# Power Supply and Energy Extraction System for the PANDA magnet

Preliminary Design Report

*Dr. Erokhin Alexandr, BINP*

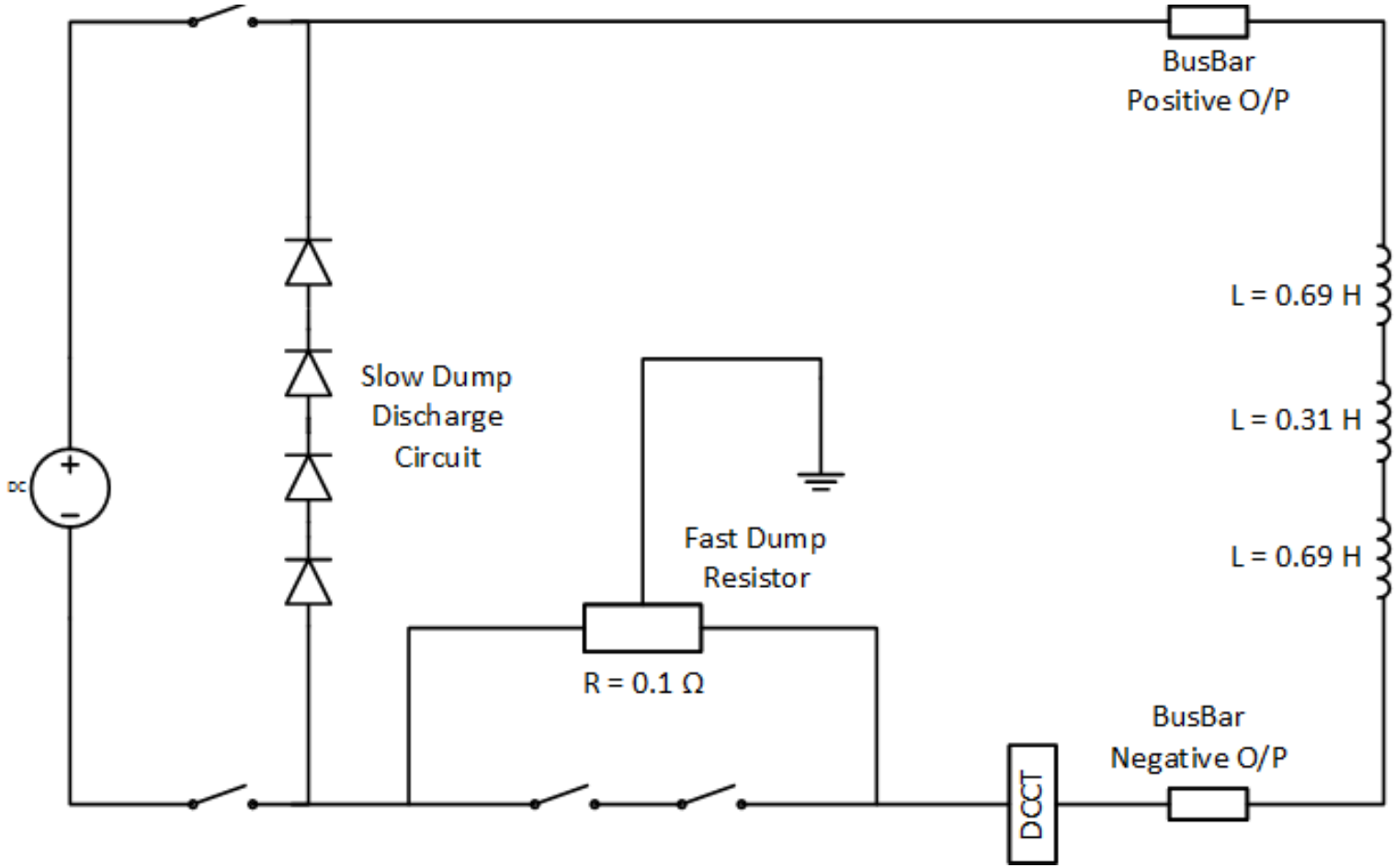
GSI, 26.04.2018

- Introduction
- Powering Circuit
- Power Supply
- Quench detection
- Energy Extraction System, basic elements
- Drawings
- Experience
- Conclusion - discussions

