Disconnectors within HL-LHC Powering

Samer Yammine (CERN) on behalf of WP6b

8th HL-LHC Collaboration Meeting

2018-10-16

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- Warm to Cold Transition in LHC
- HL-LHC Accessibility/Intervention Requirements for Powering Systems
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Warm to Cold Transition in LHC

Warm to Cold Transition in LHC

Courtesy of JC. Guillaume, L. Sburlino

Warm to Cold Transition in LHC

- Disconnection & Re-connection of water cooled cables in the LHC is:
  - Required in average once a year for high current circuits for ElQA tests
  - Time consuming & caution required during manipulation
  - Risky for current leads (fragile vs. heavy cables – above 800N damages the current leads)
  - Contact quality must be ensured
  - Presents additional risks on personnel
    - Ladder required in case of most DFBs

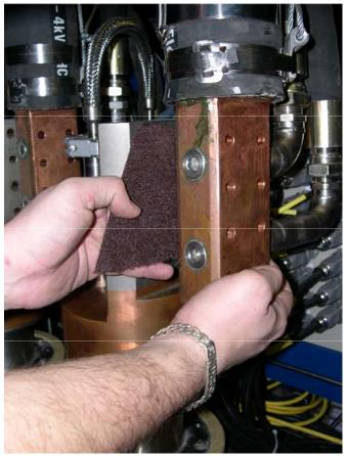
Warm to Cold Transition in LHC

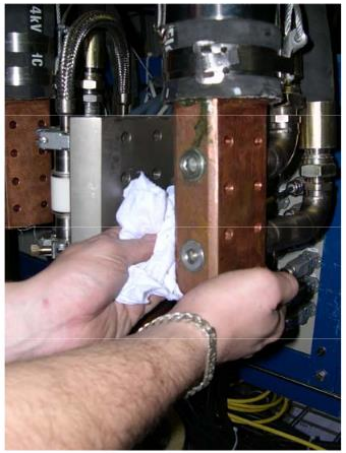
- Example: Connection of water cooled cables in the LHC

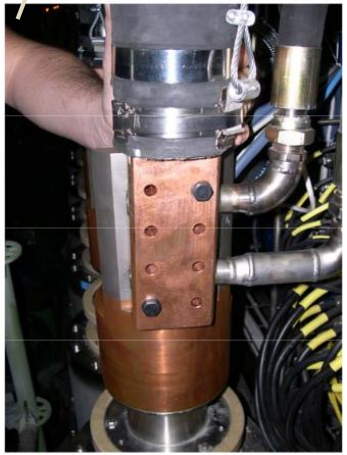
Surface Cleaning

Heavy cables positioning

Bolt torque tightening







Courtesy of P. Denis (13 kA DC cables installation procedure EDMS 822785)

Warm to Cold Transition in LHC

- Duration of on site interventions:

Circuit type	Disconnection	Connection
13 kA	8 min / cable	15 min / cable
6 - 8 kA	5 min / cable	10 min / cable
600 A	5 min / cable	5 min / cable
120 A	5 min / cable	5 min / cable

Courtesy of G. D'Angelo: estimation of time for LHC cables

- Extrapolation of total time required for disconnection and re-connection of HL-LHC cables:
  - 500 min (more than 8 hrs) of continuous work per IP side
  - Inner triplet circuits is 30% of that time (estimation: to be done at least once per year)
  - Duration does not include personnel mobility time & preparation time

HL-LHC Accessibility / Intervention Requirements for Powering Systems

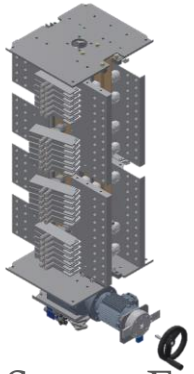
HL-LHC Accessibility/Intervention Requirements

- Provide solution to simplify the disconnection of warm & cold powering
  - Improve safety of people during intervention
  - Ensure galvanic insulation for ElQA intervention
    - 3 kV withstand level between poles and to ground with <1 µA leakage current
  - Reduce risks of damaging current leads
    - Due to mechanical strain (incorrect manipulation)
    - Due to hydraulic shocks (water hammer effect) when water is turned on/off
  - Maintain current leads contact quality without additional intervention
  - Reduce intervention time
  - Short circuit and grounding connections possibility (to maximize safety during intervention)
- Accessible technical galleries during operation
  - Electrically protected equipment (IP2X)

