DC/DC ASIC converters in 0.35µm CMOS technology

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Twepp 2011, Vienna 26-30 September 2011

Outline

- Introduction
- AMIS4
  - Design

    chip design & features

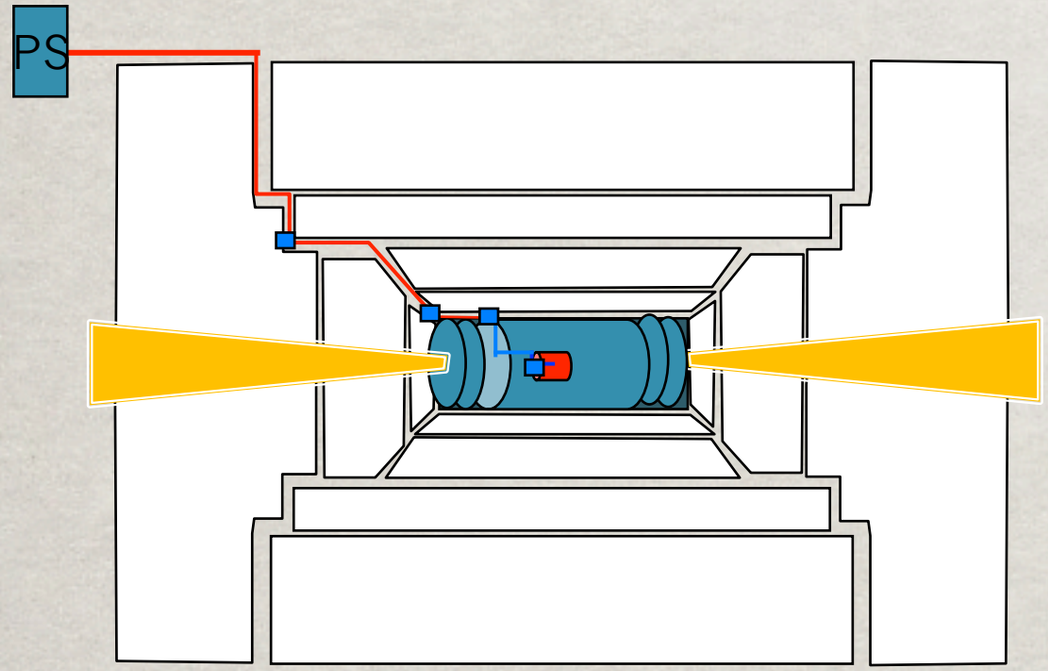
    bonding diagram

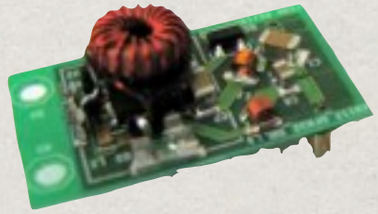
    protections
  - Tests

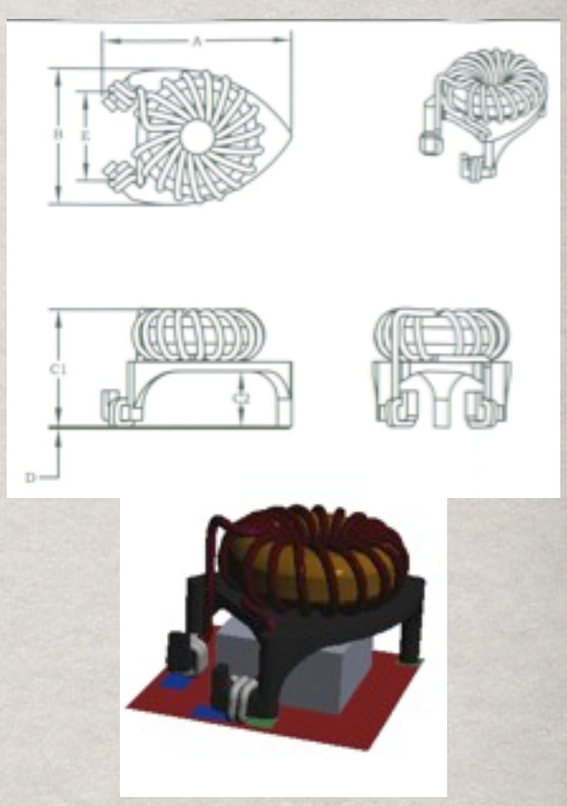
    efficiency results

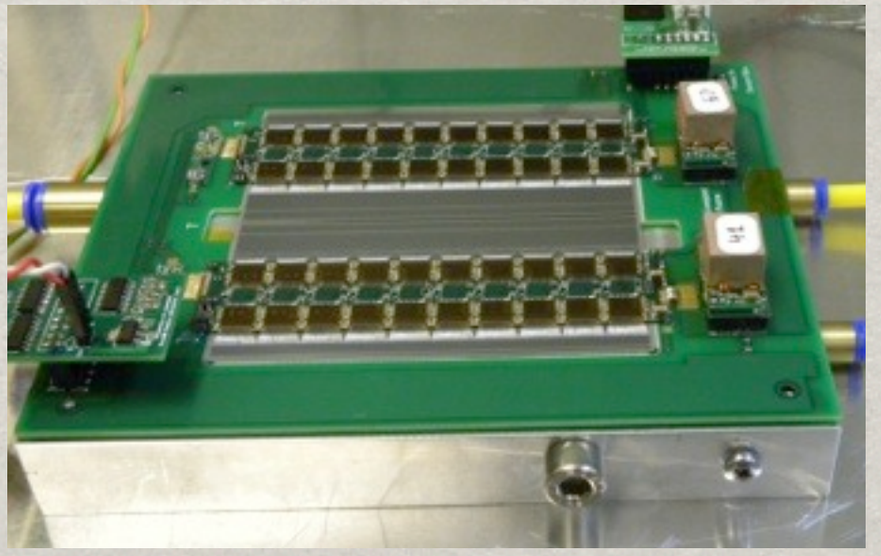
    TID radiation test results
- Conclusions

Power distribution with DC-DC converters









Constrains:

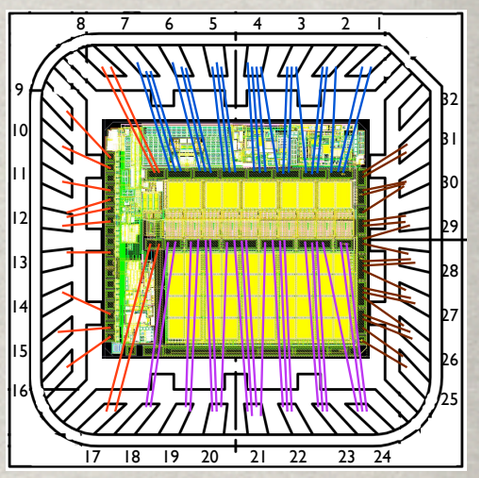
magnetic (2T-4T) fields

radiation (TID>100Mrd, fluence > 2 10^{15} p/cm^2

ions with LET<40MeV·cm^2/mg)

