Programmable Logic Controllers - PLC

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High Performance
Real Time Lab

NOVITÀ

Perché odiamo tanto i bug? Non siamo noi i loro creatori? Eliminandoli, non eliminiamo anche una parte di noi stessi? No, non è stata una debolezza o un fallimento a farli venire al mondo. È stata la luce dell'innovazione che gettiamo negli angoli bui che questi bug chiamano casa. Sono state le nostre torce a farli sgattaiolare nel mondo. In questo aggiornamento troviamo loro una nuova casa.
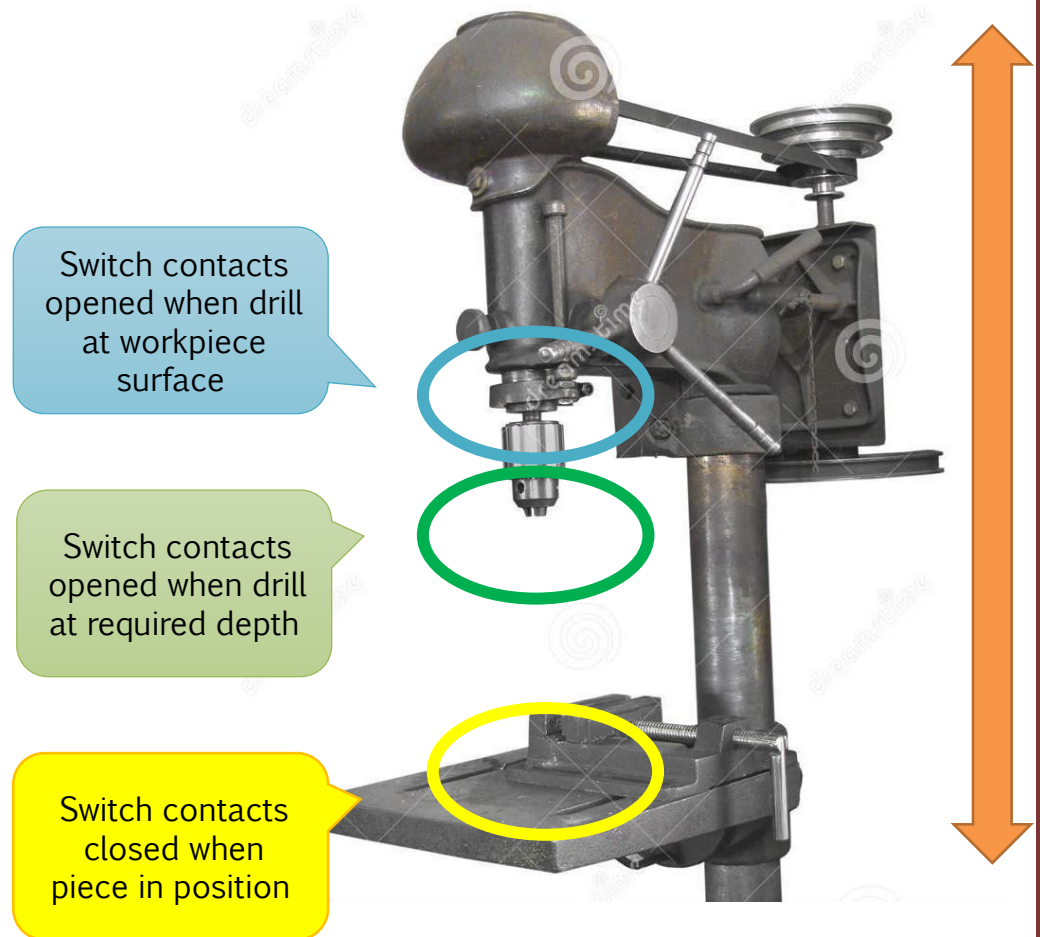
What makes a PLC different to MC/PUs?

