Status of the Electrical Installation and the Operating Principle of the $\bar{P}$ANDA Cluster-Jet Target's PLC

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Westfälische Wilhelms-Universität Münster

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Bundesministerium für Bildung und Forschung

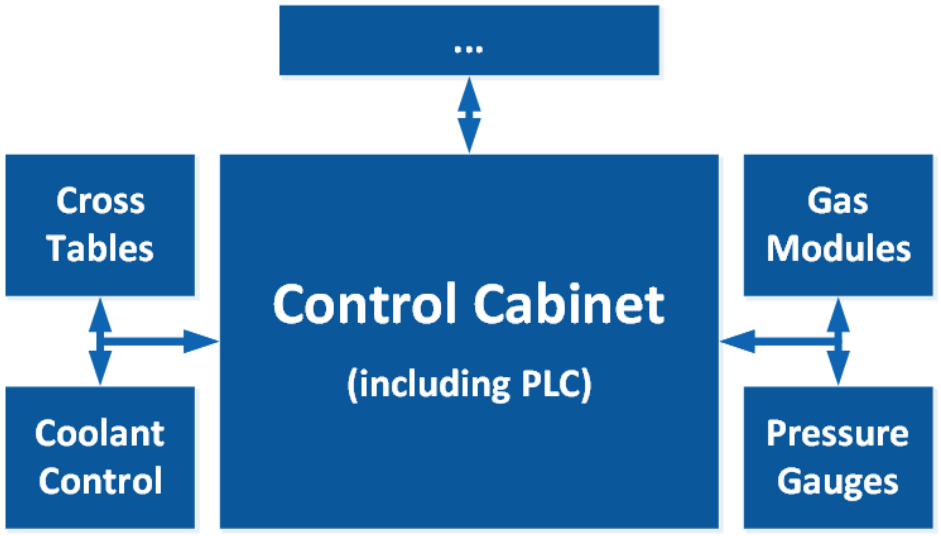
Status of the Electrical Installation

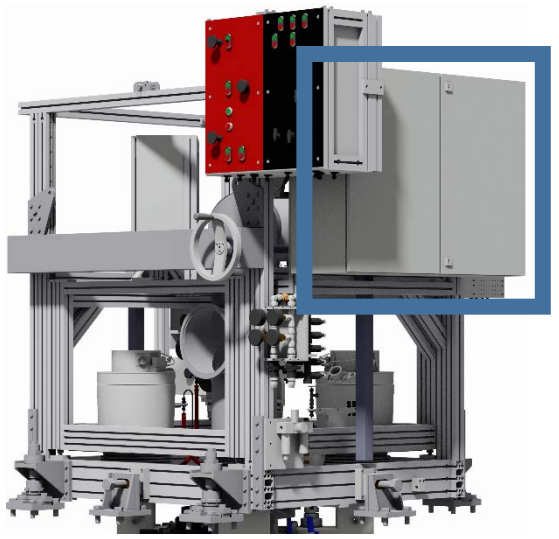
Neat new gadgets we have:

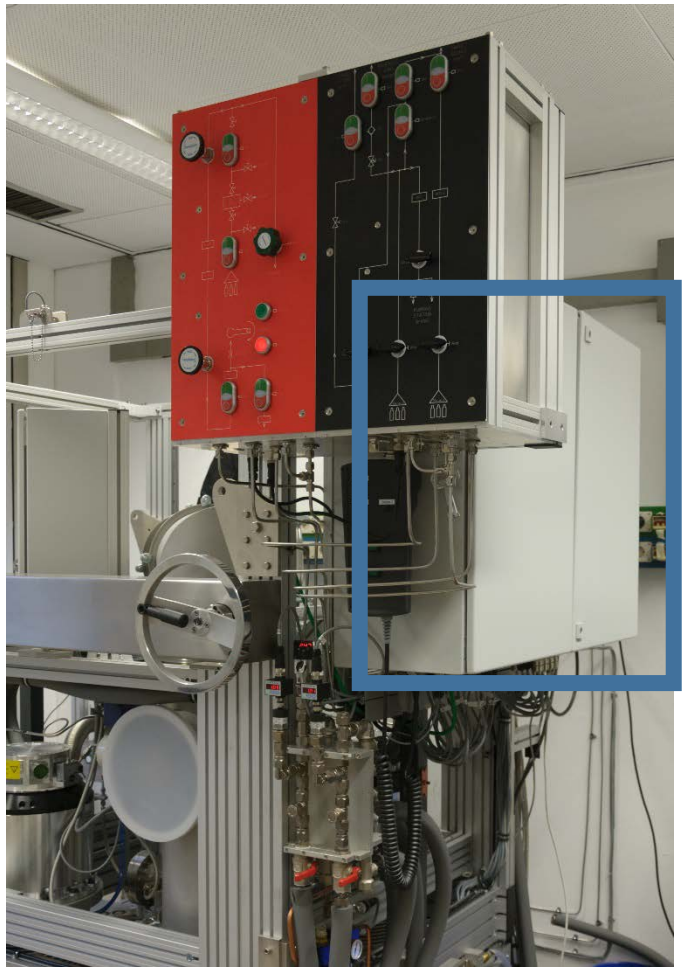
- Hitherto just e-mail messages from the target
- Uninterruptible Power Supply
- UMTS modem

✓ Our target can now message us on our mobiles during a power failure, critical errors …

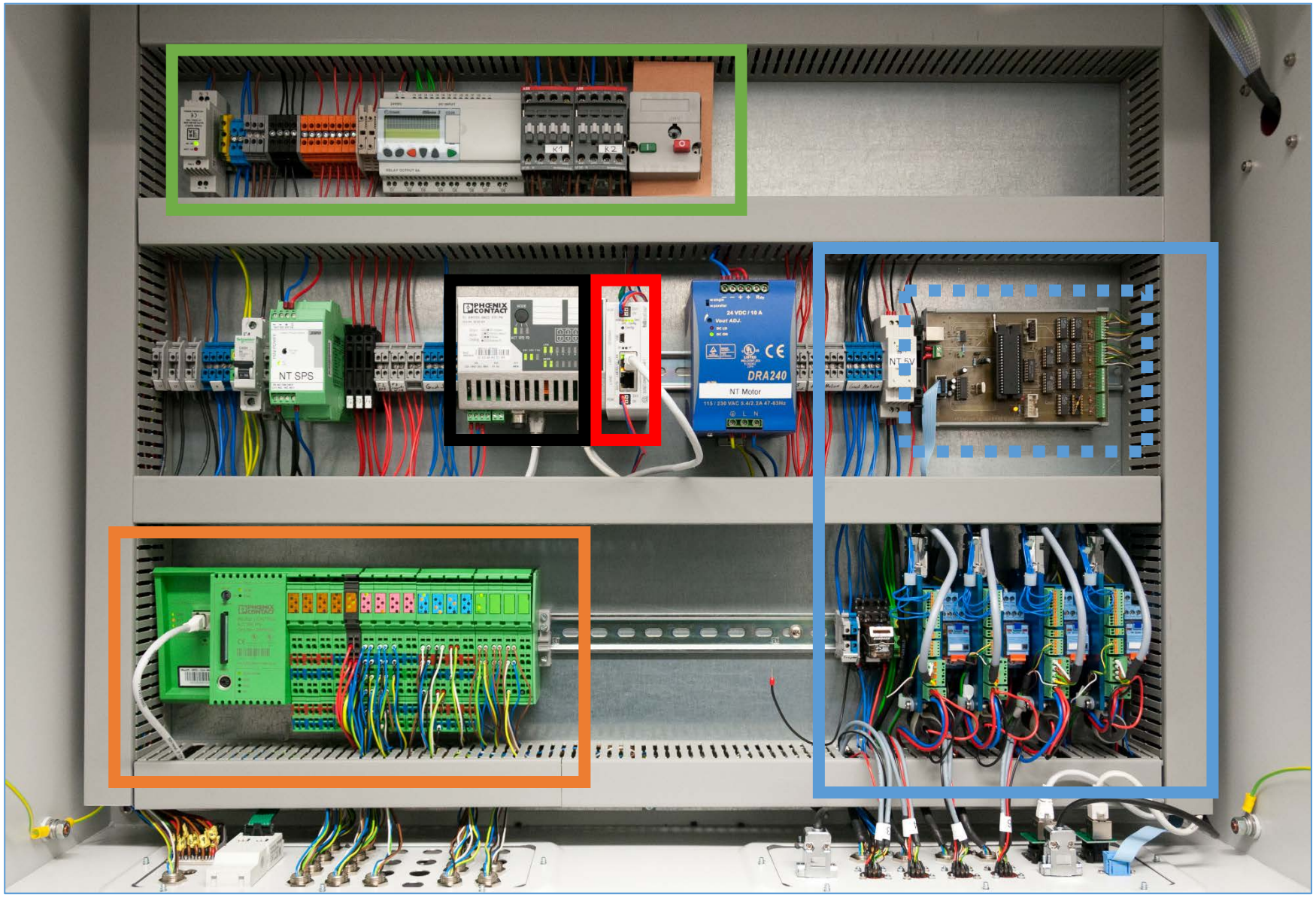
- Electrical installation mostly done on target frame side
- Electrical installation of 19“ rack cabinet is ongoing
- Skimmer and collimator cross tables are controllable
- PLC putted into operation
- All valves controllable via the (preliminary) Slow Control and the gas modules





