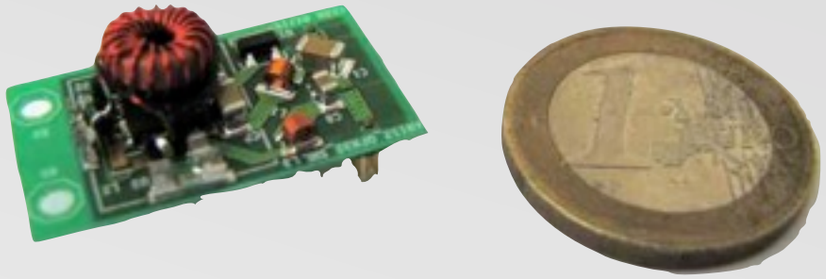


Status of WP2 (On-detector power distribution)

F.Faccio, S.Michelis, G.Blanchot, C.Fuentes, B.Allongue
- decrease in manpower as from Jan 1st with departure of S.Orlandi (fellow)

Outline

- ASIC
  - Technology
  - Design
- Full converter boards
  - Air-core inductor
  - Low-noise board design
  - Integration in detector systems

ASIC design

	AMIS2
Full control loop	✓
Dead times' handling	Fixed
On-chip regulator	No
Soft Start	Simple RC
Over-I protection	No
Over-T protection	No
Under-V disable	No

ASIC design

	AMIS2	IHP1
Full control loop	✓	✓
Dead times' handling	Fixed	Adaptive (QSW)
On-chip regulator	No	No
Soft Start	Simple RC	Simple RC with comparators
Over-I protection	No	No
Over-T protection	No	No
Under-V disable	No	No

ASIC design

	AMIS2	IHP1	IHP2
Full control loop	✓	✓	✓
Dead times' handling	Fixed	Adaptive (QSW)	Adaptive (QSW and CCM, sharp
On-chip regulator	No	No	✓
Soft Start	Simple RC	Simple RC with comparators	Full sequence with comparators
Over-I protection	No	No	✓
Over-T protection	No	No	No
Under-V disable	No	No	No

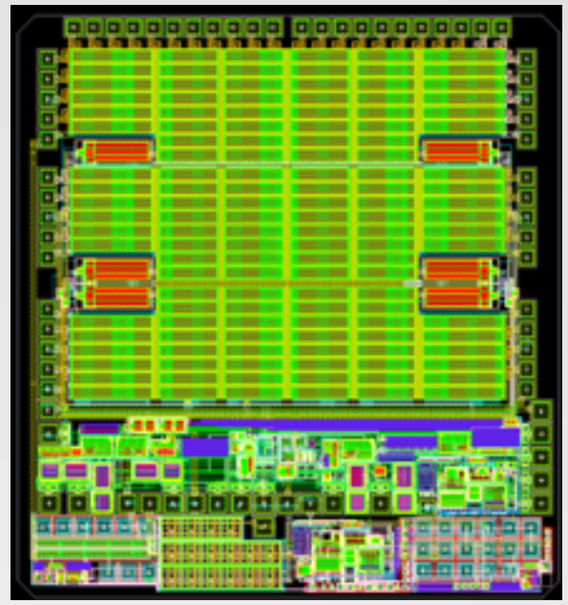
ASIC design

	AMIS2	IHP1	IHP2	AMIS3
Full control loop	✓	✓	✓	✓
Dead times' handling	Fixed	Adaptive (QSW)	Adaptive (QSW and CCM, sharp	Fixed
On-chip regulator	No	No	✓	✓
Soft Start	Simple RC	Simple RC with comparators	Full sequence with comparators	Simple RC
Over-I protection	No	No	✓	No
Over-T protection	No	No	No	No
Under-V disable	No	No	No	No

ASIC design

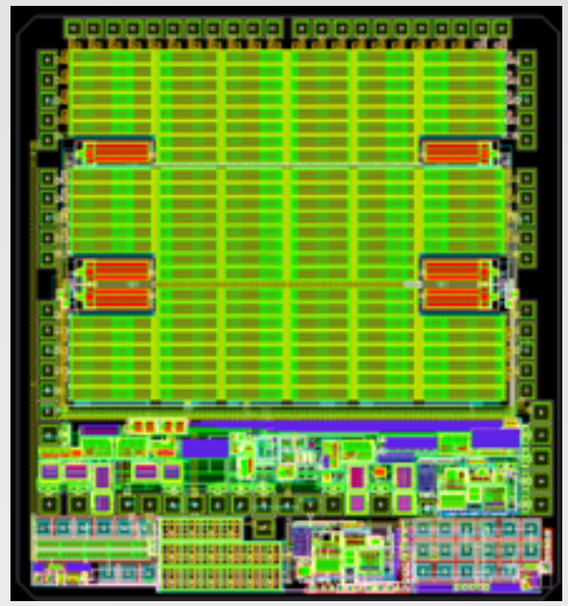
	AMIS2	IHP1	IHP2	AMIS3	AMIS4
Full control loop	✓	✓	✓	✓	✓
Dead times' handling	Fixed	Adaptive (QSW)	Adaptive (QSW and CCM, sharp	Fixed	Adaptive (QSW and CCM, smooth
On-chip regulator	No	No	✓	✓	✓
Soft Start	Simple RC	Simple RC with comparators	Full sequence with comparators	Simple RC	State machine
Over-I protection	No	No	✓	No	✓
Over-T protection	No	No	No	No	✓
Under-V disable	No	No	No	No	✓

AMIS3



AMIS3

- Converter identical to AMIS2, but with the only addition of on-chip Linear Voltage Regulator to provide 3.3V from the unique input line (10V)



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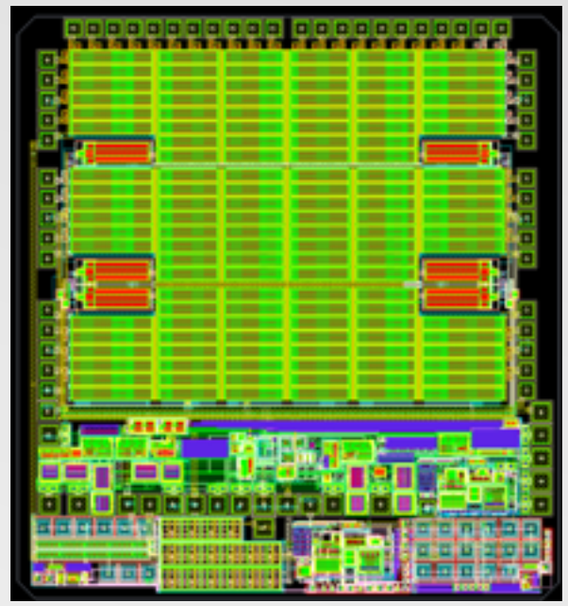

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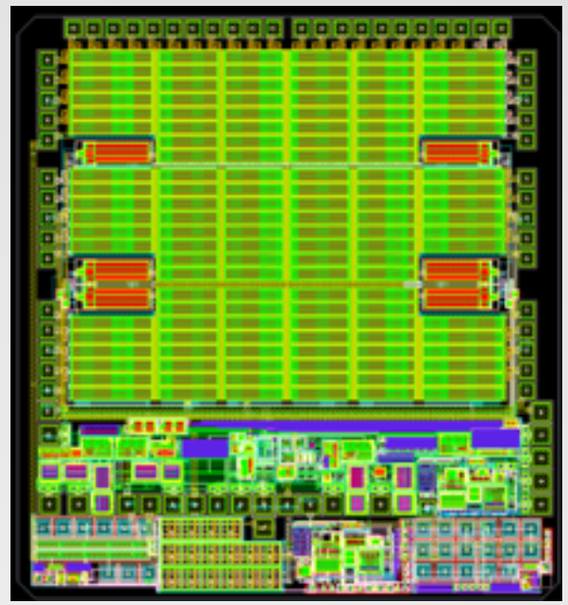

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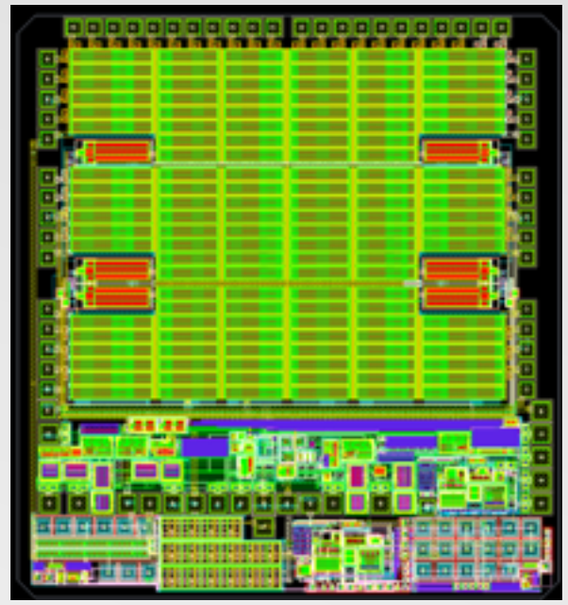

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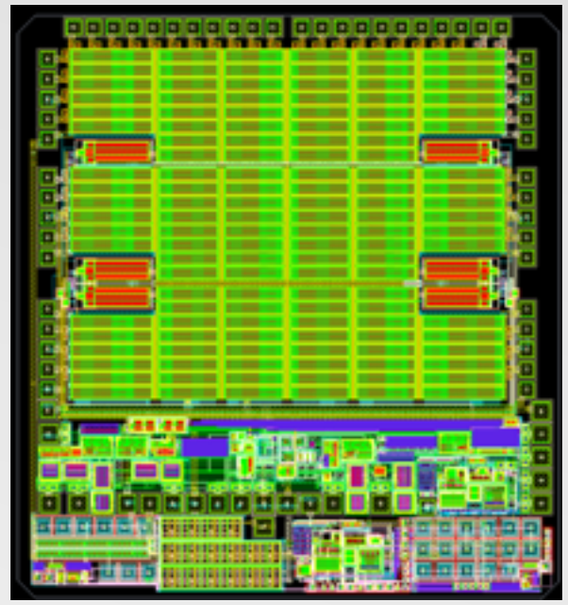

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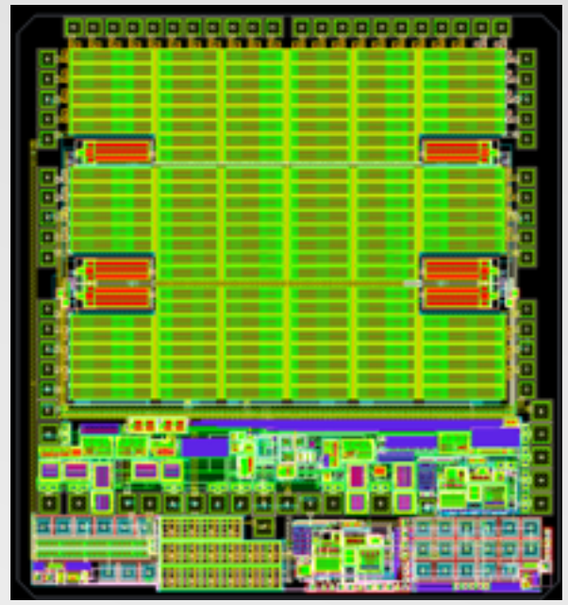

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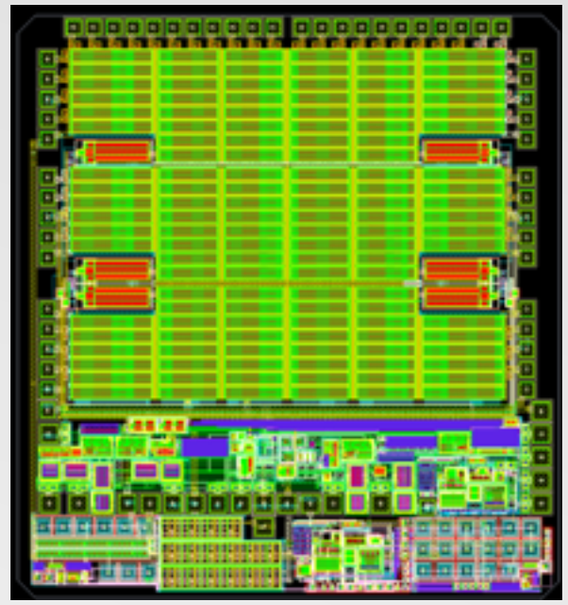
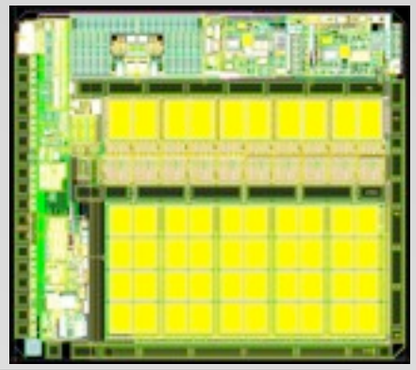
- Purpose:
  - Test again On-Semi hardware (AMIS2 manufactured in first semester 2009), especially radiation
  - Provide a working rad-tol converter not needing external regulator to colleagues working on system integration
- Packaged in QFN32 for system testing (as AMIS2)



AMIS4



- Internal BGP ref (as AMIS2) and Linear Voltage Regulators to provide on-chip 3.3V from unique input rail
- Integrated feedback loop with bandwidth of 100Khz - can be lowered with external passives
- Internal oscillator fixed at 2MHz, tunable with external components
- Vout set to 2.5V, tunable with external components
- Protection features:
  - SEU-protected state machine rules entrance and exit from failure states and beginning of Soft Start (about 2ms long)
  - Under-voltage detection at the input enables converter only above 5V
  - Over-T detection turns off the converter when on-chip T exceeds 100C
  - Over-current detection is implemented on a cycle-by-cycle basis, and limits max current on HS transistor on each cycle. After 32 consecutive detections (synchronous with clock), the converter is reset and a Soft Start begins
- Other features:
  - Enable pin to turn on-off the converter
  - Power good output flag (only asserted during ‘good’ state of the converter, with regulated Vout)

- Chip Size: ~2.875 x 2.55 mm2
- Packaged in QFN-EP 32 (first lot in QFN48 for functional test)
- To reduce parasitic resistance, unusual bonding configuration chosen (pads in the middle of the chip). Discussions on-going via IMEC with packaging house (ASE) to find appropriate, cheap and reliable assembly

- Submitted to IMEC MPW on January 24th. Purchase of 1 extra wafer should ensure availability of at least 100 parts (probably more)
- We expect testing in summer

