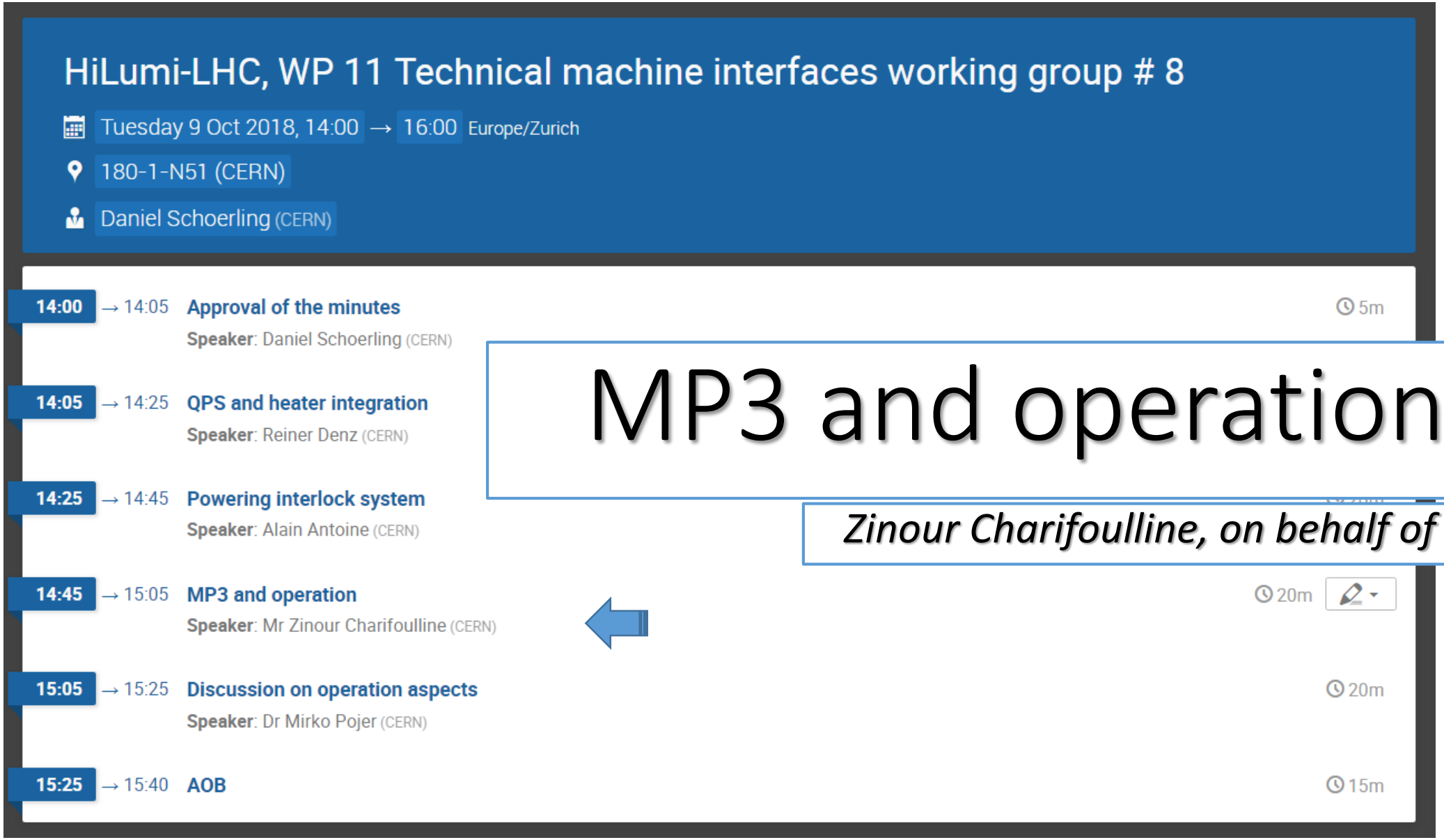

MP3 and operation

Zinour Charifoulline, on behalf of MP3

MP3 motivation: impact from installation of 11T-dipoles to HWC Powering Tests Procedures

CERN
CH-1211 Geneva 23
Switzerland

LHC

EDMS NO.	REV.	VALIDITY
1995306	0.1	DRAFT

REFERENCE
LHC-LBH-EC-0001

Date: 2017-06-11

ENGINEERING CHANGE REQUEST

Installation of the 11 T Dipole Full Assembly in LHC P7 (HL-LHC WP11)

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

The operation with proton and ion beams foreseen in the High Luminosity LHC configuration requires upgrading the Large Hadron Collide installing additional collimators in the warm insertions and (DS) regions. To this end, in the baseline scope of the H foreseen to substitute in the DS region at point 7 two 14. main dipoles (MB) each with a cryo-assembly composed dipoles with in the middle a 3.3 m long bypass cryostat collimator. A pair of 5.5 m long 11 T dipoles delivers app strength of 119 T.m, at the nominal operating current o dipole (MB). Fine-tuning of the integrated field strength ramp is envisaged by using a –nested- trim power conv dipoles will operate at 1.9 K in series with the remaining M