Tight interaction with other electrical devices

› Sensors, actuators

› *Via* switches, relays, …

› E.g, drill

Designed for non-informatics

› Programs are made of simple operations

› Easily programmable w/o high level prog. languages

Switch contacts opened when drill at workpiece surface

Switch contacts opened when drill at required depth

Switch contacts closed when piece in position

PLCs (late sixties)

Designed for implementing simple software operations

› Arithmetics, logics, timers, counters…

› That could also be implemented with dedicated circuitry

› Can be re-programmed

Physically speaking…

› Robust to vibration, highest/lowest temperature, humidity, noise..

› Rich I/O connectivity (relays)

› More reliable (i.e., less crashes)
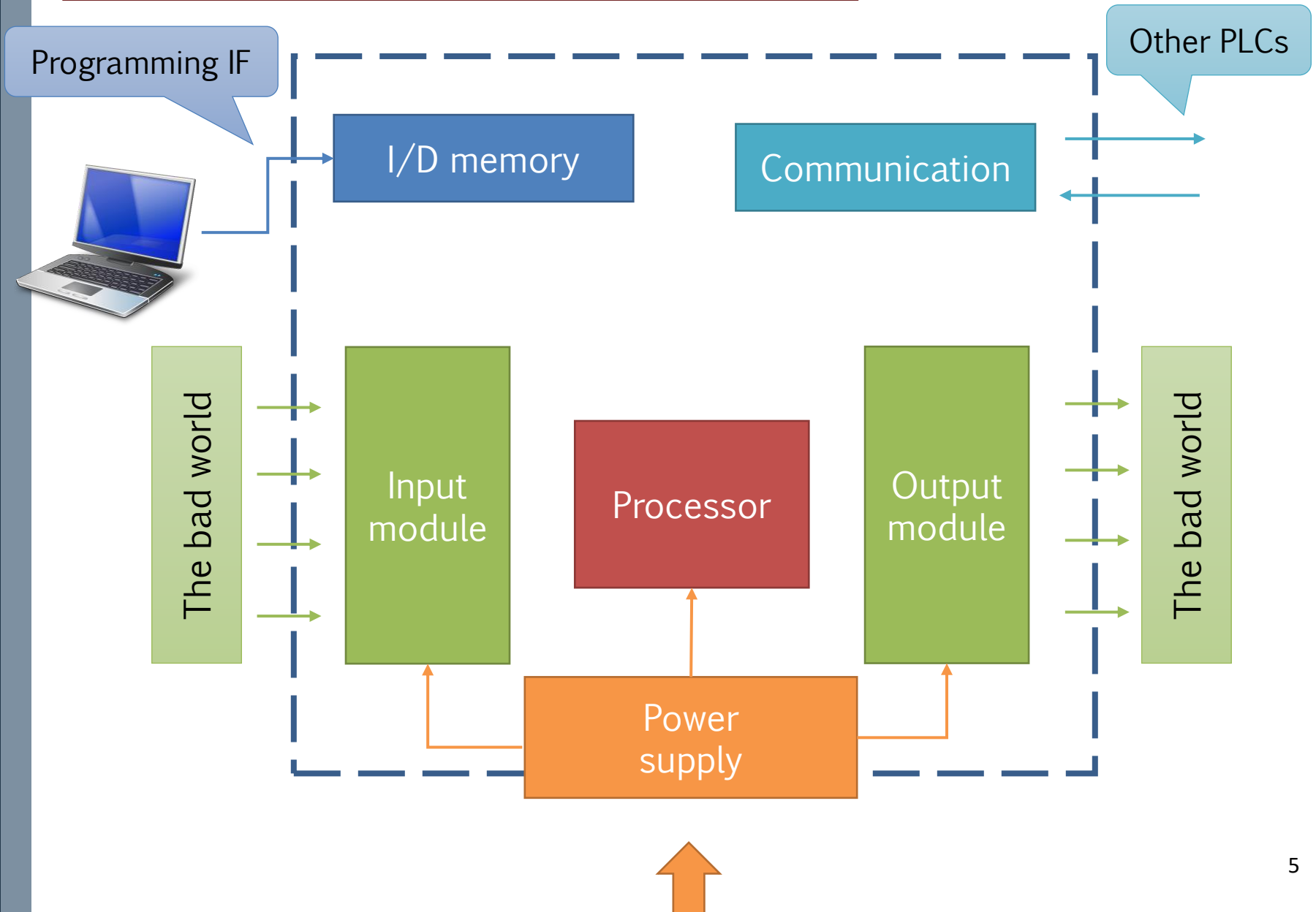
Programmable, simple architecture + no OS + connected

