ ________ mA
- $V_C =$ ________ V
- $V_{BC} =$ ________ V
- $V_B =$ ________ V

file i02906

Oppgave 23

A "smart" DP transmitter and orifice plate were recently installed to measure flow through a pipe. The orifice plate range is 0 to 150 inches WC at 0 to 1000 gallons per minute:

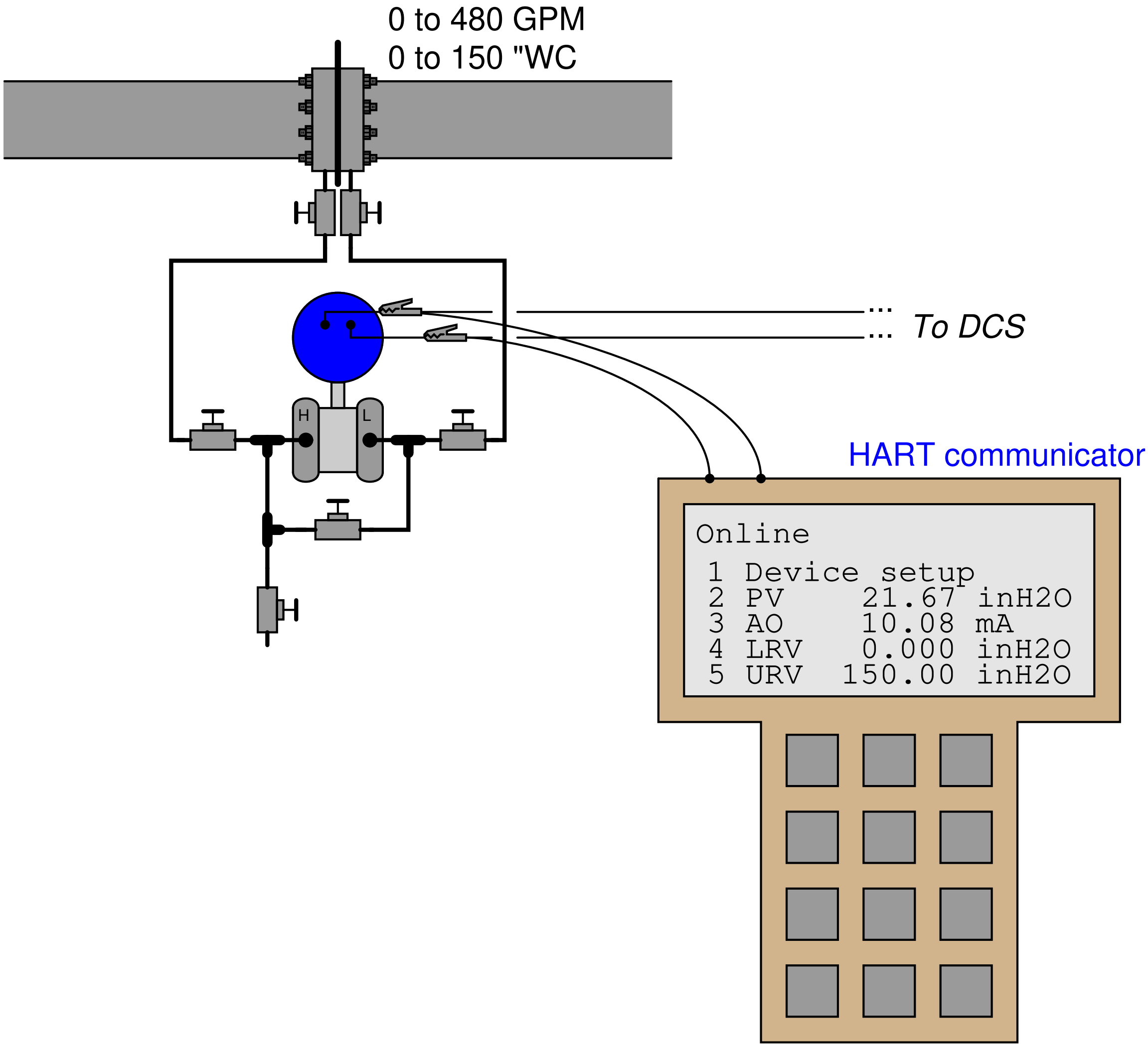


Operations personnel register a flow rate of 699 gallons per minute on the display of their DCS, which they believe to be too much. Based on what you see here, do you think there is a problem, or is this new system working as it should?

file i03428

Oppgave 24

A "smart" DP transmitter with built-in square root characterization is used to measure flow through a pipe. The orifice plate range is 0 to 150 inches WC at 0 to 480 gallons per minute:

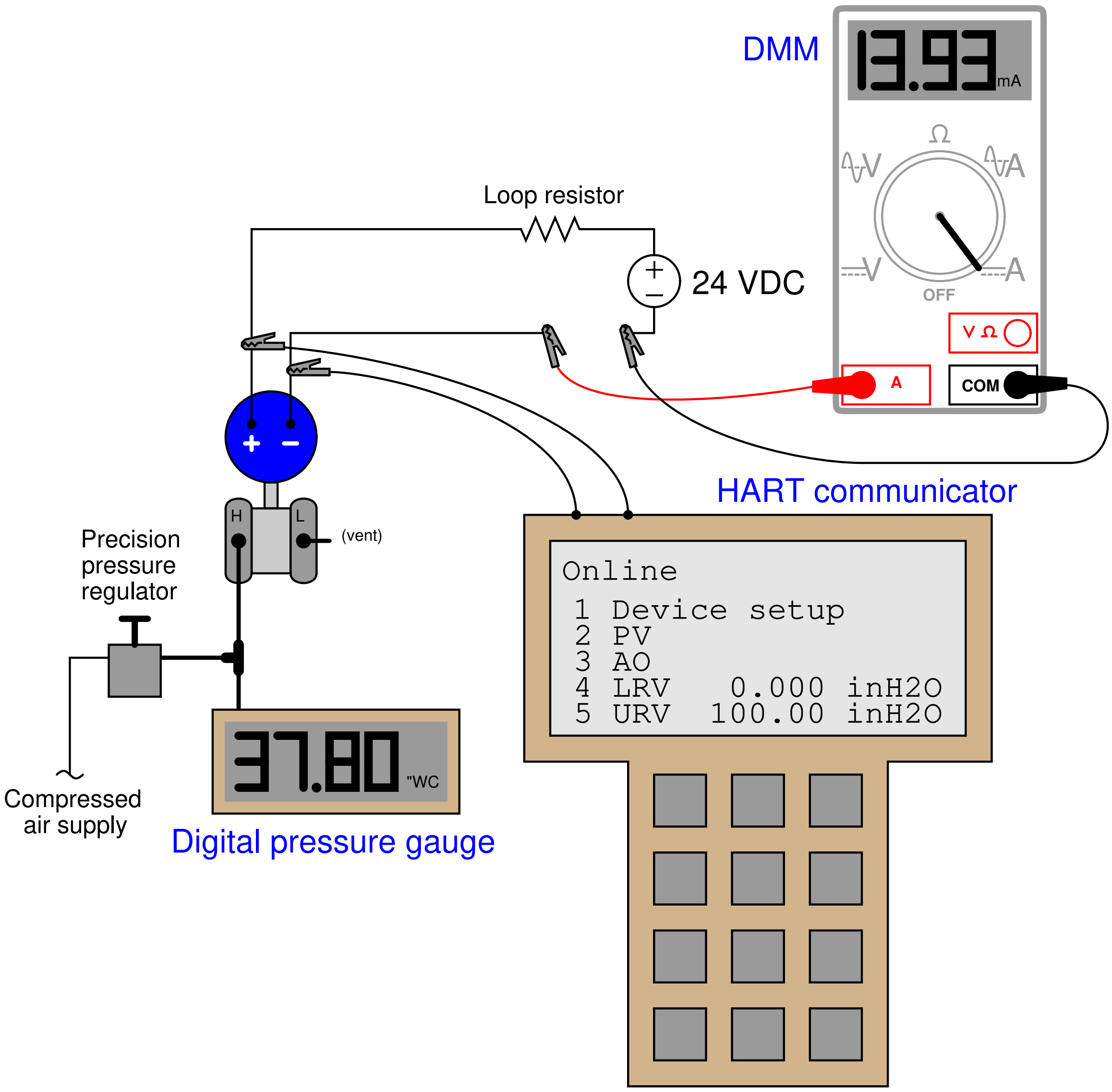


Operations personnel have strong reason to believe that the actual flow rate through this pipe is 160 GPM, yet the DCS registers a flow rate of 182.4 GPM. Based on this information, determine the likely source of calibration error in this system. Also determine whether this transmitter has square-root characterization enabled or not.

Additionally, suggest a good "next step" to perform to either pinpoint the location of this problem or correct it.
file i03443

Oppgave 25

A "smart" (digital) DP flow transmitter configured for square-root characterization is removed from service and taken to a calibration bench for testing. A technician connects a precision pressure gauge and air source to the transmitter's high port while monitoring the 4-20 mA output signal using a DMM:



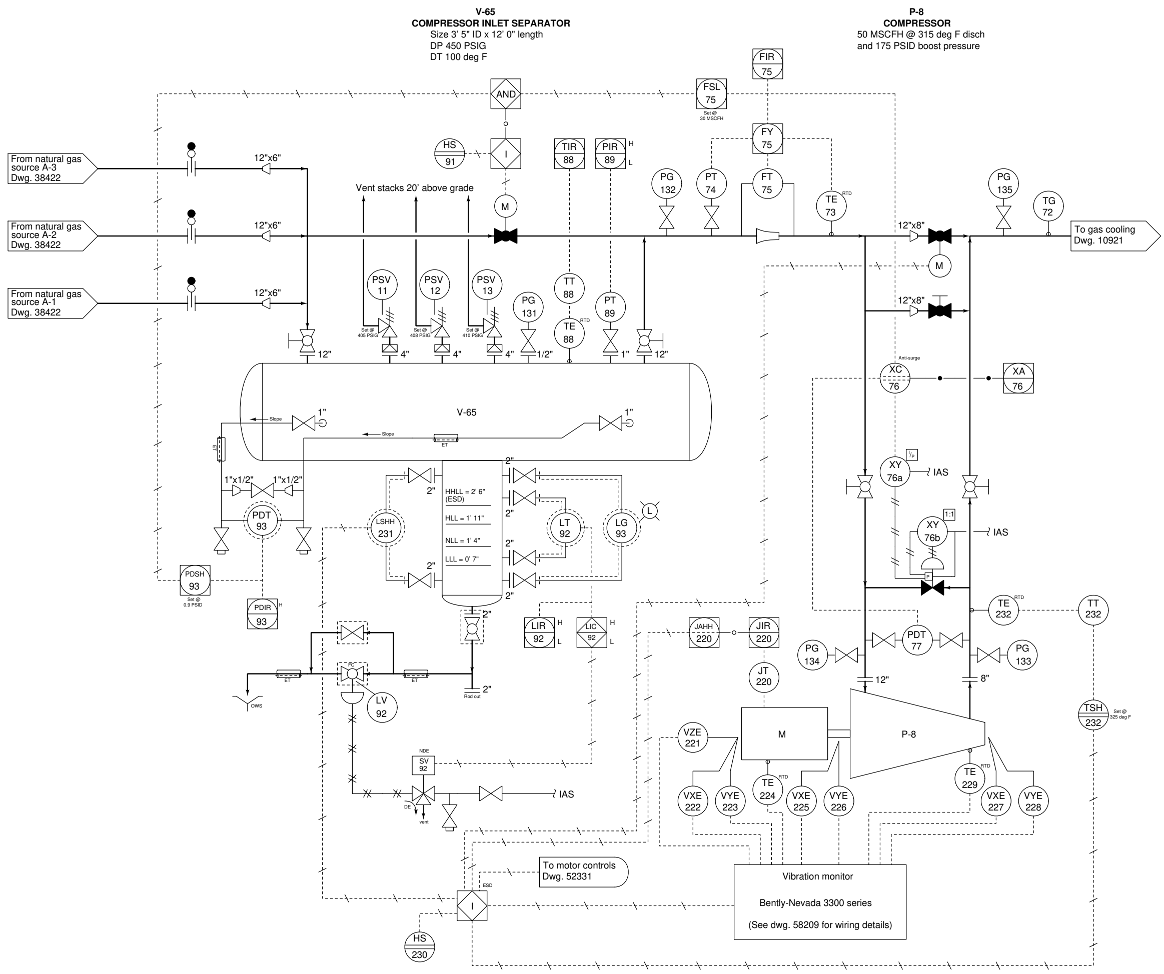
Determine what **PV** and **AO** values will be displayed on the HART communicator display if the calibration error lies entirely in the sensor (i.e. the transmitter requires a sensor trim) versus if it lies entirely in the digital-analog converter (i.e. the transmitter requires an output trim).

