Process automation
Programmable Logic Controllers (PLCs)
- the hardware -

BS UNI studies, Fall semester 2025/2026

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Outline

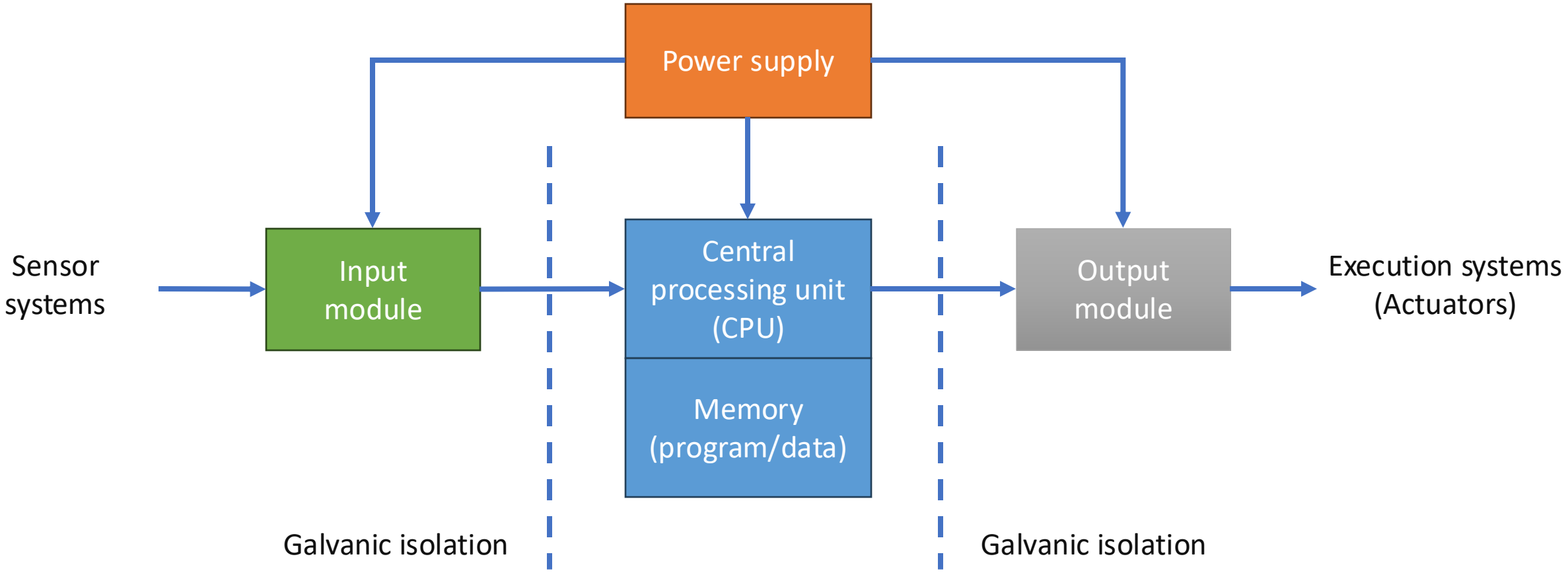
- Evolution of PLCs
- PLC architecture
- Types of PLCs
- Signal processing
- Program execution cycle
- Comparison of PLC systems
- Important PLC manufacturers
- Memory structure in PLCs