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:
D. Schoerling et al.	HiLumi-WP11-Integration

4. IMPACT

4.1 IMPACT ON ITEMS/SYSTEMS

LHC Layout	LHCLSS_0029 - IR7 LEFT, CELLS C8.L7 TO C11.L7 LHCLSS_0030 - IR7 RIGHT, CELLS C8.R7 TO C11.R7
Updated layout drawings	LHCLSSH_0013 - IR7 LEFT, CELLS C8.L7 TO C11.L7 LHCLSSH_0014 - IR7 RIGHT, CELLS C8.R7 TO C11.R7
Main dipole chain	Circuits RB.A67 and RB.A78 will be modified. Table 5 provides a comparison of the parameters before and after the change.
MP3	Hardware commissioning powering tests procedures have to be updated and established

Start point and the target to the end of LS2

- ✓ RB-circuit powering procedures, LHC-MP
- ✓ 600A-circuit powering procedures, LHC-M
- ✓ IT-circuit powering procedures, LHC-MPP
- ✓ ECR: Installation of 11 T Dipole Full Asser
- ✓ ES: 11 T Dipole Circuit – Powering and Pr

MP3 PROCEDURE

Powering Procedure and Acceptance Criteria for the 13 kA Dipole Circuits with 11 T magnets

ABSTRACT:

This document describes the hardware commissioning test procedure and the acceptance criteria for the 13 kA dipole circuits of the LHC with 11 T magnets. A list of the parameters to be acquired during the tests is given, as well as the required approvals to validate each test.

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EDMS NO. 874713

LHC-MPP

MP3 PROCEDURE

Powering Procedure and Acceptance Criteria for the 13 kA Dipole Circuits

ABSTRACT:

This document describes the hardware commissioning test procedure and the acceptance criteria for the 13 kA dipole circuits of the LHC. A list of the parameters to be acquired during the tests is given, as well as the required approvals to validate each test.

This document describes the test proced
quadrupole magnet circuits of the Inner

CERN CH-1211 Geneva 23 Switzerland

LHC

EDMS NO.	REV.	VALIDITY
874716	5.3	RELEASED

REFERENCE
LHC-MPP-HCP-0003

Date: 2016-01-07

MP3 PROCEDURE

Test Procedure and Acceptance Criteria for the 600 A Circuits

ABSTRACT:

This document describes the test procedure and the acceptance parameter specification for the 600 A superconducting circuits. A list of the parameters to acquire during the tests is given.

(Possible) Outlook:

- Circuit parameters – before and after
- PIC, QDS and EE – any principal differences?
- Main and Trim circuits – operation powering cycle
- HWC – powering tests (mainly the open questions)

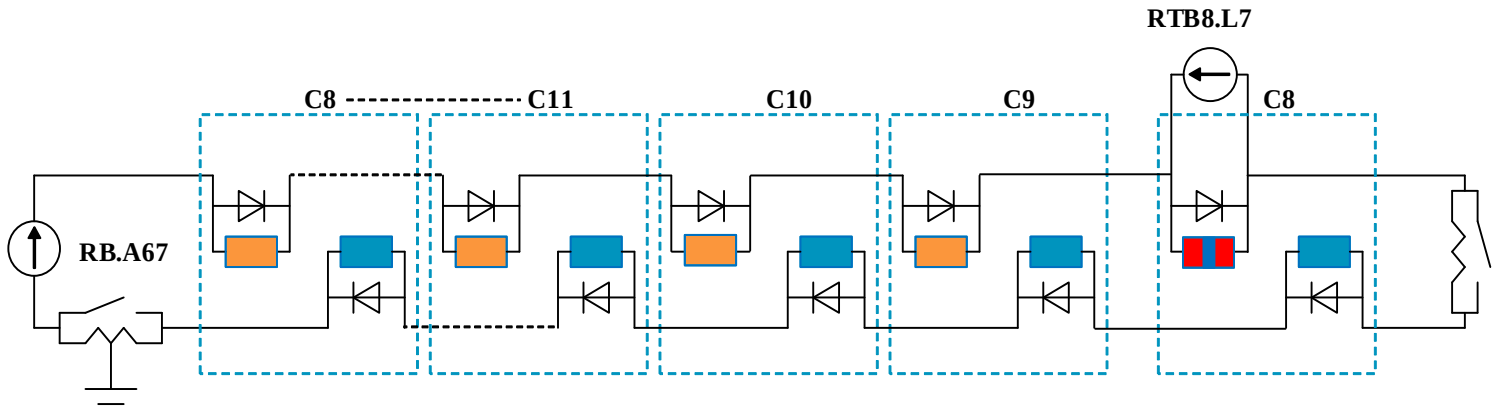
RB circuit characteristics in the current LHC configuration and after the introduction of 11 T dipole

