

Power Converters Work Package

Konstantinos Papastergiou

TE-EPC

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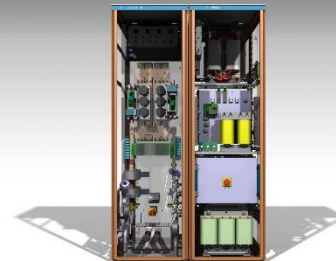
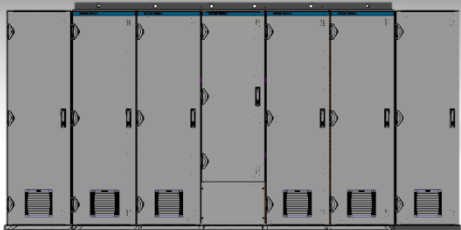
Overview

- Brief work-package description
- Production and qualification tests progress
- Latest milestones:
 - Control algorithms for energy management and for magnet field corrections
 - Testing of full-scale circuits with double powering
 - Magnetic measurements with MCB Magnet

- Conclusions

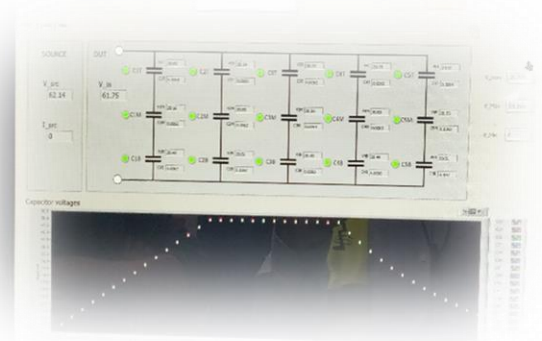
Summary of deliverables

- Power Converters (total $30\text{MW}_{\text{PEAK}}/3\text{MW}_{\text{RMS}}$):
 - 19 x Converter type Sirius
 - 26 x Converter type Sirius 2P
 - ⇒ Including 1 spare (stand-by) unit
 - 9 x Converter type Sirius 4P
 - 10 x Converter type Sirius 4P Plus
 - ⇒ Including 2 spare power converters that can replace any smaller unit
- EIS system
- Installation and Commissioning



Production of equipment

- **Power converters manufacturing completed**
- **Energy storage extension prototype being validated**
- **First energy storage units have been factory tested without issues.**
 - 322 units tested (= 9.7MJoule)
 - Initial capacitance values with less than $\pm 3\%$ for 95% of units.



Project Milestones

- ✓ **A new magnetic reset pre-function for transfer lines**

A [magnetic cycling algorithm](#) was proposed for reducing the Joule losses in Transfer Line magnets. The implementation of this algorithm in FGC3 libraries has been validated

- ✓ **Double powering scheme**

[Double powering](#) means using two power converters to power two coils of a single magnet. The objective of this test is to prove that it is possible to regulate two magnetically coupled circuits using standard FGC3 controllers. A full scale verification was performed in Norma TEF lab (b180)