Evolution over time

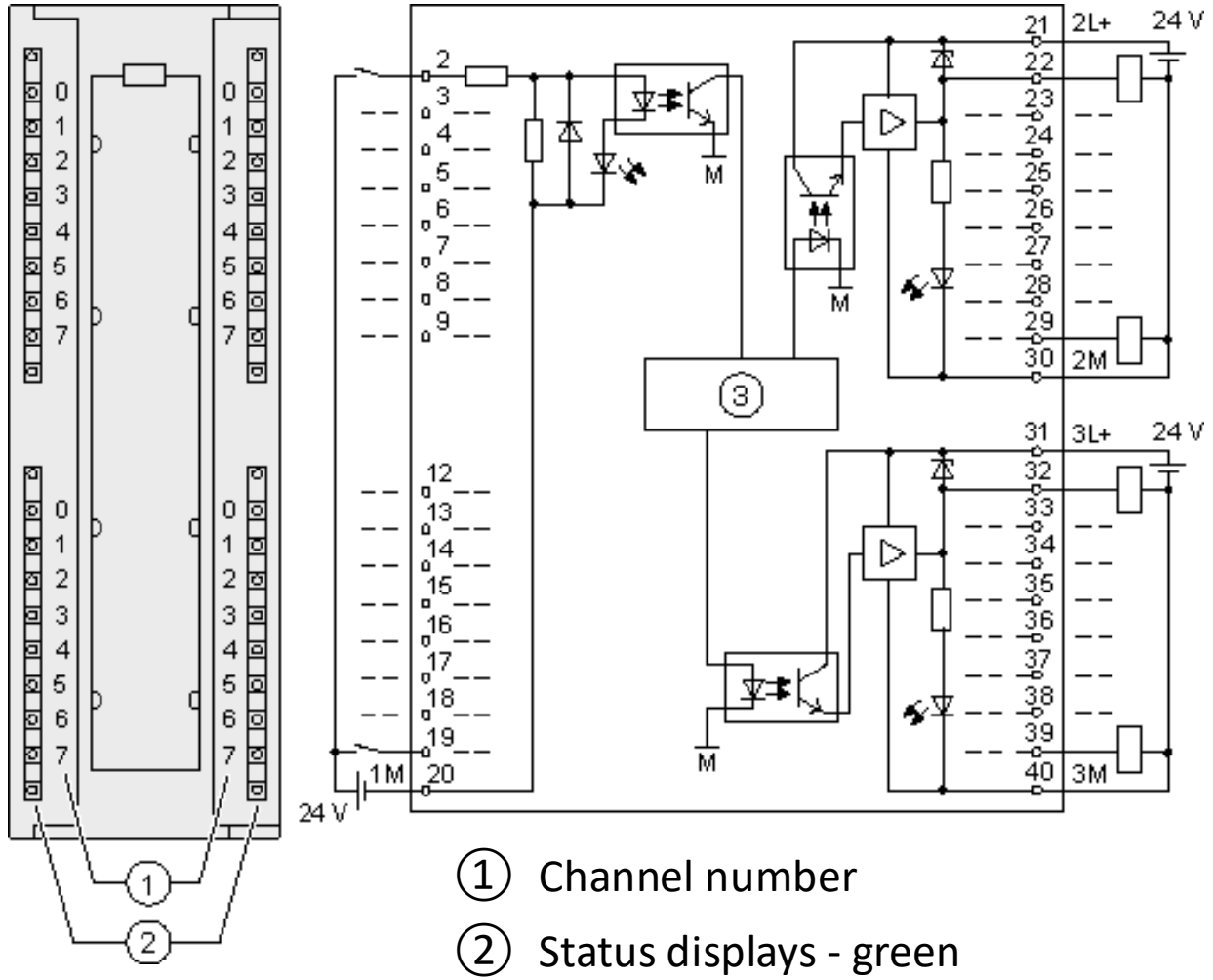
- Early Systems
  - Control: Fixed wired logic (relays)
  - Regulation: Pneumatic, hydraulic, electromechanical analog systems
- Need for New Devices
  - Rapid development of control systems
  - Robust design (resistant to dirt, water, electromagnetic disturbances)
  - Reliability and ease of use
  - Reprogrammability
  - Integration of binary and analog worlds
- Functionalities
  - Logical operations
  - Control and increasingly regulation
  - Data collection for monitoring purposes
  - Interface with higher-level control systems

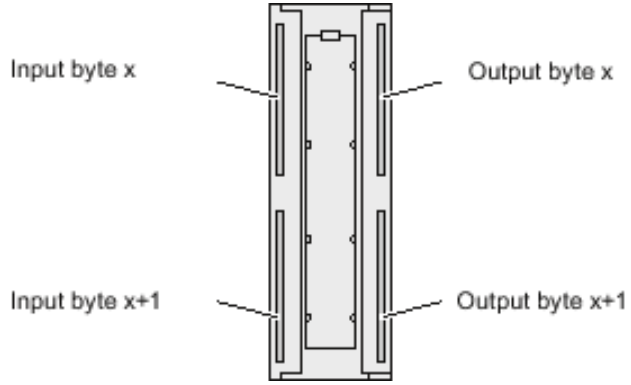
Source: https://www.axiscontrols.co.uk/products-services/services/plc-touchscreen-systems