ASIC design

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



Used in system tests

Taped-out Jan2011 still under tests, preliminary results

ASIC DESIGN

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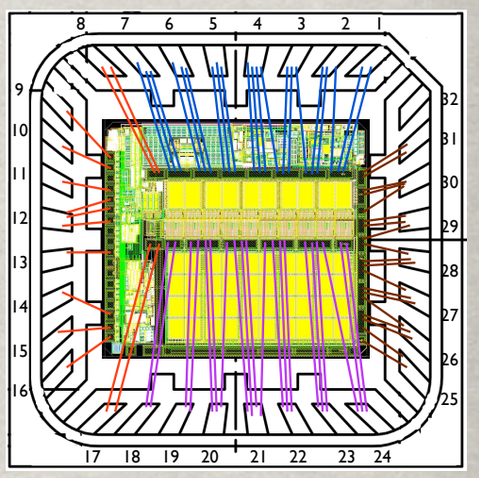

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    - TID radiation test results
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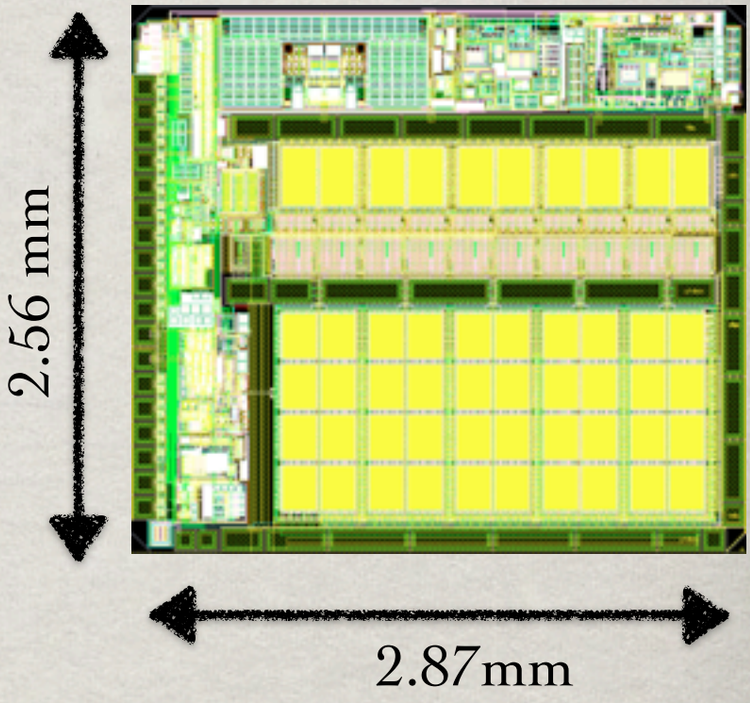
AMIS4

- Some features integrated in the prototype:
  - Bandgap
  - 4 linear regulators: Pre-Reg, Analog, Digital and Driver
  - Handling of the dead time with adaptive logic
  - Triplication and logic against SEU and SET
  - Improved power transistors' design to reduce TID effects
  - Possibility to enable only 2/5 of the power transistors for small Iout
  - Enablers
    - Complete circuit
    - Dimension of the power transistors
  - Pretection
    - Over-Current
    - Over-Temperature
    - Input Under Voltage
  - State machine for more reliable start-up procedure and handling of the signal from protection circuitry and Power Good signal generation

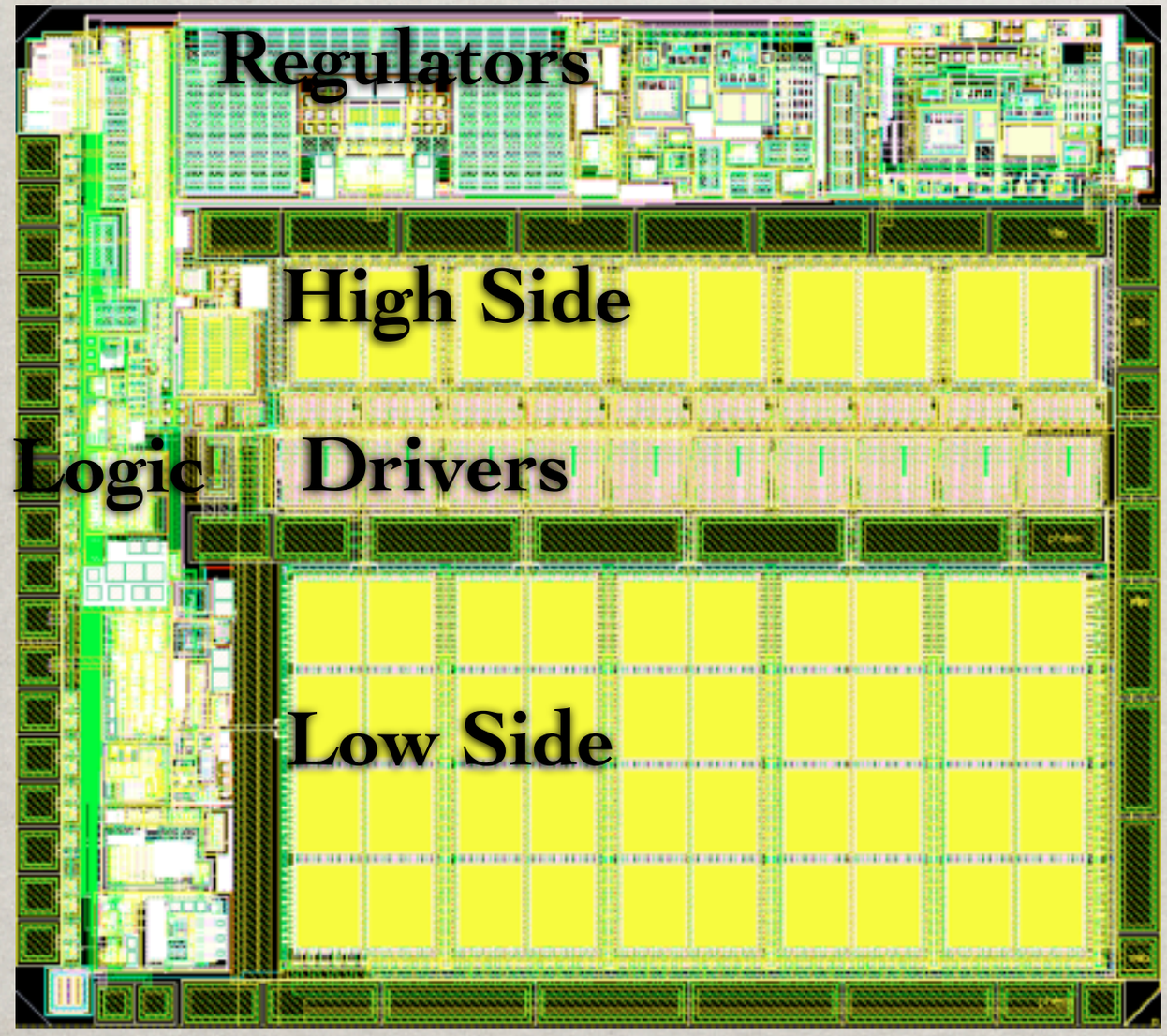
- External components needed:
  - Capacitor for one linear regulator
  - Capacitor for Bootstrap
  - Inductor
  - Input and output capacitors



