Overview of micro drive systems

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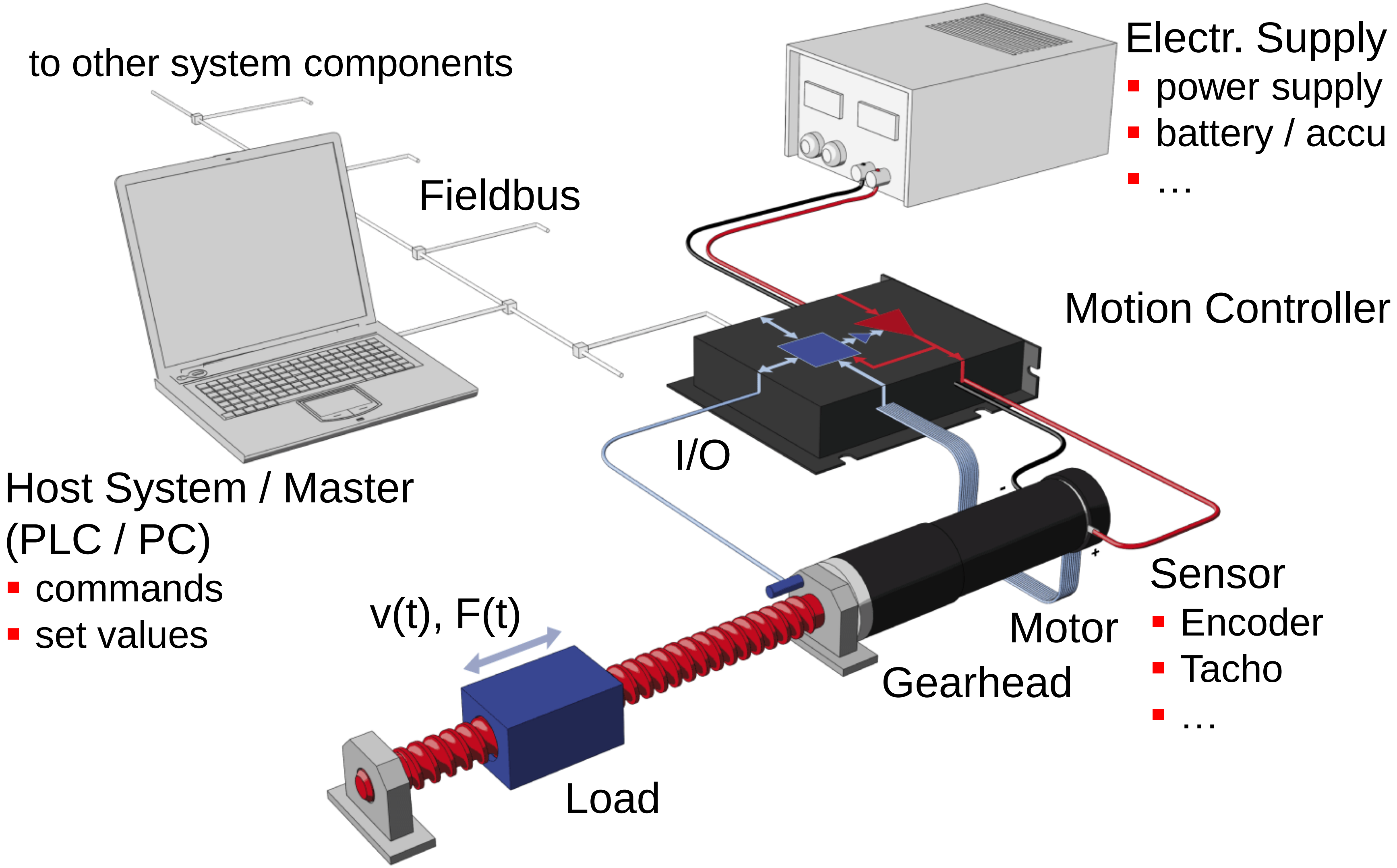
maxon motor

Agenda

- What do I want to move?
- How should the drive look like as a complete drive system?
- Which parameters are fixed, which variable?
- How do the boundary conditions look like?

- Focus: Providing clarification by means of a situation analysis.

