



Energy Extraction Systems: Status of IT-String fabrication and control electronics development

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On behalf of Energy Extraction Systems team of CERN/TE-MPE-MP



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OUTLINE

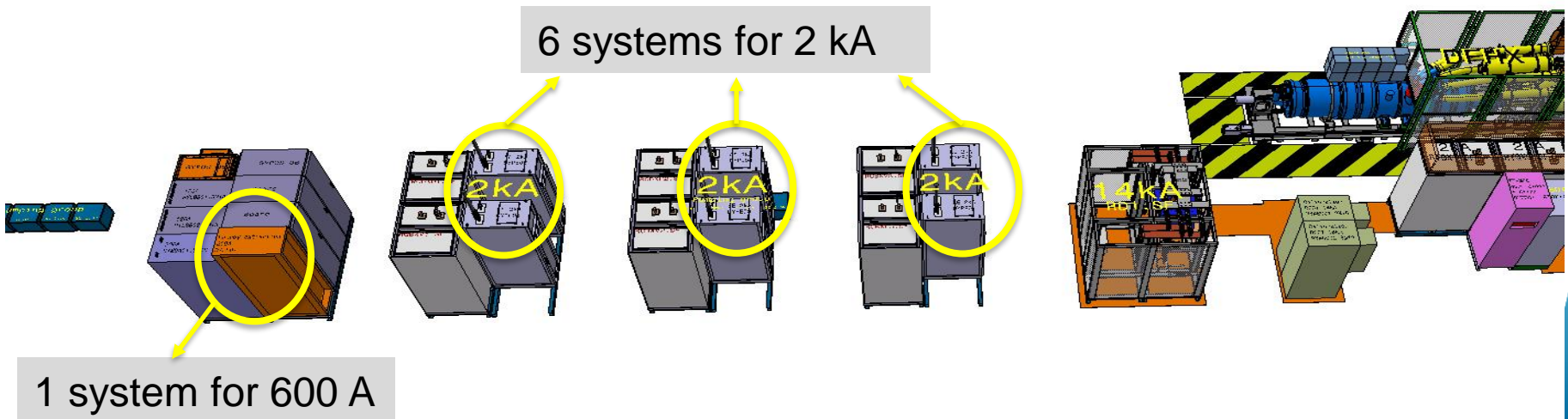
- IT-String circuits with EE systems
- Brief overview of HL-LHC EE systems
- Status of IT-String fabrication
- Control electronics development
- Summary

IT-String circuits equipped with EE systems

- IT-String circuits with EE systems

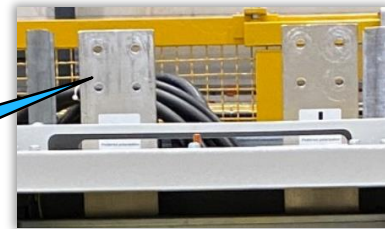
	Circuits for HiLumi	Magnet Type	I Ultimate [kA]	Number of circuits per IP side	EE Dump Resistor [Ω]
IT	Q3 – horizontal/inner	MCBXFA	1.7	1	0.15
	Q3 – vertical/outer	MCBXFA	1.5	1	0.15
	Q1/2 – horizontal/inner	MCBXFB	1.69	2	0.15
	Q1/2 – vertical/outer	MCBXFB	1.53	2	0.15
	Superferric, order 2	MQSXF	0.197	1	1.4

- In total: 7 EE systems



Vacuum switches based EE systems - Overview

- Two vacuum switches for 2 kA / 600 A connected in series
- Max. rated voltage: 1 kV
- Resistors
 - 0.15 Ω for 2 kA systems
 - 1.4 Ω for 600 A systems
- Switch opening time: < 2 ms
- Service life: > 20 000 cycles
- Full redundancy ensured at power and control parts



Power IO terminals

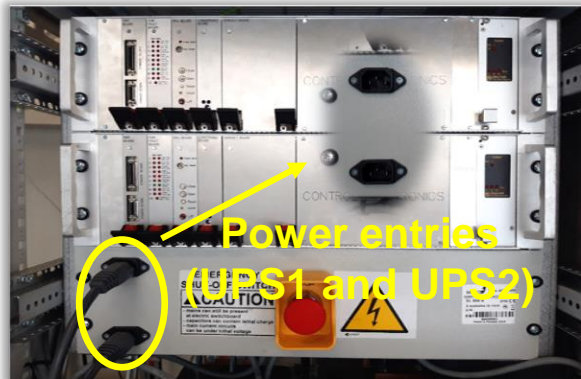


CERN control electronics

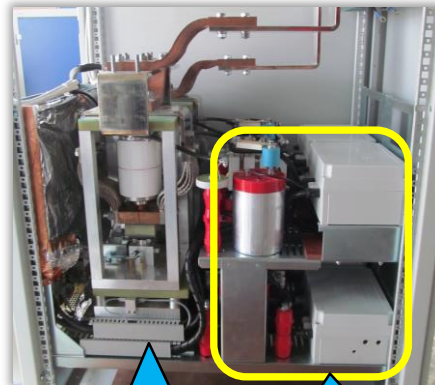
Dump resistors

Switch cassette
~75kg each

Standard EURO
rack (60x90x200)