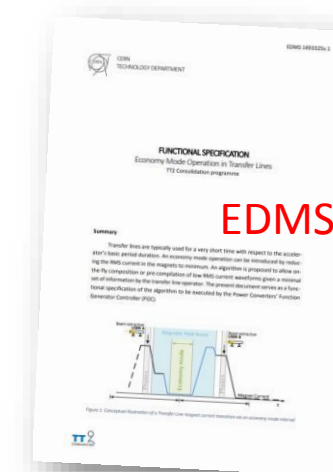
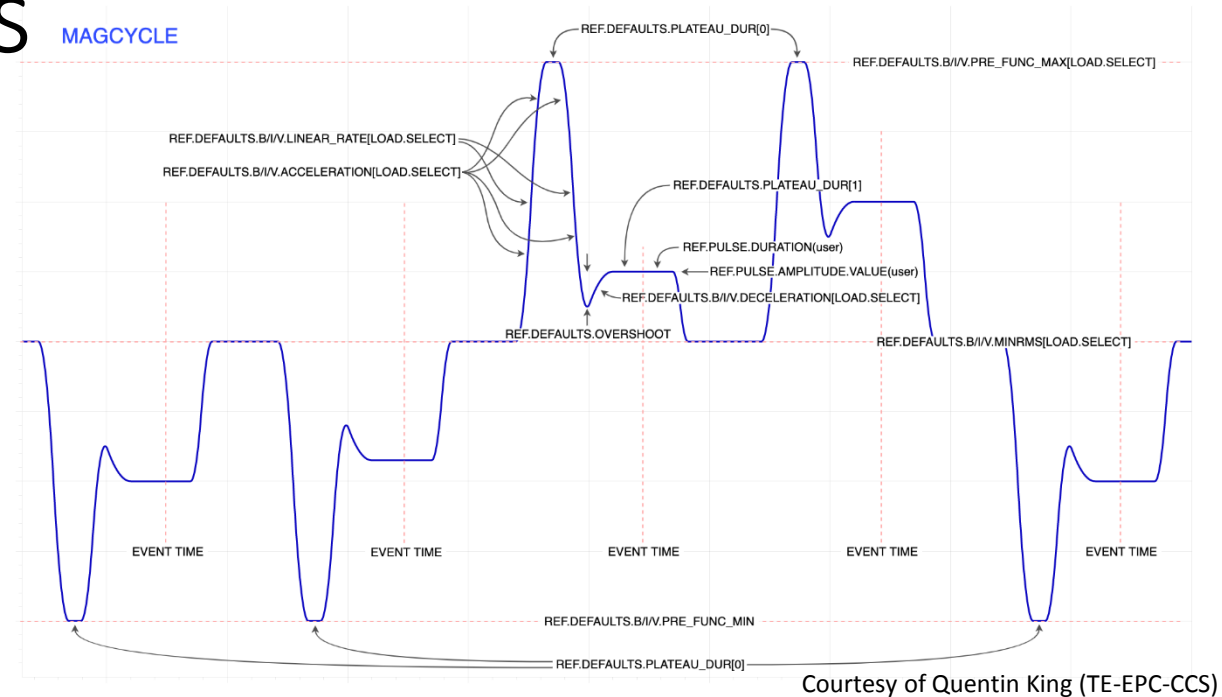
New control algorithms

■ Objectives:

- minimise RMS losses in circuit
- Allow current manipulation for faster magnetic field settling

■ Method:

- pre-function that allows a “magnetic reset” by means of magnet saturation
- Well-determined overshoot (or undershoot) to reduce eddy-current effects in magnet yoke
- “Machine learning” techniques for estimating the ramping time irrespectively of load conditions (temperature, saturation etc).