The Components of a Drive Systems



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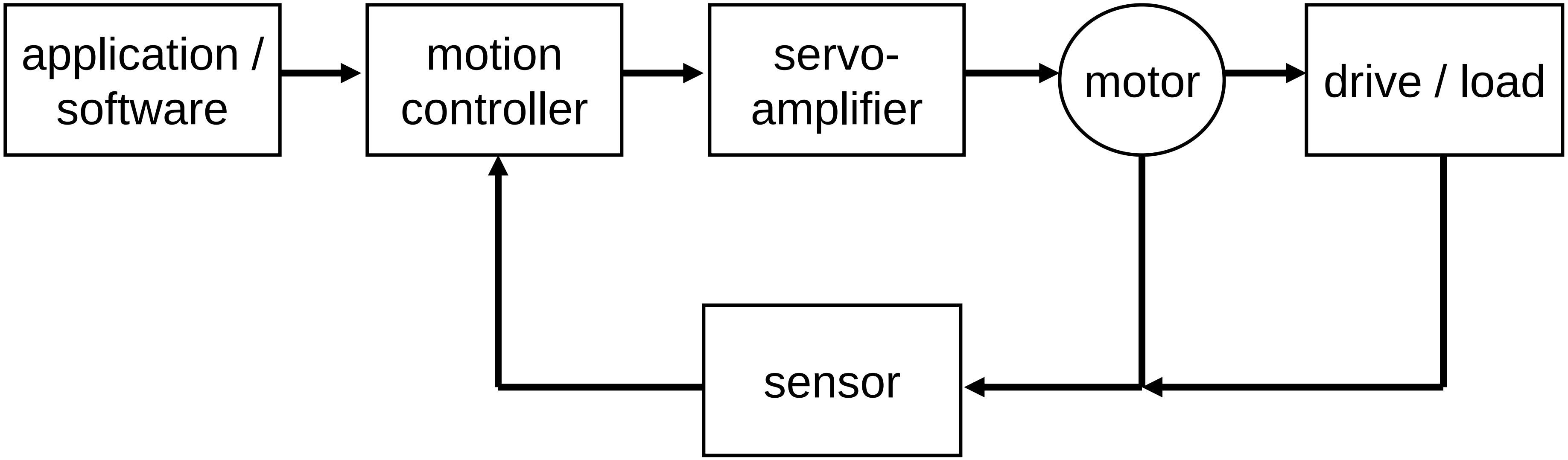
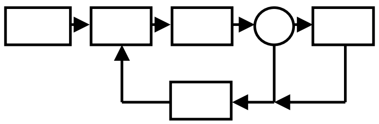


Control concept

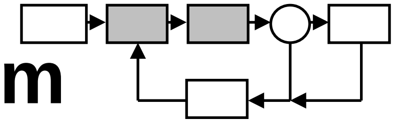


- What to control?
  - torque, current
  - rotational speed, linear speed
  - position
- In which range, with which precision?
  - Position resolution
  - Speed stability
- Which communication?
  - Integration into the supervisor system
  - Set value demand

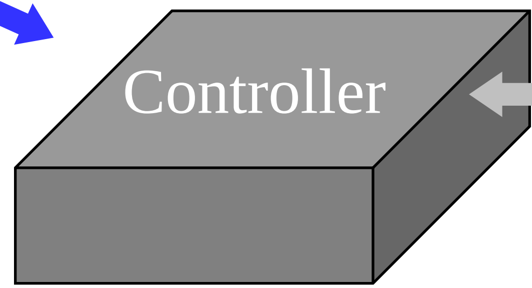
Pre-selection of

- controller, motion controller
- sensor
- motor type
- drive

Controller: The Heart of the Drive System



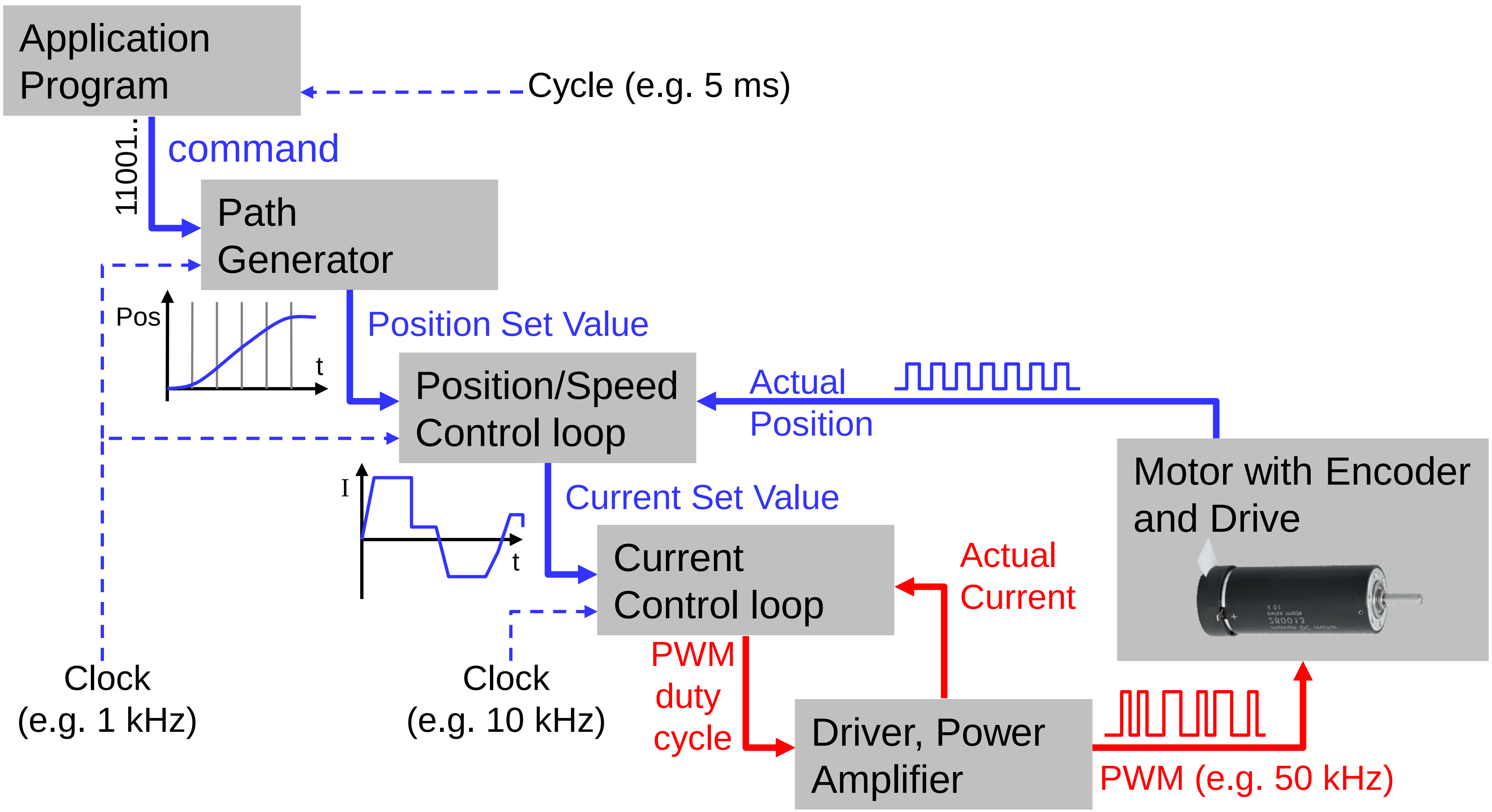
- Communication
  - Host, Master
  - I/O
- Power Supply
  - cont. current
  - max. current
  - voltage