New layout and bonding

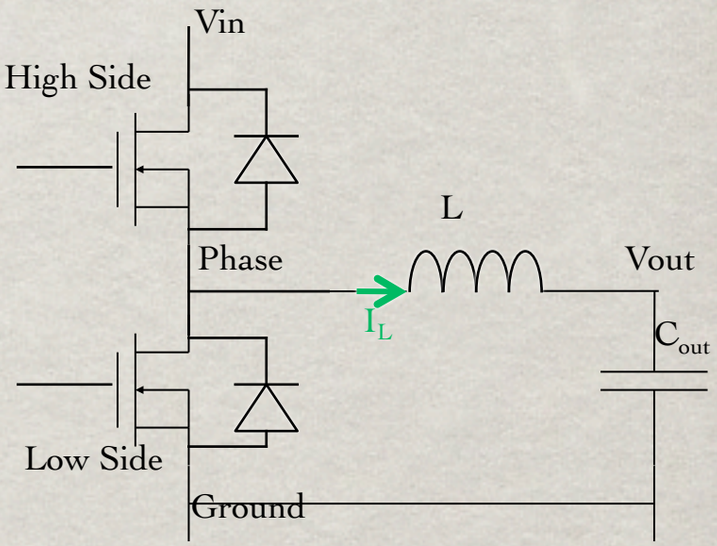
The pad disposition on-chip is very different than in our previous designs. This has been done to minimize the on-chip power distribution and optimize of the number of bonding

Vin



Gnd

Phase



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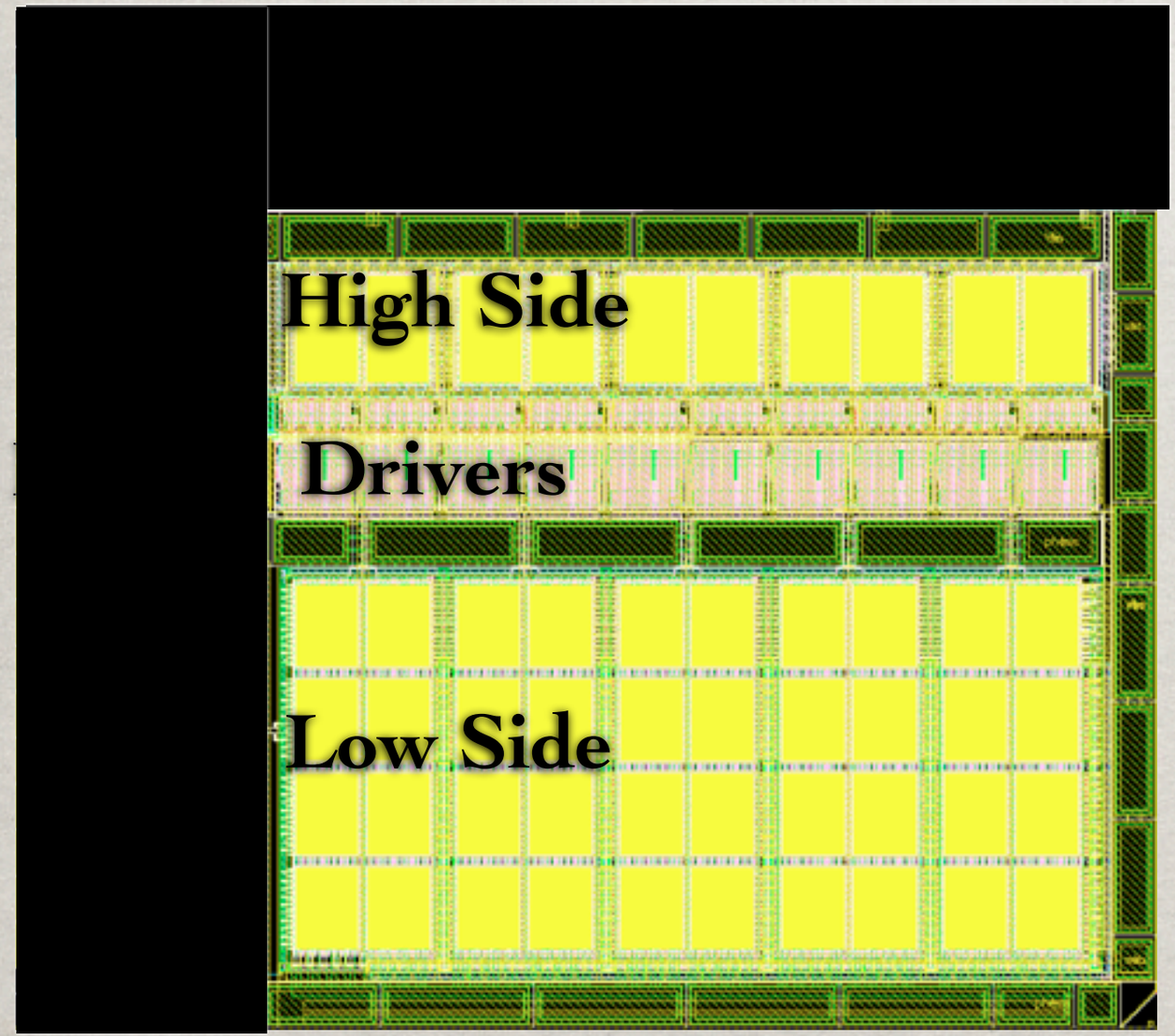