EDMS 1493325

Power Converters & Magnet joint tests

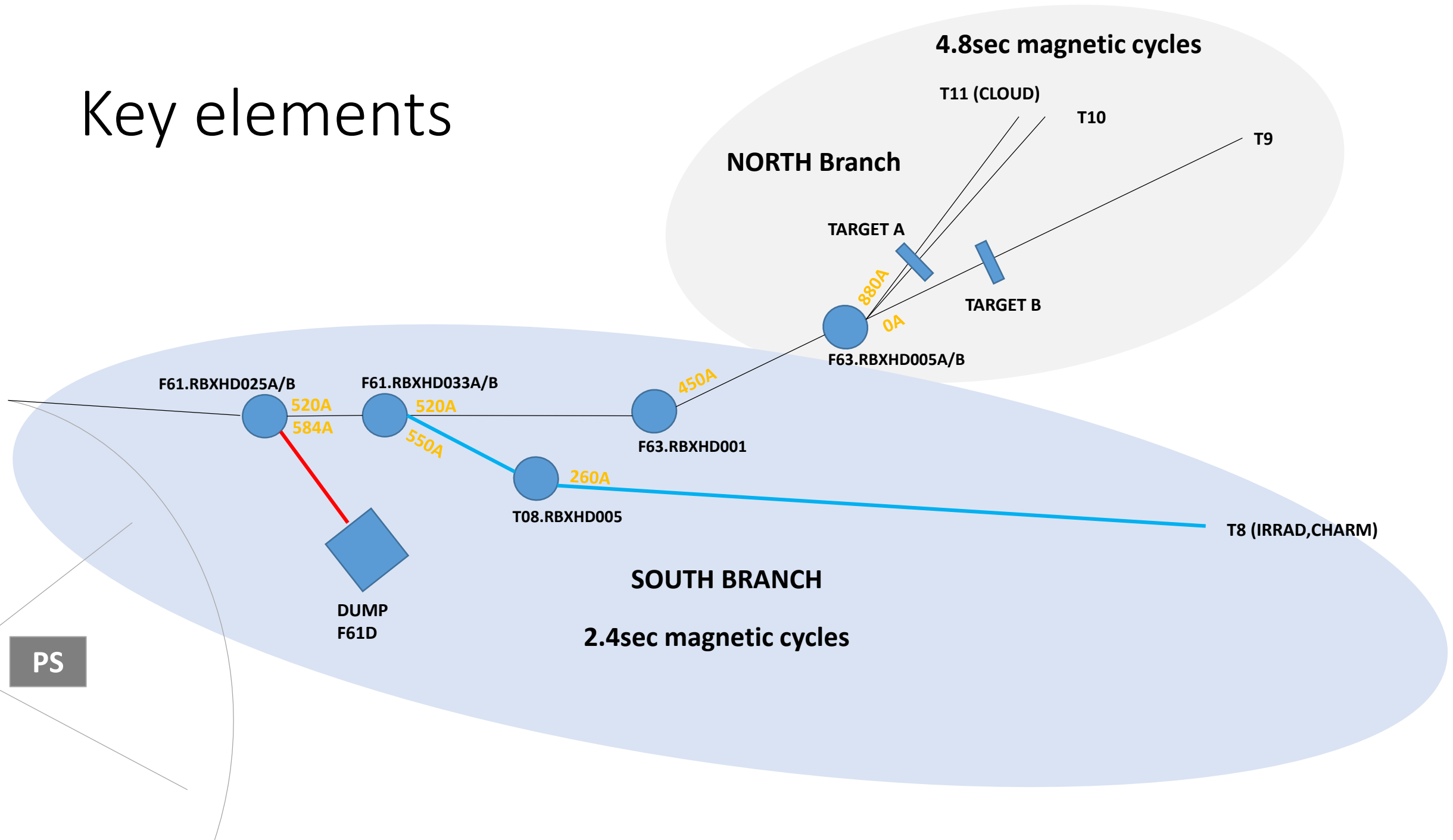


- Magnet MCB: 0.65H, 0.160mOhm
- F61.RBXHD025.A
- F61.RBXHD025.B
- Typical East Area Cycle (all users) 514A
- Peak-to-peak ripple: 40mA
- Regulation precision: 20ppm