› *Can easily be hacked!!!*
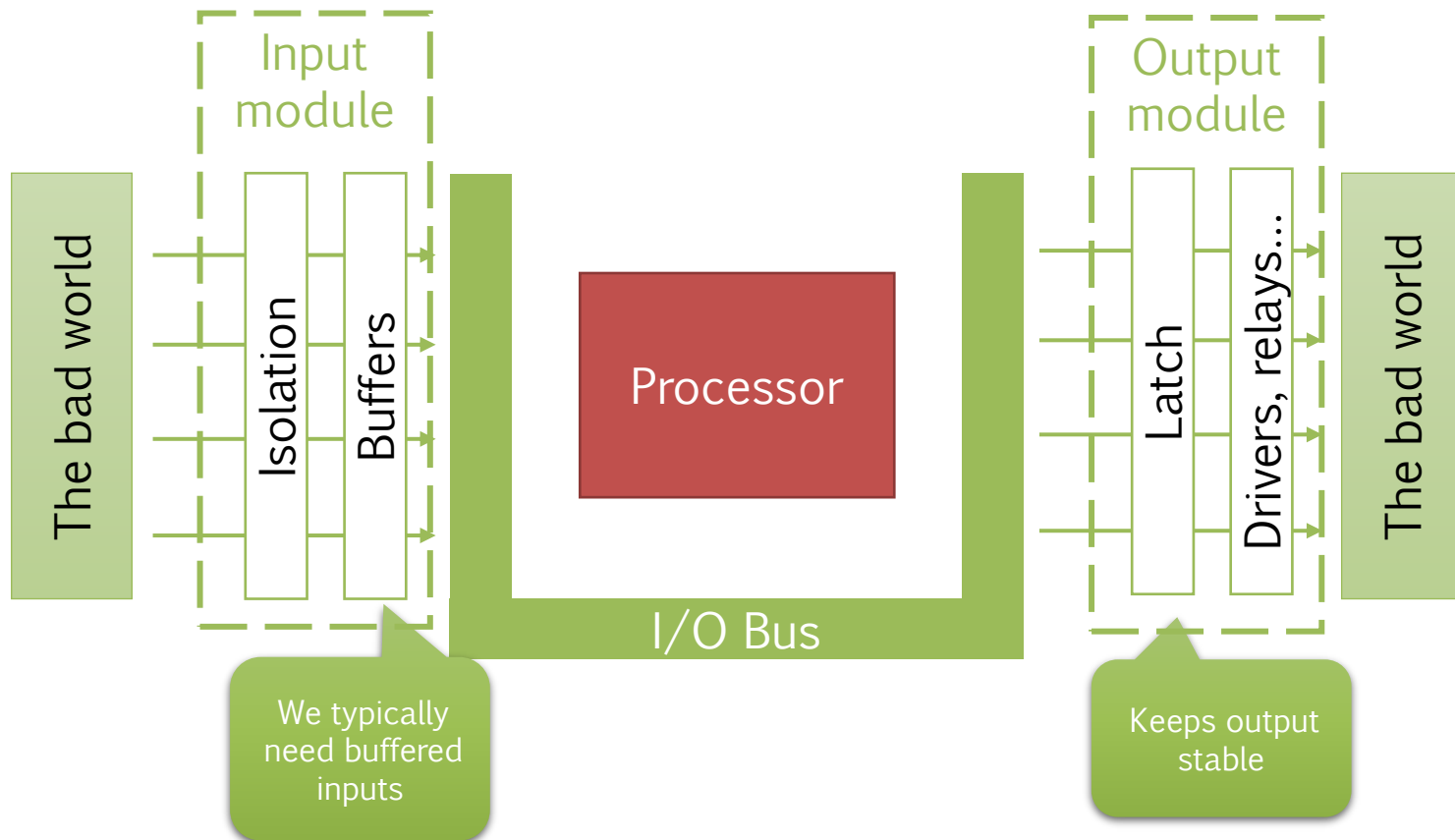
› (not part of this course…)