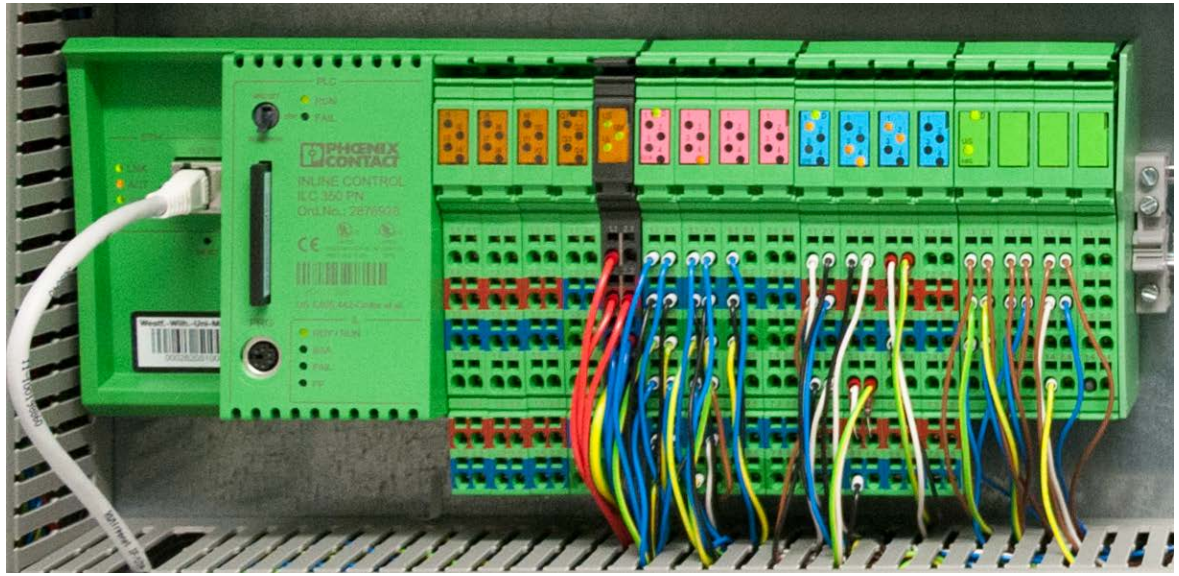


Inside the Control Cabinet



- automatic lifting system
- skimmer and collimator cross tables control
- absolute rotation encoders (dotted)
- gas modules-PROFIBUS gateway
- main PLC
- PROFIBUS gateway

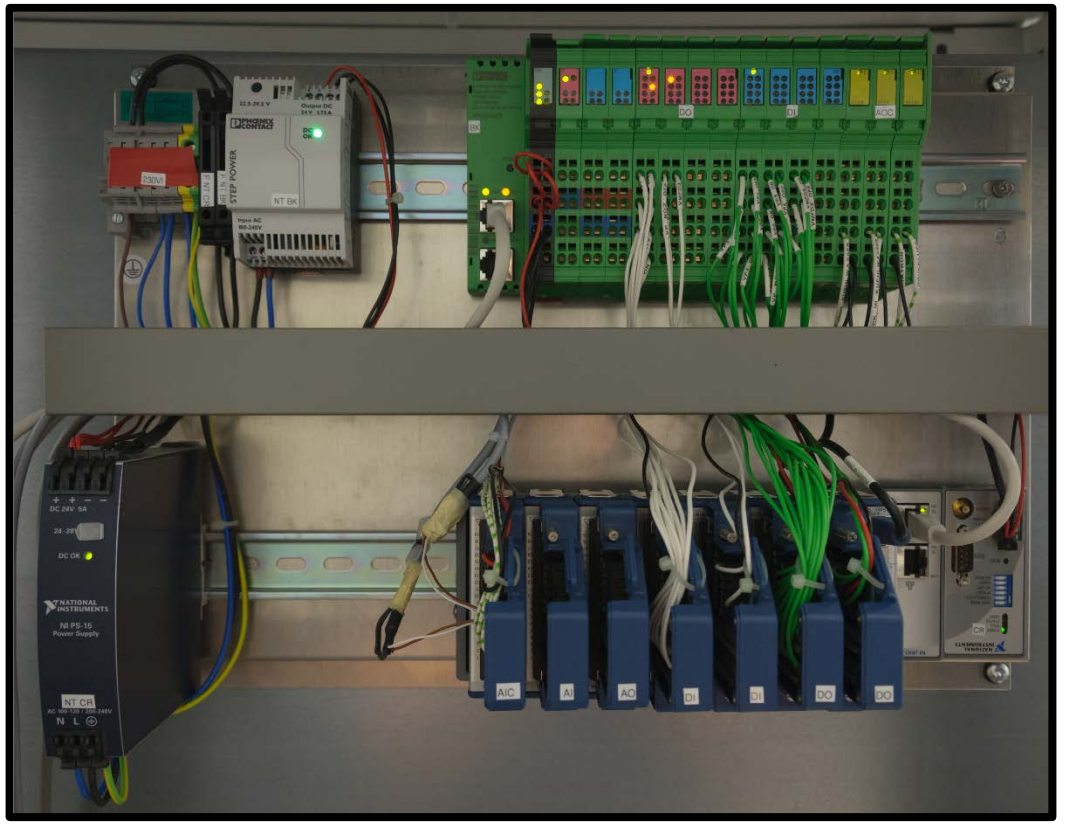
Main PLC Configuration



- Digital Outputs (0V/24V): Open valve - close valve (pulsed), …
- Digital Inputs (0/24V): Valve states (open/closed), …
- Analogue Lines (4-20 mA): Coolant Temperature, Pressures, …

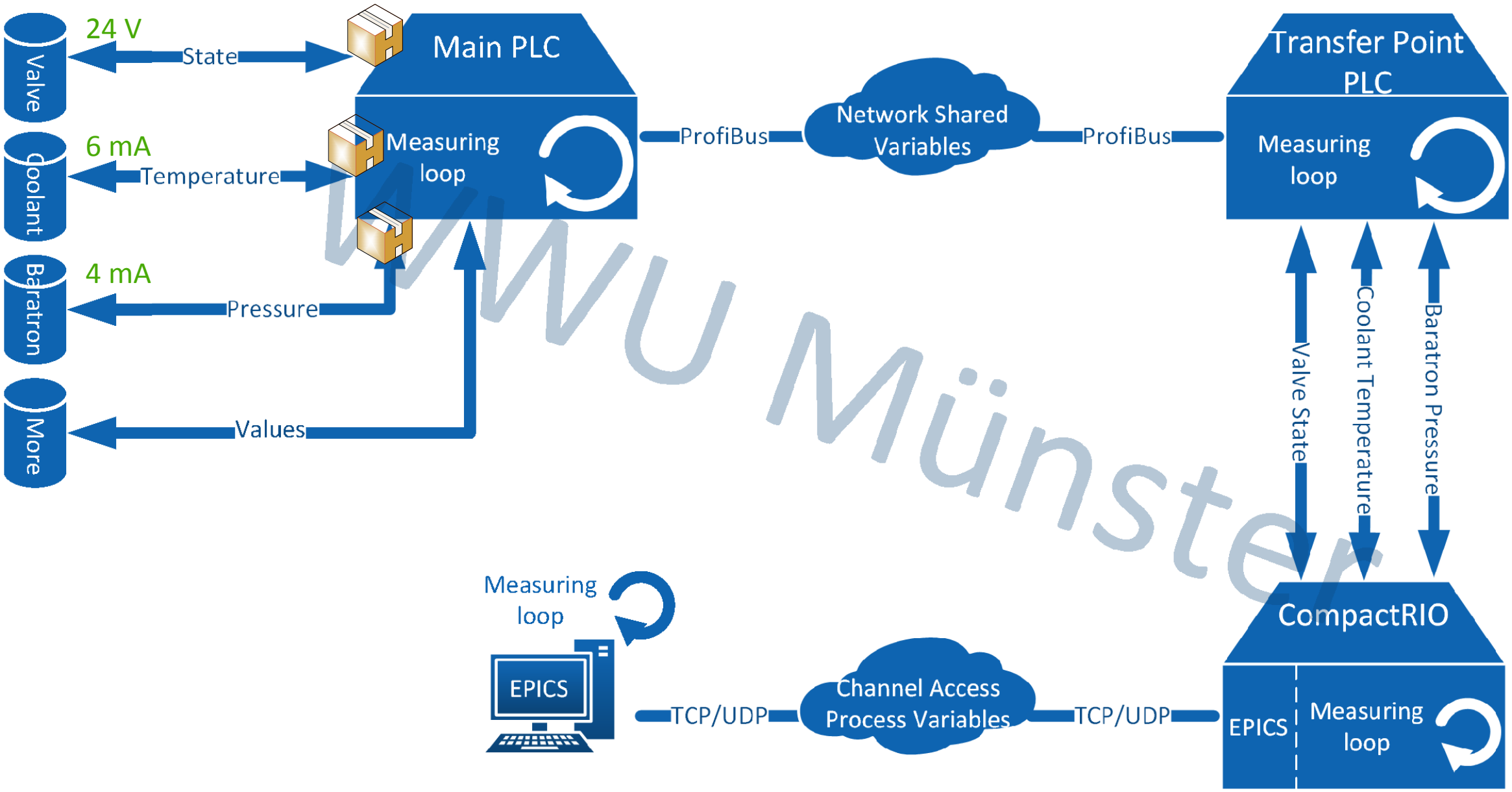
- Every measurement is given as an voltage/current value to the main PLC inputs. Same is done for the PLC outputs
  - No need to care about protocol details
- Every measurement is digitized by the main PLC and is then also accessible by the transition point PLC