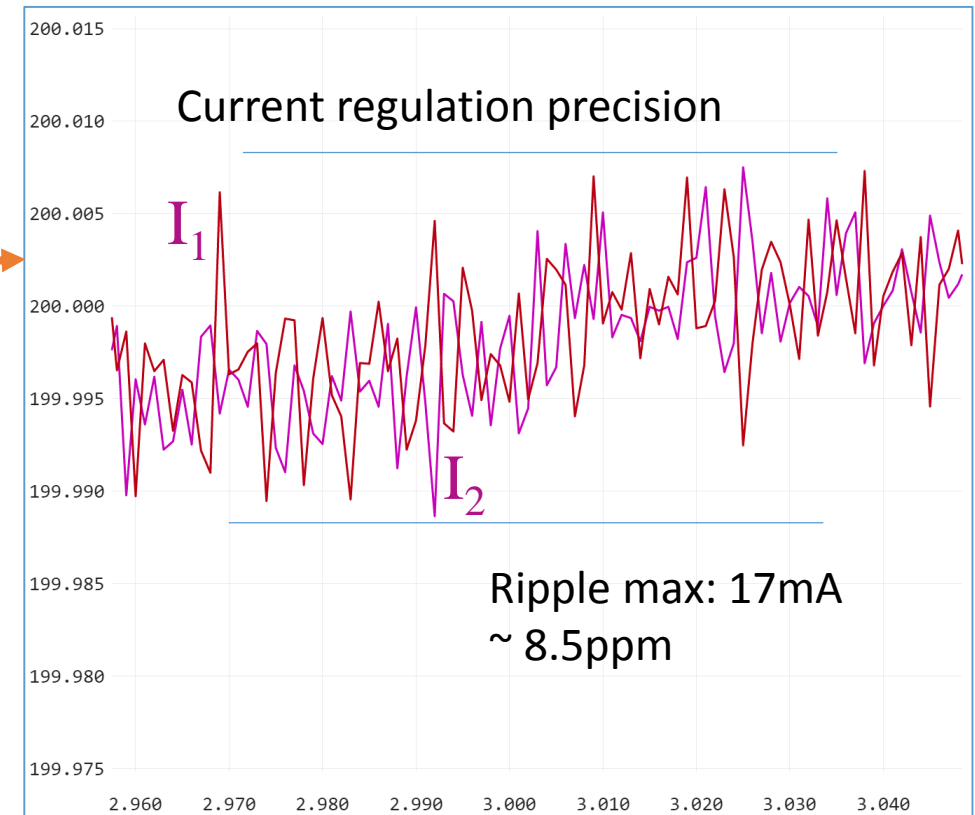
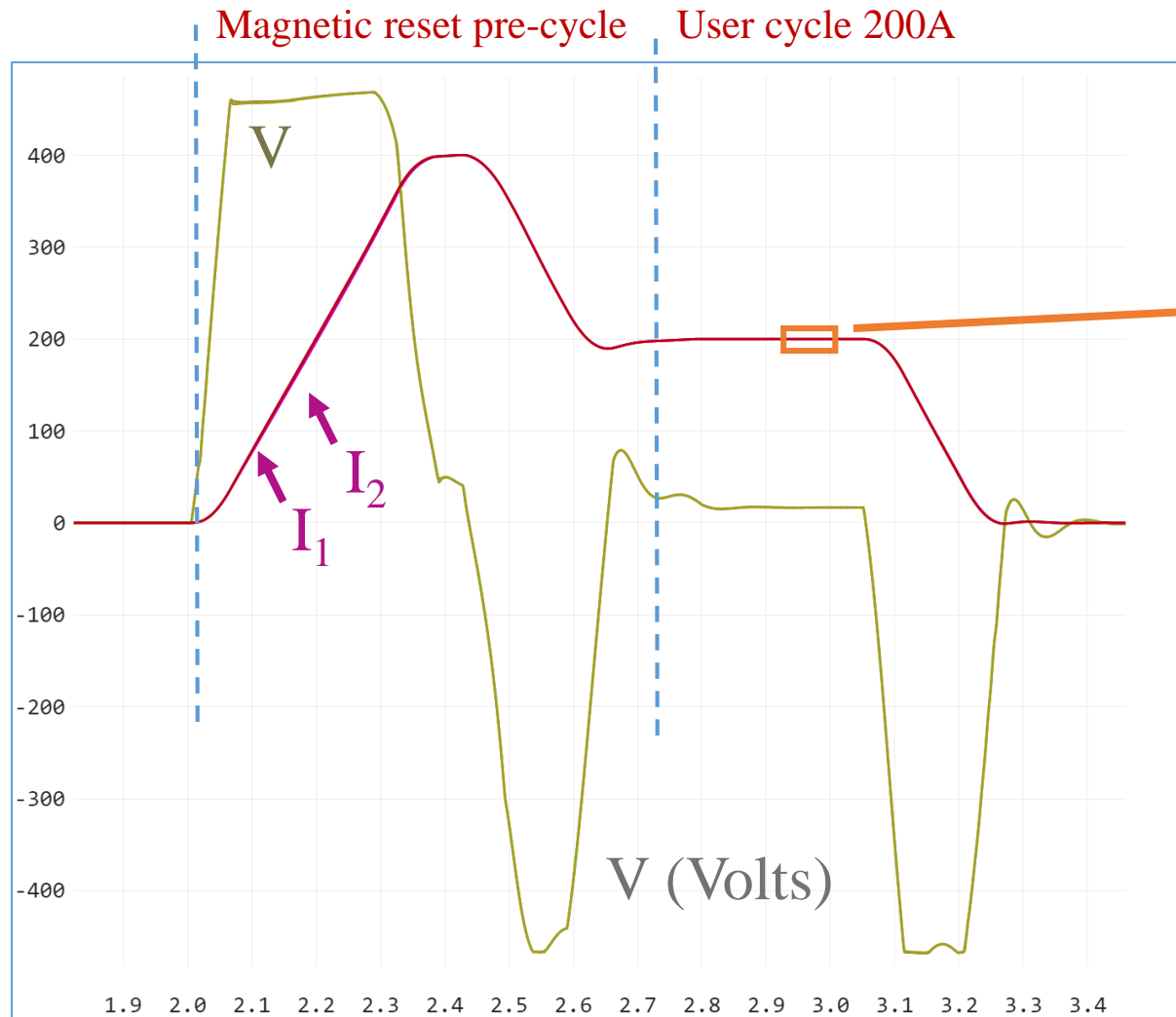
TESTS AND
ANALYSIS BY