Pink Floyd, Animals, 1977

Structure of a PLC

I/O system bus and peripherals

› Inputs: isolate, and buffer them
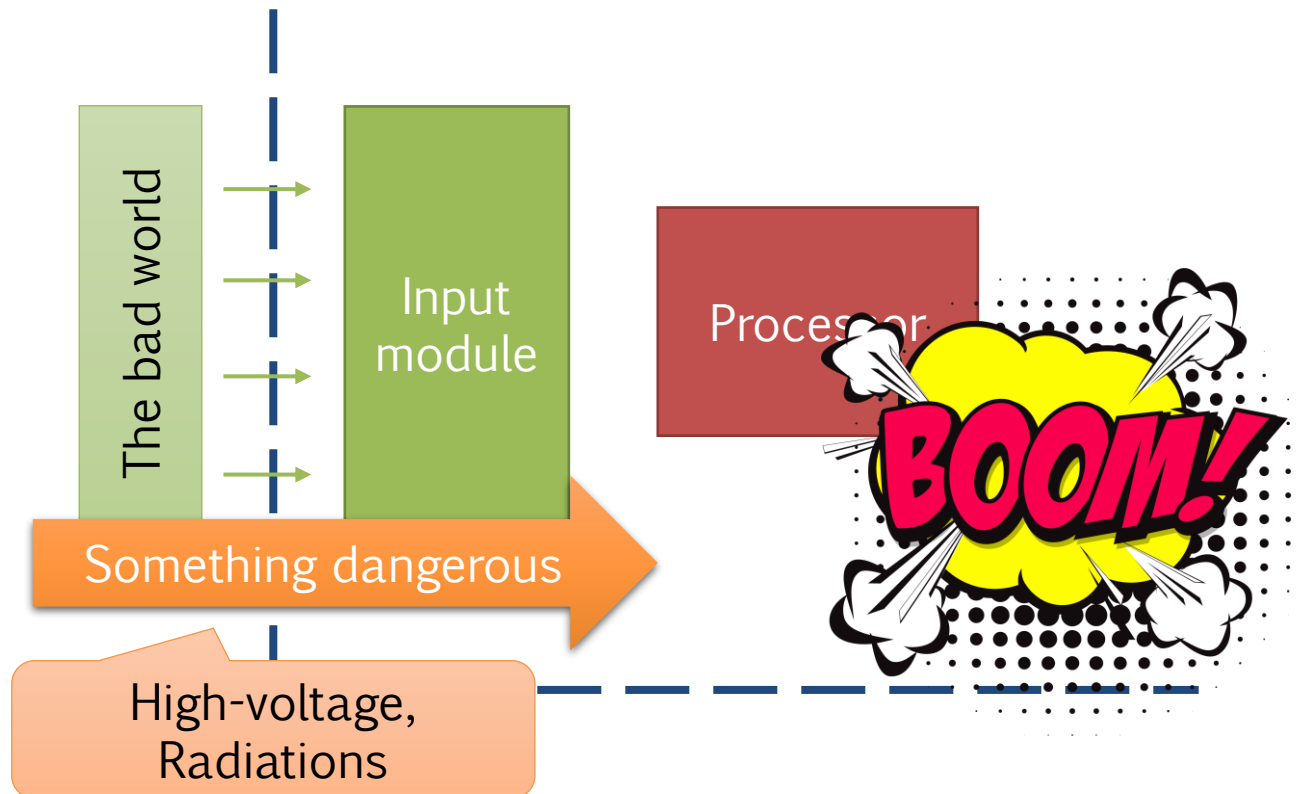
› Outputs: latch, and implement drivers for, e.g., relays

Input module

Output module

The bad world

Isolation

Buffers

Processor

Latch

Drivers, relays...

