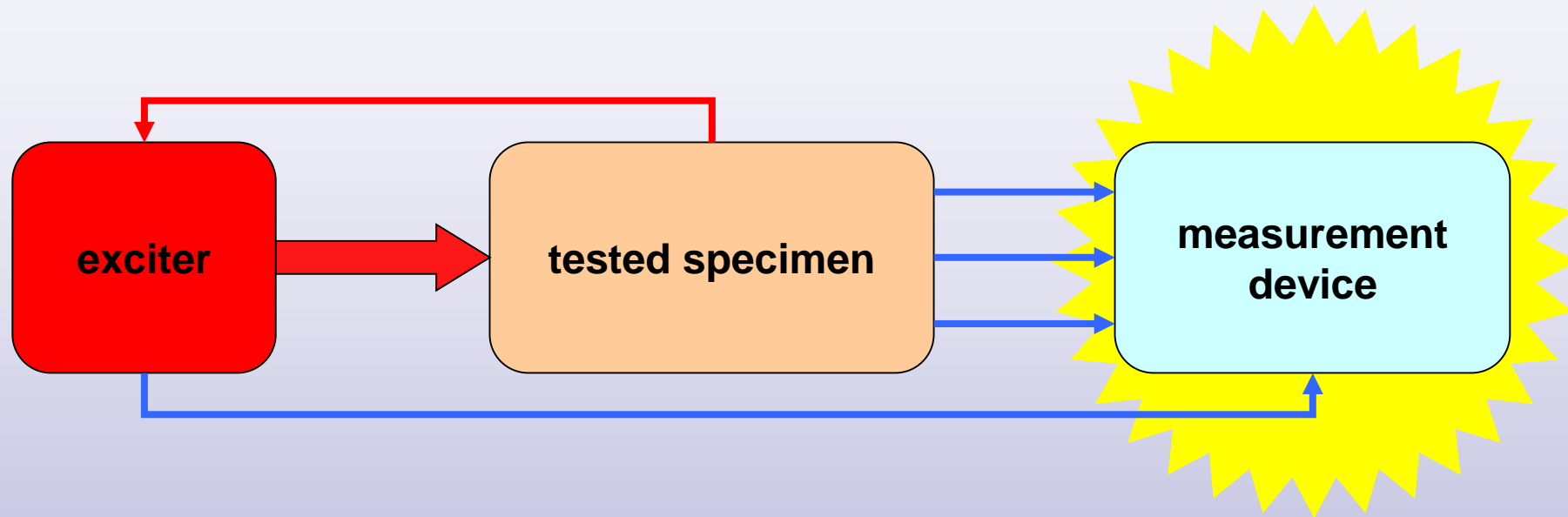


Measurement device



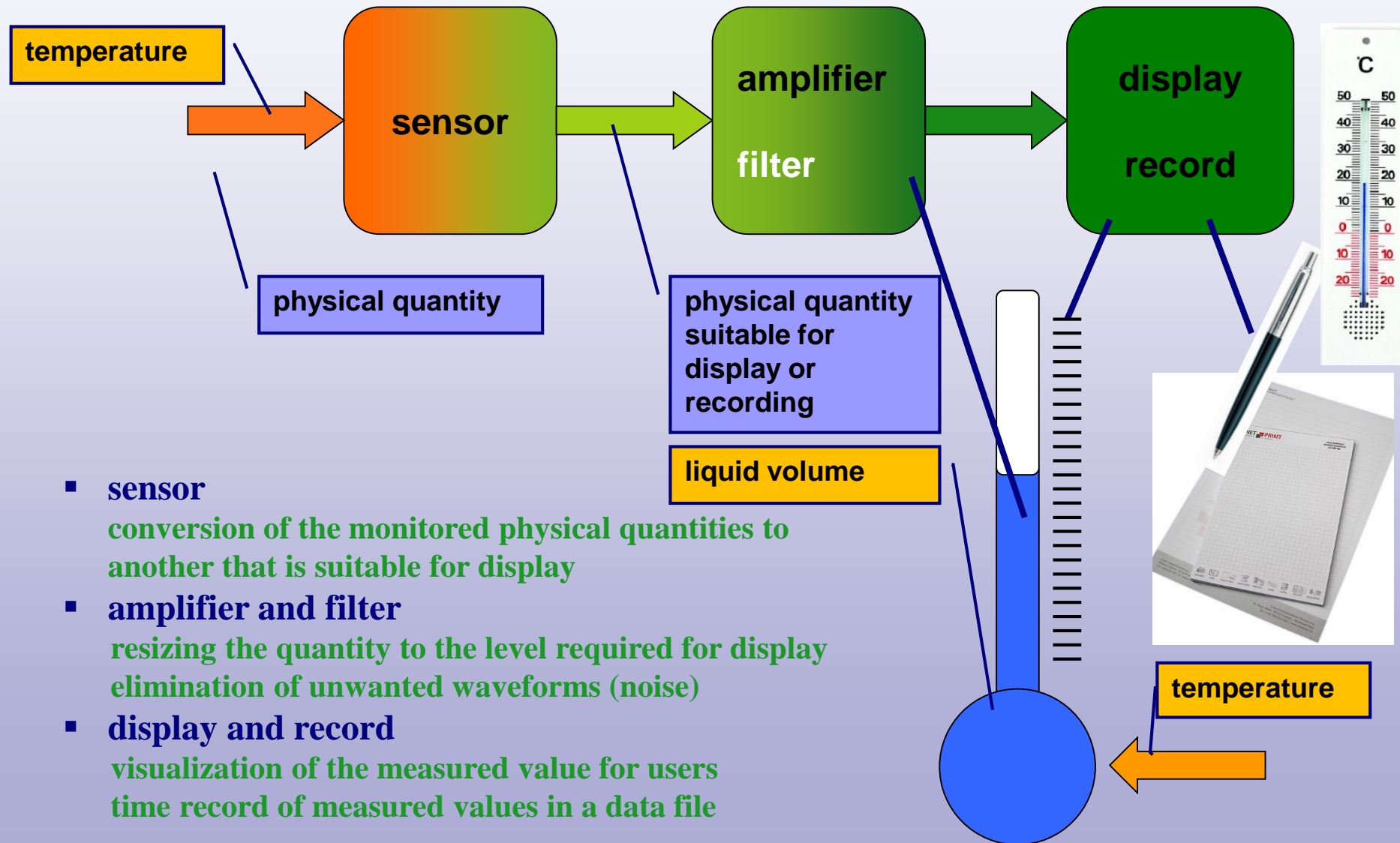
1. MEASUREMENT DEVICE COMPONENTS



Measurement device

- measures the response of the specimen to excitation
- measures excitation parameters
- displays measured data
- stores a time record of measured data in data files

1. MEASUREMENT DEVICE COMPONENTS



1. MEASUREMENT DEVICE COMPONENTS

- classification according to functional design
 - **mechanical measurement device**
converts the monitored quantity to another non-electric quantity suitable for display (liquid volume, deformation)
 - **elektrical measurement device**
converts the monitored quantity into an electrical quantity (voltage, current, charge, resistance, inductance, capacitance) and it is then used for display



2. Mechanical measurement device

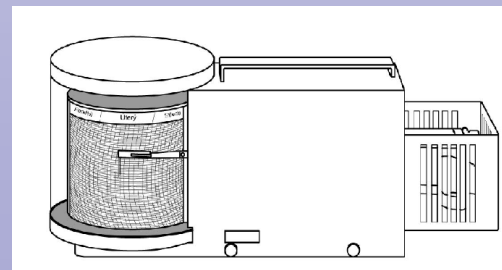
The monitored physical quantity is translated to another **non-electric** quantity suitable for display (volume of liquid, deformation,)

advantages:

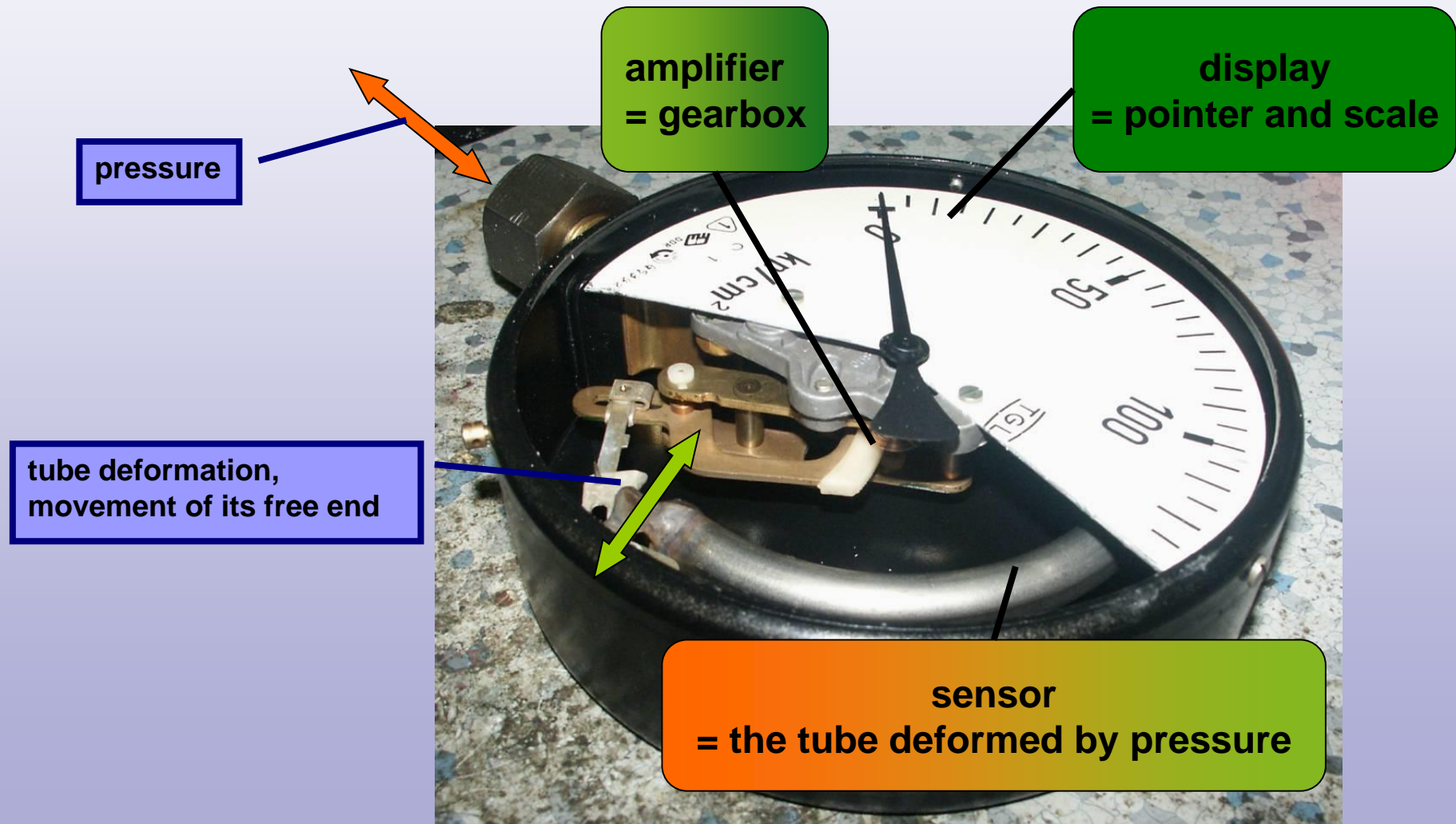
- no power supply
- no electromagnetic interference
- easy to use

disadvantages:

- the measurement and display point can not be separated
- the device consumes energy from the measured quantity
- difficult possibility of measured quantity recording (paper roll + clockwork)
- difficult record processing
- unsuitable for fast processes



2. Mechanical measurement device



3. Electrical measurement device

The monitored physical quantity is translated to **electric** quantity (voltage, current,)

advantages:

- the measurement and display point can be separated
- automatic record is possible
- suitable for fast processes

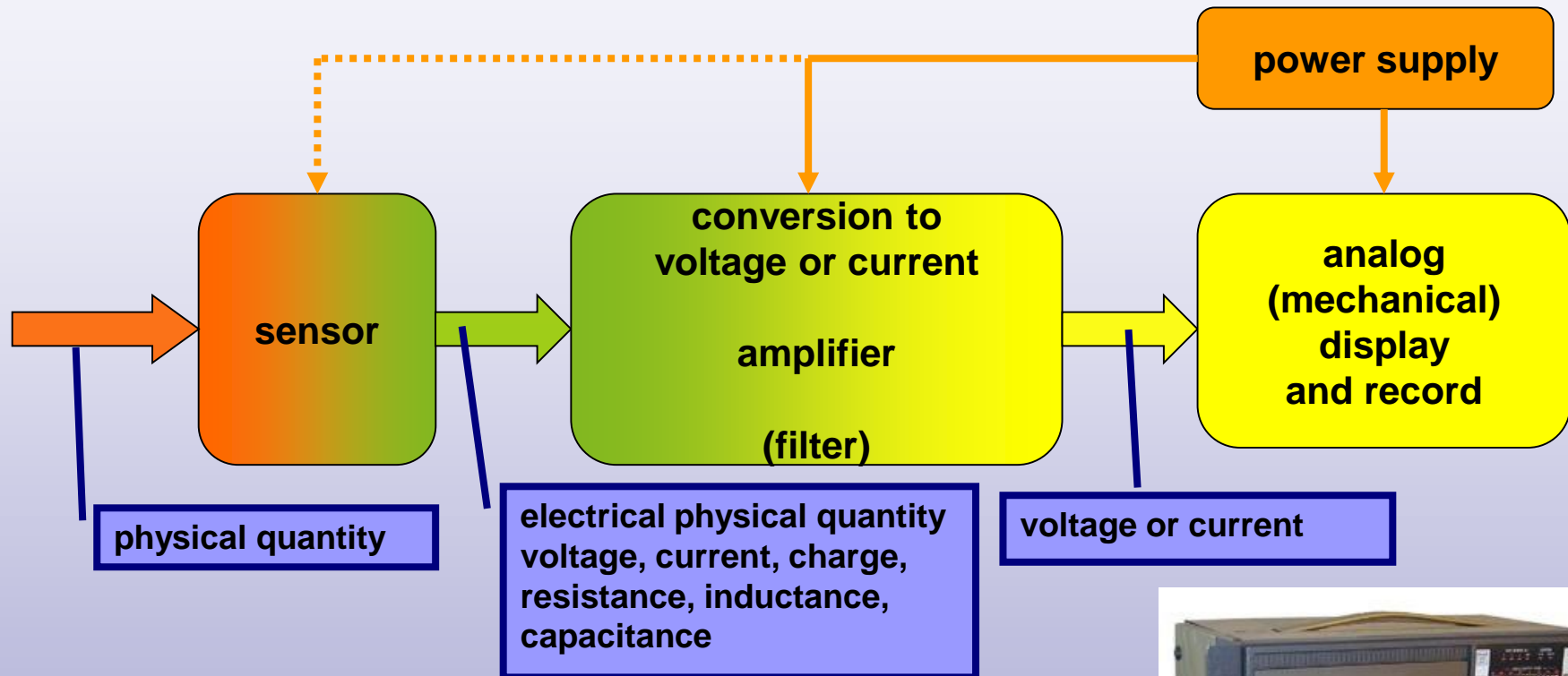
disadvantages:

- the power supply is needed
- electromagnetic interference is possible

classification according to functional design:

- analogue measurement device
- analogue – digital measurement device
- digital measurement device