Jaime Renedo Anglada, Roberto Lopez (TE-MS-C-MNC)
Carlo Petrone, Stefano Sorti (TE-MS-C-MM)
Quentin King and Konstantinos Papastergiou (TE-EPC-CCS)

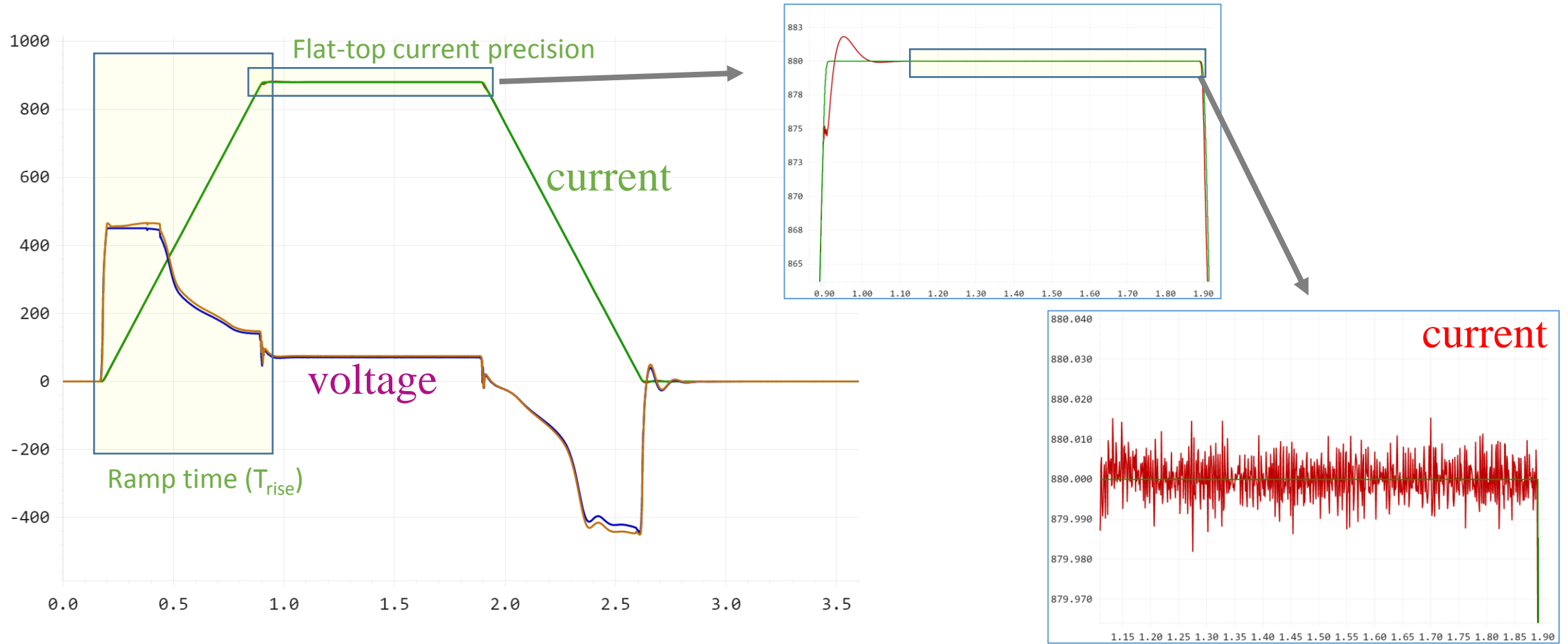
Key elements



New degauss function for transfer lines

