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A new Rad-Hard DC/DC buck converter ASIC for LHC experiment upgrades

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In view of production for Phase1 LHC experiment upgrades a new DC/DC buck converter ASIC prototype has been designed and integrated in a commercial 0.35um technology.
This circuit is called FEAST and it has been designed for radiation tolerance up to the tracker levels and it can operate in strong magnetic field. In particular resistance to Single Event Transient has been enhanced in comparison to previous prototypes.
It provides stable voltage conversion from 12V to 600mV-5V with efficiency above 80%. It embeds also protection circuits as over-current, input under-voltage and over-current.
FEAST design details, first functional and radiation tests will be presented.

Summary

In view of LHC experiment upgrades, where the front-end electronics will require higher current at lower voltage, it is necessary to study a new power distribution scheme. We propose a solution based on inductor-based DC/DC buck converters, which allow local regulation, form an input voltage up to 12V to an output voltage in the range 600mV-5V.
The converter should work in a radiation environment with a magnetic field higher as high as 4T. For this reason, and in view for production for Phase1 upgrades, custom air core inductors have been developed in order to optimize the efficiency of the converter.
In this context a radiation hard buck converter ASIC, called FEAST, has been designed and integrated in a commercial 0.35um technology with high voltage extension. This converter operates at a switching frequency of 1.5-2MHz, with an inductance 200nH-400nH and output current from 0 to 4A.
Although the previous prototype (AMIS5, presented in TWEPP 2012) was functional, a number of issues needing to be addressed before production readiness were observed. In particular sensitivity to Single Event Transient has been detected during heavy ions irradiations. In order to identify the sensitive nodes, a pulsed laser test has been done and the found weak points has been reinforced or re-designed in FEAST.
In AMIS5, p-in-Nwell diodes are widely used as gate protection clamps in circuits working at 12V. After accurate tests and contact with the foundry we discovered that these diodes, when polarized in forward region, behave like bipolar transistors. The result is a "leakage"current (5-7 mA) flowing from Vin to substrate. Hence in FEAST theses diodes has been changed with diode-connected transistors.
Additionally in FEAST the turn-off procedure has been completely re-designed in order to avoids stuck states detected in AMIS5 in some corner conditions (for example with fast input voltage transients from 10V to below 3V in less than 100us).
Samples of these circuits are expected back for testing in August, and first results - including some radiation tests at our X-ray machine - will be presented together with a detailed description of the functionality of FEAST. Plans for the pursue of the work will be presented, and in particular the organization for mass production for Phase1 upgrade.

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