Progress on Powering Options

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Richard Sumner , CMCAMAC LLC

SiD workshop, SLAC
Jan 12 - 14, 2015

- Agenda
- 2014 Liverpool Test Results
- Toroid vs Planar Coil
- Shielding Electrostatic & RF.

- ATLAS Tracker Upgrade Converters

- Need simple DAQ for Testing Converters

Planar Coil – “Up Close and Personal”

Double Trigger Noise (DTN)

With Toroid Converter

Reference measurement (CERN STV10 converter) @ 0.5fC

Ashley Greenall , UK Group

- CERN converter registers zero occupancy until 0.5fC, then registers 528/244 hits

Above picture is Double trigger noise
i.e. after a hit ; spurious counts are registered

With Planar Converter

Approx <3mm from wire bonds with improved reference @ 0.5fC

US ATLAS Moved towards Dc-Dc.

- For conducted noise configuration, Planar coil registers zero occupancy(even at 0.5fC)
- Only when close to asics are hits registered, 3/2 counts at 0.5fC, see above

Comments inserted by Yale University

Noise in Electrons Measured @ Liverpool

cern stv10 noise 589, 604 average = 601
yale planar noise 587, 589 average = 588
noise with dc supplies (no dcdc) = 580

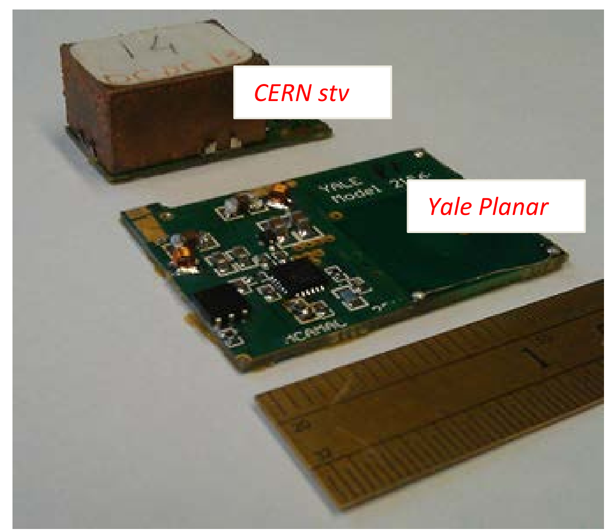
assuming the noise adds in quadrature, extract noise due to dcdc converter:

cern stv10 Additional noise = 157
yale planar Additional noise = 96

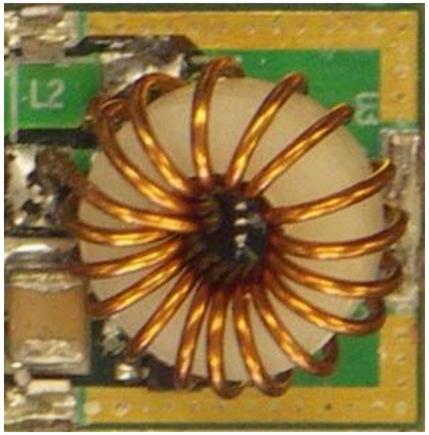
Planar Converter uses the same components except Inductor coil

Thickness of stv = 8 mm vs 3mm for Planar

Shield to Silicon strips are Electrostatics & Eddy current
Bottom side shield 2 mm from Planar coil traces
Can be mounted on the sensor with 50 µm Kapton
Cooling via sensor