Circuit Disconnector Boxes as a Part of a Global Solution

Circuit Disconnector Boxes

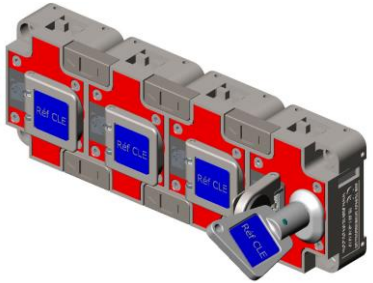
- Present WP6b disconnector concept relies on:
  - Switchable fingers type for 18 & 13 kA circuits
  - Rotative position type for ≤ 2 kA circuits
  - PLC to communicate state of the disconnectors and ensure correct manipulation
  - Panel key controller to control access and to ensure correct manipulation



18 kA System Example

2 kA System Example

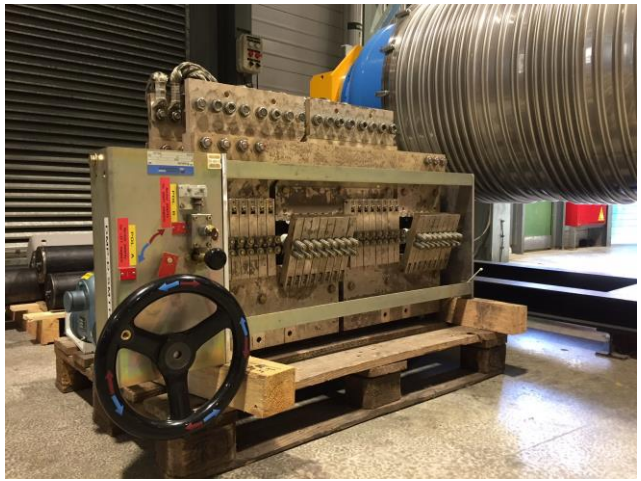
PLC System



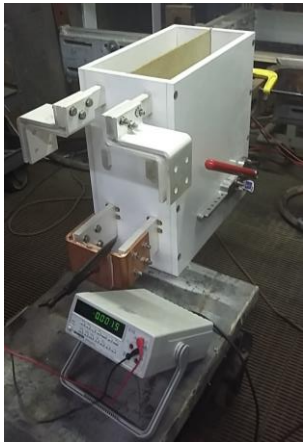
Panel Key Controller

Circuit Disconnector Boxes

- TE-EPC already have a wide experience with this type of disconnectors
  - SM18 (16 kA)
  - POPS-B (3 kA/7.2 kV)
  - Several more examples (LHCb, SPS Mains, 163 for Fresca 2, etc.)