“Behavioral” model for the converter

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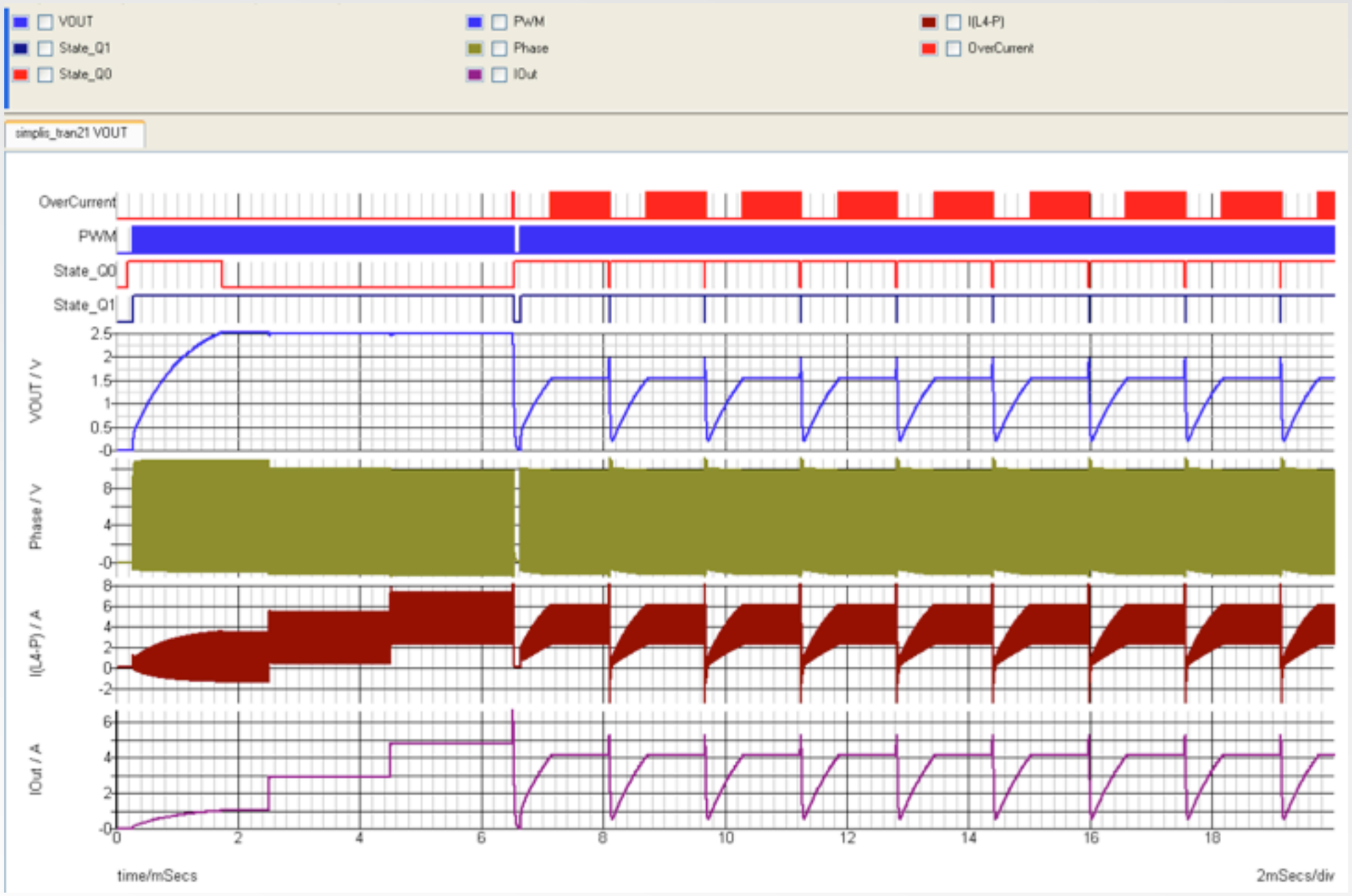
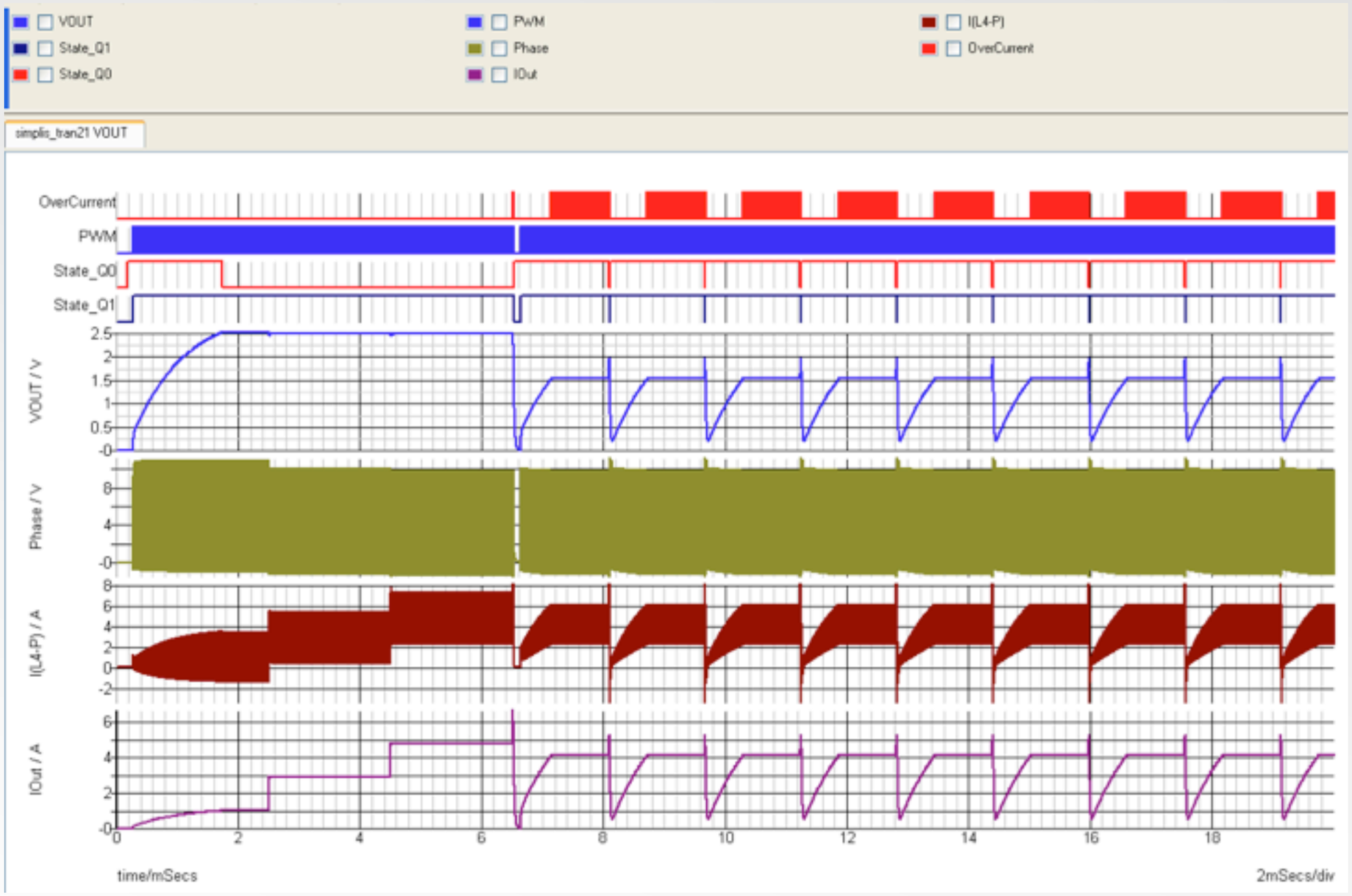
  - It will be used to simulate the converter embedded in a detector system

“Behavioral” model for the converter

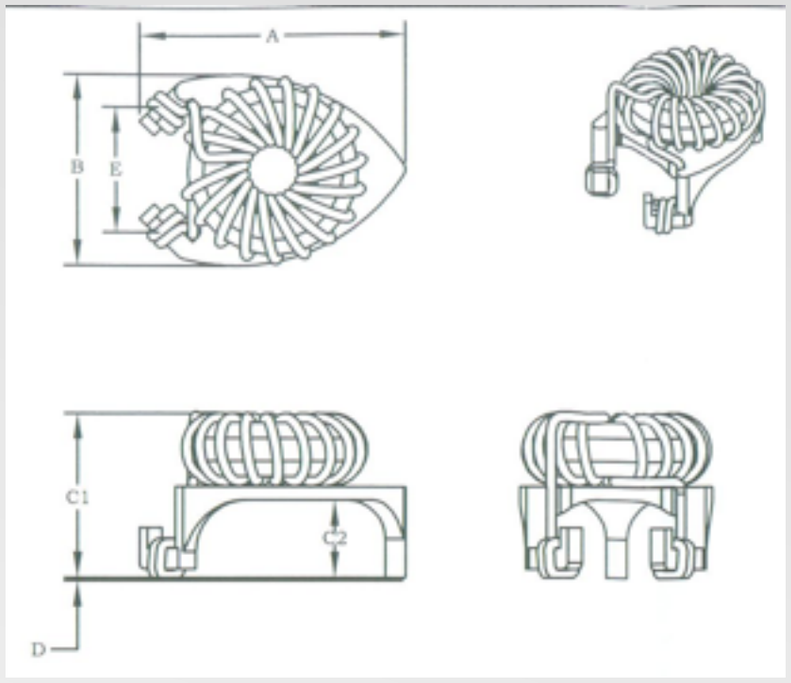


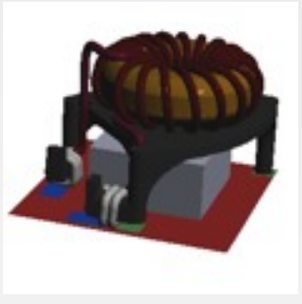
“Behavioral” model for the converter

- Example: start-up at 1A load followed by step-increases of 2A. At 7A, overcurrent protection is active.



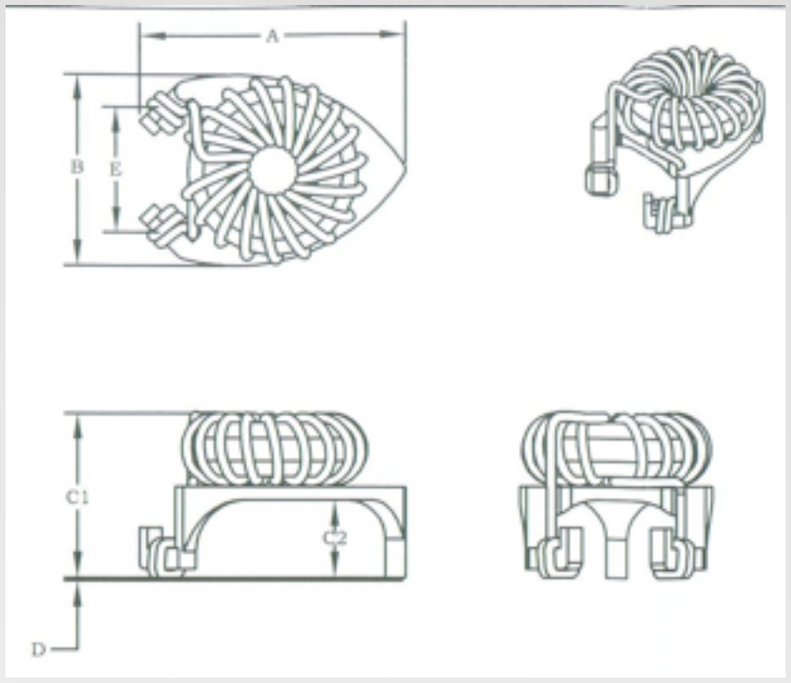
Air-core inductor

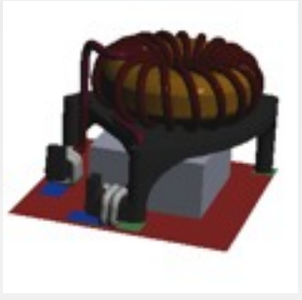




Air-core inductor

- Tolerance to B field imposes air core coils
  - Air core typical inductance values: 5-700 nH MAX





Air-core inductor

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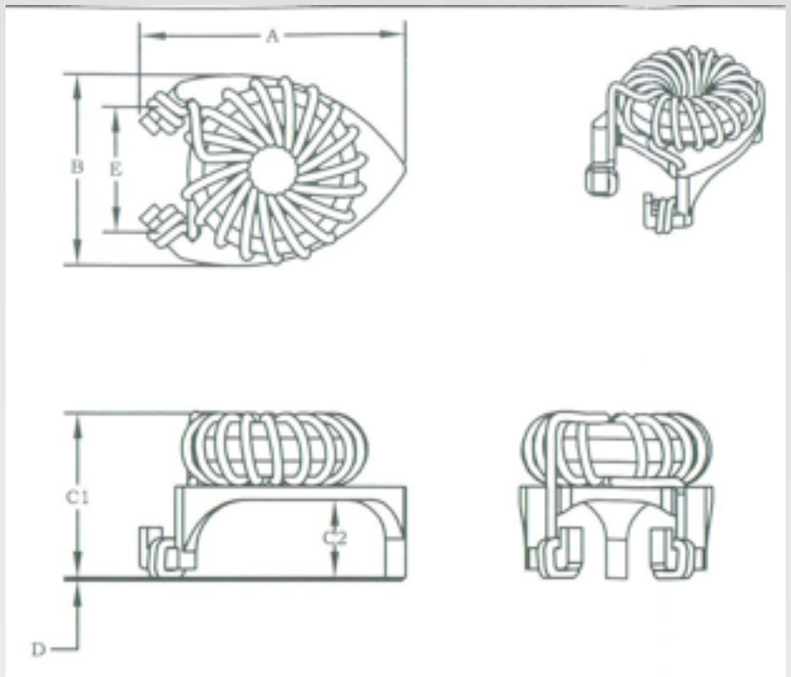
- Toroidal topology was selected in 2009
  - Compact geometry
  - Radiates significantly less magnetic field than other topologies
  - Air core toroidal inductors not available commercially: custom development enabled for mass production is required



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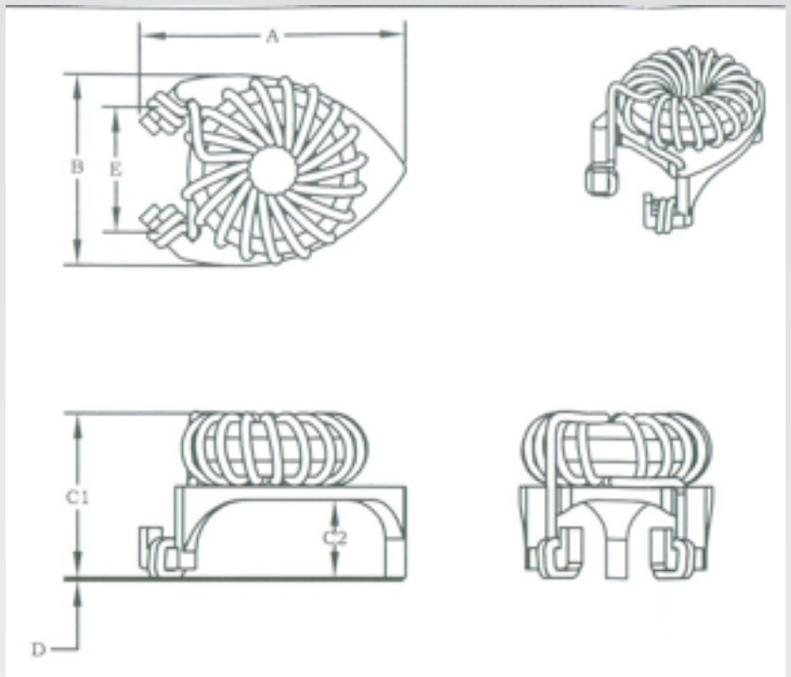
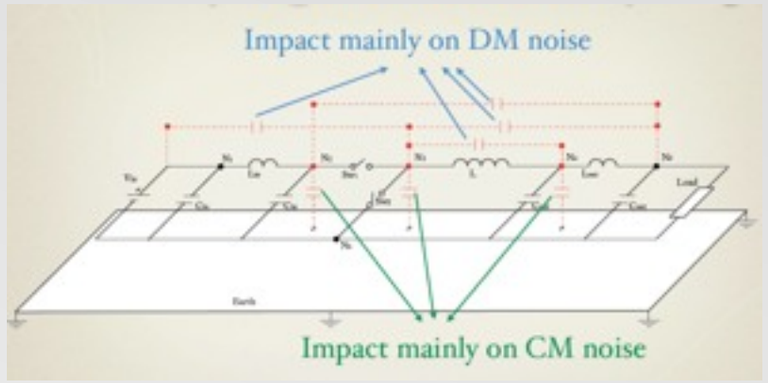
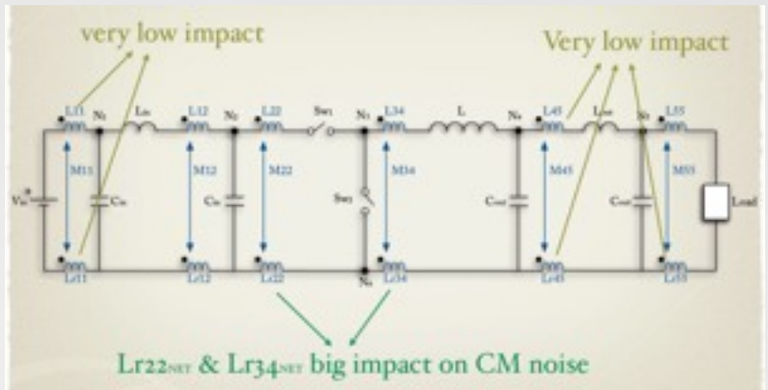
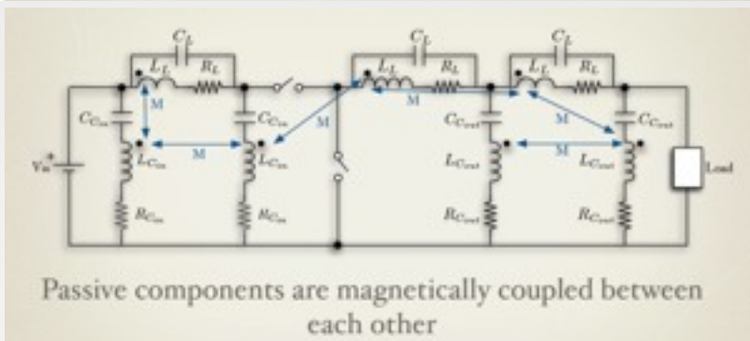
  - Air core toroidal inductors not available commercially: custom development enabled for mass production is required
- Development succeeded with Coilcraft:
  - 220nH/30mΩ air core toroid
  - Coil mounted on plastic stand-off to fit precisely above the converter ASIC
  - Prototypes delivered in 2010. One sample successfully radiation tested at PS (8E15 p/cm^2)
  - Order for production of 500 samples issued, delivery end of March
  - Expected total mass: slightly less than 0.4g