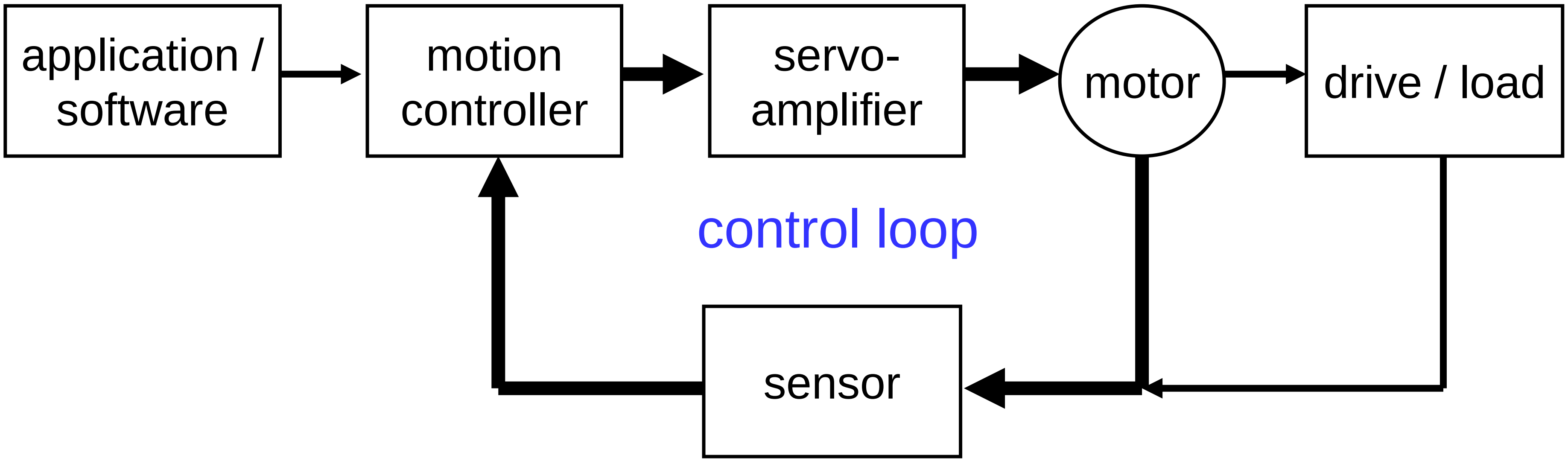
- controlled quantity
- power
- digital – analogue
- …

- Sensor
  - measured quantity
  - resolution
- Motor
  - motor type
  - power
- Gearhead, mech. drive
  - reduction ratio
  - backlash