Parameter	**If sensor trim error**	**If output trim error**
PV		
AO		

file i03473

Oppgave 26

Pressure transmitter PT-89 on this natural gas separator vessel presently has a calibrated range of 0 to 400 PSIG. Operations personnel would like you to re-range this transmitter for 300 to 375 PSIG instead:



Answer the following questions about the task of re-ranging, explaining each of your answers:

- Does the new, requested range constitute a *zero* shift, a *span* shift, or both?
- If this is a "smart" (digital) transmitter, does it need to be *re-trimmed* as well as *re-ranged*?
- Will the control room indicator PIR-89 need to be *re-calibrated*, *re-ranged*, or both?
- Will the local pressure gauge PG-131 need to be *re-calibrated* as well?
- Will the pressure safety valves PSV-11, PSV-12, and/or PSV-13 need to be set for lower "lift" pressures?
- If the maximum (factory) range of this pressure transmitter is 0 to 750 PSI and the maximum turndown ratio for the required accuracy is 20:1, will it be able to meet

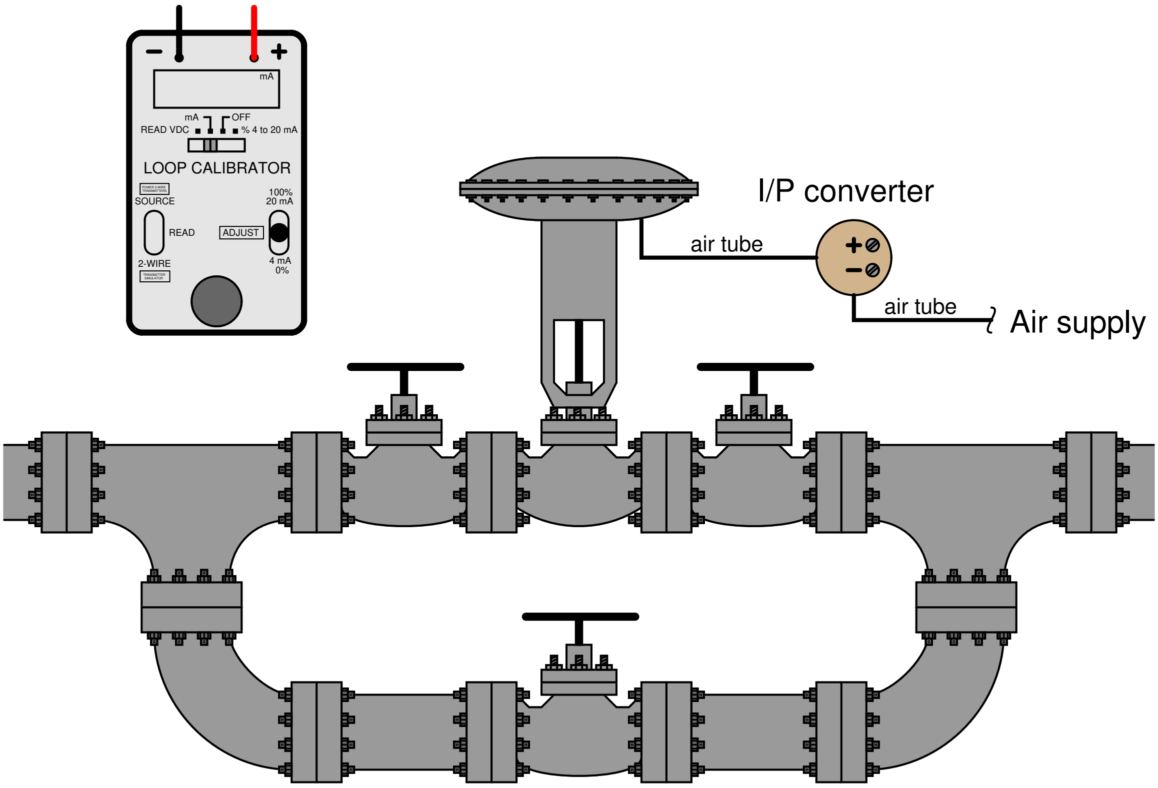
the new range? If not, what might you have to do in order to fulfill operations' request?

