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Chips for calibration of the ATLAS LAr calorimeter

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The LHC upgrade requires redoing the LAr calibration system which should provide a 16-bit range signal with 1‰ accuracy while being radiation tolerant. The former operating principle is used: a precise current is stored in an inductor, when it is switched off, a pulse is generated to be injected in the readout electronics. This is achieved by two chips: the first one, in TSMC 130nm, provides the 16-bit DAC as well as the calibration management system; the second one, in XFAB 180nm, embeds switches to generate the pulses. A description of both chips and measurement results will be presented.

Summary (500 words)

To calibrate the energy response of the ATLAS liquid argon calorimeter, an electronics calibration board has been designed. It delivers a signal whose shape is close to the calorimeter ionization current signal with amplitude up to 100mA in 50Ω with 16-bit dynamic range. The amplitude of this signal is designed to be uniform over all calorimeters channels, stable in time and with an integral linearity much better that the electronics readout.

The LHC upgrade at CERN implies an increase in the dynamic range for the electromagnetic Liquid Argon (LAr) calorimeter of the ATLAS detector, a change in the power supply system and an increase of the luminosity and thus of radiation effects on detectors. This requires completely redoing the Liquid Argon calibration system. The new system should provide a 16-bit range current (from 5µA to 320mA) with 1‰ accuracy while being radiation tolerant.

The general principle of the calibration remains the same. The calibration pulse sent inside the cryostat is an exponential voltage signal built from a precise DC current using an inductor. When this current is switched off, the magnetic energy stored in the inductor is transferred to a resistance and therefore a fast precise pulse is generated to be injected in the readout electronics. For that, two dedicated ASICS have been developed to equip the 122 calibration boards and calibrate the 200,000 calorimeter channels.

The first one, LADOC (Link And DAC Of CLAROC), made in TSMC CMOS 130nm technology, provides the 16-bit range current DAC (from 0.625µA to 40mA) as well as the calibration management system compatible with the lpGBT chip. The I2C slow control and commands to obtain pulses are treated by LADOC.

The second chip, CLAROC (Calibration of Liquid Argon Output Chip), made in XFAB HV 180nm technology, embeds four channels. Each channel is made of a current mirror with a gain of 8 in order to amplify the DAC current and to obtain the full required range (up to 320mA). The mirror is followed by a high frequency switch (1GHz) in order to generate the fast pulse for calibration.

Both chips have been extensively measured in laboratory and also under irradiation (X-Ray and protons). The performance obtained illustrated: a dynamic range up to 320mA in three energy scales with an integral linearity better than 0.1% in each of them, a response uniformity better than 0.2% and a stability better than 0.1%

The technological choices, the various R&D phases and most of the difficulties met will be discussed and illustrated by many measurements.

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