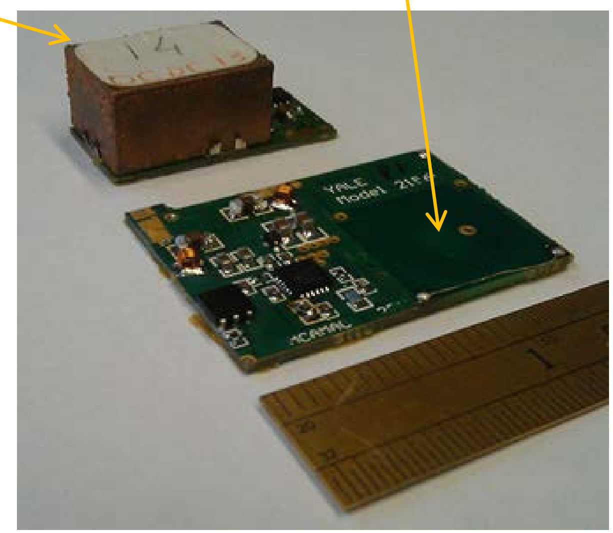


Toroid vs Planar Coil



Toroid Inductor with Shield on toroid
height = 8 mm

Embedded Spirals
Disabled for the hand wound coil
Height = 2 mm plus shield



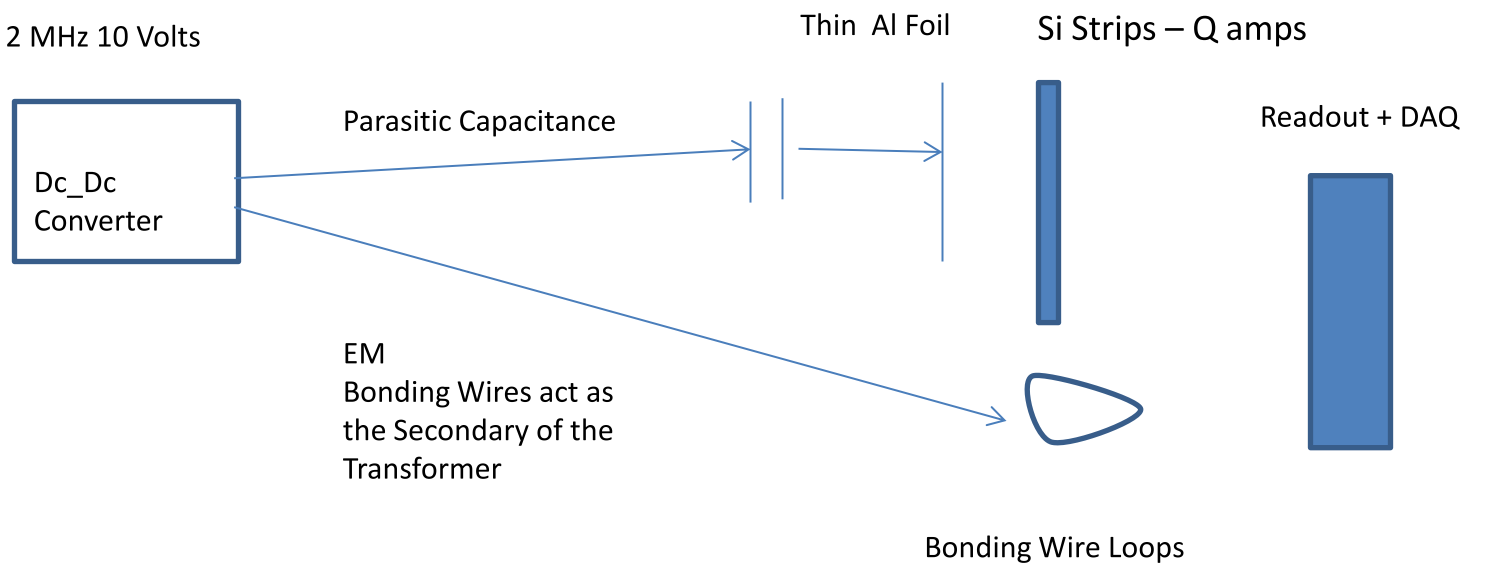
Lower Mutual Coupling if turns are
further apart but adds to DC Resistance