Optimization of full DCDC converter boards







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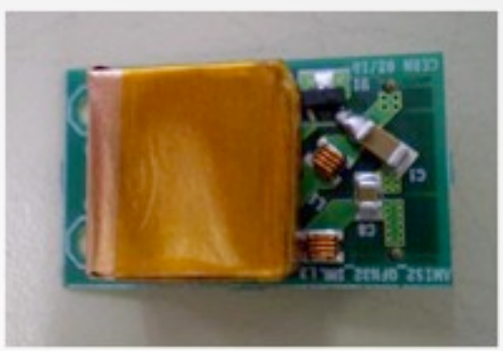
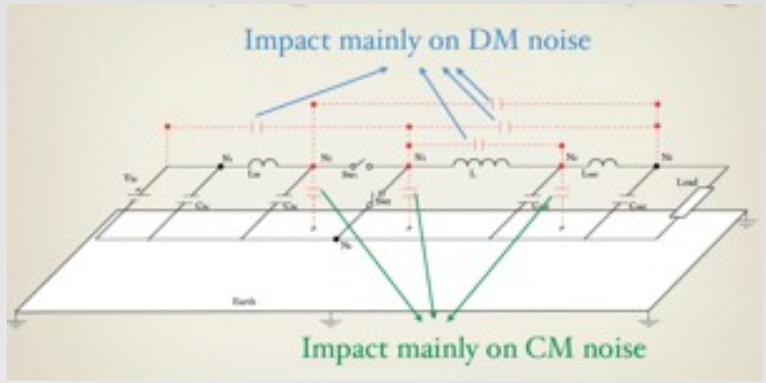
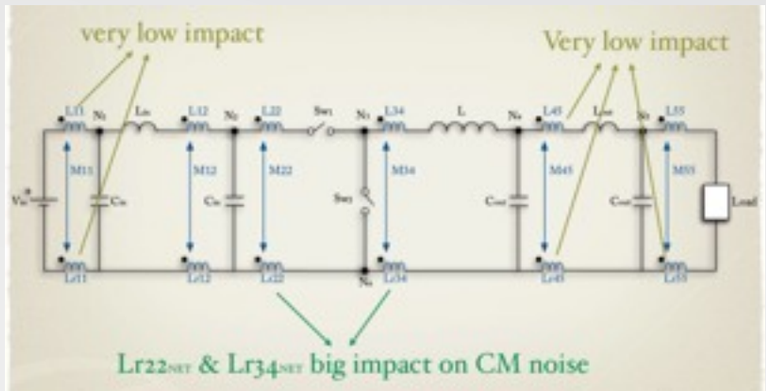
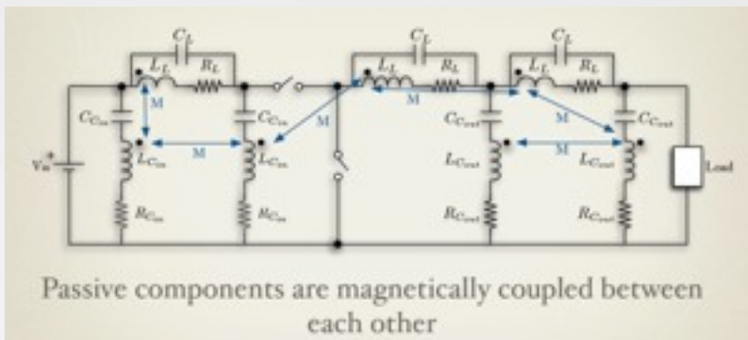


Optimization of full DCDC converter boards

- Roadmap for EMC optimization of DCDCs







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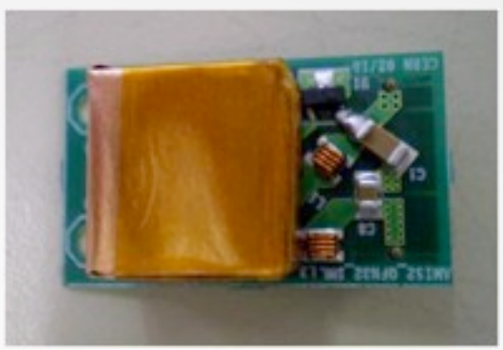
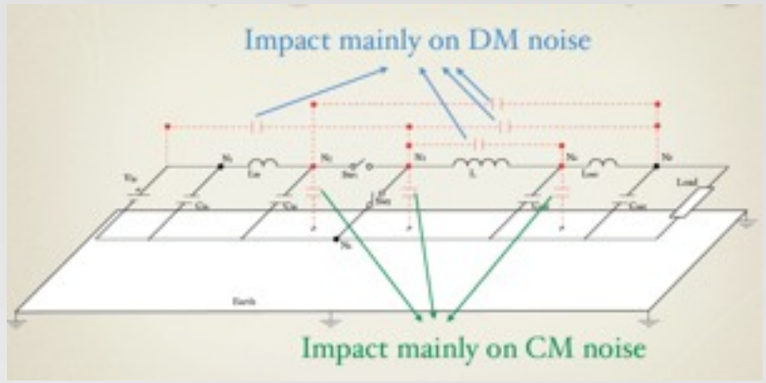
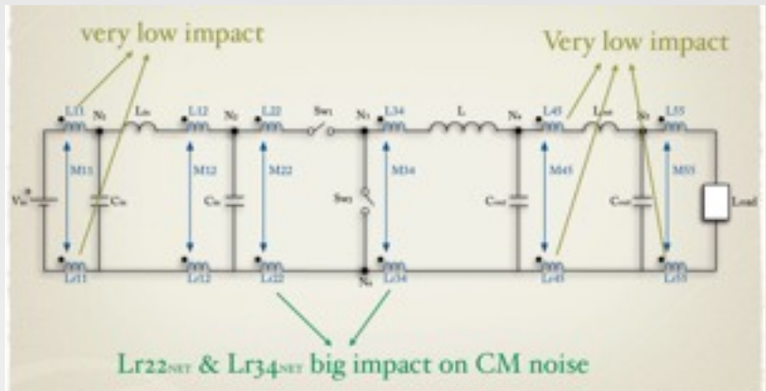
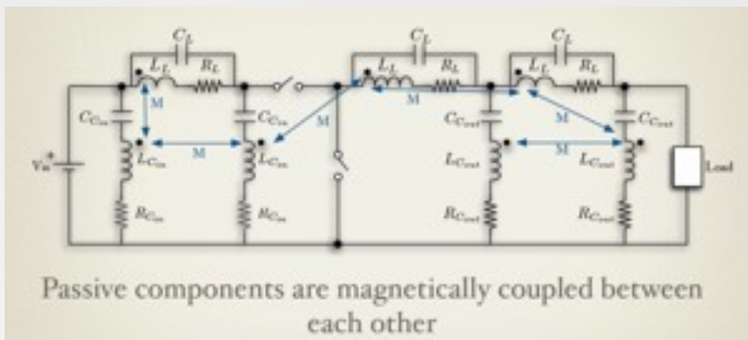


Optimization of full DCDC converter boards

- Roadmap for EMC optimization of DCDCs
  - Critical stray capacitances identification.







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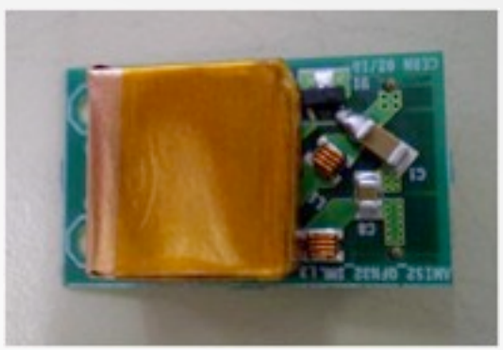

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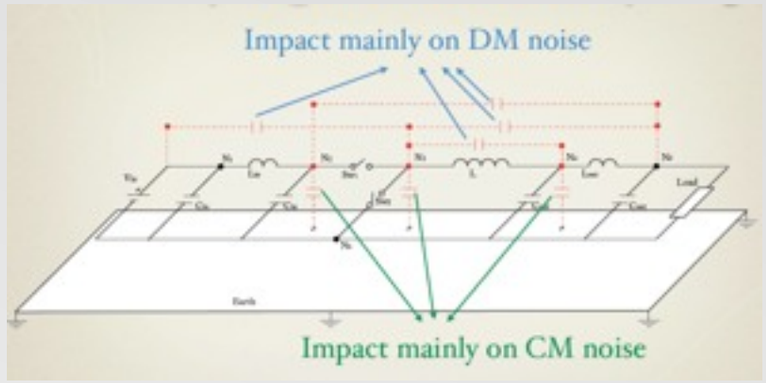

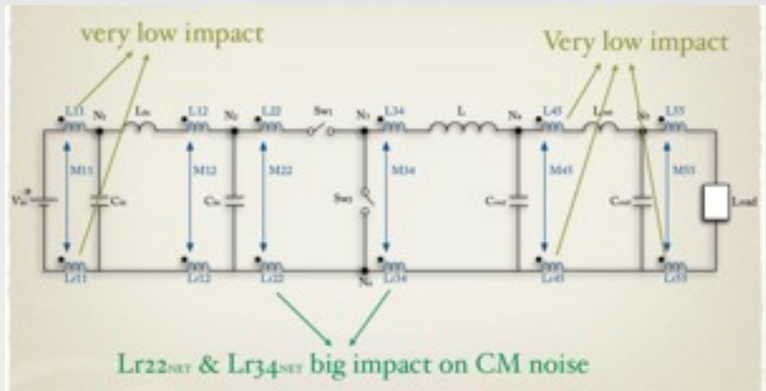

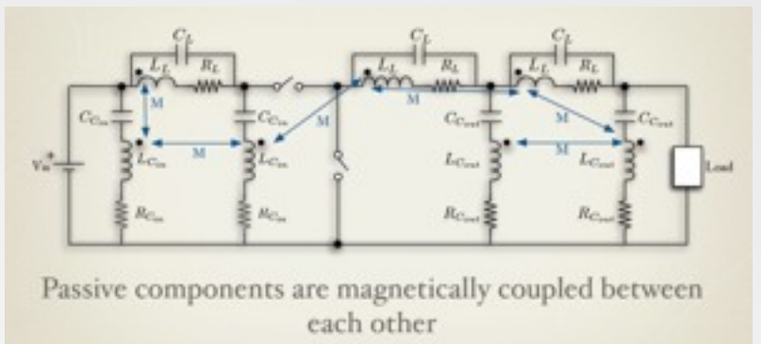

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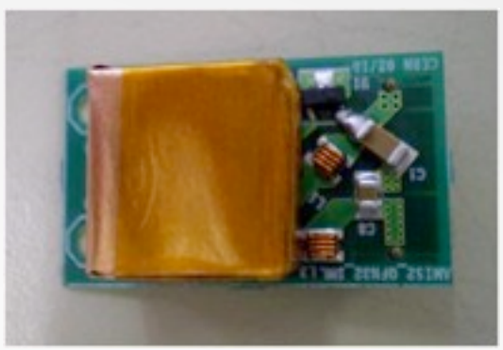

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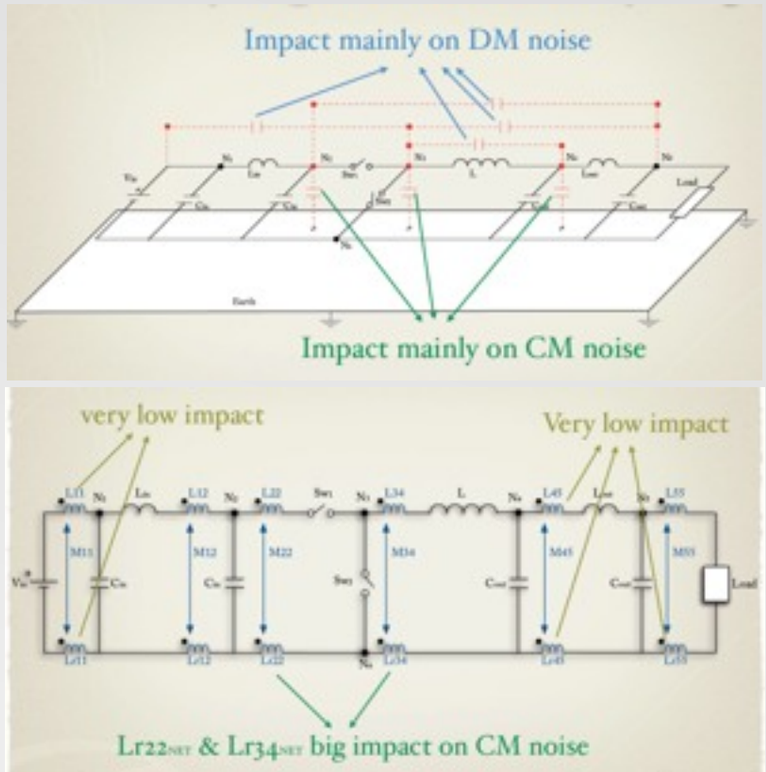

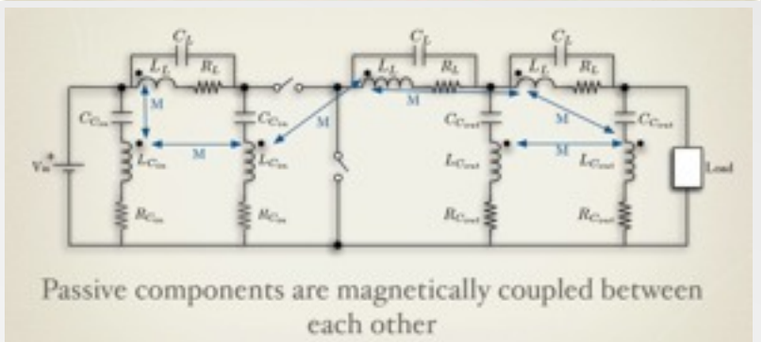

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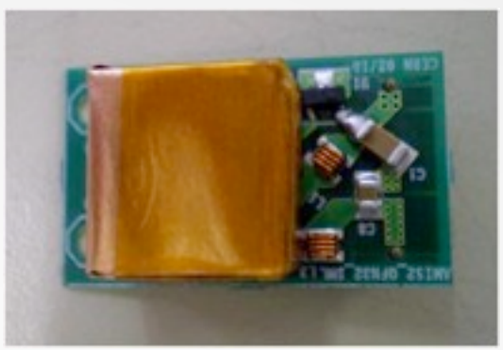

Optimization of full DCDC converter boards

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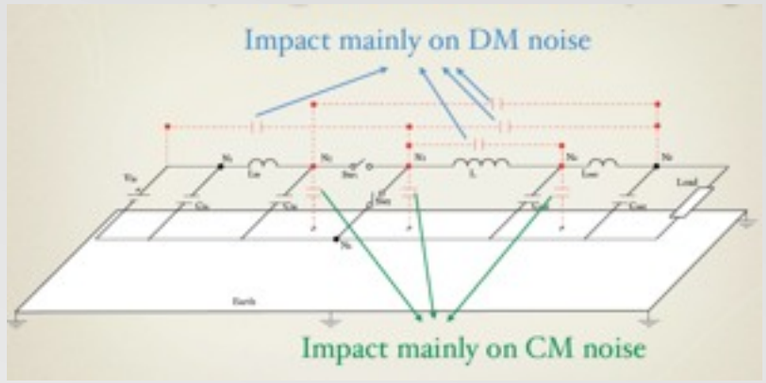
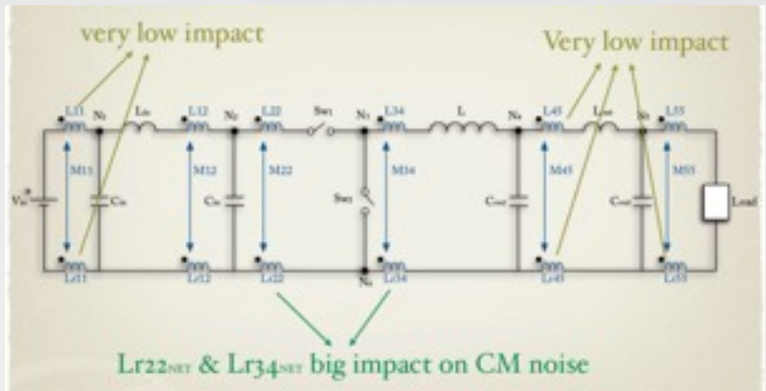
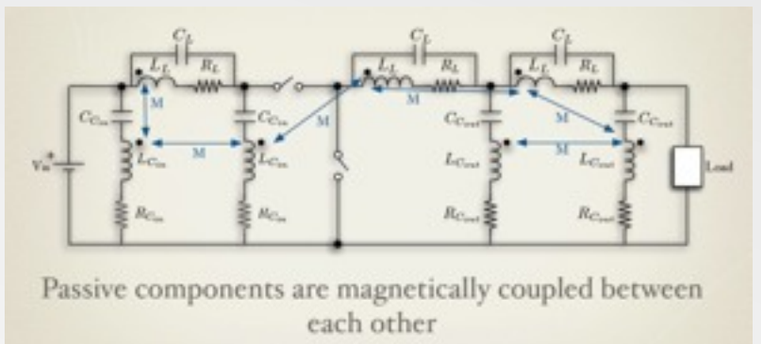
- Noise optimization of DCDCs :







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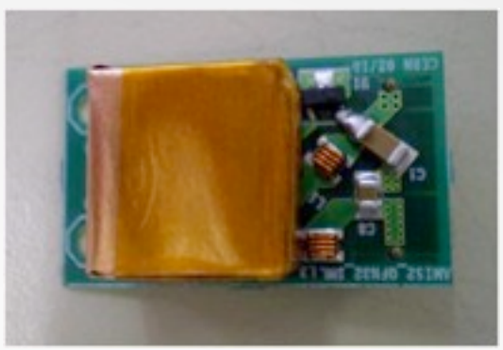

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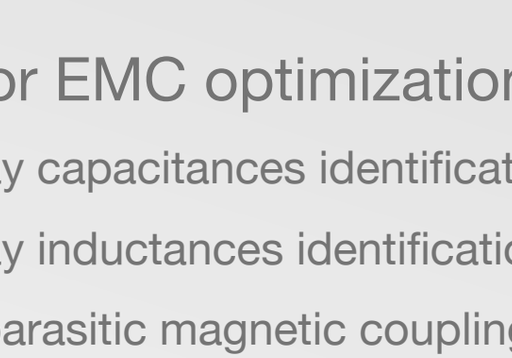