- Why do you suppose operations would like you to re-range this transmitter? In other words, what operational advantage(s) might be gained from doing so? Are there any potential disadvantages of having the new range versus the old?

file i03524

Oppgave 27

Suppose you are asked to check the calibration of a control valve before wires have been pulled to that location from a controller output. Process fluid is flowing through the pipe, bypassing the control valve until such time it is ready to be placed into service. The only piece of calibrated test equipment you have with you, though, is a 4-20 mA loop calibrator with an inoperative "Source" mode. The calibrator can measure and simulate 4-20 mA just fine, but it cannot *source* 4-20 mA.



Show how you could still (creatively) use the loop calibrator to stroke the valve despite its lacking functionality – feel free to add any other electronic component(s) as necessary to make it work. Then, calculate the necessary current to send to the valve to make it open to 75%, assuming a split-range calibration of 12 mA (closed) to 20 mA (open).

Also, determine the necessary hand-valve settings (fully shut, fully open, or partially open) in order to bypass flow around the control valve but maintain operator (manual) control over the flow rate, and determine which (if any) of these manual valves must be *locked* and *tagged* for safety while the control valve remains unfit for service.

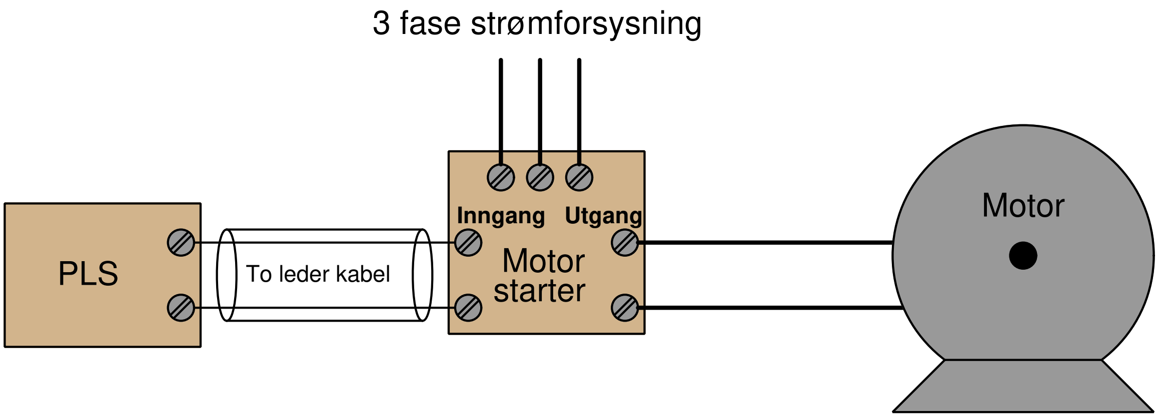
file i03617

Oppgave 28

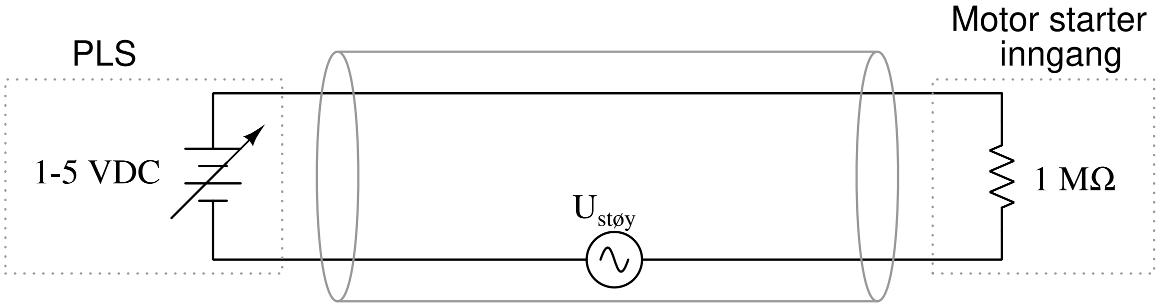
Read and outline the "LRV and URV Settings, Digital Trim (Digital Transmitters)" section of the "Instrument Calibration" chapter in your *Lessons In Industrial Instrumentation* textbook. Note the page numbers where important illustrations, photographs, equations, tables, and other relevant details are found. Prepare to thoughtfully discuss with your instructor and classmates the concepts and examples explored in this reading.
file i03905

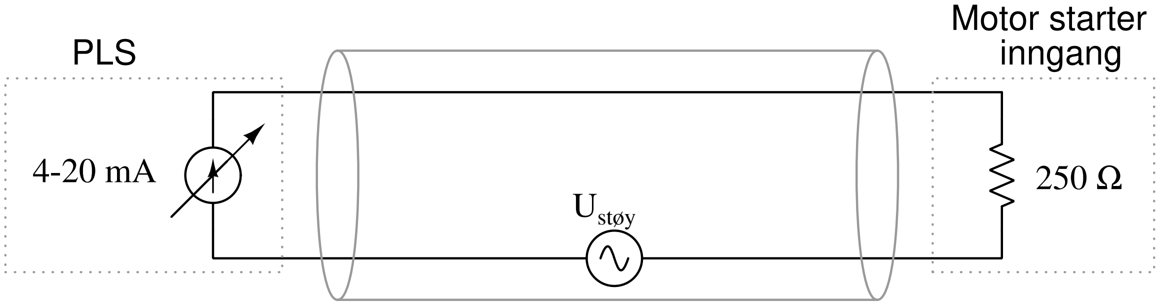
Oppgave 29

Elektriske signaler blir ofte brukt til å overføre informasjon i automatiseringsystemer. Et eksempel på dette kan være at en PLS skal gi informasjon om hvor fort en motor skal rotere.