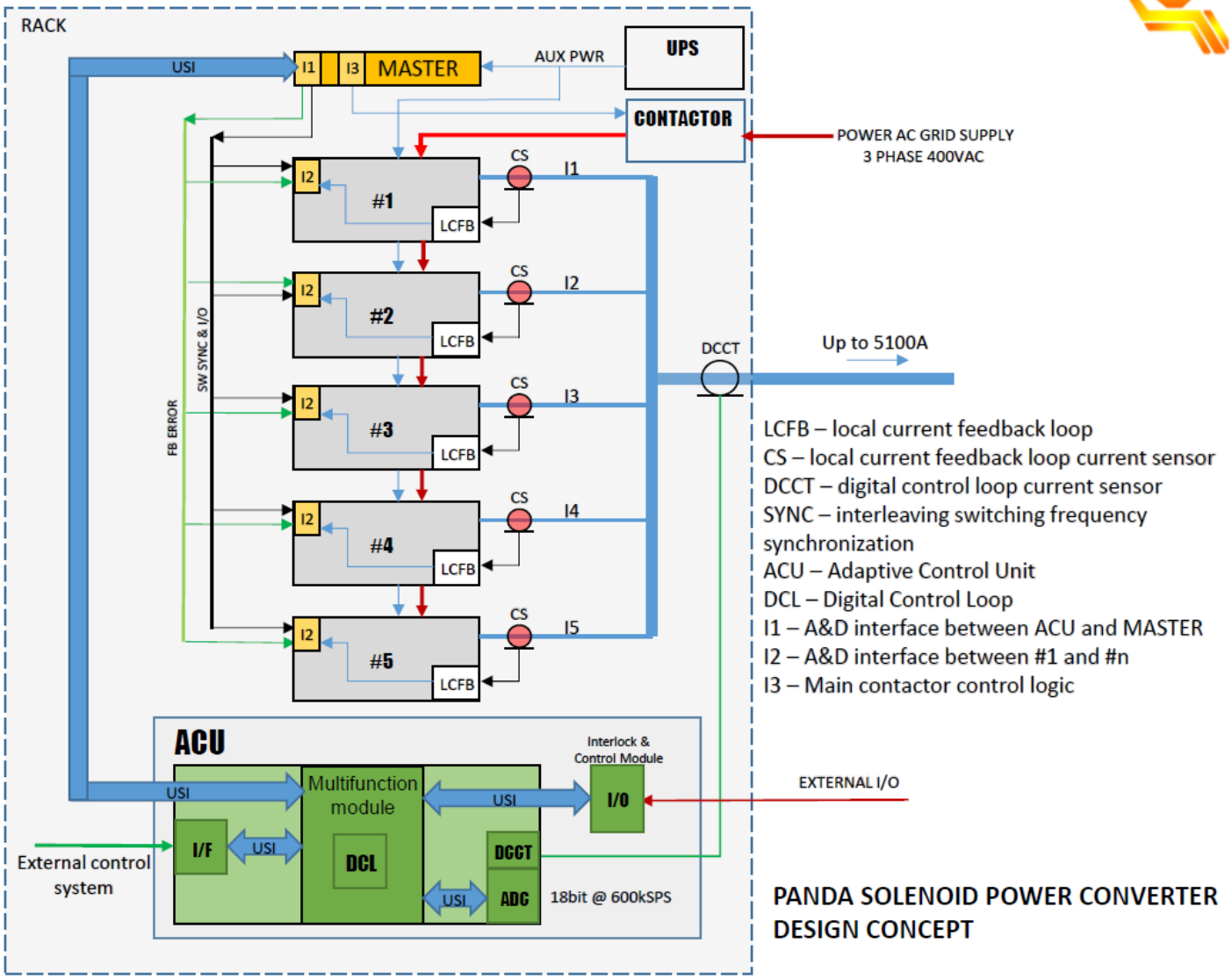
**Requirements for the external protection system (Quench detection and Energy Extraction):**

- The amount of the stored energy to be extracted is 20MJ. Stored energy should be extracted to the external dump resistor with the value of 0.1 Ohm. The active elements of the dump resistor should not be hotter than 100C. Cooling time should be specified;
- Quench detection circuit should provide fast detection of the normal phase appearing. The discrimination time should be about 1s(?!) and the threshold – about 0.5V;
- Number of the voltage tabs and the locations of their connections should be determined;
- Dump resistor should have as minimal as possible stray inductance and must be installed next to the extraction switch;
- The opening time is not specified;
- Dump resistor value - 0.1 Ohm. Middle point should be introduced and grounded in order to minimize the voltage between the coil and ground.