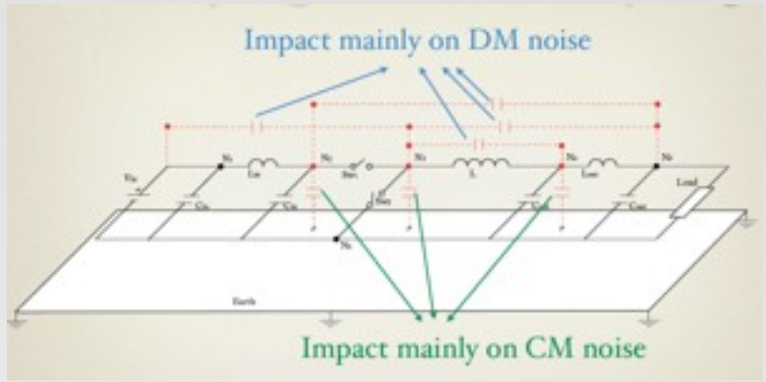

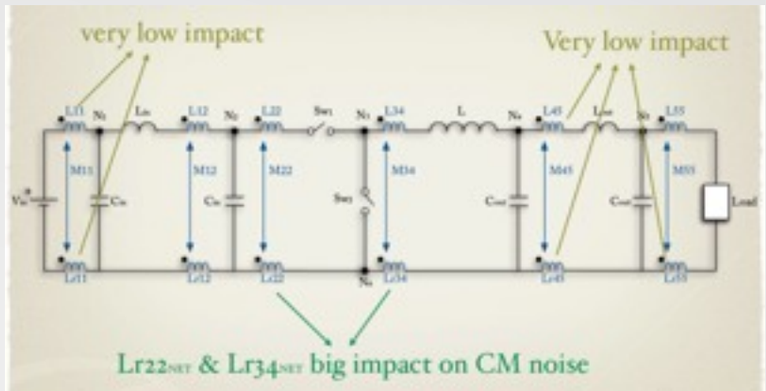

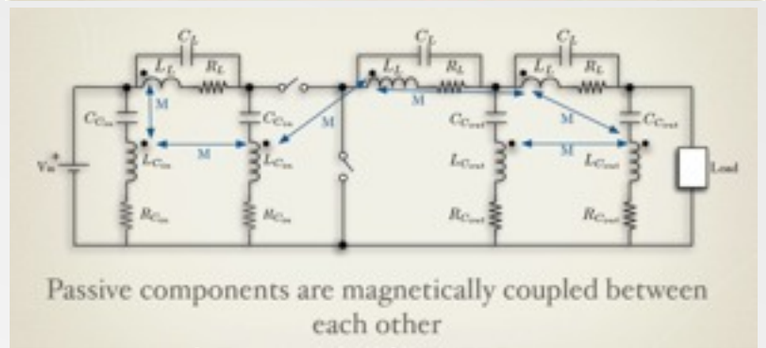

C.Fuentes talk @ TWEPP

Optimization of full DCDC converter boards

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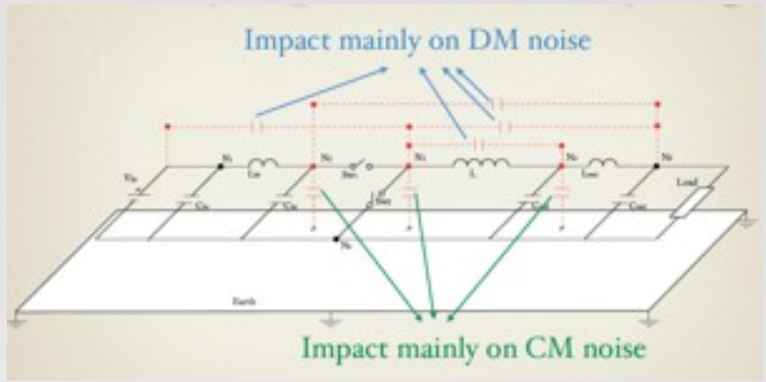

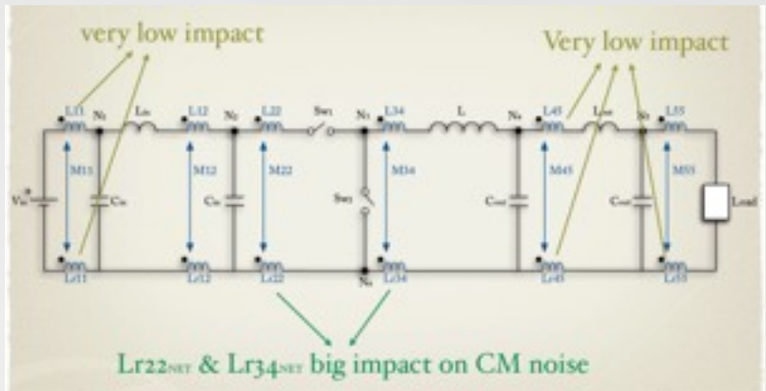

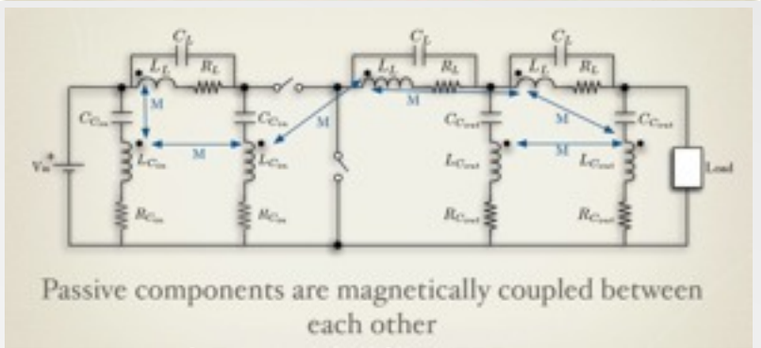

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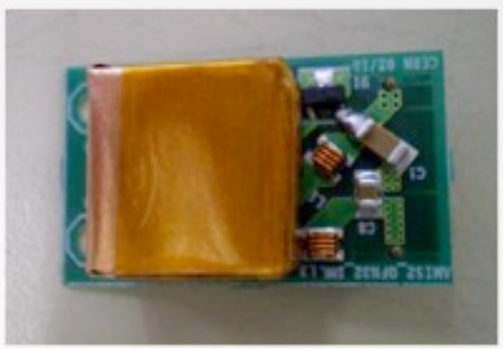

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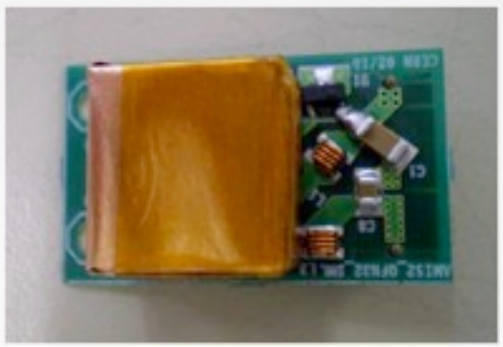

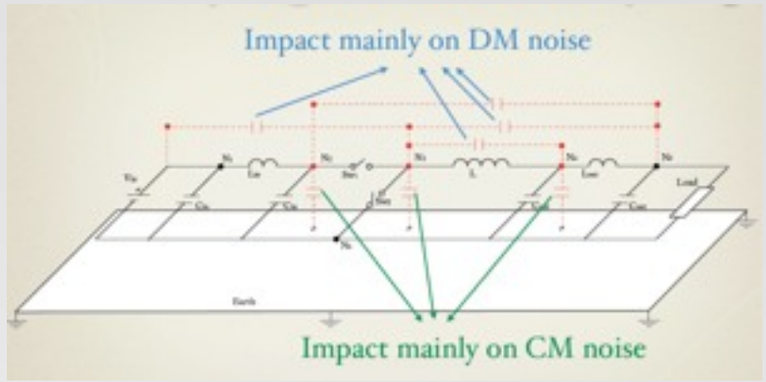

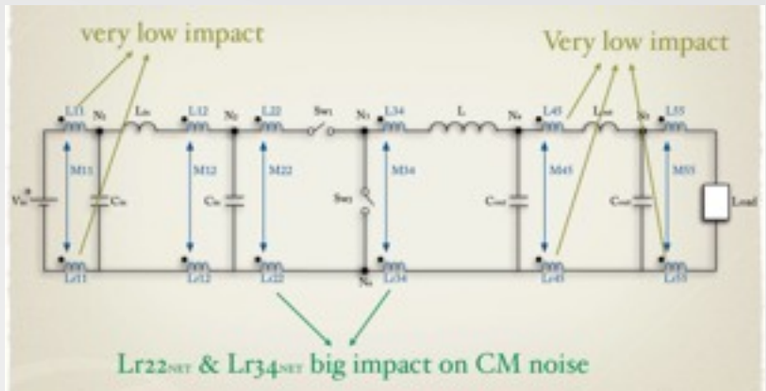

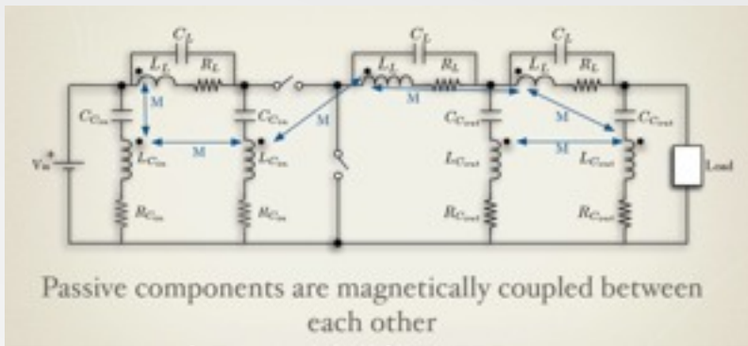

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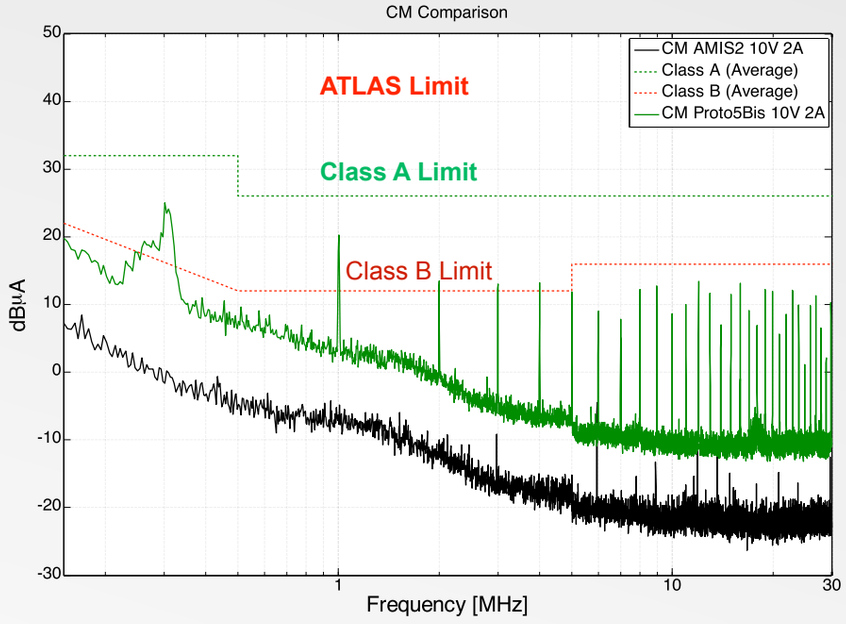

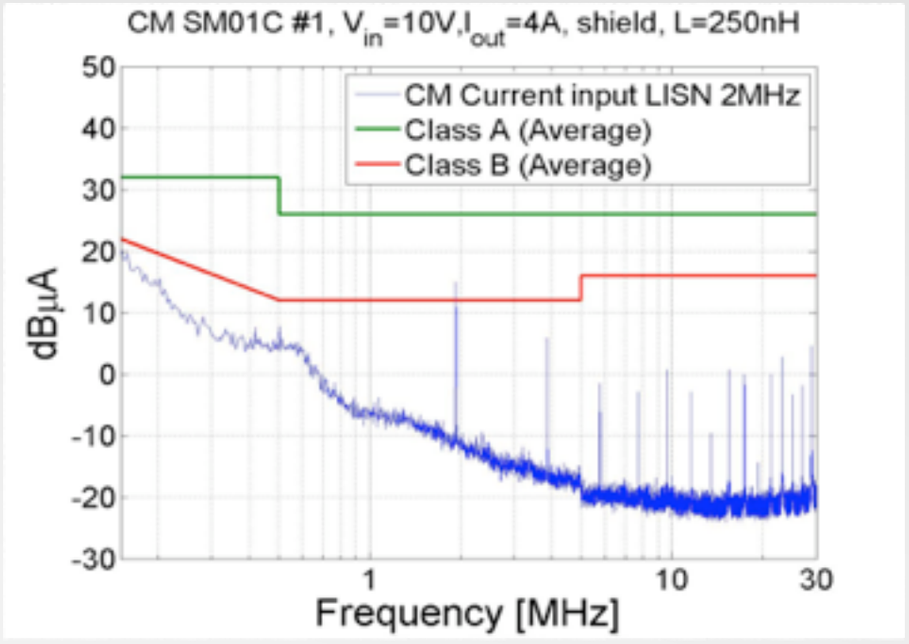

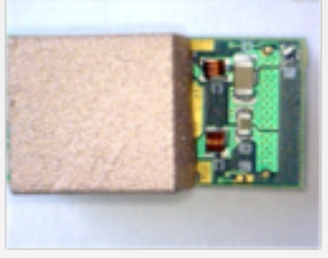

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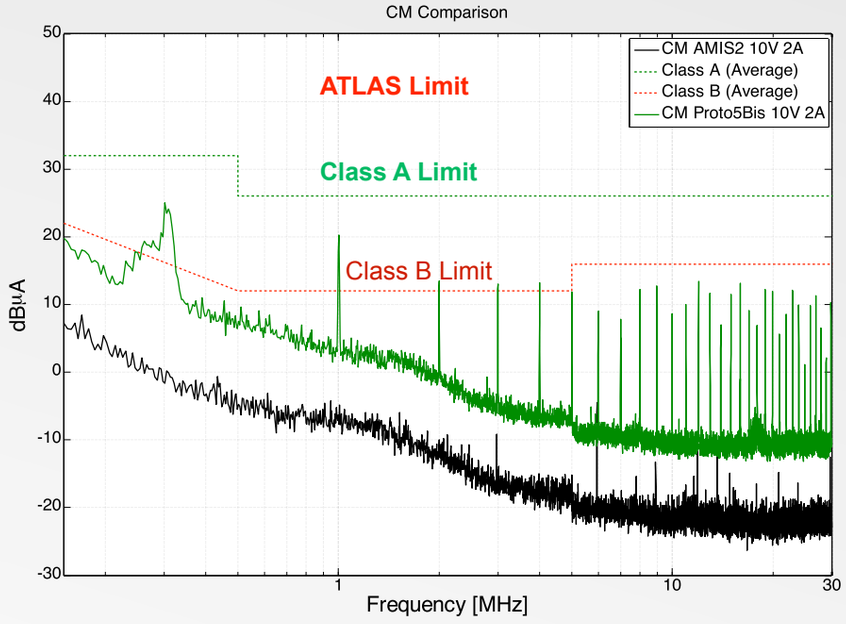

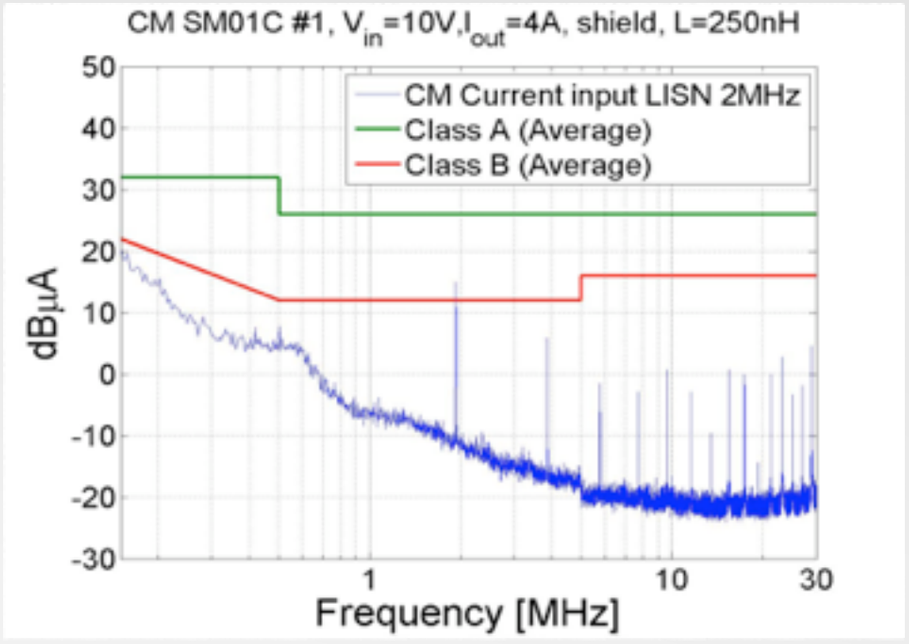

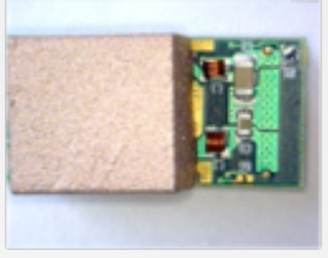

Full converter boards

- Using the AMIS2 ASIC
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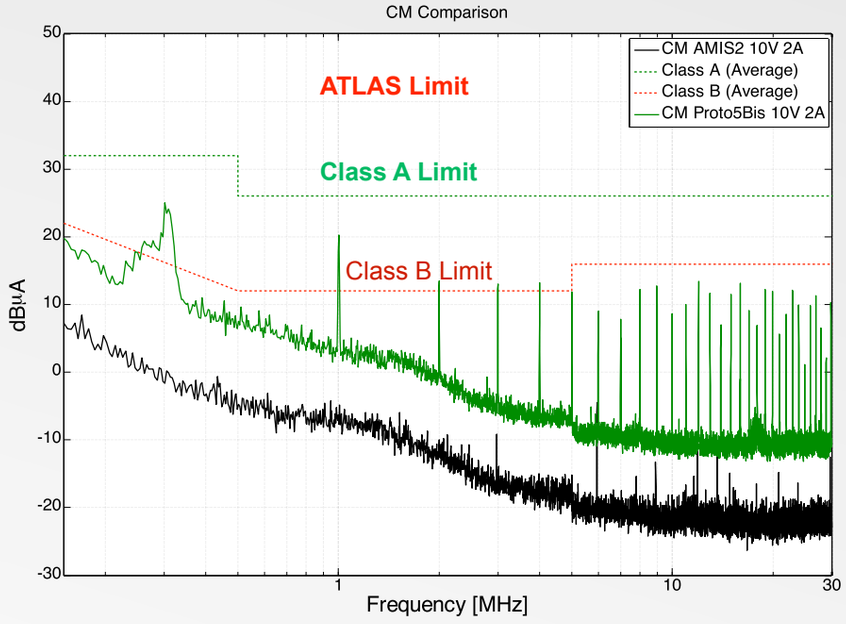