	Circuit	LHC	HL-LHC
Maximum required RB PC voltage	RB.A67, RB.A78	171 V	171.6 V
Total RB circuit inductance	RB.A67, RB.A78	15.708 H	15.734 H
RB circuit DC cable resistance	RB.A67, RB.A78	1 mΩ	1 mΩ
RB circuit crowbar resistance	RB.A67, RB.A78	0 mΩ	0 mΩ
RB circuit energy extraction resistance	RB.A67, RB.A78	140 mΩ	140 mΩ
RB circuit natural time constant	RB.A67, RB.A78	15700 s	15740 s
Energy extraction time constant	RB.A67, RB.A78	112 s	113 s
Maximum required Trim PC voltage	RTB8.L7, RTB8.R7	NA	5V
Trim circuit inductance	RTB8.L7, RTB8.R7	NA	0.132 H
Trim circuit DC cable resistance	RTB8.L7, RTB8.R7	NA	13 mΩ
Trim circuit crowbar resistance	RTB8.L7, RTB8.R7	NA	70 mΩ
Trim circuit natural time constant	RTB8.L7, RTB8.R7	NA	10 s
Maximum common voltage of the trim circuit in case of energy extraction	RTB8.L7	NA	433 V
	RTB8.R7		425 V
Maximum common voltage of the trim circuit in case of energy extraction + earth fault	RTB8.L7, RTB8.R7	NA	910 V

No significant changes!

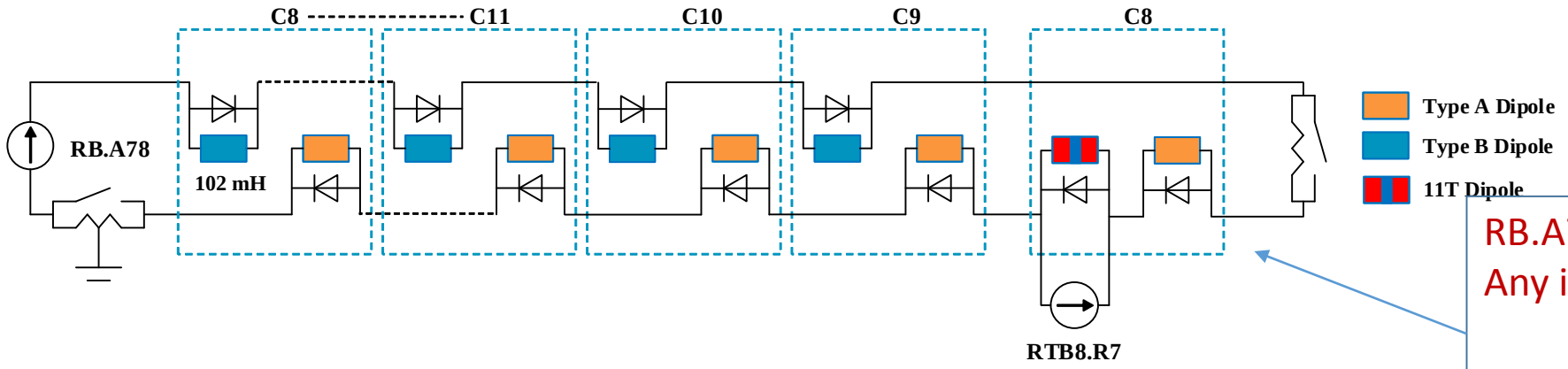
LHC-LBH-EC-0001

RB.A67 an RB.A78 configurations for the HL-LHC with the 11T trim power converter.



Newly done bus-bar segments
Any impact on the powering?

Possible earth fault in the trim PC?
The same as at any other place of the circuit?



RB.A78: little dissymmetry in line 1&2
Any impact on the powering?

- FPA transitions?
- Voltage feelers pattern?
- STEAM simulations going on

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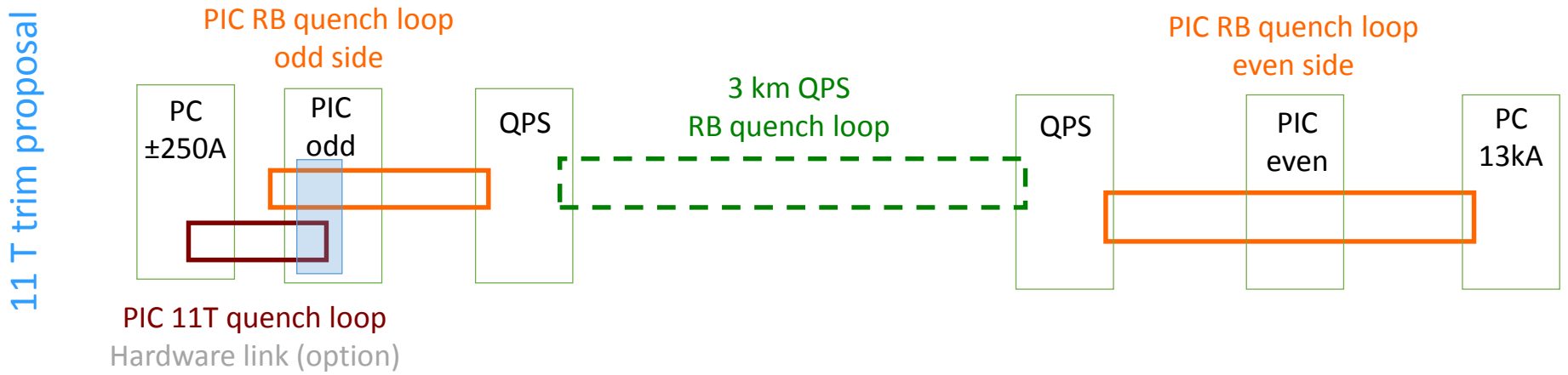
The interlock requirements of the 11 T circuit