- ***Powering circuit***



- ***General design of five paralleled current sources controlled by ACU***

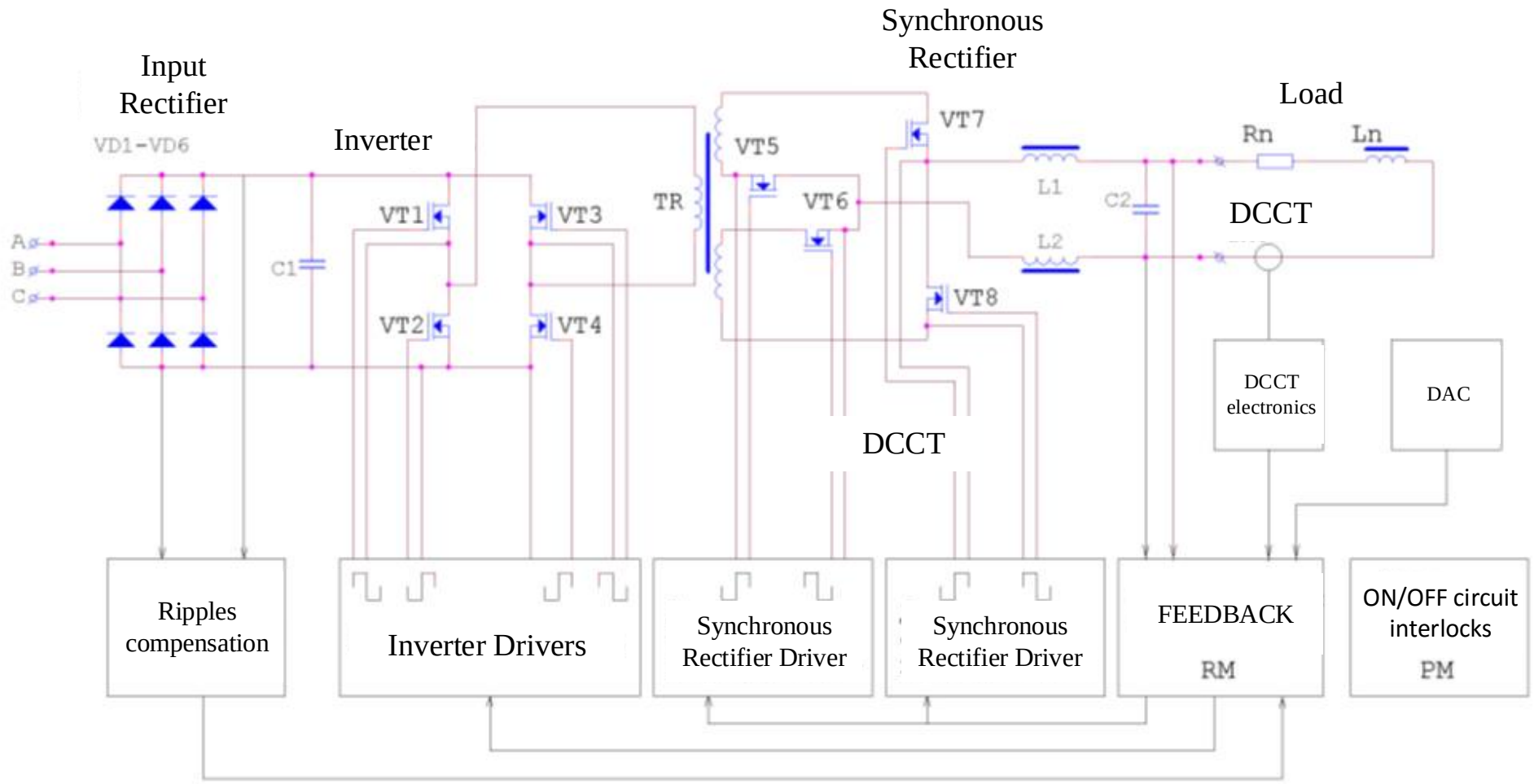



LCFB – local current feedback loop
CS – local current feedback loop current sensor
DCCT – digital control loop current sensor
SYNC – interleaving switching frequency synchronization
ACU – Adaptive Control Unit
DCL – Digital Control Loop
I1 – A&D interface between ACU and MASTER
I2 – A&D interface between #1 and #n
I3 – Main contactor control logic

**PANDA SOLENOID POWER CONVERTER DESIGN CONCEPT**

- **Power Supply (Current Source – VCH1300)**


- **Power Supply – block diagram**



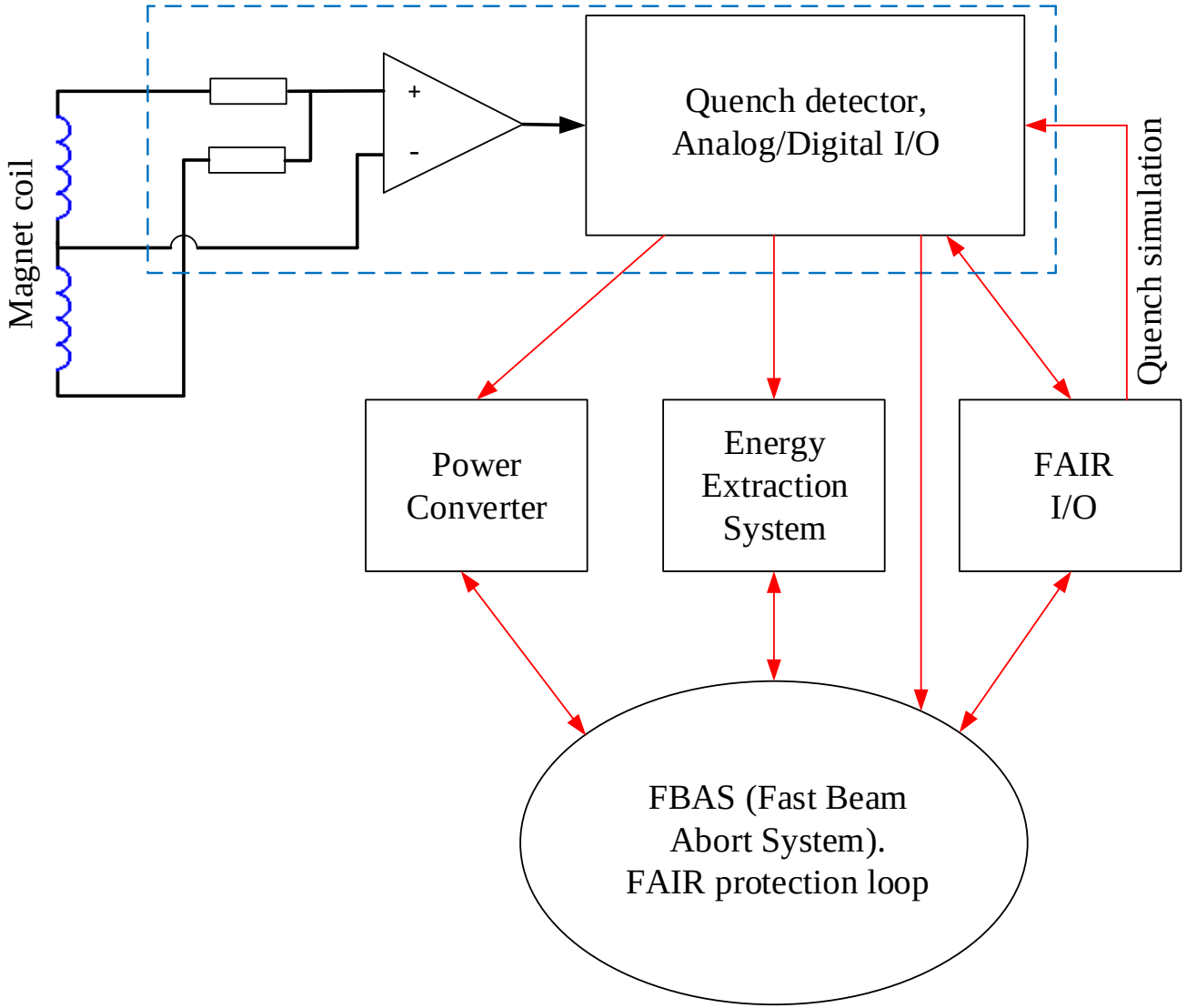
## Power Supply (one VCH1300) – parameters

- Nominal output power 15.6kWt;
- Nominal output current 1300A;
- Nominal output voltage 12V;
- 8 hours run Stability - < 0.01% from nominal;
- Output ripples in voltage:
  - 0-300Hz - < 10mV rms,
  - 0-40кГц – < 100mV rms;
- Control Interface – CAN
- Form factor 19” x 4U