Architecture of a PLC



Architecture: input and output modules





① Channel number

② Status displays - green

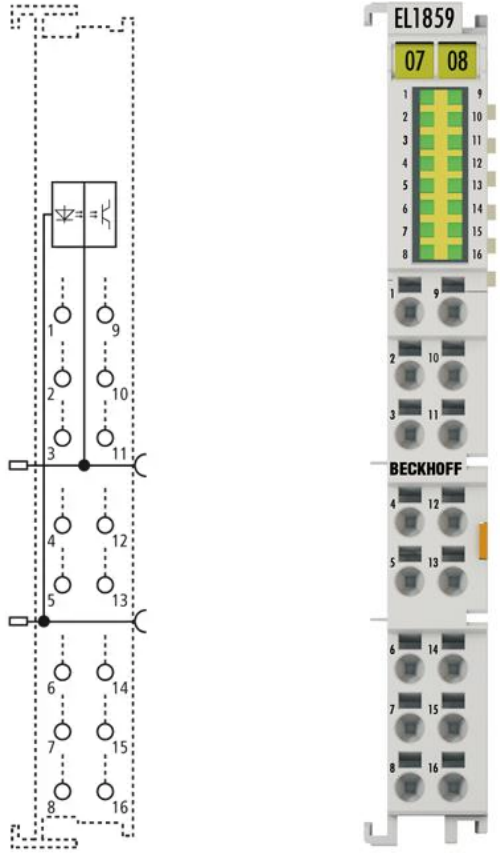
③ Backplane bus interface

Architecture: input and output modules

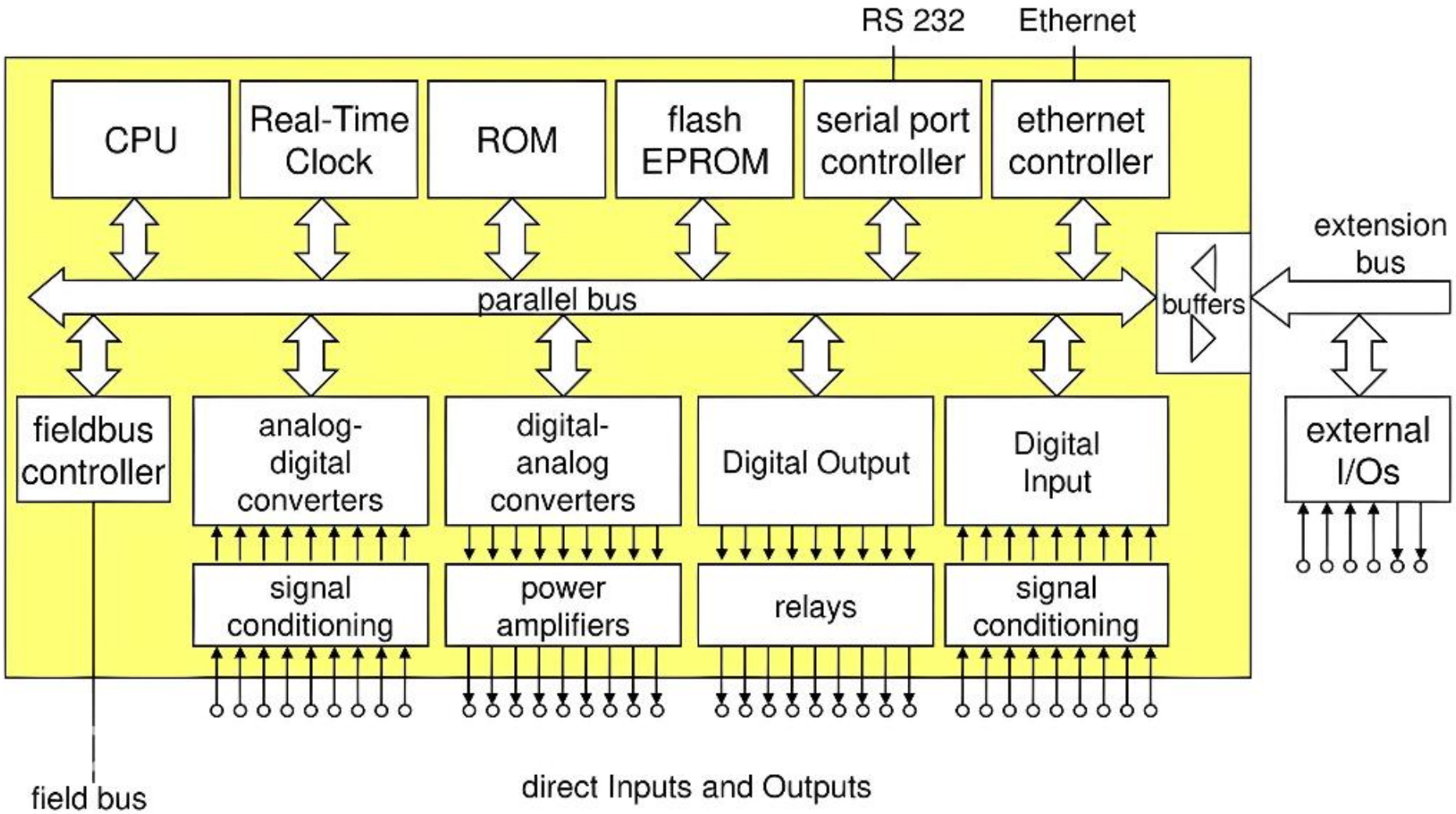
Galvanic Isolation - Example: EL1859 Module

Galvanic isolation is made between the power current of channels (inputs/outputs) and the communication bus (E-bus).

