# § 3 Process Peripherals

3.1 Interfaces between the technical process and the automation computer system
3.2 Sensors and actuators
3.3 Representation of Process Data in Automation Computers
3.4 Input/ output of analog signals
3.5 Input/ output of binary and digital signals
3.6 Field bus systems

## Chapter 3 - Learning targets

- to know the kinds of interfaces in an automation system
- to know what sensors and actuators are and how they are built up
- to know how data is represented in automation computers
- to understand how an analog to digital conversion and back is done
- to know different kinds of converter realizations
- to be able to explain how a digital input and output of process signals is done
- to know what is meant by a field bus
- to be able to explain the different bus access methods
- to know how the PROFIBUS communication is working
- to know the most important features of the CAN bus

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## Input/Output Interfaces

Transmission of process signals between the technical process and the automation computer system

– Process signal input:

acquisition of process data

**temperature**

– Process signal output:

manipulation of actuators

**close valve**

## Possibilities for the connection

– connection via bundles of lines

**conventional way**

– connection via bus coupler module (I/O nodes)

**utilization of field bus coupler**

– connection via sensor/ actuator bus system

**most modern way :utilization of intelligent sensors and actuators**

## Direct connection of sensors and actuators

– within the product automation

– short lines to micro controller

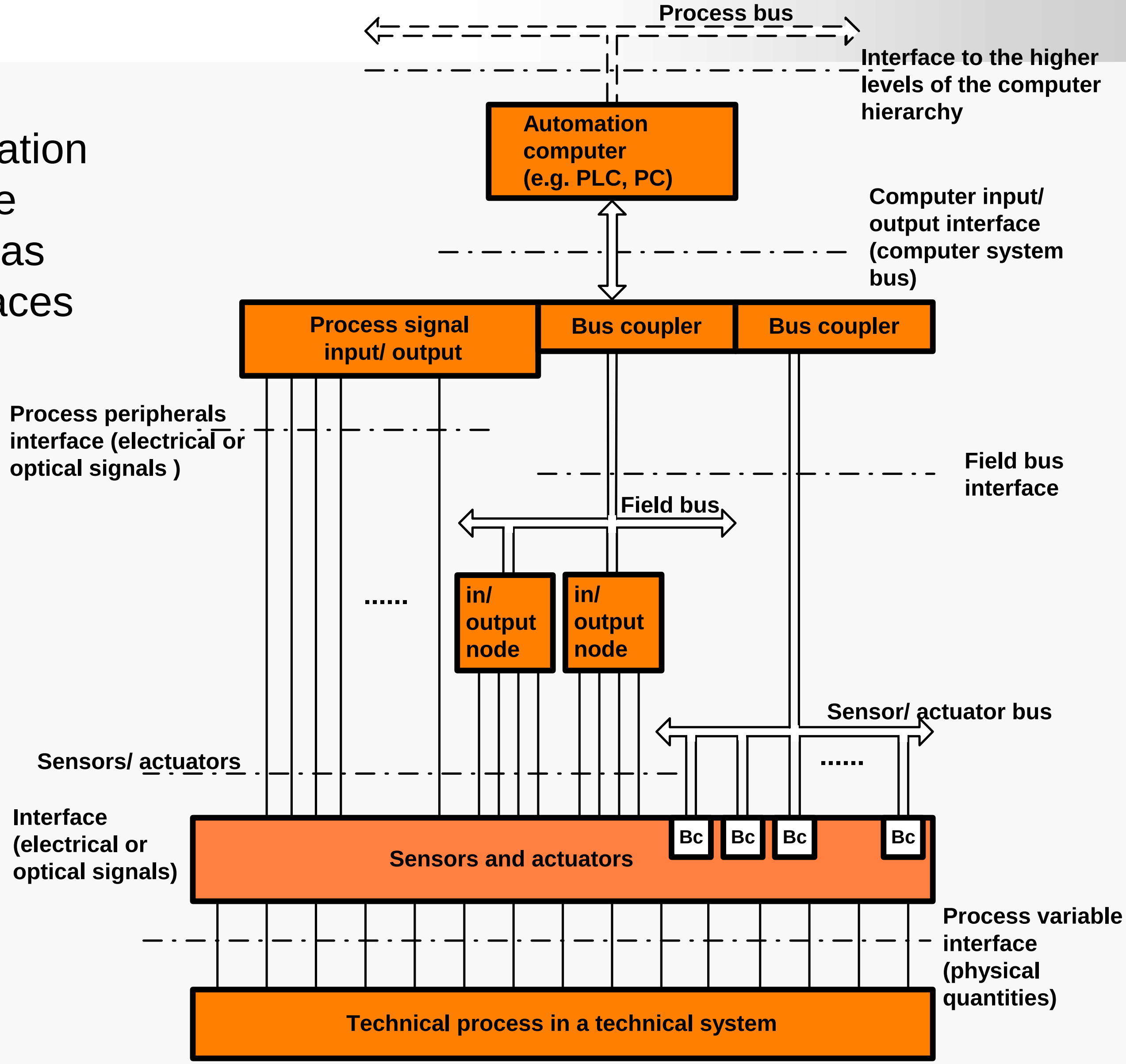
## Input/ output via field bus systems

– within plant automation

– reduction of cabling and installation costs

## Overview

Facilities for the coupling of automation computers with the technical process as well as with interfaces



## Requirements of a bus system on actuator sensor level

- Sensors/actuators of different manufacturers connectable
- Short system reaction time
- Small connection costs
- Small construction volume
- Simple handling with wiring and start-up

## Objectives of the actuator-sensor-interface (AS i)

- Adjustment on actuator sensor level
  - ð Small data set per participant
  - ð Short response times
- Replacement of the parallel wiring of binary actuator/sensors
  - ð Signals and voltage supply using the same line

## Characteristics of AS i

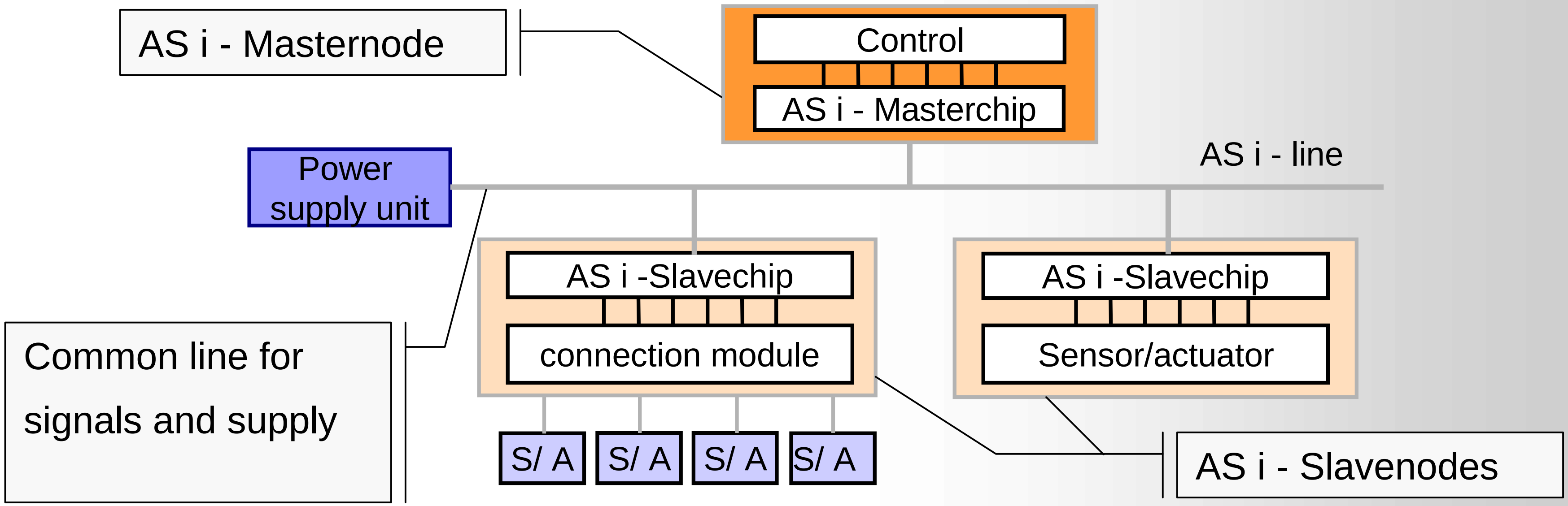
- User defined network structure
- Transmission principle
  - single-master-system with cyclic polling
  - one fixed address per slave
  - max. 31 slaves per line
  - up to 4 sensors/actuators per slave
- Transmission medium
  - not protected and not twisted two-wire line
  - common use for data and energy
- User data and cycle time
  - 4 bits user data
  - 5 ms max. cycle time

  ð Cycle time adapts to the number of slaves

## AS i- principle structure

– 1 Masternode — Costs of masterchip approx. 10 €
  - Variant 1: nodes integrated in controlling
  - Variant 2: separate locking module (e.g. for PLC)
  - Supervises bus communication

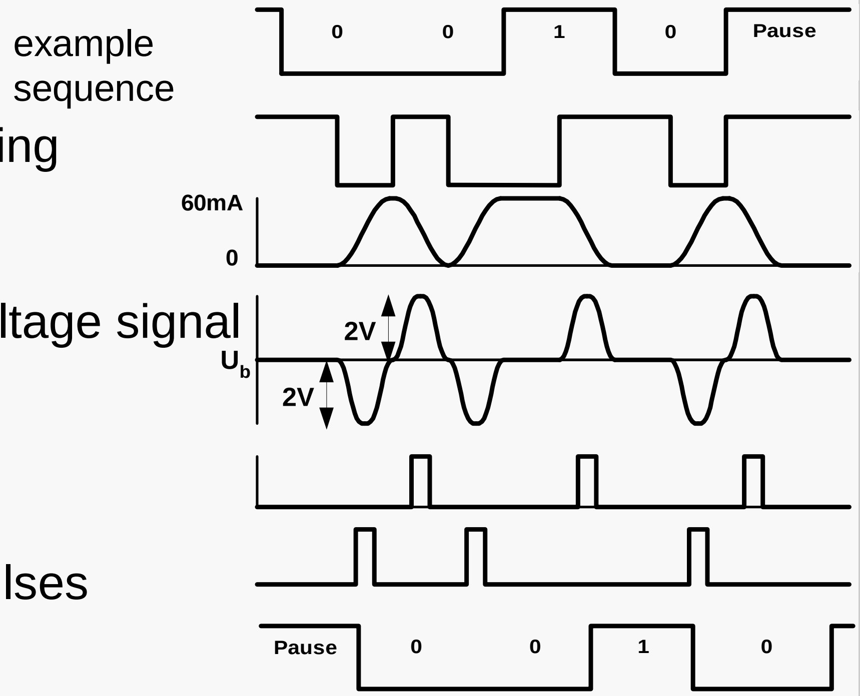
– Slavenodes — Costs of slavechip approx. 5 €
  - Variant 1: Sensor/actuators with integrated AS i - slavechip
  - Variant 2: Separate connection module



## Signal and supply on the same two-wire line

- Signal is modulated on DC voltage supply
- Condition: no direct current contingent of the signals

## Realization by means of alternating pulse modulation (APM)




<u>sender</u>

- Target bit sequence in Manchester coding
- Generation of a current signal
- Transformation of current signal into voltage signal
  - ð Intrusion on supply voltage

<u>receiver</u>

- Detection of positive and negative impulses
- Recovery of the original bit sequence

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## Sensors

**measuring value transducer**

### Tasks

- Recording of physical process variables
- Transformation into a form that is suitable for further processing
- Supervision of limits of values
- Self-test
- Self-calibration
- Adaptation to a bus system

} Intelligent Sensors (Supervision of limits of values, Self-test, Self-calibration, Adaptation to a bus system)

**according to the automation system**

## Sensor element

**detecting device, transmitter**

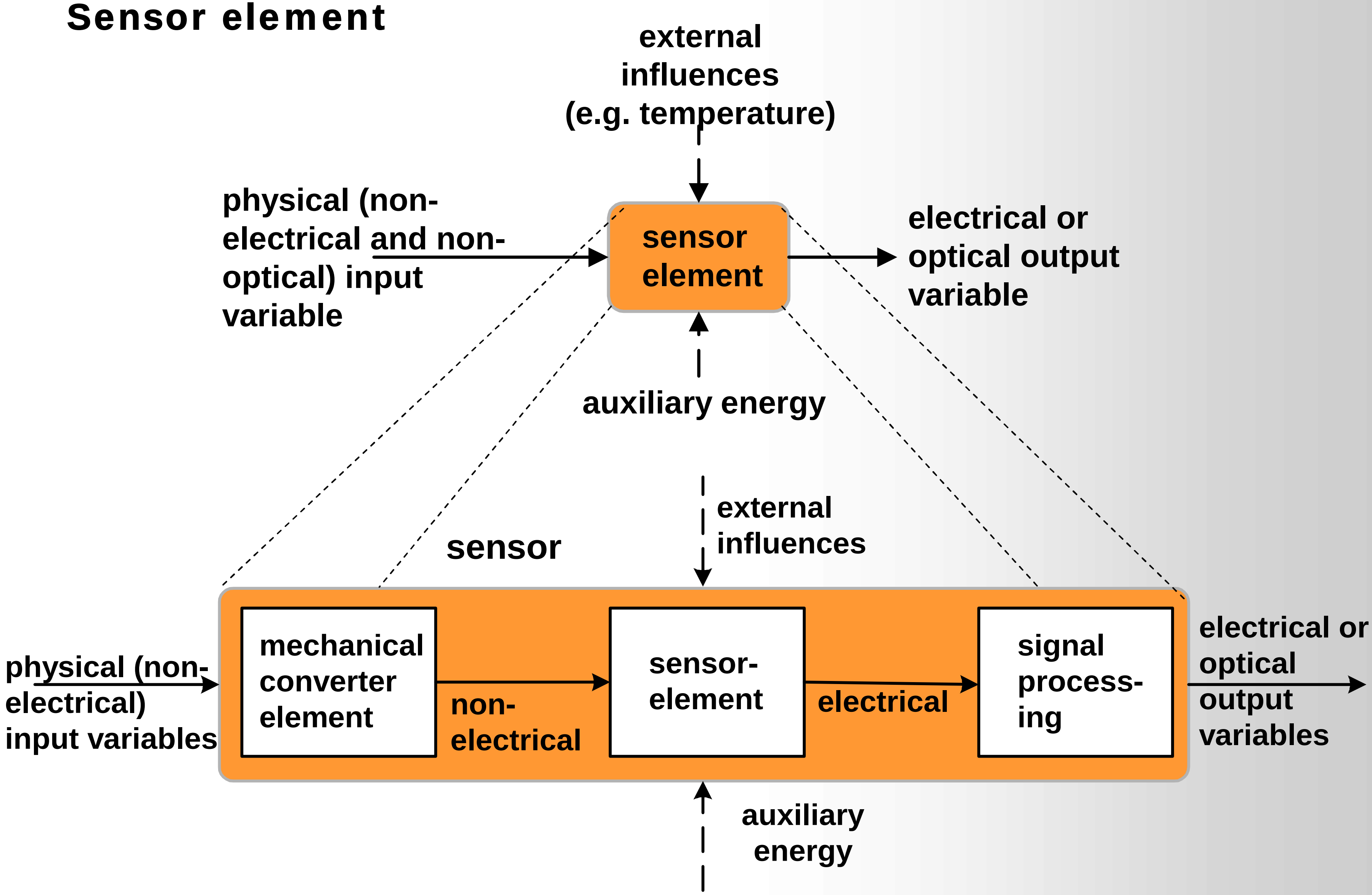
### Task

Transformation of a non-electrical, physical variable into a electrical or optical value