To vanlige standarder for styresignaler er 1-5V og 4-20mA.
Det kan se ut som valget mellom 1-5V og 4-20mA er et tilfeldig. Men en av disse har mye større tolleranse mot støy på overføringskabelen. Her vises et skjema for de to signalstandardene, komplett med spenningsgenerator for støykildene på kablene.

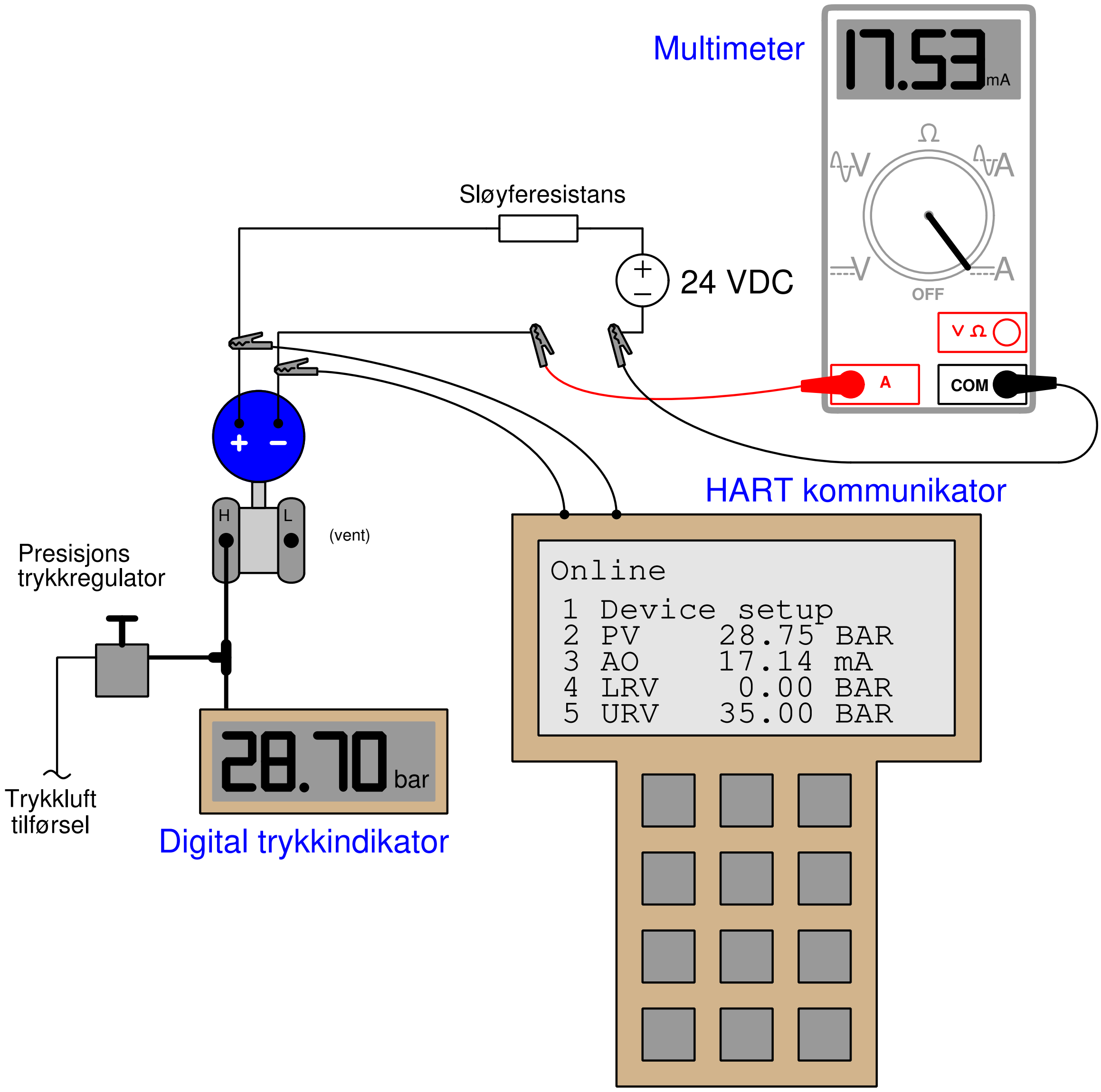




Bruk Kirchhoffs spenningslov til til avgjøre hvilen signalstandard som gir mest spenningsvariasjoner på motorstarterens inngang, og dermed påvirker motorens hastighet mest.
file if001.tex

Oppgave 30

En SMART DP-celle er tatt ut av drift og tatt med for benkkalibrering. En automatikker kobler til et presisjons trykkmanometer og en luftkilde til High inngangen på DP-cellen, mens han måler strømutgangen med et multimeter.