Radiation Length Comparison Toroid vs Planar

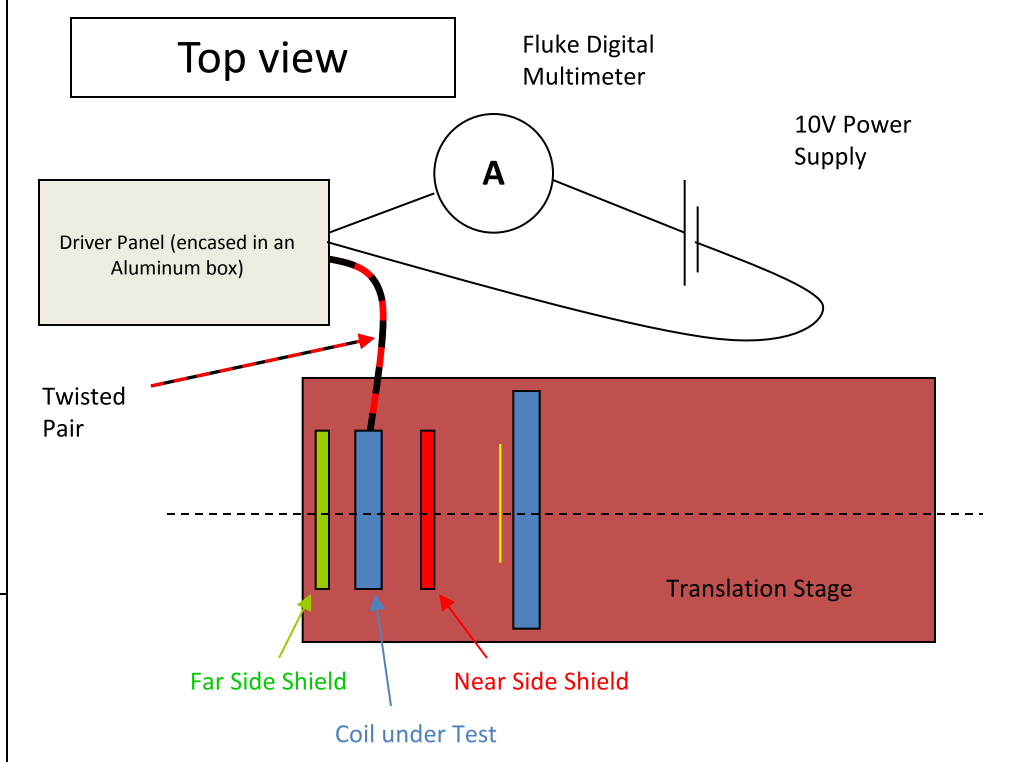
	L	wire length	Cu wire milliohms	wire dia mm	vol cubic mm	Mass, grams	Rad Length % Avrg 100 cm2
Cern toroidal coil	413.000	341.632	32.455	0.480	128.727	1.150	0.09%
planar coil, same L, same R	415.000	203.472	34.387	0.361	57.661	0.5151	0.04%
planar coil, same L, same mass	415.000	203.472	8.546	0.723	115.482	1.0316	0.08%
planar coil, same R, same mass	967.000	310.860	32.951	0.455	111.031	0.9918	0.08%

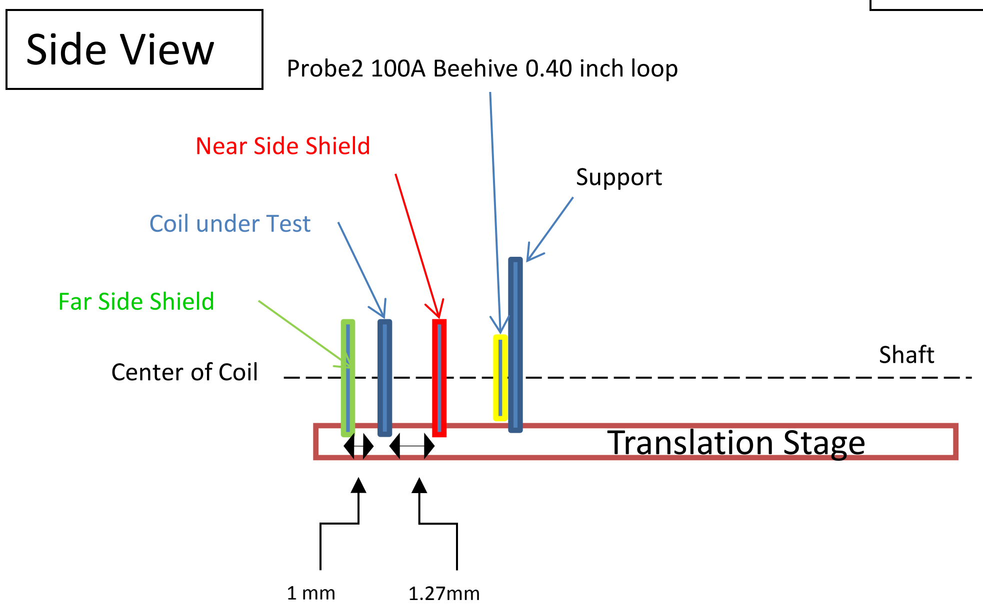
This simple example compares a toroidal inductor and a planar inductor. The inductance is calculated using the simple formulas for a toroid and a solenoid found on the hyperphysics pages on the web. Just Google toroid inductance or solenoid inductance and choose the hyperphysics link