Redundant UPS powering



Vacuum
interrupter

Auxiliary
circuits

IT-String EE systems fabrication

- The purchase order was sent to the manufacturer in Oct 2021 after carrying out a market survey and going through the tender process
- The complete design file was accordingly provided to CERN and subsequently approved – Jan 2022
 - Several improvement/upgrades required by CERN were introduced
- Production process started in Feb 2022
- The first 2 pre-series (one for 2 kA and another for 600 A) were recently delivered at CERN (Sep 2022)
 - Factory acceptance tests were executed. Results were presented and accepted by CERN
 - A delay 1.5 months was accumulated due to the shortage of raw materials and semiconductor components

IT-String EE systems pre-series validation at CERN

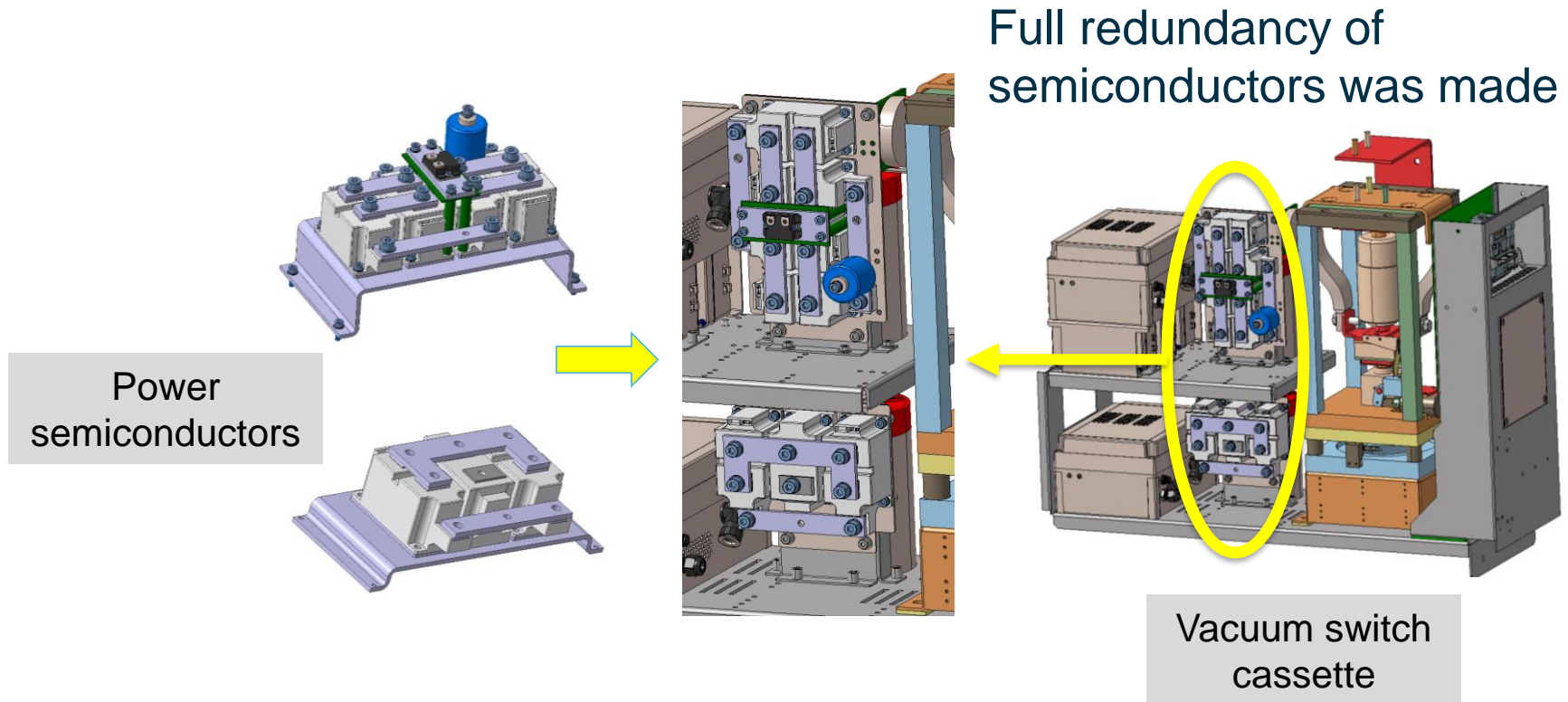
- Qualification tests of delivered EE systems pre-series:
 - Tests setup → prepared
 - Test procedure was written
 - Test execution takes 1-2 weeks
- Results expected within 2-3 weeks
- If successful, a green light for production of the remaining EE systems will be given to the manufacturer
- Completion of production and entire delivery of all IT-String systems is expected in Jan 2023
 - The manufacturer ensured all materials and components → no production delay is expected
- Tender documentation for series production to be finalized by the end of Oct 2022