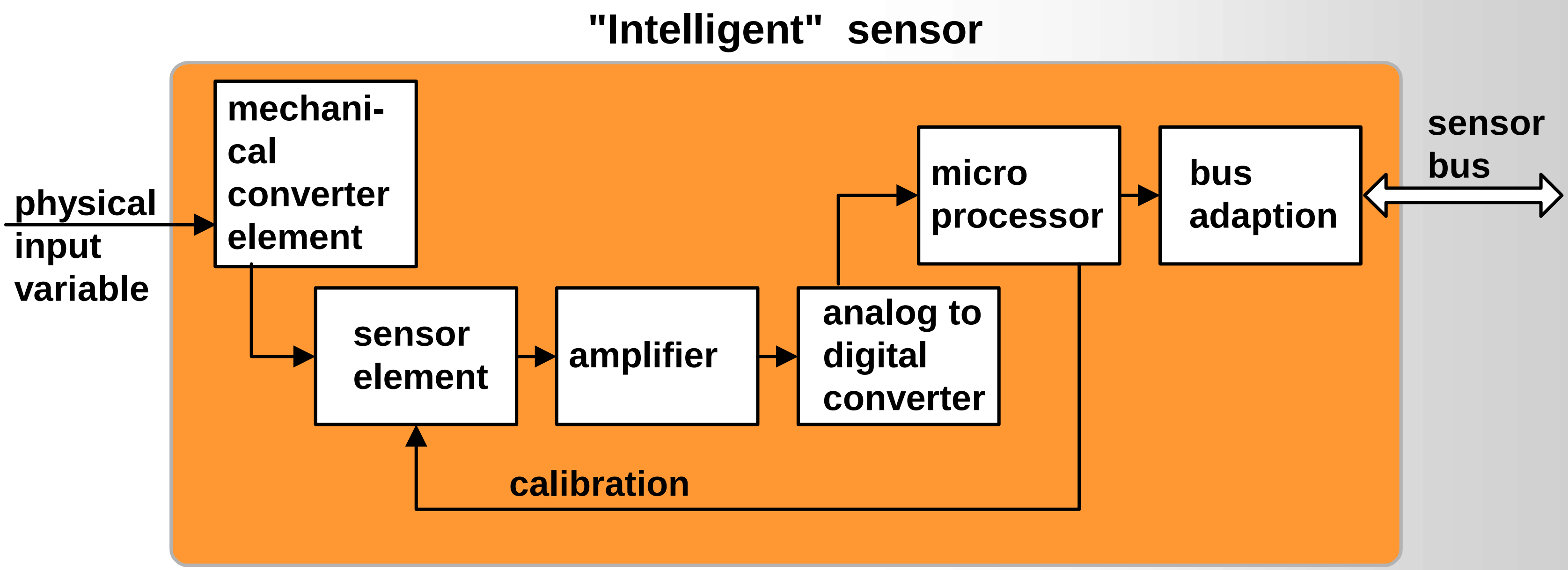
### Usage of physical effects

- Variation in resistance
- Variation of inductance
- Variation of capacity
- Piezoelectric effect
- Thermo-electrical effect
- Photo-electrical effect
- Eddy current effect
- Radiation absorption

## Sensor element



# Intelligent sensor



## Classification of sensor elements according to the kind of sensor output signal

- digital sensors
- binary sensors
- amplitude analog sensors
- frequency analog sensors

Sensor system

Integration of several sensors for different process variables with the evaluation electronics on one component

## Binary sensors

- Yes/No information
- Limit value transmitter/ threshold transmitter
- Example: end switch, light barrier

## Digital sensors

- Conversion of a non-electrical, measured quantity into a digital output signal
- Conversion possibilities
  - **Direct conversion**
    Conversion of the non-electrical signal with encoder disc (rotating movement) or encoder ruler (linear movement) into a digital signal
  - **Indirect conversion**
    Conversion of non-electrical signal into an amplitude analog signal, then analog to digital conversion

## Amplitude analog sensors

- The transformation of a non-electrical, measured quantity into an amplitude analog output signal. The amplitude of the electronic output signal is proportional to the physical quantity to be measured
- Often with transducer step in the same case
  - amplification
  - normalization
  - linearization
  - temperature compensation
- For all important measured values available

## Frequency analog sensors

- Outputs an alternating voltage signal whose frequency is proportional to the physical value to be measured.
- Advantages:
  - Insensitiveness against disturbing interferences on the transmission lines
  - Simple frequency-digital conversion with a counter
  - No loss of precision from amplification and transmission
  - Simple potential separation with transmitter
- Even in comparison to amplitude analog sensors

# Different kinds of sensor elements

| physical process variable | sensor element | output variable |
|---|---|---|
| temperature | thermo element<br>metal resistor<br>semiconductor resistor<br>(negative temperature coefficient resistor)<br>ceramic resistor<br>(positive temperature coefficient resistor) | mV<br>variation in resistance<br>variation in resistance<br><br><br>variation in resistance |
| pressure | pressure-can with membrane and strain gauge element<br>pressure-can with silicon-membrane (piezo resistive effect) | variation in resistance<br>variation in resistance |
| force | strain gauge element<br>inductive force sensor<br>Piezoelectric sensor | variation in resistance<br>variation of inductivity<br>charge |
| Rotational speed | Impulse generator<br>Impulse counter | V<br>pulse sequence |
| acceleration | Silicon piezo-resitor<br>Silicon condensator | variation in resistance<br>variation in capacity |
| flow | ring piston meter<br>inductive rate of flow measurer | pulse sequence<br>mV |
| approach | Hall-element out of silicon | mV |
| angle | angle encoder<br>pulse generator | digital value<br>pulse sequence |
| moisture | lithiumchloride moisture sensor | mV |
| Light intensity | photo diode<br>photo resistor | µA<br>variation in resistance |

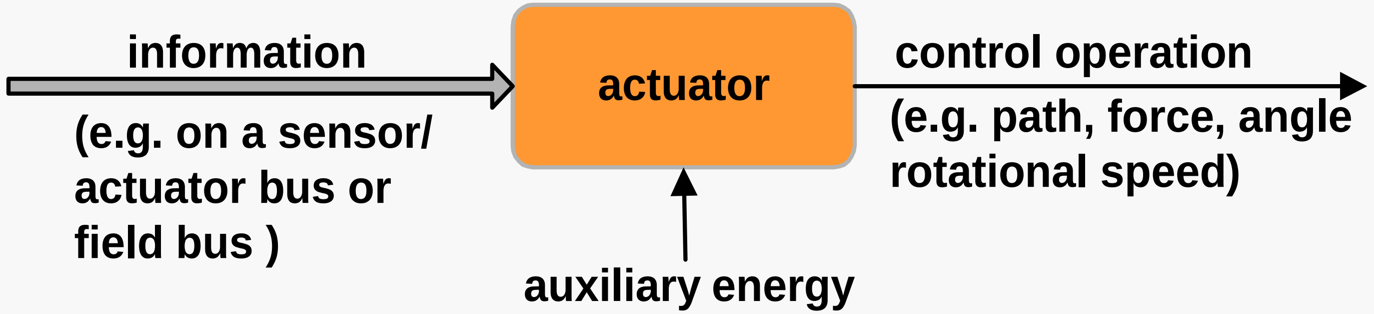
## Actuators

Tasks

Conversion of the information obtained from the automation computer system into manipulating interventions in the technical process

**“muscles” of the automation system**

## Actuator as a converter of information into a control operation




Actuator for different manipulated variables

- optical variables
- mechanical variables
- thermal variables
- flows

## Actuators with mechanical output quantities

| actuator principle | actuator |
|---|---|
| electronic mechanical movement | electro-motor, stepper motor, electro-magnet, linear-motor |
| hydraulic cylinder | hydraulic actuator |
| pneumatic cylinder | pneumatic actuator |
| piezoelectric effect | piezoelectric actuators, electrostrictive actuators |
| magnetostrictive effect | magnetostrictive actuators |
| electrorheologic effect | electrorheologic actuators |
| magnetorheologic effect | magnetorheologic actuators |
| electrically produced gas pressure | chemical actuators |
| bimetal effect | thermo bimetal actuators |
| memory metals | memory metal actuators |
| silicon micro techniques | micro mechanical actuators |

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## Kinds of electrical process signals

- Analog process signals
  - amplitude analog
  - frequency analog
  - phase analog
- Binary process signals **switch position**
- Digital process signals **n-bit word**
- Process signals in the form of pulses **rotational speed indicator**
- Process signals in the form of pulse edges

  **state transition of a process variable**

## Conversion of analog process variables

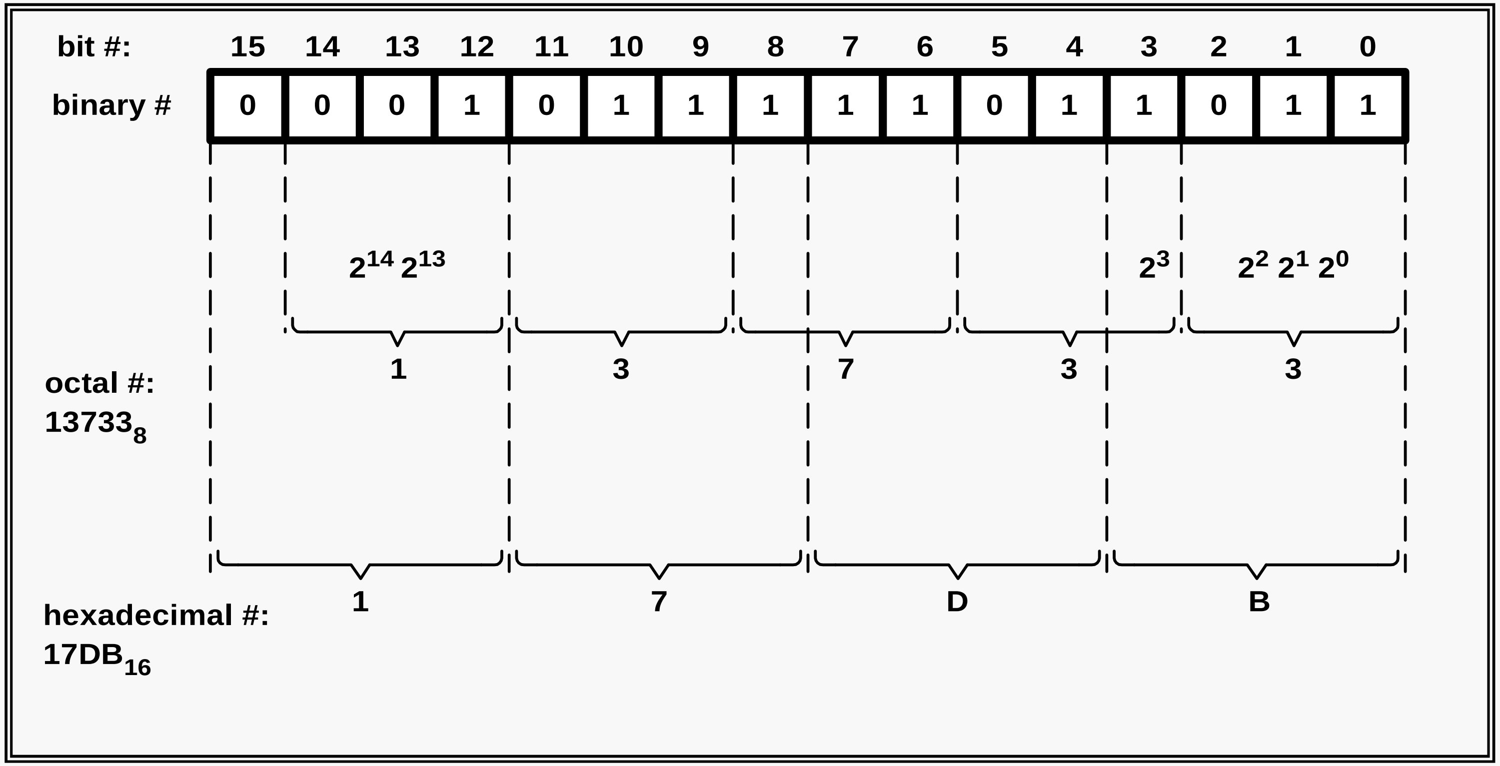
Analog process variables have to be converted into digital values before they could be used in a computer system. Therefore, the analog value range is discretised.

| representation error (% of maximum value) | value coding by the AD-converter bits | decimal | necessary word length (in bytes) |
|---|---|---|---|
| 0,39% | 8 | 0 ... 255 | 1 |
| 0,1% | 10 | 0 ... 1 023 | 2 |
| 0,025% | 12 | 0 ... 4 095 | 2 |
| 0,006% | 14 | 0 ... 16 383 | 2 |
| 0,0015% | 16 | 0 ... 65 535 | 2 |

Important: A word length of 16 bit is sufficient for representing analog process variables.

## Representation of digital process variables

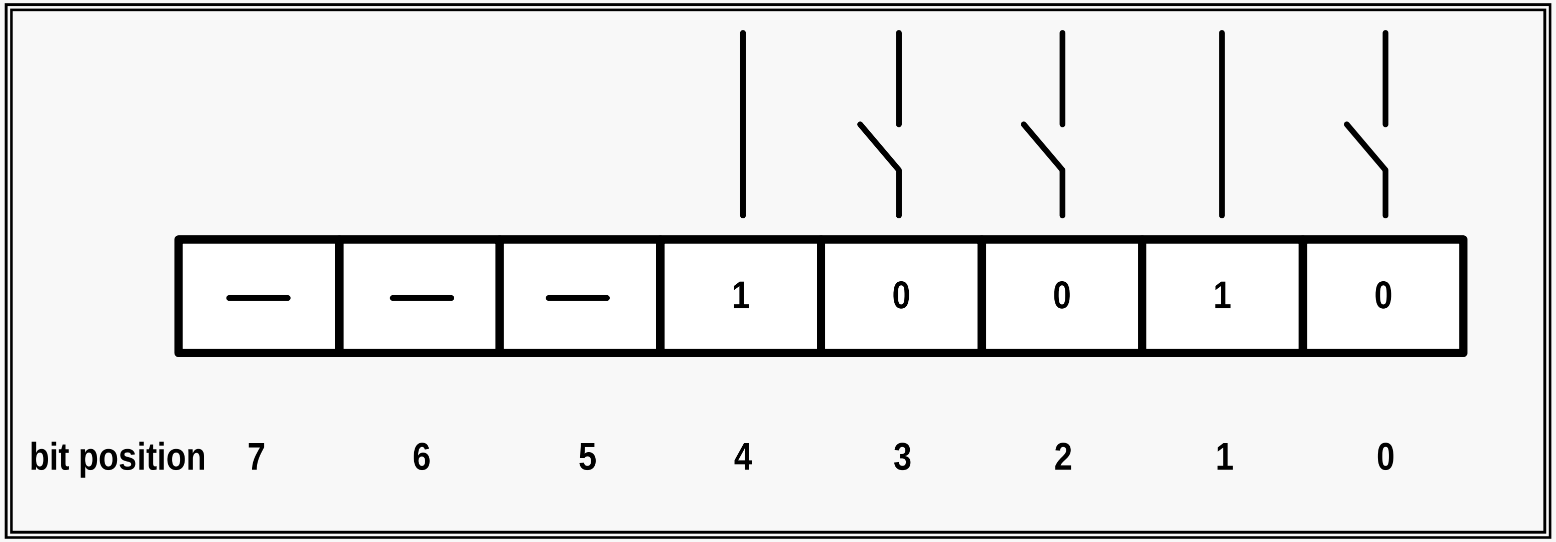
Digital process variable are usually represented as binary, octal or hexadecimal values. The picture illustrates each encoding.




Important: A word length of 16 bits is normally sufficient for representing digital process variables.

## Representation of contact positions

Contact positions are frequently summarised as a computer word. In such case single bits have to be addressable and modifiable.




Important: A word length of 16 bits is normally sufficient for representing binary process variables and pulse shaped process variables.