Noise Coupling from Dc-Dc to Readout



Eddy Current Shield Measurements



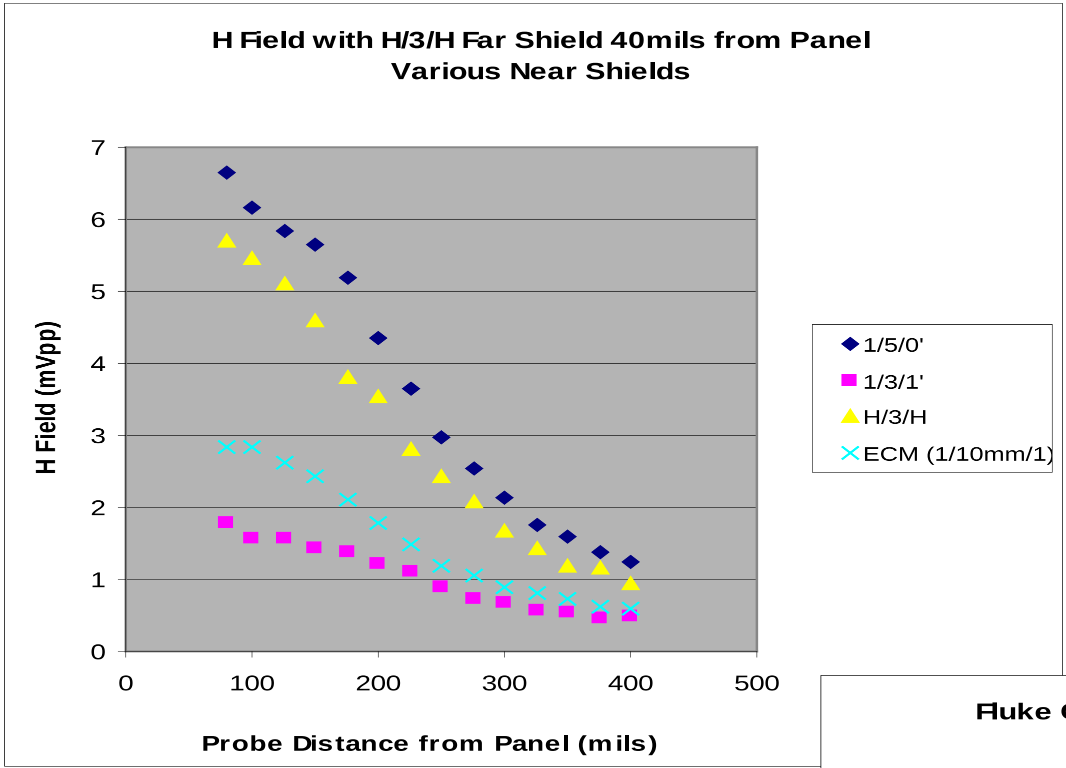


The Shields

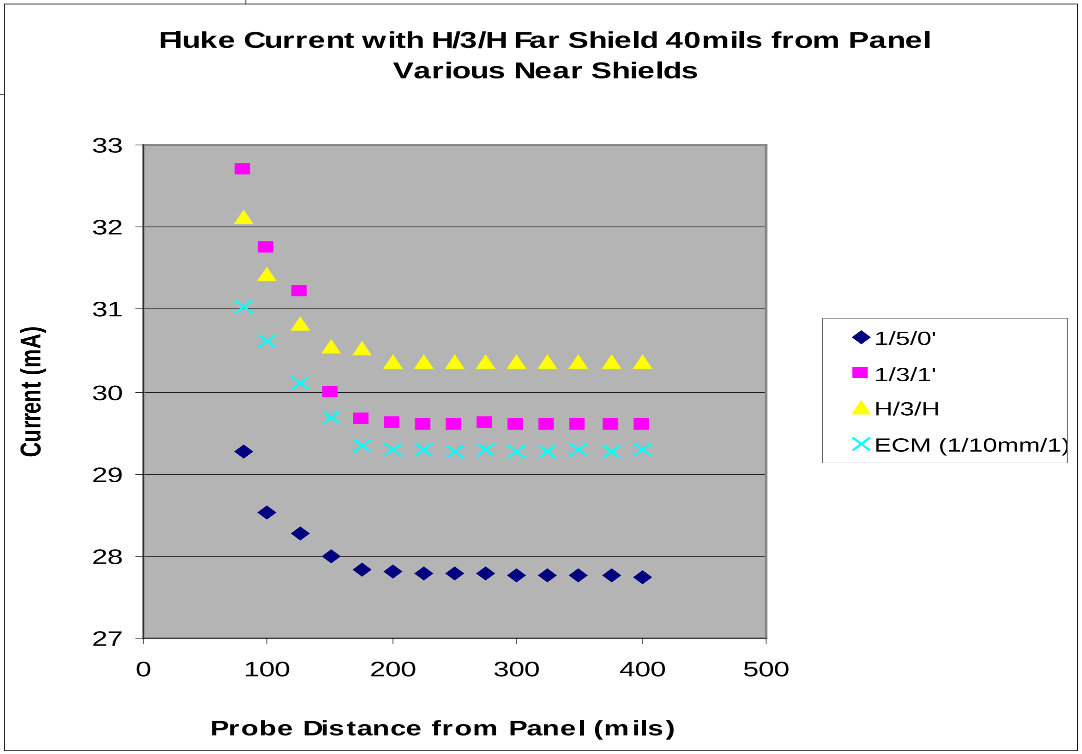
Far side Shield H3H: Half Oz/ 3 mil thick/ Half Oz

4 Types of Near Side Shield