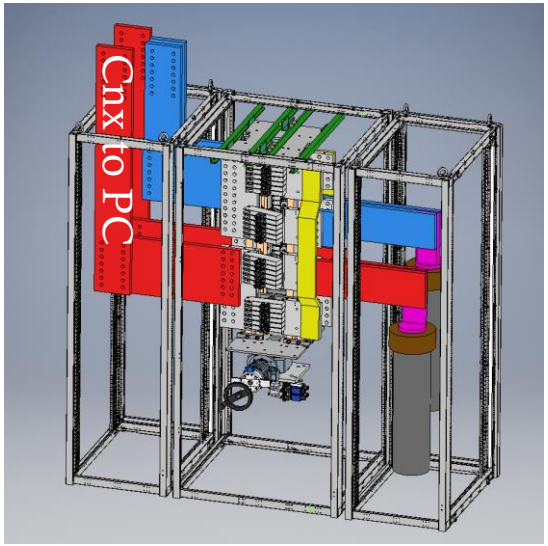
SM18



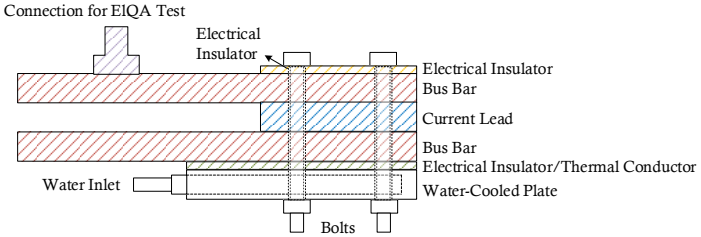
POPS-B

Circuit Disconnector Boxes

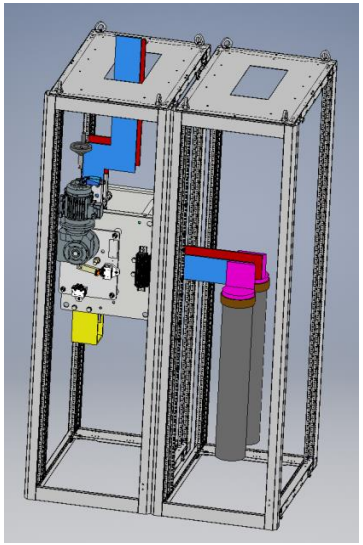
- Some conceptual sketches for HL-LHC



18 kA System



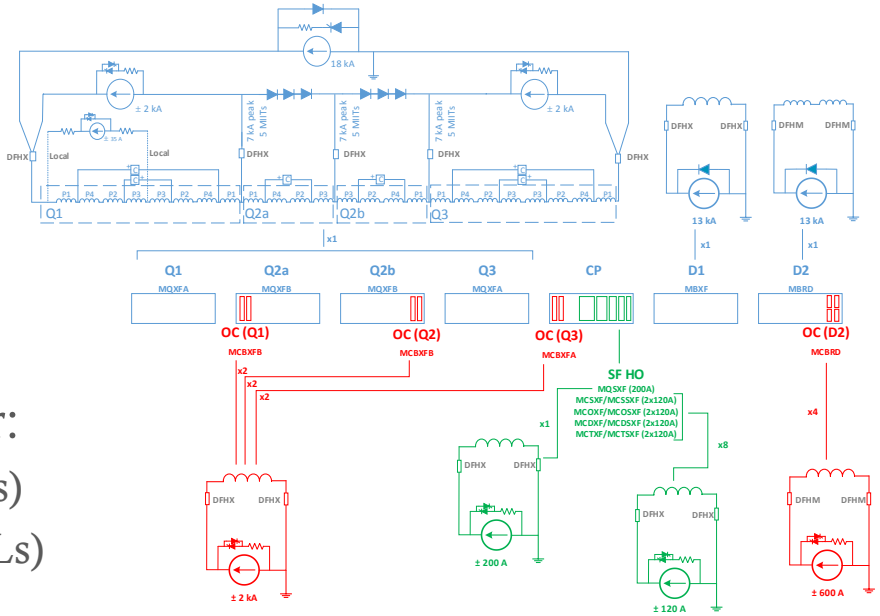
18 kA Current Leads Interfaces



2 kA System

Circuit Disconnector Boxes

- Considered for circuits in the URs
  - 1x18 kA circuit
  - 2x13 kA circuits
  - 8x2 kA circuits
  - 4x0.6 kA circuits
  - 1x0.035 kA circuit
- CDBs are not considered (so far) for:
  - 1x0.2 kA circuit (could be moved to ULs)
  - 8x0.12 kA circuit (could be moved to ULs)