**Question: Why use 32 bit computers for automation tasks?**

**Larger address space, shorter calculation times**

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## Various forms of analog process signals

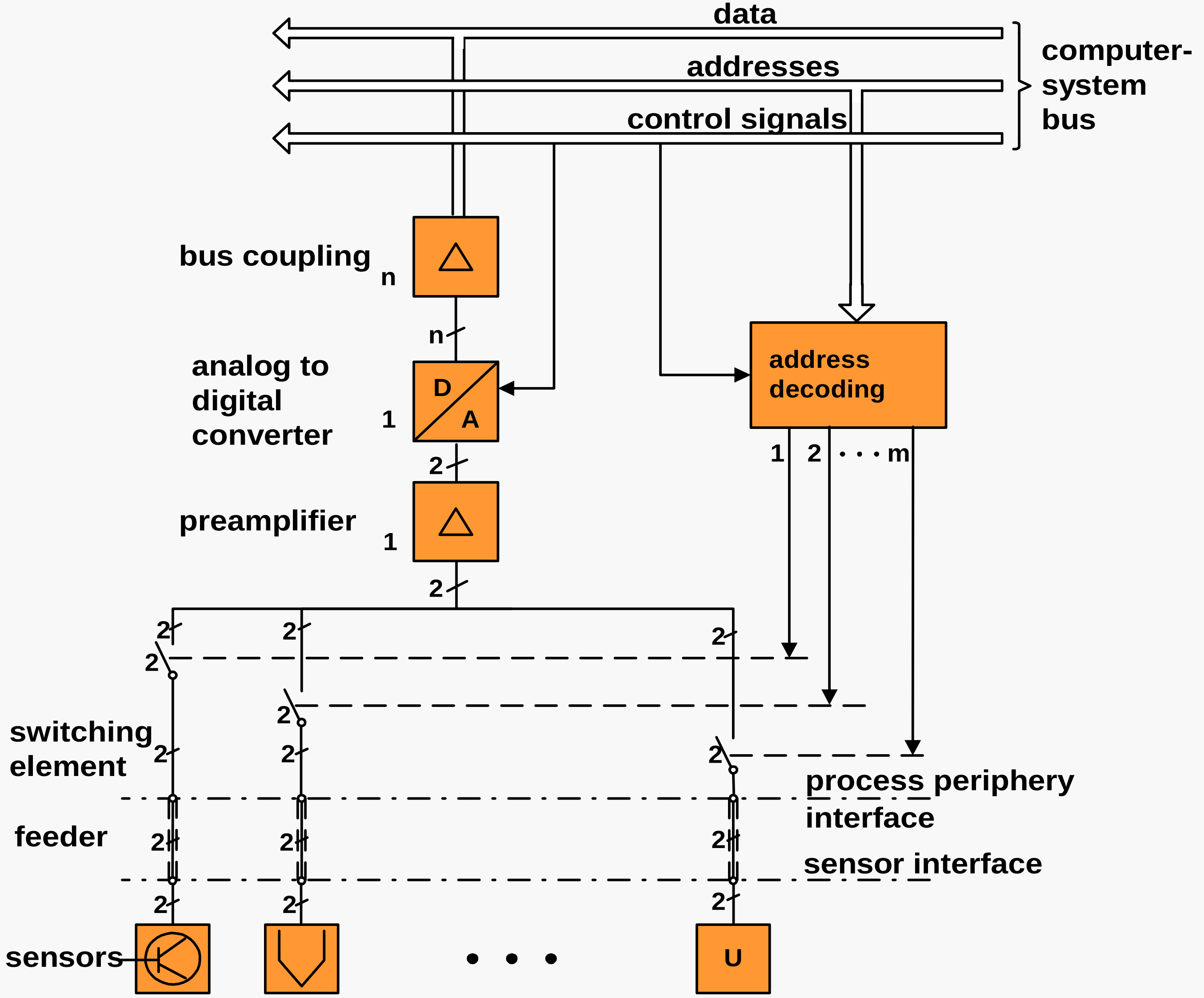
- electrical voltage signals
- electrical current signals
- electrical analog resistance values

## Various forms of signal conversion

Realization arises from the requests of the complete system

- quick A/D conversion — **Signals are needed immediately**
- slow A/D conversion — **Usage of the process time**

## Fundamental structure

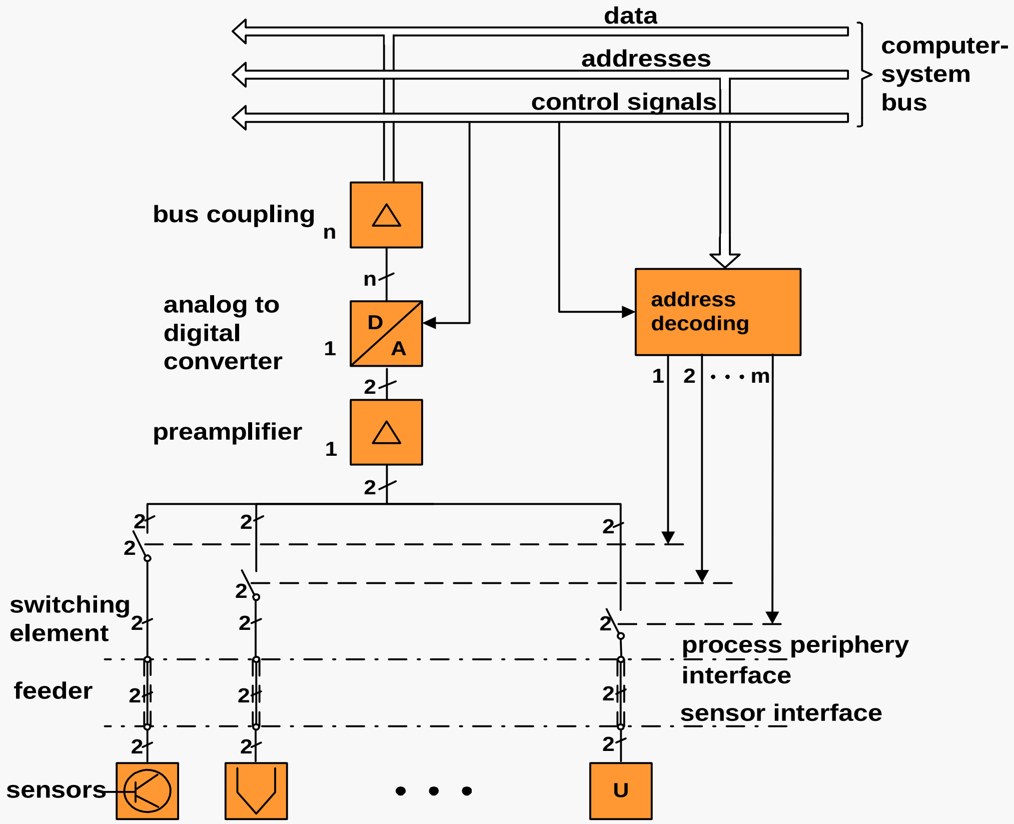


## Fast analog to digital conversion

– Fast analog to digital conversion
ADC with conversion time of 1-100 μs, i.e.

**Sampling frequency > 10.000 samples per second**

1. Through-switching of the selected analog signal to the ADC and conversion
2. Input of the converted value via the data bus



## Slow analog to digital converter

– Slow analog to digital converter
ADC with conversion time of > 100 µs, i.e.

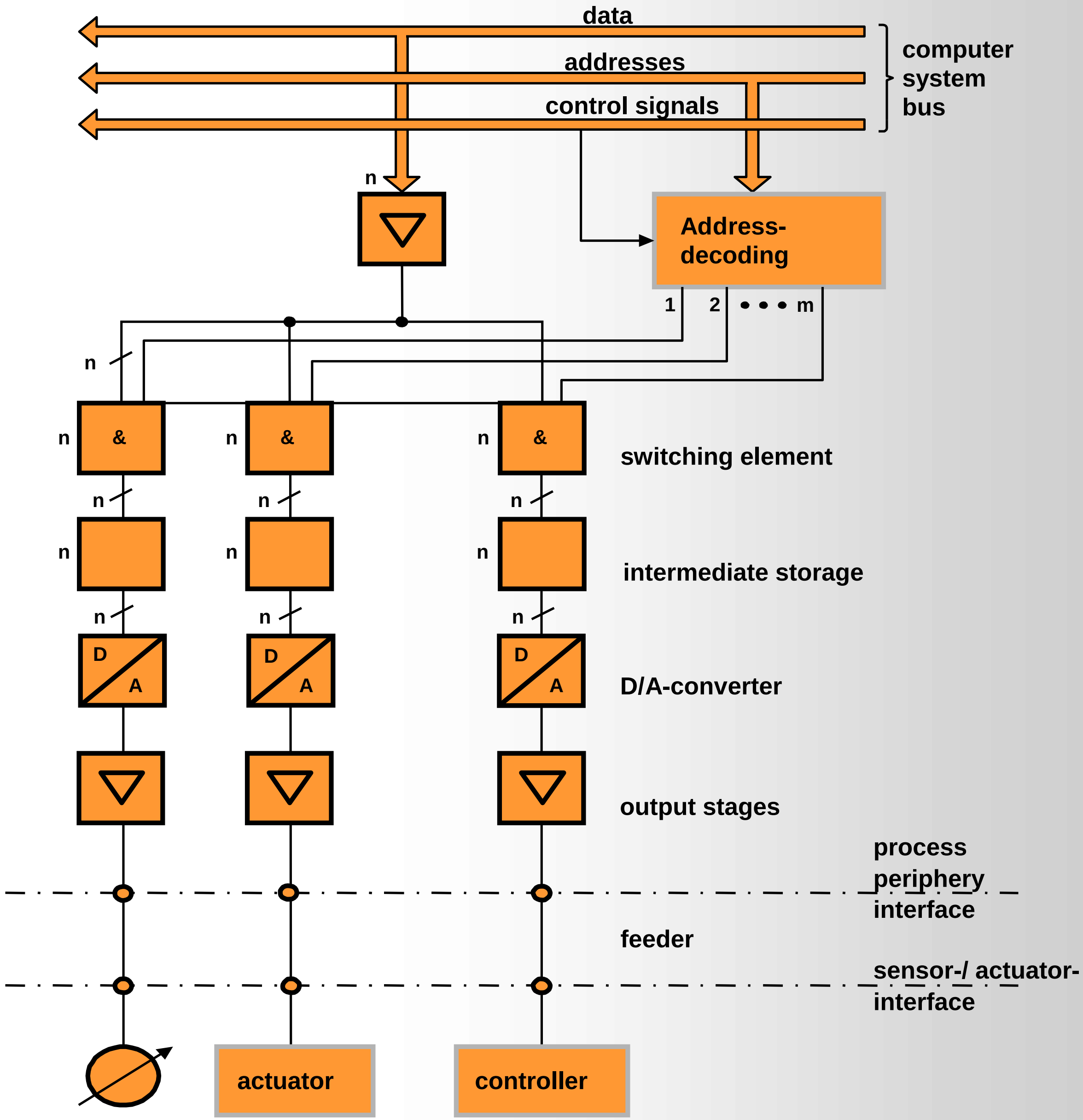
**Sampling frequency < 10.000 samples per second**

1. Address of the analog signal is output to the switching device
2. Conversion into digital value is initiated
3. A different program is initiated, to use the (rather long) conversion time
4. When conversion is completed an interrupt signal is created
5. The corresponding interrupt program reads in the converted information

## Analog output

Conversion of the digital, time-discrete values from the automation computer into continuos signals




Structure of an analog output module

## Remarks to the analog output

- Intermediate storage is necessary in order to store the information at the switching element
- Analog control operations often through servo motors that are controlled by binary signals over the digital output
- Analog output value corresponds to time span of the binary signal output

## Types of analog to digital converter

- Instantaneous value converter
  - single values of an analog process signal are sampled and converted into digital values

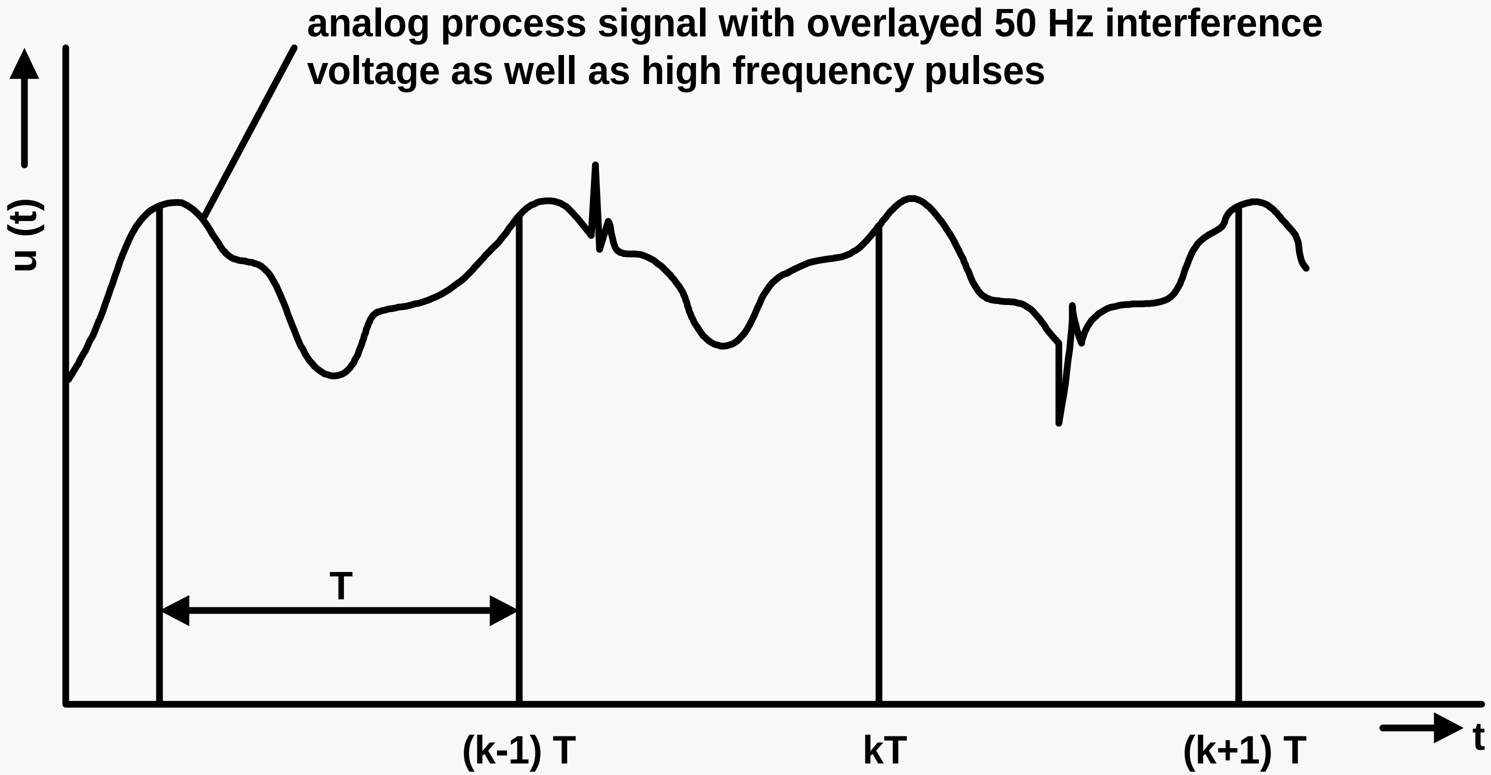
- Integrating converter (Mean Value Converter)
  - Analog process signal is integrated over a period T of the net frequency and the mean value is calculated
  - Mean value is converted into digital value

$$u(kT) = \frac{1}{T}\int_{(k-1)T}^{kT} u(t)dt$$

  - Advantage: high measurement safety accuracy
  - Relative low effort
  - Elimination of high frequency non-periodic disturbances
  - Suppression of line frequency interference voltages
  - Only applicable for relatively slowly changing process signals

## The principle of the integrating ADC

$$u(kT) = \frac{1}{T}\int_{(k-1)T}^{kT} u(t)dt$$




**T = multiples of 20 ms with 50 Hz line frequency**

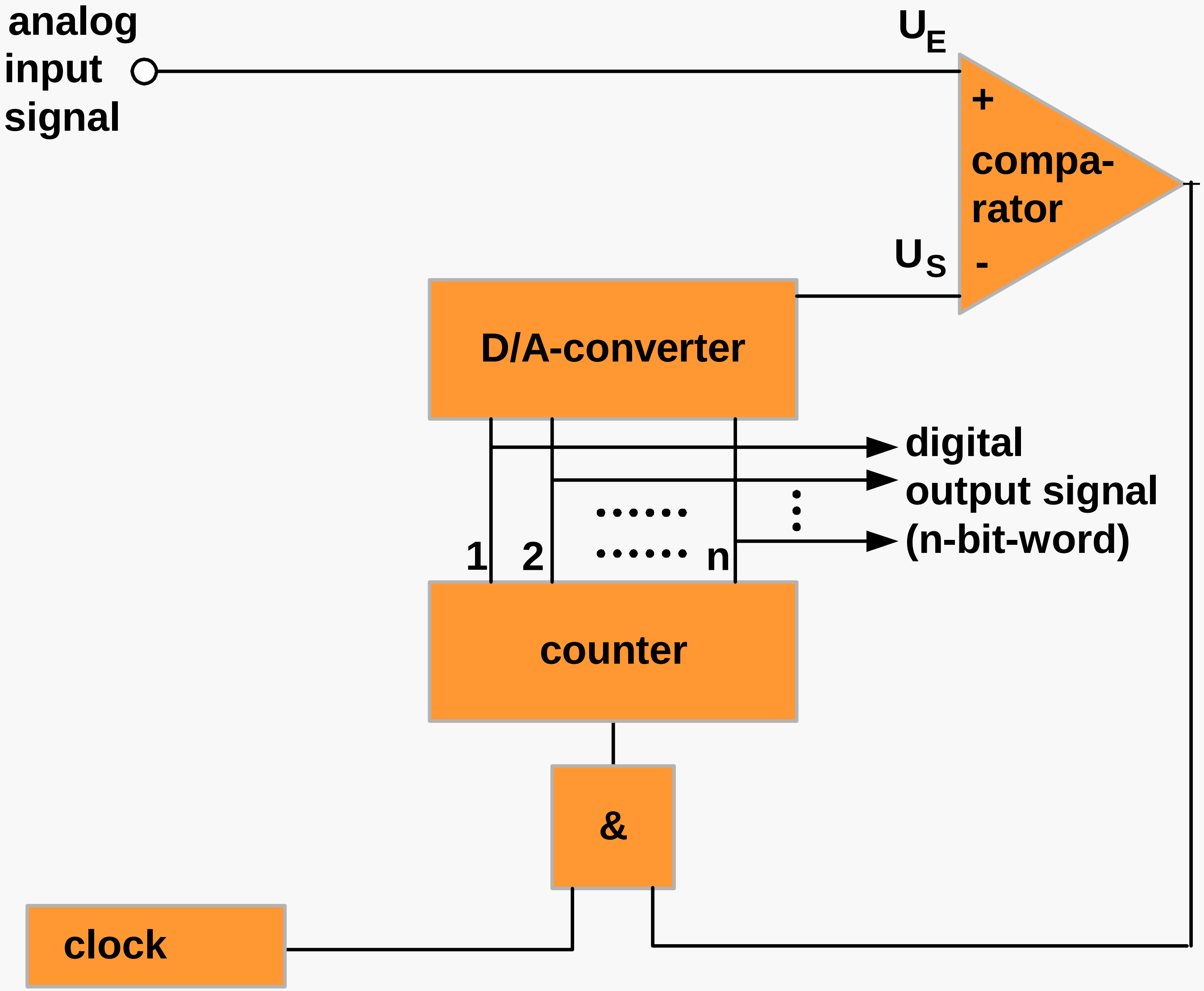
# Conversion methods for analog to digital converter

| | Instantaneous value converter | Mean value converter |
|---|---|---|
| Advantage | High conversion speed<br>$10^4$ ... $10^8$ values/s | High interference voltage suppression |
| Disadvantage | Interference pulses cause falsification of digital values | Low conversion speed |
| Convertion method | Counter method,<br>step method,<br>direct method | Voltage time or<br>voltage frequency converter |

