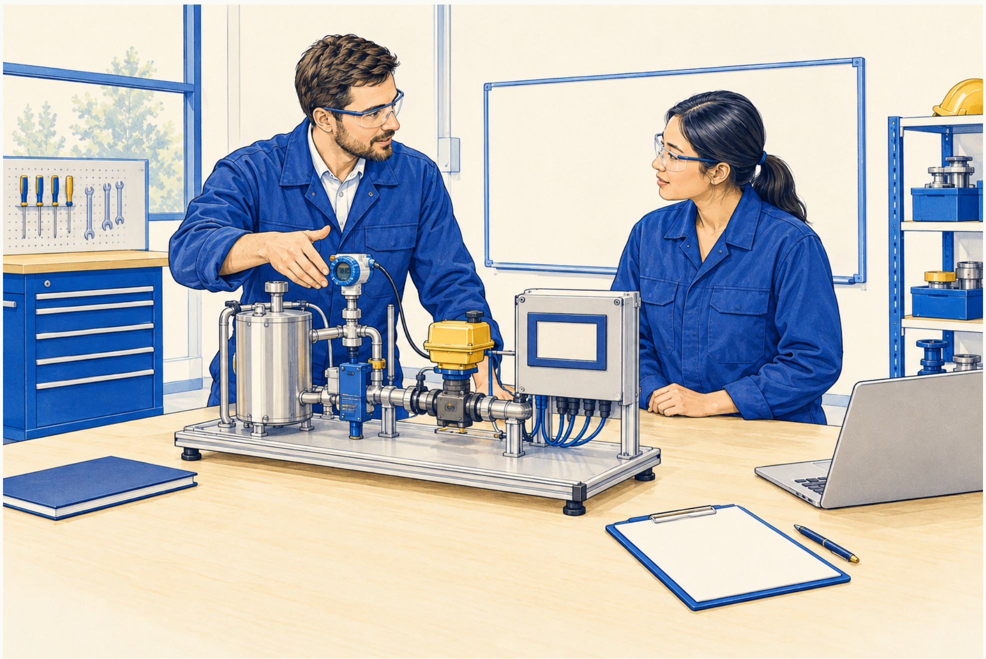
Distinguish a feedback controller from statistical monitoring

Identify the elements of a physical feedback loop, calculate a defined error and distinguish controller action from statistical monitoring.



An error of two is not an actuator command

Fictional case: a teaching controller has setpoint 50 and measured value 48 in fictional temperature units. The defined error is setpoint minus measurement, so it is 2. The core loop retains these exact values and the separate disturbance and SPC-monitoring paths. Technician Kai must explain the diagram without prescribing a valve position or PID gain.

Your role and the reference condition

Controls engineer and process learner
Normal: A specified controller compares measured feedback with a reference and applies its authorized control law through an actuator; measurement and disturbances are represented accurately.
Gap: A learner says "error 2 means open the valve 2%" and moves the SPC chart into the fast control loop.

Work within these conditions

1. The numbers are fictional and have no equipment operating meaning.

2. No control law, gain, output scale, safety interlock or tuning procedure is supplied.

Fictional teaching case. Supplied observations support the exercise; proposed actions are not verified customer results.

See how the method works

An engineering feedback loop measures a variable, compares it with a setpoint and uses a controller and actuator to influence the physical process. The sensor returns information so the loop can respond to disturbances. With the stated sign convention, error is setpoint minus measurement. That arithmetic does not specify the controller output: a real control law, dynamics and safety design determine the action. Statistical process monitoring asks a different question about patterns over time and sits outside this simplified fast loop. Do not interpret a control-chart signal as a recipe for tuning gains or bypassing equipment protections. This diagram explains roles, not a safe implementation for a particular machine.

01 Setpoint: 50

Target in fictional temperature units.

02 Controller: error 2

Compare 50 − 48; actual control law determines the output.

03 Actuator

Applies the authorized controller output to the process.

04 Physical process

Responds to actuator influence and disturbances.

05 Sensor: 48

Measures the process variable and returns feedback.

06 Disturbance

External influence on the physical process.

07 SPC monitoring

Examines recorded measurements in time order outside this fast loop.

Read every connection

1. Step 1 > 2
setpoint
2. Step 2 > 3
authorized control law
3. Step 3 > 4
physical influence
4. Step 4 > 5
measured variable
5. Step 5 > 2
feedback48
6. Step 6 > 4
disturbance
7. Step 5 > 7
measurements over time

Disturbance enters physical process.

SPC observes behaviour over time outside this fast loop.

No tuning values, operating recipe or safe machine command is provided.

Follow the evidence and decisions

Inspect the supplied case inputs

Loop element	Supplied role/value
Setpoint	50 fictional units
Sensor reading	48 fictional units
Error definition	Setpoint minus measured value
Controller output	Not calculable without the authorized control law
Disturbance	Acts on the physical process
SPC	Observes recorded measurements over time separately

01 / Trace the physical and information paths

Kai follows setpoint to controller, controller output to actuator, actuator influence to process, and measured feedback from sensor to controller. He identifies the disturbance entering the process.

Why: A loop diagram should distinguish information from physical influence. A missing feedback edge changes the mechanism, not merely the picture.

Evidence / check: Every core edge is accounted for, including sensor return and disturbance entry.