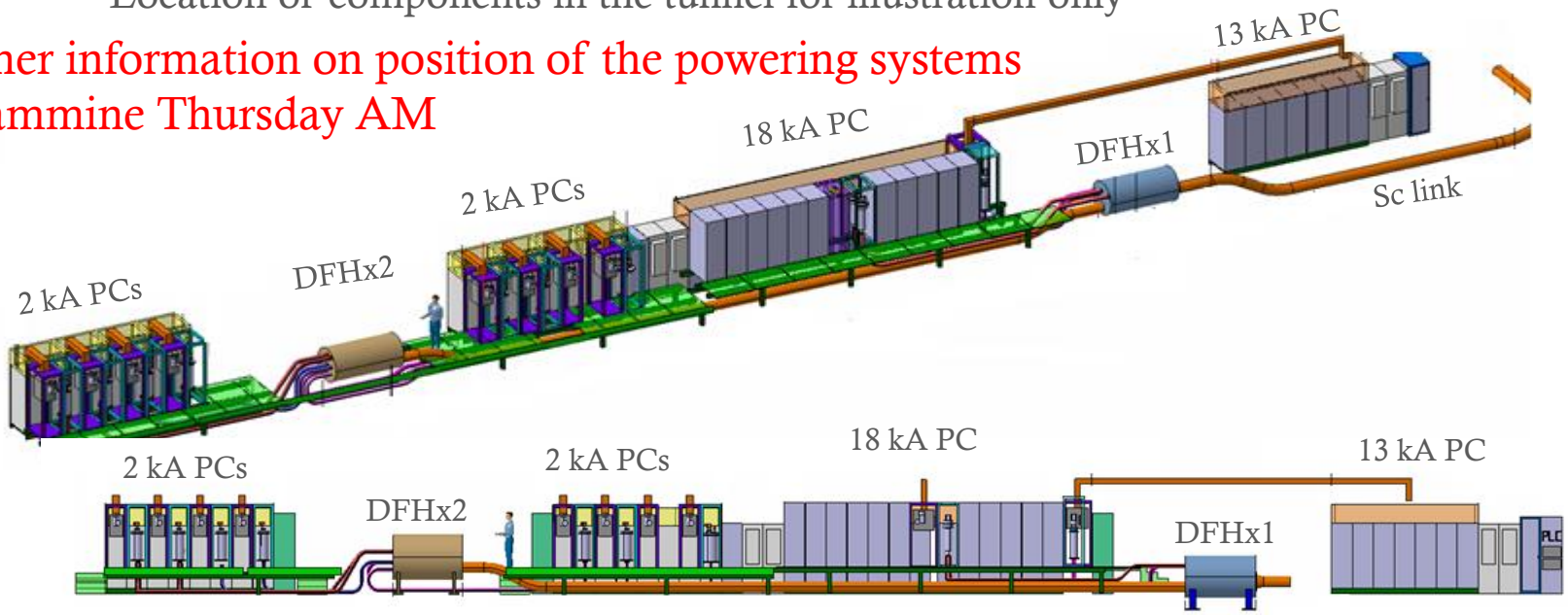


Proposal for Operation of the Circuit Disconnector Boxes

Operation of the Circuit Disconnector Boxes

- Proposed integration concept with circuit disconnector boxes
  - Location of components in the tunnel for illustration only

Further information on position of the powering systems
S. Yammine Thursday AM

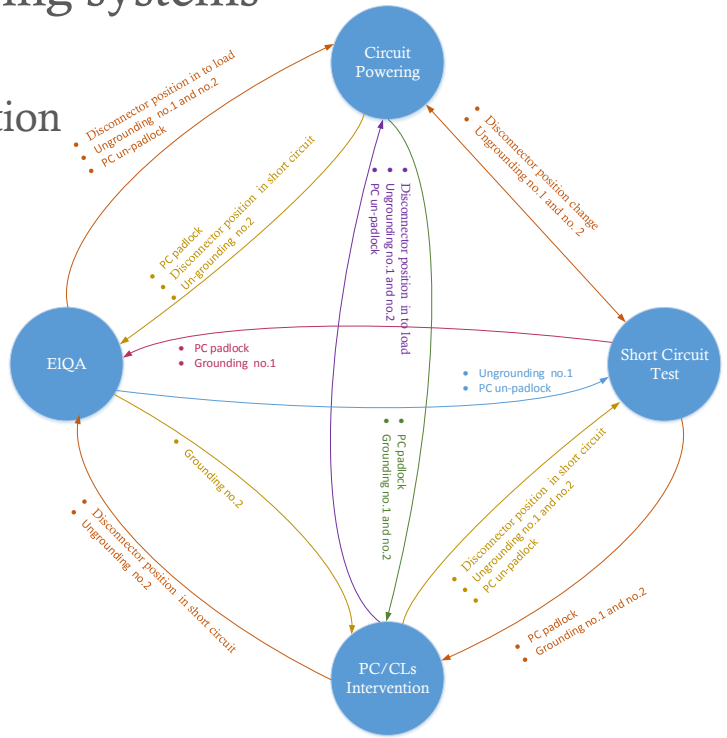


Optimization on-going (WP6a and WP6b)