The bad world

I/O Bus

We typically need buffered inputs

Keeps output stable

Input isolation: electrical decoupling

Some physical signals might be dangerous for the internal circuitry

› Need to find a way to capture their value…without damaging the HW

› E.g., Optoisolation/optocoupling

› PLCs support a variety of input Voltages, from 5V to 240V…

The bad world | Input module | Processor | **BOOM!**

Something dangerous →

High-voltage, Radiations

Optoisolation (principle)

A photo-transistor is triggered by a (digital) LED which is driven by the physical signal

› Transistors also work as an amplifier, so its output is proportional to LED input

› No electrical coupling
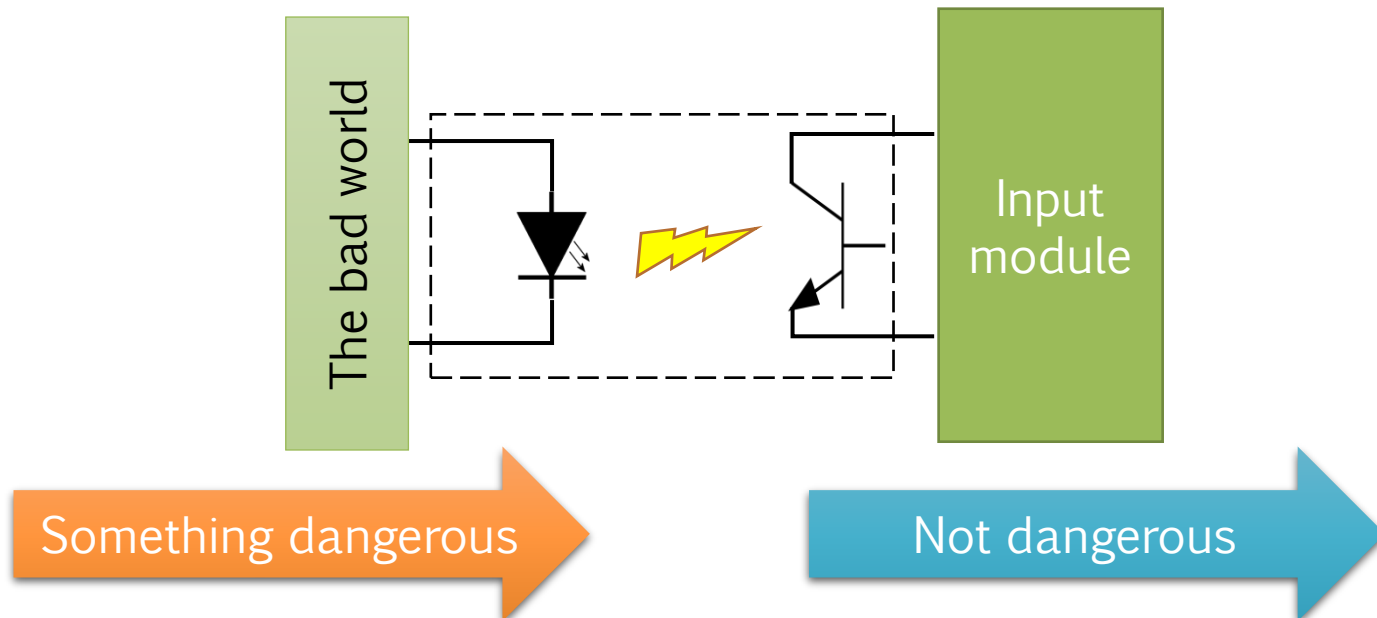
Output channel

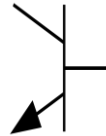Has a **latch** to keep analog output stable

Can be of three types

1. **Relays** to drive current to an external circuit
   - Small circuit can drive high current (voltage)
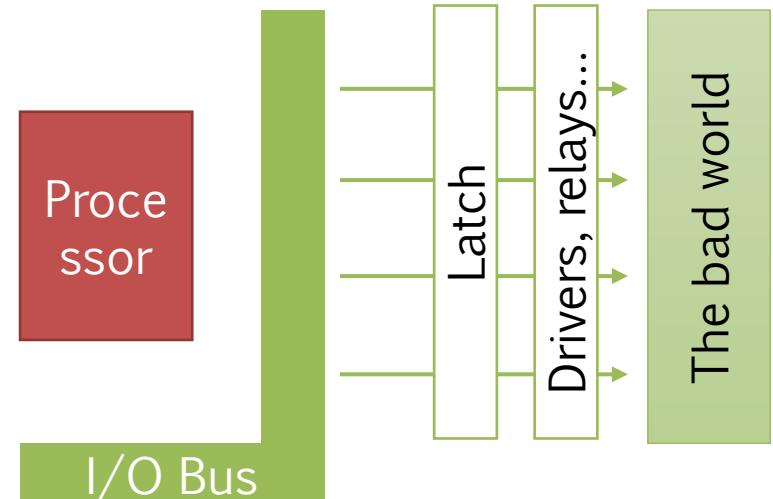   - Ensures isolation
   - Slow

