PLANT TYPES AND CONTROLS

Plant types

In spite of wide diversity of applications, the principles of automation are similar.

There are a few basic types of plants and the same control system hardware and basic software is shared by most applications.

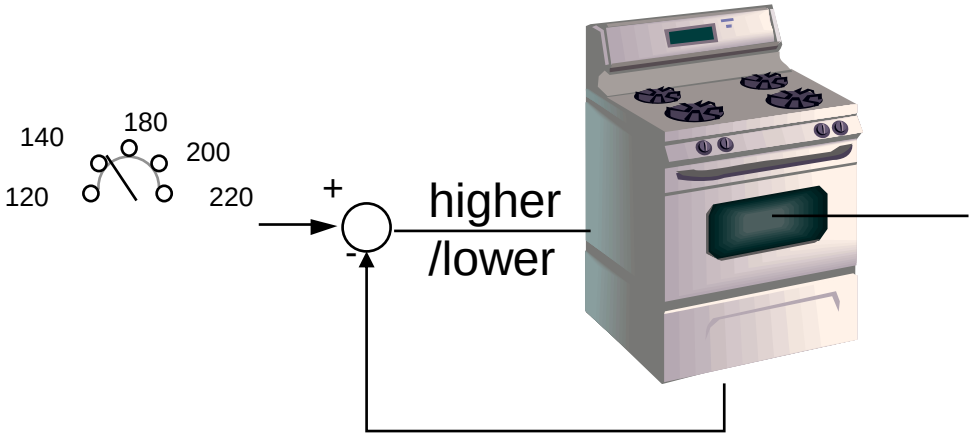
Control Tasks

measure - command - control

Open loop and closed loop

temperature

open loop: temperature is imprecise, depends on ambient temperature and cooking quantity
but time of heating can be modulated.

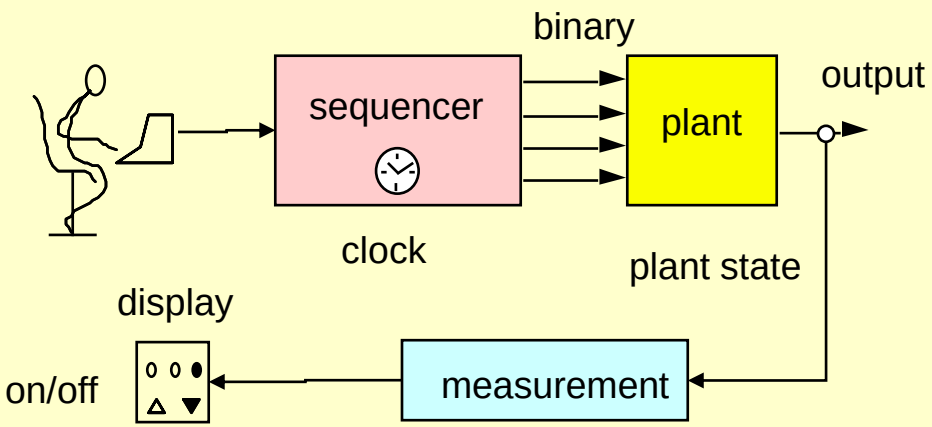


closed loop:
temperature closely controlled, requires measurement of the output variable (temperature)

Open loop and closed loop

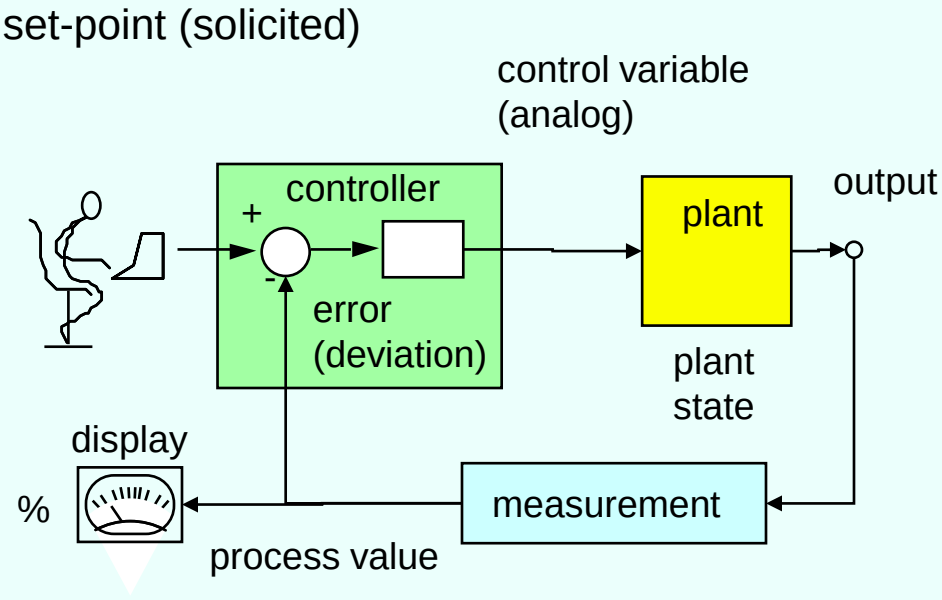
open-loop control / command

keywords: sequential / combinatorial, binary variables, discrete processes, "batch control", "manufacturing"



closed-loop control / regulation

keywords: feedback, analog variables, continuous processes, "process control"