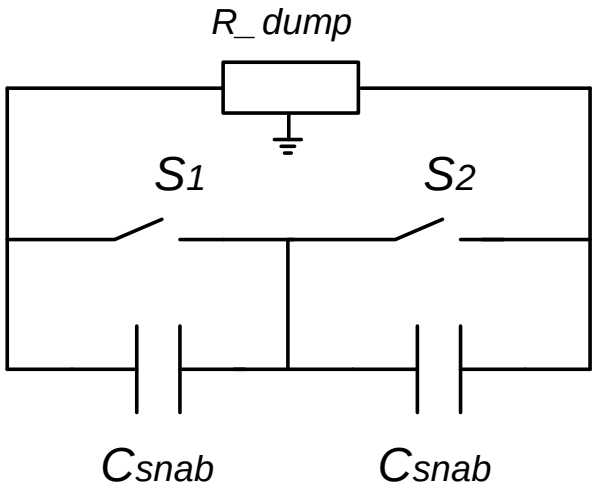
## Power Supply (one VCH1300) – parameters

- Interlocks:
  - Overcurrent (I > “Imax”);
  - Overpower (Pload > “Pmax”);
  - Phase distortion for more than 20% ;
  - Over temperature of the power part;
  - External Load faults: temperature, water (including water for PS rack);
  - Earth fault?
- Conditions:
- External conditions – room temperature 10– 35$^0$C;
- Input power line – 3 phases 380V with neutral.
- Cooling – distilled water not warmer than 30$^0$C,
- Maximal input pressure 6bars,
- Water consumption 2 liters/min,
- Water gradient with the maximal power < 10$^o$C
- Sizes 547*550*133mm, weight 25kg.

- **Quench detector, functional diagram**



- ***Energy extraction System***

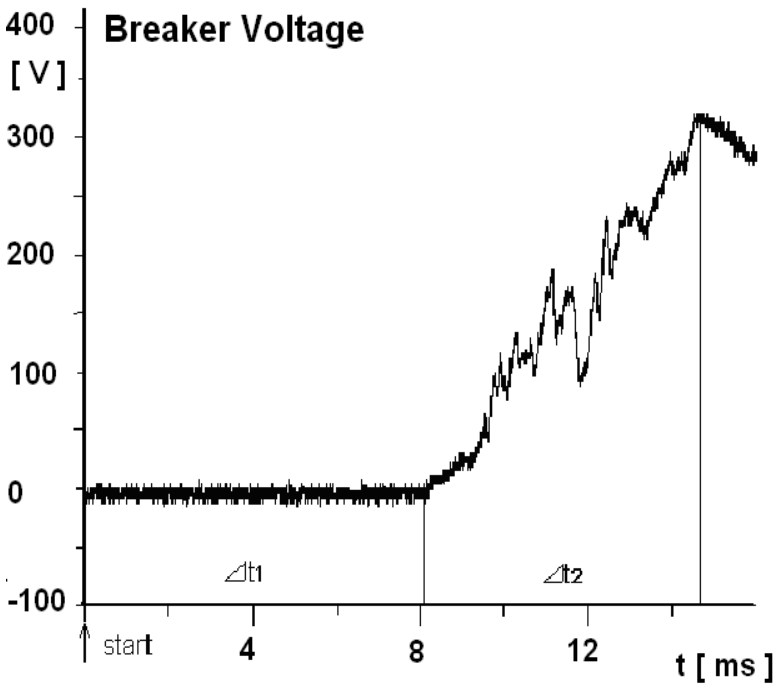



*Electromechanical Breaker as a main protection element (Switch)*

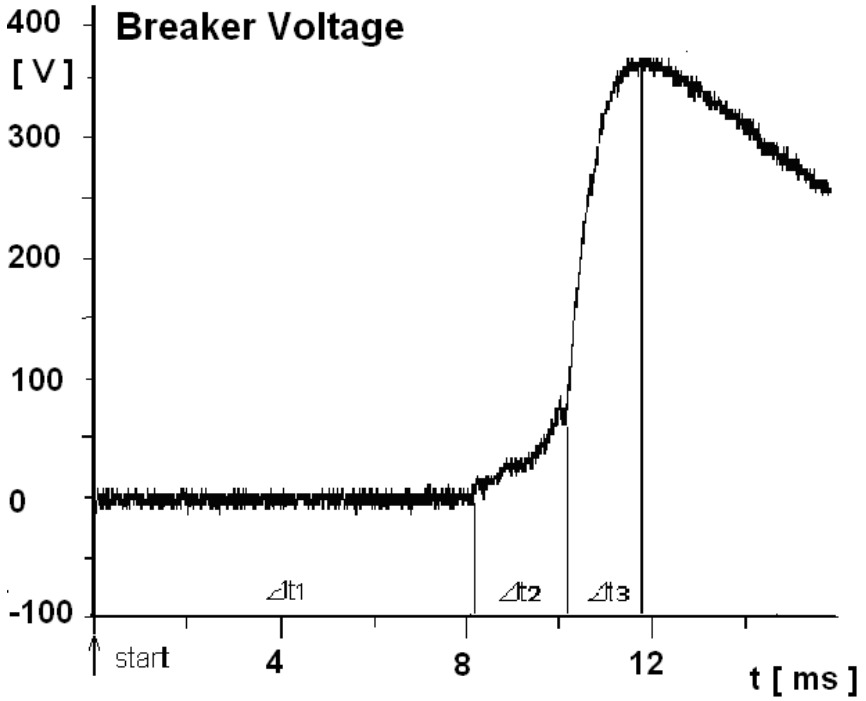
| № | Parameter | Value | Unit |
|---|---|---|---|
| 1. | Maximal current | 5400 | A |
| 2. | Energy stored in the magnet | 20 | MJ |
| 3. | Current polarity | Any | |
| 4. | Maximal inductance in a circuit | 1,69 | Hn |
| 5. | Dump resistor value | 0,1 ± 5% | Ohm |
| 7. | Maximal overtemperature of the Dump Resistor | 80 | K |
| 8. | Maximal time constant for the energy extraction | <10 | s |