Transition Point PLC



- Transition point PLC is connected/synced via PROFIBUS with the main PLC
- Transition point PLC is mirroring main PLC inputs/outputs
- Every PLC output is directly connected to a CompactRIO input and vice versa
- CompactRIO is just reading/writing analogue/digital signals

Reading Measurement Values from the PLC



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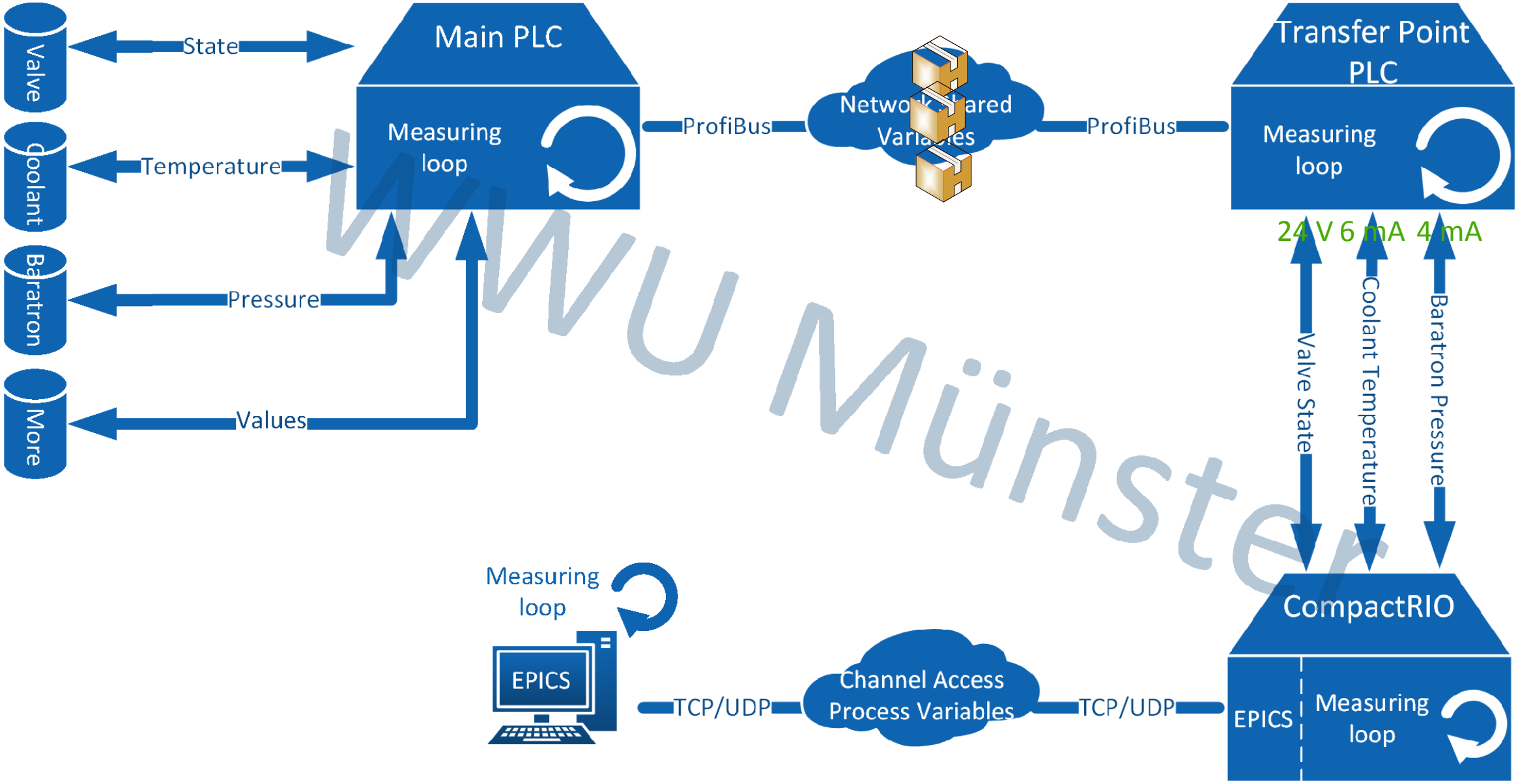