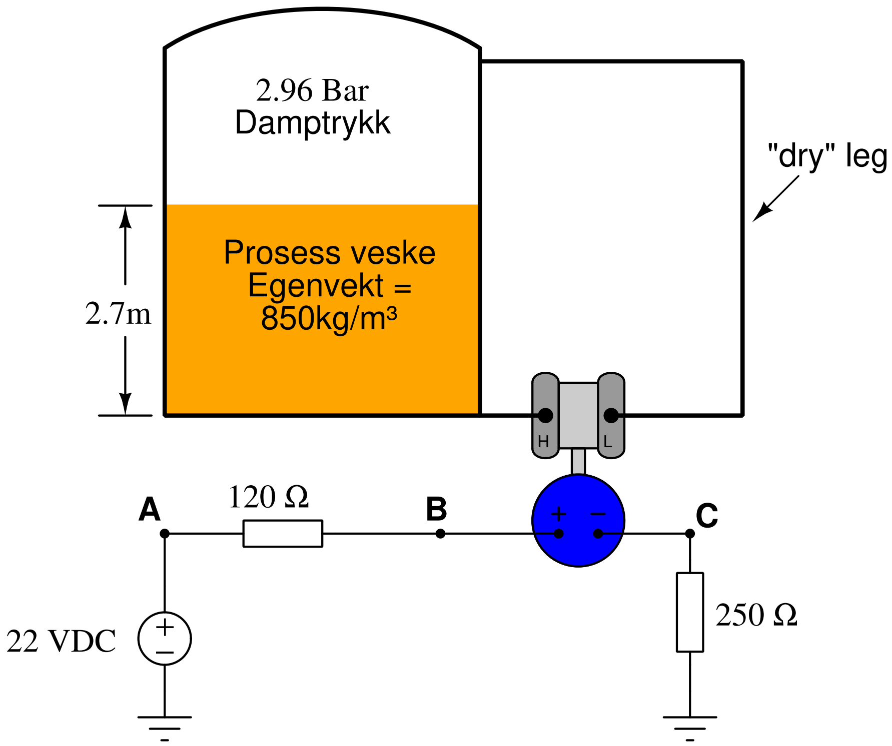


Regn ut avviket i % av måleområde for *sensor trim* og avviket i % av måleområde for *utgangstrim*. Forklar hvorfor en må ha en HART kommunikator for å kunne regne disse avvikene sepparat.

file if002.tex

Oppgave 31

Regn ut I, U_C, U_{BC} og U_B basert på at transmitteren er kalibrert for et måleområde fra 50mbar til 400mbar. Transmitteren har et utgangssignal på 4-20mA Vis alle utregninger.



Svar

Svar 1

This is a graded question – no answers or hints given!

Svar 2

This is a graded question – no answers or hints given!

Svar 3

This is a graded question – no answers or hints given!

Svar 4

This is a graded question – no answers or hints given!

Svar 5

Simply setting the LRV and URV values is not actually *calibrating* the transmitter to accurately correspond to reality. If this concept is hard to grasp, imagine a transmitter whose LRV and URV values are set perfectly, and whose DAC is calibrated just right, but whose ADC suffers from a zero shift. The microprocessor will "think" the pressure is something different from what it really is, and it will output an incorrect (zero-shifted) milliamp signal as a result.

In order to perform a sensor trim, you must connect a known pressure source (a *standard*) to the transmitter's input port and correlate that standard pressure to the pressure value registered by the microprocessor. When trimming the output, you must connect a precise milli-ammeter in series with the transmitter's output current to correlate the intended current signal of the microprocessor to the actual current.

Svar 6

The motor drive input in the 1-5 volt signal system "sees" more noise voltage than the motor drive input in the 4-20 mA signal system.

Follow-up question: what bad effects do you think noise superimposed on the DC signal cable would have on motor speed control?

Challenge question: why do you suppose the 1-5 volt signal system requires a much greater input impedance (1 MΩ) than the 4-20 mA signal system? What might happen to the voltage signal received at the motor drive's input terminals if the input resistance were much less?

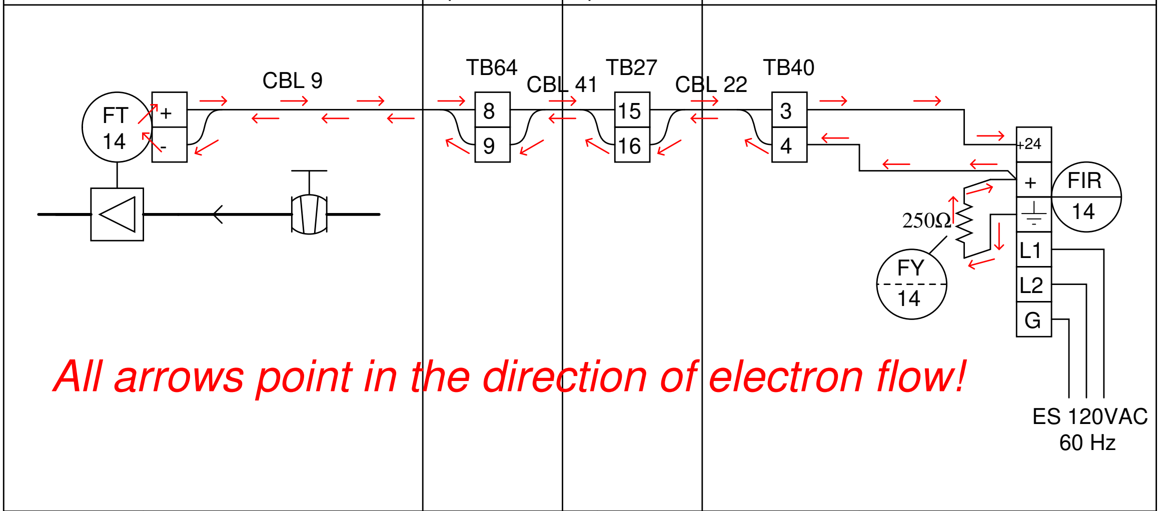
Svar 7

Percent of range	Transmitter current	V_{CD}	V_{EF}	V_{FG}	V_{AB}
0 %	4 mA	24 V	1 V	0.2 V	22.8 V
25 %	8 mA	24 V	2 V	0.4 V	21.6 V
50 %	12 mA	24 V	3 V	0.6 V	20.4 V
75 %	16 mA	24 V	4 V	0.8 V	19.2 V
100 %	20 mA	24 V	5 V	1 V	18 V

The Rosemount 3144 temperature transmitter, for example, requires a minimum of 12 volts at its terminals to function in the analog mode, and 18.1 volts in order to properly function while communicating using the HART digital-over-analog protocol. Note how the operation of such a 3144 transmitter in a loop with a 24 volt power supply and 300 ohms worth of resistance would be jeopardized near the upper end of the signal range.