- ***Energy extraction System***

- *Electromechanical Breaker and help of snubber against the arc*

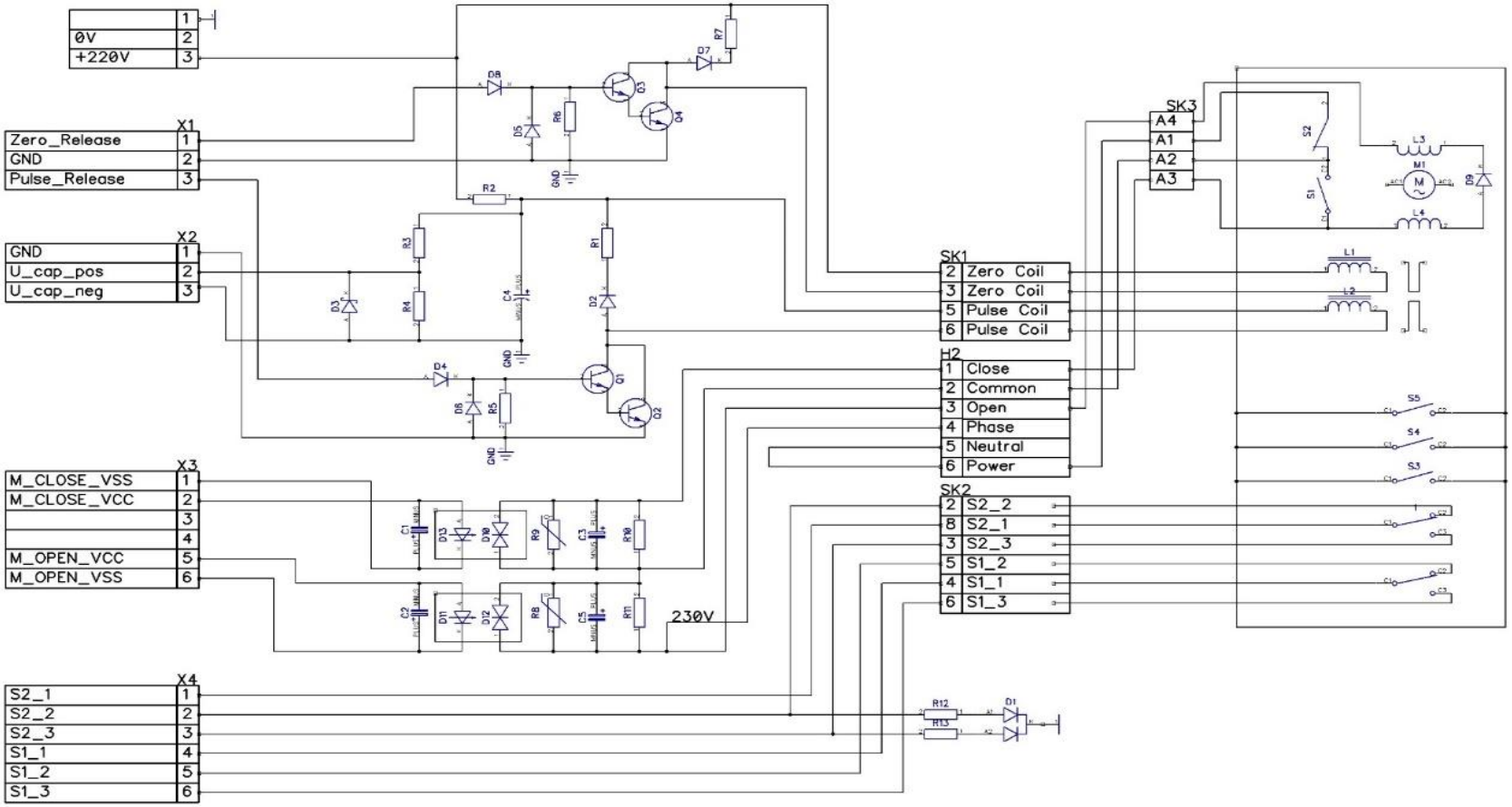



*Voltage over the contacts while opening the circuit with* $C_{snab} = 0$