1. Half Oz/ 3 mil thick/ Half Oz
2. One Oz/ 3 mil thick/ One Oz
3. One Oz/ 5 mil Thick/ Zero Oz
4. One Oz/ 10µm/ One Oz



10 mV = 1 µT @ 2 MHz



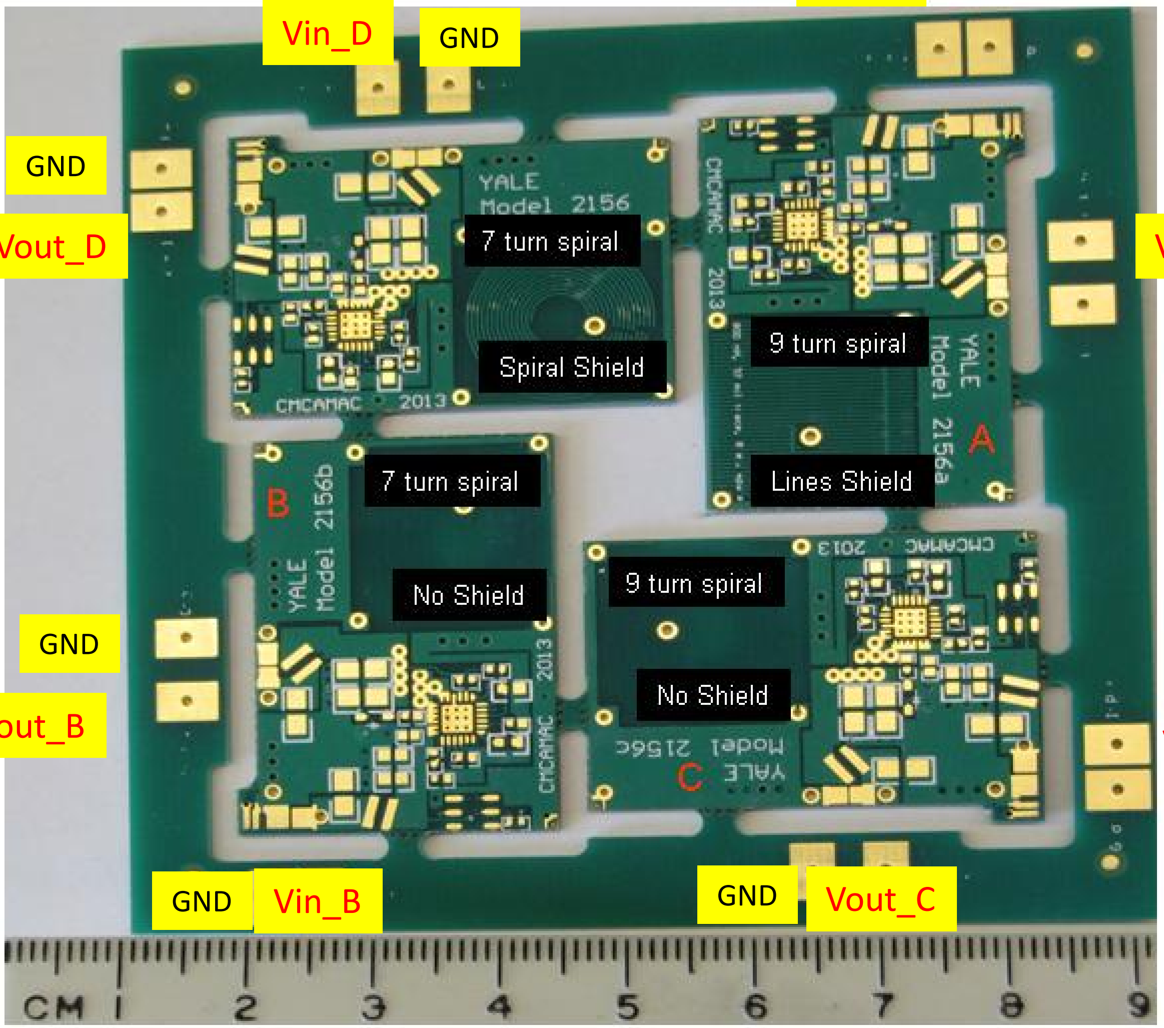
Shielding Measurements
Yale University
January 07, 2015

