



Current Leads Heating System Design, System Testing and Commissioning

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Outline

- Scope of Current Lead Heating System
- Introduction to CLHS for HL-LHC
- Overview of CLHS system / components
 - Key components
- System testing and commissioning
 - Individual components testing mockup
 - Global system testing at warm/cold
- Conclusions

Scope of CLHS

- Each superconducting circuits of the HL-LHC Inner Triplets and Matching Sections will be equipped with HL-LHC HTS current leads (600A to 18kA circuits). In order to ensure their safe operation, a current lead heating system (CLHS) is required.
- The CLHS avoids water condensation, ice formation and guarantees that the temperature at the top of the current lead stays above the dew point during machine operation.
- Each Current Lead Heating System is composed of a Heater Control Unit, a Heater Power unit , Heater Cartridges and Temperature sensor (thermocouple).



Heater cartridge and
Temperature sensor



Heater power unit



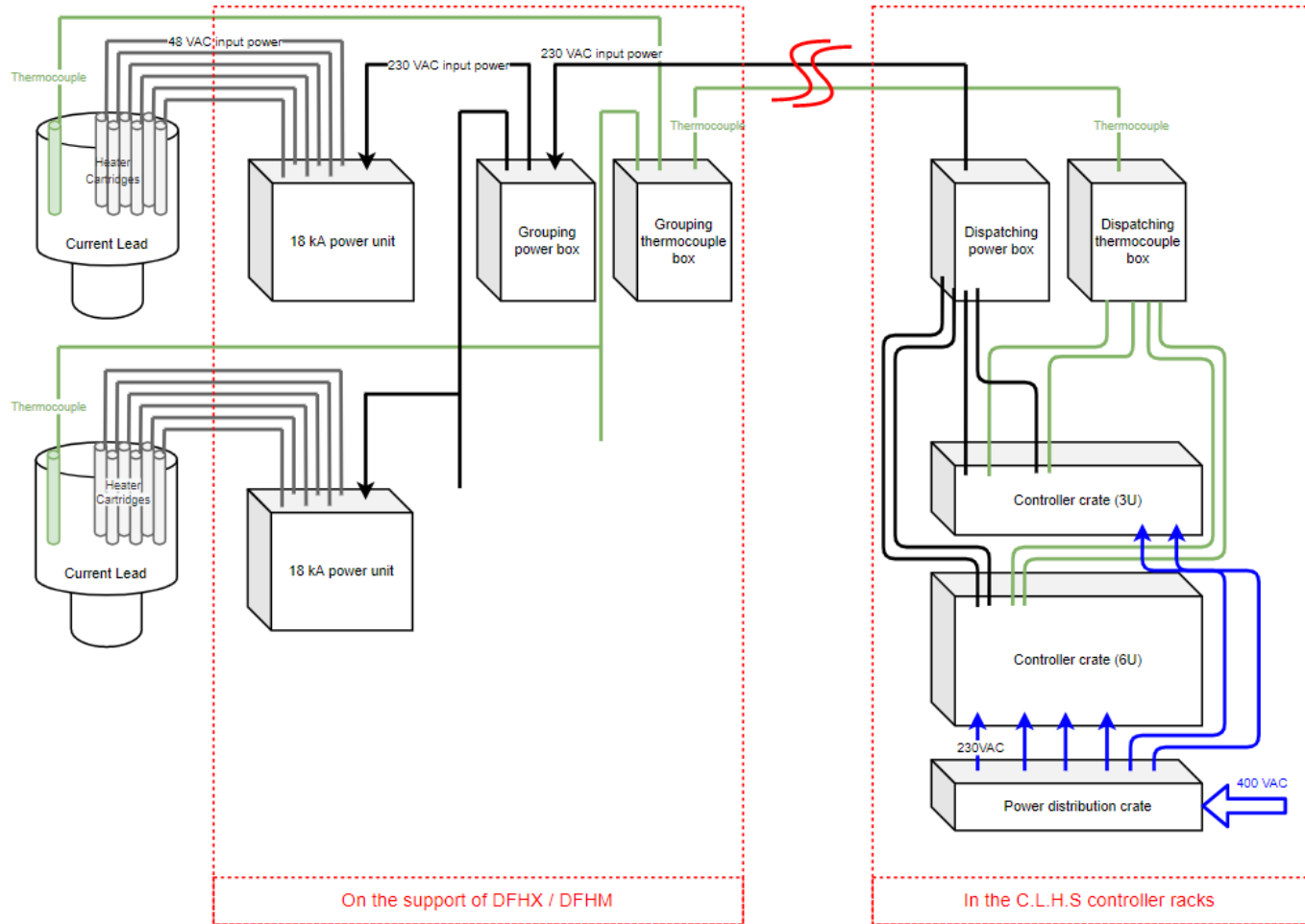
Heater control unit

Introduction of CLHS for HL-LHC IT

- CLHS for HL-LHC circuits is being developed following the functional specification, EDMS 2770173 prepared by WP6a.
- Main specs:
 - 19 leads** for Inner Triplet circuits (DFHX) and **10 leads** for Matching Section circuits (DFHM), total of **29 leads**.
 - Heater cartridges powered 48 VAC (isolation transformer)
 - Specific power needed per current lead type:

	Type of lead	Number of leads per system	Number of cartridge heater per lead	Maximum Power per lead [W]
Inner Triplet	18 kA	4	6	1800
	7 kA	3	2	250
	2 kA	12	2	250
Matching Section	18 kA	2	6	1800
	0.6 kA	8	1	125

Overview of the C.L.H.S. for HL-LHC IT



CLHS main components

- The heating system of each current lead is made of:

- **Heater Control Unit**

- Temperature regulation
- Power electronic (SSR)

- **Heater Power Unit**

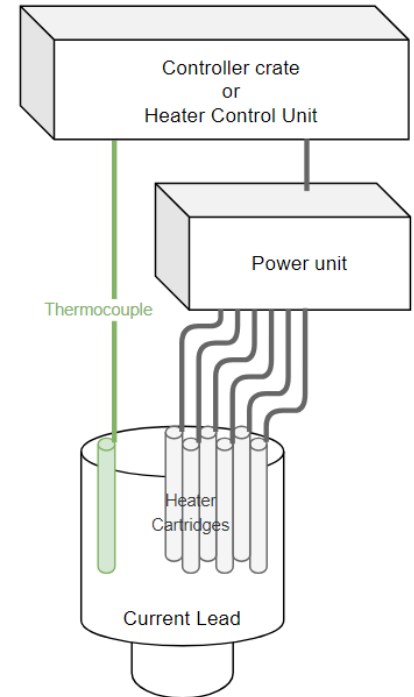
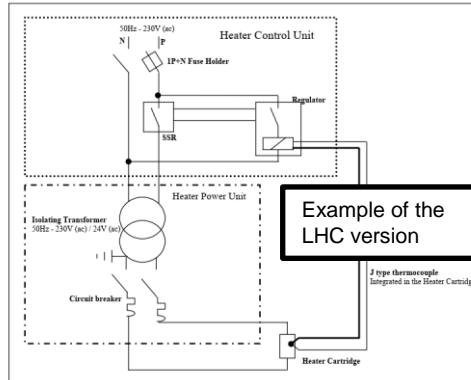
- Isolating transformer (3 kV) (230/48 VAC)
- circuit breaker

- **Cartridge Heaters:**

- From 1 to 6 cartridges per lead, 48 VAC, 125 W to 300 W

- **Temperature Sensor**

- Thermocouple J-type installed on the warm terminal of each lead



Heater control unit (1/2)

- The heater control unit will be based on the recently upgraded system for the LHC installed in RR13 and RR17, ECR 2891352.
- The unit is composed of:
 - Communication board (DQAMH)
 - Temperature regulation (DQLSU)
 - Power electronic (SSR)



↑
DQAMH
↑
DQLSU
↑
SSR

Heater control unit (2/2)

- The heater control unit will allow remote monitoring and maintenance capabilities:
 - Temperature measured by CLHS is transmitted to NXCALS and available in Timber
 - Remote restart of the local communication
 - Standalone mode in case of communication lost
 - Remote settings for temperature regulation parameters
- A standard QDS remote power cycle unit will be used to power the heater control unit:
 - Allowing to switch on/off all crates remotely



Heater power unit

- Heater power units will be located close to the DFHX / DFHM, installed on a frame, distributing the power (48VAC) to the heater cartridges installed on the current leads.
- The integration study is ongoing (WP6a)
- The unit will assure:
 - Power distribution (230 VAC to 48 VAC)
 - Galvanic insulation between current leads and electronics



System testing and commissioning

- Individual components testing:
 - Each component of the CLHS will be tested individually: from the heater cartridges, to the heater control unit, before their installation.
 - An individual system test will be performed on a mockup, simulating the global installation.
- Global CLHS testing:
 - After installation in the IT string, the entire CLHS could be tested, at warm before the cooldown starts.
 - With the cooling of the current leads, the system should be verified and its performance assessed.

Conclusions

- CLHS for HL-LHC is being developed according to functional specification.
- Integration studies by WP6a have started, with 3D models provided by WP7 (support on DFHX).
- The heater control unit is based on the recently developed version by TE/MPE-EP running in the LHC (RRs in IP1) since Feb.2023.
- Each subsystem will be tested individually in the lab and a global test will be performed on a mock-up.
- After installation on the IT String, the CLHS will be tested before the cool-down starts. During cool-down and at cold, the performance of the system will be monitored.

Thank you for your attention !