02 / Calculate only the defined error

Using the stated convention, Kai computes $50-48=2$ fictional units. He writes the convention because an alternate sign definition would change the numerical sign.

Why: The error has the units of the compared variable. It is not automatically an actuator percentage or an instruction to adjust equipment.

Evidence / check: The record contains setpoint, measurement, sign convention and error units.

03 / Identify the missing output authority

He explains that the actual controller law, configuration, dynamics and limits determine the command. The exercise supplies none, so no valve opening or gain can be derived.

Why: A proportional-looking arithmetic shortcut would invent a control law and ignore physical constraints. The correct teaching response is to identify what is missing.

Evidence / check: Controller output is explicitly not determined from the supplied values.

04 / Separate SPC monitoring

The recorded sensor values can also feed a time-order statistical monitoring view outside the fast feedback path. That view can reveal longer-term behavior and prompt investigation through the process response.

Why: Statistical monitoring and engineering feedback serve different functions. A control-chart limit is not a controller setpoint, and a chart signal is not itself a tuning command.

Evidence / check: The diagram preserves a separate measurement-to-SPC branch.

05 / Describe a safe learning comparison

Kai proposes using a simulation or approved training system to show how a disturbance changes measurement and how an authorized controller responds. Real settings remain under qualified engineering control.

Why: Understanding the mechanism can be taught without providing unvalidated operating instructions. The lesson should develop reasoning about paths and authority.

Evidence / check: The next exercise labels simulated behavior and does not modify actual equipment.

Completed feedback-loop interpretation record

Question	Completed answer	Boundary
What is the error?	50−48=2 fictional units	Defined sign convention
What moves the process?	Actuator under controller command	Command not supplied
Where does disturbance enter?	Physical process	Not a specification change
Where is SPC?	Separate recorded-data monitoring	Not the fast control law

The sensor reading is suspect

The sensor reports 48, but an approved independent check indicates a measurement fault.

Decision

Escalate through the applicable instrumentation/process procedure and distinguish measurement validity from a real process deviation. Do not tune the controller to compensate for an unverified sensor problem.

Reasoning

The loop acts on feedback; bad measurement can mislead both controller and monitoring. Repair authority and safe state depend on the actual system.

What would change the decision?

The evidence record marks sensor validity unresolved and names the qualified owner.

Practise with a changed case

Change the setpoint and compare the functions

New fictional simulation has setpoint 60, reading 63 and the same error convention. A learner proposes an actuator command of−3 and says a control-chart signal confirms that command.

Input	Value
Setpoint	60
Measured value	63
Error convention	Setpoint minus measurement
Control law	Not supplied

Your task

1. Calculate the error with units.
2. Explain why an actuator command remains unknown.
3. Draw separate feedback and SPC paths and identify where a disturbance acts.

Use the next page to record your reasoning before reading the answer.

Your practice worksheet

Change the setpoint and compare the functions

Reference and measurement

Error sign/units

Missing control law

Physical feedback path

Statistical monitoring branch

Complete your reasoning before turning to the answer. Use the separate learner workbook for group practice.

Check your reasoning and transfer it

1. Error=60−63=−3 fictional units. That is a comparison result, not an actuator command; the authorized control law and system constraints are not supplied.

2. Sensor feedback returns to the controller; controller output drives the actuator and process. A disturbance acts on the process. SPC examines measurements over time separately and does not validate an invented command.

Suggested completed record

Item	Result	Meaning
Error	−3 fictional units	Measurement above reference under this convention
Actuator output	Undetermined	Need authorized control law
SPC signal	Monitoring evidence	Not a tuning instruction

Plausible wrong turns

1. Error units do not become actuator percentages by assumption.

2. Statistical and engineering control are different mechanisms.

Evidence of a sound answer

1. Use the stated sign convention.

2. Preserve every feedback edge.

3. Avoid invented gains or operating commands.

Take the learning back to work

Commitment	Agreed follow-through
Owner	Qualified controls engineer with process owner
Record	Controlled loop design, instrument status and monitoring-response records
Review	At approved changes and relevant abnormality reviews
Verification evidence	Valid measurement and verified behavior under authorized design
If unresolved	Investigate sensor/process/controller evidence through the qualified authority; never infer tuning from a teaching diagram.

Help someone else apply the method

Prepare

1. Loop-element cards
2. Arrows of two styles
3. Simulation-only value cards

Minutes	Activity and coaching prompt
5	Trace the loop Which arrows carry information and which influence the process?
8	Calculate the defined error What units does the result have?
10	Work the 60/63 case What remains unknown despite correct arithmetic?
5	Debrief sensor fault Why might adjustment worsen the problem?

Debrief

1. Require a visible sensor-return edge.
2. Do not reward a guessed output command as a more complete answer.

Individual or remote practice

Draw both paths first, then annotate only values actually supplied.

Connect the method and check its boundaries

Before application

1. Defined measured variable and sign convention
2. An identified physical process and disturbance

Outside this lesson

1. PID tuning or machine-specific commands
2. Replacement of SPC by a controller

NIST: Control loop

NIST: Control loop

A control loop relates sensor measurements, controller/setpoint logic and actuator commands with process feedback.

Public primary-source summary; underlying paid standards/forms are not reproduced.

Open this lesson and its visual aids