Loop Diagram: #2 unit feed flow	Revised by: Reynolds Navier-Stokes	Date: April 1, 2005

Field process area	Field panel P5	Field panel P30	Control room



Tag number	Description	Manufacturer	Model	Calibration	Notes
FT-14	Vortex flow transmitter	Yokogawa		0-250 GPM 4-20 mA	
FY-14	250 Ω resistor	n/a		+/- 0.1 %	
FIR-14	Paper chart recorder	Bristol-Babcock		1-5 VDC	

Partial answer:

- Voltage across FY-14 resistor = **2.6 volts** ; Flow rate = 100 GPM
- Voltage between terminals TB40-3 and TB40-4 = **19.8 volts** ; Flow rate = 200 GPM
- Voltage across FT-14 transmitter terminals = ________ ; Flow rate = 175 GPM
- Voltage between terminals TB64-8 and TB27-15 = ________ ; Flow rate = 200 GPM

Svar 9

Partial answer:

- If a wire breaks loose at TB56-4, creating an "open" fault in the loop circuit, determine what will happen at the alarm unit (AAH, AAL-41) and also where you would expect to measure voltage in the loop circuit and where you would expect to measure *no* voltage in the loop circuit. *The AAL would trip (but not the AAH), and we would expect to measure voltage between the wires of cable 52 but not between the wires of cable 30.*

- If a fire breaks out near the conduit through which cable 52 runs, causing the conductors inside cable 52 to *short* together, what will happen in this system? Where would you expect to measure voltage in the loop circuit, and where would you expect to measure *no* voltage in the loop circuit? Where would you expect to measure current in the loop circuit, and where would you expect to measure *no* current in the loop circuit? *The AAL would trip (but not the AAH), and we would expect to measure no voltage anywhere in the loop circuit. However, we would still have current at the terminals of the AIT-41 transmitter (although no current to the right of the short).*

Svar 10

Partial answer:

- Voltage drop across transmitter signal terminals =
- Voltage drop between TB40-3 and TB27-21 =
- Voltage drop across 250 Ω resistor = **2.6 volts**
- Voltage drop between TB12-3 and TB27-21 =

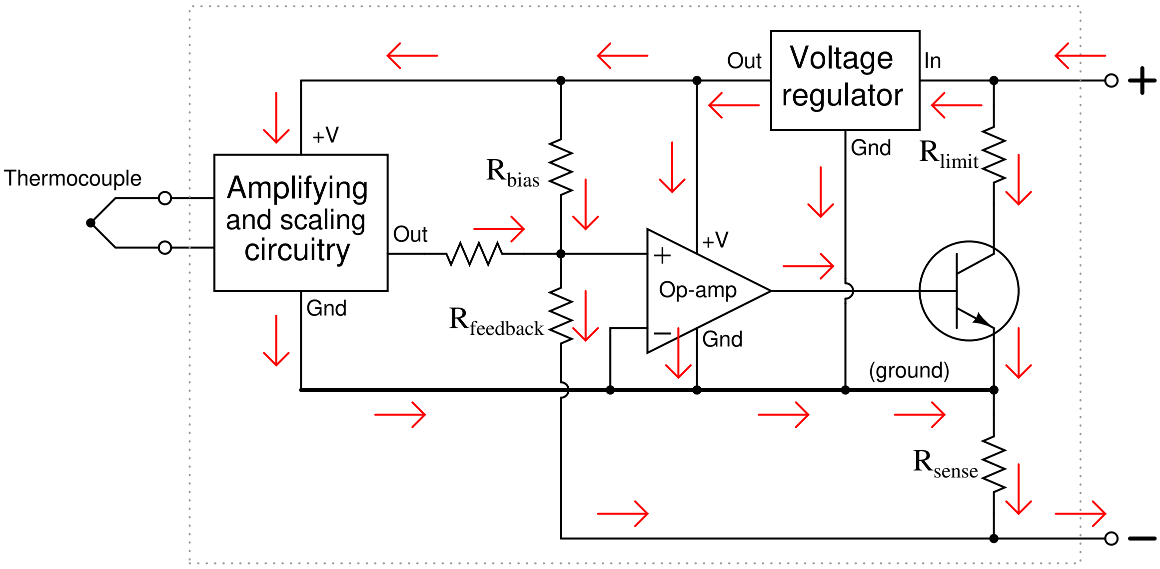
Svar 11

- Voltage between terminals TB64-8 and TB64-9 = 22.512 volts
- Voltage between terminals TB64-10 and TB64-11 = 2.744 volts
- Voltage between terminals TB27-15 and TB27-16 = 25.256 volts

Hint: if you are having difficulty analyzing this circuit, try re-drawing it in schematic form (all current-carrying components in a straight line to show their series connections).

Svar 12

$I_E = 4.3$ mA



All arrows drawn in the direction of conventional flow

Follow-up question: how would the transmitter circuit respond to an increase in temperature sensed by the thermocouple? How about a decrease in loop power supply voltage (24 volts → 20 volts)?

Challenge question: it is important for instrument accuracy that we make R_{bias} and $R_{feedback}$ resistors rather large in value. Explain why.

Svar 13

This is a graded question – no answers or hints given!

Svar 14

15.43 milliamps of current equates to a percentage value of 71.44%:

$$\frac{15.43 - 4}{16} \times 100\% = 71.44\%$$

This, in turn, represents a pH value of:

$$0.7144 \times (12 - 2) + 2 = 9.144 \text{ pH}$$

This largely agrees with the controller's display, which tells us there is a *slight* calibration error on either the part of the controller or the resistor. The huge discrepancy between this calculated pH value and what the hand-held pH meter registers, however, tells us there is either a problem with the pH transmitter, the pH probe, or the hand-held meter. We may further conclude there is no problem with the 250 Ω resistor or the indicating controller.