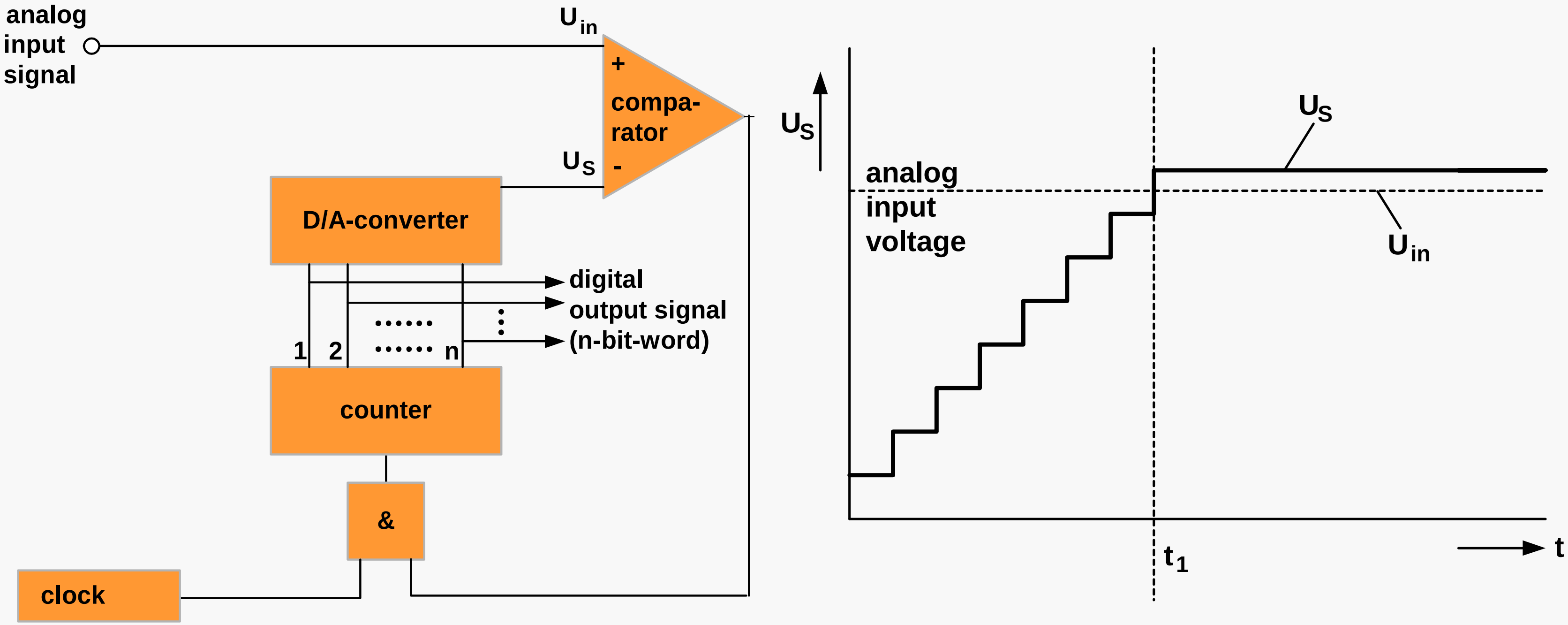
# Instantaneous-value-ADC using the counter method

Basic structure



## Principle procedure

- $U_s$ at the output of the DAC
- compare to $U_{in}$
- in case of equality the counter gets no impulse
- otherwise counter is increased
- new counter signal is D/A converted
- method is repeated until $U_s > U_{in}$



## Instantaneous-value-ADC using the counter method

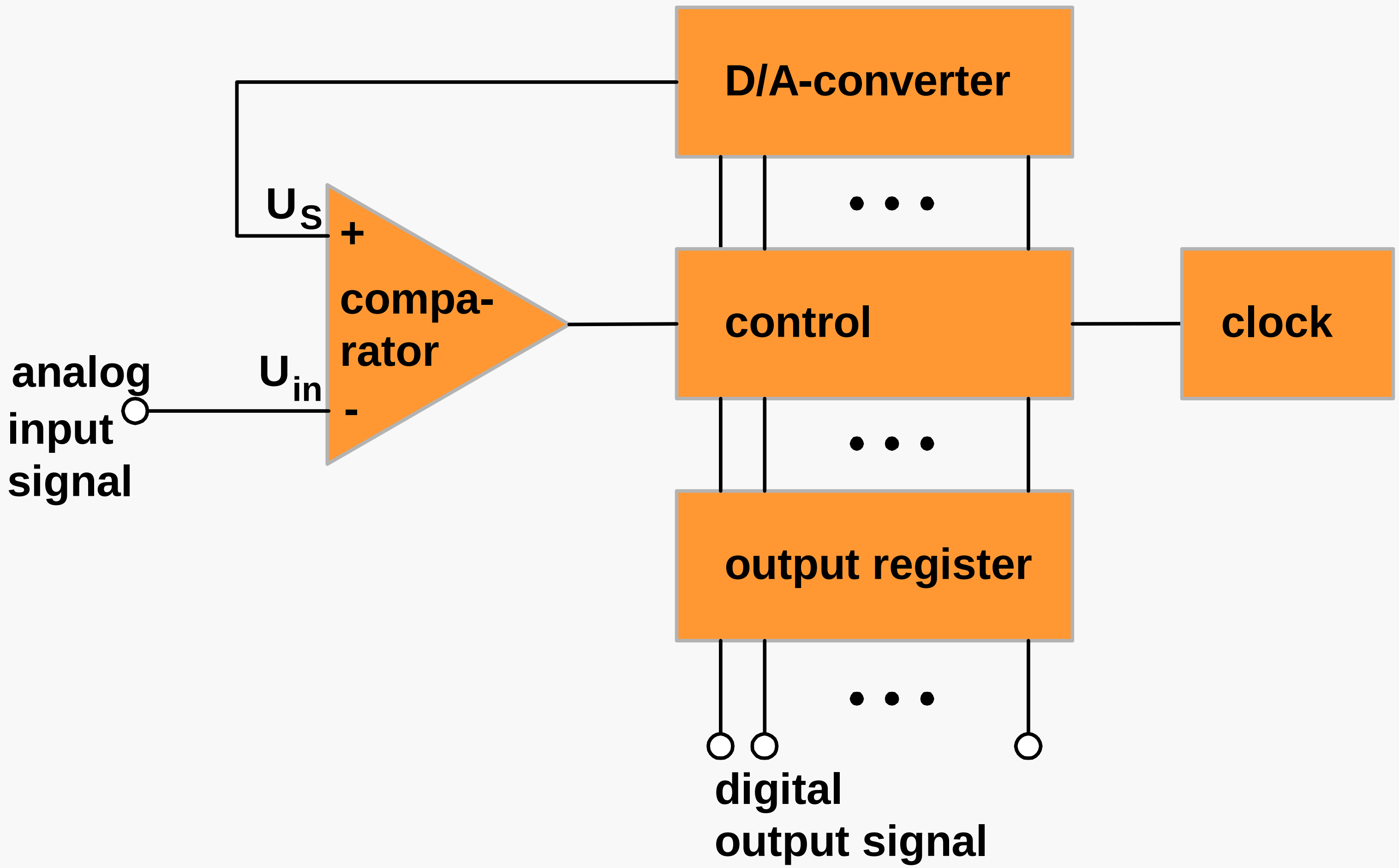
Conversion time T is depending on:

- Transient behavior of the DAC
- Switching speed of the comparators
- Input voltage
- Word length of the digital output ($2^n$ steps in worst case)
- Clock rate f

**Clock frequency depends on rise time of the DAC and switching speed of the comparator**

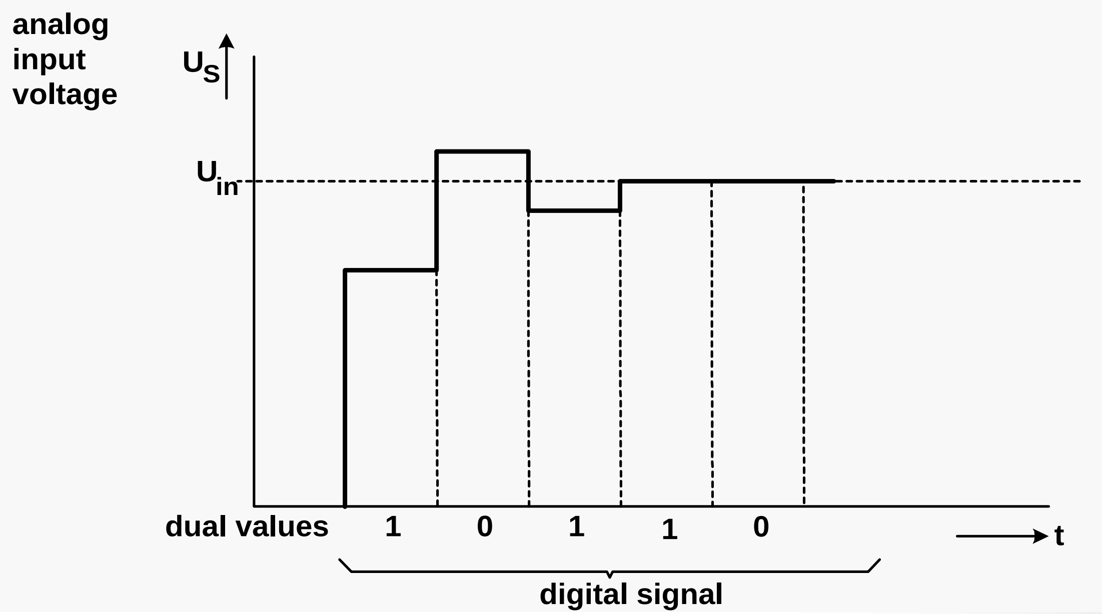
# Instantaneous-value-ADC using the step method

Basic structure



## Principle procedure

- Control sets highest order bit (MSB = Most Significant Bit)
- $U_S$ at exit of the DAC
- Comparison with $U_{in}$
- If $U_{in} > U_S$ MSB stays set, if not reset
- Method is repeated for further bits
- After the last comparison (bit n) the value of the analog input signal is represented digitally encoded in the output register



# Instantaneous-value-ADC using the step method

## Conversion time T

– constant (after n steps results are available)

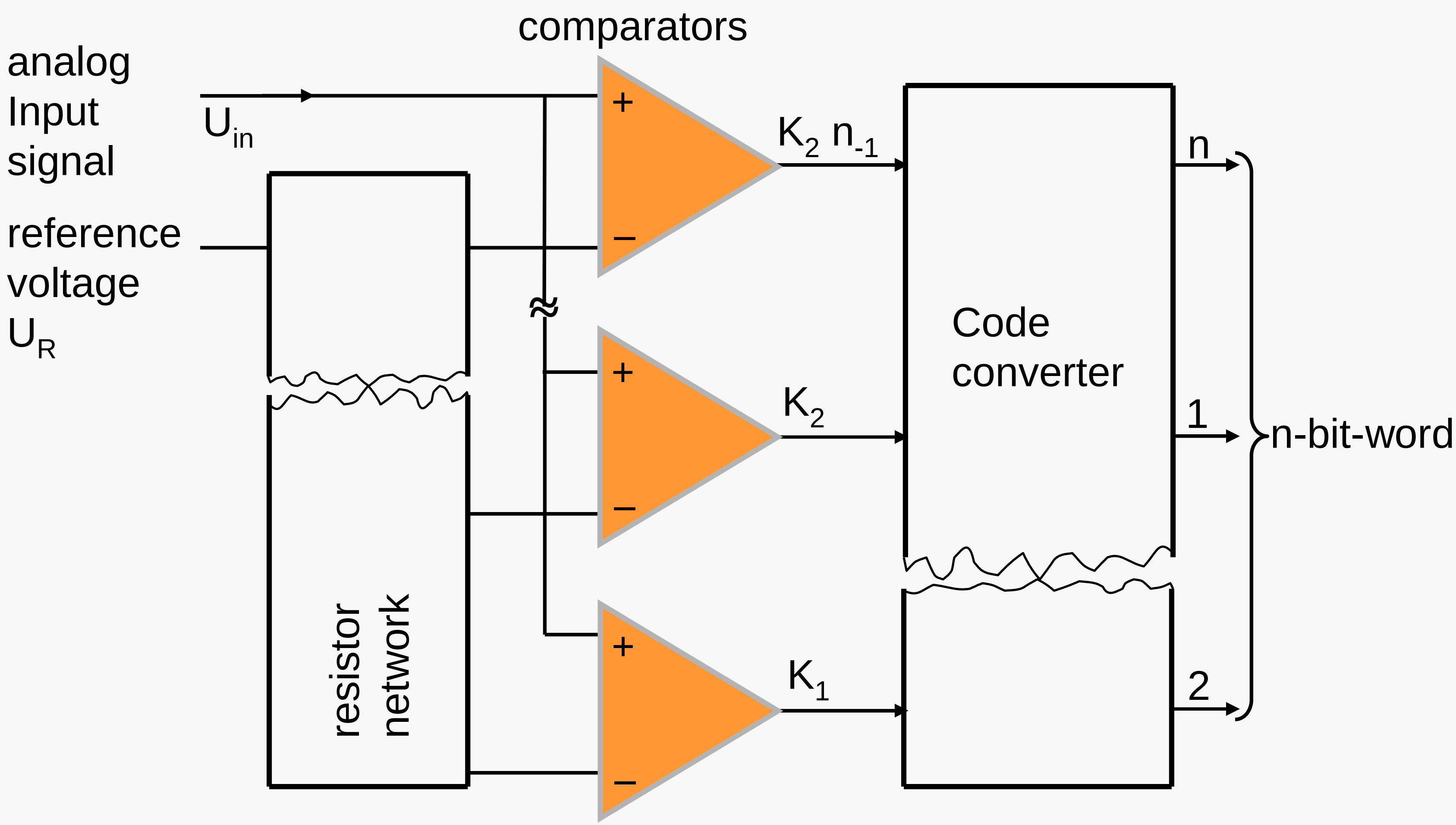
– T = n/f

– Limitation through
  - settling time of the DACs
  - switching speed of comparators

# Instantaneous-value-ADC using the parallel conversion method

Principle structure



## Principle procedure

- Input signal is given to $2^n$ - 1 comparators
- Reference voltages are produced over resistor network with reference voltage source
- Conversion through code converter in n-bit-word