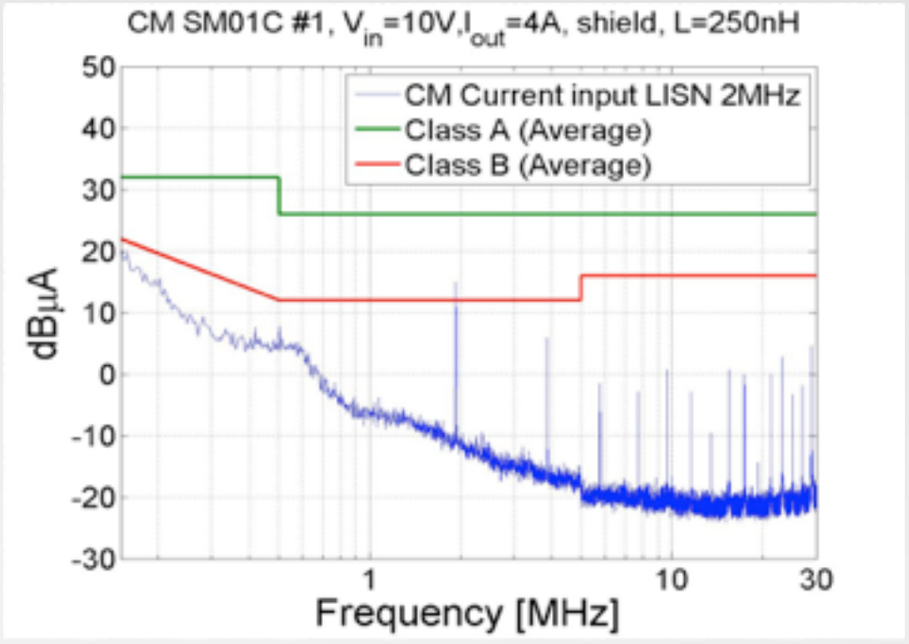

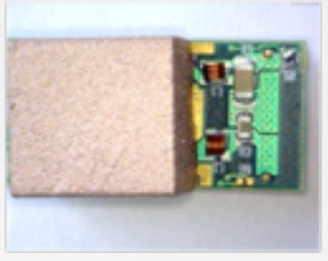

Full converter boards

- Using the AMIS2 ASIC
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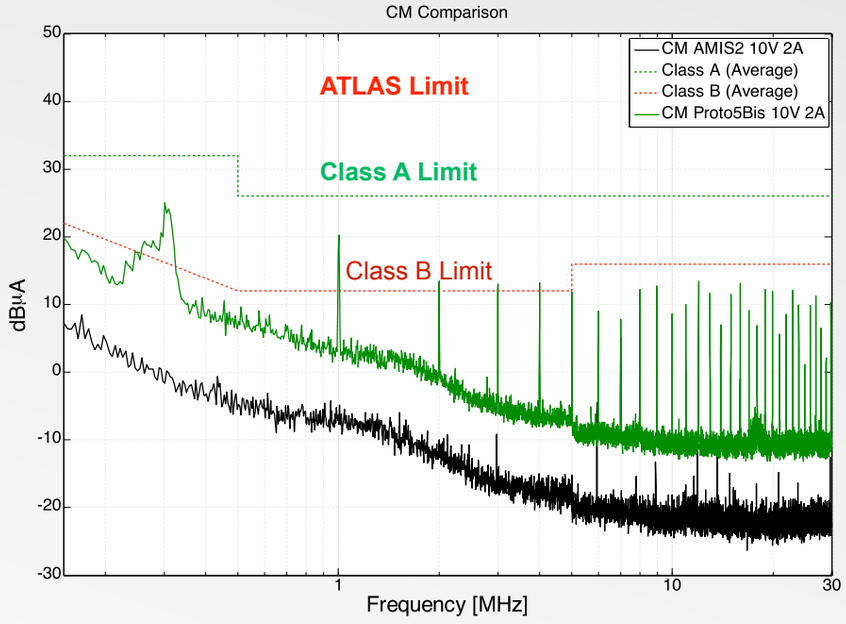
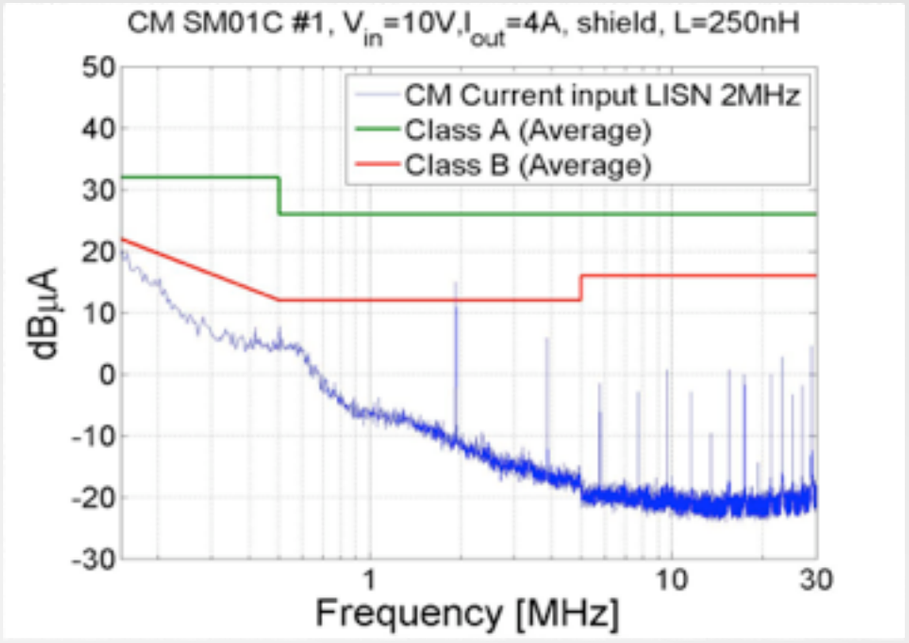
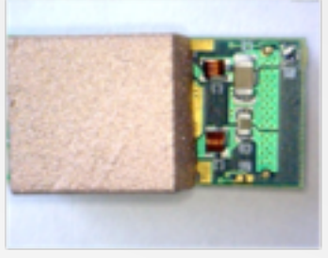
  - Very compact design, need only for few external components



- Using a commercial DCDC circuit (LTC3605) - SM01C





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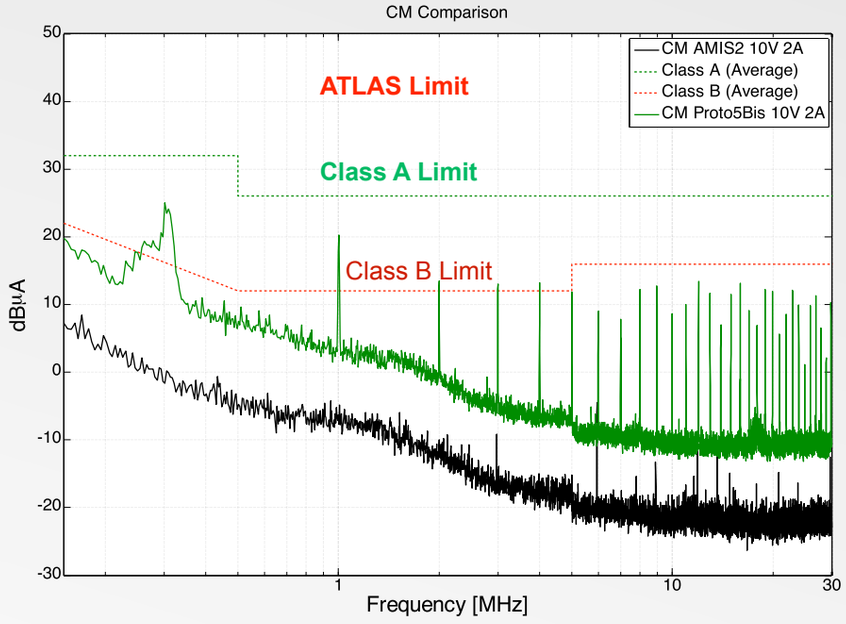
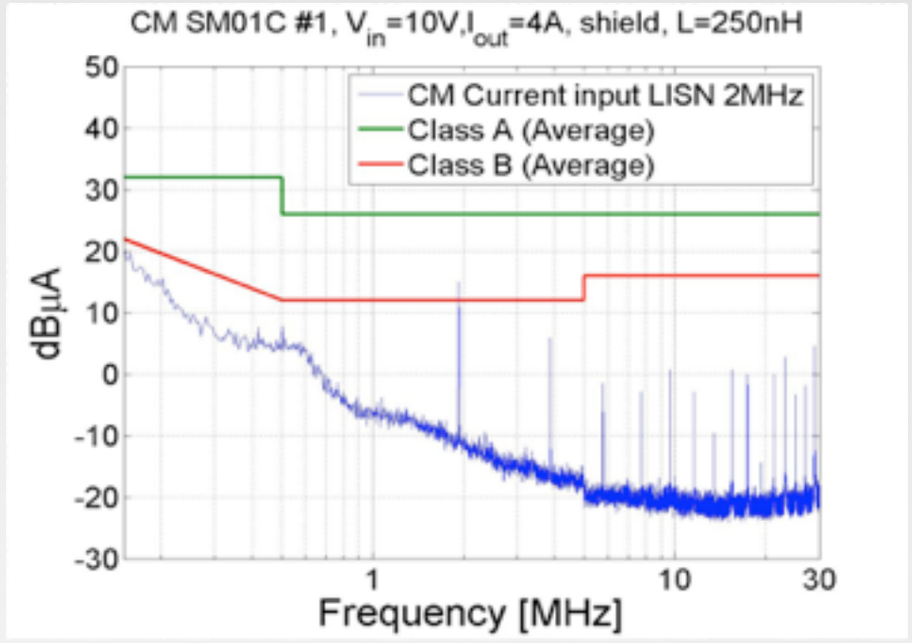
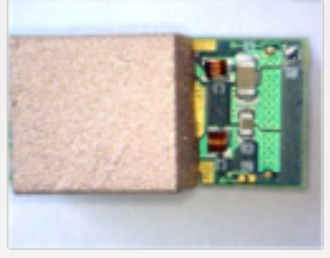
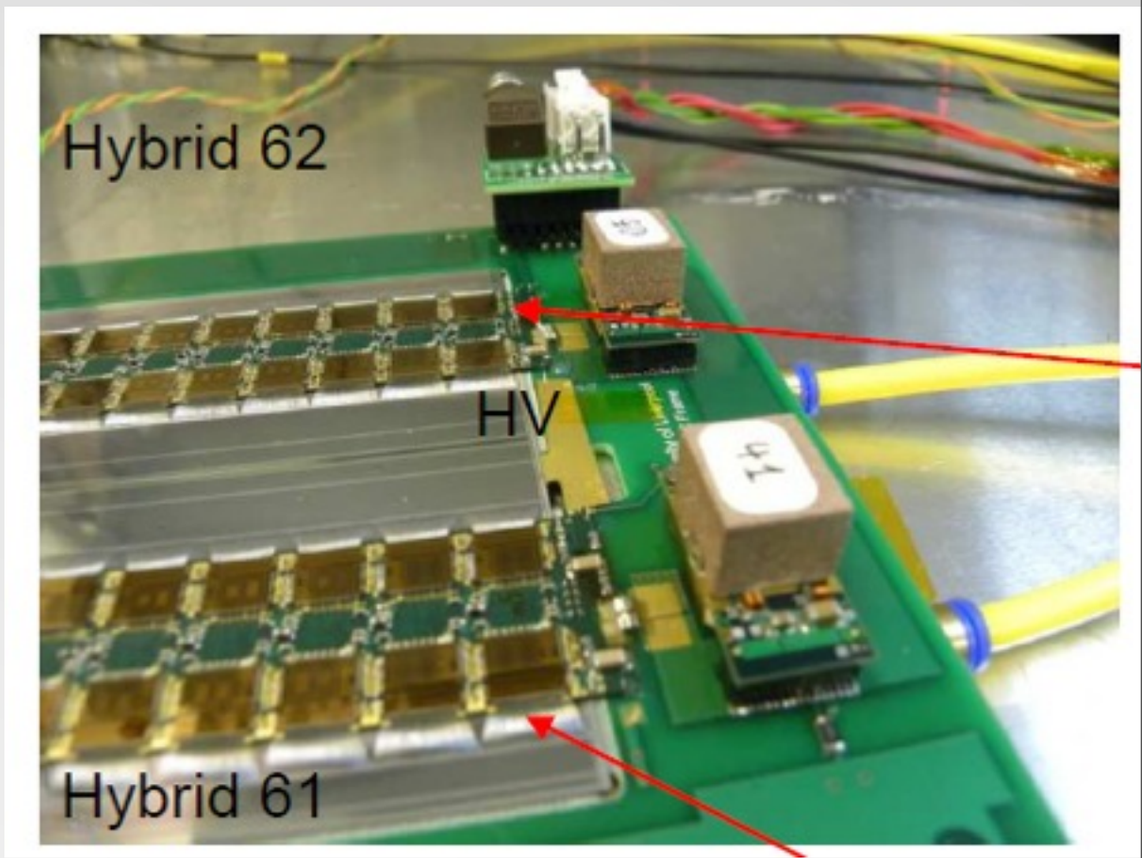


- Using a commercial DCDC circuit (LTC3605) - SM01C
  - Designed to provide up to 5A to match requirements of ATLAS SCT prototype modules





Measurements with ATLAS SCT prototype modules



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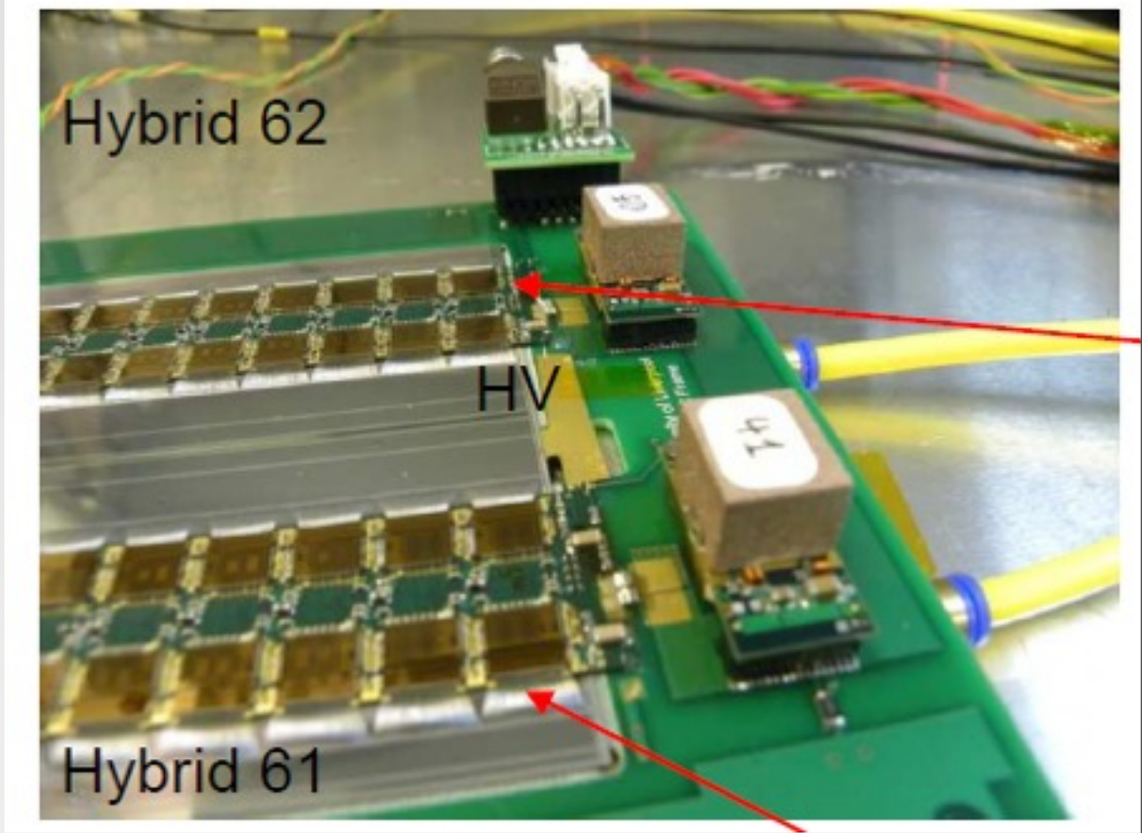