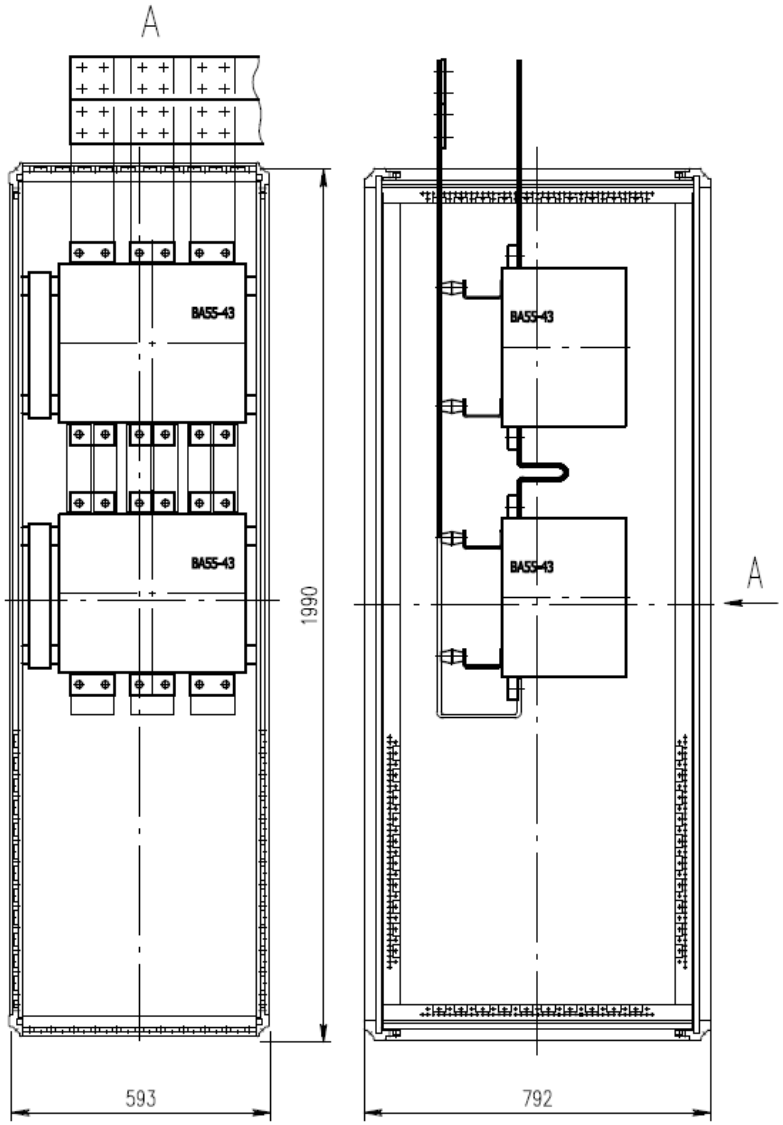



*Voltage over the contacts while opening the circuit with* $C_{snab} = 0.8$ *mF*

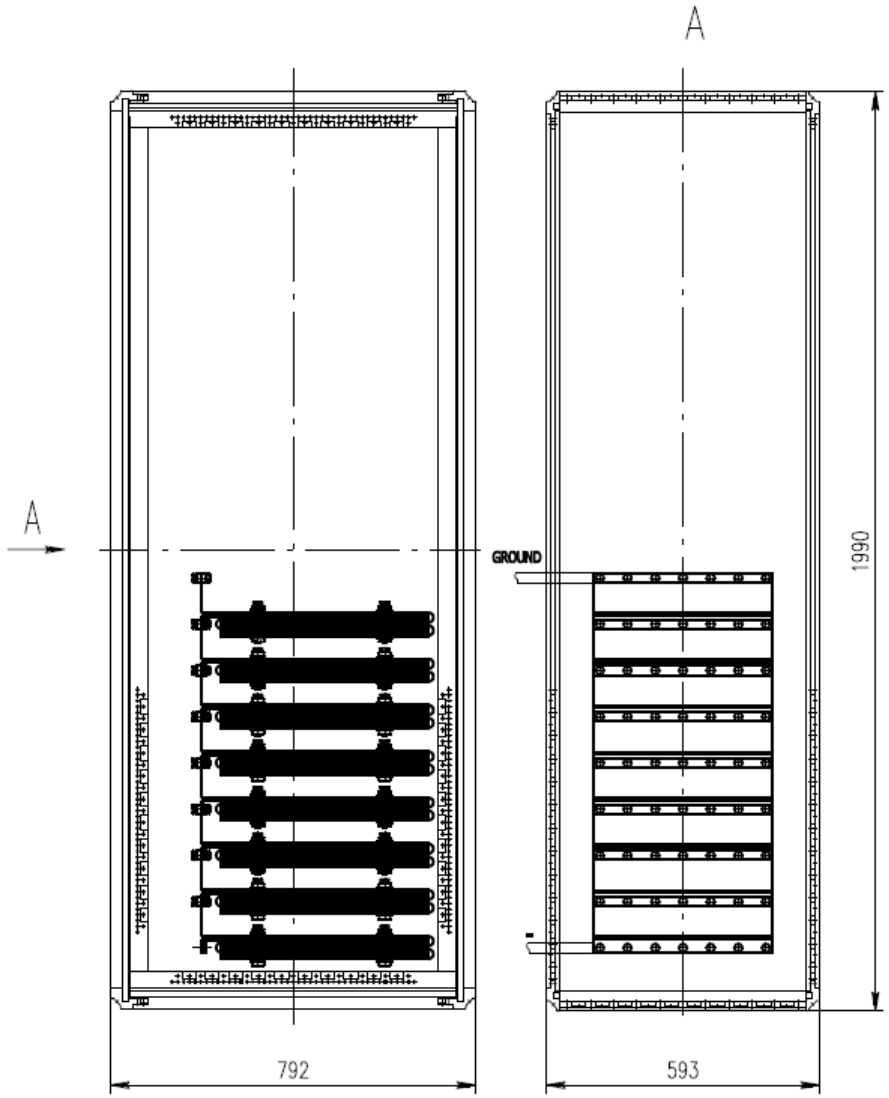
- ***Energy extraction System***
- ***Low level electronics***