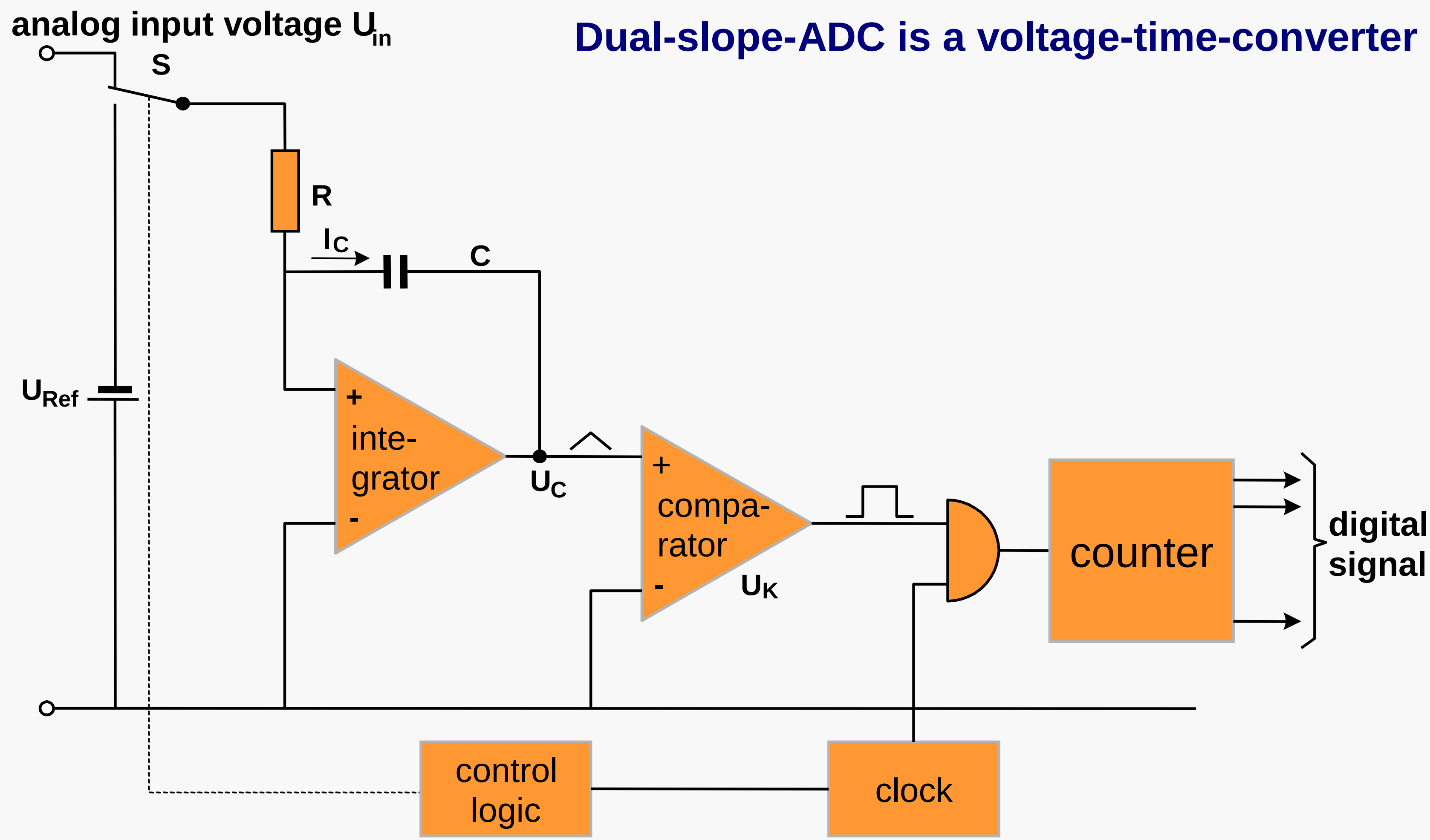
## Conversion time

- Dependent on switching speed of the comparators and of the code converter
- $10^8$ values/sec
- Very costly, 8-bit ADC needs $2^8$ - 1 comparators

# Integrating ADC using the "Dual-slope-method"

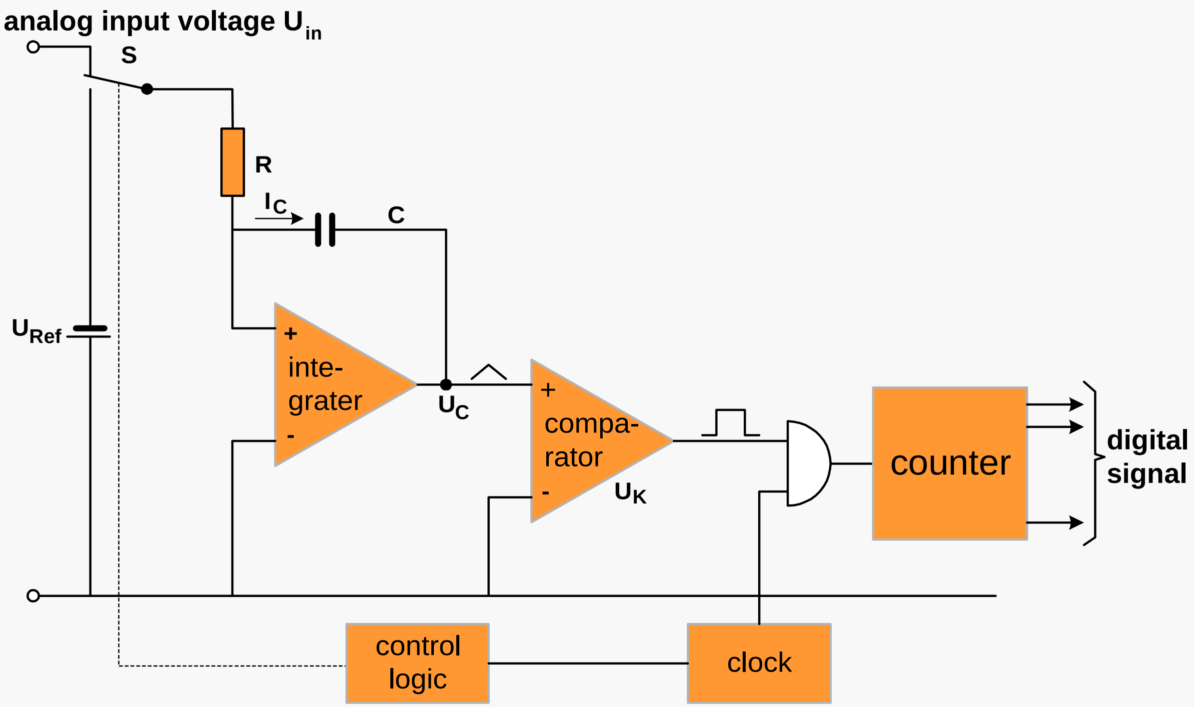
Basic structure

Dual-slope-ADC is a voltage-time-converter

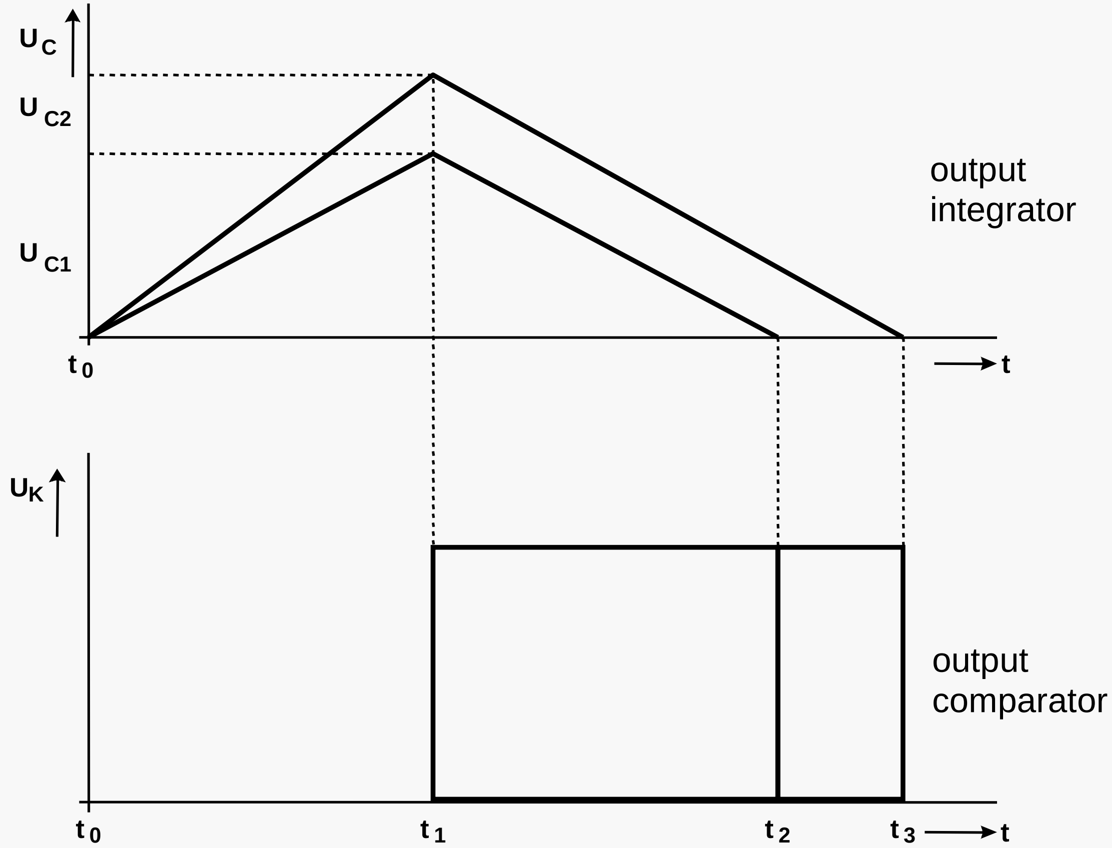


## Principle procedure

- Capacitor C is charged from $t_0$ until $t_1$ with the current $I_C = U_{in} /R$
- $U_{Ref}$ is set at the input of the integrator at time $t_1$
- Capacitor C is discharged, $U_{in}$ defines the time span of discharge
- Time until $U_0$ = 0V is directly proportional to $U_{in}$
- Measurement of time span with a counter, which counts the impulses generated by time clock



# Course of signals in ADC according to the “Dual-slope- method”



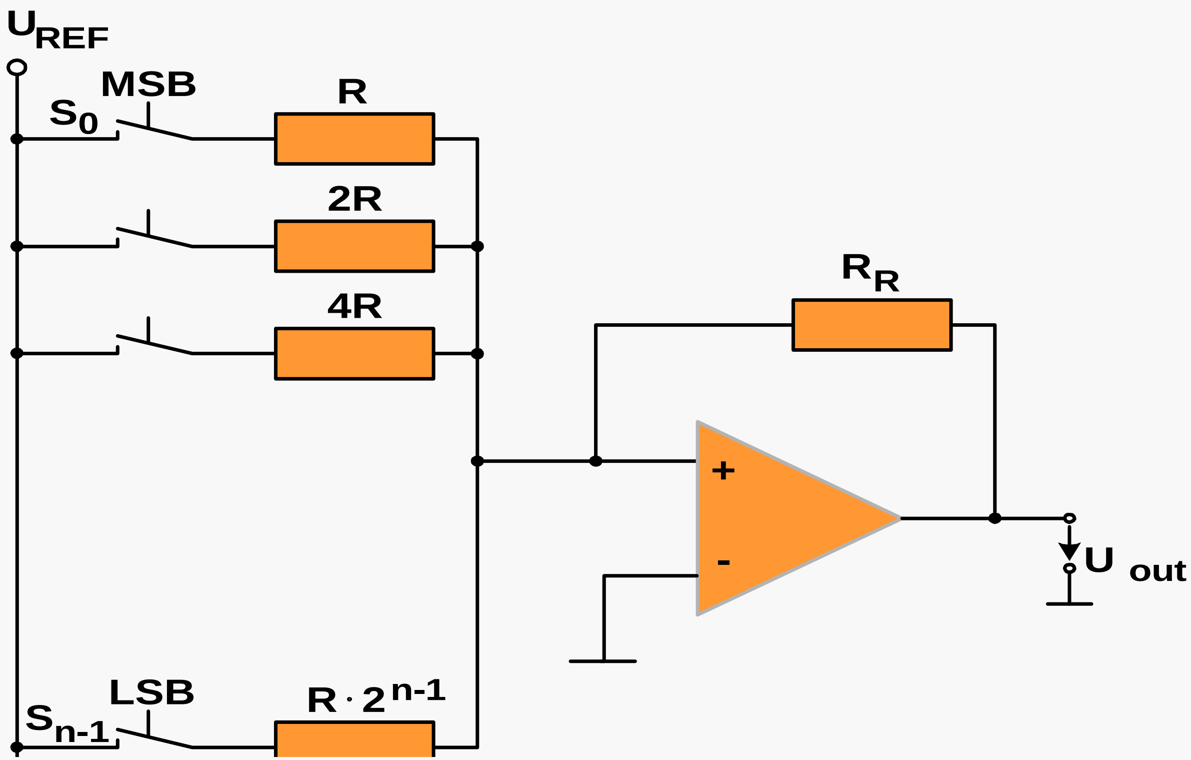

## Advantages

- Long term variations are not influencing the measurement
- Precision is independent of the product of R∗C, it is only dependent on the precision of the reference source and of the operation amplifiers

## Types of digital-to-analog converter

- Most of the DACs are using a direct method with resistance network
- Various characteristics of the resistance network
- Various ways of realizing a DAC with resistor network
  - DA-conversion via the summing up of weighted currents
  - DA-conversion via a conductor network

## Realization of a DAC by summing up of weighted currents

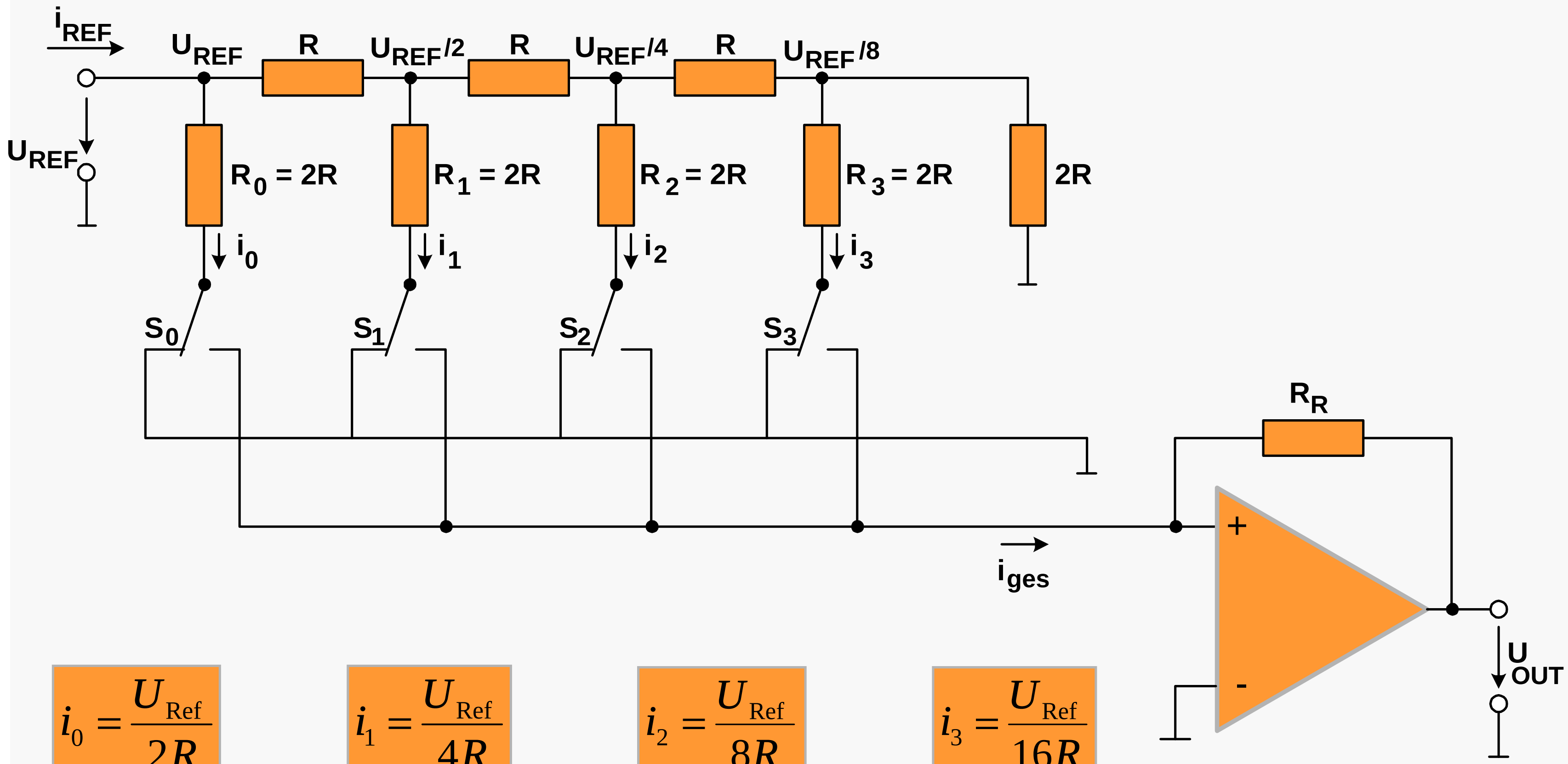



Disadvantages:

- very different potentials on the switches
  (Bipolar transistors or field-effect transistors)
- necessary precision of the very different resistors is hard to fulfill

# Realization of a DAC with the help of a conductor network




$$i_0 = \frac{U_{\mathrm{Ref}}}{2R}$$ $$i_1 = \frac{U_{\mathrm{Ref}}}{4R}$$ $$i_2 = \frac{U_{\mathrm{Ref}}}{8R}$$ $$i_3 = \frac{U_{\mathrm{Ref}}}{16R}$$

Currents add up according to position of switches to current $i_{sum}$

Operation amplifier creates $U_{out}$

Switches are often bipolar transistors of field-effect transistors

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## Digital input

– Input of single binary process signals
  e.g.: limit switch, maximum value transmitter