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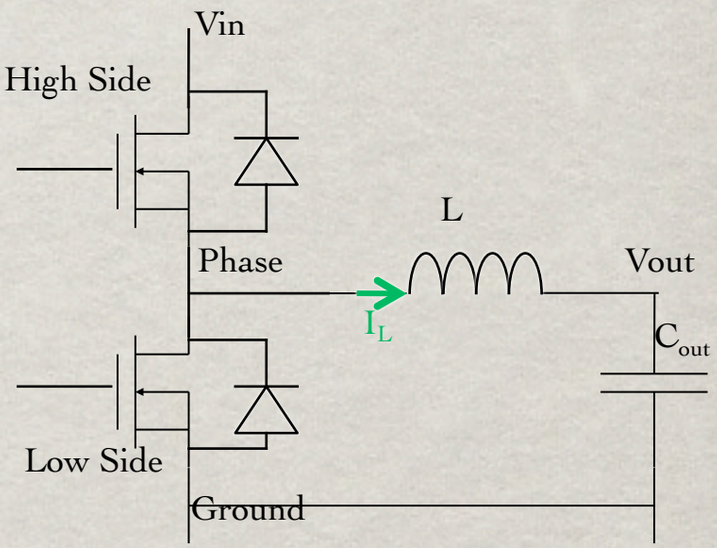

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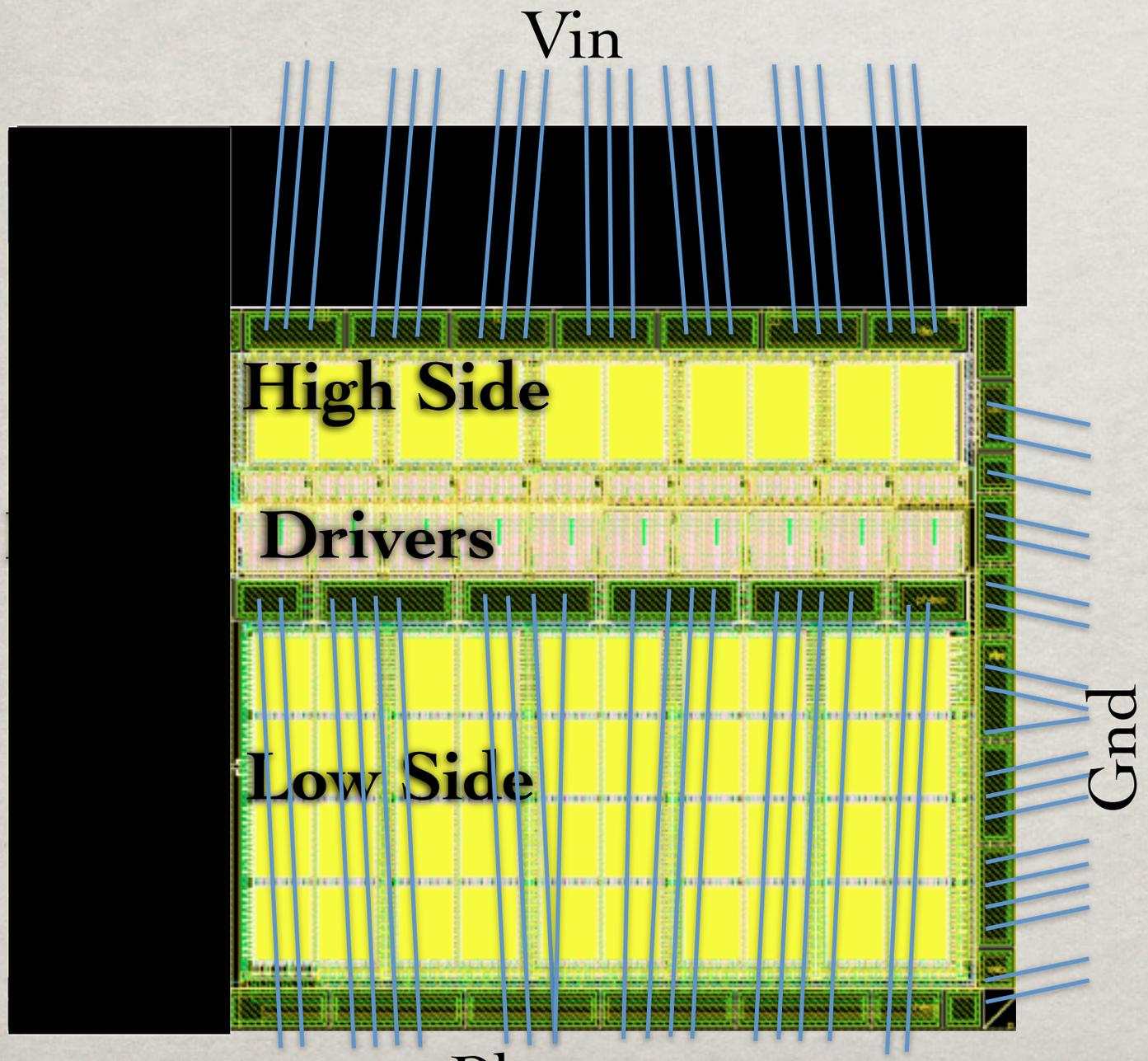