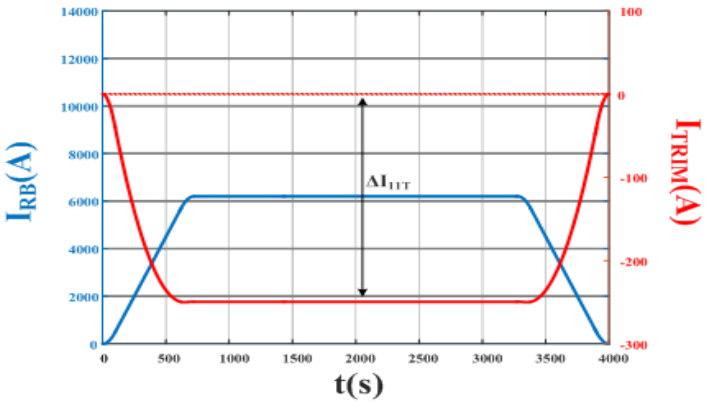
Interlock case	PIC Action on RB Circuit	PIC Action on Trim Circuit	Beam Dump
Quench in RB circuit	Fast Power Abort	Fast Power Abort	Yes
Powering Failure in RB Circuit	Slow power Abort	No action	Yes
Powering Failure in Trim Circuit	No action	Slow Power Abort	Yes
QDS trip in the trim current leads	No action	Fast Power Abort	Yes
Switch opening request by RB PC	Fast Power Abort	Fast Power Abort	Yes
Cryo-failure & Earth Fault (?)	Slow Power Abort	Slow Power Abort	Yes



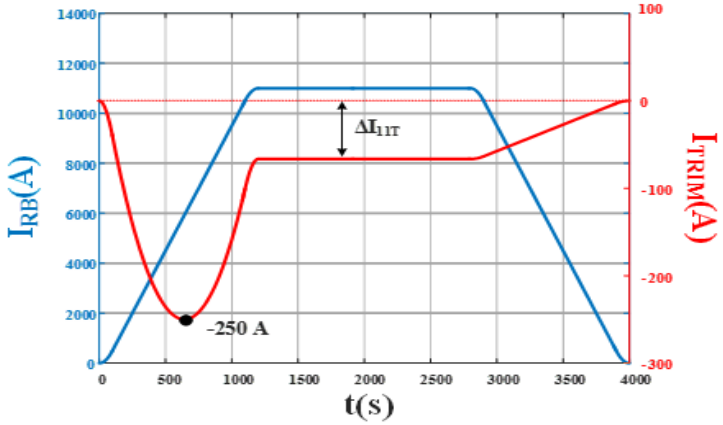
"Proposal is to treat 11T trim in the PIC as separate circuit (like other correctors in the sector)."
Proposed implementation of the 11 T trim circuit in the Powering Interlock Controller (PIC)
Daniel Wollmann, 28/11/2017

LHC-LBH-EC-0001

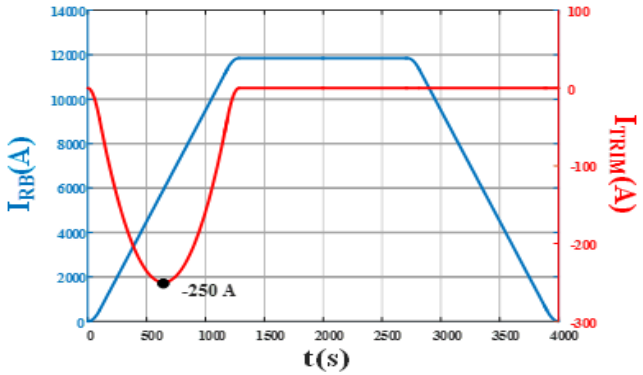
The trim and the main currents vs time for four energy levels



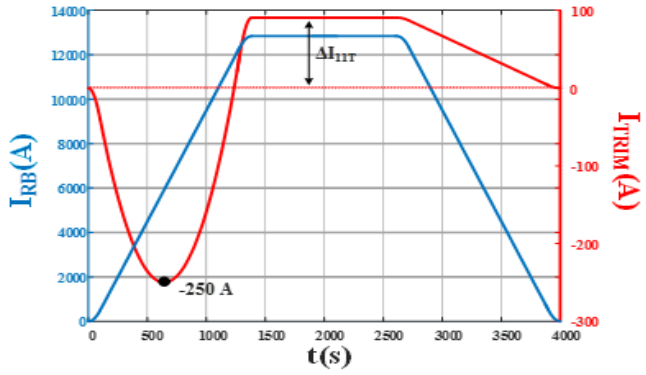
3.5 TeV / I_{RB} = 6 kA / ΔI_{11T} = -250 A



