Low Voltage Power Supply Schemes Experiences with the HADES-Upgrade

- Short Overview: HADES + Upgrade + Motivation
- DC/DC converters used at the FEE
- LDO based system
- Summary



High Acceptance DiElectron Spectrometer HADES Upgrade: DAQ



- 100.000 front-end channels
- 100 kHz event rate
- 400 MByte/s data rate

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DC/DC-Converters and Analog Electronics

- Paul Horowitz, Winfield Hill: The Art of Electronics (The Bible) + all experts
 - Don't use DC/DC converters for analog electronics!
- This really motivates to try it out!



Switcher vs. Linear Regulation

DC/DC vs LDO:

- Pro:
 - More efficient for large ΔV and high currents
 - Galvanic isolation is possible
- Cons:
 - Produces noise: conduced and radiated
 - Larger footprint depending on current
 - More expensive

DC/DC Market

- Point-of-Load Alliance: POLA
 - multisourcing of pin-compatible, nonisolated, pointof-load power modules

30A output current 2.95-3.65V input voltage range Output voltages from 0.8V up to 2.5V Industry standard POLA™ compatible 34.8 x 28.5 x 9.00 mm High efficiency, up to. 93% Auto Track™ sequencing pin More than 2.1 million hours MTBF



Proprietary solutions: e.g.: μModules





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Concept



- 48V standard power distribution over larger distances
- 5V bus voltages on PCB
- Second DC/DC regulation at the point of load
- Filtering at the load



First Application: 128 channel TDC





- DC/DC supplies and filters
- Down to 20ps time resolution
- FPGA-TDC: 10ps RMS time resolution (no tails)



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Filtering



HADES

- Pi-Filters: Low ESR Caps, Ferrite beads
- Second order: Common-Mode-Filters

TOF

- TOF: 128 channel PMT discriminator and charge measurement
 - Completely based on switchers on the same board
 - No channels fire down to a sub 1mV threshold
 - No change in performance if linear lab supplies are used as a reference!
- Conclusion: small common and differential noise on the PCB doesn't matter!
 - PSRR value of modern OpAmps: 60-80dB (DC)

RPC Weight States

- amplification (factor 100) + discrimination + charge measurement
 - Distributed system with DC/DC separated and filtered
 - No difference in performance between linear lab power supply and custom DC/DC solution could be measured





Shower

- 96 channel ADC
 measurement
- Differential signal input
- DC/DC directly on board
- No noise floor on the ADC measurement







- 30k channels pad-plane
- 700e noise
- DC/DC on • FEE didn't work

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50cm distance solved the issue completely



Multiwire Drift Chamber





- 40k antennas
- Very sensitive to radiative noise => no DC/DC directly at the detector
- Huge effort to deal with linear regulators: heat, high currents, etc.



MDC power-supply



• 8 times 180A power supplies, 1500W each



Conclusion

- Horowitz, Hill: Are right and wrong at the same time!
 - Conductive noise seems to be under control with "simple" filtering
 - Most of the FEE-electronics can be built with switchers
 - Radiative noise is seen, if DC/DC is close to very sensitive detectors (like drift chamber antennas)
 - Distance (50cm) helps a lot (no noise measurable, on the 700e level)
 - Your mileage may vary but it is worth a try
 - New low noise devices on the market every week
 - Hot topic