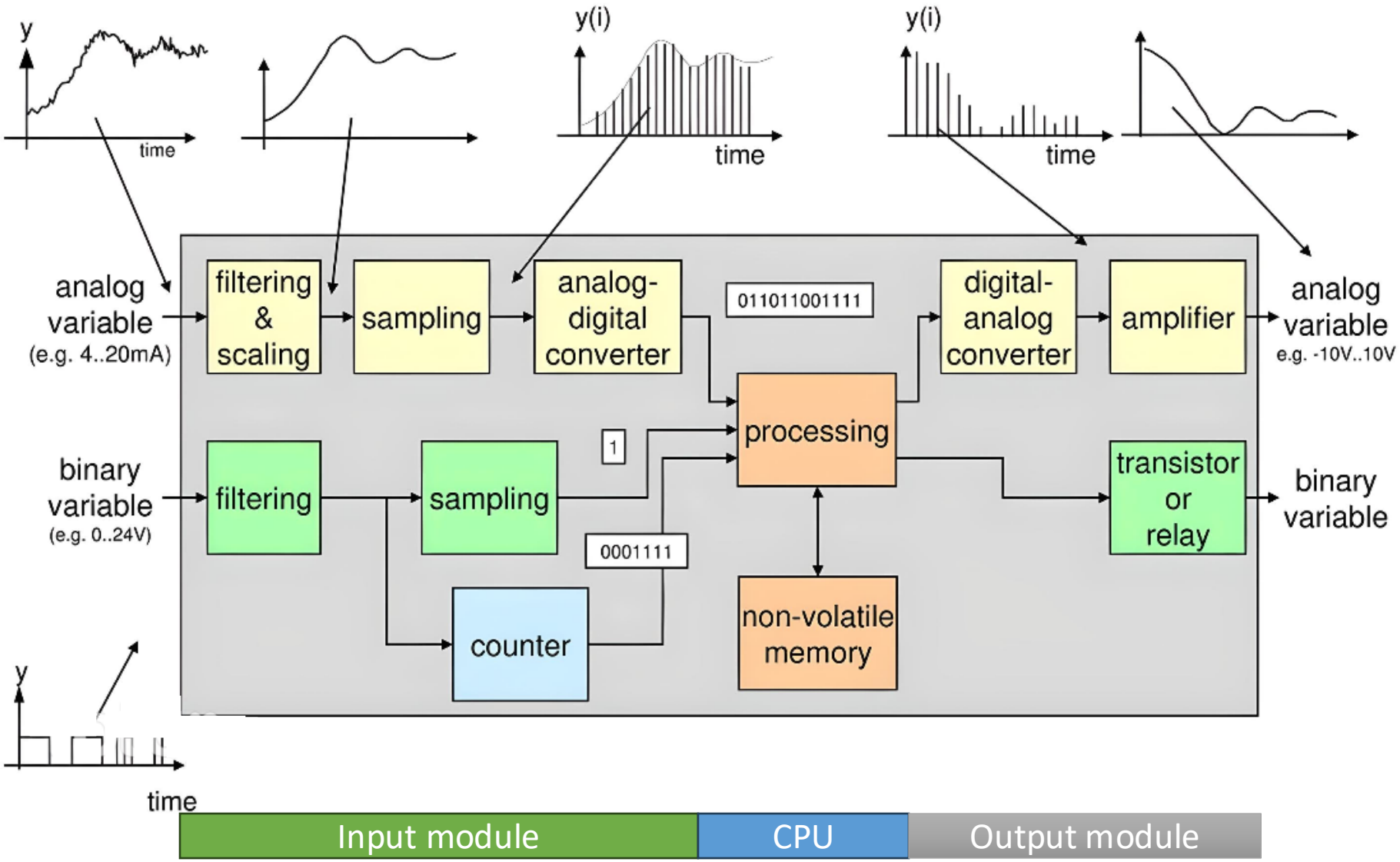
There is no isolation between channels in this case.