Example: position control loop

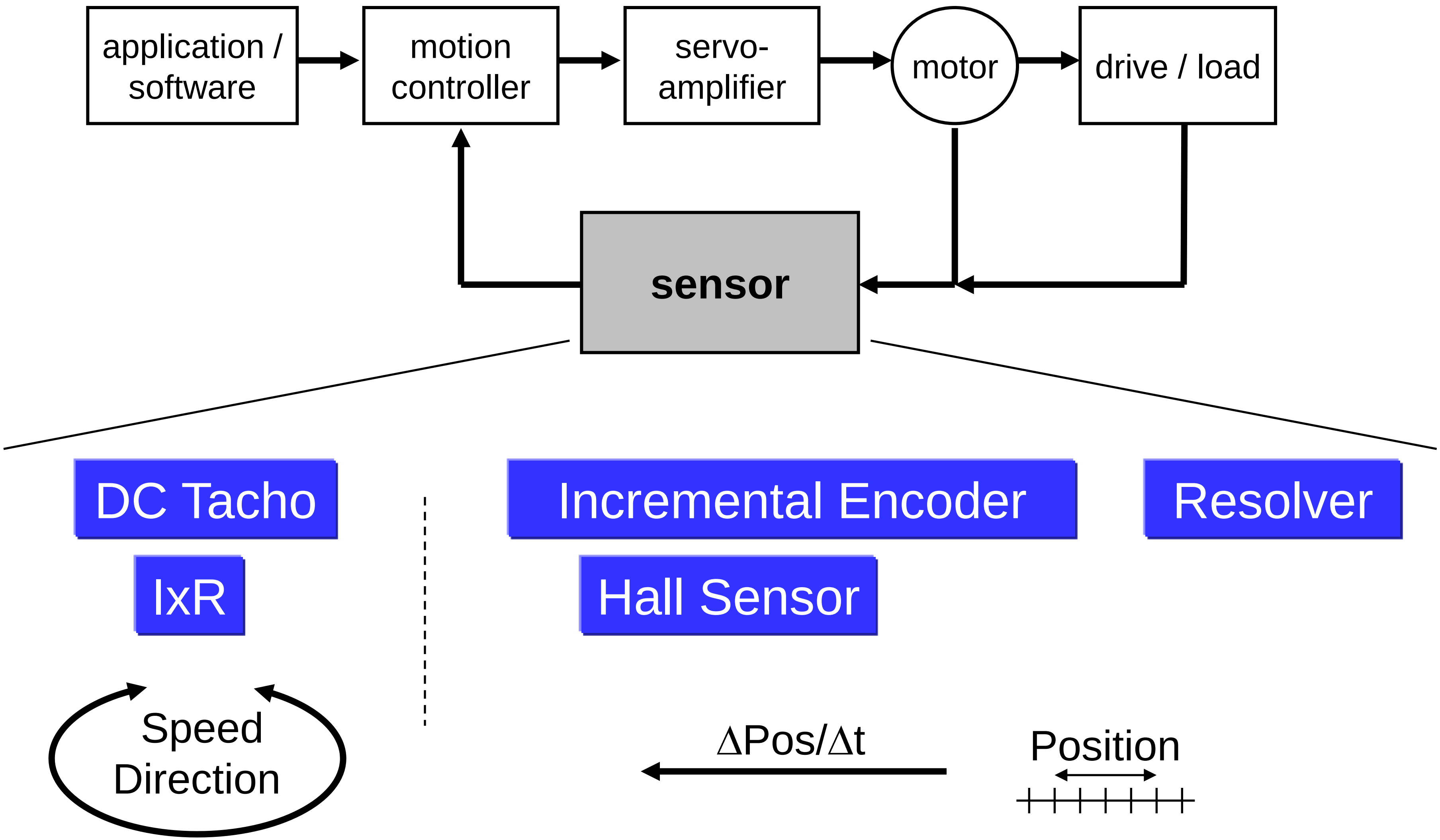


Task and control accuracy



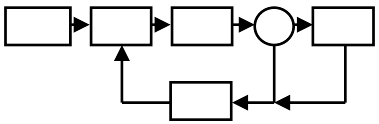
- The accuracy of control is the combined result of **all components** in a drive system!
  - resolution, precision
  - signal amplification, control parameter
  - phase shifts, time shifts, backlash, mech. play

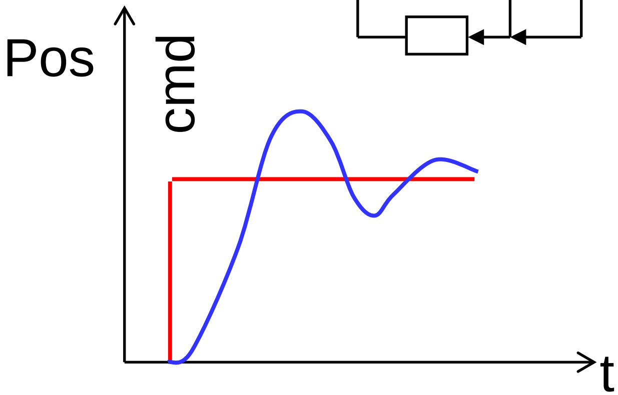
Sensors

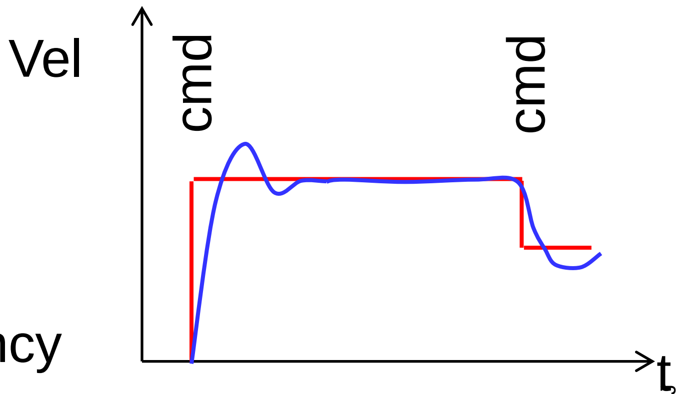

application / software
motion controller
servo-amplifier
motor
drive / load
sensor
DC Tacho
IxR
Speed Direction
Incremental Encoder
Resolver
Hall Sensor
ΔPos/Δt
Position

Accuracy has many aspects

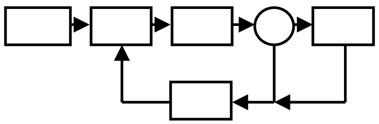
- position accuracy
  - absolute, relative, repeatability
  - overshoot permitted?
  - mechanical play in couplings and gears, …
  - encoder resolution
- speed accuracy
  - corrected in which time?
  - min. speed given by encoder resolution
  - max. speed given by max. encoder frequency
  - speed ripple given by current and/or torque ripple
- electronic components
  - resolution of analogue-digital or frequency-voltage converters
  - band width, temperature drifts