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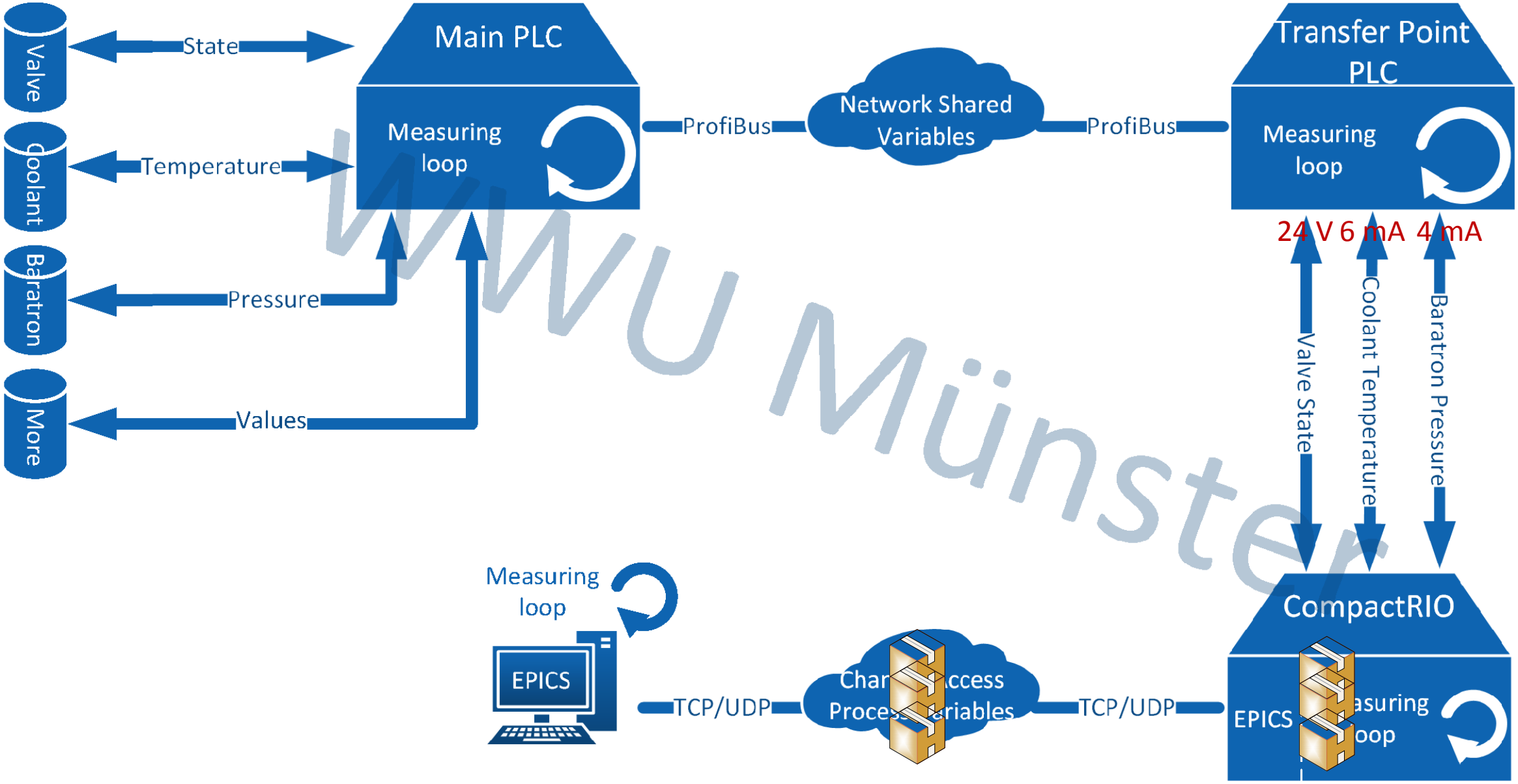
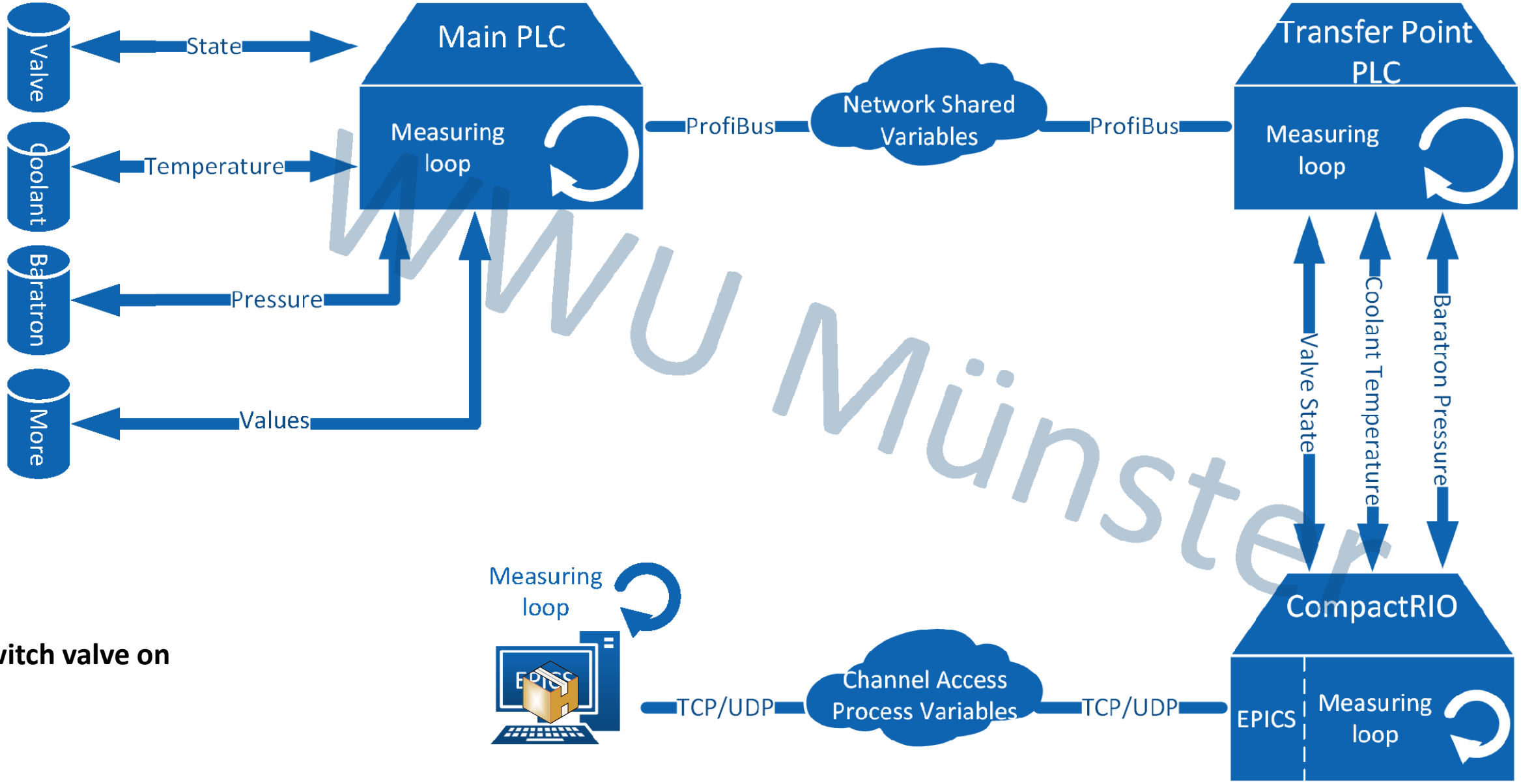
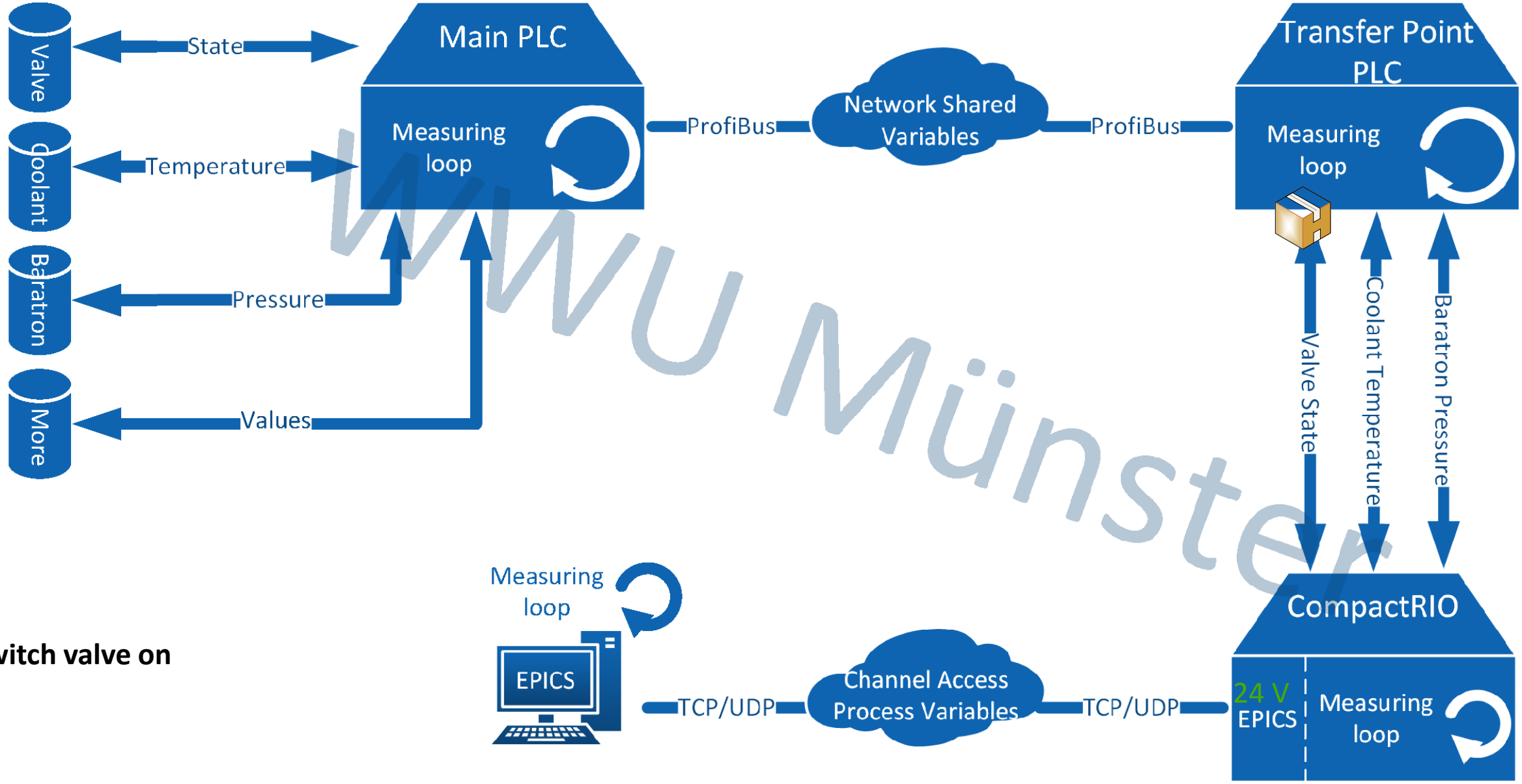