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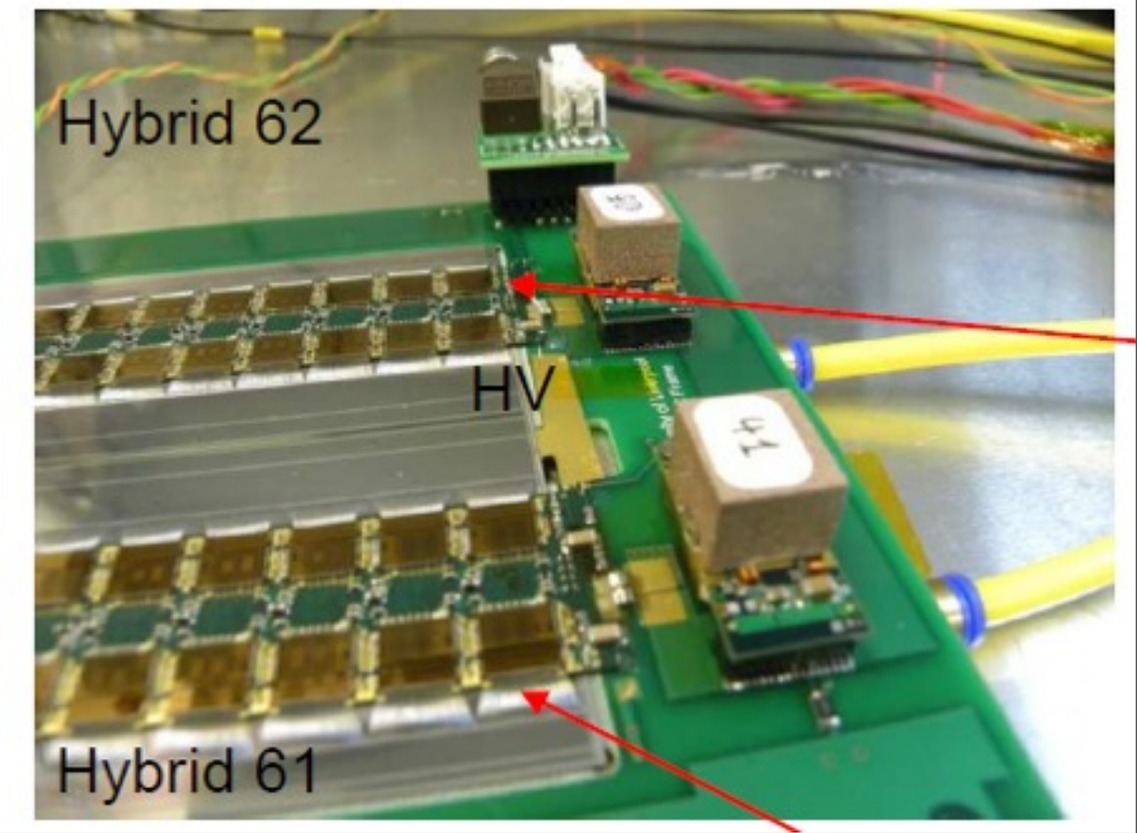

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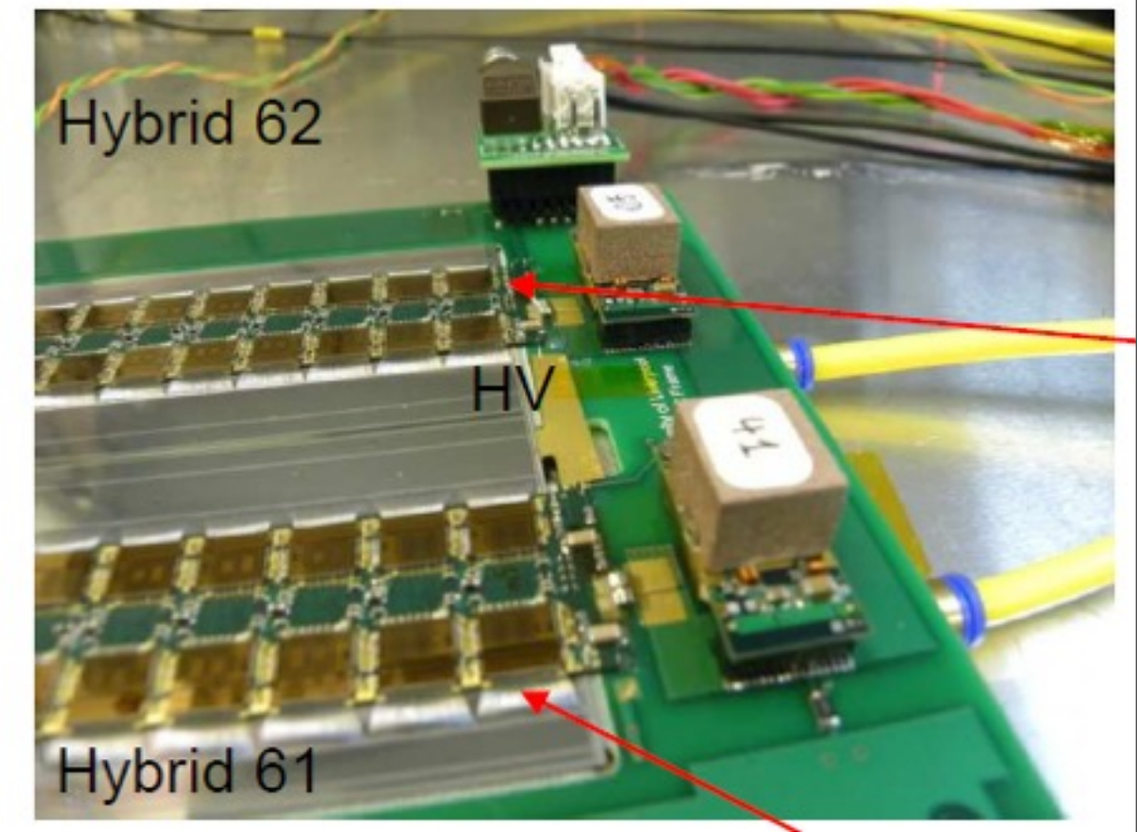

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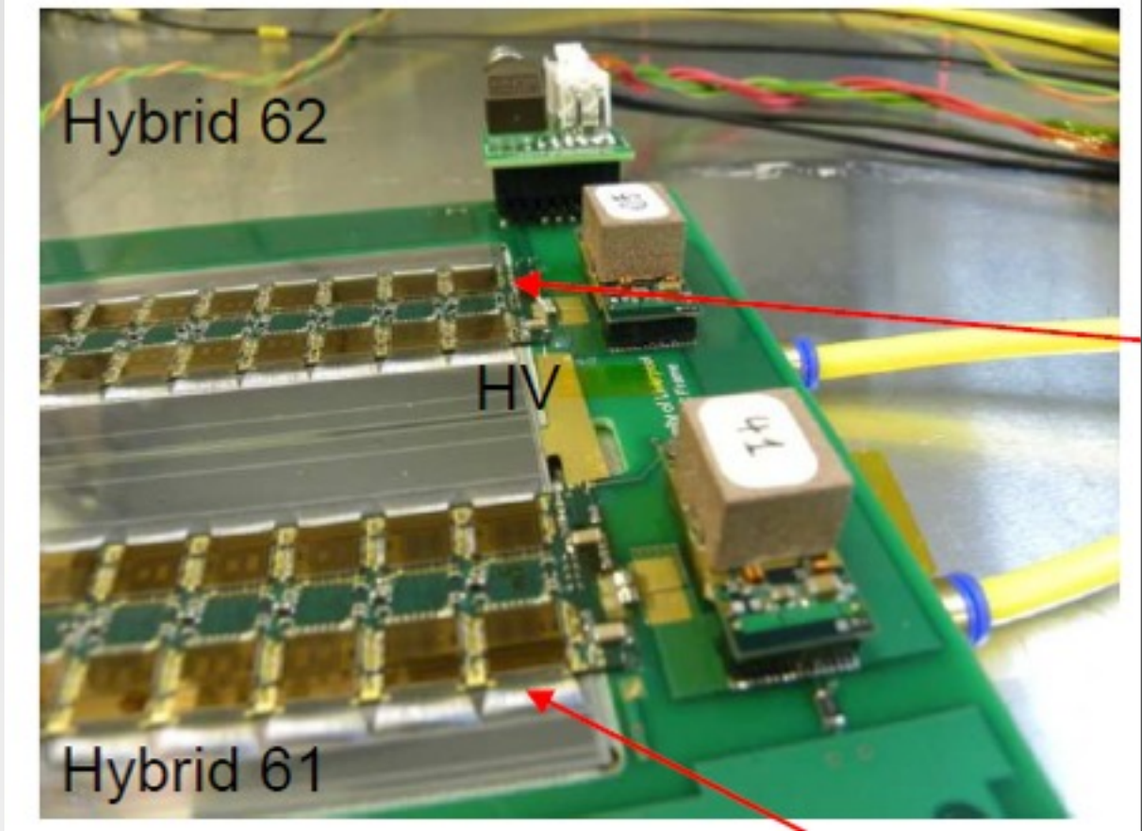
- The compatibility between SM01C and the ATLAS stave modules is now achieved, using copper foil shields



Shielding EM fields

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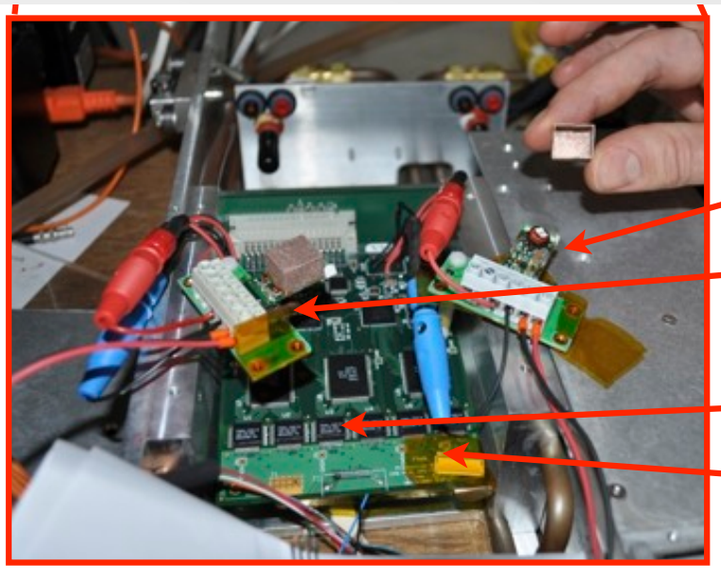
- 2 approaches have been followed to prototype manufacturable shields, both based on a coated plastic support. Metal (Cu) is either painted as a Cu-loaded varnish, or deposited (on-going work)
  - A dedicated test board has been developed to measure the effectiveness of all shields and define the optimum material and thickness
  - A simulation study will be performed and results compared to experimental benchmarks

Interest in using our DCDC converters



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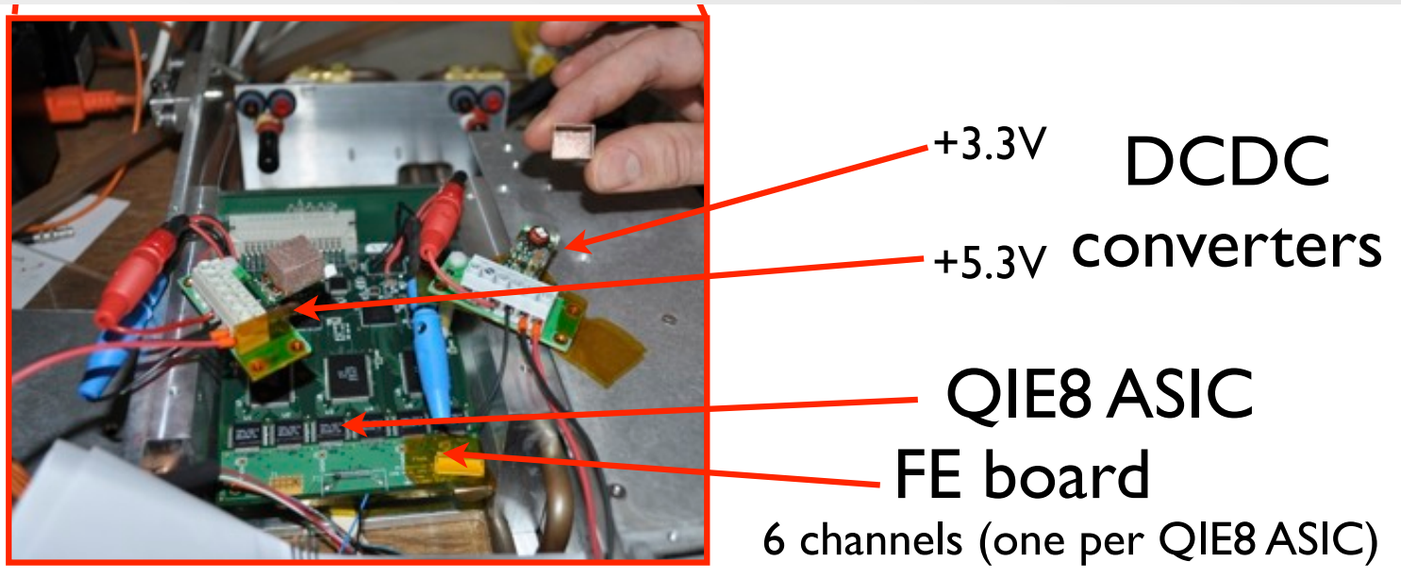

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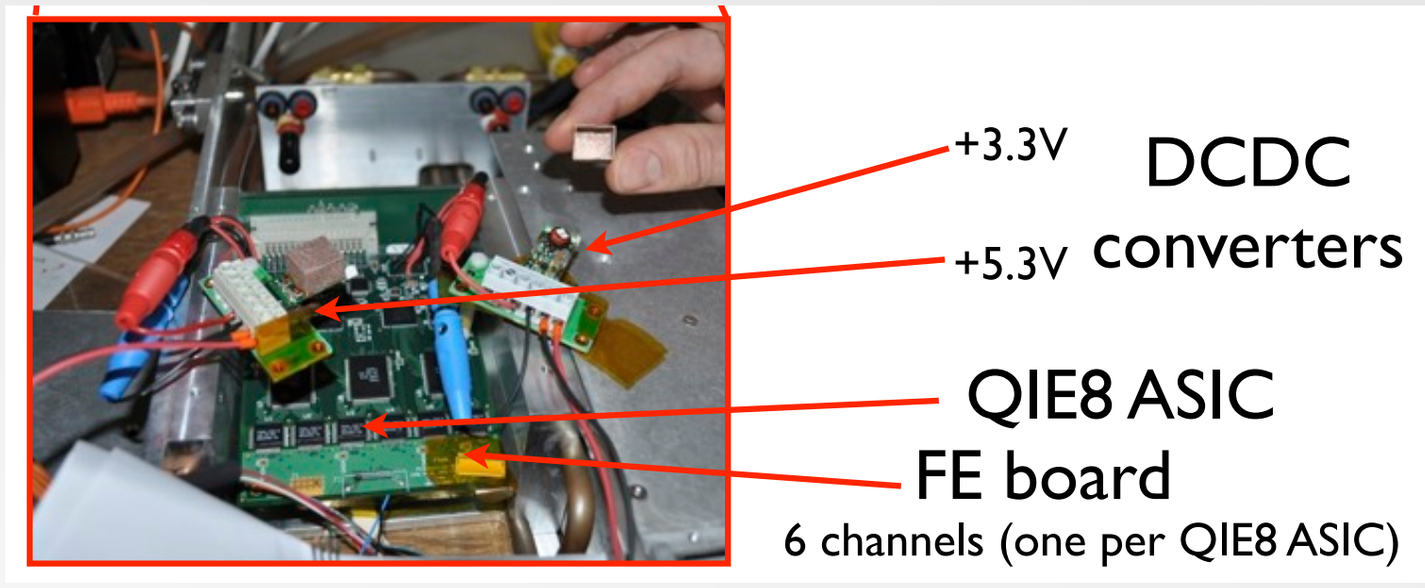

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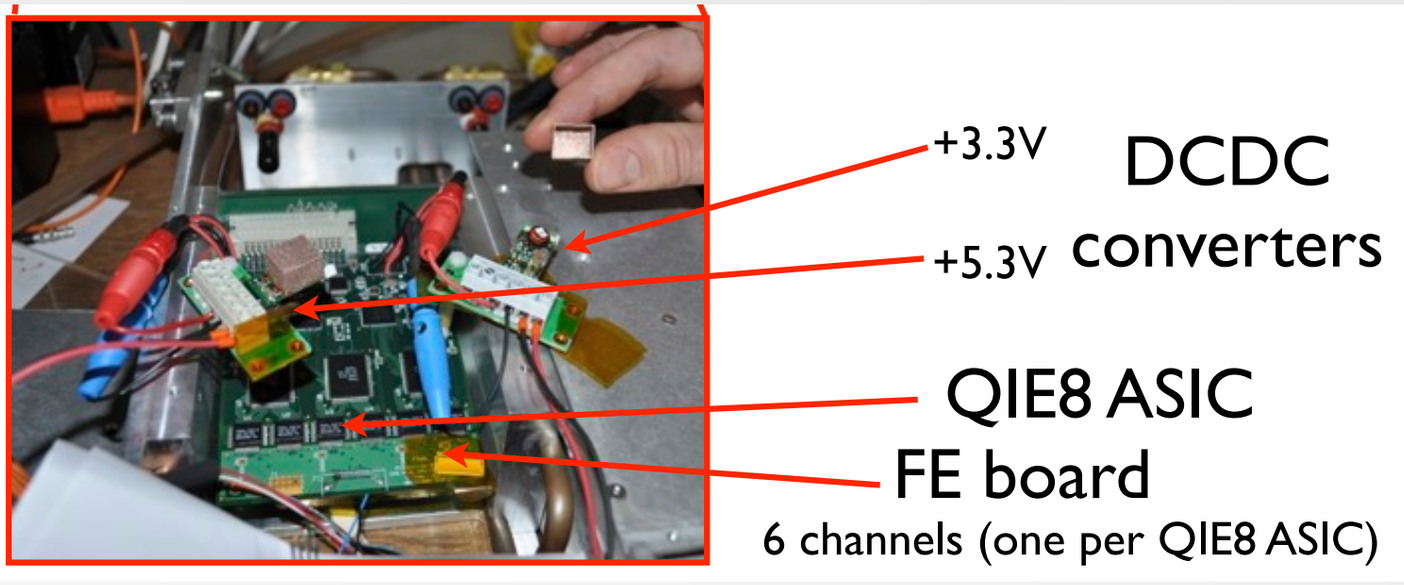