– Input of groups of binary process signals
  e.g.: position of multistage switch

## Kinds of binary input signals

– binary voltage input
– binary current input
– binary contact input
  - power supply for contact transmitter
  - facility for the suppression of contact bounces

## Distinction regarding signal parameters

- Static digital input
  - High and low for binary signal correspond to the two states
- Dynamic digital input (impulse input)
  - Edges of the signal act as binary signal parameter
  - Transitions from high to low and vice versa set the assigned storage element
  - Spontaneous digital input if interrupt is triggered

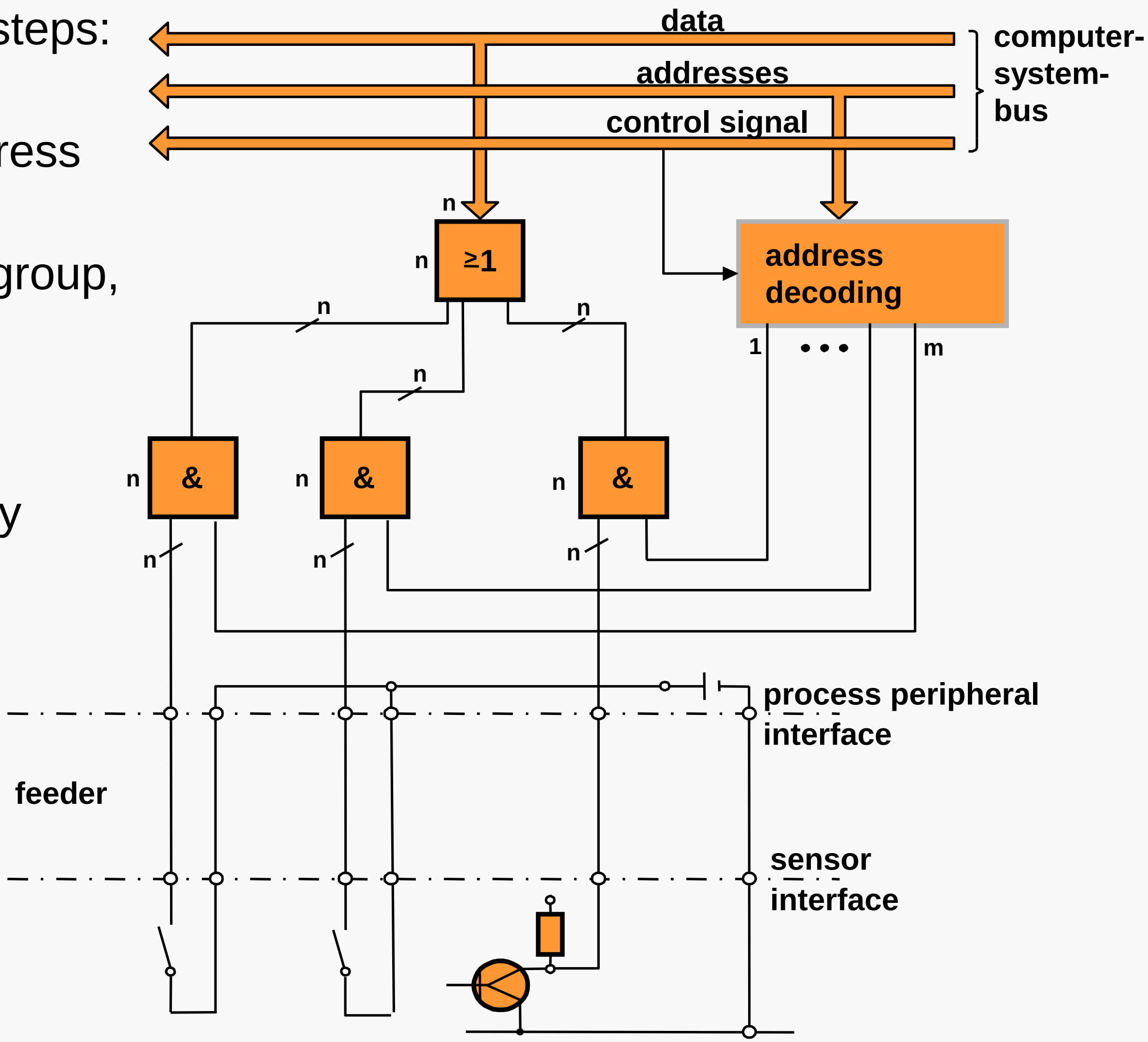
 

## Structure of a module for the static digital input

Input operation in two steps:

1. Provision of the address of the binary signals, that are gathered to a group, on the address bus

2. Switching-through of the addressed binary signals to the data bus



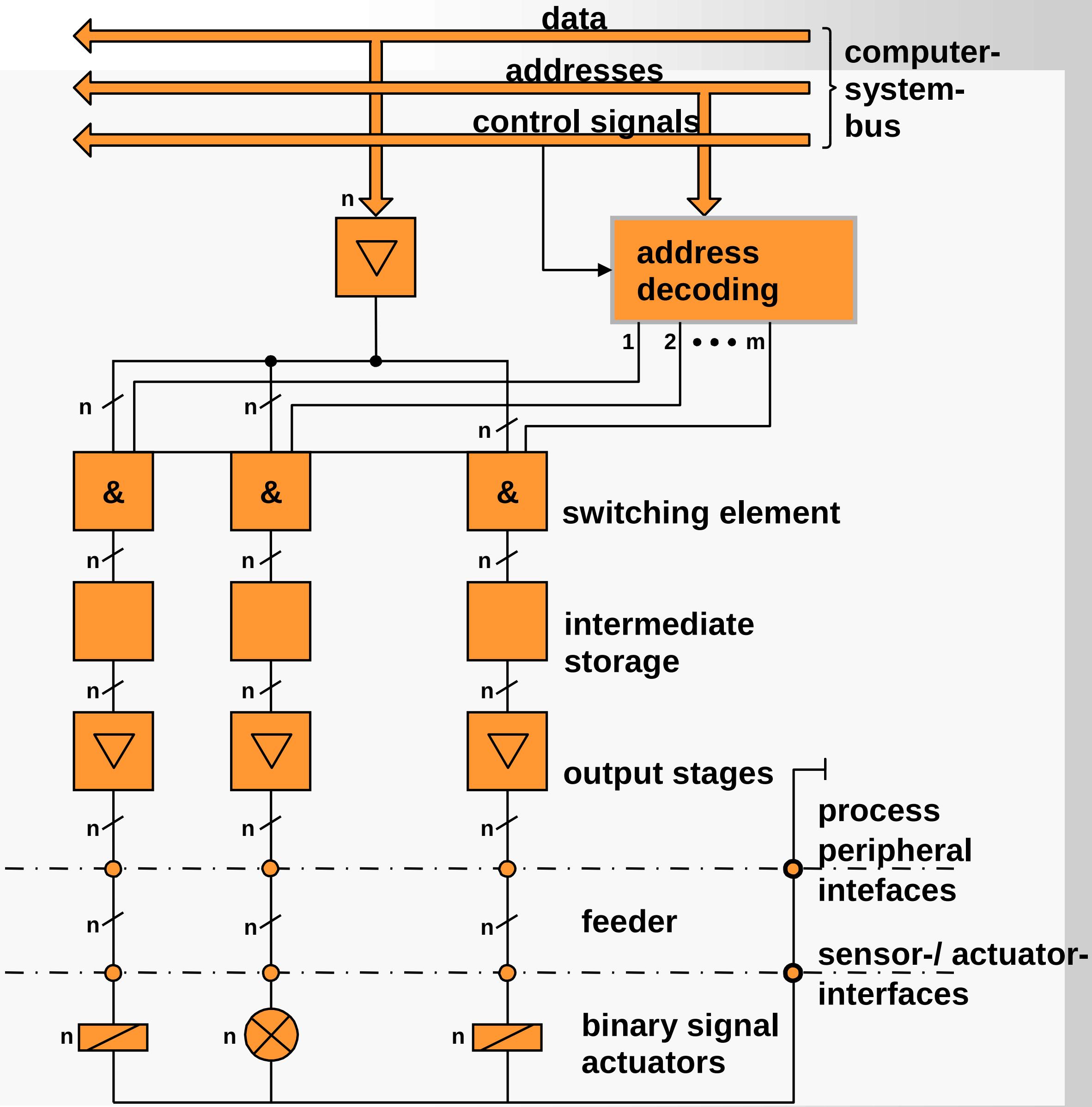
# Digital output

Structure of a digital output module

– Output of single binary signals

– Output of a group of binary signals

**for the realization of continuous signals**



## Kinds of binary output signals

- Voltage output
- Current output
- Output of potential-free contact positions

## Execution of digital output

- Output signal of process computer is only valid if according address is output on the address bus
- Control of devices (contactor, relays, lamps) need a continuous signal as input signals

  ð **Intermediate storage**

Output operation in three steps:

1. Provision of the address of the word to be given out
2. Output of the selected binary signal in the intermediate storage
3. Output of the continuous signal from the intermediate storage to the connected device

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## Motivation for the introduction of a field bus system

Weaknesses of conventional connection techniques:

- **1 line per component is very consuming**
- **inflexible in modification and amplification**

ð Use of serial bus systems for communication between the sensors/ actuators and the automation computer system in order to reduce planning and installation costs

Application fields:

- plant automation
- production automation
- automobile electronics (control and monitoring)

# Requirements on field bus systems

Differentiation between general requirements as

- Reliable communication under all environmental conditions
- Simple handling through maintenance staff
- Simple and robust connection technique
- Intrinsic safety in explosive areas

Application-oriented requirements as

- Number of input/output signals,
- Complexity,
- „Granularity“,
- Plant extension,
- Real-time requirements.

## Terminology

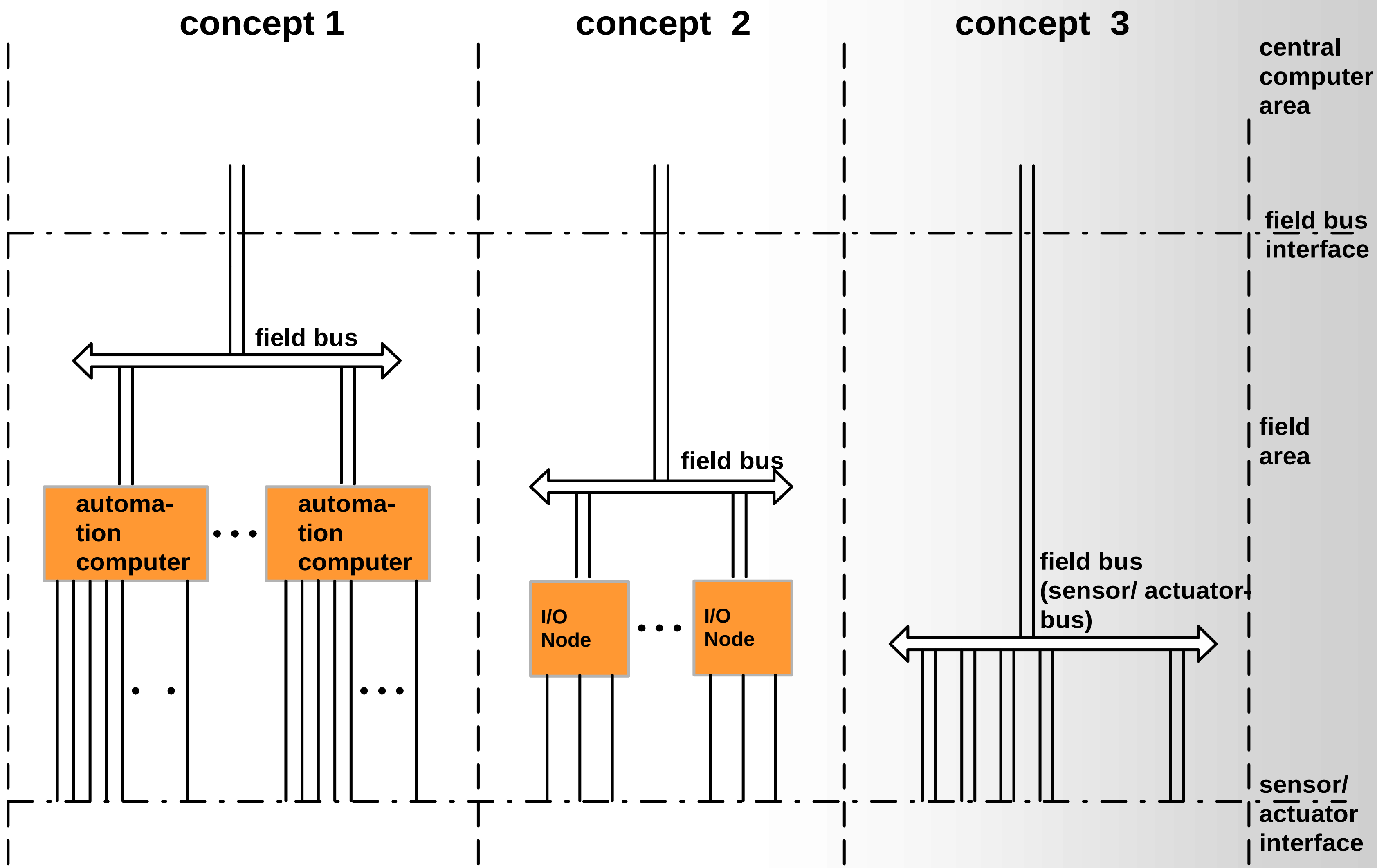
| | |
|---|---|
| Field area: | That part of the automation system that is spatially close to, or in direct connection with, the technical process |
| Field devices: | Measuring instruments, switch gears, controlling devices, that interact directly with the technical process |
| Field bus systems: | Serial data communication systems for the data exchange within the field area. Special requirements on the security of the data transfer: data integrity, EMC (Electromagnetic Compatibility) |

## Field bus systems

| Examples | Manufacturer or main application area |
|---|---|
| – AS-Interface | 11 actuator/sensor manufacturers, simple interface of binary field devices |
| – INTERBUS-S | Phoenix Contact<br>Employment in manufacturing automation |
| – PROFIBUS (Process Field Bus) | „cooperative project field bus"<br>European field bus standard |
| – Foundation Fieldbus | Field bus Foundation<br>American field bus standard |
| – FIP (**F**lux **I**nformation **P**rocess bus) | French - ital. Consortium<br>French field bus standard |
| – CAN | BOSCH - main field of application in automotive industry |
| – EIB (European Installation Bus) | Manufacturer of electric installations<br>Building automation |

# Classification of field bus concepts



## Kinds of bus access methods

Bus access methods = rules for the transmission of messages

– Deterministic bus access

- determined methods for transmission rights
- predictable response time

E.g.: master/slave-method, Token-Passing method, TDMA method

– Random bus access

- permanent monitoring of the bus
- event driven communication
- low/middle bus load
- non-predictable response time

E.g.: CSMA method (CSMA/CD, CSMA/CA)

## Master / slave method

– Principle

- Superordinate bus participant (master) controls bus access

– Advantages

- simple organization
- guaranteed maximal response time

– Disadvantages

- maximal latency time is proportional to the amount of bus participants
- in case of master failure there is no communication possible

**Examples: AS-Interface, Bit-bus, Profibus**

## Token-Passing-Method

Passing on of the Token (transmission right) from participant to participant after a maximal time span

## Different kinds of Token-Passing-methods

- Token Bus
  - Line topology
  - Logical sequence of participants
- Token Ring
  - Ring topology
  - Sequence of transmission rights according to physical sequence

Advantages:
+ good, predictable real-time behavior
+ very good high load suitability