Courtesy of S. Maridor

Operation of the Circuit Disconnector Boxes

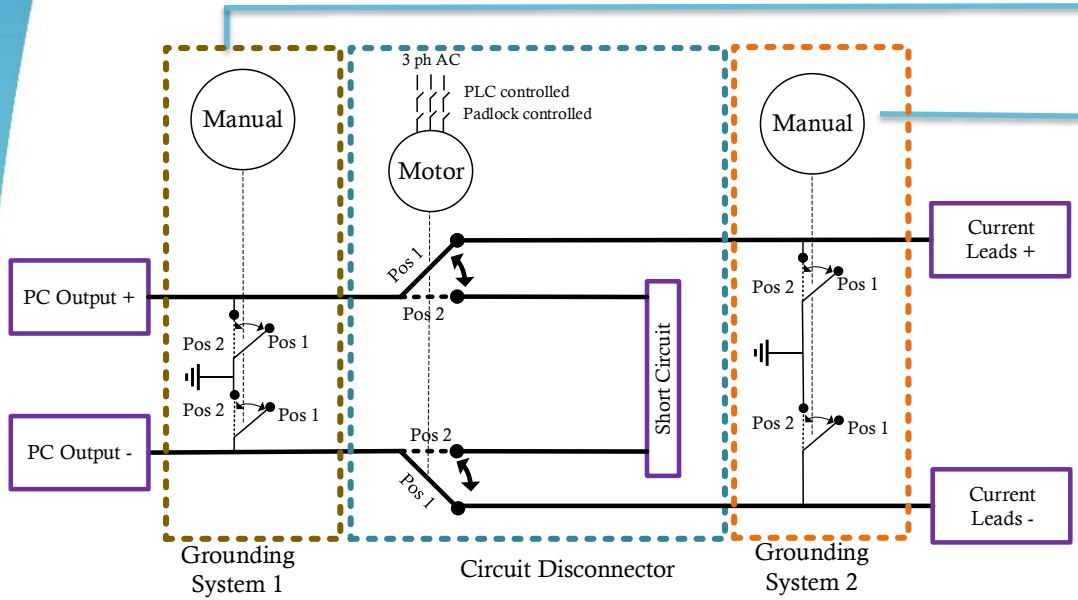
- Four configurations of the powering systems
  - System in powering configuration
  - Power converter in short circuit position
  - Power converter intervention
  - Current leads intervention
  - ElQA



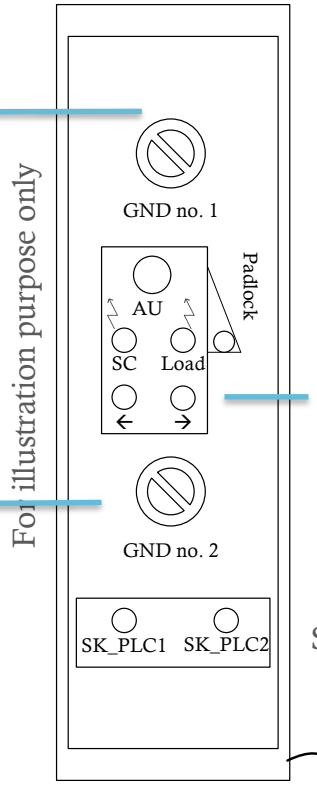
State Machine for Configurations (Under Discussion)

Operation of the Circuit Disconnector Boxes

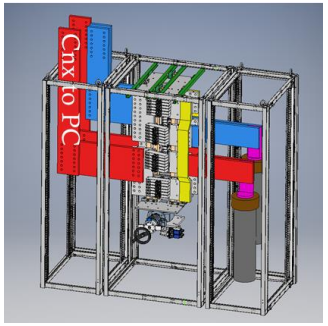
- Electric scheme of the disconnector



Proposal (to be finalized at WP6b/MCF)



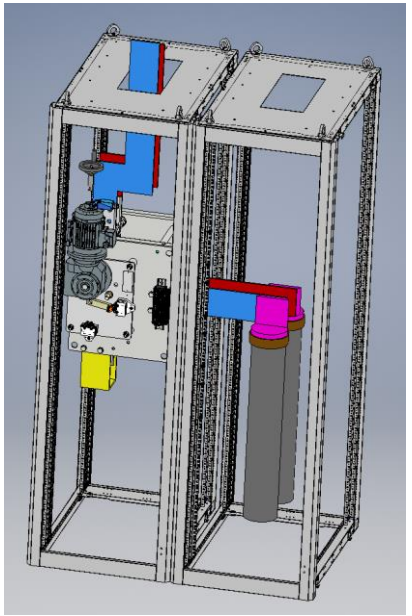
Disconnector Rack Front Panel



System at SM18

Operation of the Circuit Disconnector Boxes

- Proposal of sequence for disconnector position inversion sequence
  - Ensured by first line intervention team (TE-EPC)
  - Padlock of power converter
  - Grounding of DC circuit
  - PLC liberation of key when conditions are met
  - Disconnector position change verified by PLC
  - Key returned to panel key controller