Backup slides

Overview of the control crates in the UR

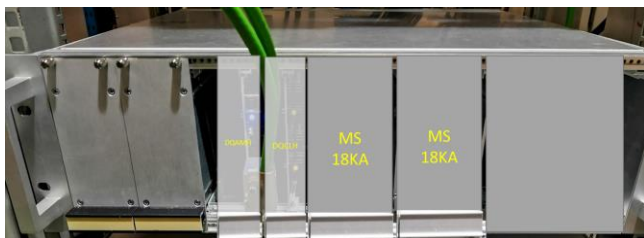
IT 18 kA:
based on the
future 3U – 6
kA in LHC



IT 2 kA /
7 kA and
MS 600
A: based on
the
future 6U
– 600A in
LHC

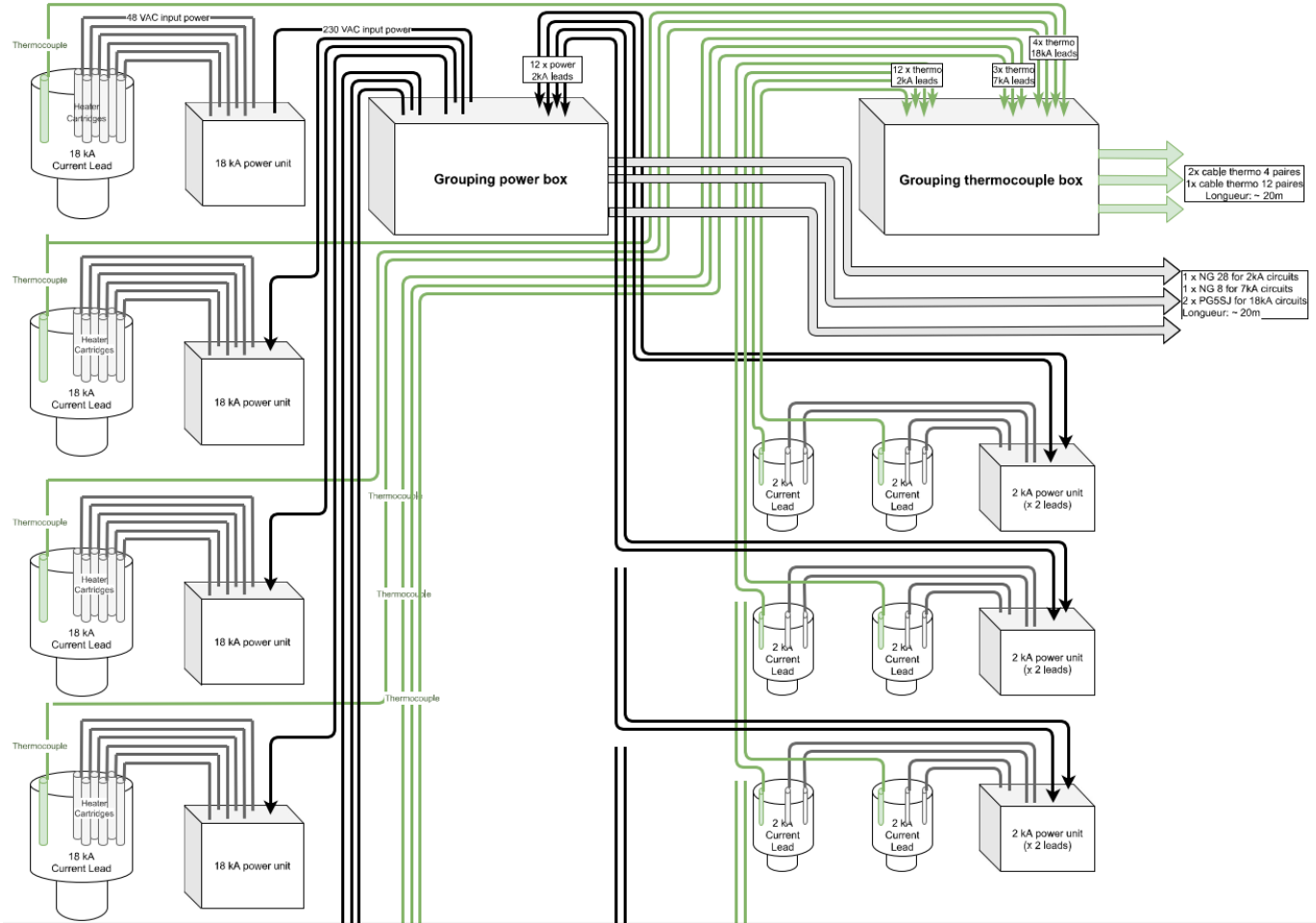


MS 18KA:
based on the
future 3U -
13KA in LHC



- For Inner Triplet leads:
 - 3U crate:
 - 4 x “cassettes” for 18 kA leads (1 “cassette” = 1 lead of 1800 W)
 - 6U crate :
 - 1 x “cassettes” for 7 kA leads (1 “cassette” = 4 leads of 250 W)
 - 3 x “cassettes” for 2 kA leads (1 “cassette” = 4 leads of 250 W)
 - ...
- For Matching Section leads:
 - 6U crate : same crate as for IT leads
 - 2 x “cassettes” for 600 A leads (1 “cassette” = 4 leads of 125 W)
 - 3U crate:
 - 4 x “cassettes” for 18 kA leads (1 “cassette” = 1 lead of 1800 W)

Overview of the C.L.H.S. for IT circuits



Overview of the C.L.H.S. for MS circuits