Detailed architecture



Signal Reception and Transmission



PLC types

Compact PLCs
- Monolithic design
- Fixed number of I/O
- I/O are usually binary
- Expansion possibility
- One microprocessor

Modular PLCs
- Wide selection of modules
- Communication between CPU and modules via a parallel bus
- Highly capable (can be multiprocessor systems)
- No human-machine interface (HMI)
- Mounted on a rail
- Large systems

Small Modular PLCs
- Medium to large systems
- No fans
- Cheaper than large modular PLCs

PLC types

Soft PLC
- Runs as a program on a personal computer
- PCI(e) card for communication bus
- Utilizes the resources of the personal computer

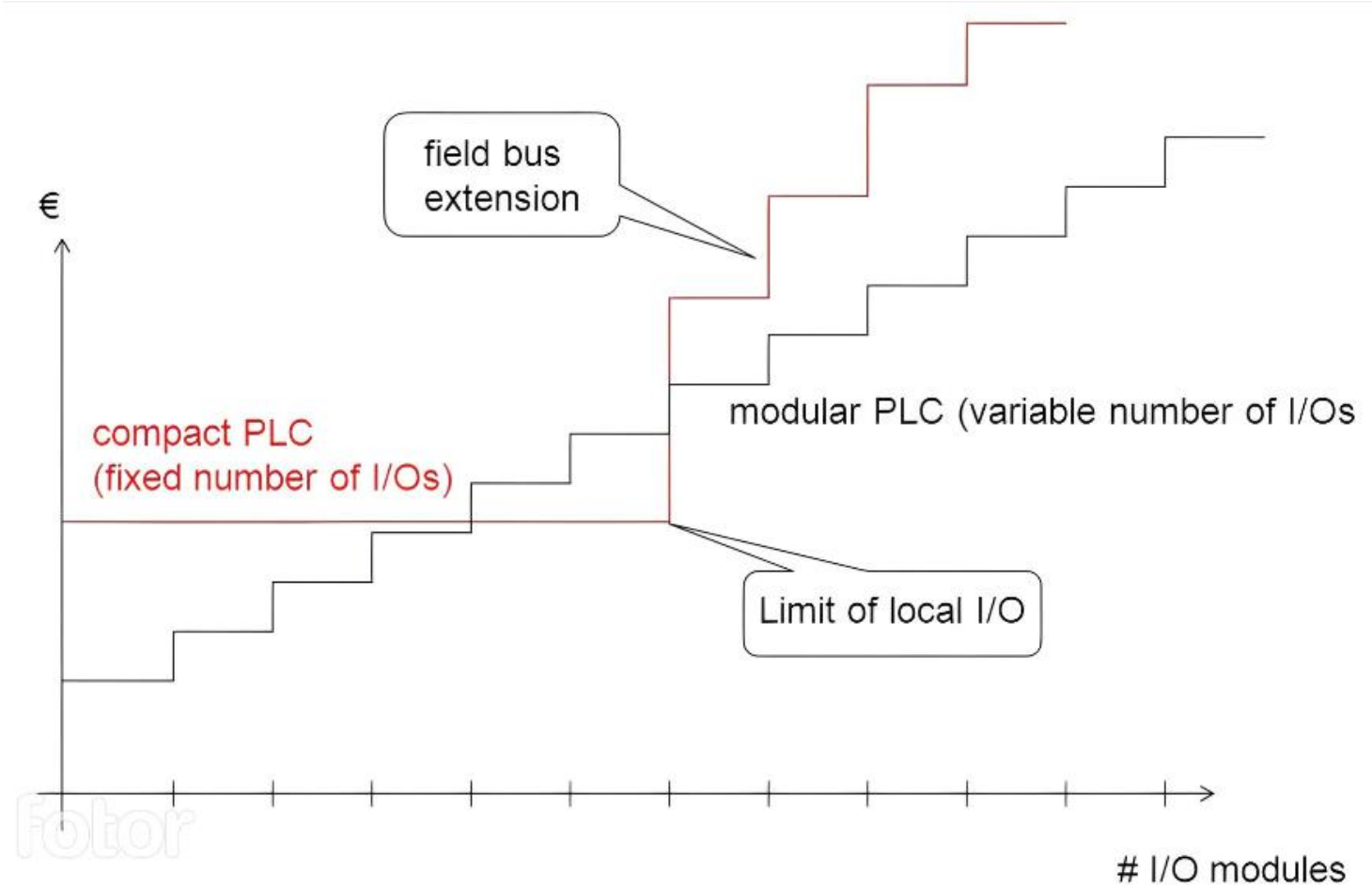
Industrial PCs
- Competitors to modular PLCs
- Do not have local I/O modules
- Limited modularity
- HMI interfaces available