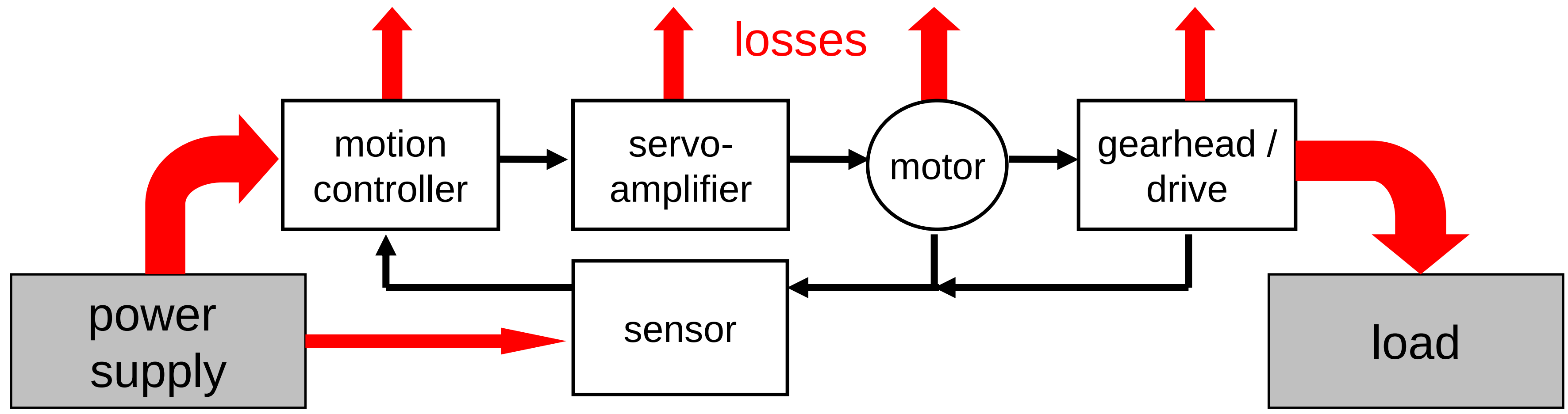






Power flow





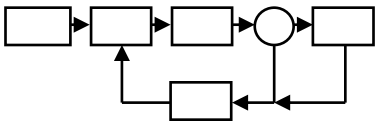
$P_{el} = U \cdot I$

$P_{mech} = v \cdot F$

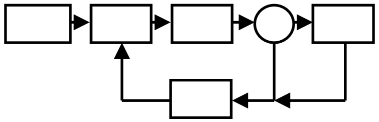
$P_{mech} = \omega \cdot M$

- power:
  - consists of two components : One component can only increase at the expense of the other.
  - energy is not stored: Power flow
  - Power: a „constant“ reference value of the drive system

Power: Basic rules



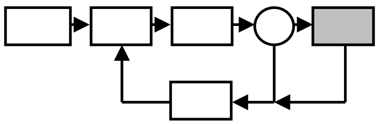
- Electrical power must be higher than the required mechanical power of the load.
  - compensation of losses
- Drive components must fulfil both power factors independently
  - force as well as speed
  - current as well as voltage
- Power is limited by the drive components
  - the weakest link in the drive chain counts
  - applies to both power factors independently