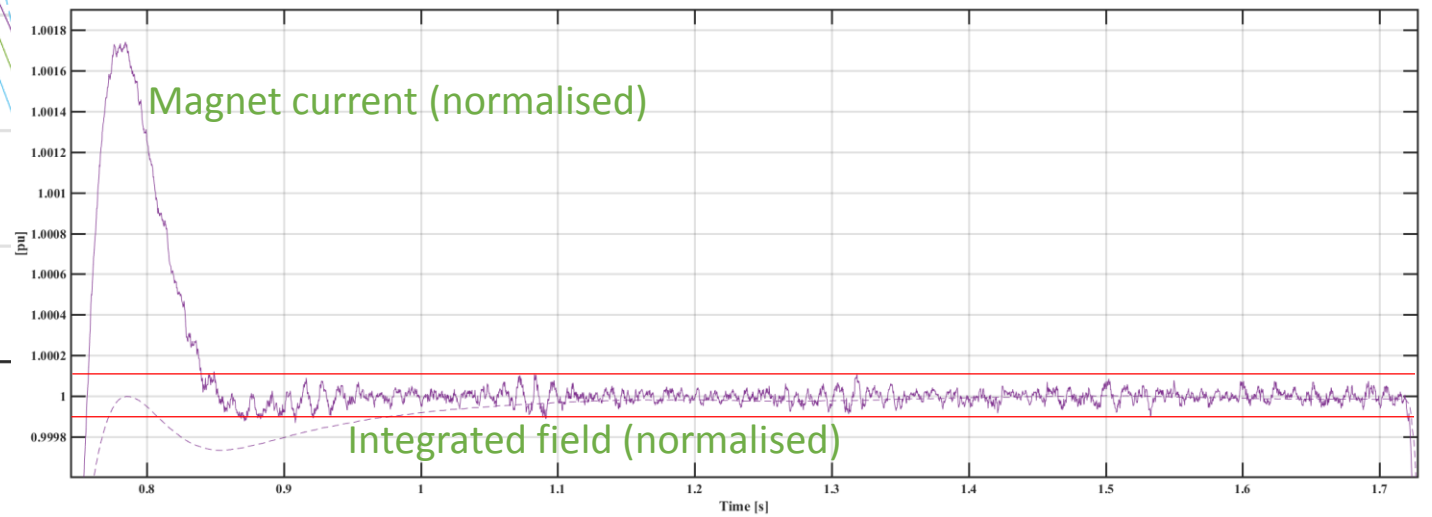
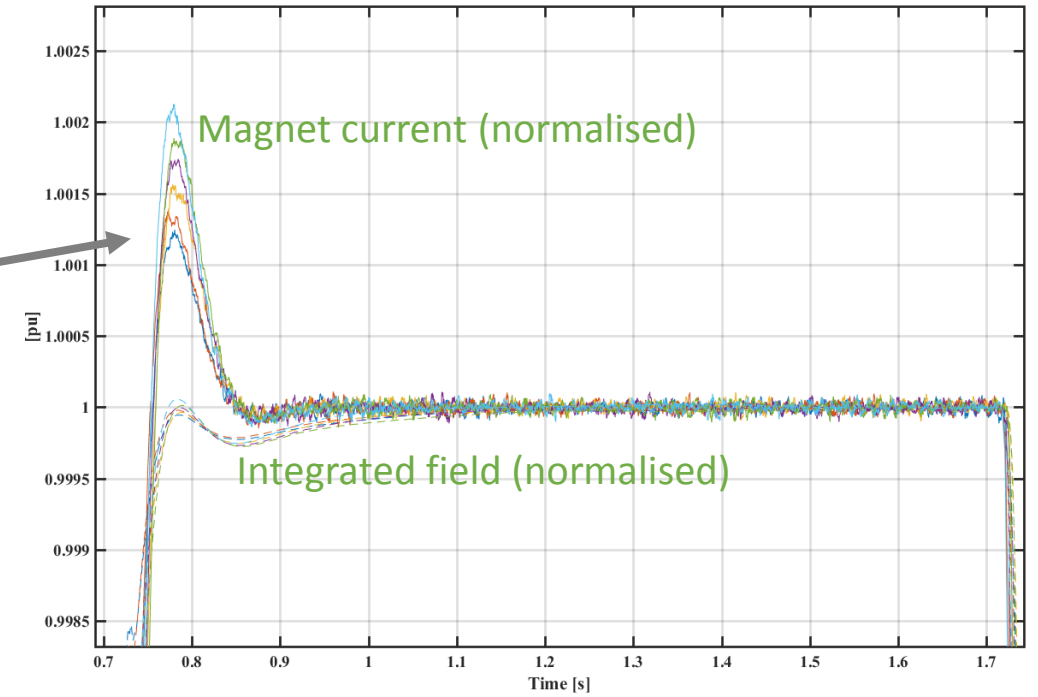
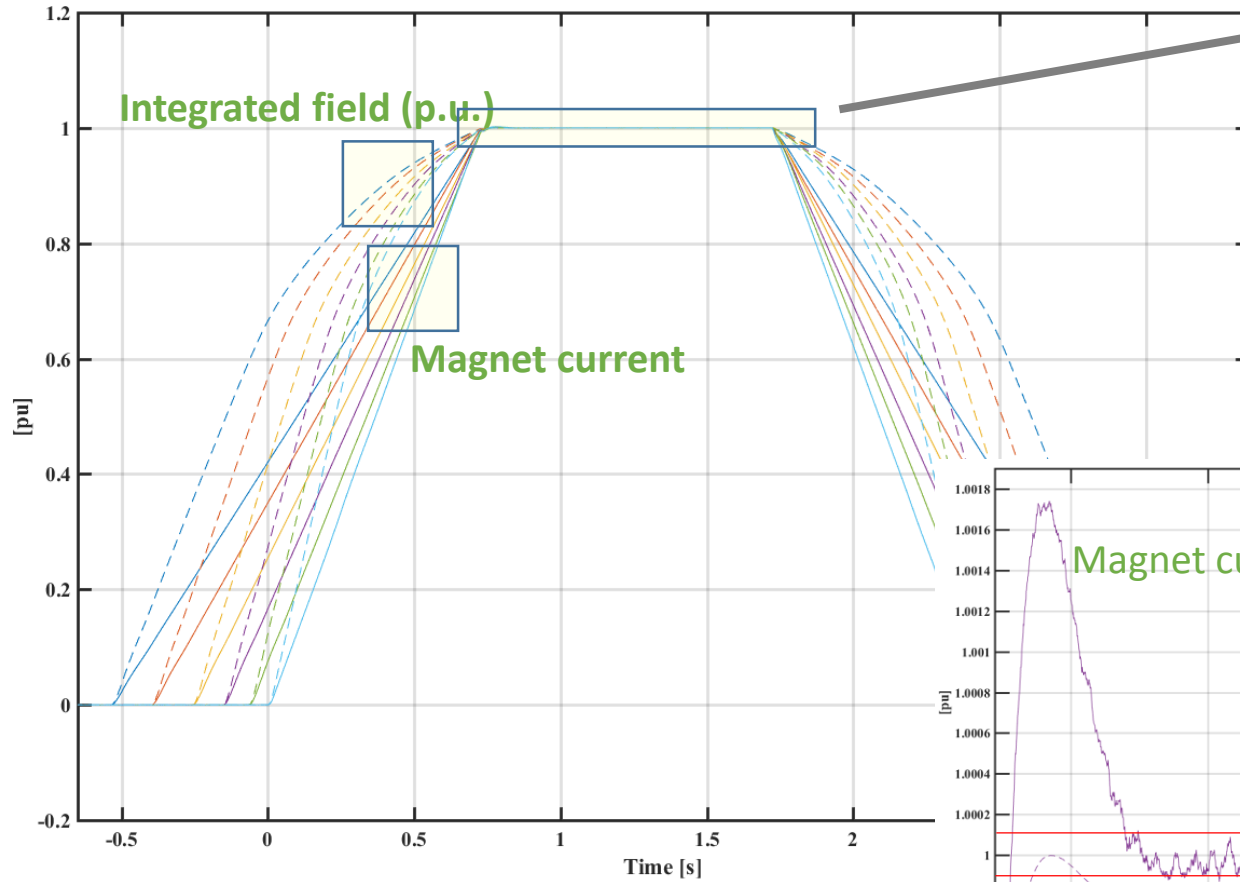


