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bPOL48V, rPOL48V and linPOL48V: 48V-input-rated rad-hard POL converters for HEP experiments

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Three new Point-of-Load (POL) converters, suitable for the High Luminosity –Large Hadron Collider (HL-LHC) experiments and for space/avionic applications, are under development. The two DCDC converters, called bPOL48V and rPOL48V, allow a significant improvement in the power delivery requirements as they can provide higher power at an increased input voltage of 48V, compared to existing solutions. The linear regulator, called linPOL48V, can supply up to 200mA with programmable output voltage, from up to 48V input. This work addresses the characterization of bPOL48V and linPOL48V, which are approaching production readiness, and the first results obtained on the rPOL48V prototype.

Summary (500 words)

A compact, rad-hard and efficient power distribution strategy for HEP detectors, based on two cascaded Point-of-Load DCDC converters, was proposed in previous works: a first-stage converter (bPOL12V) creates a 2.5V domain from a 12V input line, which powers the opto-electronic components. Second-stage converters (bPOL2V5) further step down the voltage to supply the front-end analog and digital circuits. These converters are today in production for the HL-LHC. In this work, a new conversion stage is introduced, able to step down the voltage from an input line up to 48V. It can provide a larger output power compared to existing converters and can be used to supply several bPOL12V, significantly reducing the current in the long cables from the off-detector power supplies.

Two converters, bPOL48V and rPOL48V, are in design phase. Both use commercial Gallium Nitride (GaN) devices as power switches, which offer a reduced on-state resistance and a faster switching speed compared to silicon MOSFETs and are highly tolerant to radiation. Furthermore, a rad-hard linear regulator, linPOL48V, has been developed.

bPOL48V is a buck converter able to provide 12A maximum output current. Its output voltage can be programmed down to 1.2V, making it usable for 12V-20V to 1.2V-2.5V and 48V to 5V conversion ratios for future developments. Its controller has been designed at CERN using a high-voltage commercial 0.35µm CMOS technology. It features several internal linear regulators to supply the control circuitry and the external power modules, a predictive logic to optimize the dead times and a voltage-mode control loop. The efficiency at full load is above 90% (48V to 12V), the converter has been tested up to a TID of 50Mrad without appreciable change in the performance, while single event tests showed that there are no destructive events up to an LET of 88 MeV*cm2/mg. Only rare Single Event Transient on the output voltage have been found, with transient duration of less than 10µs and amplitude smaller than 20% for LET=40 MeV*cm2/mg. Displacement damage tests are ongoing, and the results will be included in the final version of this work. bPOL48V is production ready, 30 wafers have been produced.

rPOL48V is based on a resonant architecture, which significantly reduces the inductors value, allowing to use commercial off-the-shelf components. It has a fixed conversion ratio of 4 and features very high efficiency and output current up to 50A. A non-rad-hard version of this converter has been developed using commercial components: commercial drivers and GaN devices, and a FPGA for the control. In parallel, a rad-hard version of the drivers and the controller is being designed at CERN. The developed prototype shows that this is a very promising architecture, with a peak efficiency over 96% and 93% at full load.

linPOL48V can provide a selectable voltage and up to 200mA from to 48V input. It has been already tested for TID and SEE, showing similar radiation tolerance to bPOL48V.

The three POL converters will be presented in detail in the final paper along with all the electrical and radiation characterization.

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