



# New Four Quadrant R2E $\pm 600A \pm 10V$ for LHC

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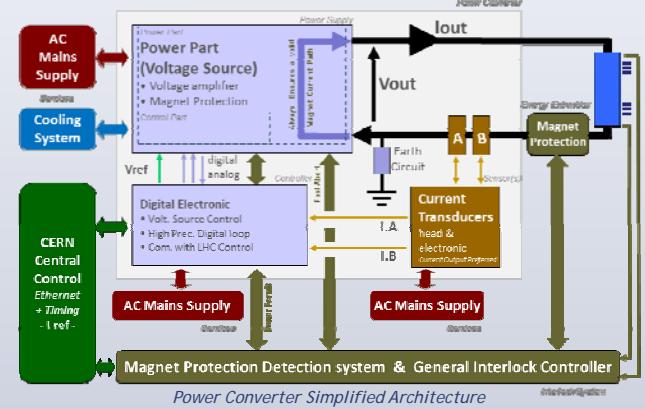
CERN – European Organization for Nuclear Research

**ABSTRACT** The LHC (Large Hadron Collider) particle accelerator makes extensive use of power converters, with a high precision regulated output current requirement. The level of radiation will increase, and higher availability is required for each system. High availability in 4-quadrant converters is crucial in LHC operation. To get this aim, a new redundant, modular and radiant tolerant 4-quadrant linear converter is developed modifying the control strategy of current converters in LHC. This poster introduces the R2E LHC [600A; 10V] power converter, 162 units in the LHC are impacted.

### CERN POWER CONVERTER ARCHITECTURE

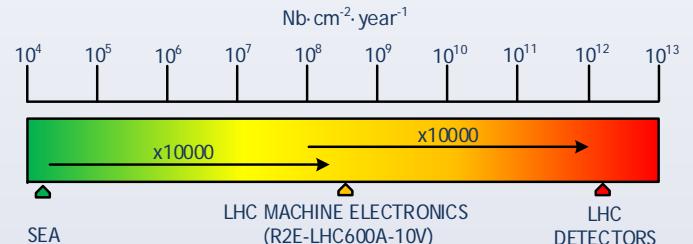
#### CERN Power Converter Radiant Tolerant Validated

- A voltage power source unit
- Two high precision current transducers (DCCT)
- High Precision digital controller (FGC)



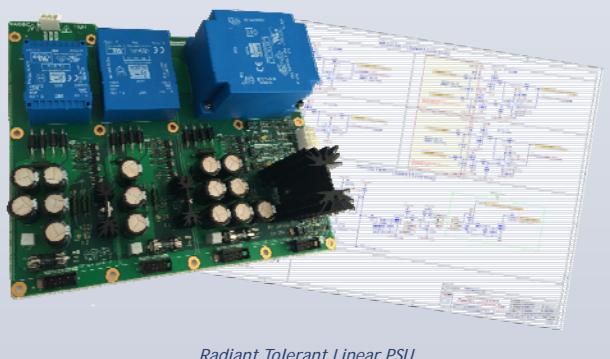
### RADIANT TOLERANT DESIGN

#### High – Energy Hadron Fluence

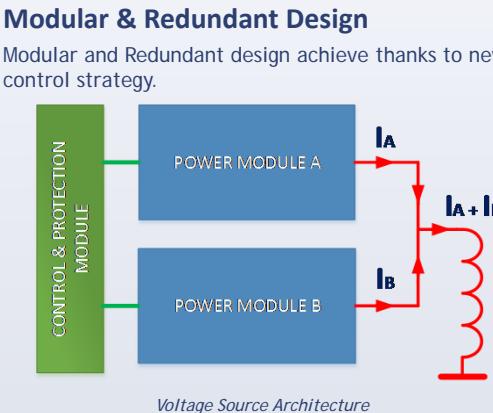


#### Radiant Tolerant Circuits & Components

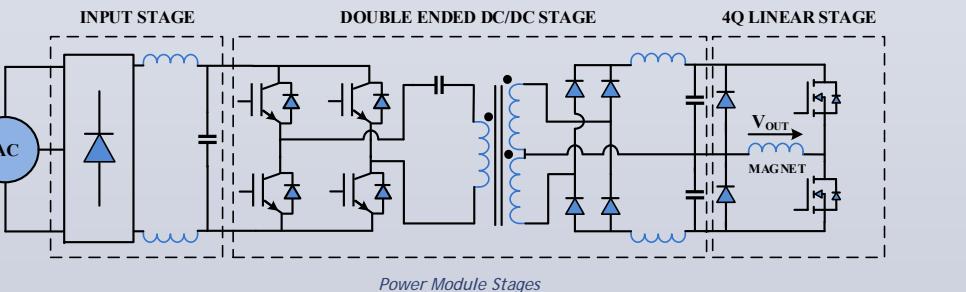
- Simple and redundant circuits developed following radiant tolerant criteria
- Minimum number of references and well known components used
- All components qualified under radiation