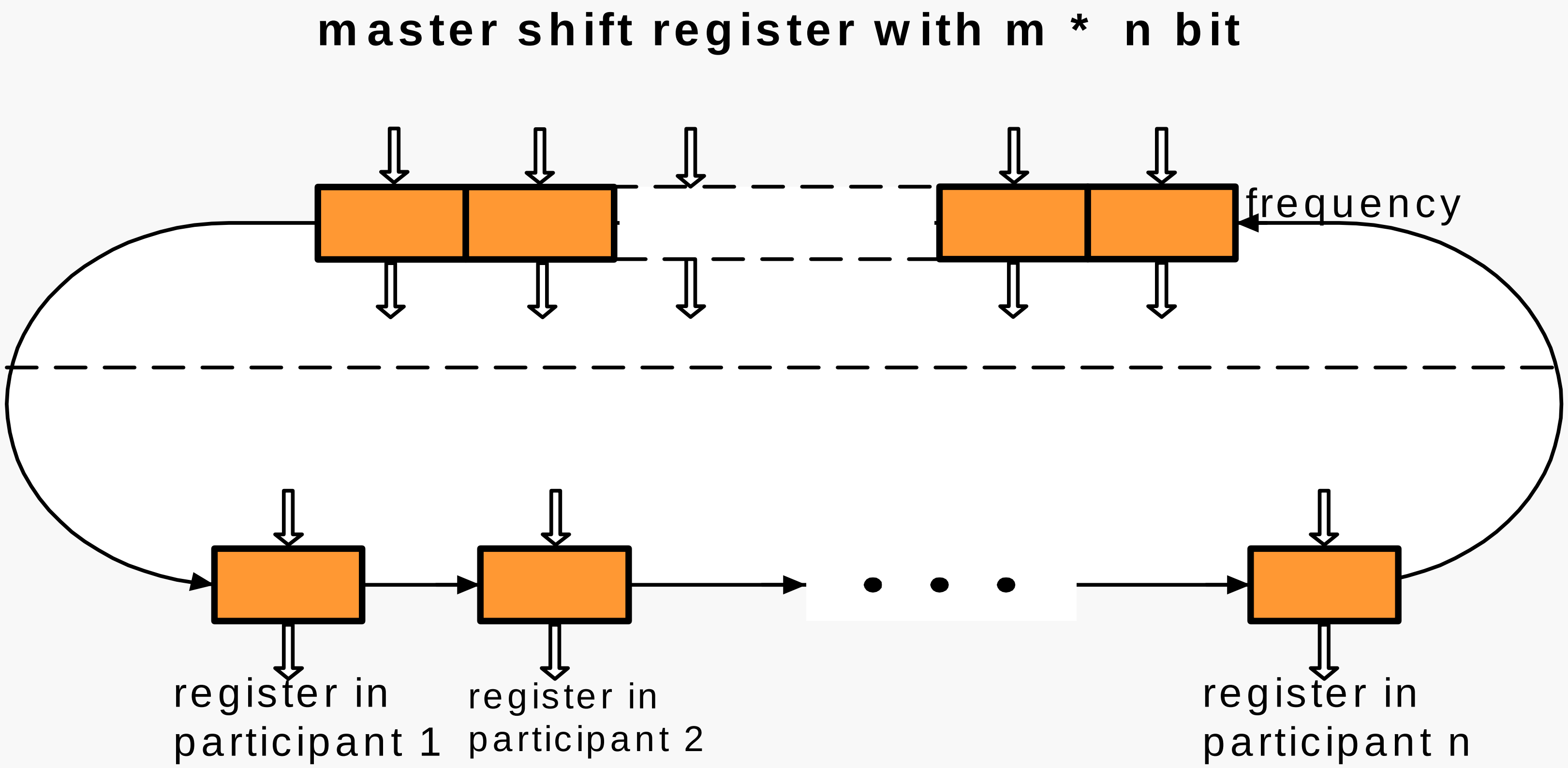
Disadvantages:
- long delay times in case of occurring errors
- supervision of the token passing
- re-initialization after loss of token

**Example: Profibus**

## TDMA- Method (1)

Time Division Multiple Access

- Within a period (TDMA-cycle) each participant is assigned one or several time slots of determined length
- Principle of distributed shift registers



# TDMA- Method (2)

Advantages

- short, constant cycle time
- low protocol overhead

Disadvantages

- synchronization of participants necessary
- not suitable for autonomous participants
- low flexibility, no dynamic adaptation

**Example: INTERBUS-S**

## Method with random bus access

### CSMA-Method

**Carrier Sense Multiple Access**

– Principle:
Each participant has bus access without explicit broadcasting right dispatching. (Multiple Access)

– Expiration of a transmission procedure:

1) each participant checks if bus is free/occupied (carrier sense)
2) if bus is free, it starts transmission
3) in case of collisions, try transmission once again

– Different kinds of the CSMA procedure:

- CSMA-CD (Collision Detection)
- CSMA-CA (Collision Avoidance)

## CSMA / CD - Method (Collision Detection)

- Recognition of collisions through data comparison
- Transmission repetition after participant specific waiting period

Advantages

- low bus load
- short latency time in low load situation

Disadvantage

- long waiting periods in high load situation

# CSMA / CA-Method (Collision Avoidance)

**Avoidance of collisions through priority rules**

## Priority rules

– Address-Arbitration

Participant with lowest or highest address asserts in case of simultaneous attempts of transmission.

Example: CAN-Bus

– Time span assignment

After the completion of a transmission participant specific waiting time

## PROFIBUS

- Field bus family
  - PROFIBUS - DP (Decentralized Periphery)
  - PROFIBUS - FMS (Field Message Specification)
  - PROFIBUS - PA (Process Automation)
- Distinction of master and slave participants
- Master participants (active participants)
  - Transmission of messages without request in case of Token possession

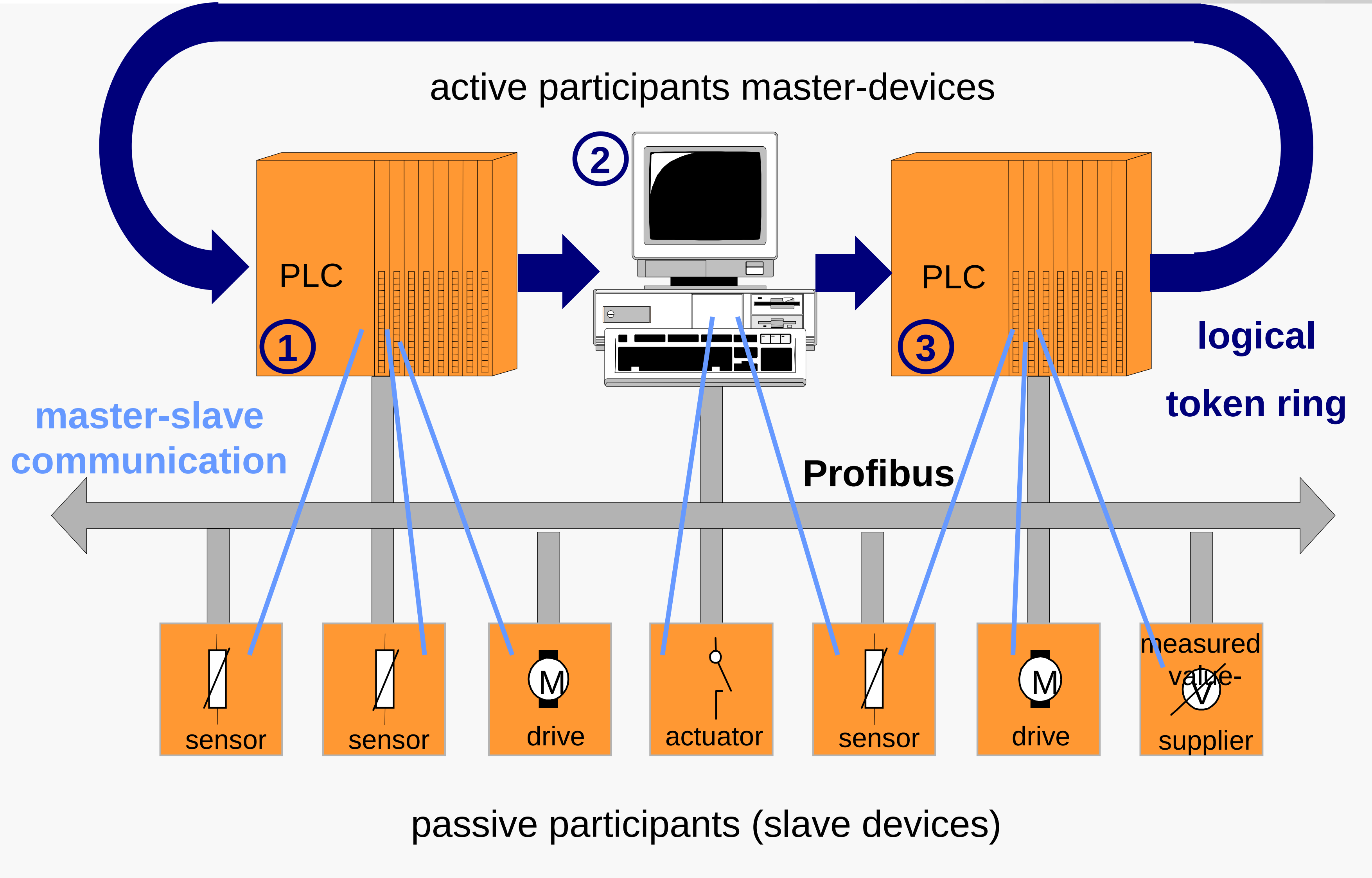
**Token-Passing-Method for active participants**

- Slave participants (passive participants)
  - No Token possession possible
  - Acknowledgement of messages
  - Message transmission on request

**Master-Slave-Method for the communication with passive participants**

## Hybrid access method in the Profibus



## Interbus-S

– Objective:

Transfer cyclically resulting data in the sensor-actuator-area without large overhead.

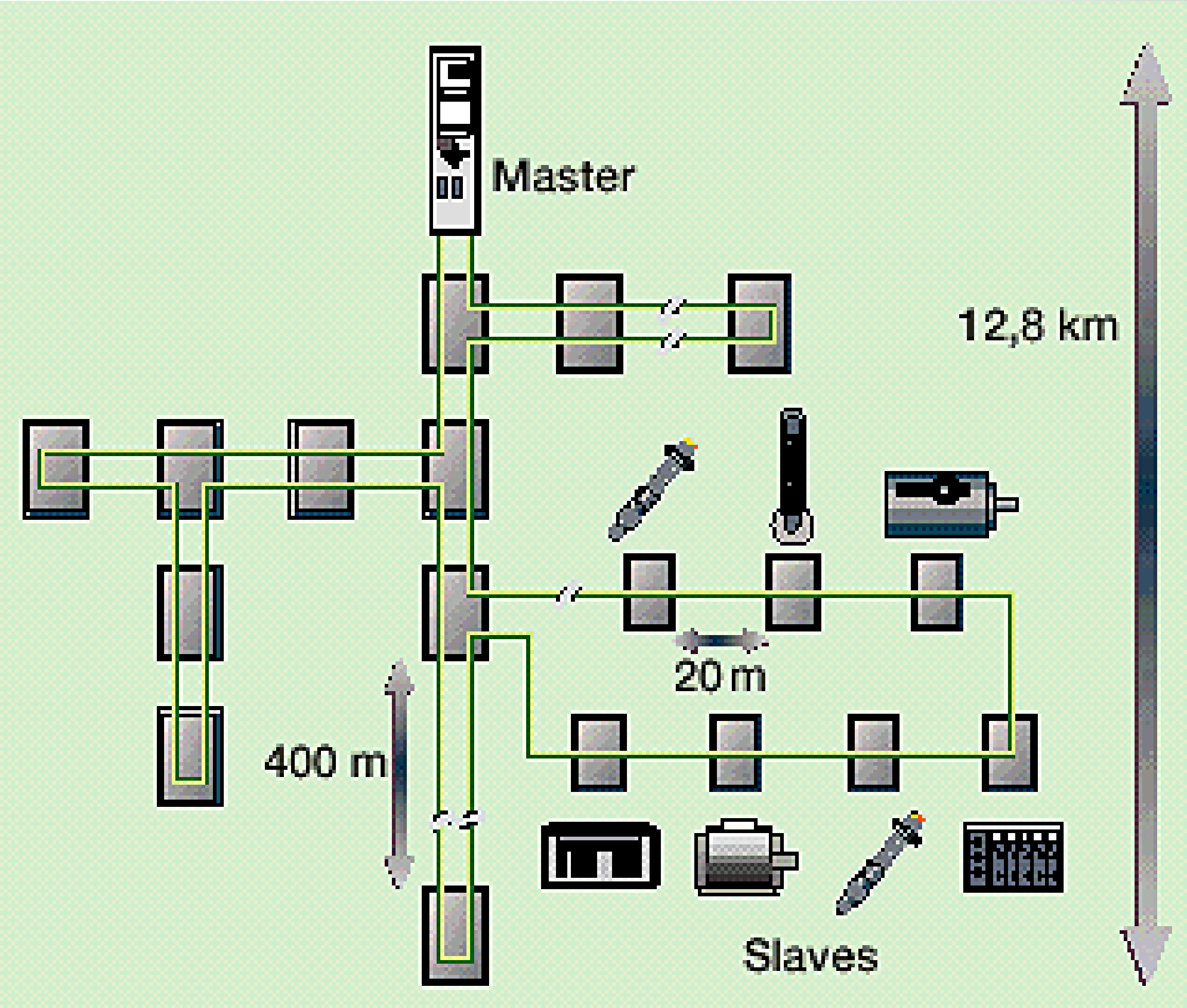
– Topology

- active ring
- Master-Slave method, fixed telegram length, deterministic ring
- transfer rate: 500 kBits/s
- max. 4096 I/O-points
- extension of the bus: 400 m (between 2 far bus users)
- total extension 13 km

– Physical addressing

The assignment of the data to the single participants is not carried out via the award of a bus address but automatic by the physical placement of the participants in the system

## Example of an Interbus configuration



# Principle of the shift register

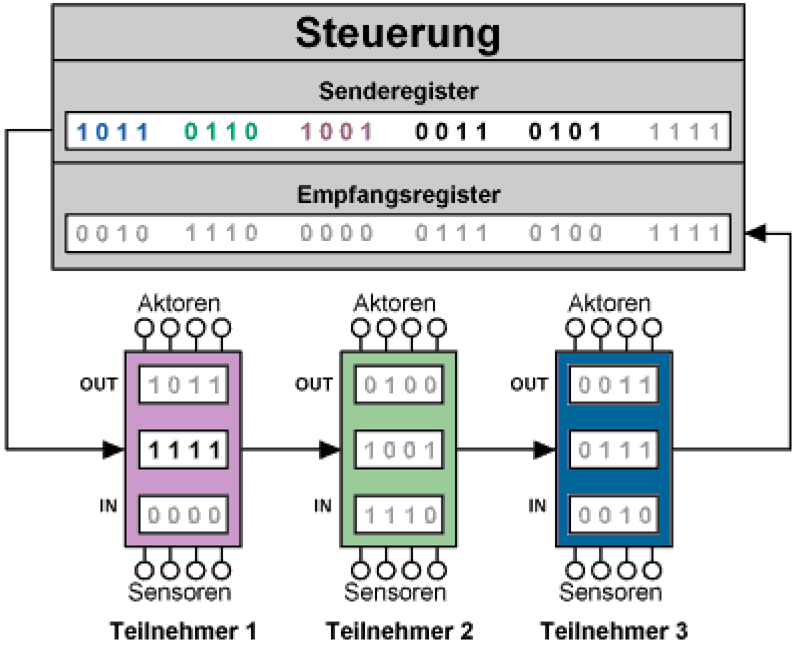
- The Interbus is a closed shift register ring
- The information flows only in one direction
- The information is shifted through the complete ring, one bit after another

[ref.: Interbus ONLINE-Seminar, www.interbus.com]

## Protocol

The data are lying in the send register ready for the participants (TN1, TN2 and TN3).

At the beginning of the data chain stands the loopback, at the end the FCS and Control



## Application areas of CAN (Controller Area Network)

Developed by Bosch/Intel for the application in **automobile industry**

- Airbag
- ABS
- Motor management
- Air conditioning systems


## Building instrumentation and control

- elevator control
- supervision
- alarm systems
- air-conditioning system

## Industrial automation

- process engineering
- machine tools

## Characteristics of CAN

- Message oriented addressing
  Several objects can be located on one node. The object is addressed not the node.
- Multi-master bus access method
- In case of access conflict: bus arbitration according to priority through non-destroying, bit-wise arbitration according to CSMA/CA Method
- Short length of messages (0...8 byte)
- Transmission rate up to 1Mbit/s (of a maximum bus length of 40m)
- Various error recognition mechanisms
- Self-test through error counter
  Does a node cause too many errors it uncouples itself from the bus step by step.