2. **Transistor** type
   - Faster than relays
   - Only for DC
   - Sensitive to overcurrent (might brake) requires optoisolators
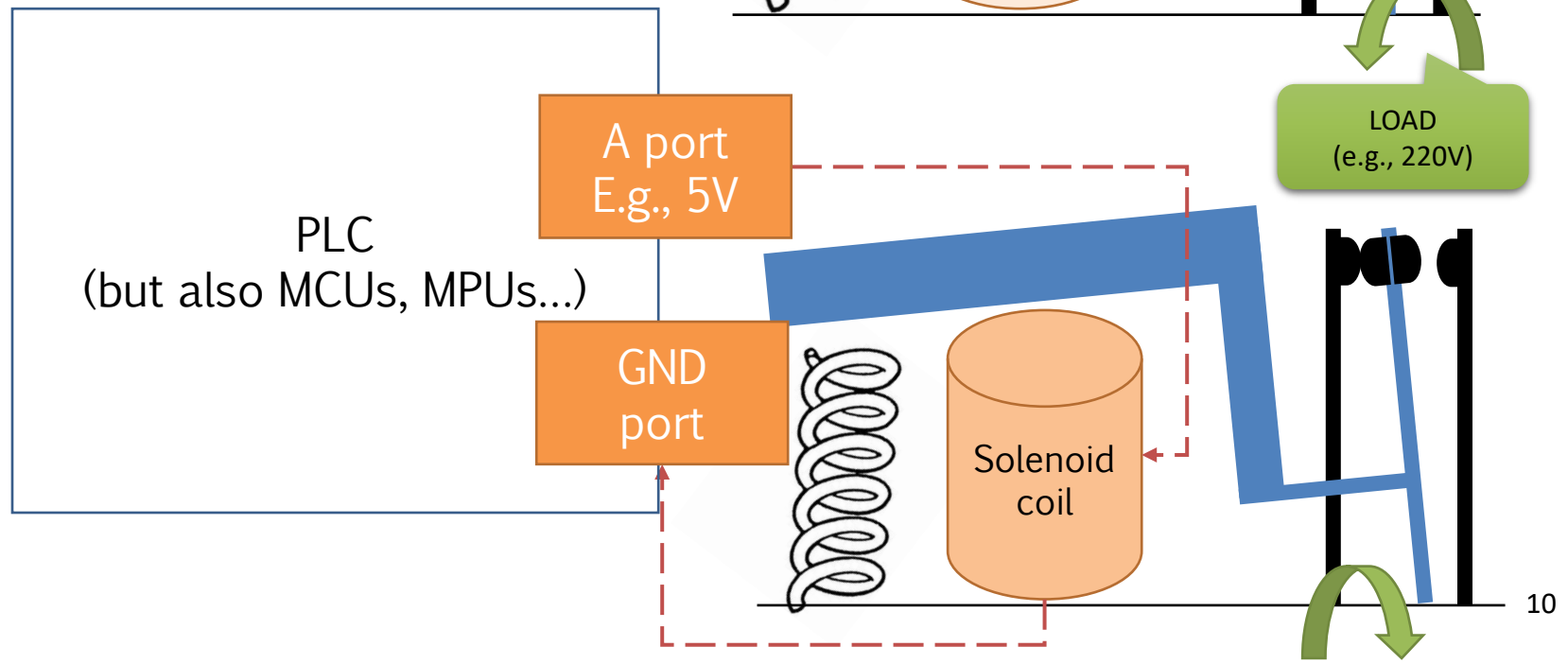
3. **Triac** with optoisolators
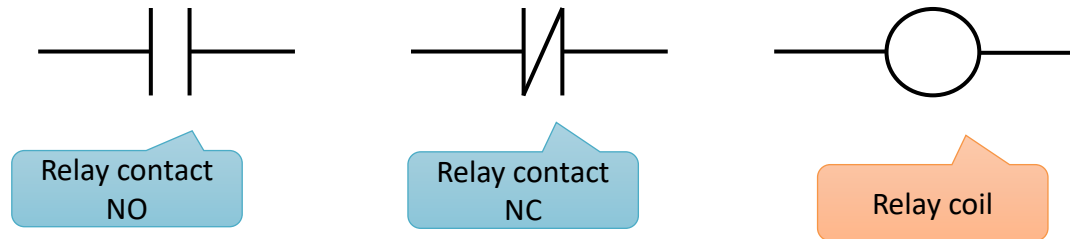   - For AC current
   - Sensitive to overcurrent