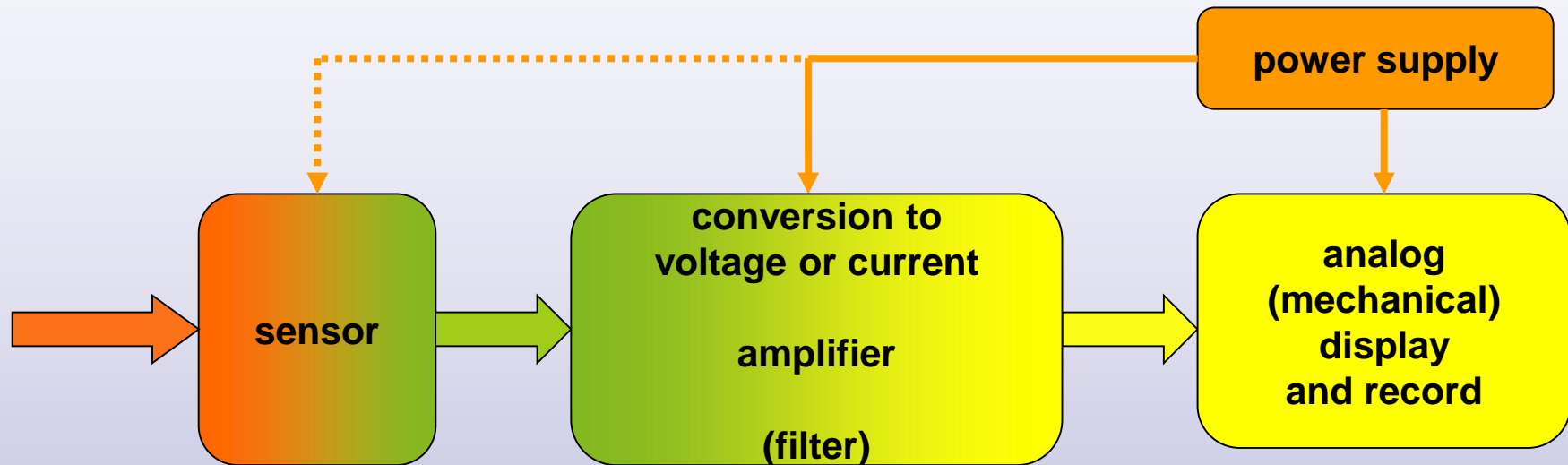
3.1. Analogue measurement device



display by
the pointer and scale



3.1. Analogue measurement device



advantage:

- **display and record 100% information**

disadvantages:

- **the display and recording are again "mechanical", ie they require mechanical action for their operation = low resistance to vibration, dust, humidity,**
- **loss of quality (noise) during transmission over longer distances**
- **difficult processing of analog data**

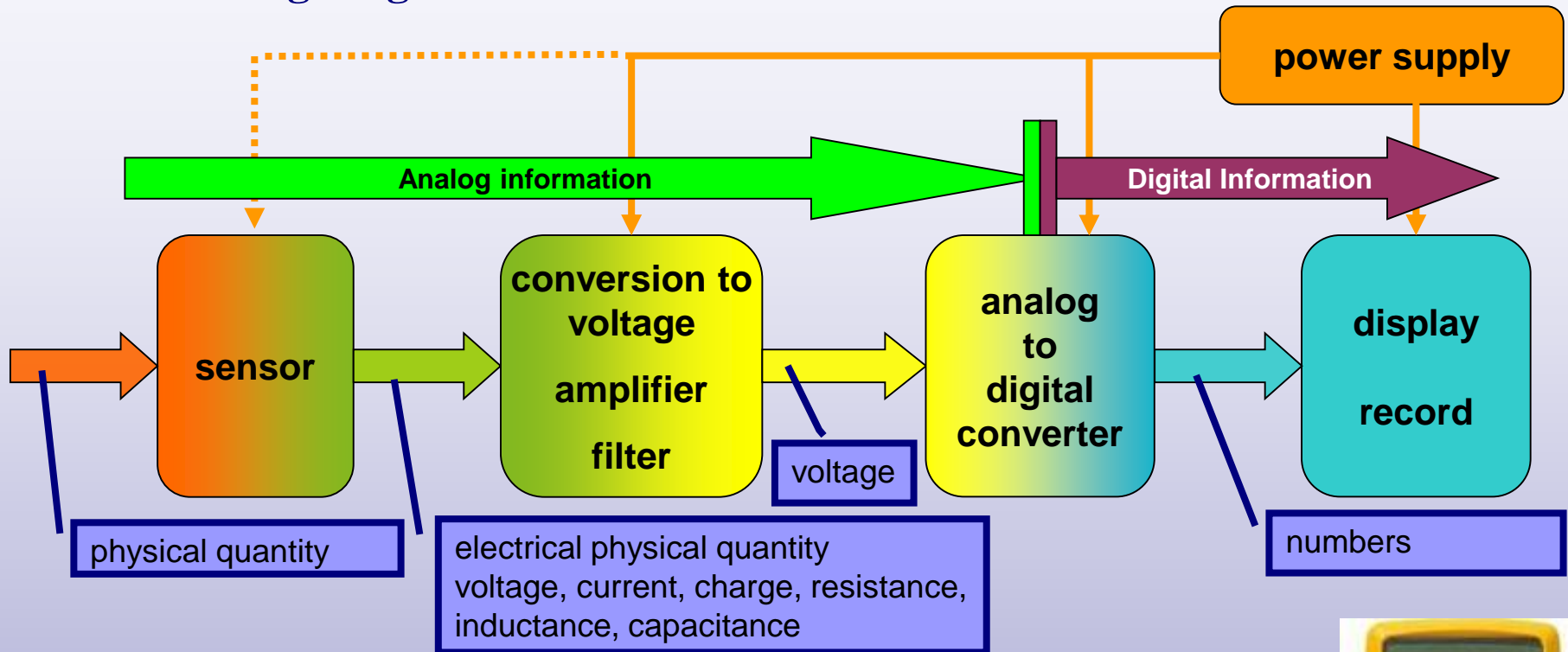
3.1. Analogue measurement device

Analogue measurement device



Museum of Technology

3.2. Analog - digital measurement device



- currently the most used solution
- the A/D converter can only input an electrical voltage in a specific range ($\pm 10V$, $\pm 5V$)
- the sensor output electrical quantity must be converted to electrical voltage and amplified to the required range for the A/D converter



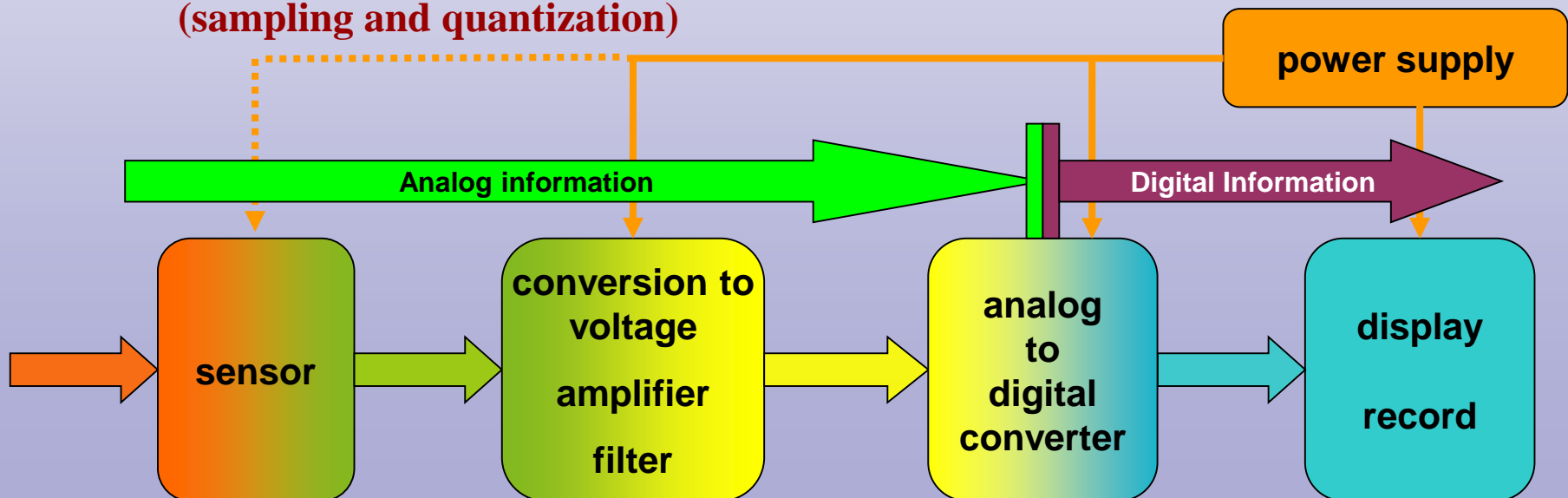
3.2. Analog - digital measurement device

advantages:

- display and recording has no mechanical parts = high resistance to vibration, dust, humidity,
- unlimited life of the recording media
- digital signal transmission without loss of quality
- easy data processing - data files

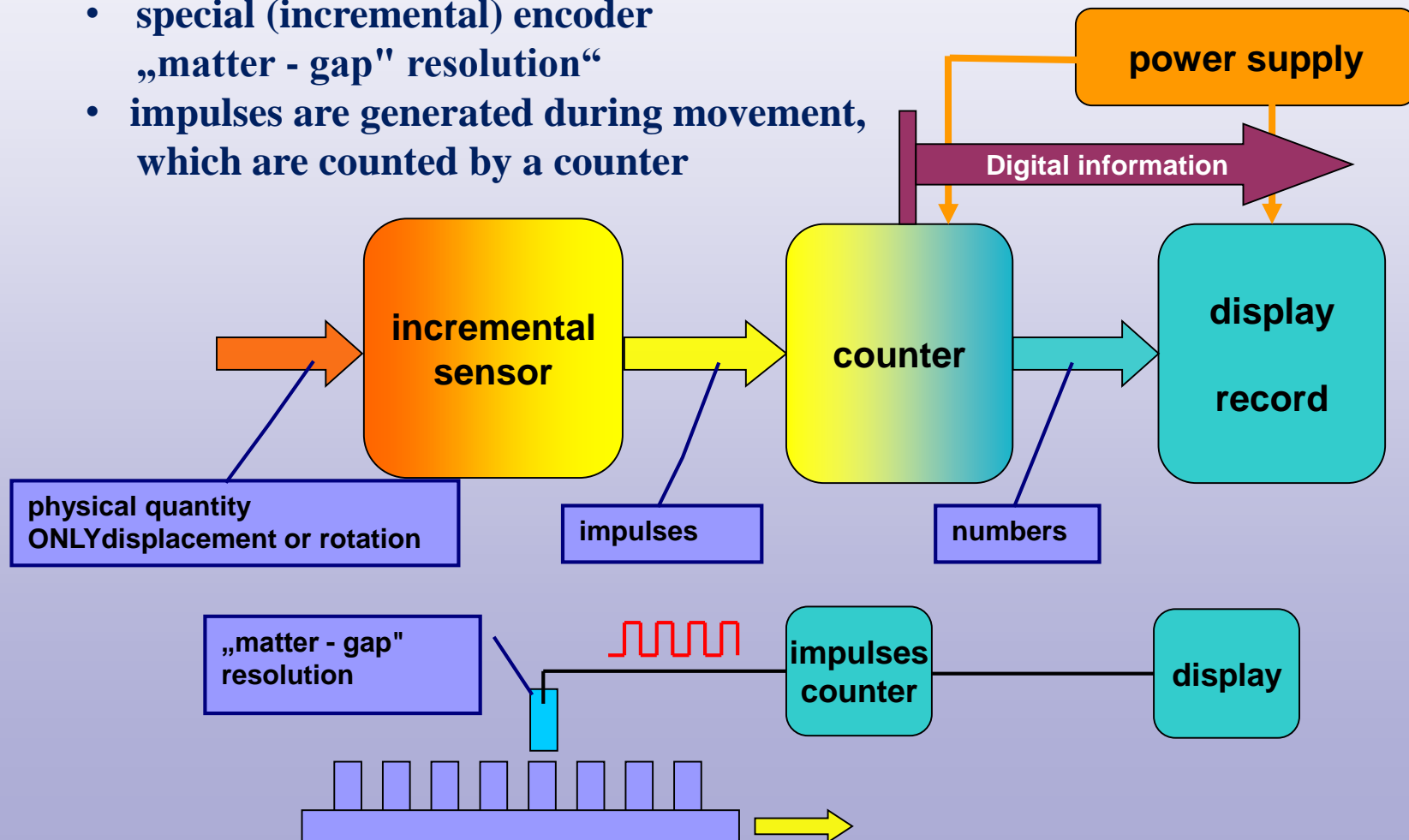
disadvantages:

- there is a partial loss of information in the A / D converter (sampling and quantization)



3.3. Digital measurement device

- direct conversion of a physical quantity (only movement or rotation) into digital information
 - special (incremental) encoder „matter - gap” resolution“
 - impulses are generated during movement, which are counted by a counter



3.3. Digital measurement device

frequent use on machine tools →



advantages:

- direct conversion of movement or rotation to digital information
- no analogue part
- high resistance to electromagnetic interference
- high accuracy

disadvantages:

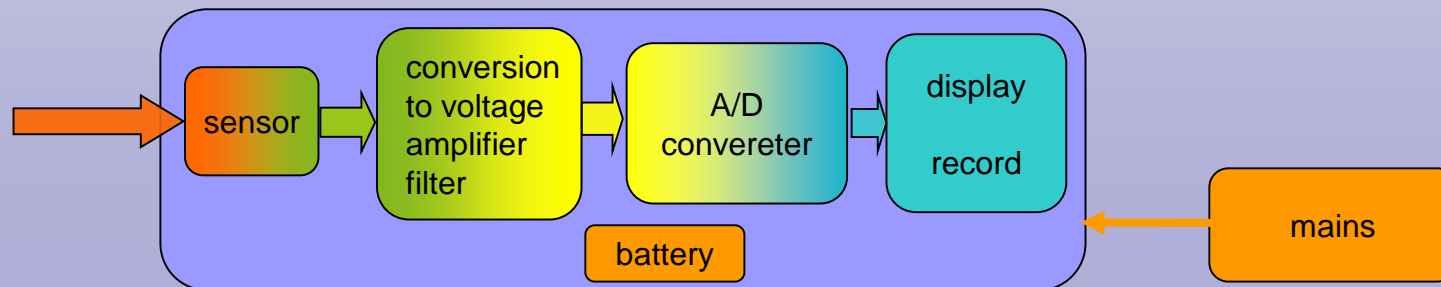
- unknown value after switching on

4. Variants of the analog digital measurement device

- 4.1. compact device
 - the measurement location is the same as the display and recording location
- 4.2. distributed device
 - the measurement location is different from the display and recording location
 - 4.2.1. separate sensor
 - 4.2.2. separate sensor and amplifier
 - 4.2.3. separate display and record

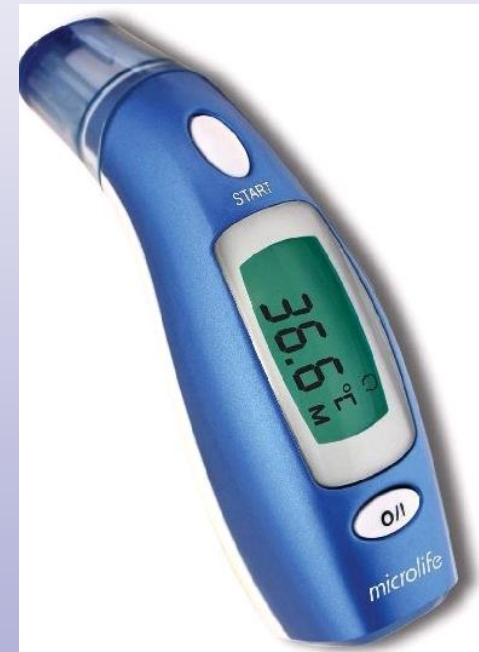
4.1. compact measurement device

- all components are concentrated in one device
- advantages:
 - easy to use
 - high resistance to electromagnetic interference
 - battery or mains powered
- disadvantages:
 - the measurement location and the display location cannot be separated
 - single-purpose device, a separate device is required for each measurement quantity