6.5 TeV / I_{RB} = 11 kA / ΔI_{11T} = -67 A



7 TeV / I_{RB} = 11.85 kA / ΔI_{11T} = 0 A



7.5 TeV / I_{RB} = 12.84 kA / ΔI_{11T} ≈ 100 A

Standard Cycles :

- 7.5 TeV – 12.85 kA (Ultimate)
- 7.0 TeV – 11.85 kA (Nominal)
- 6.5 TeV – 11kA (Actual)

Special Cycles (Calibration, Reduced Energy, etc…)

- 3.5 TeV – 6 kA
- 2.5 TeV – 4.2 kA

The impacts to the HWC powering tests: to be considered and discussed by MP3

LHC-MBH-ES-0001

The main steps of the entire HWC powering test (RB-circuit)

Main&Trim? PC team

PCC Power converter configuration

PQC Powering for QPS Preliminary Calibration

Might be needed since the nQPS splice protection configuration will be modified.
DQQBS open questions:

- To be within 2-4 mV without compensation?
- Any coupling effects due to the trim-circuit?

PIC2 Powering interlock controller check with current in the circuit

Main&Trim? PIC team

PLI1 Powering to injection current

PLI2 Powering to first intermediate current

PLIM Powering to confirm the proper operation of the snubber capacitors

PLIS Powering for splice mapping

PLI3 Powering to second intermediate current

PNO Powering to nominal current

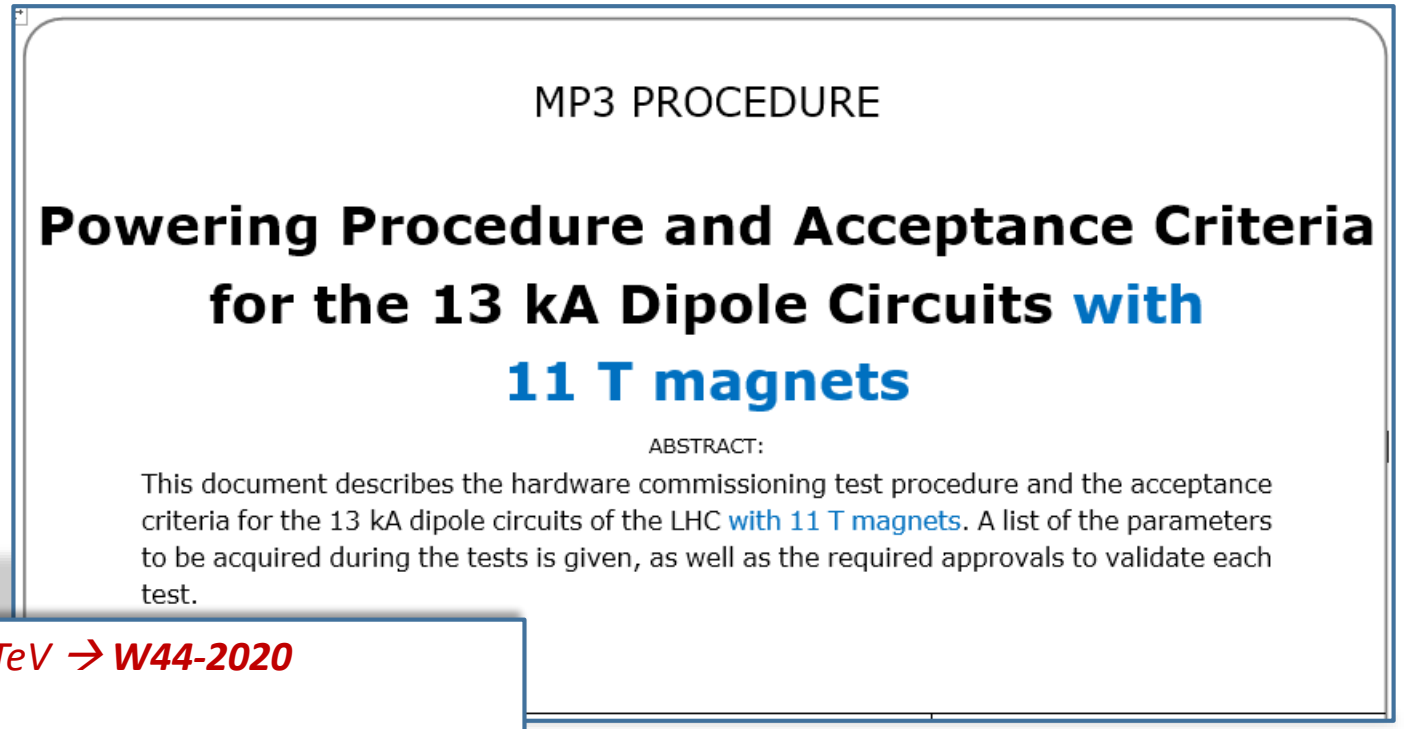
Subject to be discussed by MP3 (not yet started)
Open questions:

- Intermediate current level?
- Special tests for QPS (flux jump, …)?
- HP quench tests on 11T-magnets?
- New tests to check the DFBs?
- Combined powering?
- …

To be started - soon

To be finished – when?