Special Versions
- No fans
- Wide temperature range
- Resistance to vibrations
- Example: Locomotive

PLC Manufacturers

- **Europe**
  - Siemens – SIMATIC (60% market share)
  - Beckhoff
  - ABB
  - Schneider Electric
  - WAGO
  - Phoenix Contact
  - Robotina – Cybro (Slovenia)
- **Worldwide**
  - GE & Fanuc
  - Honeywell
  - Invensys (Foxboro)
  - Rockwell (Allen-Bradley)
  - Emerson (Fisher Control, Rosemount, Westinghouse)
  - Hitachi, Toshiba, Fujitsu, Yokogawa

Compact vs. modular PLCs

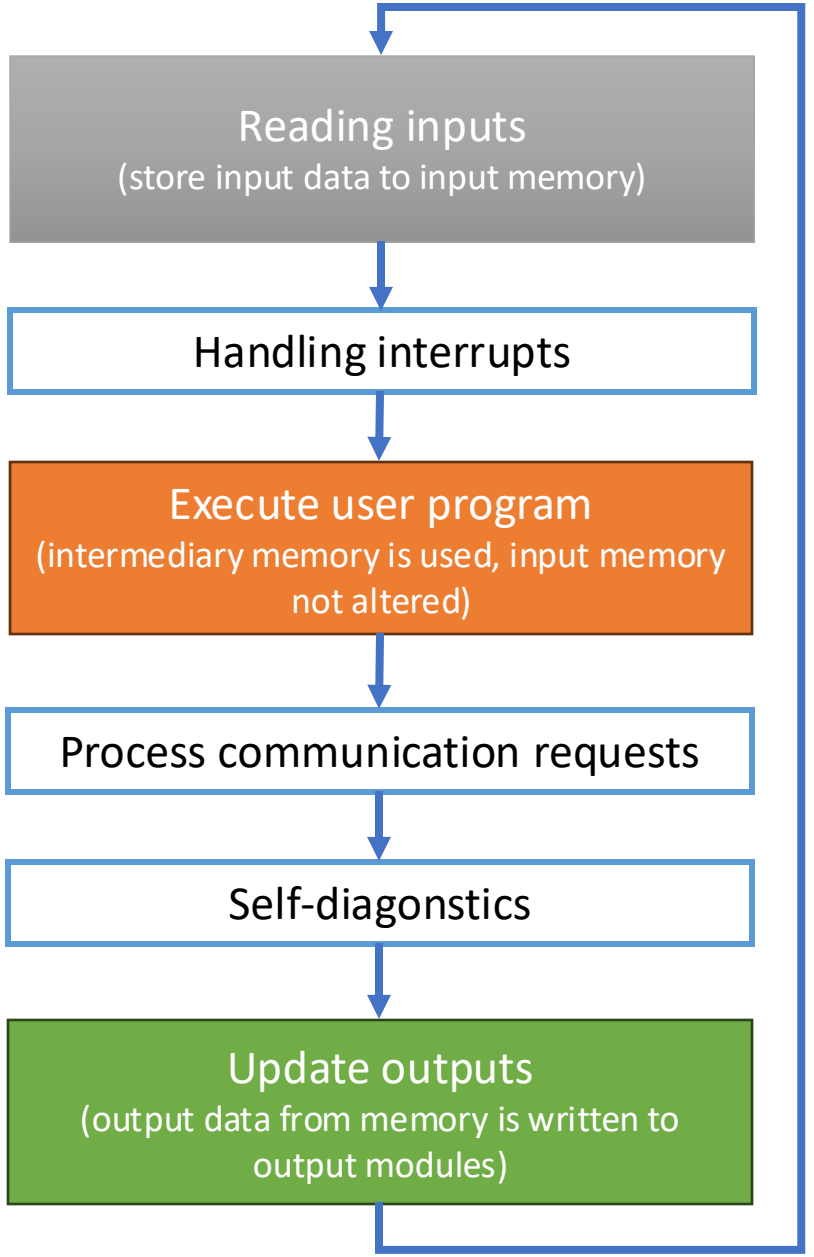


Comparison: PLC and Industrial PC

PLC	Industrial PC
Basic hardware and software: - modular design - programming in relay logic (IEC 61131 standard)	More complex hardware and software: - high-level programming languages
No standard user I/O devices	Screen, keyboard, mouse
Sequential execution of a single program (usually)	Executes multiple programs simultaneously
Deisgned for maintainance by electricans	Maintainance performed by computer scientist/programmer
Troubleshooting easy due to basic design, errors indicated visually	Error handling and debug handled by programmer