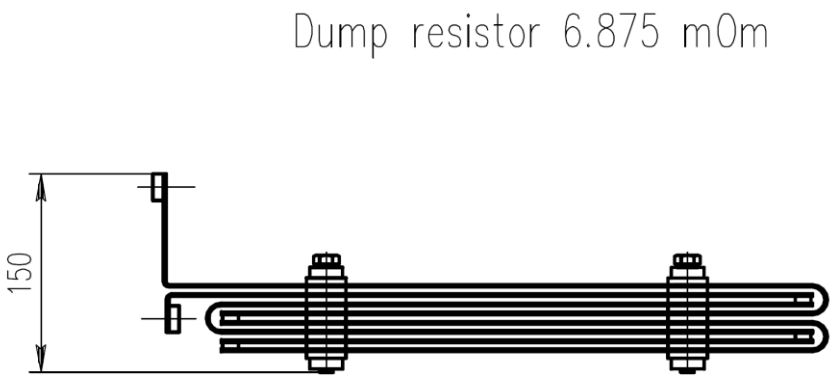


- ***Energy extraction System, preliminary design***

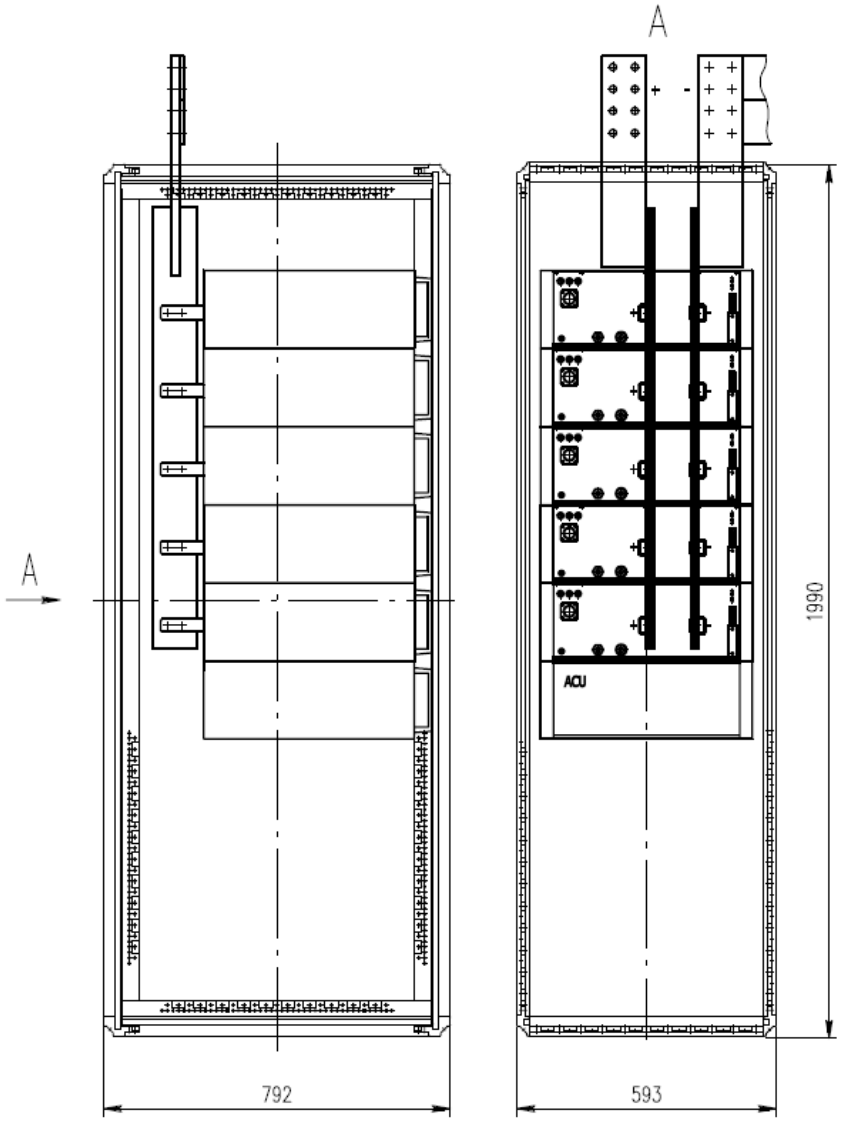


- ***Energy extraction System, Dump Resistor***

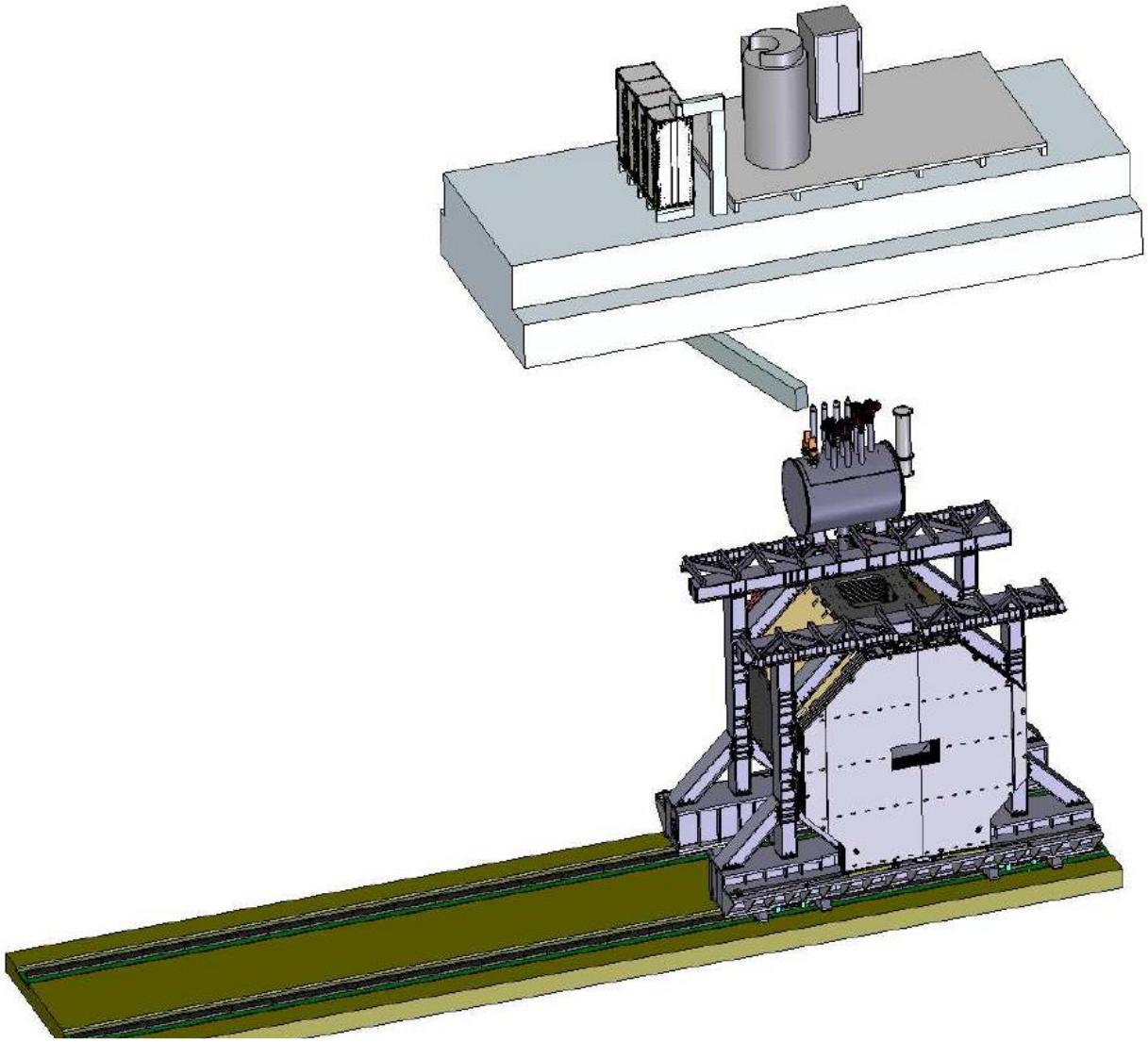


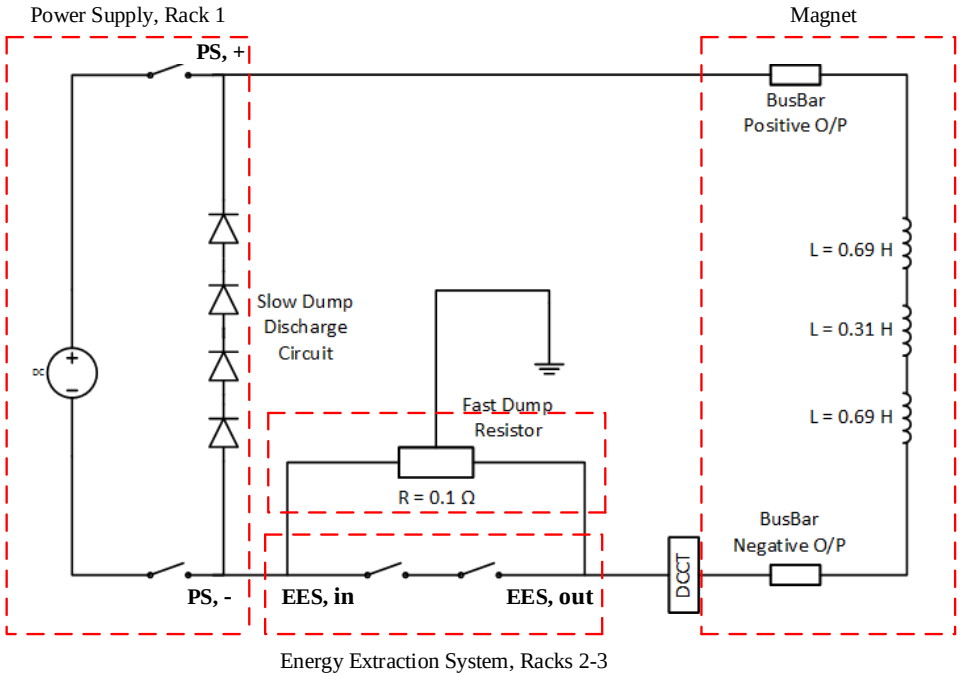
- ***Power supply rack, preliminary design***