Test station in b.272 (CERN)

Power electronics

- Re-design of power electronics was done at CERN
- Modifications announced last year were successfully integrated by manufacturer



IT-String systems implement the last power electronic design

Control electronics of vacuum switch EE systems

- The IT-String EE systems are foreseen to operate using the currently existing electronic units
- All control chasses were produced and delivered earlier this year and they are ready for installation



Existing control unit (front and back sides)

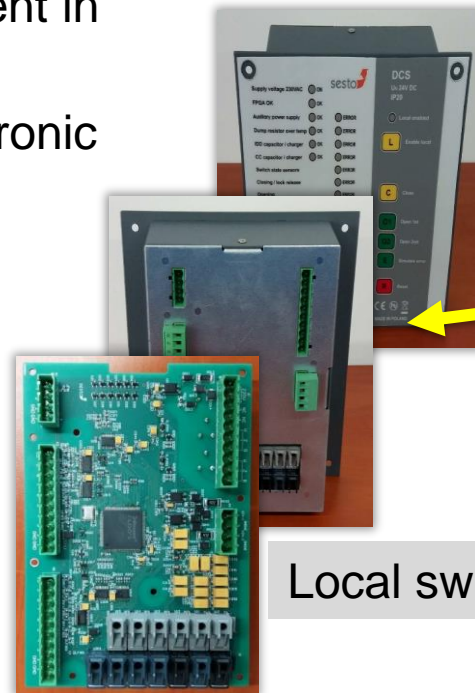
- An effort is being done presently to develop a versatile electronics, which should be common for all EE systems, In the same way, also vacuum-switches-based EES could profit of it.
- For series production (underground installation) a new control chassis will be installed

Control electronics development

- Motivation:
 - Optimization of the existing unit and centralizing all control functions
 - Design of a modern and easy maintainable electronics applicable for all EE systems at CERN.
- Some benefits for HL-LHC systems
 - Modular approach → easy replacement in case of failure
 - Maintainability - when obsolete electronic boards can be easily replaced
 - No signal cables, less connectors
 - Better EMI resistivity
 - Easier debugging



High level control unit



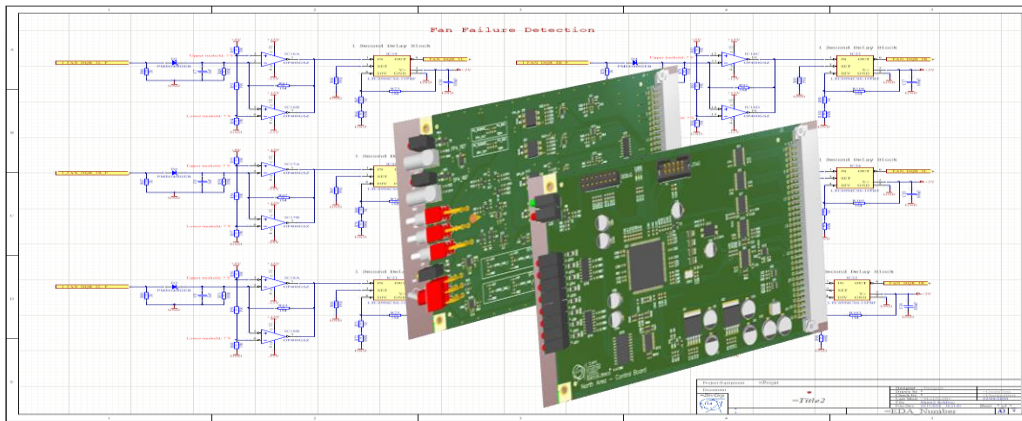
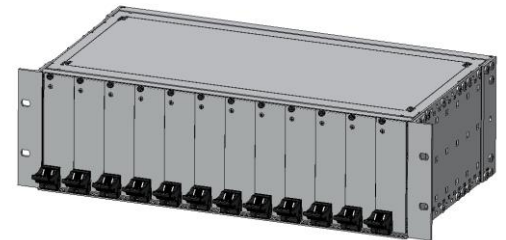
Local switch control unit



Control electronics development status

- Design concept is completed
- Electronic architecture is finished
- PCB design is ongoing
 - Two boards are on the layout stage
 - Components procurement in ongoing
- Functional specifications ongoing in parallel

3U chassis



PCB design and layout

- Eight electronic boards
 - DQAMS com. board
 - Two redundant FPGA-based control boards
 - FPA board
 - Interlock board
 - Analogue conditioner
 - Two driver boards
 - LV power supply

Summary

- The last version of the new power design is fully integrated in the IT-String EE systems
- The new control electronics design is ongoing. Prototype is expected for tests by (Mar-Apr) 2022
- IT-String facility is not affected by electronic design. Its systems will run with the existing control unit. They will be retrofitted later with the new chassis and remain spare for HL-LHC tunnel
- Entire delivery of IT-String systems is expected in Jan 2023. They validation will be in Feb-Mar.
- Tender documentation for the series production: preparation started. It is expected to be ready by the end of Oct.



Thank You!