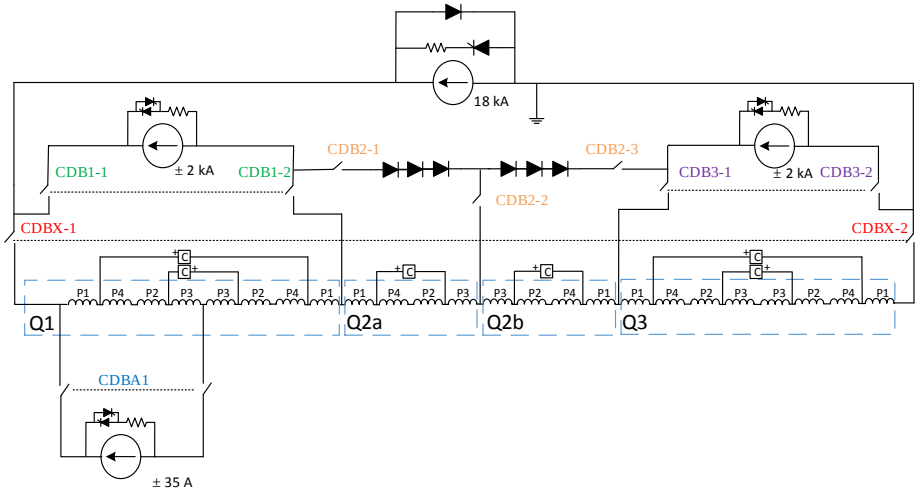
Operation of the Circuit Disconnector Boxes

- PLC verifies the correct conditions for disconnector manipulation
  - Current in the circuit is zero
  - DCCT is operational
  - Power converter is OFF
  - PC output and CLs are grounded

- PLC ensures security on two levels when conditions are not met
  - De-energizes the motor AC connection
  - Blocks the access of the key for padlock
  - Key transported from PLC rack to the CDB rack for intervention
  - Only people with the correct procedure could intervene

Operation of the Circuit Disconnector Boxes

- HL-LHC inner triplet main circuit
  - Four electrically connected powering circuits
  - Six connected CLIQ systems as voltage sources
  - Slightly modified intervention procedure will be proposed (discussions ongoing)
  - Discussions are ongoing to be able to intervene on PCs without CLIQ discharge