PLC program cycle

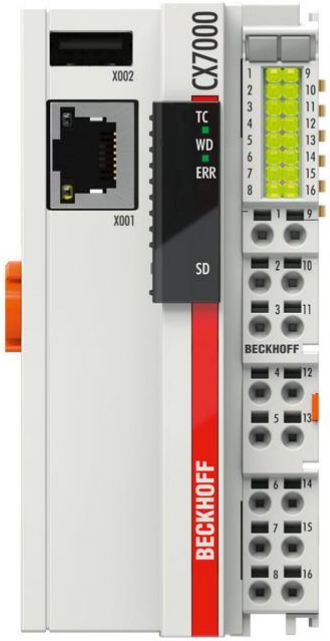
- Cycle time (scan time)
- Typically a few milliseconds (10 ms)
- Depends on:
  - Processor speed
  - Input reading method, program interpreter (LAD vs. ST)
  - Length and complexity (logic, arithmetic) of the program
- Operating System:
  - Ensures the correct execution of the program cycle
  - Manages memory



PLC memory organization

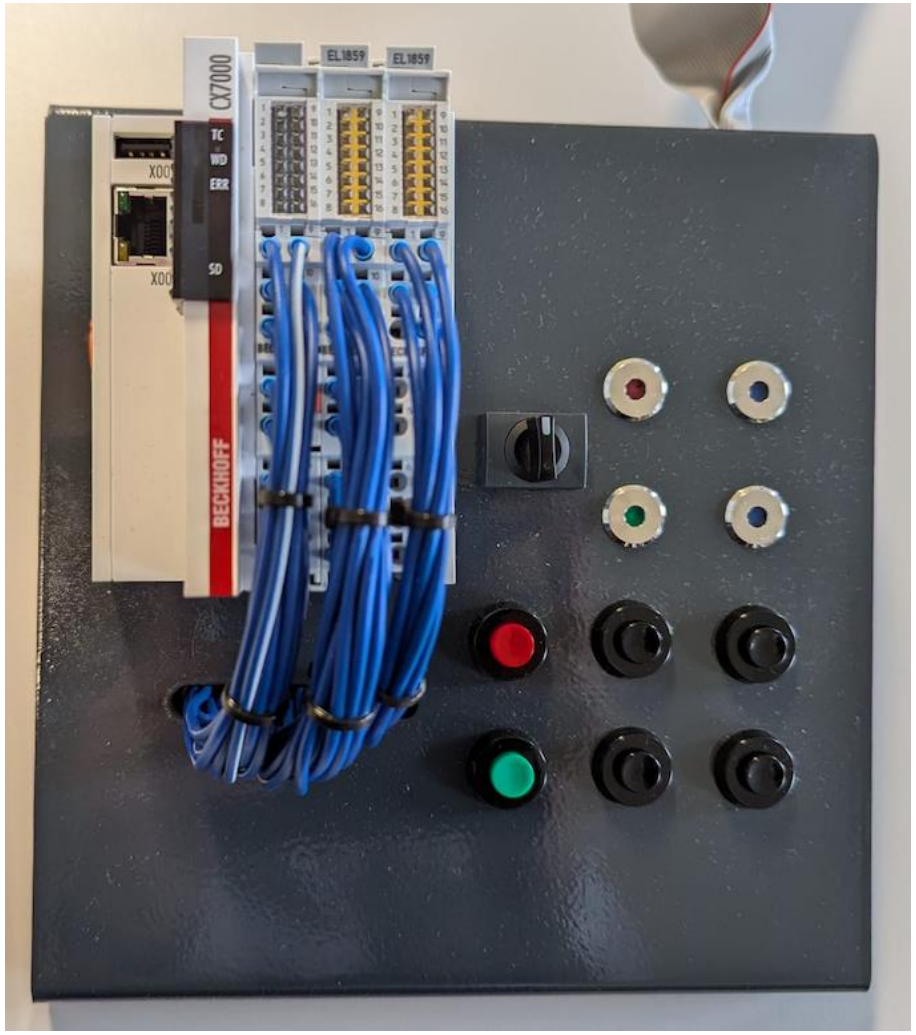
- Data Memory:
  - Purpose: For storing the operating system and user program.
  - Types:
    - Dynamic (RAM)
    - Non-volatile (Flash, EPROM, SD cards)
- Working Memory:
  - Purpose: Used for executing the program (intermediate memory image).
  - Type:
    - Dynamic (RAM)
- System Memory:
  - Purpose: For storing the processor state, including:
    - Input image, output image, bit memory, timers, counters
    - Stack of local function data
    - Block stack
    - Interrupt stack
    - Diagnostic memory
  - Type:
    - Dynamic (RAM)