Thanks!



MP3 PROCEDURE

Powering Procedure and Acceptance Criteria for the 13 kA Dipole Circuits with 11 T magnets

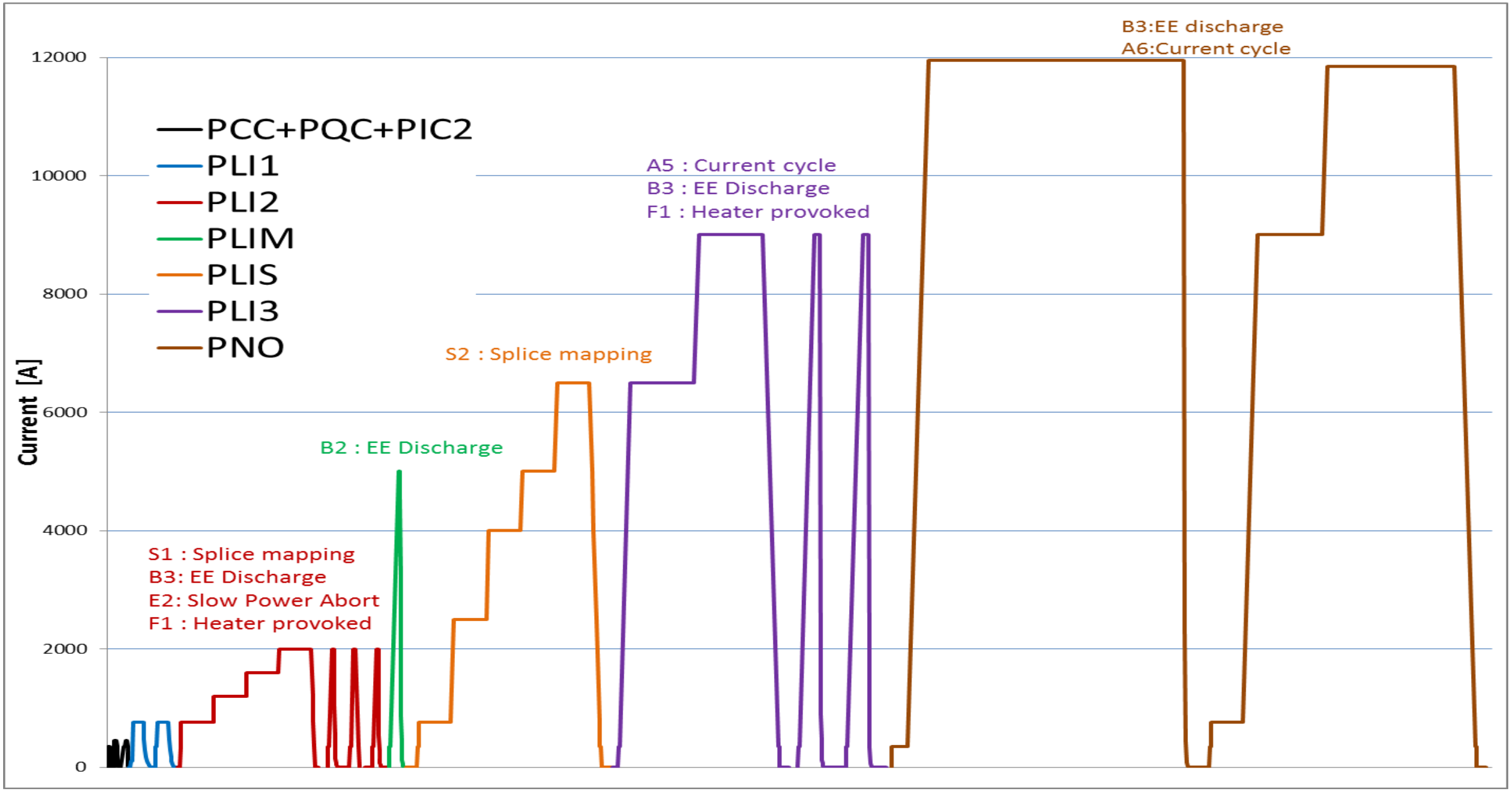
ABSTRACT:

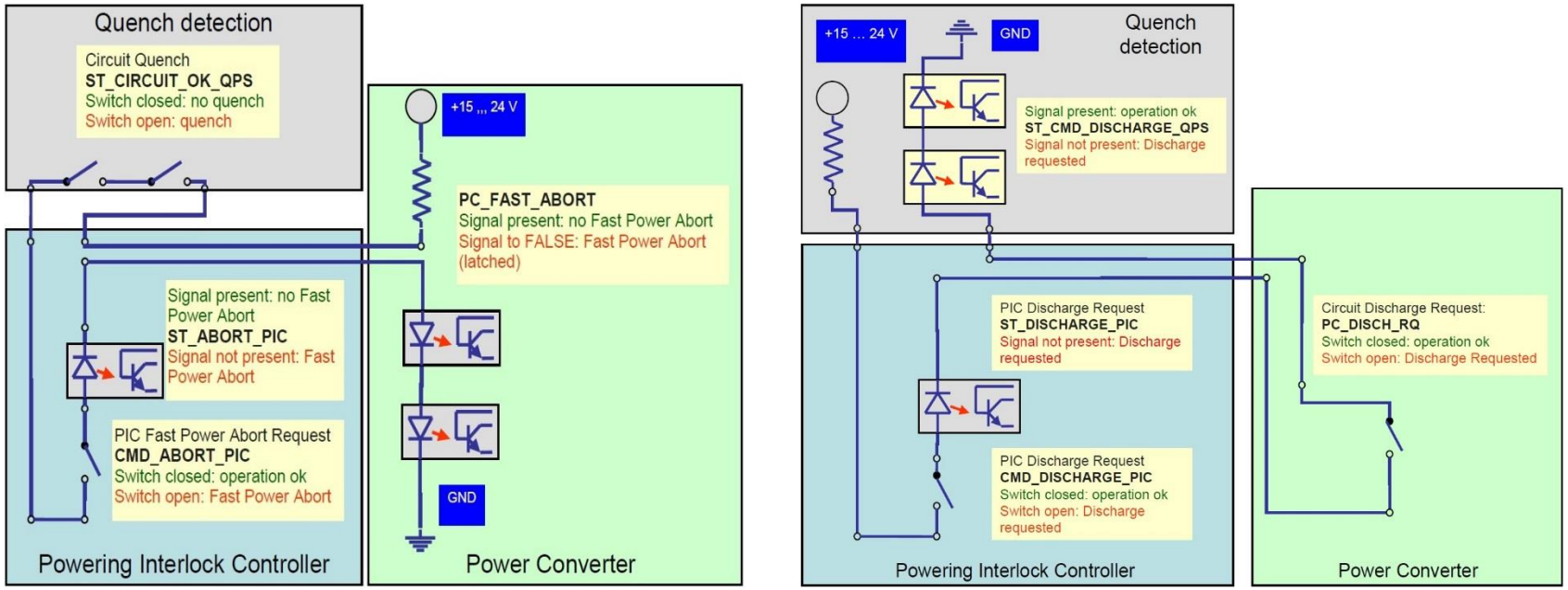
This document describes the hardware commissioning test procedure and the acceptance criteria for the 13 kA dipole circuits of the LHC with 11 T magnets. A list of the parameters to be acquired during the tests is given, as well as the required approvals to validate each test.

- ✓ *Powering tests and training quench campaigns at 7 TeV → **W44-2020***
- ✓ *Decision for the present dipole removal, deadlines:*
  - ✓ *LSS7R -> End of September 2019*
  - ✓ *LSS7L -> End of January 2020*