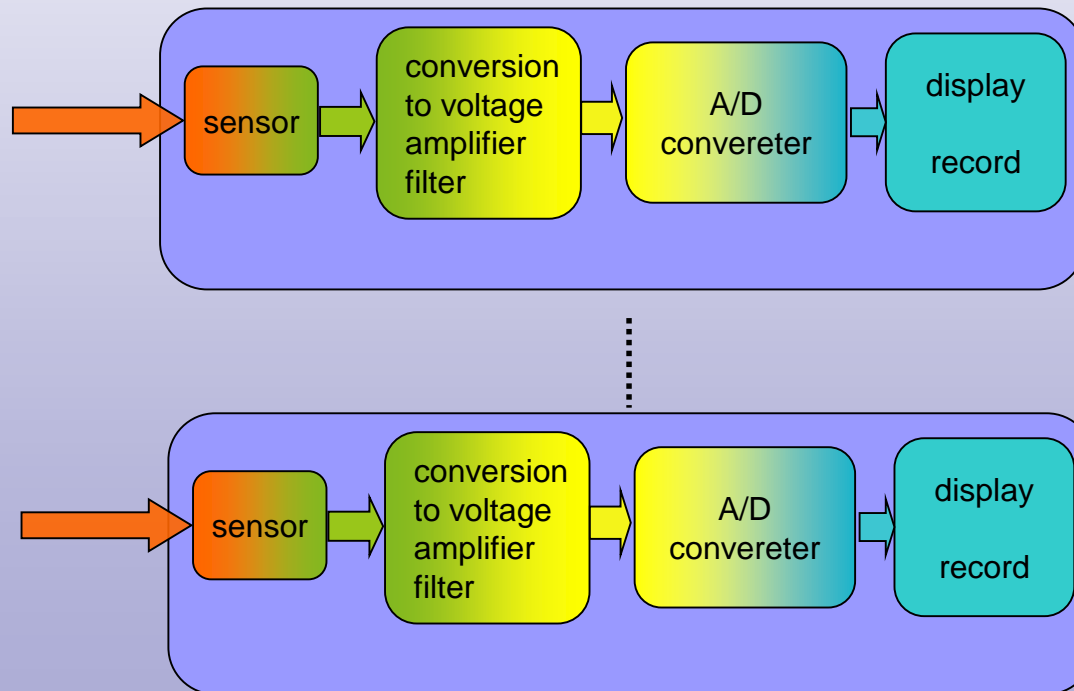
4.1. compact measurement device

- examples



4.1. compact measurement device

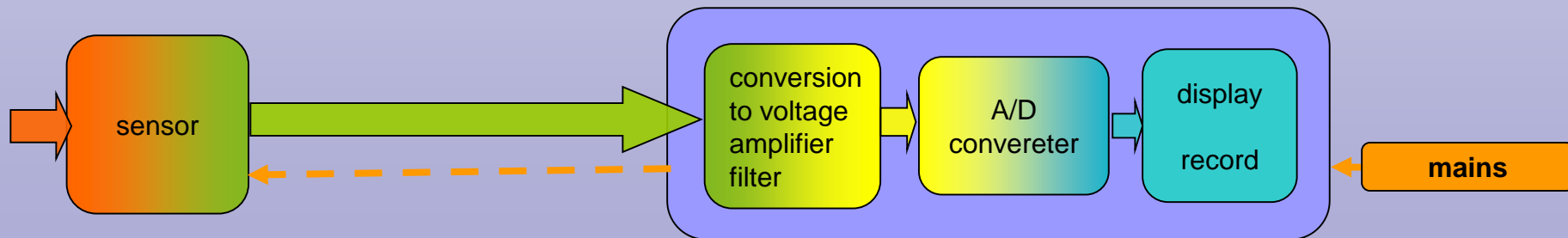
- measurement of multiple quantities
- disadvantages:
 - more separate displays - little clarity
 - data records divided into multiple files - difficult processing
 - difficult devices synchronization



4.2. distributed device

4.2.1. separate sensor

- **separate sensor and everything is else concentrated in one device**
- **advantaged:**
 - **one universal device and many different sensors can be used**
 - **low price**
 - **simple sensor without electronics**
 - **high temperature and mechanical resistance**
- **disadvantage:**
 - **a weak signal from the sensor is transmitted**
 - **the worst variant in terms of electromagnetical interference**
 - **suitable only for laboratory use, not for industry**
 - **the length of the connecting cable is limited (max. meters) and a special cable must be used**
 - **if the sensor needs to be powered, additional connecting wires are needed**



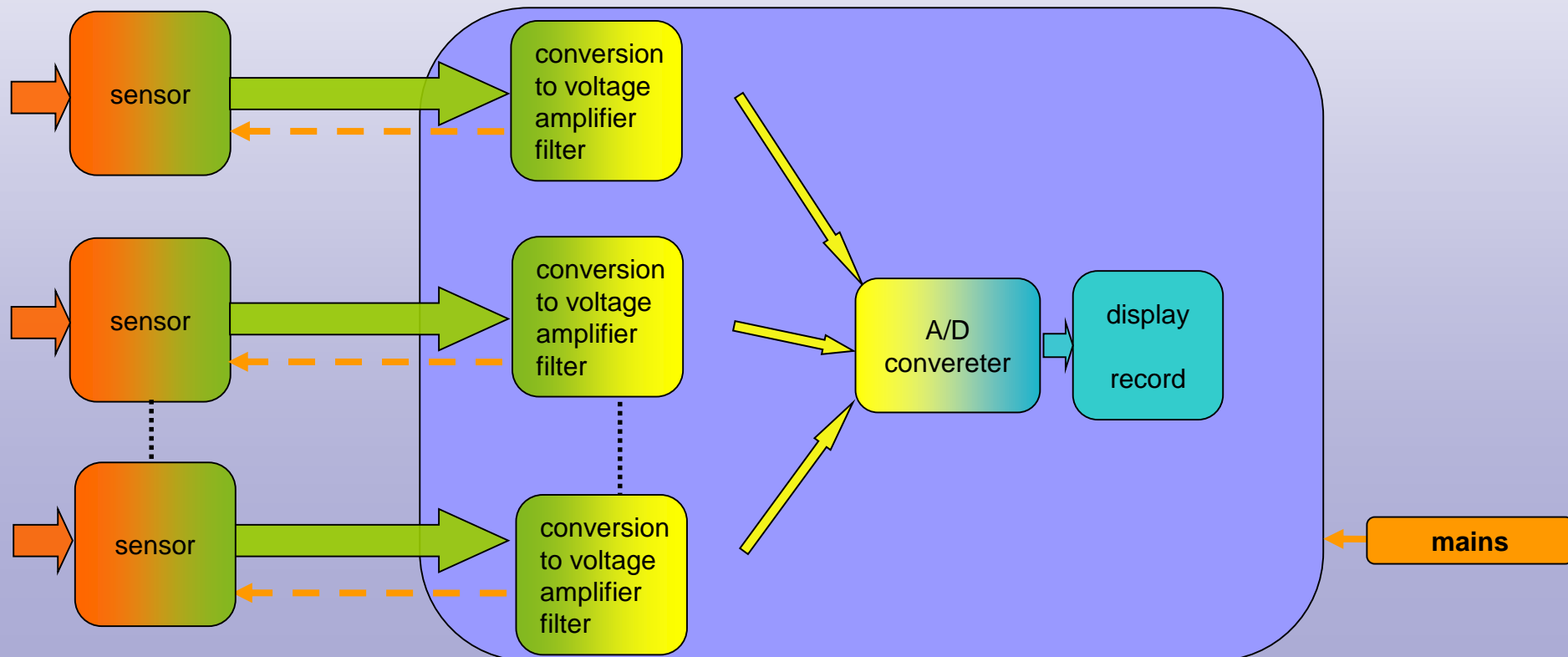
4.2.1. separate sensor

- examples



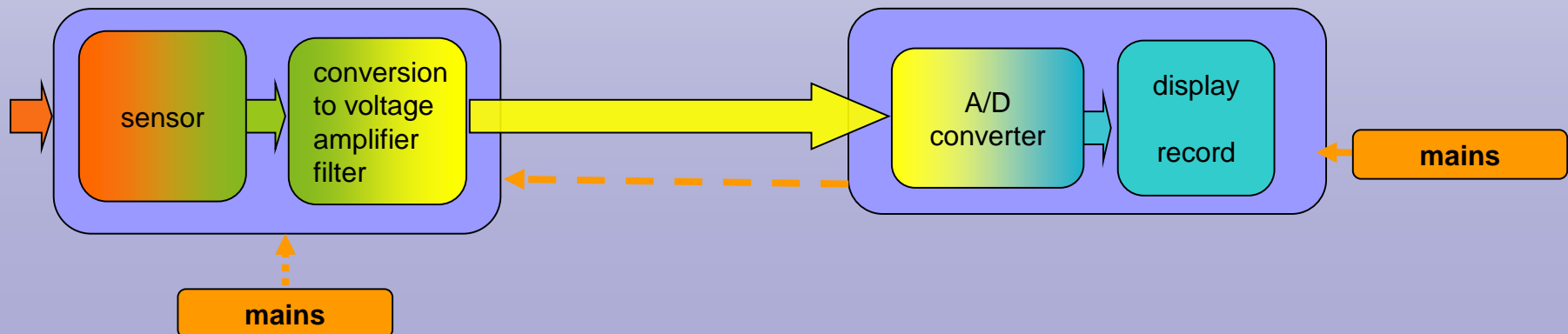
4.2.1. separate sensor

- measurement of multiple quantities
- advantaged:
 - one display for all channels - clear display
 - one data file for all channels - easy processing
 - A/D conversion in one device - easy channel synchronization