### R2E-LHC600A-10V POWER CONVERTER TOPOLOGY

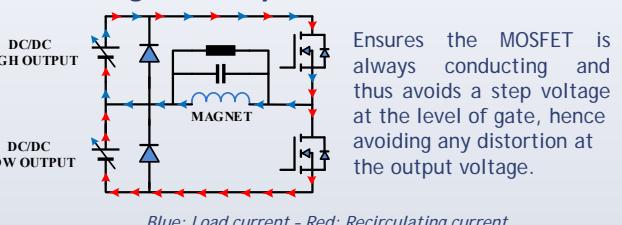


A new converter (R2E-LHC600A-10V) is carried out, formed by two power modules working as parallelizable current sources of  $\pm 400A \pm 10V$  each. One additional module controls the output voltage providing the current reference to both power modules. The magnet protection systems are located in the control module (they were located in the rack in the old version). This new structure provides full modularity, redundancy and reduces the time to repair.

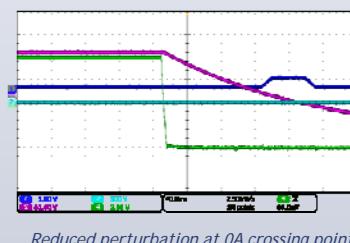


### 0A CROSSING POINT PERTURBATION

#### Recirculating current system.

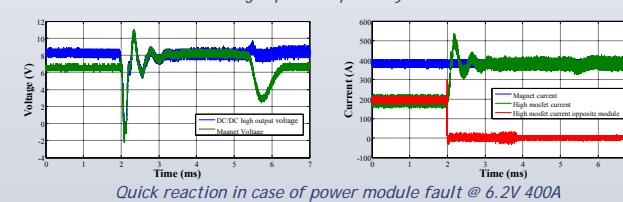
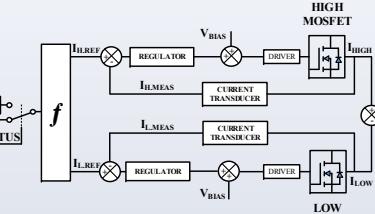


Recirculating current is activated before the 0A crossing point.



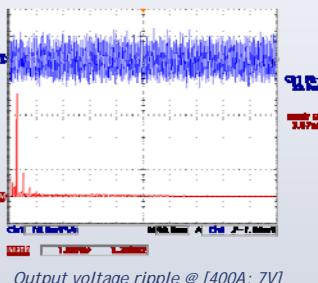
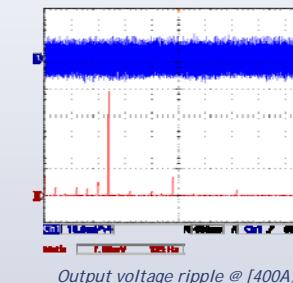
Reduced perturbation at 0A crossing point

### QUICK REACTION WHEN ONE POWER MODULE FAILS



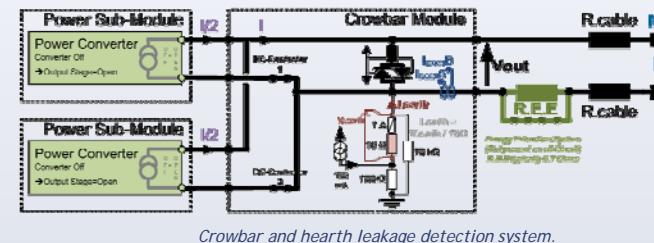
If one power module fails, the remain power module has to supply the full power. A control that provides a short response time versus this situation is implemented.

### LOW LEVEL OF OUTPUT NOISE



Very low level of output noise achieve thanks to the 4-Quadrant output linear stage.

### SUPERCONDUCTIVE MAGNET PROTECTION



#### Crowbar System

The system is based on a 50 mΩ Power Resistance series back-to-back thyristors being fired at a given output voltage ( $\pm 13V$ ), and then providing a safe path for magnet current.

#### Earth System

Detection system is an active system, since relying on a 100mA current source powering a 100Ω resistor connected between earth and negative polarity of the Power Converter. A common mode voltage is then created, ( $100mA \times 100\Omega$ ) making possible to detect an earth fault even with converter being OFF. (OFF, not condemned).

### SUMMARY

A new topology and control strategy are developed to comply with nominal LHC requirements. These modifications have been successfully implemented in a new converter prototype.

In next future, HL-LHC upgrade will demand new 4-quadrant converters, with a higher level of operating currents. It will be possible to feed these magnetic circuits with several power modules in parallel. A redesign could be done considering an undetermined number of power modules in parallel.