Demonstration of “double powering” (full current)



line	corrected circuit n	Full Converter name	Magnet	Lmag	Rmag	Cable leng	Lcbl	Rcbl	Ltot	Rtot	Trise	Tft	Tfal	Tot	Tee	Tbp	Imax	Irms	Vm	Po,rm	Pcbl
F63	F63.RBXH005.A	RPBFB.251.F63.RBXH005.A	MCBsplit	0.3195	0.08	480	0.000048	0.019968	0.319548	0.099968	0.70 s	0.45 s	0.57 s	1.72 s	4.33 s	4.80 s	880	375A	450	14kW	3kW
F63	F63.RBXH005.B	RPBFB.251.F63.RBXH005.B	MCBsplit	0.3195	0.08	480	0.000048	0.019968	0.319548	0.099968	0.70 s	0.45 s	0.57 s	1.72 s	4.33 s	4.80 s	880	375A	450	14kW	3kW

Magnet studies



Cycle 880A peak

Closing remarks

- Supply contracts IT-1486 and IT-1518 nearly finished
 - Energy storage units to be received in May 2020 according to plan
 - Extra energy storage cabinets being validated, to be delivered in January 2020
 - All power converters qualified and stored.
- Controls ready
 - Algorithms integrated in class 63 and deployed.
- EIS
 - Solution validated by experts and chassis under development.
- Studies and tests
 - All studies completed including magnetic measurements.