Writing Measurement Values to the PLC

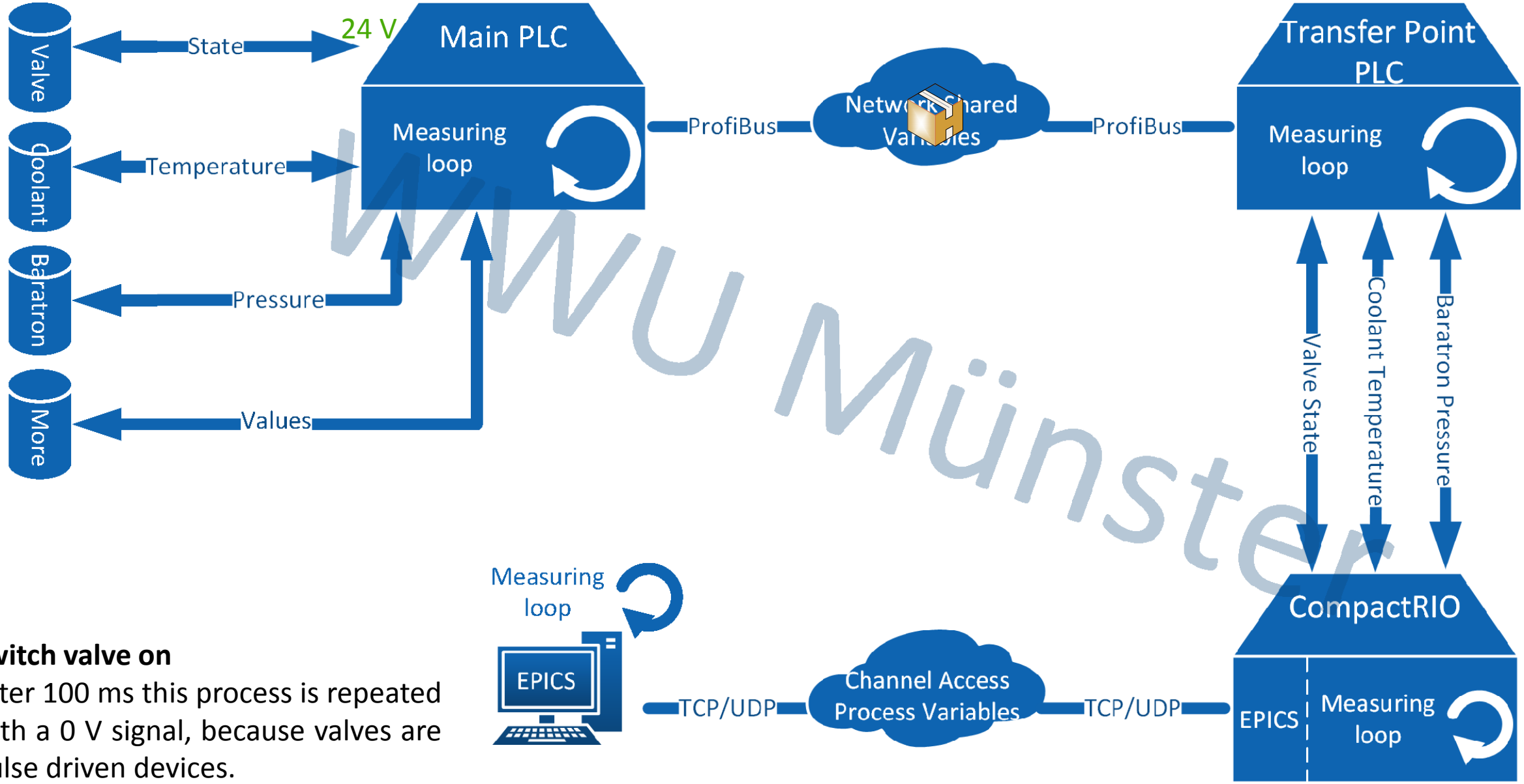


Switch valve on

Writing Measurement Values to the PLC



Switch valve on



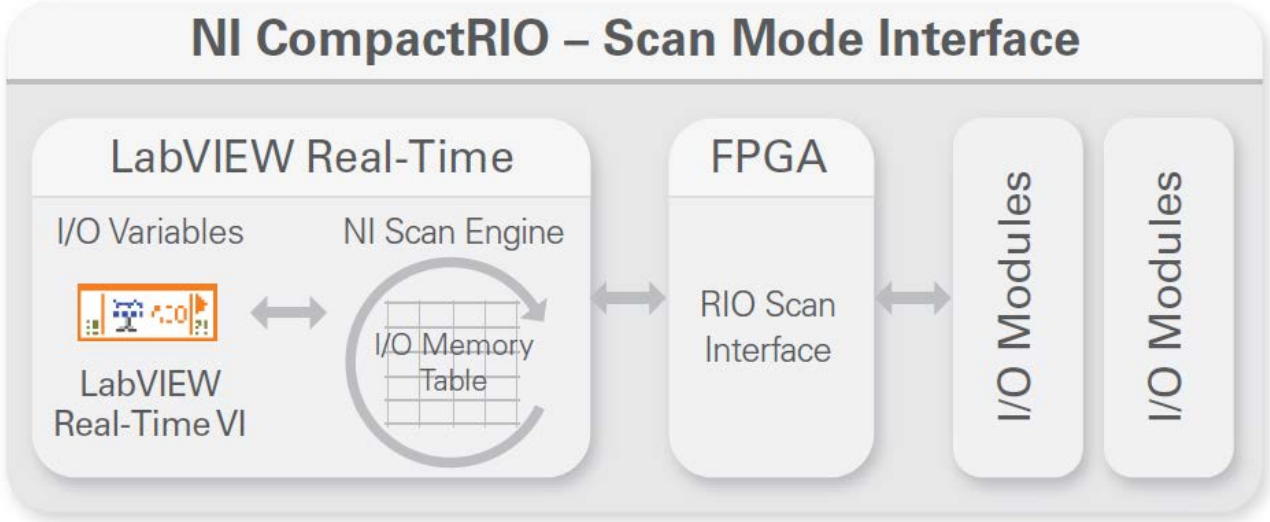
Switch valve on

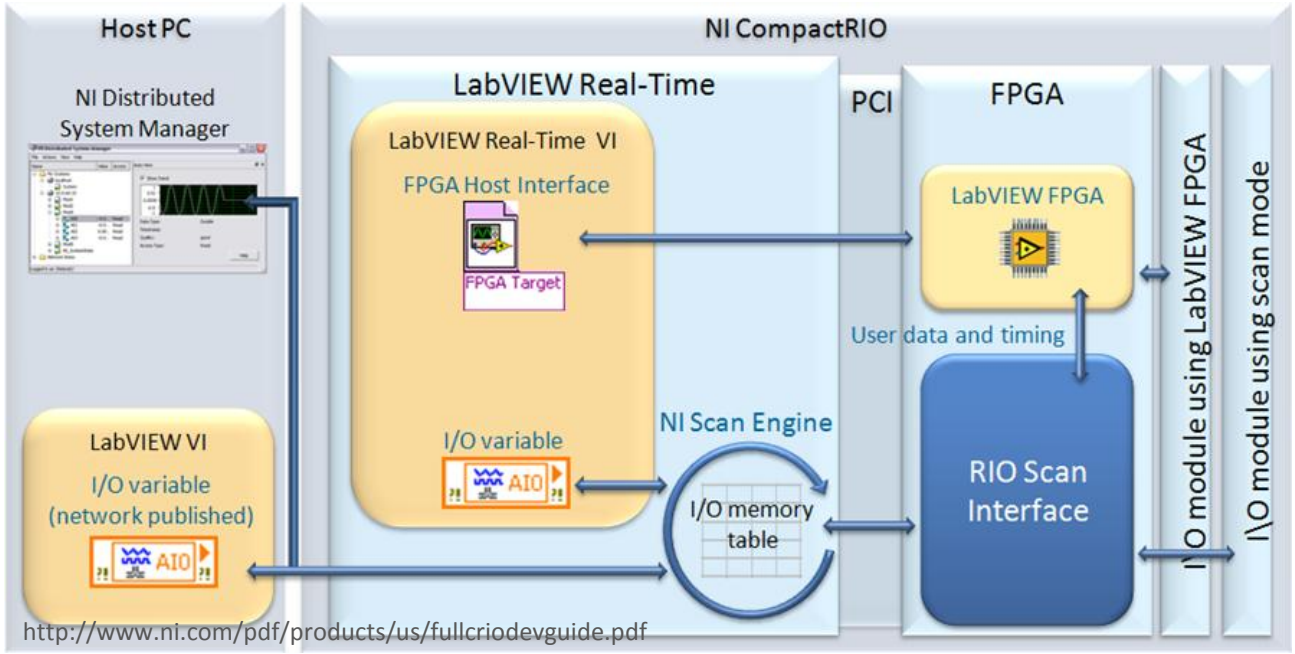
After 100 ms this process is repeated with a 0 V signal, because valves are pulse driven devices.

NI CompactRio-9074

400 MHz, FPGA, 128 MB Ram, 512 MB Hard Disk, 1 RS232, 2 x 100 Mbit/s Lan Connectors

NI-9208 16 (4-16 mA) Channels	NI-9205 16 (24 V) Channels	NI-9264 16 (24 V) Channels	NI-9425 2 x 32 (24 V) Channels	NI-9476 2 x 32 (24 V) Channels	NI-9871 4x RS485
CI	AI	AO	DI1 DI2	DO1 DO2	RS485





http://www.ni.com/pdf/products/us/fullcriodevguide.pdf

Different programming modes:

- Direct FPGA programming
- Scan Mode

Rule of thumb:

- FPGA if frequency > 500 Hz or CPU usage > 60%

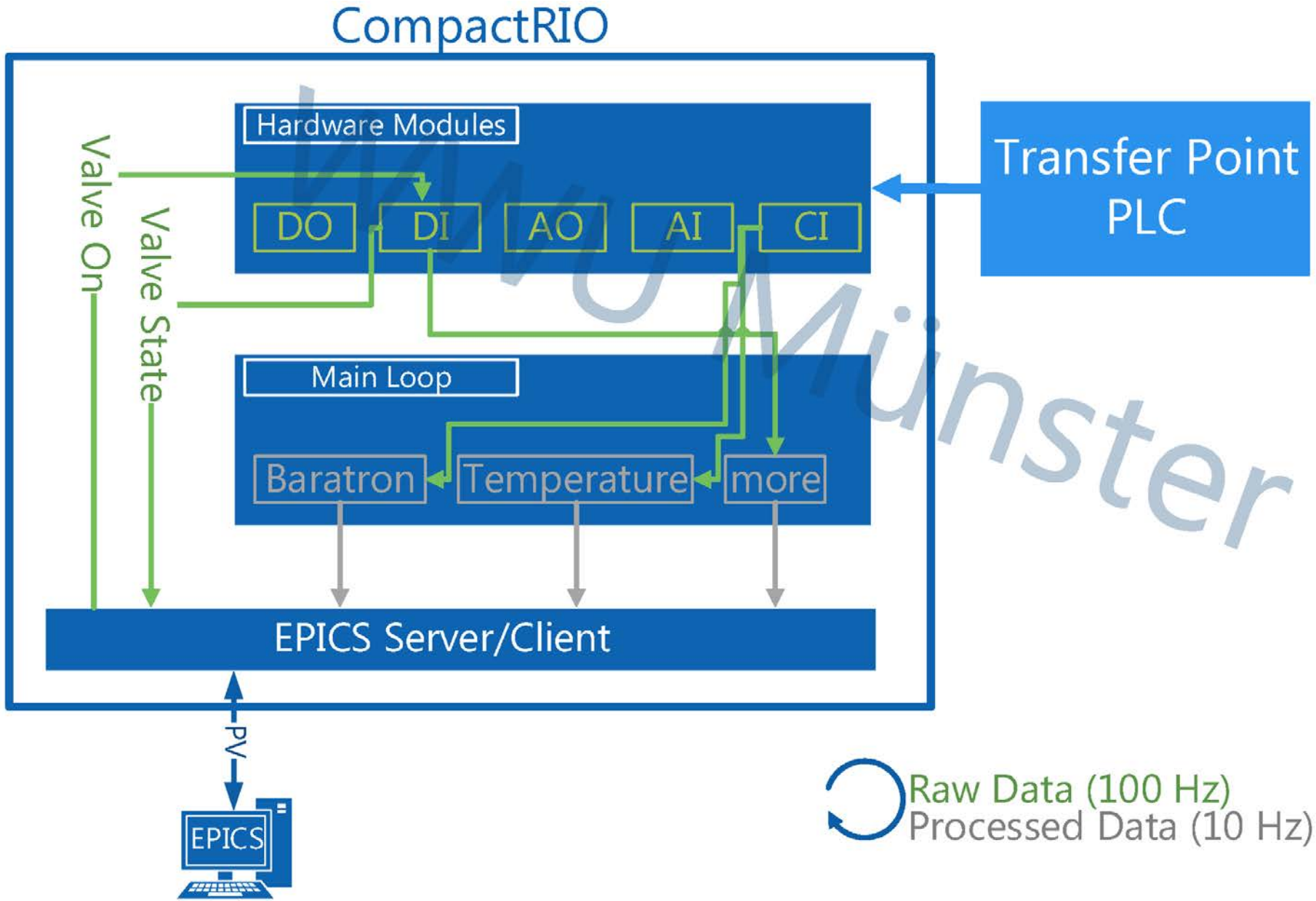
Advantages of Scan Mode:

- More simple Programming
- Dynamically initialize/detect modules
- Fault Engine available
- Diagnostic and Debugging

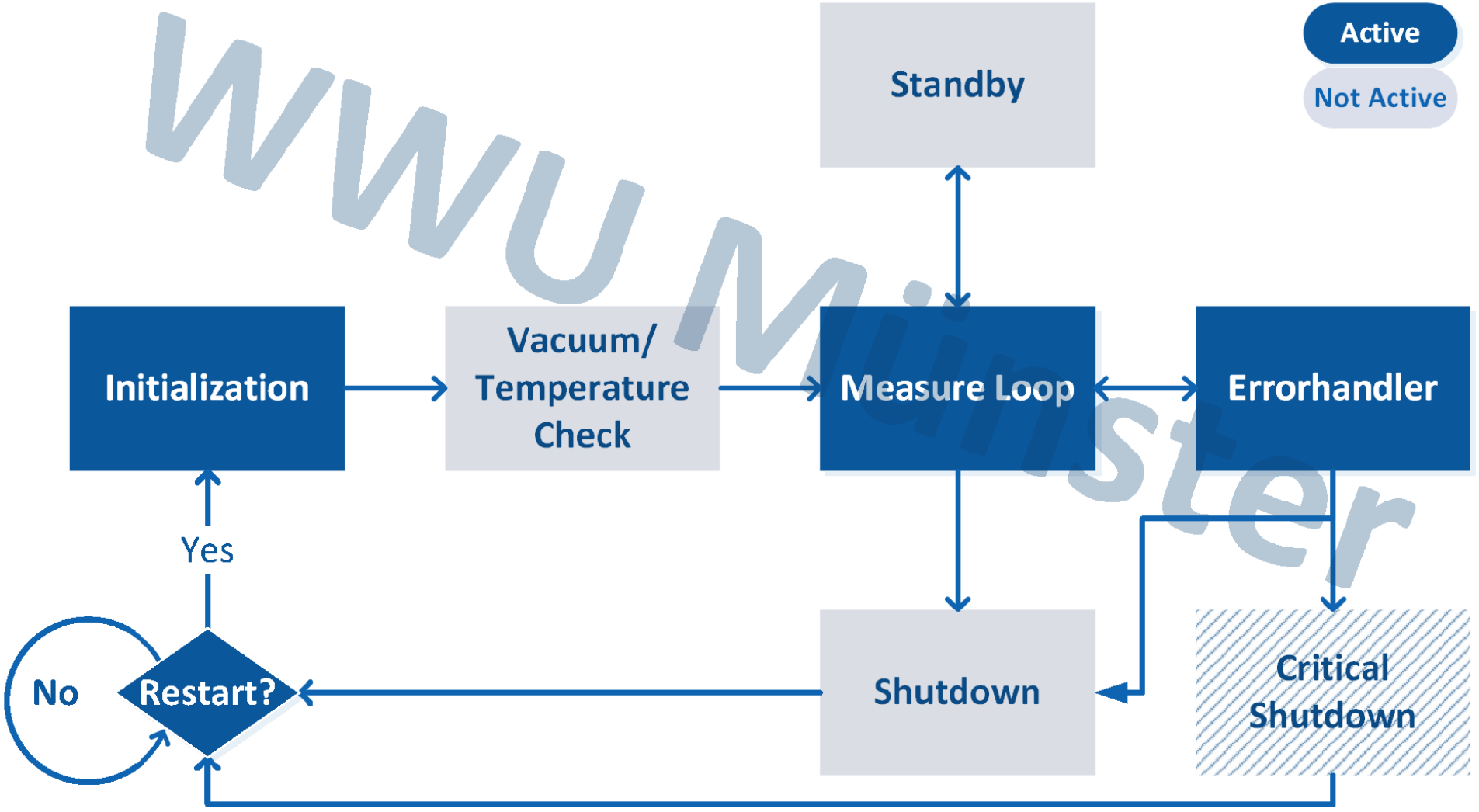
If more speed is needed: Hybrid Mode

- Scan Engine and use of FPGA
- Disadvantages:
  - Little more overhead
  - Whole Module only accessible through direct FPGA programming
  - Less simple programming

Data Flow Inside the CompactRIO

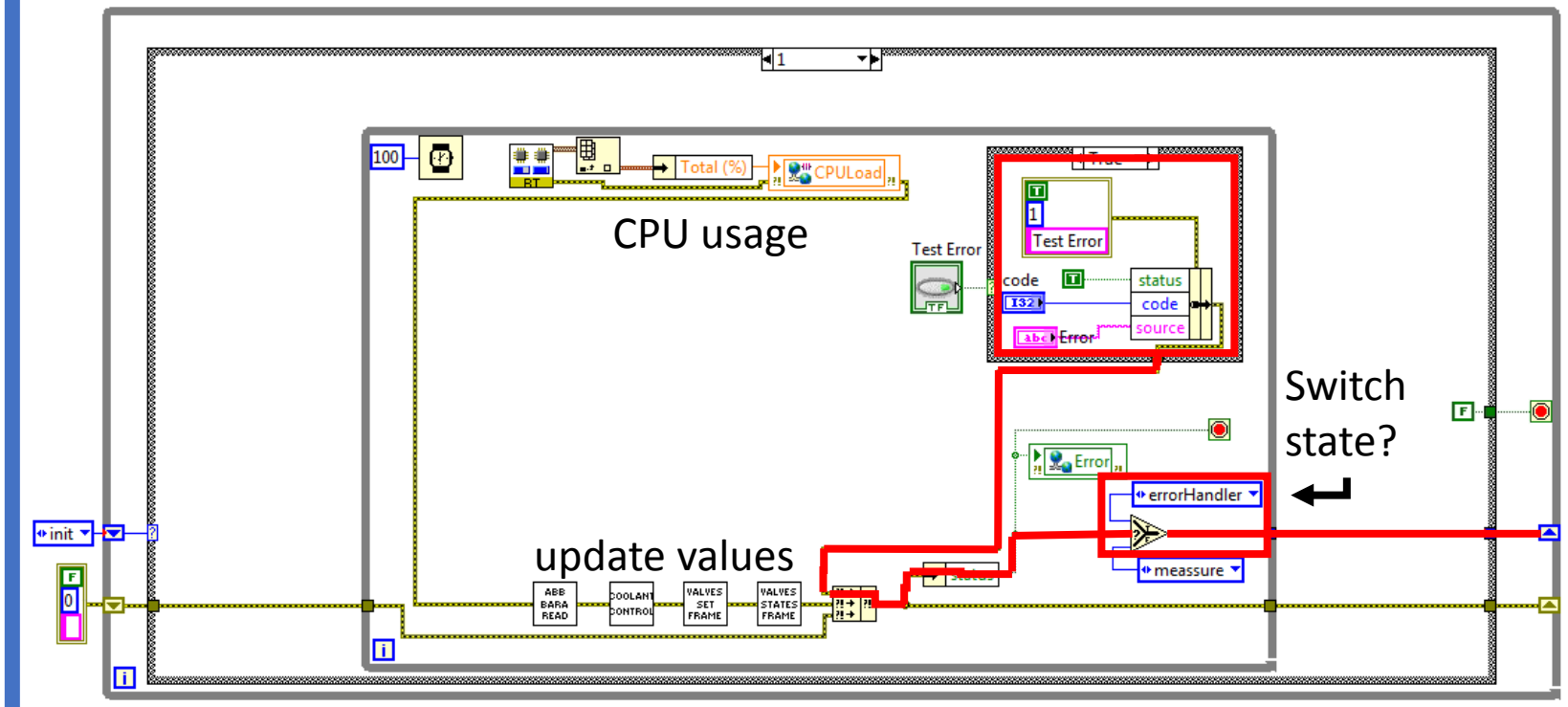


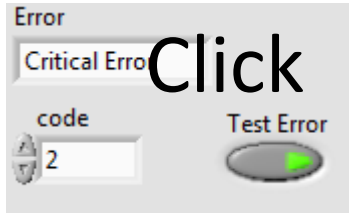
Finite State Machine for the (preliminary) Slow Controll of the Cluster-Jet Target