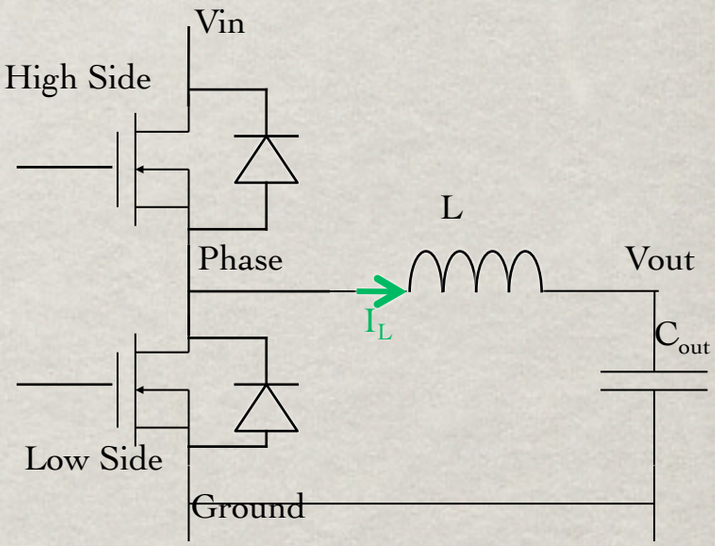

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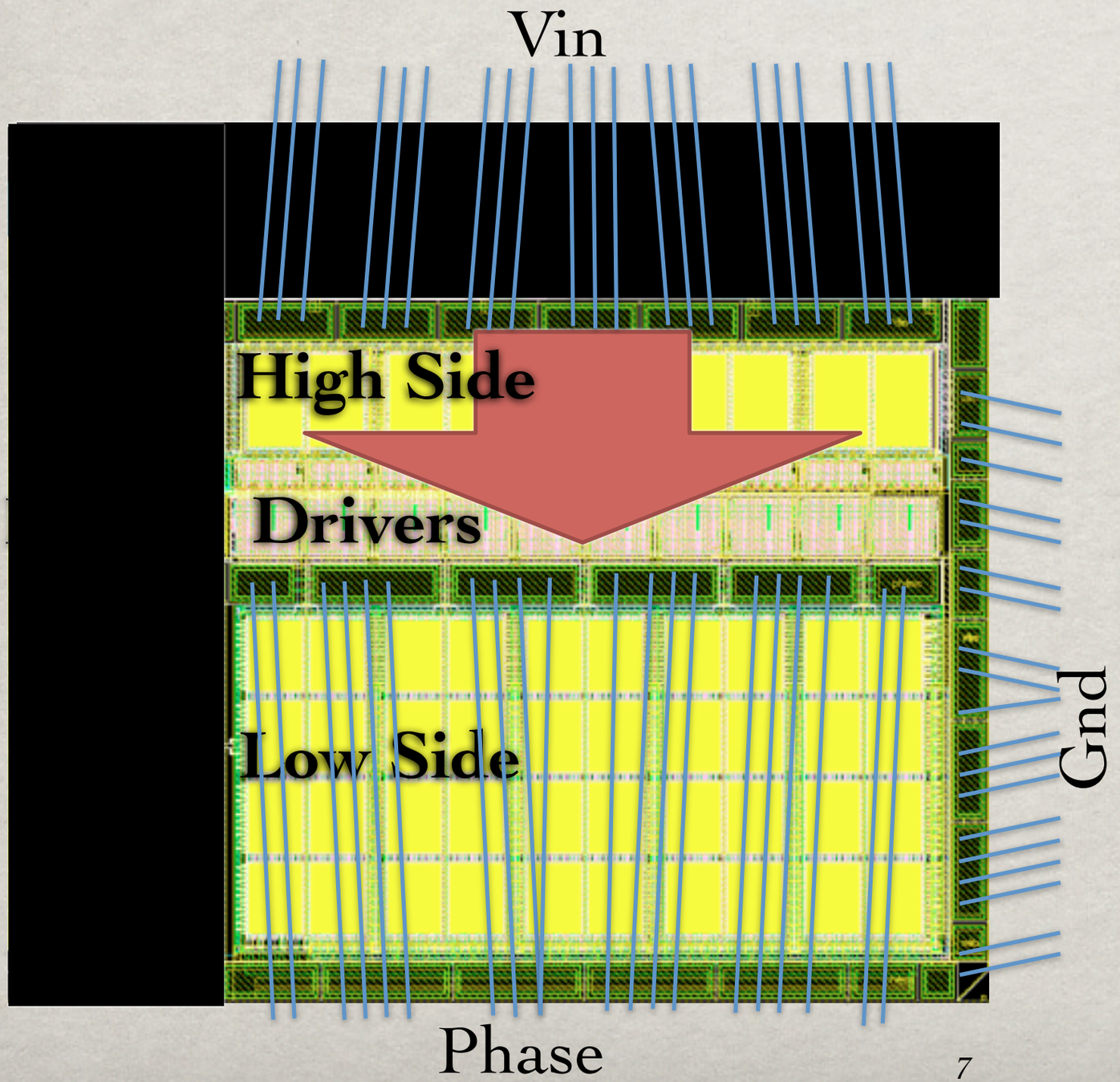