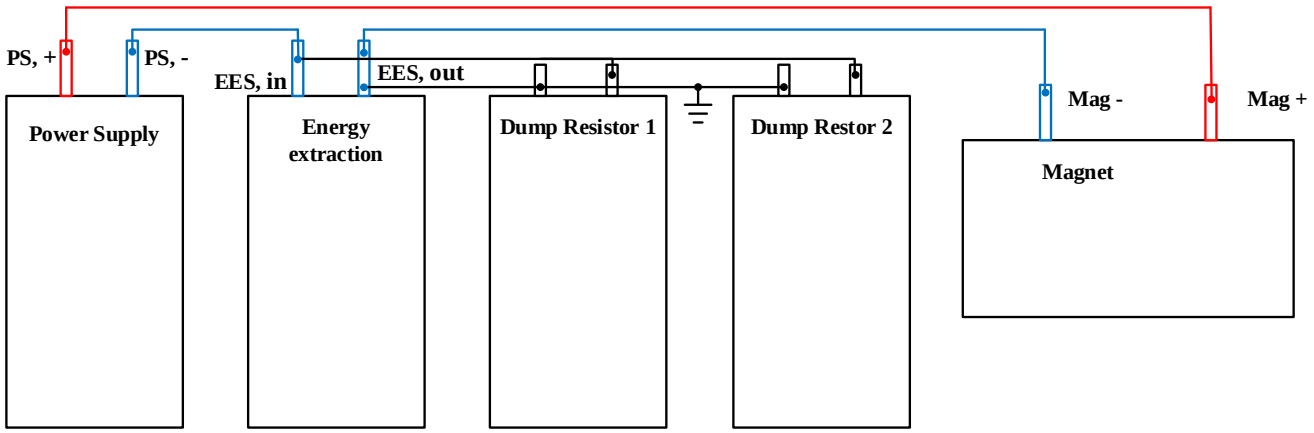


- ***3D view***



## Overall topology and cabling



- ***Energy extraction Systems – experience***

- Example - 222 energy extraction systems for the LHC corrector magnets delivered by BINP to CERN.

Two systems per rack

Racks in the LHC tunel

# Thanks for Your Attention!