Background: relays

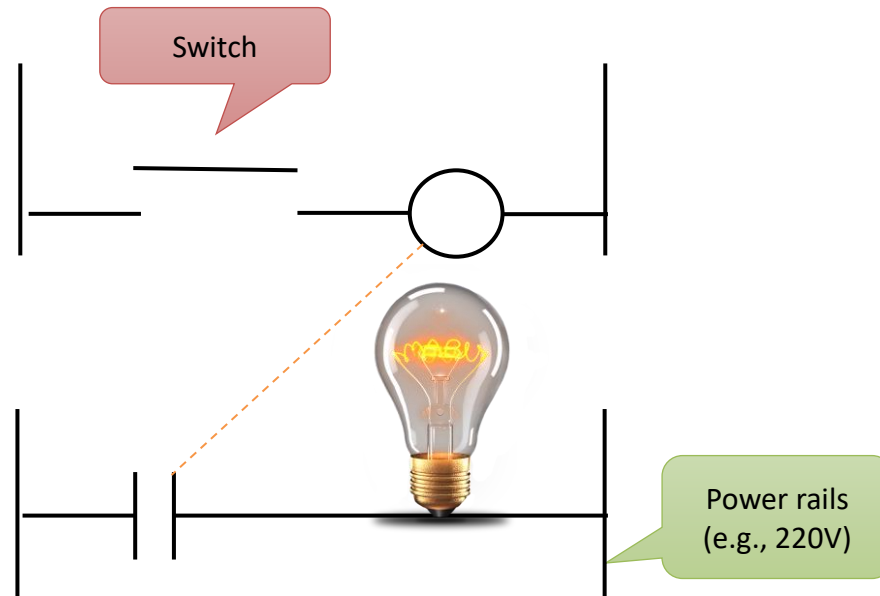> Used to control high-voltage switches via low-voltage analog port such as GPIos

Symbols

Relay contact NO

Relay contact NC

Relay coil

Possible circuit to turn on a light

› Switch can either be manual or driven by PLC/MCU..
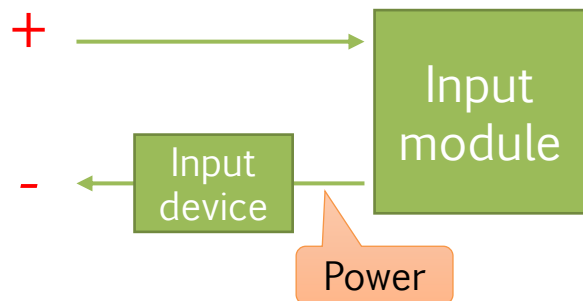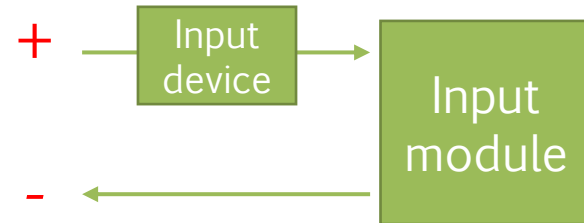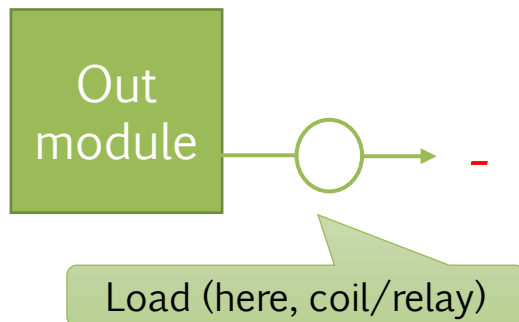
Switch