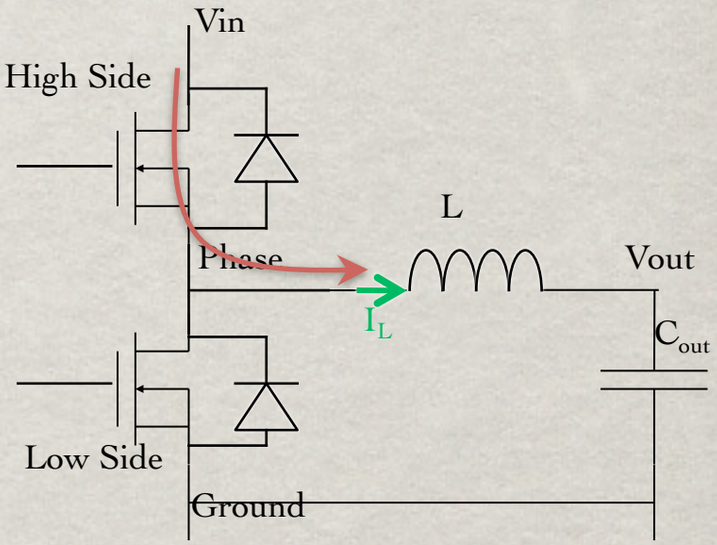

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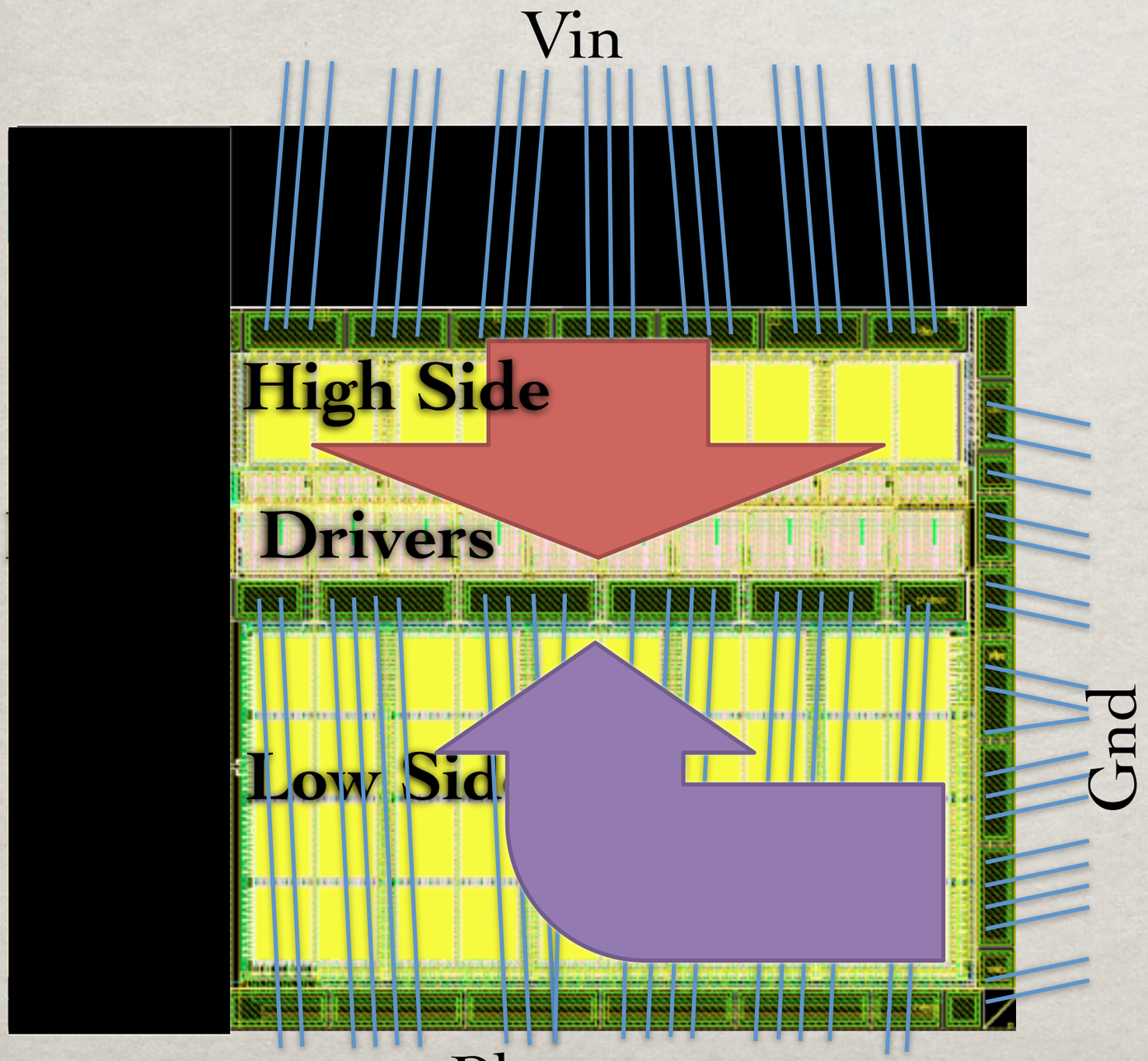
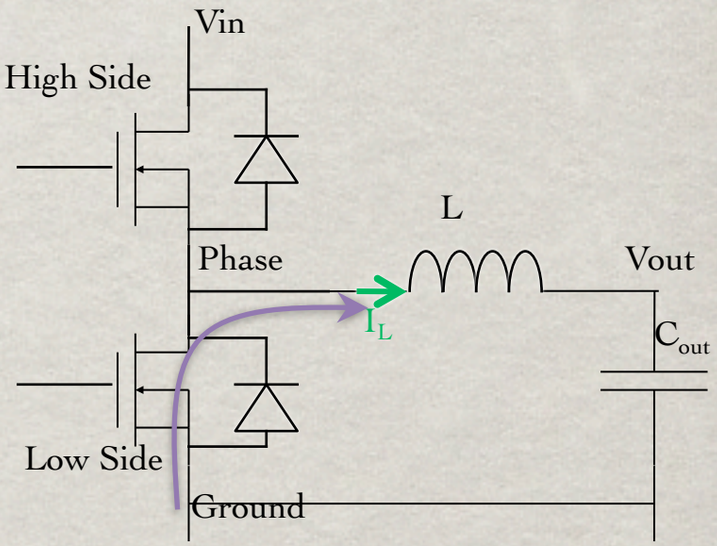
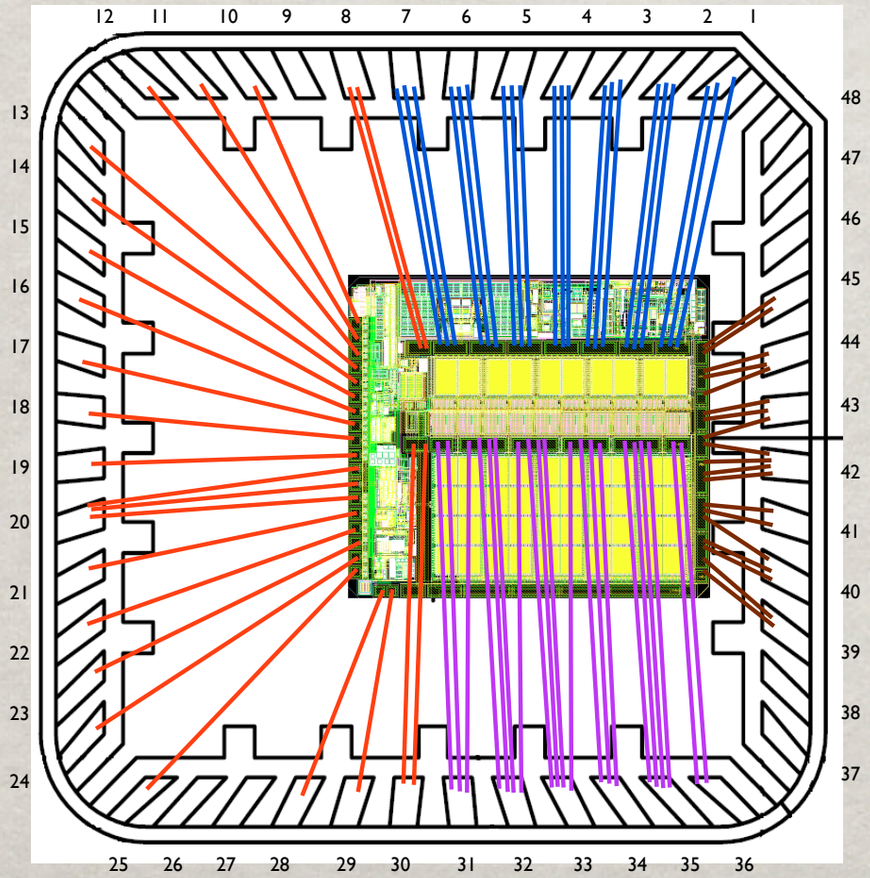




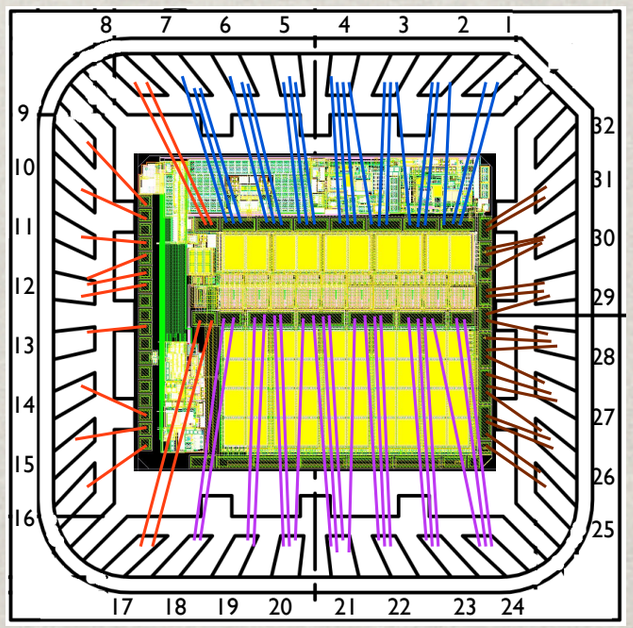
Bonding Diagram

The ASIC will be packaged in QFN48 for first testing phase, then in QFN32 for system tests.
This bonding diagram is feasible for mass production.