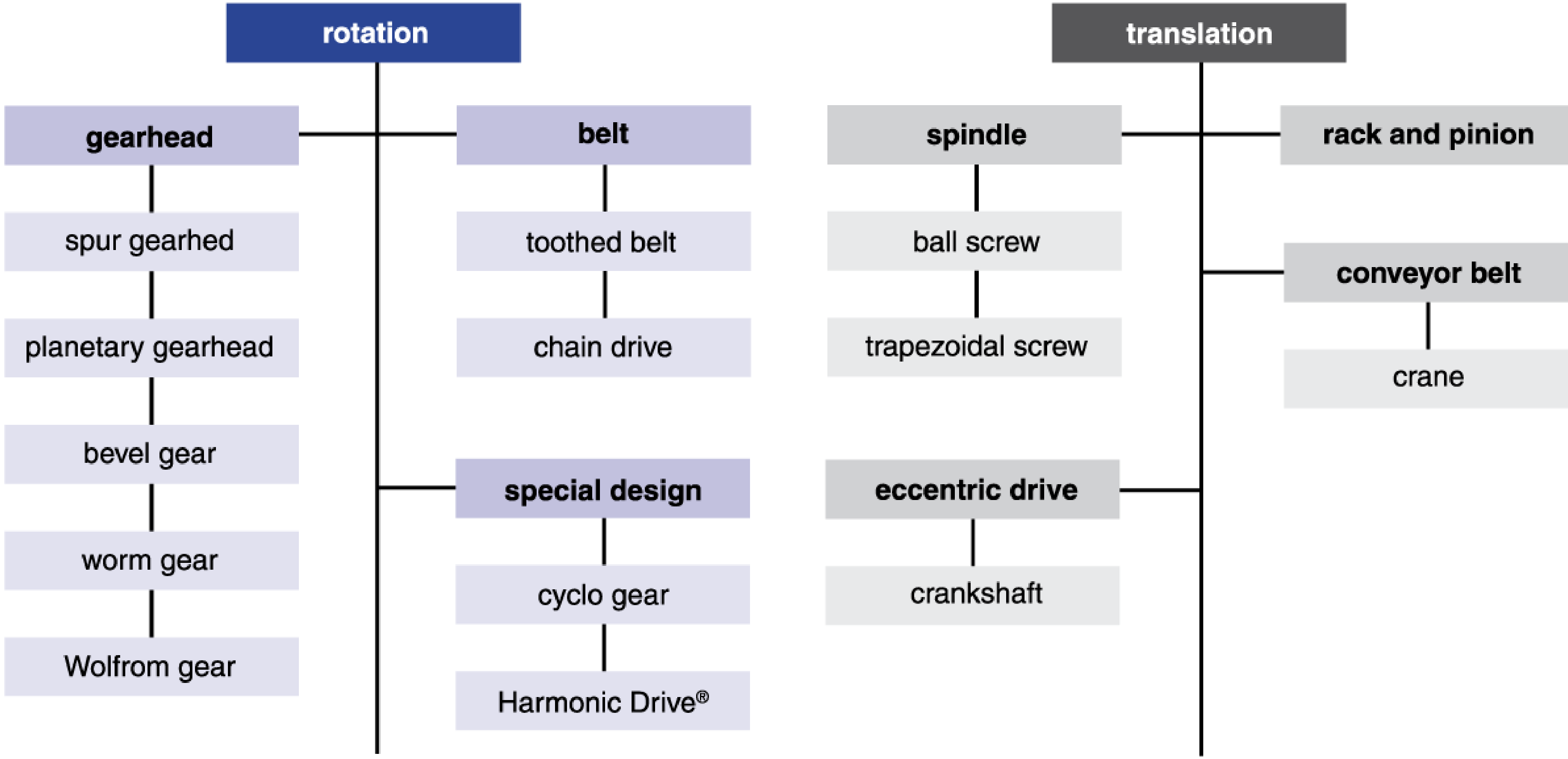


Transformation of power

- transformation of power
  - electrical to electrical: e.g. trafo, power stage of controller
  - electrical to mechanical: e.g. motor
  - mechanical to mechanical: e.g. gearhead, mech. drive
- power losses described by efficiency
- typical efficiency values
  - pulsed power stage 90%
  - DC motor optimum 80-90%
  - planetary gear per stage 90% (worm gear: <40%)
  - ball screw 80-90% (trapezoidal screw: 40%)

Load types and mechanical drives





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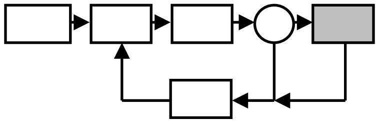


- Rotation
  - torque
  - angular speed, rot. speed
  - angular acceleration of moment of mass inertia

$$M = J \cdot \alpha = J \cdot \frac{\Delta\omega}{\Delta t} = J \cdot \frac{\pi}{30} \frac{\Delta n}{\Delta t}$$

  - angular position accuracy
  - mechanical play

- Translation
  - forces
  - speeds
  - linear acceleration of masses

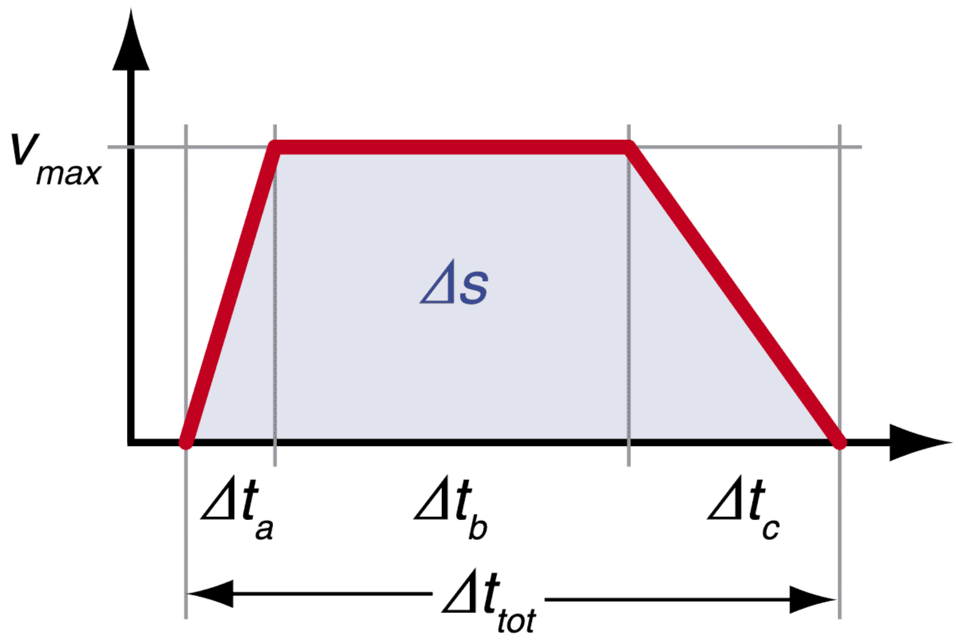
$$F = m \cdot a = m \cdot \frac{\Delta v}{\Delta t}$$

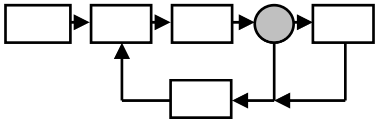
  - position accuracy
  - mechanical play

Operation mode

- How does a working cycle look like?
- How many times is it to be repeated? Dwell times?
- How large are the forces how high the speeds?

