Abstract: Submit to
The 3rd International Workshop on Power Supply on Chip
PowerSoC12, November 16-18, San Francisco, CA

Why DC-DC Converters for High Energy Physics?

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The recent discovery of the Higgs particles at the LHC (Large Hadron Collider) was made by two very large particle detectors (CMS and ATLAS) These consist of a large magnet that is filled with and surrounded by, particle detector systems. These detectors have to operate in very high magnetic fields and high radiation levels. Millions of electronic readout signal channels are needed to track, identify and measure the many particles that are produced in high energy collisions.

Yale designed and built the powering system for the ECAL (Electromagnetic Calorimeter) part of the CMS detector at LHC. The front end electronics is located inside the detector and required a total of 50,000 Amps at 2.5V. Using linear regulators (35,000 of them!) at the point of load, the power delivery efficiency was only 40% but if the cost of waste heat removal is included the efficiency is 25%.

Efficient power delivery has been recognized for many years as a major issue for large, high energy physics experiments. DC to DC conversion provides a means to reduce the cable bulk and mass, and the power and heat removal requirements of experiments.

Collaborative efforts over more than five years by groups in Germany, at CERN, and elsewhere in Europe have made progress, but have also demonstrated that the DC-DC conversion requirements of high efficiency, low noise generation, small size and a large voltage reduction ratio are difficult to satisfy simultaneously.

At Yale, we are developing a two stage converter starting with 48 Volts and ending with 1.2 Volts. The intermediate bus (close to the detectors) is 5 volts and converters for 5V to 1.2V will be used at the point of load. High frequency operation is essential to allow use of air core inductors and keep physical size and mass small.

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