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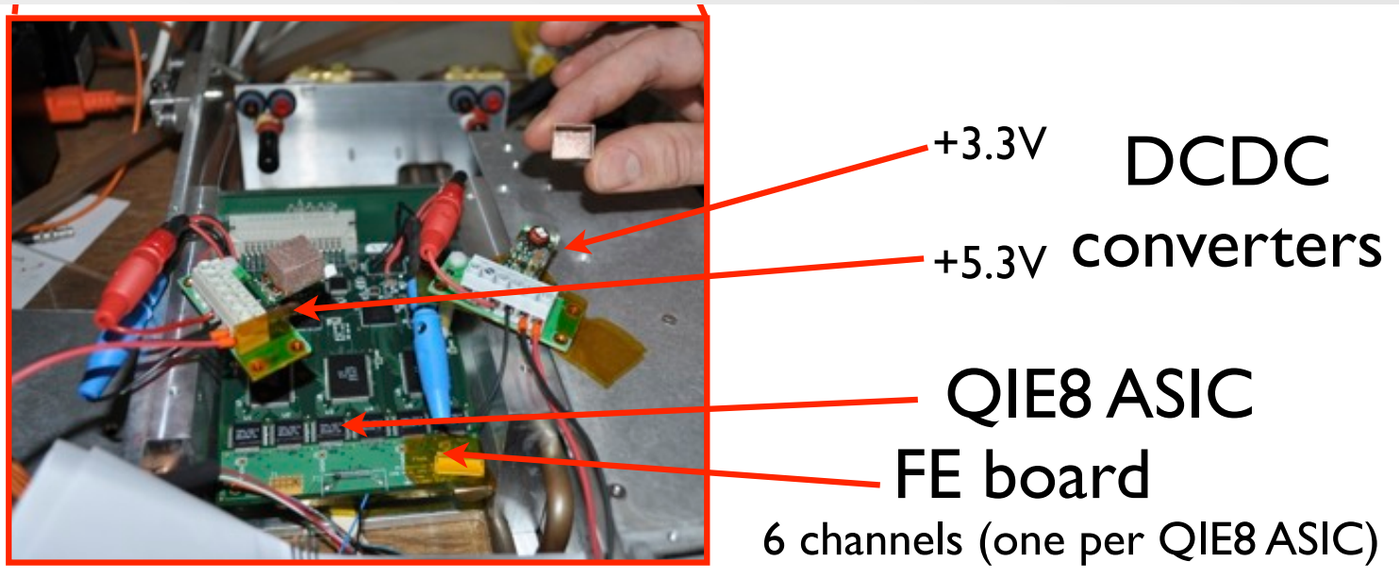

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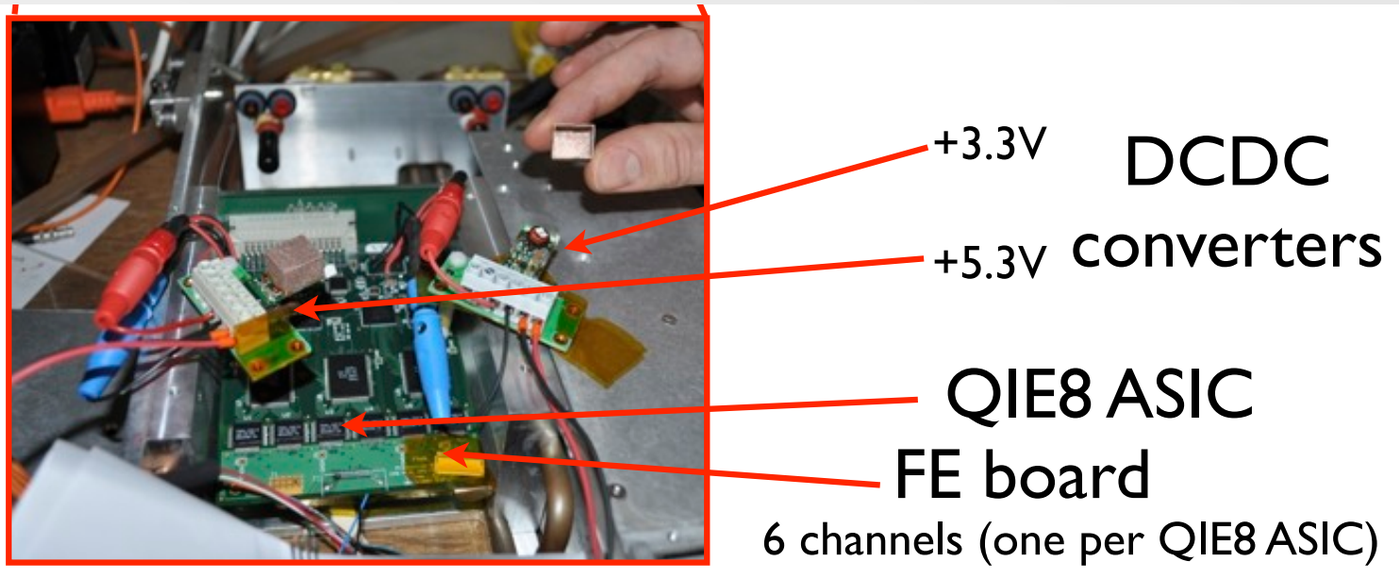

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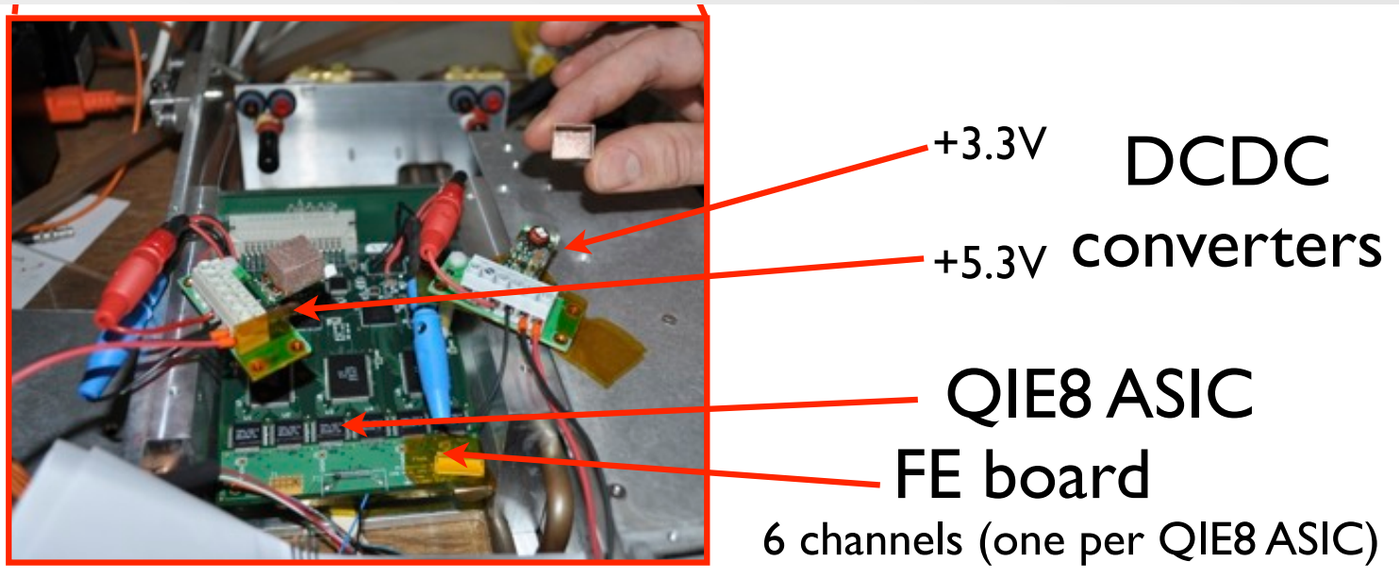

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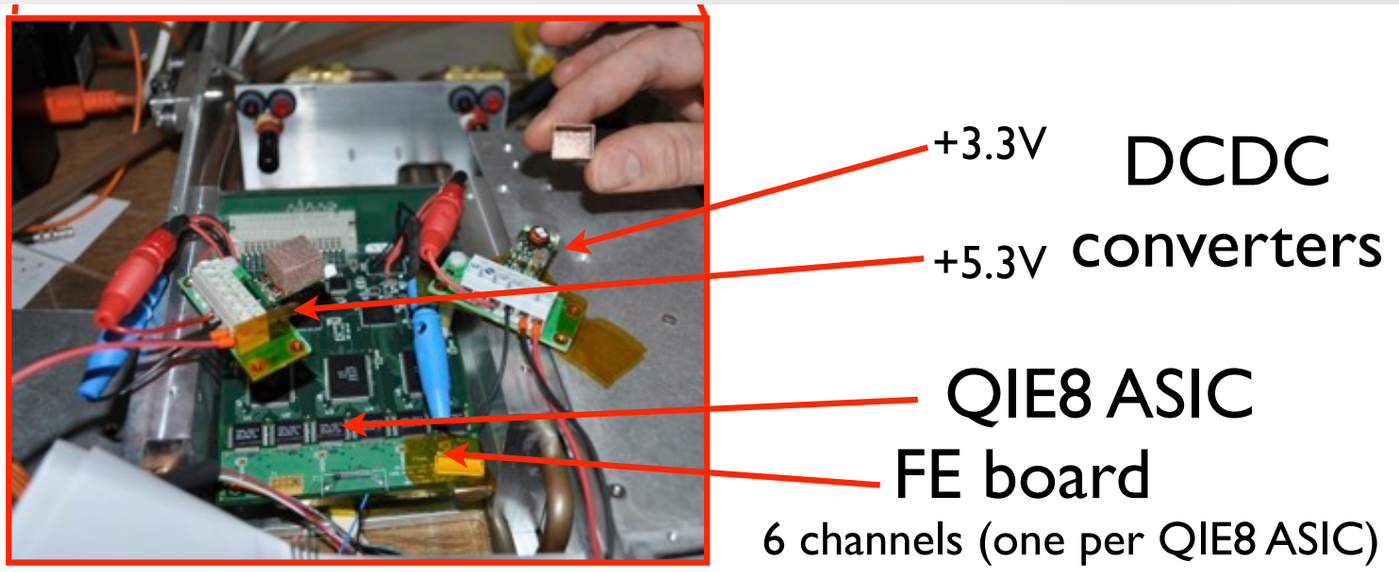

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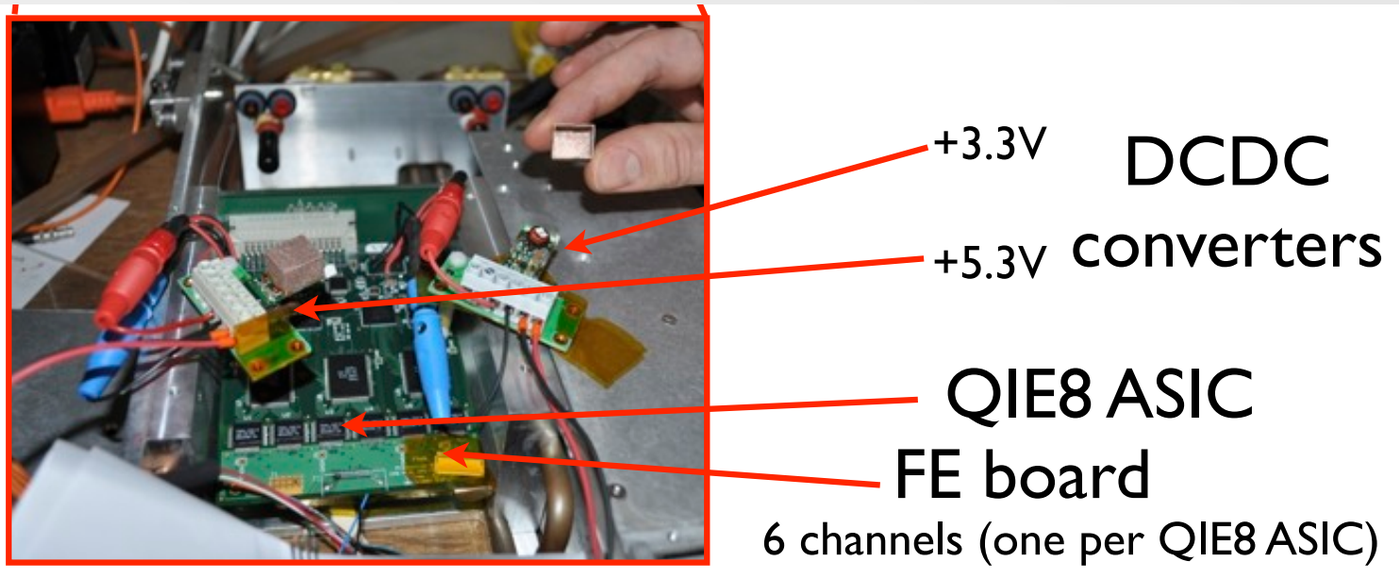

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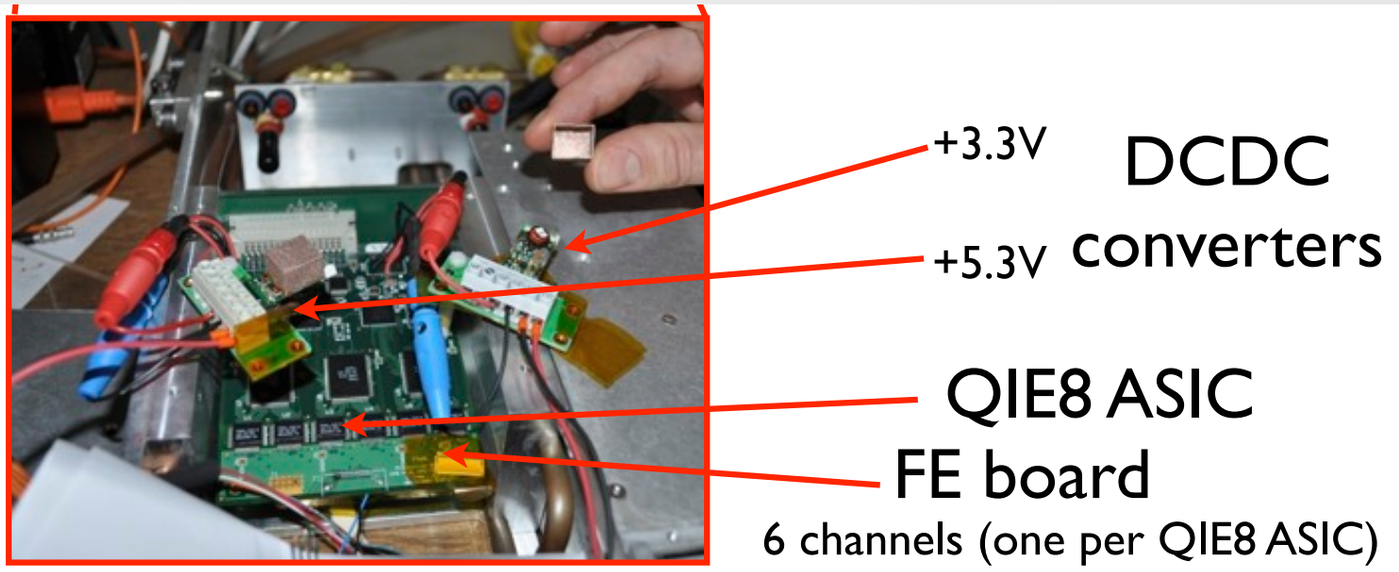

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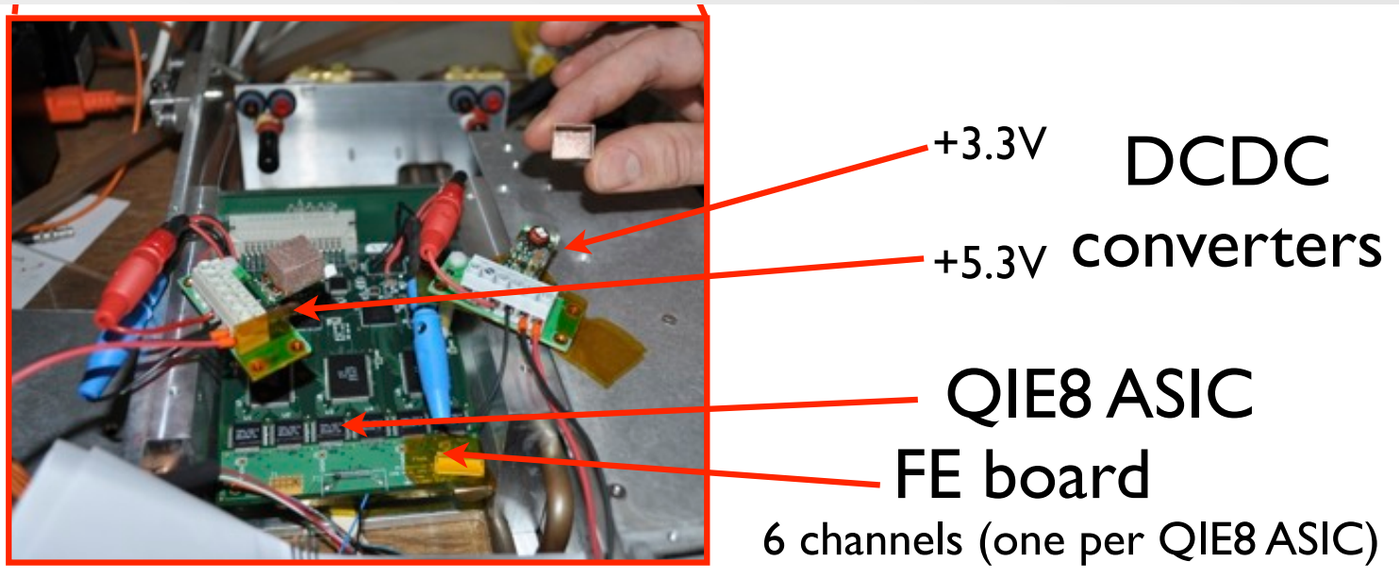