4.2.2. separate sensor and amplifier

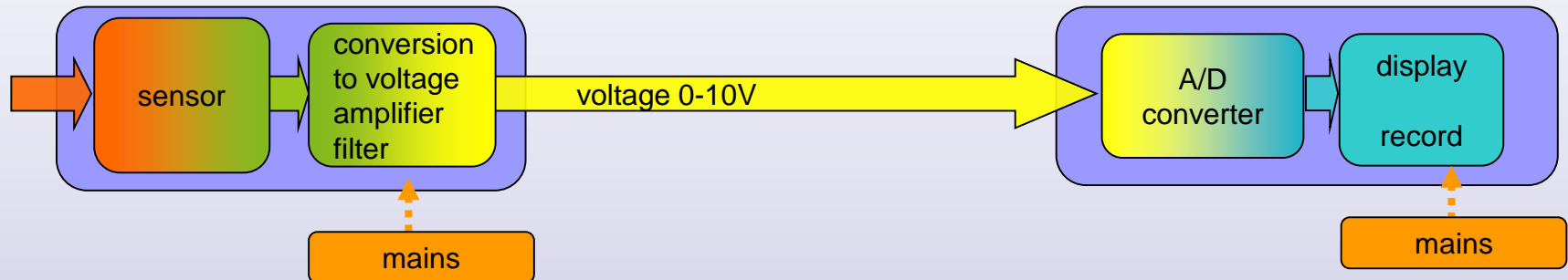
- currently a fast-growing variant - miniature electronics can be inside the sensor housing
- advantages:
 - the amplified signal is transmitted
 - high resistance to electromagnetic interference
 - can be used in an industrial environment (standard signal 0-10V or 4-20mA is transmitted)
 - large length of the connecting cable (up to km), lower demands on the quality of the cable
 - the sensor and amplifier can be powered from a separate source
- disadvantage:
 - the sensor contains electronics - limited resistance to temperature and mechanical influences



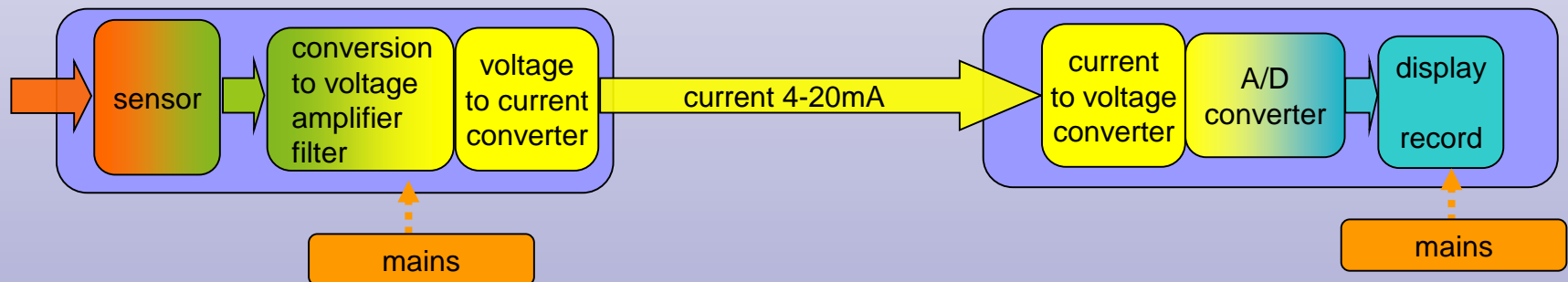
4.2.2. separate sensor and amplifier

▪ two versions of signal transmission

- laboratory version - signal is transmitted as el. voltage in the range 0 - 10V



- industrial version - the signal is transmitted as el. current in the range 4 - 20mA



- the range 4 - 20mA corresponds to 0 - 100% of the measured quantity, so, the minimum current is 4 mA for zero input
- this is protection against cable interruption, if the current is zero, it means interruption of the connecting cable, not zero value at input

4.2.2. separate sensor and amplifier

Examples

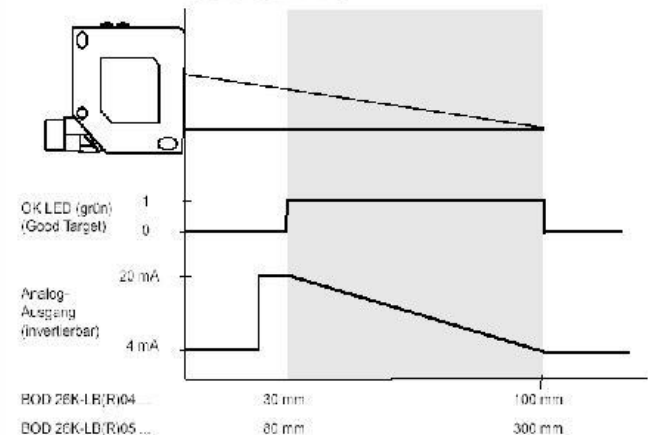
Laboratory version



<input type="checkbox"/>	Part Number ^^	Switching output ^^	Sensing Range (mm) ^^	Resolution ^^ max.	Grey shift max. (90%/18% Reflectivity) ^^	Output signal ^^	PreviewIcon
<input type="checkbox"/>	BOD 26K-LA01-C-06		85	0.08 mm		0...10 V DC	
<input type="checkbox"/>	BOD 26K-LA01-S4-C		85	0.08 mm	<3.0	0...10 V DC	
<input type="checkbox"/>	BOD 26K-LA02-C-06		85	0.02 mm		0...10 V DC	
<input type="checkbox"/>	BOD 26K-LA02-S4-C		85	0.02 mm		0...10 V DC	
<input type="checkbox"/>	BOD 26K-LB04-S115-C	2xPNP-Transistor	100	0.1% of Full Scale		4...20 mA	
<input type="checkbox"/>	BOD 26K-LB05-S115-C	2xPNP-Transistor	300	0.1% of Full Scale		4...20 mA	
<input type="checkbox"/>	BOD 26K-LBR04-S115-C	2xPNP-Transistor	100	0.1% of Full Scale		4...20 mA	
<input type="checkbox"/>	BOD 26K-LBR05-S115-C	2xPNP-Transistor	300	0.1% of Full Scale		4...20 mA	
<input type="checkbox"/>	BOD 26K-LB06-S92-C	PNP, N.O./N.C. switchable	100	0.1% of Full Scale		4...20 mA	
<input type="checkbox"/>	BOD 26K-LB07-S92-C	PNP, N.O./N.C. switchable	300	0.1% of Full Scale		4...20 mA	