Function of computers in control systems

open-loop functions

Data acquisition and pre-processing

Data transfer between plant and operator

Display the plant state

Logging and history recording

Simulation and training

Process optimization algorithms

closed-loop functions

Protection and interlocking*

Regulation

Process-driven sequential control

the control system acts directly and autonomously on the plant

Interlocking*: prevent dangerous actions, such as all lights on green at a crossing

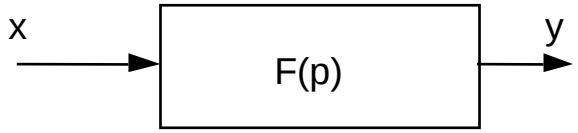
Discrete and continuous plants

discrete control

continuous control

Continuous plants

Examples: Drives, Ovens, Chemical Reactors



Continuous plants (processes) have states that can be described by a continuous (analog) variable (temperature, voltage, speed,...)

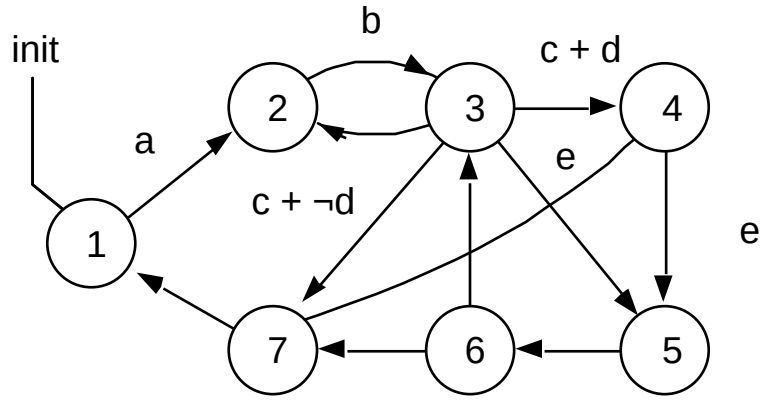
Between plant input and plant output, there exists a fixed relation which can be described by a continuous model (transfer function).

Continuous plants are mostly reversible and monotone:
This is the condition necessary to control them, i.e. impose the value of their output.

The transfer function may be described by a differential equation, simplified to a Laplace or a z-transform when the system is linear.

The principal control task in relation with a continuous process is its *regulation* (maintain the state on a determined level or trajectory)

Discrete plants



A discrete plant is modeled by well-defined, exhaustive and non-overlapping states, and by abrupt transitions from one state to the next caused by events.

Discrete plants are mainly reversible, but not monotone:
the removal of the stimulus which caused a state transition will not necessarily bring the plant back to the previous state.

Example: a lift will not go back to the previous floor when releasing the button that called it.

Going back to a previous state may require transit through several other states.

Discrete plants are described by Finite State Machines, Petri Net, State transition tables Grafcet, SDL or Sequential Function Chart diagrams.

The main task of a control system in relation with discrete plants is their command.

Continuous and batch processes

Continuous process

continuous flow of material or energy

e.g. motor control, cement, glass, paper production,
rolling mill for wires, plate or profiles,
newspaper printing: 23 m/s, steel wire 90 m/s

Main task: **regulation**

Batch process

discrete processes with handling of individual elements

e.g. Numerical Controlled machine, packing machines,
Bottle-filling, manufacturing, pharmaceutical and chemical processes.

Main task: **command**

Mixed plants

In reality, all plants consist of discrete and of continuous processes.

Example 1: Motor Control of a cable-car with speed control and stop at stations

Example 2: A bottle-filling line is in principle a continuous process, but each step consists of a sequence of operations

All parts must de described individually.

Processes can be described as continuous within a discrete state or as non-linear, continuous process.

Example: Time-triggered set-point of an oven temperature.

Mixed Plants are the normal case - a question of point of view.

All processes have some continuous and some discrete behavior

The main categories in industry

industry distinguishes the following categories of applications:

"process control": continuous processes, associated with fluxes,
e.g. sewage water treatment, petrochemical process, cement…

"batch control": semi-continuous processes, associated with individual products,
e.g. fine chemicals, pharmaceutical, brewery…

"manufacturing": also called “factory automation”
discrete processes, associated with transformation of parts,
e.g. automobile industry, bottle-filling, packaging