stackup, 2156, 2156a, 2156b, 2156c
thick, 487, 792, 486, 811 nanohenries
thin, 481, 796, 492, 816

2156 and 2156b 7 turns, b has spiral shield 2156a and 2156c 9 turns, c has straight lines shield
Inductance lower with Shield

Q- Meter
C= 470 pF
F = 8 MHz / 10 MHz

Thick 59 mils
Thin 34 mils



Satish Dhawan
Yale University
May 18, 2013

Coil Manufacturer - Wurth Elektronik eiSos

Each Converter PCB 10 mm x 63 mm. Different Coil Configuration

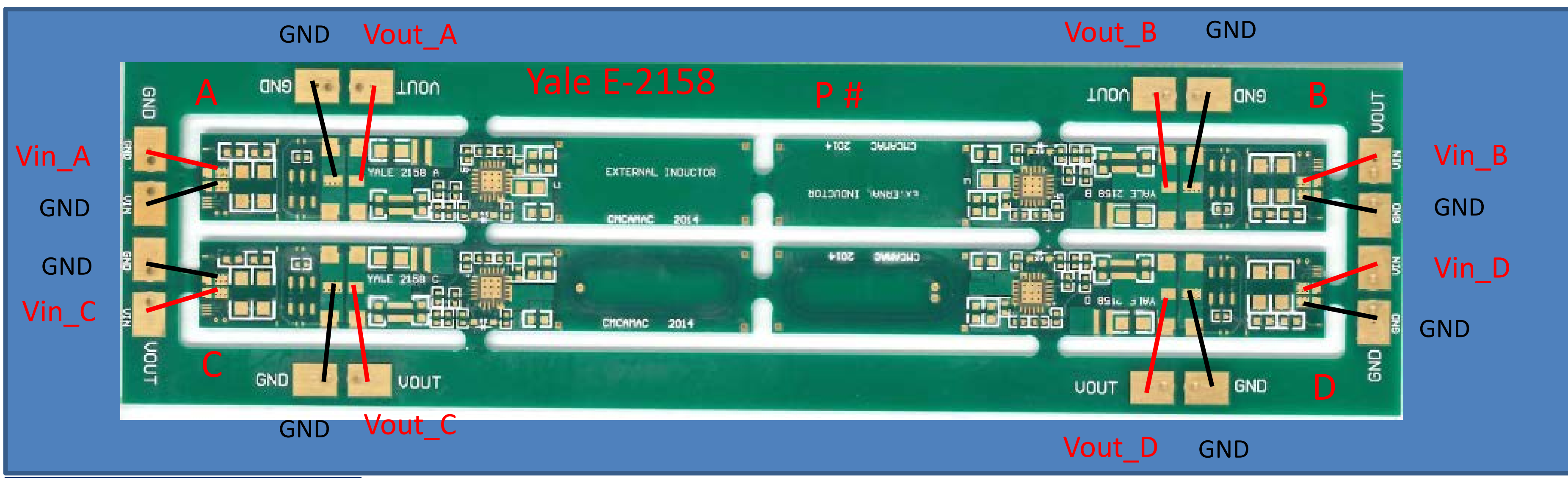
Channel D: Embedded Coil with 2 via: 687 nH, 83 mΩ