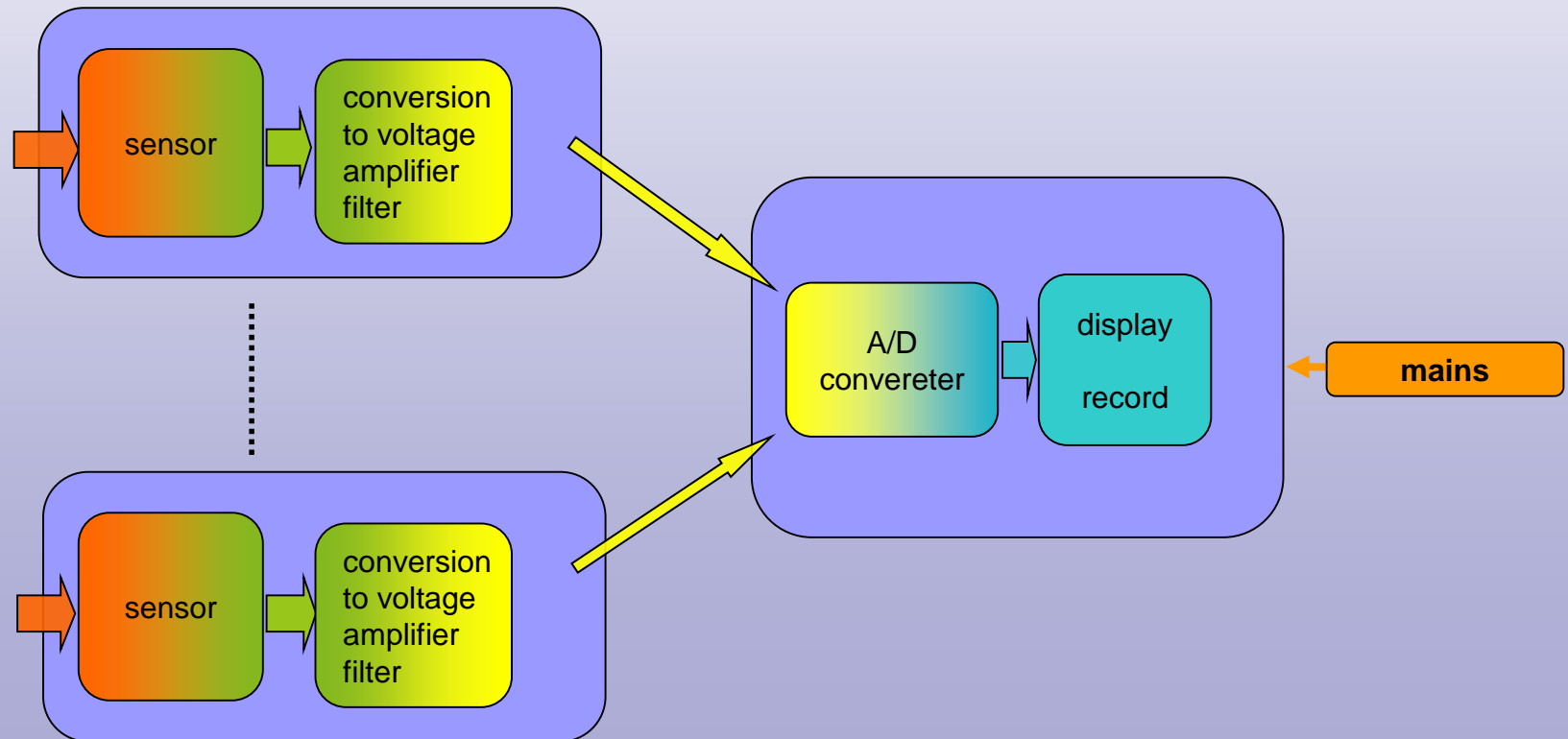
Laboratory version

Industrial version



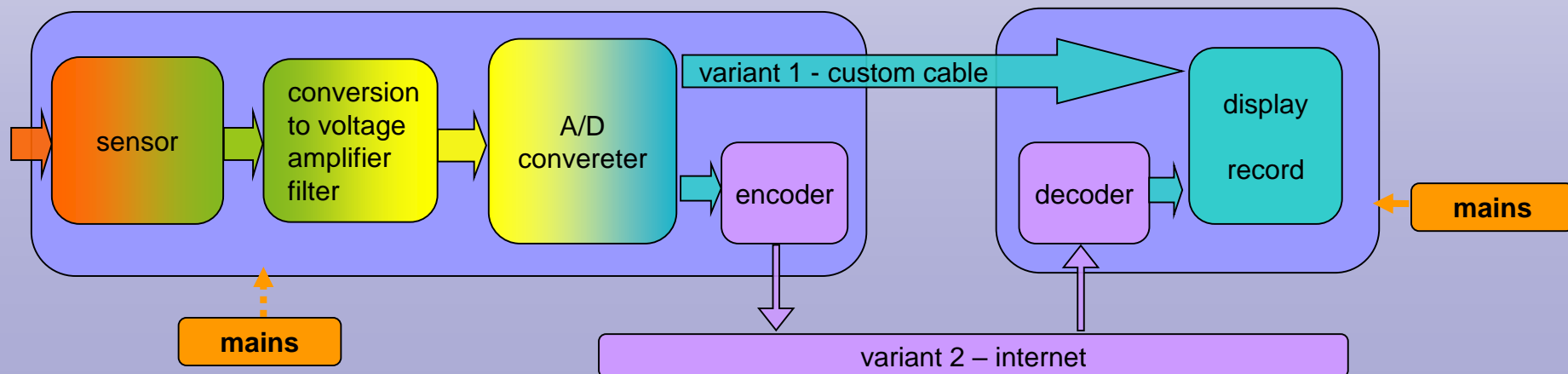
4.2.2. separate sensor and amplifier

- measurement of multiple quantities
- advantaged:
 - one display for all channels - clear display
 - one data file for all channels - easy processing
 - A/D conversion in one device - easy channel synchronization



4.2.3. separate display and record

- the majority of the measuring device is at the measuring point, only the display and the record are separate
- currently a fast-growing variant - miniature electronics can be inside the sensor housing
- **advantades:**
 - a digital signal is transmitted
 - very high resistance to electromagnetic interference
 - unlimited transmission line length
 - wireless transmission can be used (WIFI)
 - custom cable or public infrastructure (internet) can be used for data transmission
- **disadvantage:**
 - the measurement speed is limited by the transmission capacity of the digital line