The proper setup of the loop calibrator is to place it into the "READ" (measure) mode so that it functions as a simple ammeter, then connect it in series with the output of the 4-wire transmitter. This may be done either with the indicating controller still in the circuit, or removed from the circuit.

Svar 15

Svar 16

Svar 17

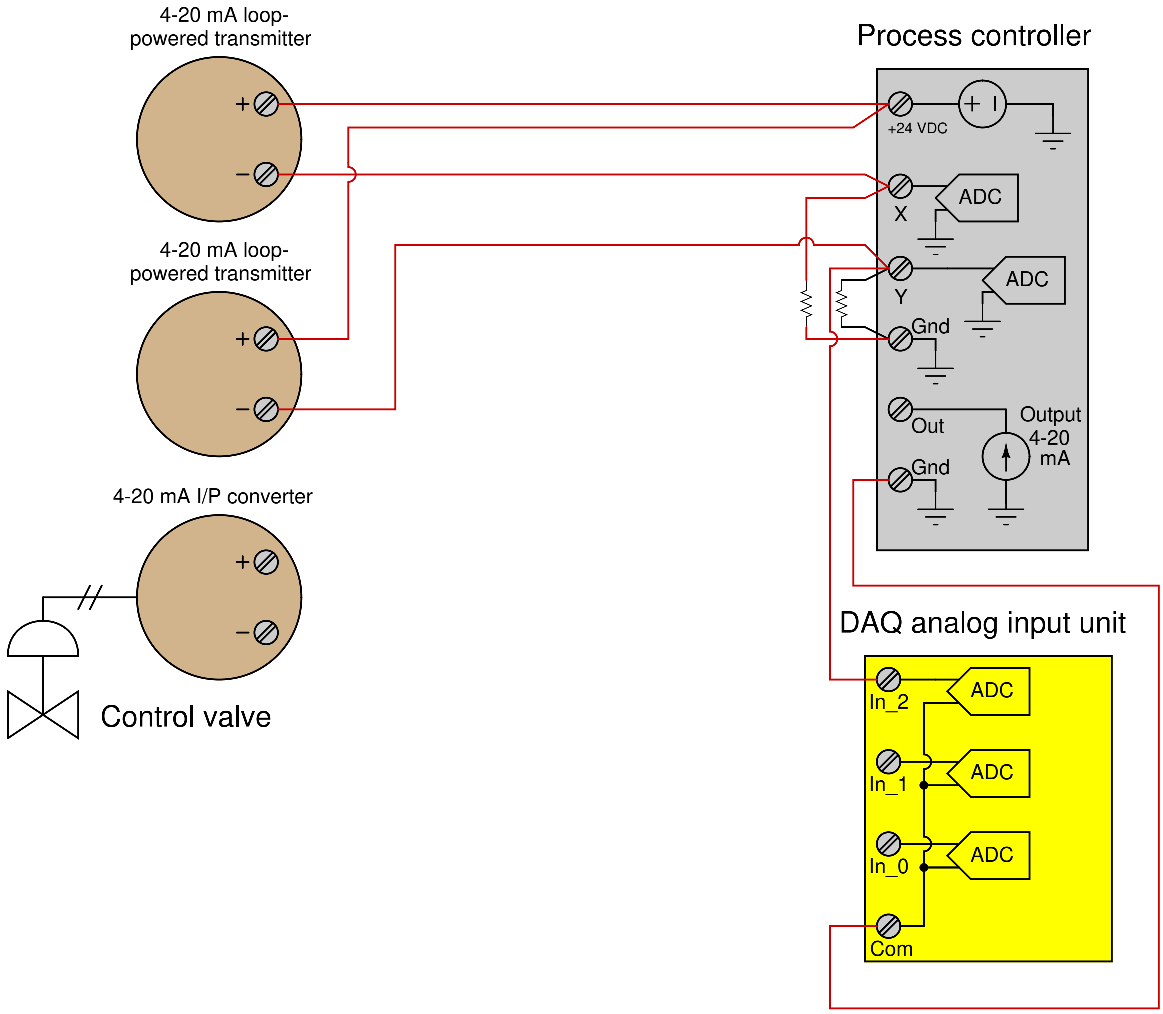
Svar 18

Svar 19

This is a graded question – no answers or hints given!

Svar 20

Partial answer:



Note that shielded cables and shield grounds are omitted from this diagram for the same of simplicity.

Svar 21

Svar 22

- $I =$ **12.77** mA
- $V_C =$ **3.192** V
- $V_{BC} =$ **17.28** V
- $V_B =$ **20.47** V

Svar 23

The problem lies with the DCS: to be specific, someone has configured square-root characterization in it as well as within the transmitter!

Svar 24

The calibration error lies either with the transmitter, the impulse lines (unequal fluid heights inside), or with the orifice plate itself. The transmitter does have square-root characterization enabled.

A good "next step" would be to block and equalize the transmitter manifold to check what its PV and AO parameters register with no applied differential pressure.

Svar 25

This is a graded question – no answers or hints given!

Svar 26

Svar 27

This is a graded question – no answers or hints given!

Svar 28

Svar 29

The motor drive input in the 1-5 volt signal system "sees" more noise voltage than the motor drive input in the 4-20 mA signal system.

Follow-up question: what bad effects do you think noise superimposed on the DC signal cable would have on motor speed control?

Challenge question: why do you suppose the 1-5 volt signal system requires a much greater input impedance (1 MΩ) than the 4-20 mA signal system? What might happen to the voltage signal received at the motor drive's input terminals if the input resistance were much less?

Svar 30

Svar 31

- $I = \underline{\mathbf{12}}$ mA
- $U_C = \underline{\mathbf{3}}$ V
- $U_{BC} = \underline{\mathbf{17.56}}$ V
- $U_B = \underline{\mathbf{20.56}}$ V