Channel C: Embedded Coil with 1 via: 703 nH, 83 mΩ

Channel B: External Coil: Wurth 540 nH* with short Leads

Channel A: External Coil: Wurth 540 nH* with short Leads

* With BK Precision LCR Meter



DC-DC Converter Model E-2158
Yale University
October 19, 2014

System Testing

- DcDc Converter @ Yale
- Thickness of Converters – Shield thickness!
- Detector + Readout @ SLAC Liverpool for ATLAS Strip Upgrade
- DAQ: RAL, Liverpool, BNL HSIO, SLAC
- Very difficult to use & NOT portable without the experts.

- We need a simple to use DAQ. Is it possible ?

Prospects for Future

- Lower Mass @ 5 MHZ
- Topology Change Charge pump, Buck or something else?
- GaN Power switches have lower losses but the Driver is an issue

The END

Backup Slides

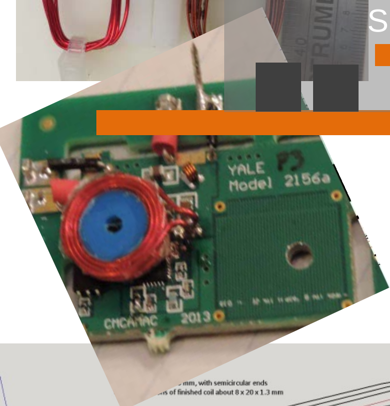
The coil dimensions are approximately those of the toroid used in the feast DC DC converter (coil radius 1.7 mm, toroid radius 4.5 mm). The formulas are for circular coils so I used the average toroid radius. For the planar coil I used the approximate dimensions of our latest oval coil made by Wurth, again using the average coil radius. The dimensions are adjusted to give a coil with the same inductance as the toroid, about 400 nano Henry. I calculated the approximate length of wire needed in both cases. The toroid wire has a diameter of 0.48 mm.

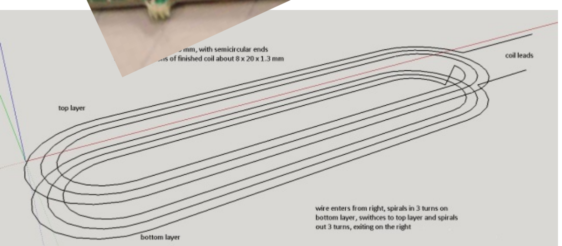
In the first example I adjusted the wire size of the planar coil to give the same DC resistance as the toroid. Then the total mass of the copper wire in the planar coil is less than half of the mass of the copper in the toroid coil.

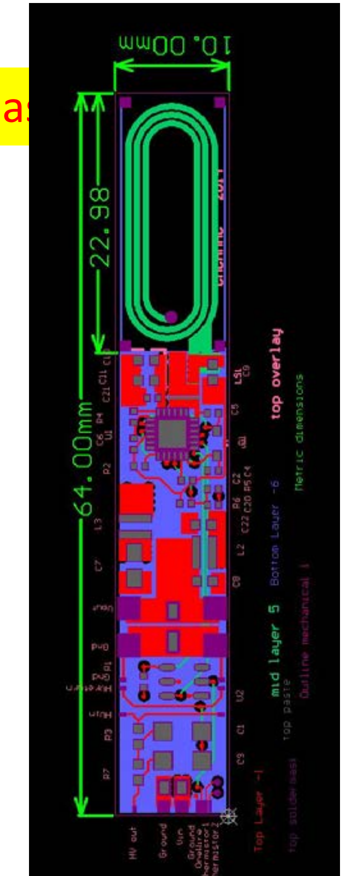
In the second example I adjusted the wire size of the planar coil so the mass of copper is the same as in the toroid, the DC resistance of the planar coil is about 25% of the toroid coil. For the same load current this will reduce the the power loss of the planar coil to about 25% of the loss in the toroid coil. For large load currents, this will substantially improve the overall efficiency.