- continuous operation
- cyclic operation
- On-Off operation
- short term operation





Motors up to about 500W

- DC motor with brushes
  - simple control: applying a voltage
  - Life time limited by brush system (typically 3‘000-5‘000h)
  - Max. speed limited by brush system (up to 15‘000 min^{-1})
- EC motor without brushes
  - control: electronic commutation necessary
  - Life time only limited by ball bearings (typically > 20‘000h)
  - High speeds up to 80‘000 min^{-1} possible
- Stepper motors
  - „digital“ motor, simple positioning possible
  - Open loop
  - Life time limited by bearings
  - max. speeds limited (2‘000 to 5‘000 min^{-1})
- (Linear motors)
  - Direct linear drive

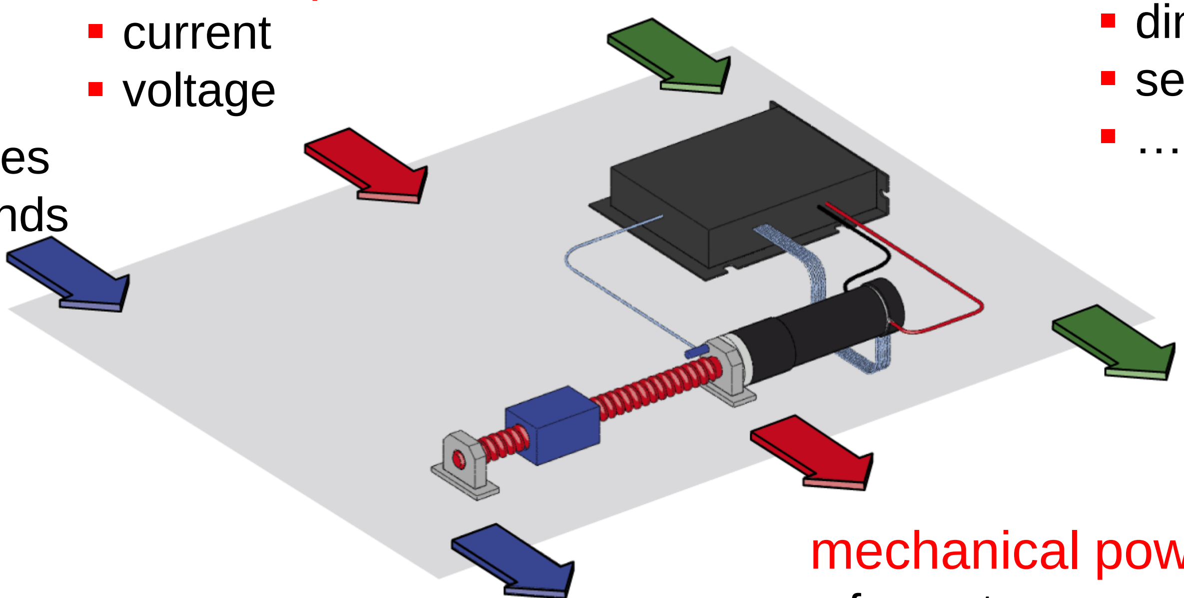
Drive system as a black box

environment
- temperature, atmosphere
- impacts, vibration
- …

electrical power
- current
- voltage

task
- set values
- commands

boundary conditions
- dimensions
- service life
- …

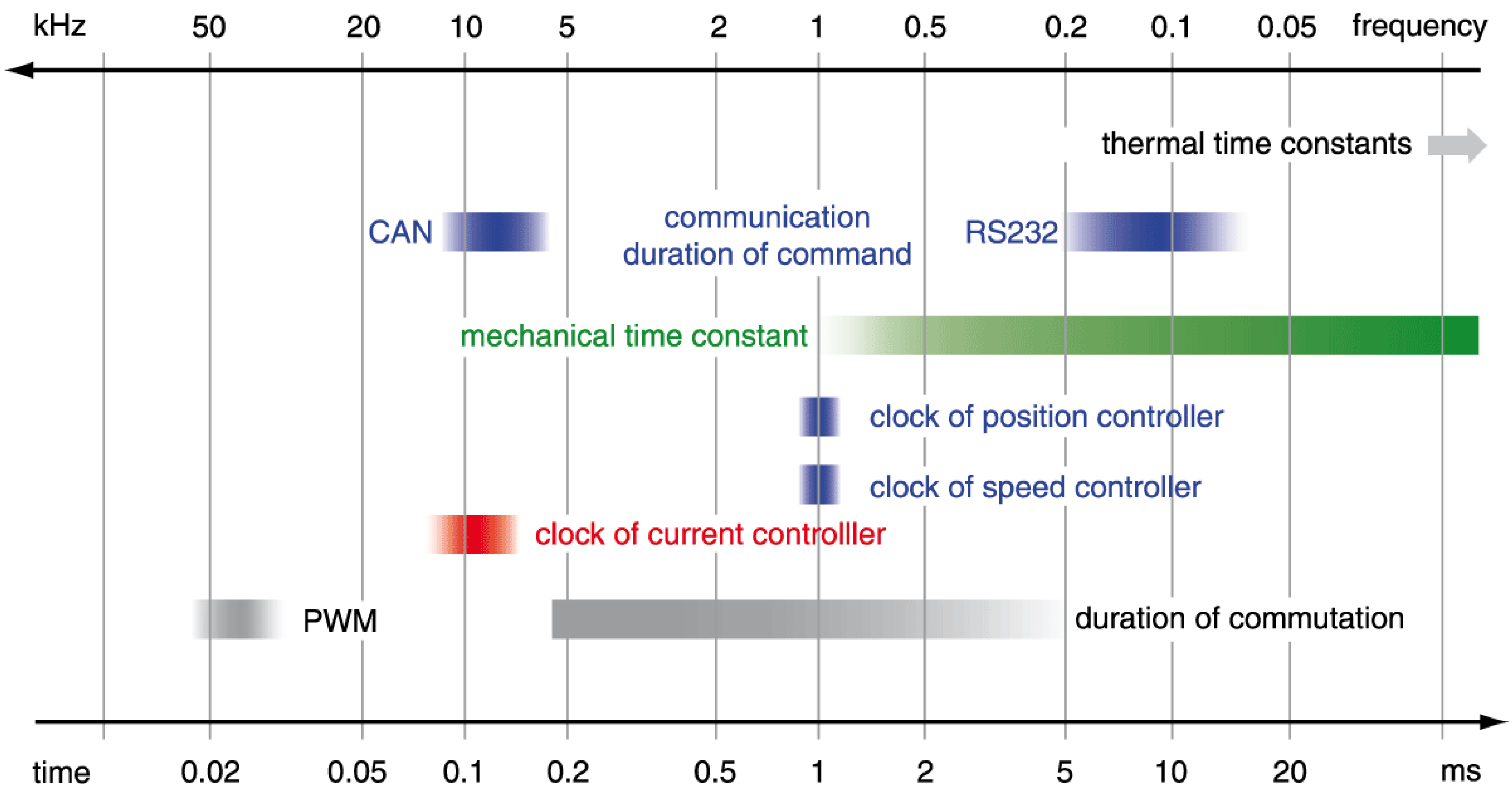


emissions
- electro magnetic
- heat
- noise
- …

mechanical power
- force, torque
- velocity, speed

quality, accuracy
- resolution
- mech. play

Time and frequency aspects

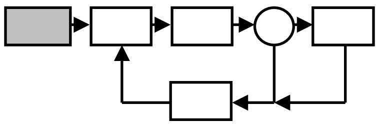


Particular boundary conditions

- dimensions
  - length, diameter
- service life
  - specific depending on load cycle, ambient conditions and application
  - given as service hours or numbers of working cycles
  - limited by the weakest component
- temperature, atmosphere
  - can influence the achievable power and service life
- noise, vibration
  - specific depending on load cycle, mounting and ambient conditions, application
  - influences on service life

Interfaces: Connections

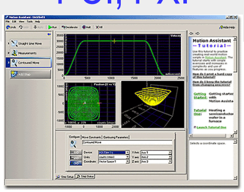