Conclusion

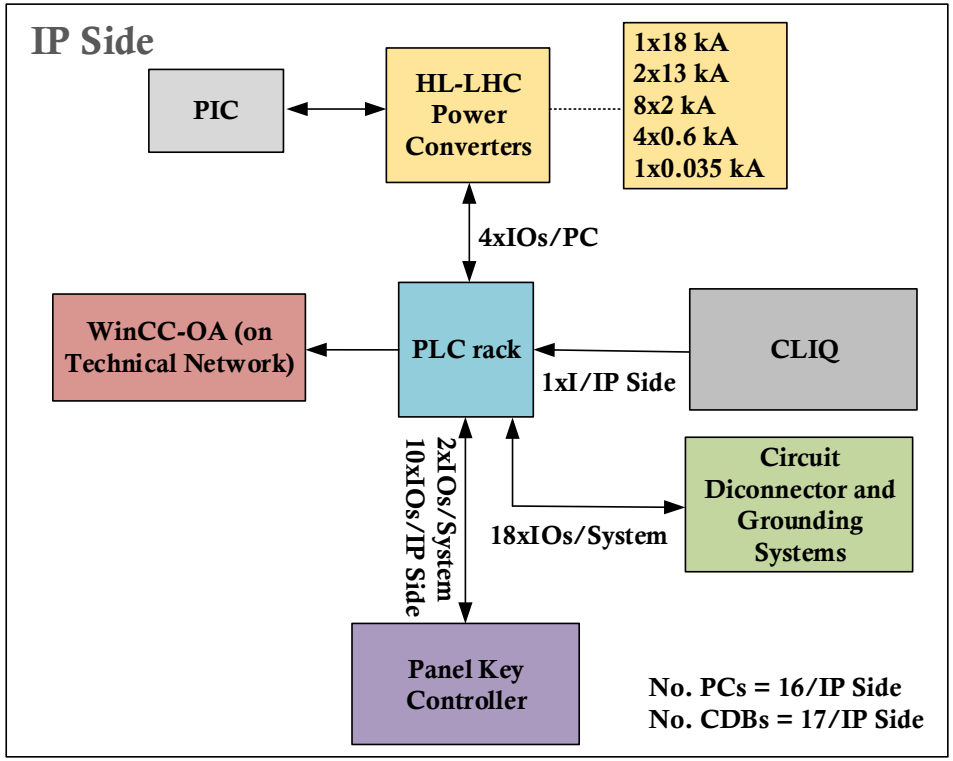
Conclusion

- Disconnectors improve conditions for intervention on the equipment
- Study of powering systems with disconnectors is being finalized
- Operation guidelines for the disconnectors are undergoing
- Same TE-EPC service as for padlocking a power converter is proposed
- PLC helps with increasing safety but does not replace human intervention

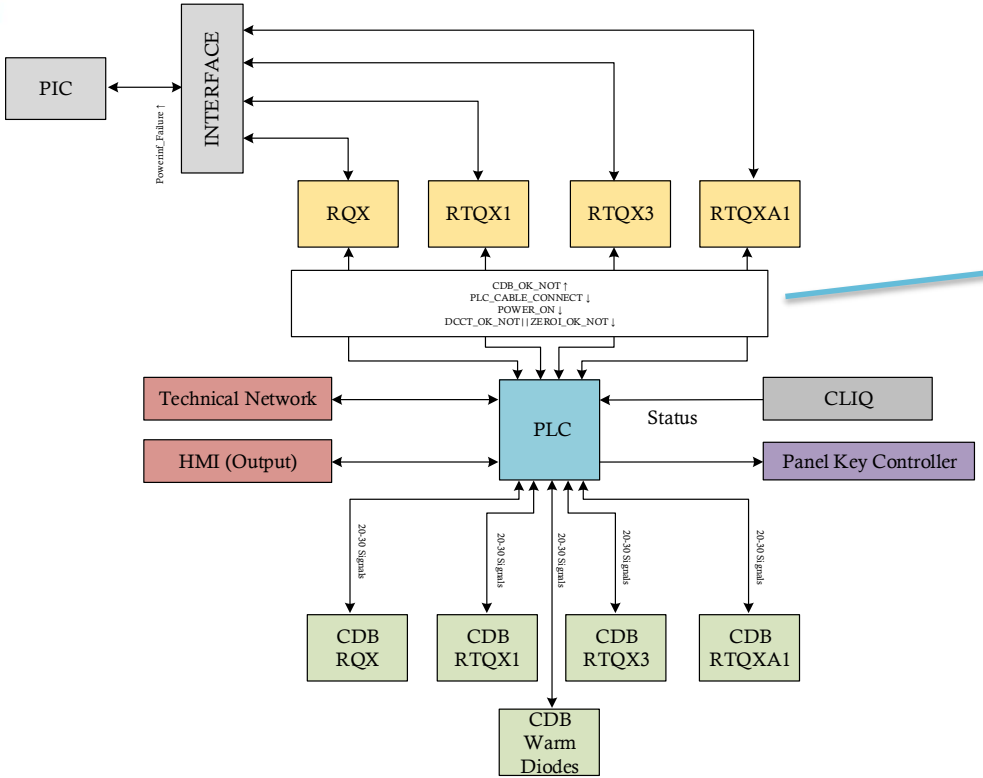
Thank you for your attention

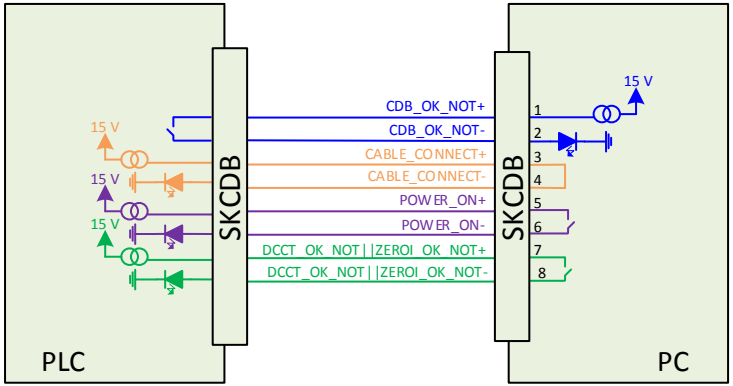
Additional Slides

Signal Interfaces



Signal Interfaces





Intervention on the IT Main Circuit