# CAN for environments with heavy electromagnetic disturbances

Interference detection mechanism

– Bit stuffing and de-stuffing. After 5 bits with the same logic state one bit of the opposite logic state is added.
stuffing by the sender
de-stuffing by the receiver

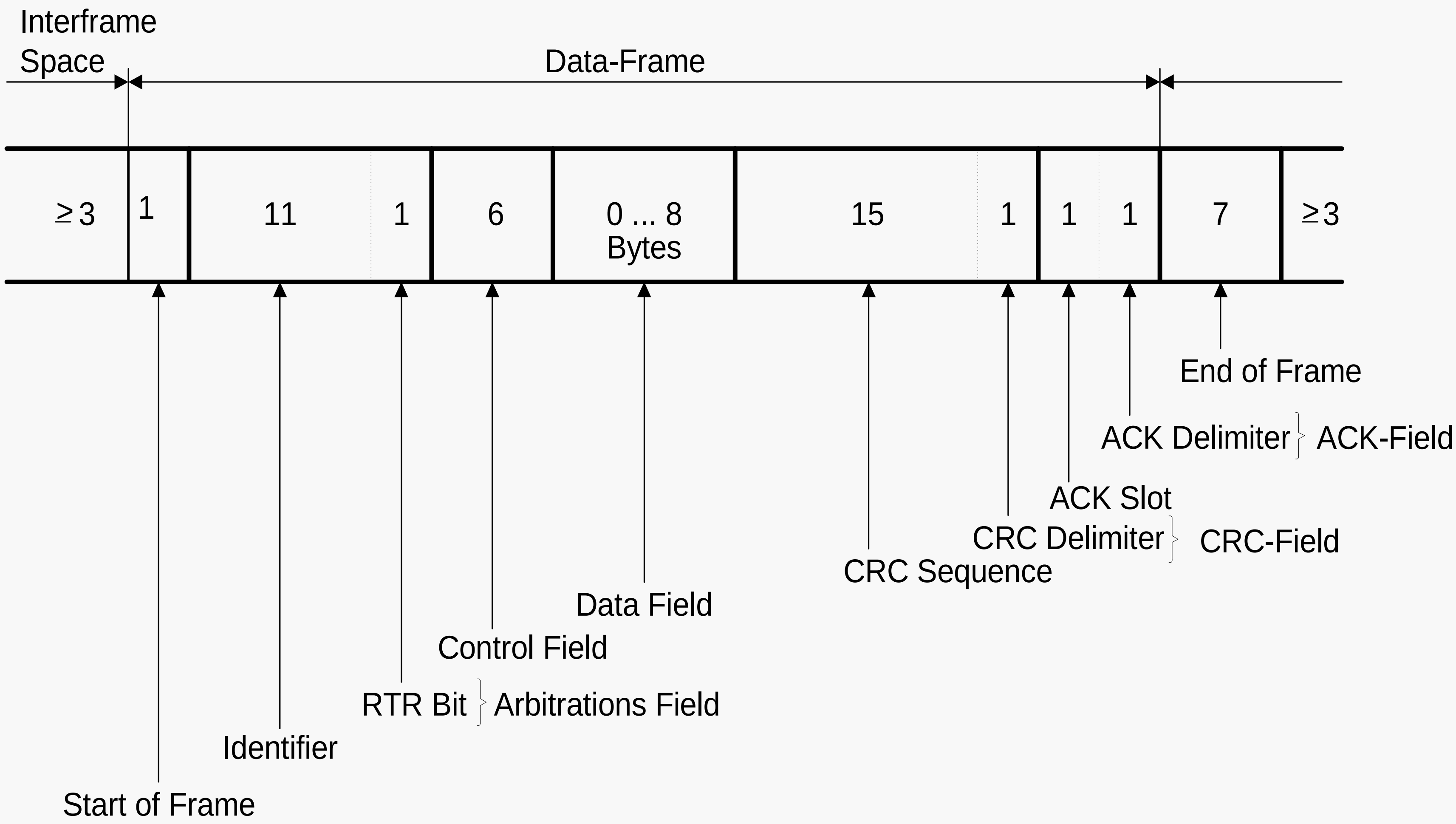
– 15 BIT CRC (cyclic redundancy check)
cyclic binary code with
64 message digits
15 control digits
Hamming distance d = 6
ð Residual error probability

**$P_{RE}$ = 4.7 x $10^{-16}$**
**Ethernet $P_{RE}$ = $10^{-7}$**

– Bus level check
simultaneous backward reading

– Message frame protection
checking of the frame for correctness

# Data frame


Interframe
Space
Data-Frame
≥3
1
11
1
6
0 ... 8
Bytes
15
1
1
1
7
≥3
End of Frame
ACK Delimiter
ACK-Field
ACK Slot
CRC Delimiter
CRC-Field
CRC Sequence
Data Field
Control Field
RTR Bit
Arbitrations Field
Identifier
Start of Frame

## Principle of the time control

Time control: Actions are triggered by progression of time

## Advantages of the time control

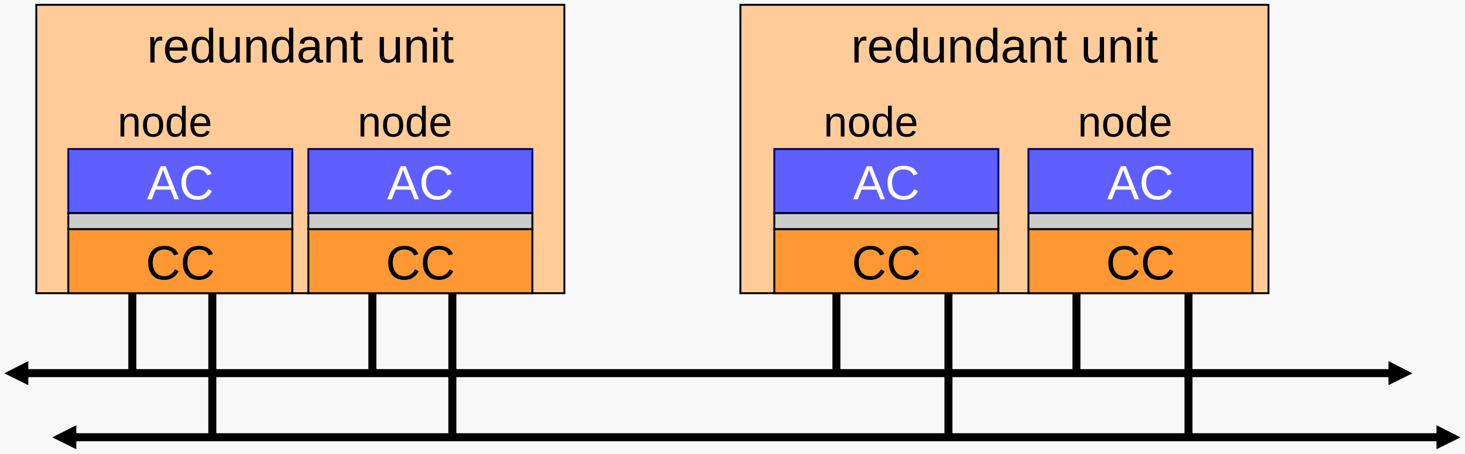
- Determinism
  - Safety properties easier to verify
- Synchronization of the applications on different nodes
  - Coupling of redundancies for the realization of fault tolerance
  - Distribution of a closed effect chain for the realization of distributed control applications

**è Use in safety critical areas e.g. X-by-wire**

## Disadvantages of the time control

- inflexible to unexpected events
- inflexible to additional expansions and changes of the system

## Construction of a time controlled architecture




AC: application controller

CC: communication controller

- *Distributed system* (*cluster*): Set of nodes which communicate via a bus system
- Static hardware redundancy: two or more nodes are doing the same task
- Bus system is also constructed with redundancy

## Properties of the time controlled communication system

– Synchronization:
  All bus users refer to a global clock

– Time slot method:
  Every bus participant has access to the bus at a definite time interval determined before

– Static messages scheduling
  The sending time slots are determined statically before runtime

– Integrated network management:
  Recognizing a node failure, integration of nodes

– Redundancy management:
  Every arbitrary single fault is tolerated

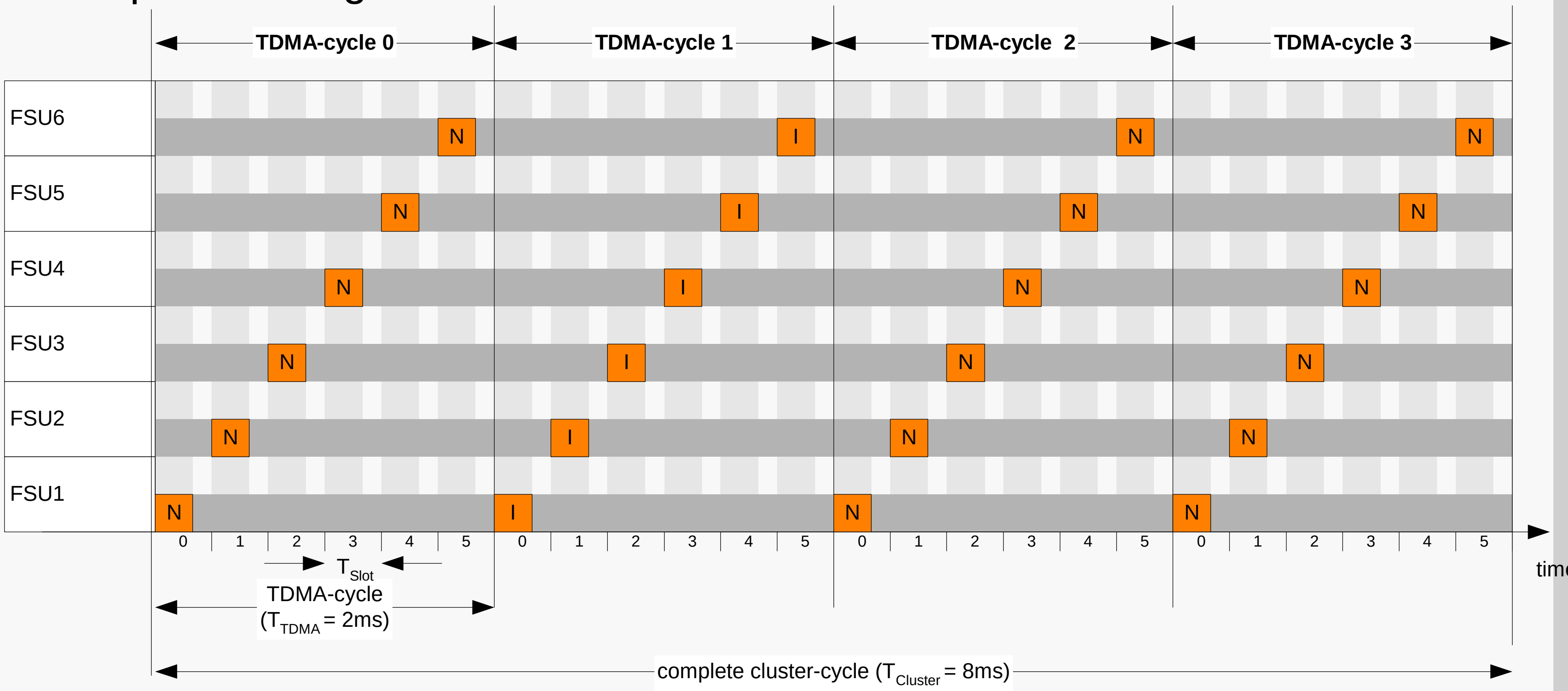
**Examples:**

TTP: TU Wien, TTTech

FlexRay: FlexRay-Consortium (BMW, DC, Bosch, Motorola, Philips)

# Message schedule

## Example: Message schedule for TTP




**Legend:** N Normal-frame I Initialization-frame

## Disadvantage: inflexible to nonforeseeing events

è New attempt: FlexRay

Integration of additional message frames for dynamic contents

## Question referring to Chapter 3.2

Your task is to design a level sensor for a water tank.

Which parameters can be used to determine the level of a tank?
Which type of sensor element could you use to create such a sensor ?

## Answer

- Measurement via distance:
  - potentiometer circuit
  - ultrasonic sensor
  - capacitive sensor
- Measurement via pressure:
  - pressure tin with diaphragm and strain gauge
  - pressure tin with piezoelectric element
- Measurement via weight:
  - balance using a force sensor (strain gauge or piezoelectric element)

## Question referring to Chapter 3.3

The control of a motor's rotation speed has to be made. For that, the incoming current and the motor's rotation will be measured by an inductive sensor and a light barrier, respectively. In case that the incoming current is to high, the motor has to be automatically shut down through a switch.

Which kinds of process signals can you identify?

## Answer

- The measurement of the incoming current with an inductive sensor yields a analog process signal.
- The measurement of the motor's rotation with the light barrier yields a pulse shaped process signal.
- The shutdown command represents a digital process signal.

## Question referring to Chapter 3.4

The mean value converter is an analog to digital converter. Which of the following statements do you agree?

## Answer

f ¨ The value in the middle of an interval is sampled every time.

ü Error voltage with frequency of the supply voltage is always suppressed.

f ¨ The converter can only be used for fast changing signals.

ü Every time a complete period of the supply net frequency is integrated

ü A comparatively low effort is necessary for the technical realization.

ü It is a time discrete method.

## Question referring to Chapter 3.6

Which of the following statements regarding to deterministic / random bus access do you agree?

## Answer

ü using a deterministic bus access there is a fixed method for the access of a participant

f ¨ using a random bus access each participant is able to write on the bus every time

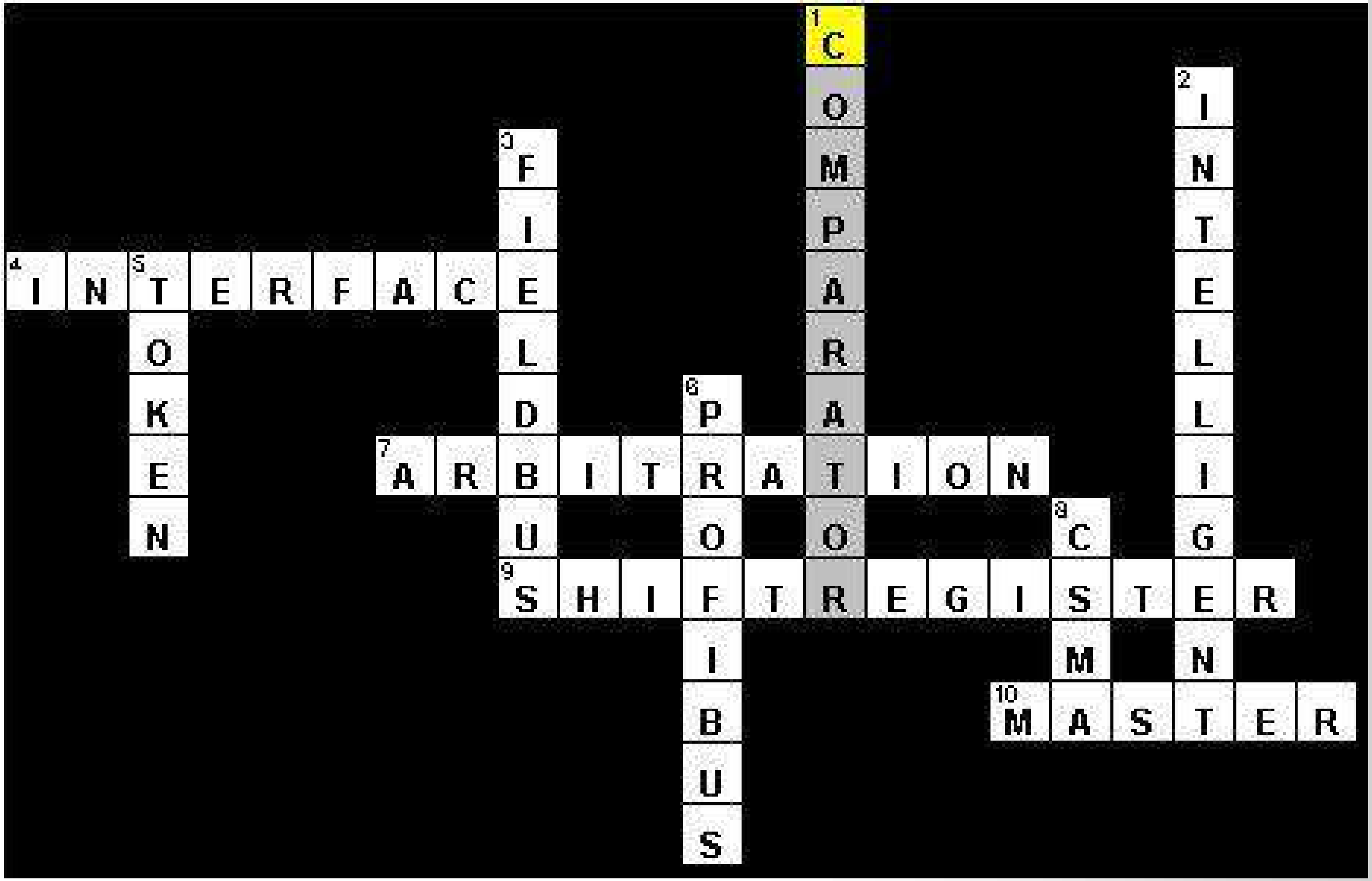
ü using a deterministic bus access definite statements regarding to the response behavior are possible

f ¨ a deterministic bus access allows faster response times

f ¨ the token-passing method is a method with random bus access

f ¨ using the random bus access a concurrent write process of several participants onto the bus always results in a destruction of the transmission

# Crosswords to Chapter 3



# Crosswords to Chapter 3

## Across

| | |
|---|---|
| **4** | Connection between systems (9) |
| **7** | Process to avoid data package collision on CAN bus (11) |
| **9** | Principle of data transmission in the Interbus-S (5,8) |
| **10** | Element with control rights in a deterministic bus access method. (6) |

## Down

| | |
|---|---|
| **1** | Circuit for comparison of currents. (10) |
| **2** | Term used for sensors with integrated connection to bus system, self-calibration and self-test. (11) |
| **3** | Communication system for the data exchange in the field area. (5,3) |
| **5** | Specific message to assign the right to send messages (5) |
| **6** | Bus system with an hybrid communication (8) |
| **8** | Method with random bus access (4) |