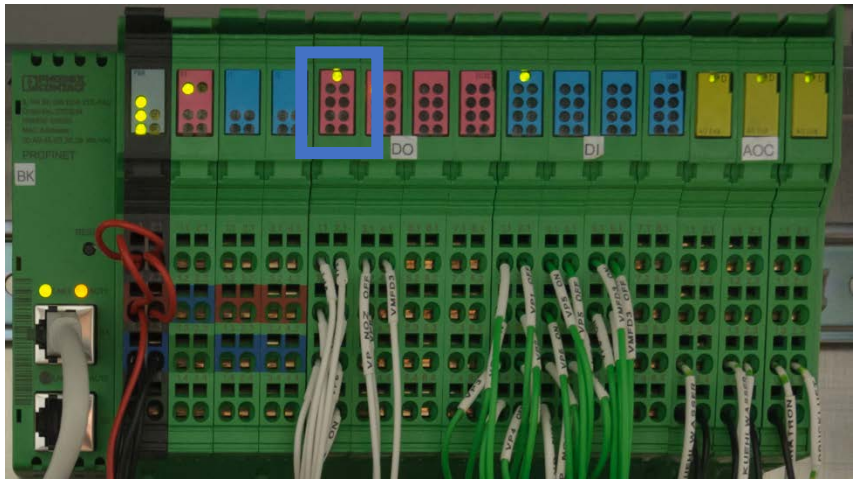


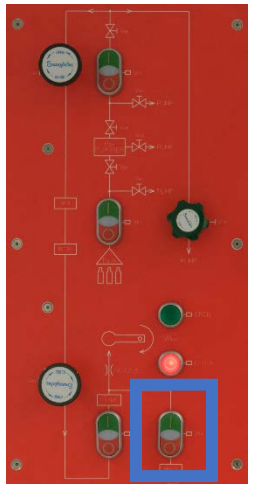
Example Run of the Infinite State Machine

CompactRIO

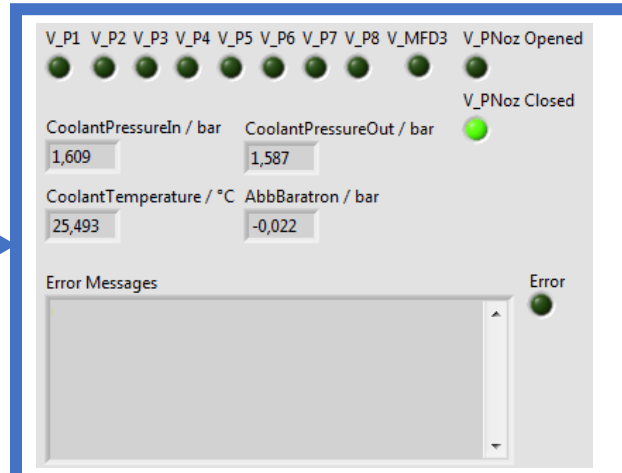








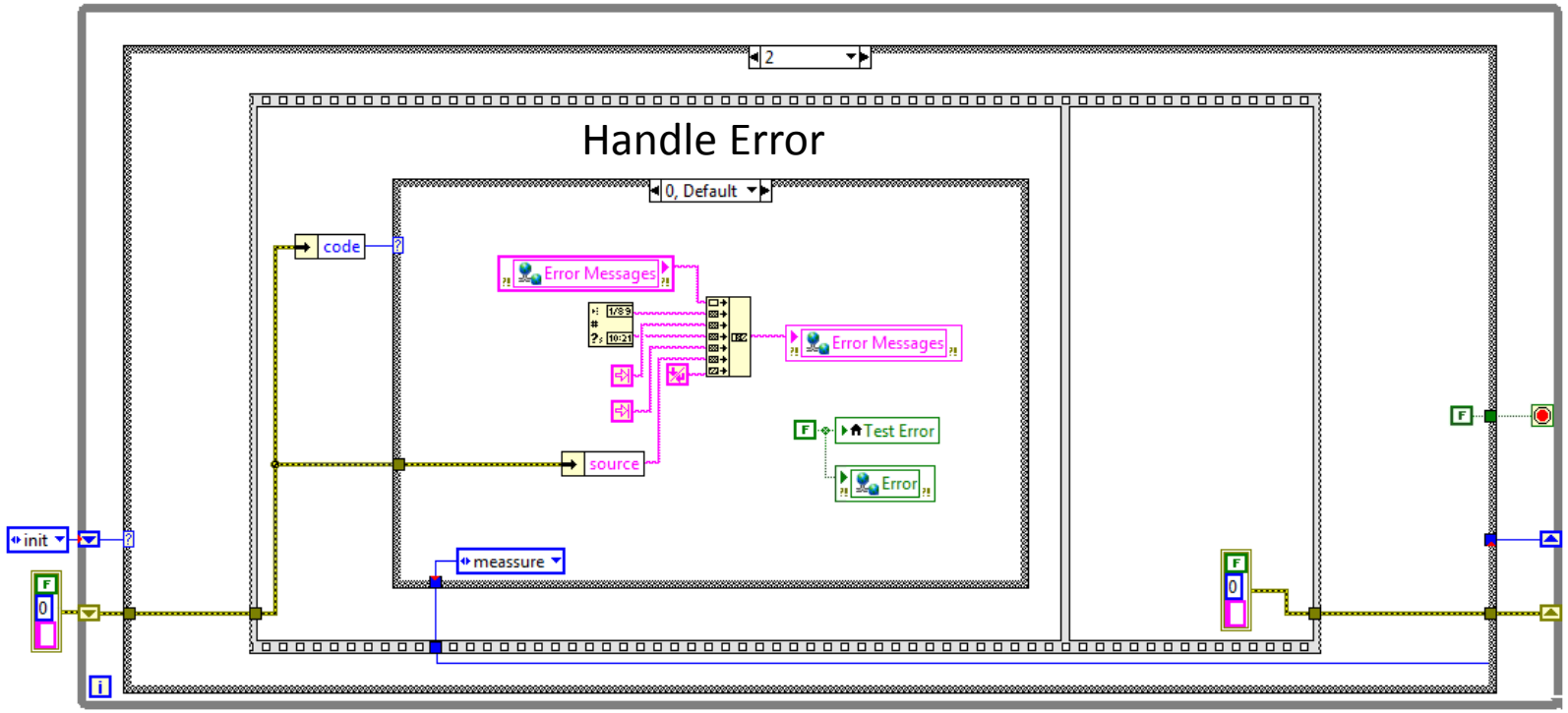
EPICS

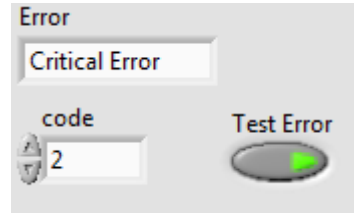


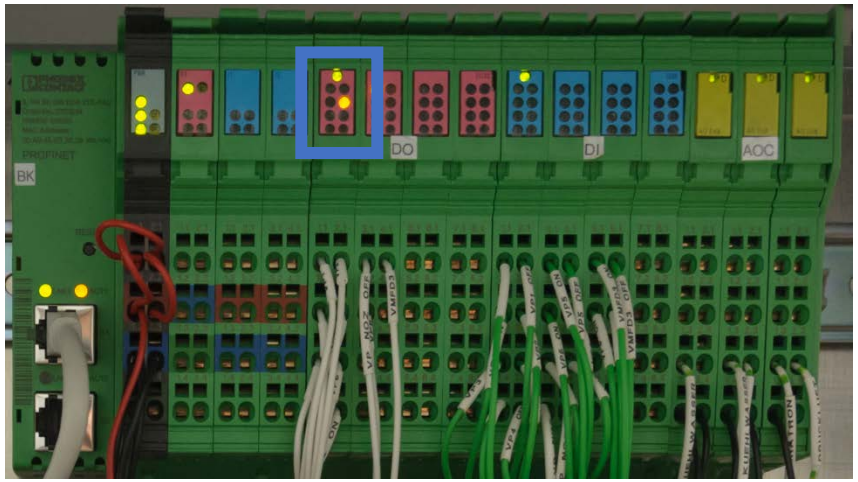
PC

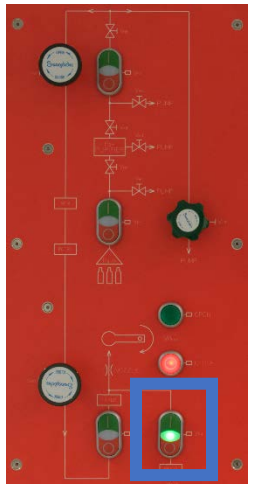
Example Run of the Infinite State Machine