- electrical connections
  - cable type, cable length, colours
  - plug
  - strain relief
- mechanical interface
  - mounting type, mounting pilot, threads, number and location of bolt holes
  - output shaft: length, diameter, flats
  - drive elements, pinions, couplings
  - tolerances

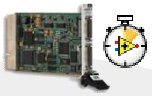


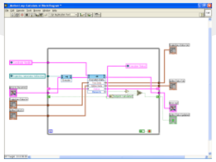
Supervisor

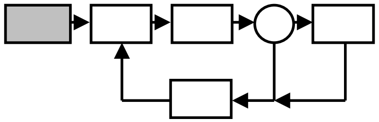
- Depending on the choice of the motion controller

PC based	Distributed	Customized
PC based (Plug-In) PCI, PXI	**Distributed** CANopen	**Custom** RTOS, FPGA
PCI/PXI Motion Controller	EPOS	cRIO, cFP, DAQ









Supervisor

- Graphical Programming with LabVIEW
- Application development with NI Motion Assistant
- EPOS Studio

Example „PC based“ Developing a Robotic Manipulator for Cancer Therapy

The Challenge:
Developing an automated robotic manipulator for performing photodynamic therapy (PDT) on cancer patients.
The Solution:
Using graphical system design to design a robot capable of precise movement and highly accurate placement of PDT therapy
Product:
LabVIEW, Motion Control, PXI/CompactPCI
Author:
Houssam Bitar, Lebanese University

Example „Distributed"

- Several drives which have to work together (e.g. conveyor belt) and which are distributed over a longer distance

maxon

Example „Customized“ Development of a wafer scriber

The Challenge:
Developing a automated wafer scriber that requires minimal service and engineering support.
Solution:
Using the National Instruments PAC-Platform and NI LabVIEW to develop the system
Products used:
Data Acquisition, LabVIEW, Motion Control, Programmable Automation Controllers (PACs), Vision

Author(s):
P. C. Lindsey, Micro Processing Technology, Inc