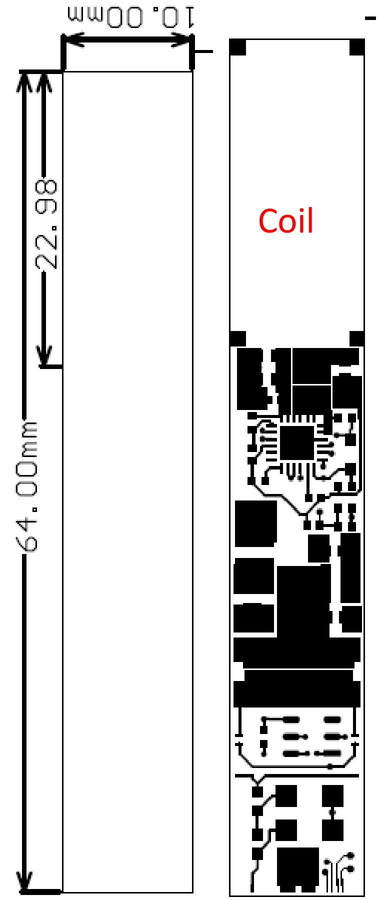
In the third example, I adjusted the number of turns and wire size to get about the same mass of copper and the same resistance. The result is about twice the inductance. This reduces the ripple current to half. But the turns have increased from 6 to 9, so the ripple magnetic field (the EMI) is reduced to about 75% of the field in the first two examples.

Some Coil Ideas

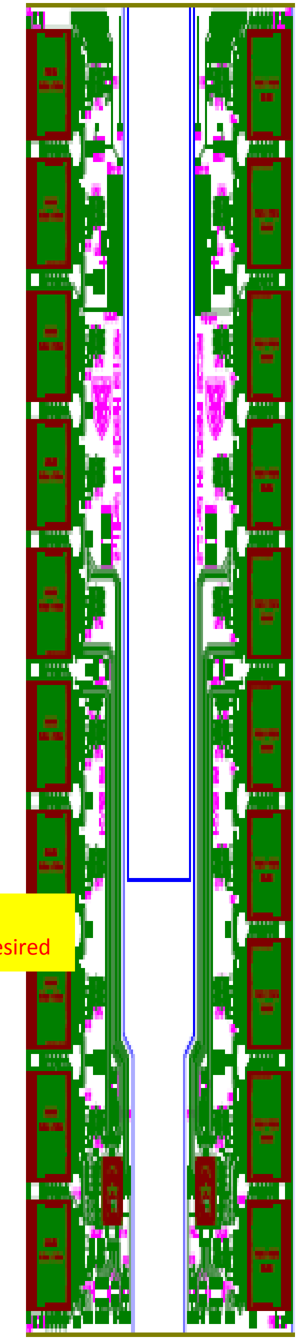








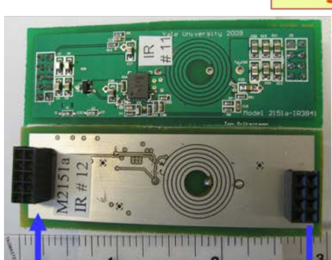
New design with dimensions
10 mm gives tight fit, 9 mm is desired



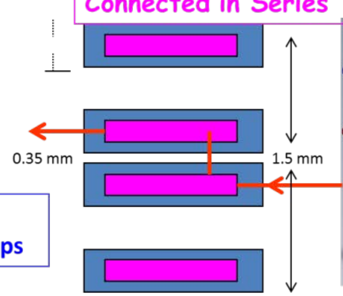
Silicon Strips & Readout ASICs

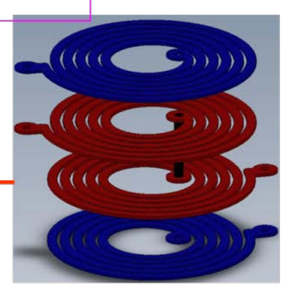
Yale Model 2151- Year 2009

Plug In Card with Shielded Buck Inductor



Coupled Air Core Inductor Connected in Series





This shield is less effective.
We have different shield for top & bottom

Yale University
August 02, 2014