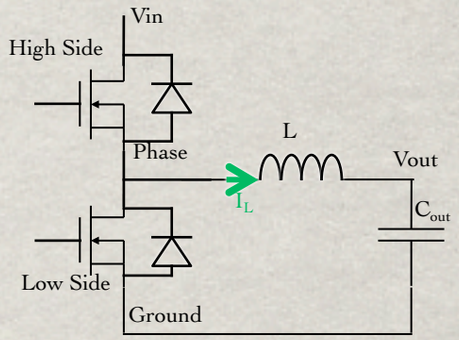
QFN48, 7x7 mm^2



QFN32, 5x5 mm^2



Switch dimensions



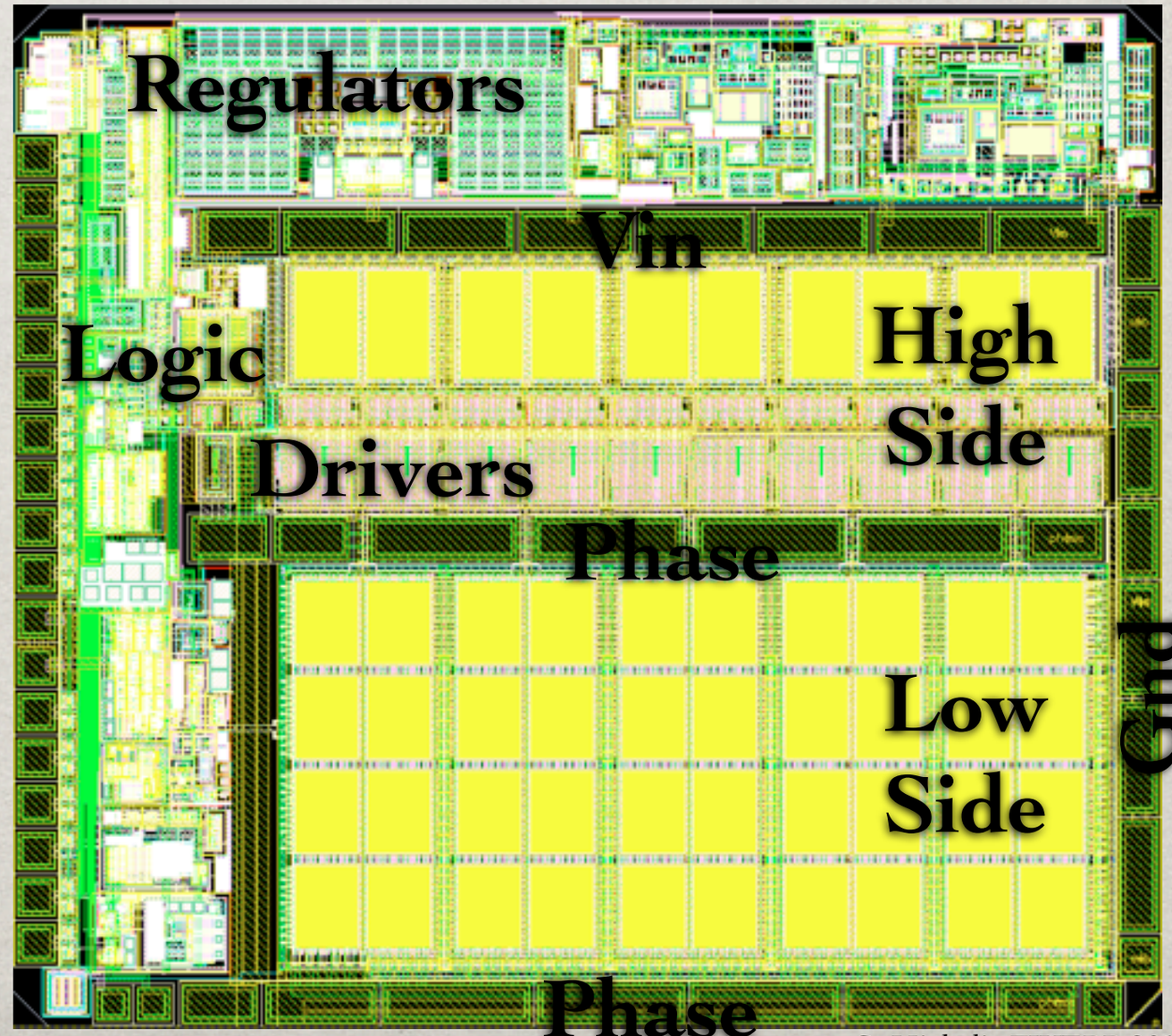
Power transistors have been carefully for maximum efficiency for

Iout=1-3A

L=200nH-400nH

f=1-3MHz

With an external pin only 2/5th of the switches can be enabled
This allows having less power dissipated in switching and driving operations



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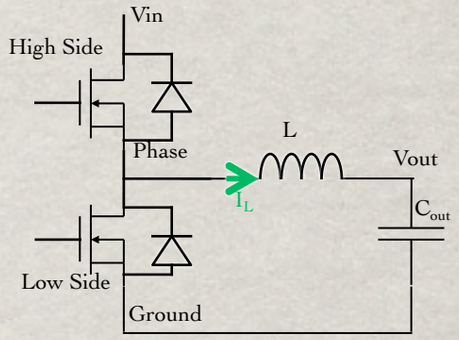