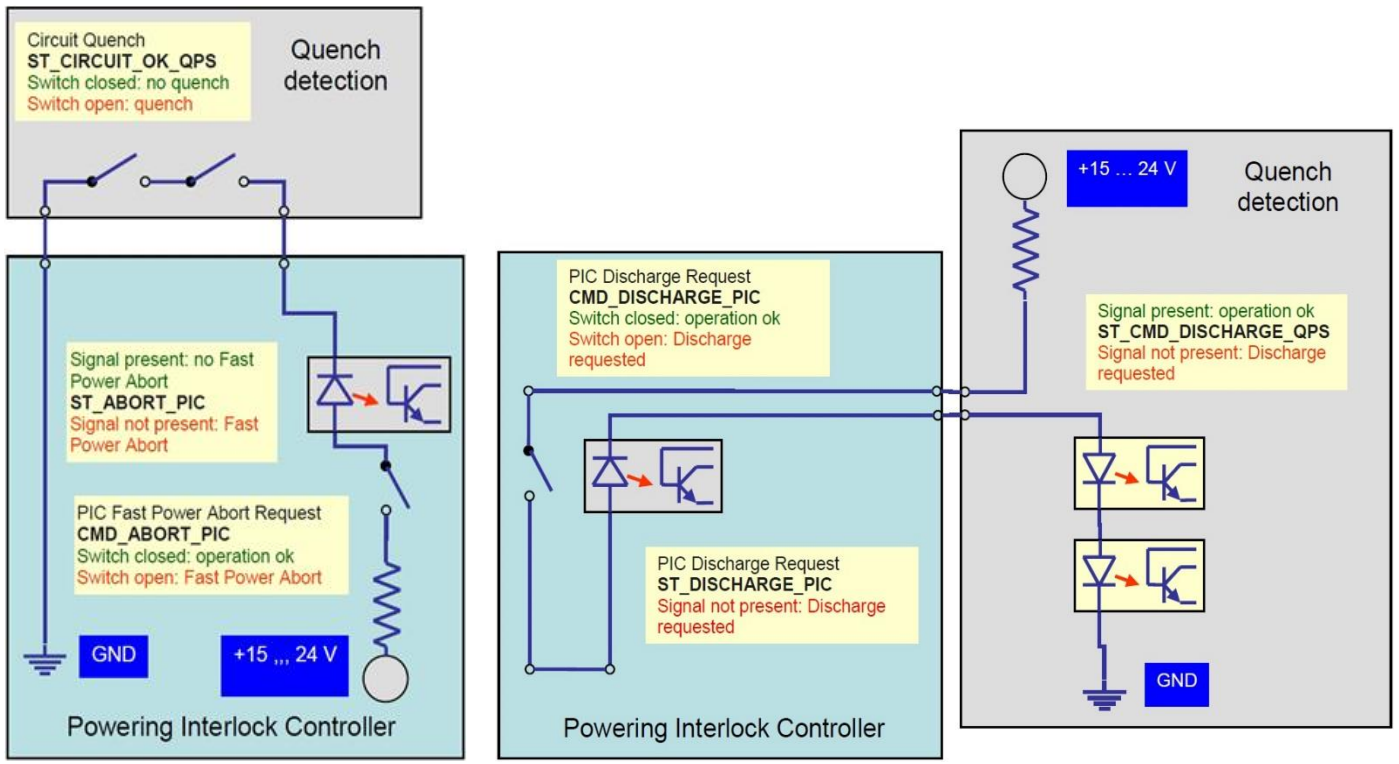
Marzia Bernardini, LS2-days, 09/10/2018

Appendix

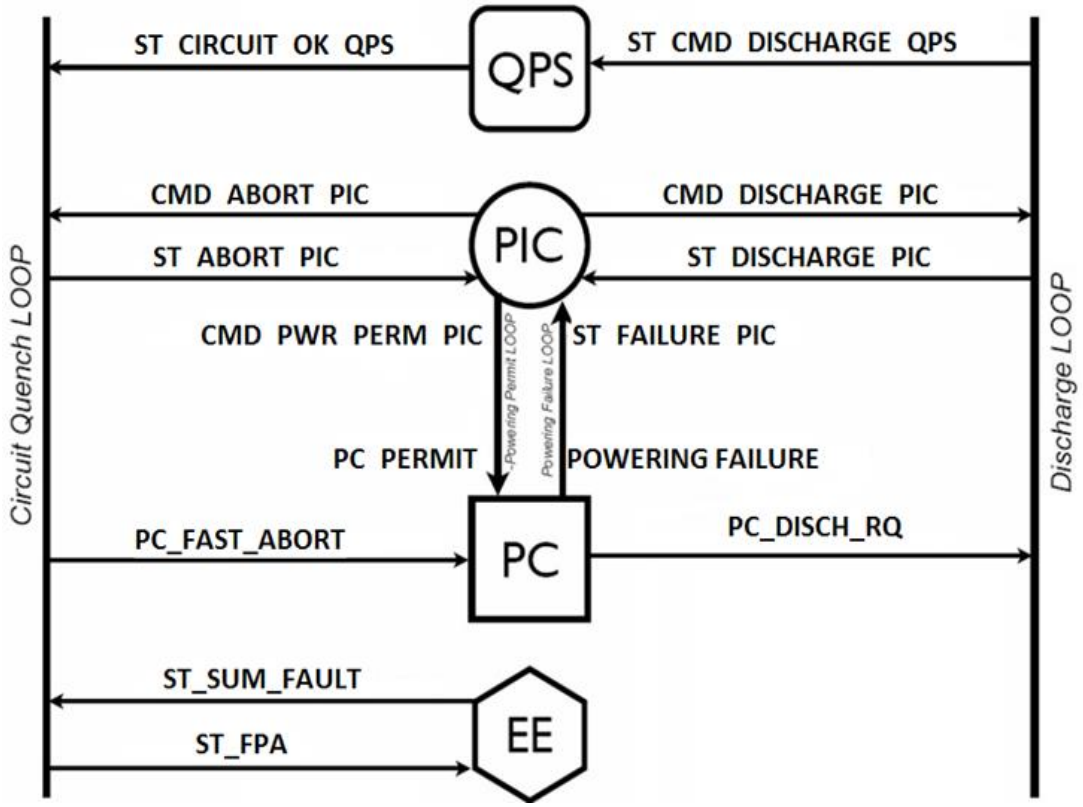

B3:EE discharge
A6:Current cycle
PCC+PQC+PIC2
PLI1
PLI2
PLIM
PLIS
PLI3
PNO
A5 : Current cycle
B3 : EE Discharge
F1 : Heater provoked
S2 : Splice mapping
B2 : EE Discharge
S1 : Splice mapping
B3: EE Discharge
E2: Slow Power Abort
F1 : Heater provoked
Current [A]
12000
10000
8000
6000
4000
2000
0



Circuit Quench Loop (left) and Discharge Loop (right) for main dipole circuit in even points.



Circuit Quench Loop (left) and Discharge Loop (right) for main dipole circuits in the odd points.



Interface of interlocked equipment with PIC via quench and discharge loop (RB-circuit).