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Electromagnetic Compatibility of a Low Voltage Power Supply for the ATLAS Tile Calorimeter Front-End Electronics

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The front end electronics of the ATLAS Tile Calorimeter is powered by DC/DC conveters that sit close it. The performance of the detector electronics is constrained by the conducted noise emissions of its power supply. A compatibility limit is defined for the system. The noise susceptibility of the front end electronics is evaluated, and different solutions to reduce the front end electronics noise are discussed and tested.

Summary

I. POWER DISTRIBUTION SCHEME FOR THE TILE CALORIMETER

The amount of power required by the front-end electronics of the Tile Calorimeter of the ATLAS experiment imposes the presence of switched power supplies made of custom radiation tolerant DC/DC converters. The power supplies are located inside the detector near the front-end electronics.
The noise of the DC/DC converters deteriorates the performance of the detector: it must be filtered out.

II. EVALUATION OF NOISE PERFORMANCE

The high frequency noise seen by the fast readout electronics is estimated from the pedestals data acquired with the complete data acquisition chain. The noise of the system is estimated by a selection of parameters computed over several runs and on all the channels:
• RMS of the pedestals distribution.
• Gaussian property of the pedestals distribution.
The low frequency noise is evaluated from data sampled by the current integrators ADC.
On the other hand, the noise performance of the power supply is measured on each low voltage output as common mode current amplitude and as voltage ripple for the differential mode component.

III. NOISE PROPERTIES OF THE CONVERTERS

The DC/DC converters emit large common mode currents at the switching frequency and its harmonics, exceeding the limits in use. Beyond the switching frequency, the CM current amplitude is below the usual limits.
The common mode current path is modelled and the amplitude is measured. From this, appropriate filters can be applied.

IV. FRONT-END SUSCEPTIBILITY

The measurements made show that the fast readout electronics is sensitive to high frequency common mode currents (5MHz to 100 MHz). The DC/DC converters noise was already below the usual limits, but further filtering is required due to the high susceptibility of this part of the electronics.
Similar measurements on the slow readout electronics show that this part of the electronics is very sensitive to low frequency ripple (below few kHz). The operating point of the converters must be tuned to minimize the ripple.

V. FILTERING METHODS

Several methods allow reducing and filtering the common mode currents. Among those, the following devices were tested: common mode chokes on the primary and secondary side of the converters, ferrites on the low voltage outputs, decoupling capacitors

between each input and output pins to the case. The chokes show the best performance, especially when placed on each output; however, they are too bulky to fit in the tight space of the low voltage box. As an alternative, ferrites and decoupling capacitors were successfully tested.
The low frequency ripple is minimized by setting the DC/DC converter operating point around mid-capacity. This adjusted at the feedback components of the converters.

VI. CONCLUSION

The noise properties of the DC/DC converters were compared with the susceptibility of the fast and slow readout electronics. From this a noise coupling model was established, and different filtering solutions were exercised. Among those, the use of ferrites and common mode decoupling capacitors appeared to be most suitable method that allows operating the front end electronics within the detector noise specifications.

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