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Radiation Tolerant Power Converter Controls for the LHC

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The Large Hadron Collider (LHC) at the European Organisation for Nuclear Research (CERN) is the world's most powerful particle collider. The LHC has several thousand magnets, both warm and super-conducting, which are supplied with current by power converters. Precise magnetic fields are created, ensuring the correct conditions for beam operation. If the magnetic field is incorrect the beam will be affected and beam losses can occur: in cases this leads to the execution of an emergency dump of the energy stored in the circulating beam before the losses become unacceptable. As beam losses can also cause localised heating in magnets, a failure in magnet powering can also lead to the execution of an emergency discharge of energy stored in the magnetic circuits.
Each power converter is controlled by a purpose-built electronic module called a Function Generator Controller (FGC). This hardware allows remote control of the power converter state, and forms the central part of a closed-loop control system where the power converter Voltage is set, based on the converter output current and magnet-circuit characteristics. Some power converters and FGCs are located in areas which are exposed to beam-induced ionizing radiation. There are numerous radiation induced effects, some of which lead to a loss of control of the power converter, directly impacting upon the accelerator's availability.
In 2015 and 2016, following the first long shut down, the LHC will re-start with higher intensity beams, and higher beam energy. This is expected to lead to a significantly increased rate of radiation induced effects in materials close to the accelerator. Recent radiation tests indicate that using the current FGC would lead to an unacceptable loss of availability of the machine. A new FGC known as the FGClite is being designed to work reliably in the radiation environment expected in the LHC tunnel in the post-LS1 era.
This paper outlines the concepts of power converter controls for machines such as the LHC, and introduces the risks related to radiation effects on electronics. The FGClite project is then described, with its key concepts and challenges: aiming for high availability in a radiation field.

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