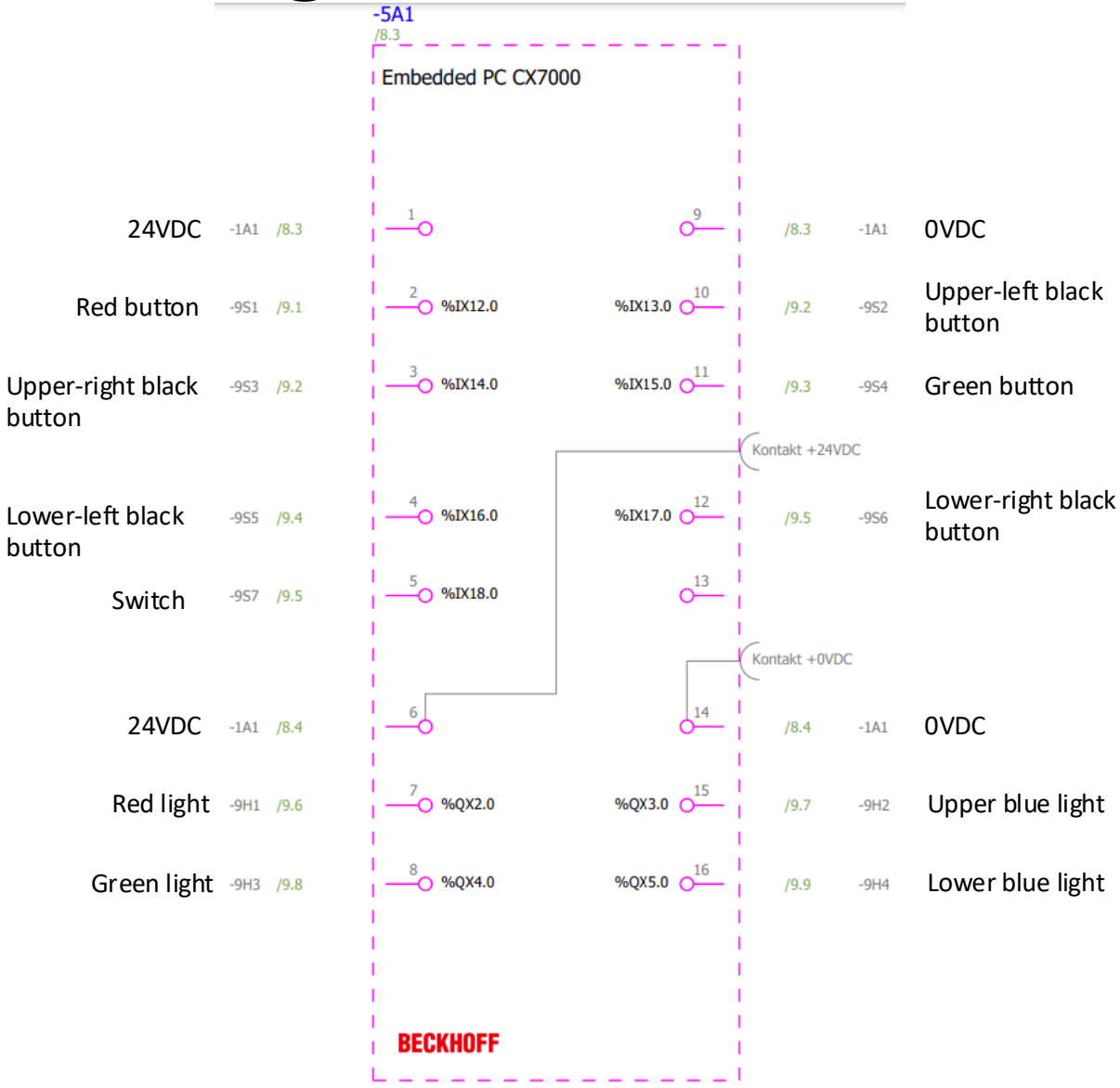
Beckhoff CX7000



- Arm® Cortex®-M7 single-core processor with 480 MHz
- Slot for a microSD card and an Ethernet interface
- eight integrated multi-functional inputs
- four integrated multi-functional outputs
- does not have a fieldbus interface
- the control system is programmed with TwinCAT 3 via the Ethernet interface.

Beckhoff CX7000 – lab config schematic





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