CompactRIO



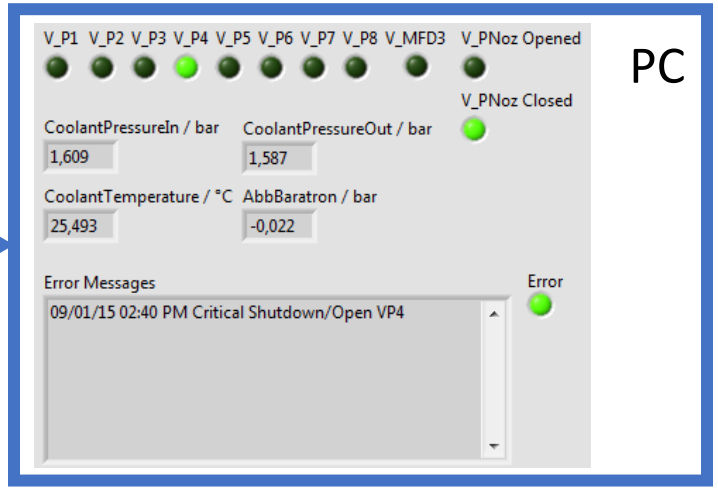




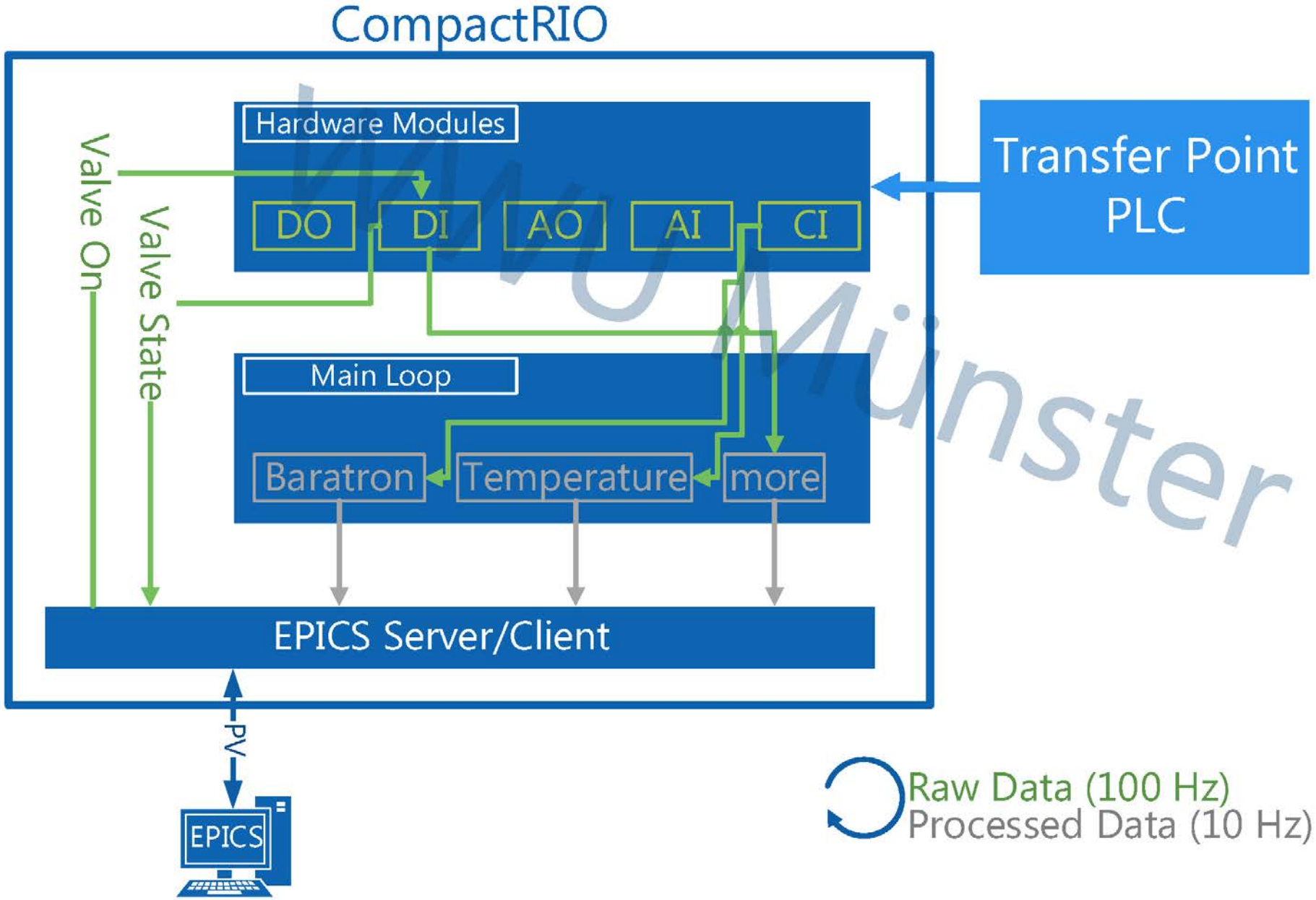


EPICS

PC



Later Connection Point of the final CompactRIO to the PLC



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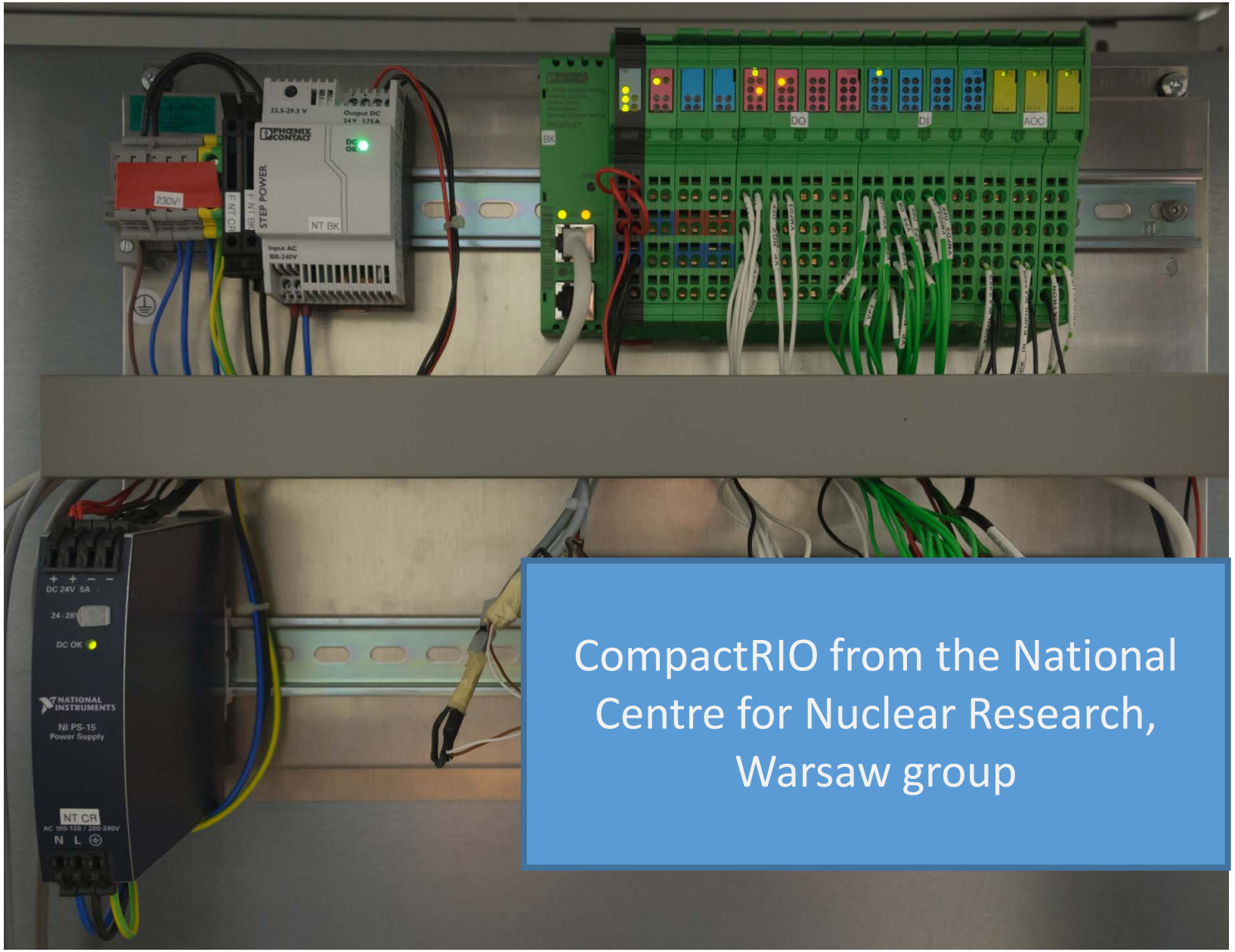


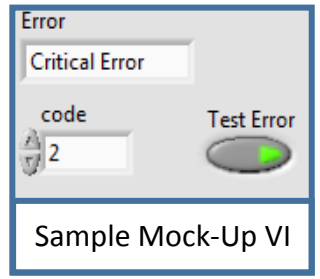
CompactRIO from the National Centre for Nuclear Research, Warsaw group

Replace recipe for our CompactRIO with the Warsaw one:

- Plug‘n‘Play design – „simple“ 1:1 rewiring
- No need to know where the devices are located and which connectors are used
- Final Slow Control just needs to know which value ranges and input formats (voltage/current/…) are given
  - Examples:
    - Baratron measurand range: 0 bar – 30 bar → value range: 4 mA – 20 mA
    - Open Valve: 100 ms pulse on the corresponding DI line of the transfer point PLC

- Exceptions:
  - Only talking about devices connected to the PLC, no RS232/RS485/LAN/… devices
  - Current outputs of the spherical joint cross table potentiometer directly connected to CompactRIO and given to our cross table control as EPICS Process Variable

- Simple PLC design/connection interface has advantages
  - For the Slow Control team testing their code while the target is not accessible during assembly/future beam times
  - Via function generators, mock-up VIs, loop back VIs… (we use this techniques also for non PLC devices)



Collaboration between Münster and Warsaw group:

- Detailed lists of all parts and measurands, flow charts, concept papers, …
  - Already shared with Warsaw group
  - Happy to help if some information is missing/outdated
  - Missing manuals
- Share our know-how gained by using our preliminary Slow Control
- Looking forward to have constructive discussions about problems and ideas
- Welcome you to our institute to have a look at the target and its control devices