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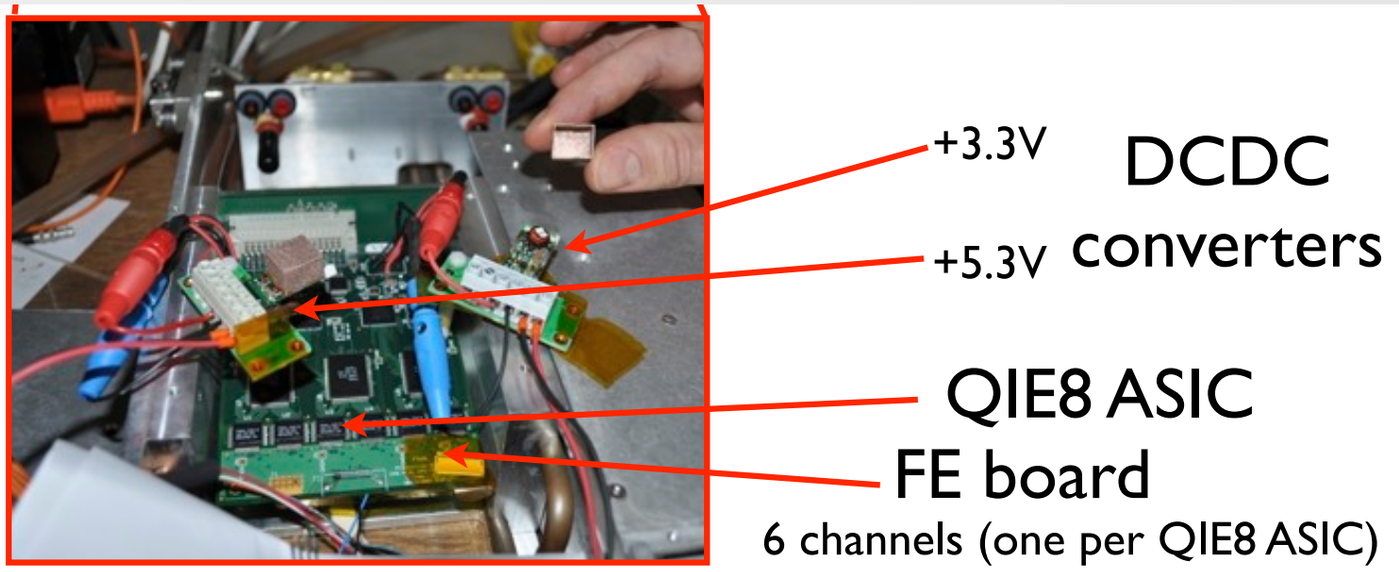

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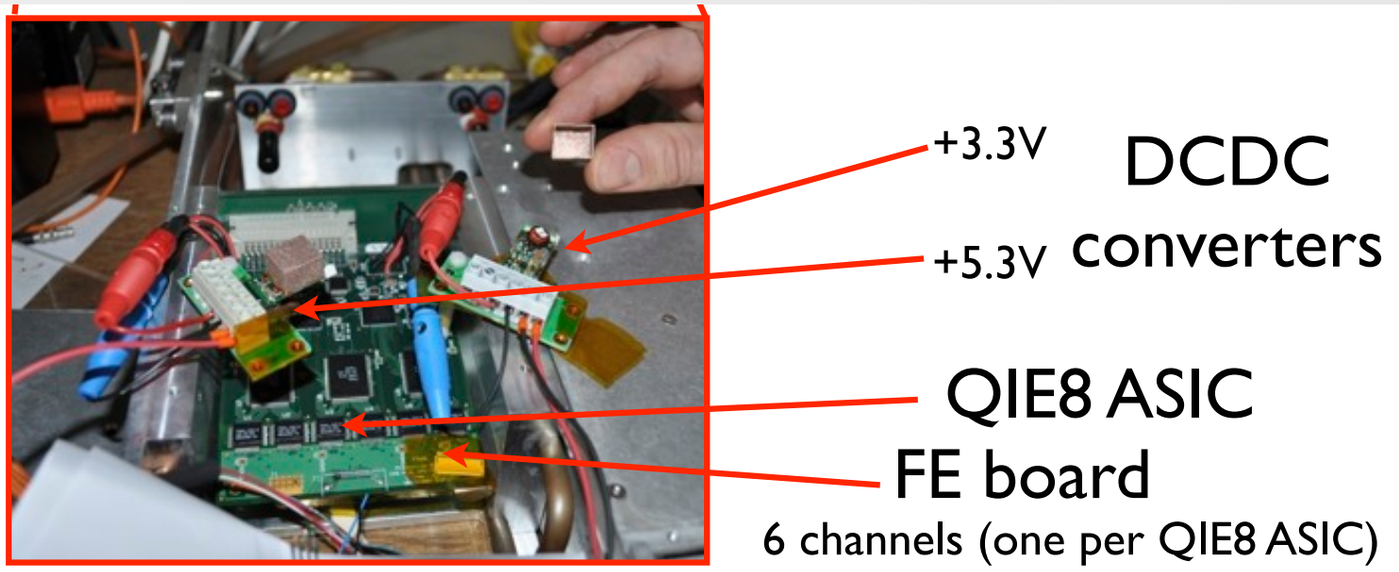

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- Phase1 upgrade of CMS pixels (RWTH Aachen, PSI, Fermilab, ...)
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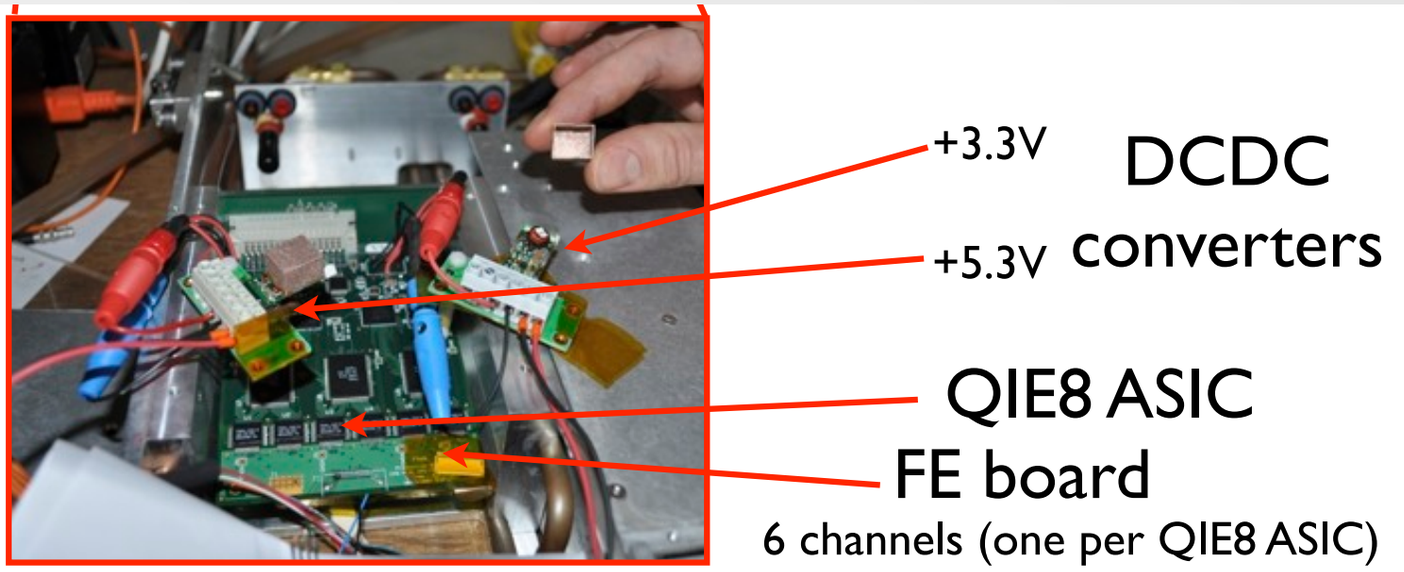

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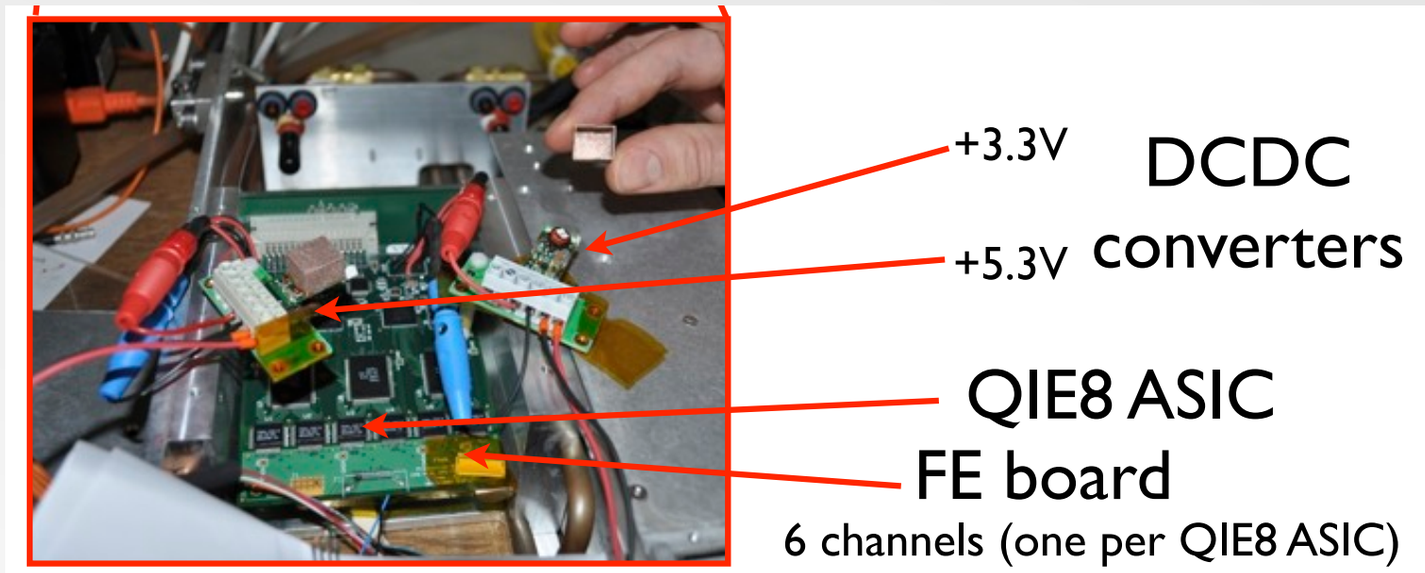

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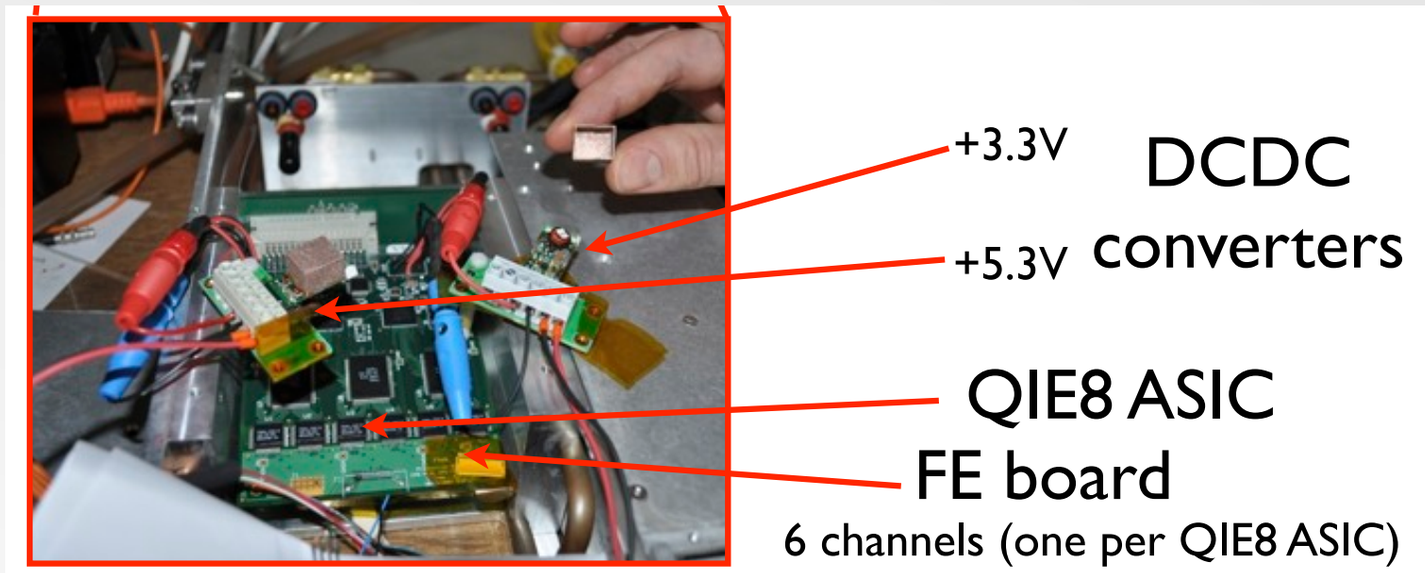

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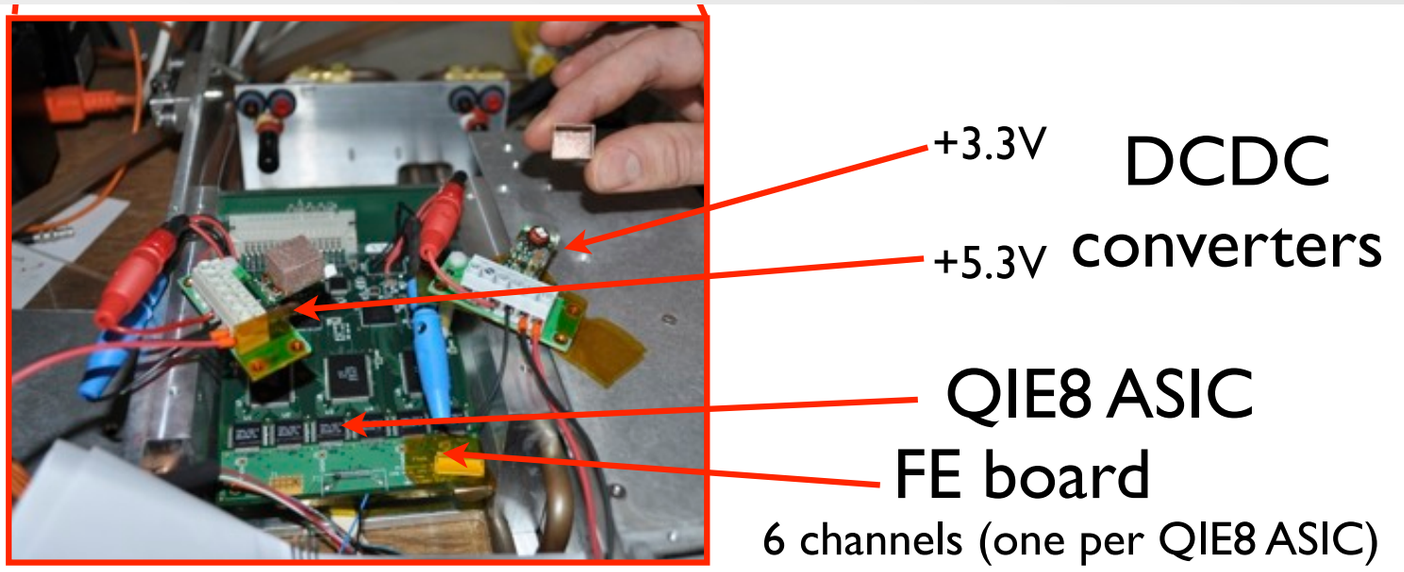

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- Phase2 upgrade of LHCb calorimeter (Barcelona, D.Gascon)

Summary

- ASIC
  - Technology
    - On-semi 0.35um technology fully validated. This is baseline for Phase1 developments
    - IHP 0.25um technology still under evaluation, in collaboration with IHP. SEB test in April should tell if this technology is quickly usable for our development
  - Design
    - 2 prototypes in production in On-Semi 0.35um. AMIS4 contains full protection features and is very close to a final design (to be confirmed by measurements...)
- Full converter boards
  - Low-noise board design
    - Know-how acquired and confirmed by results
    - Low-noise and compact prototypes available for both ASIC and commercial DCDC
  - Special components
    - Inductor design chosen, transferred to industry and in production
    - Shield requirements being studied, and prototypes produced
  - Integration in detector systems
    - Measurements on different systems confirm that power can be provided by DCDC converters without impacting the noise performance