Power rails
(e.g., 220V)

11

Who powers the in/output?

Both input and output DC devices models can be connected to PLC input module
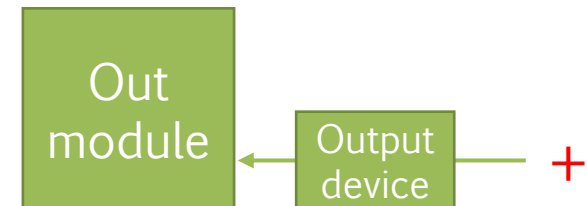
› …but who gives the power to whom?

› **Sourcing** (PLC's input module gives power) vs. **sinking** (input device gives power)


Sourcing

Sinking

Power

Load (here, coil/relay)

Input devices

Sensors, that convert a signal from one physical form to another form

› Aka transducer

› Can be digital/discrete (easy to handle) or analog (requires A/D conversion)

Typically measured/assessed in:

› **Accuracy** of the measured value wrt the real one
  – e.g., thermometer can have ± 0.1°C error

› **Range** of the measurable value
  – e.g., -10°C to +20°C

› **Response time** to get to **steady state** upon variation of the measured value

› **Sensitivity**
  – e.g., thermocouple might vary 10µV for every 1°C

› **Stability** if input signal stays constant

› **Repeatability**, aka sensitiveness to variation in the environment/sensor

› **Reliability**, that is, how often does it break?

Steady state
(detected value)

Sensor value

time
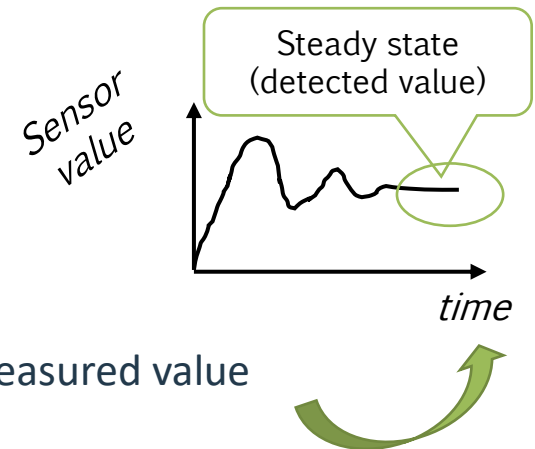
Common sensor types

›   Mechanical/proximity switches

›   Other proximity sensors (e.g., via ultrasounds)

›   Photoelectric sensors

›   Encoders (for lateral physical displacement)

›   Temperature

›   Position (distance) sensor

›   Strain (*it: tensione*)

›   Pressure

›   Liquid level / fluid flow

Smart sensors already have buffering/isolation circuitry onboard, and already produce safe and digital value

›   Can also have a processor and small EEPROM!

›   Standard interface, e.g., IEEE 1451.4

Output devices

Recap: output ports are relays or transistor/triac w/optoisolators

› Relays to drive a current switch (on/off)

› Solenoid operated valves (open/close)

› DC motors or AC motors with current conversion

› Rotating motor, aka *stepper*

› *...*

PLC programming (aka IEC 61131)

References

Course website

› http://hipert.unimore.it/people/paolob/pub/Industrial_Informatics/index.html

My contacts

› paolo.burgio@unimore.it

› http://hipert.mat.unimore.it/people/paolob/

Resources

› Alessandro Fantechi, «Informatica Industriale», Città Studi Edizioni

› W. Bolton, ''Programmable Logic Controllers'', 6th edition, Newnes

› A "small blog"
 – http://www.google.com