4.2.3. separate display and record

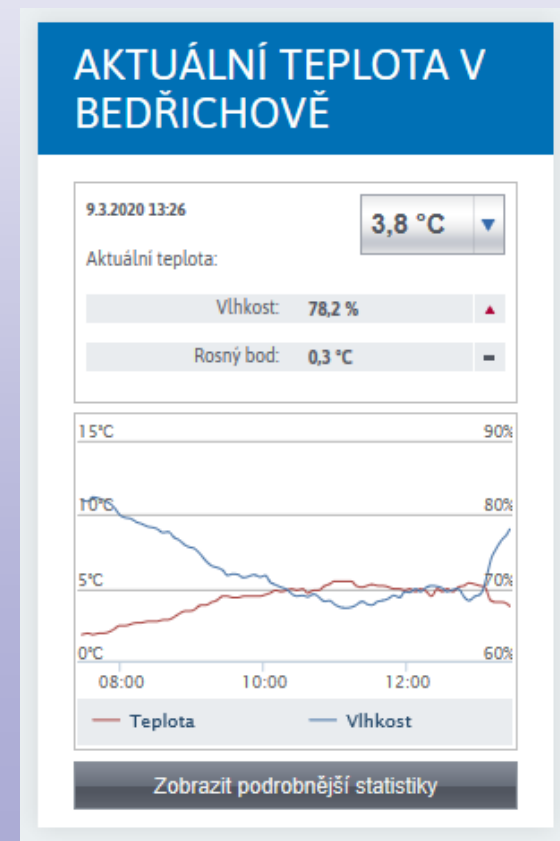
- examples



temperature and humidity sensors in the Jizera Mountains

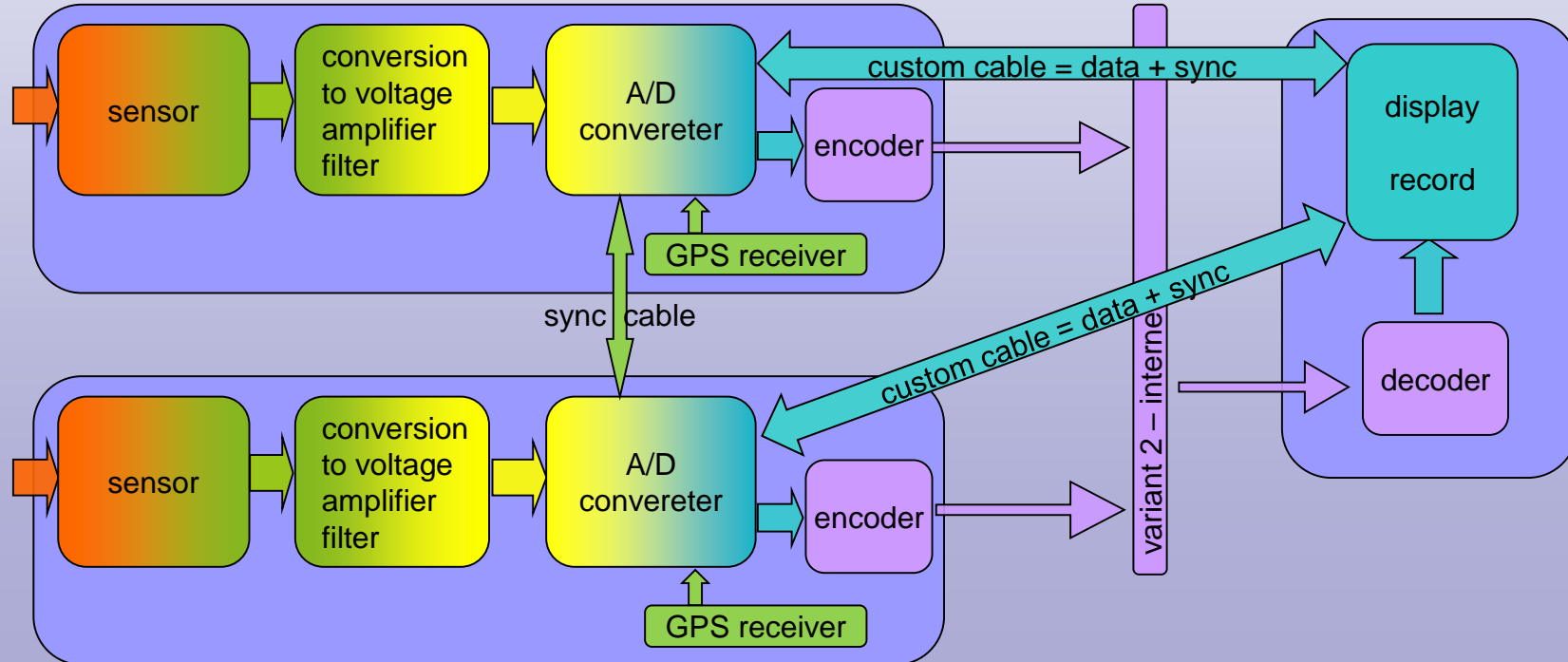
very important data for waxing cross-country skis

display data on a web page



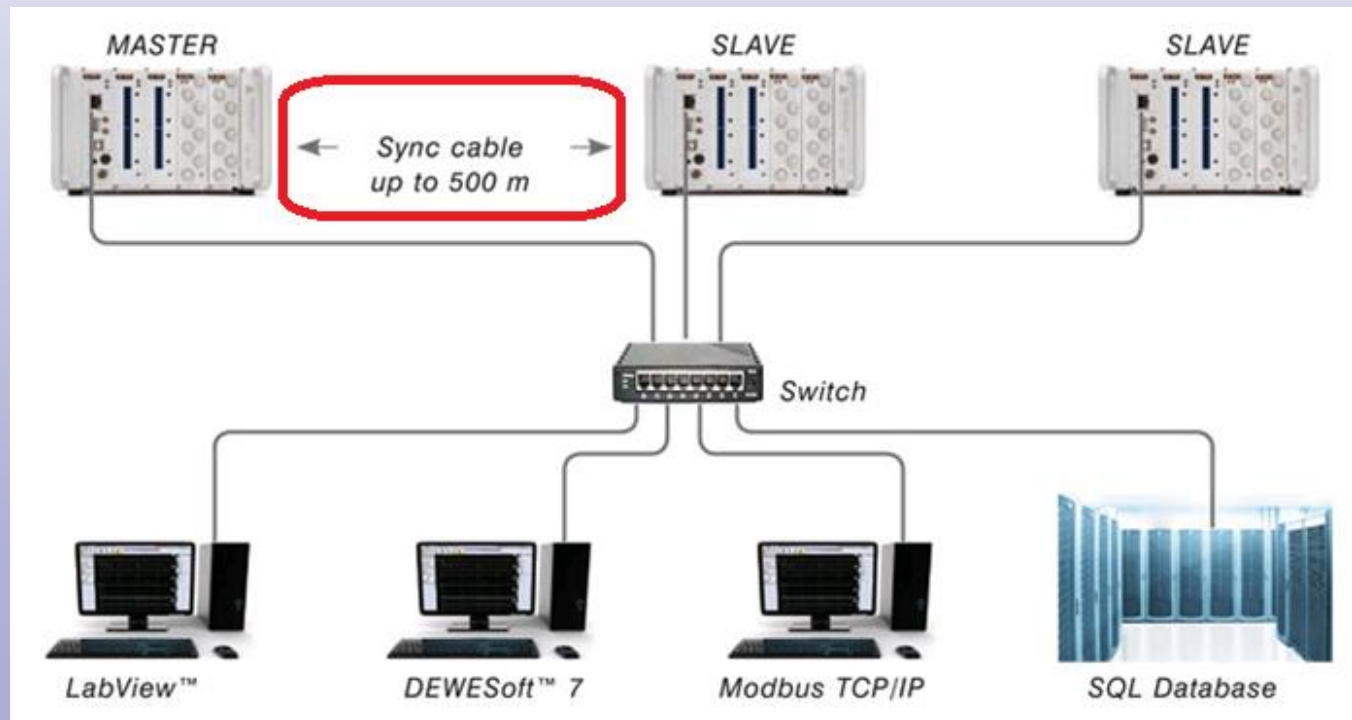
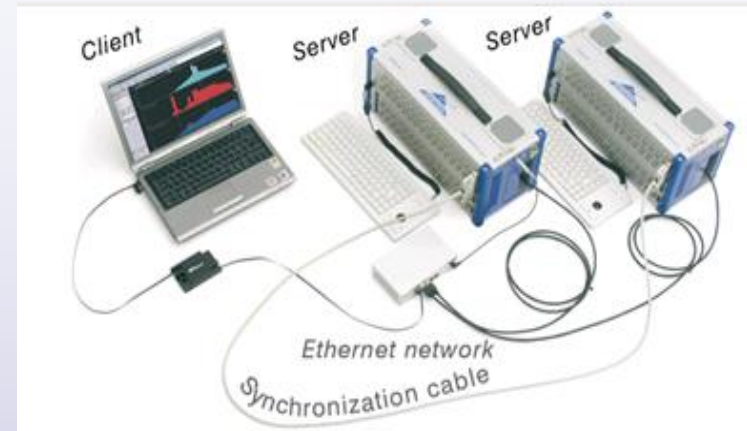
4.2.3. separate display and record

- measurement of multiple quantities
- channel sync problem
 - variant 1: the custom cable can transmit synchronization pulses in addition to the data
 - variant 2: the internet shared by many users at the same time cannot transmit synchronization pulses
 - classic solution: sync cable between devices is used (the cable has a limited length)
 - modern solution: the device has a GPS receiver and the exact time the GPS system is used for synchronization



4.2.3. separate display and record

- examples



Exam questions

- measurement device components
 - block diagram (p. 3)
 - classification according to functional design (p. 4)
- mechanical measurement device
 - principal, advantages, disadvantages (p. 5)
- electrical measurement device
 - principal, advantages, disadvantages, classification (p. 7)
 - analogue measurement device, block diagram, advantages, disadvantages (p. 9)
 - analog - digital measurement device, block diagram, advantages, disadvantages (p. 12)
 - digital measurement device, block diagram, advantages, disadvantages (p. 13)
- variants of the analog digital measurement device (p.15)
- compact measurement device
 - block diagram, advantages, disadvantages, (p. 16)
 - measurement of multiple quantities, block diagram, advantages, disadvantages (p. 18)
- separate sensor
 - block diagram, advantages, disadvantages, (p. 19)
 - measurement of multiple quantities, block diagram, advantages, disadvantages (p. 21)
- separate sensor and amplifier
 - block diagram, advantages, disadvantages, (p. 22)
 - measurement of multiple quantities, block diagram, advantages, disadvantages (p. 25)
- separate display and record
 - block diagram, advantages, disadvantages, (p. 26)
 - measurement of multiple quantities, block diagram, sync. variants (p. 28)