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Ideas on DC-DC Converters for Delivery of Low Voltage and High Currents for the SLHC / ILC Detector Electronics in Magnetic field and Radiation environments.

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We are exploring various way of employing 48 volt DC-DC converters capable of running in high magnetic fields and /or radiation environments of the SLHC and ILC detectors. Tradeoffs with respect to voltage conversion ratios, currents deliverable, radiation, and magnetic field are explored.

Summary

We have been thinking about DC-DC voltage regulators capable of running in up to 5T field and LHC upgrade radiation environment.

Yale University was responsible for the design of the 2.5 V power distribution of the CMS ECAL detector in which the front end electronics requires 50,000 amps. The 750 odd power leads from the power supplies to the 36 super modules dissipate 100 Kilo Watts. The efficiency of the power delivery form the output of the power supplies is less then 40%.

So we ask ourselves “Is there a better way to deliver power to the front end electronics”. There may be techniques available in different fields to need our requirements of radiation environment, high power density and magnetic fields.

Hera is a few different new ideas.

1. Last year Intel Corporation gave a demonstration of a 100 MHz Dc-DC converters built in 90 nm technologies. For several years, their Circuit research laboratory has explored air and ferrite coils with frequencies of up to 480 MHz. They have showed the feasibility of building air coils in 90 nm silicon die. See Ref.1
2. VICOR Power Corporation, a maker of DC-DC converters, has 200 watt power density in a small package of the size of a matchbox with half the thickness. Their simulations show that for a Sine Amplitude Converter Voltage Transformation Module designed to convert 48V to 2V at up to 80A in 1/2 cubic inch using a shielded air core transformer and achieve a full load efficiency exceeding 90%. See Ref.2
3. Many semiconductor companies have ICs with complete DC-DC regulators with output currents of a few amps. The market for these is driven by battery operated handheld gadgets like cell phones, Ipods, blackberries etc.
4. In the past 15 years, there has been a great deal on interest in the power distribution driven mainly by the PC industry. There are books and publication on new topologies that can be used.

The silicon trackers for the SLHC needs a few amperes for the strip hybrids and the Staves/ladder mat take 35 amps. The total tracker current may be about 30 Kamps.

The applications shall be common to all the LHC upgrade detector systems and applicable to ILC. The ILC detectors power can be pulsed to keep the average power low but the electronics need the voltage and peak current to operate.

This development is being pursued with some involvements of the companies like VICOR, Intel Corporation’s research laboratory, Wiener, CAEN etc.

We shall discuss the tradeoffs with the magnetic filed, high radiation environment and current that can be delivered in a single unit.

Ref. 1: Proceedings of the 2004 International Symposium on Low Power Electronics and Design (ISLPED’04) 1-58113-929-2/04 $20.00 ACM
Ref. 1: http://www.vicorpower.com/products/vichip/vtm/index.php

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