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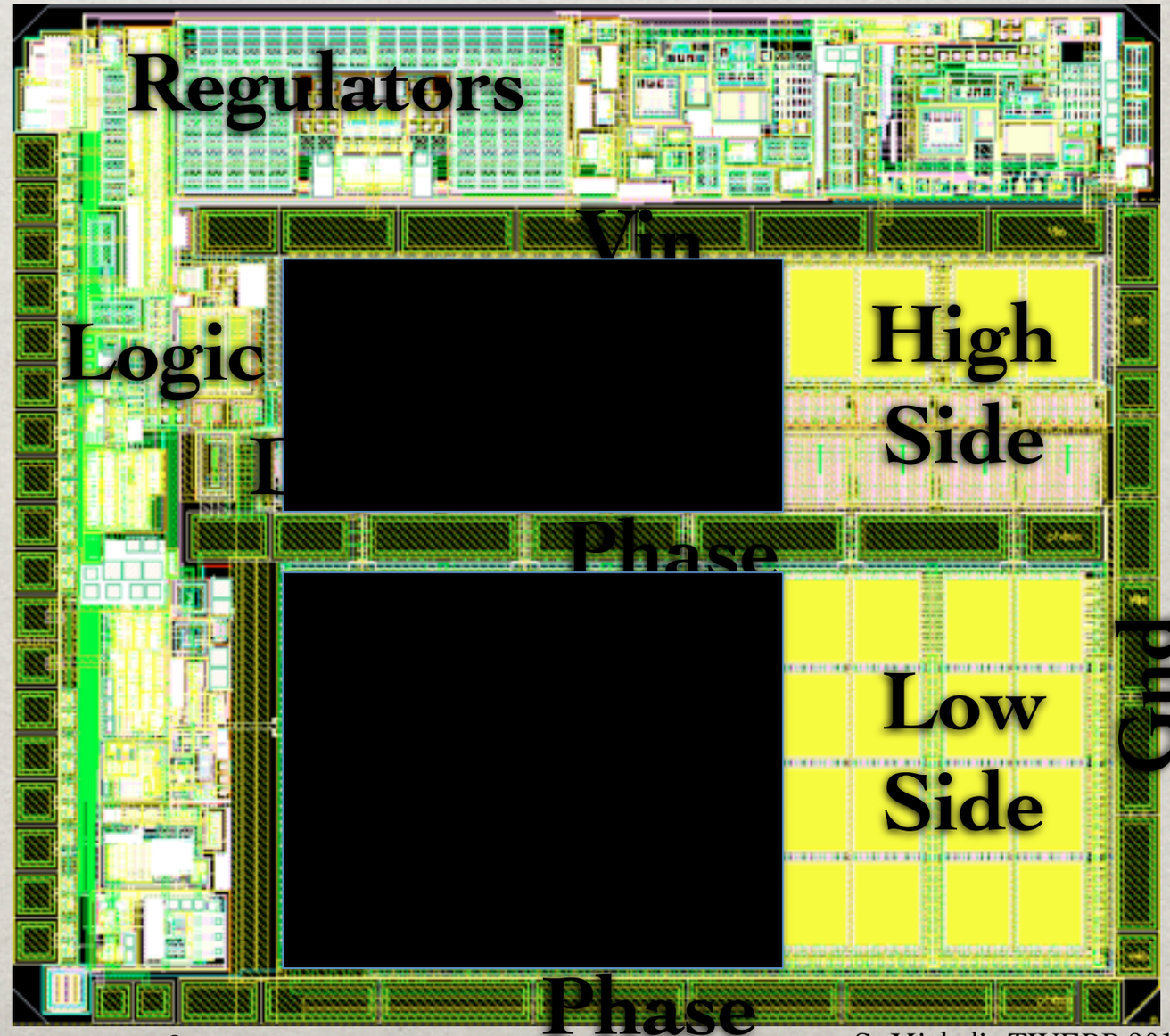
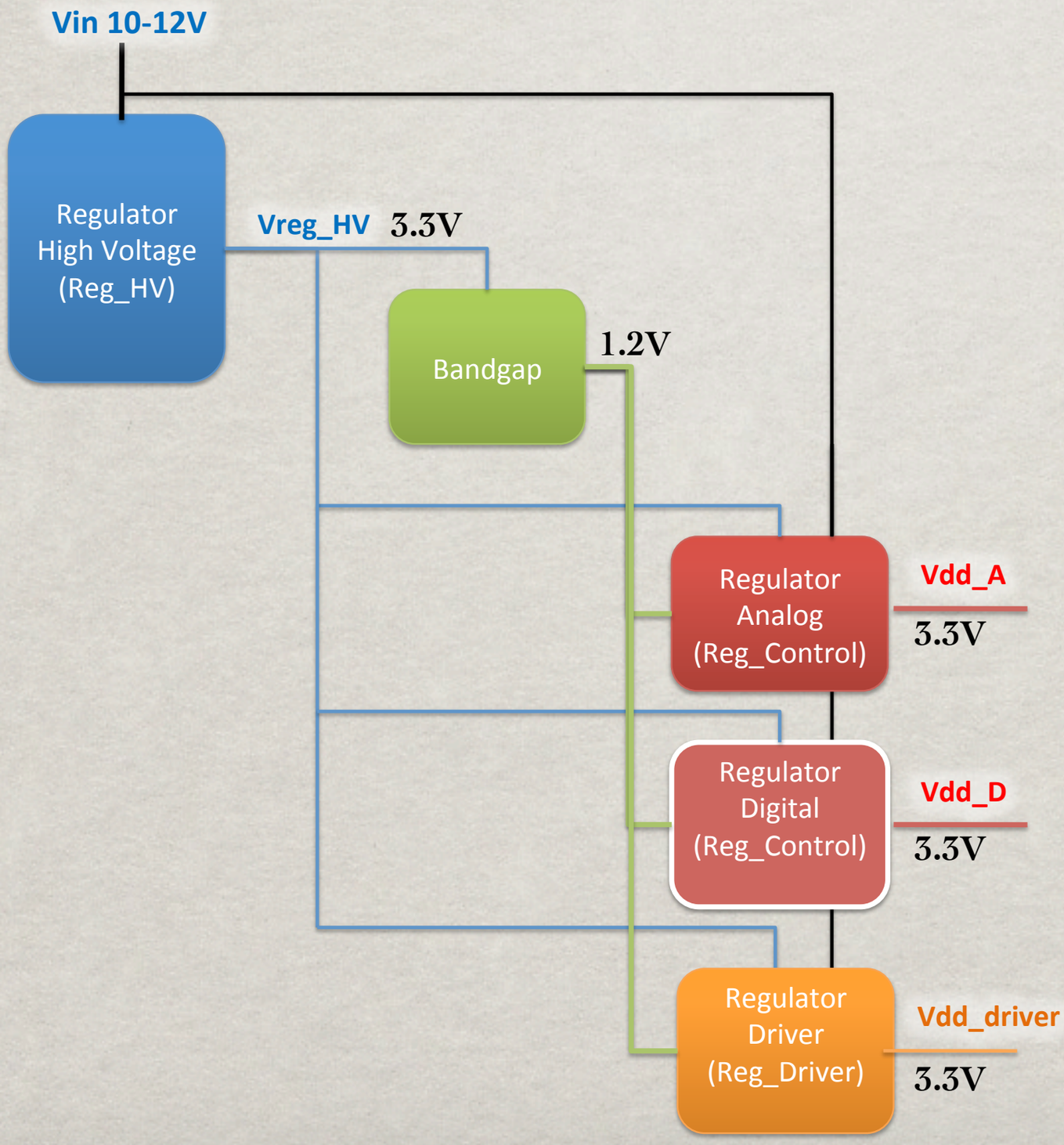


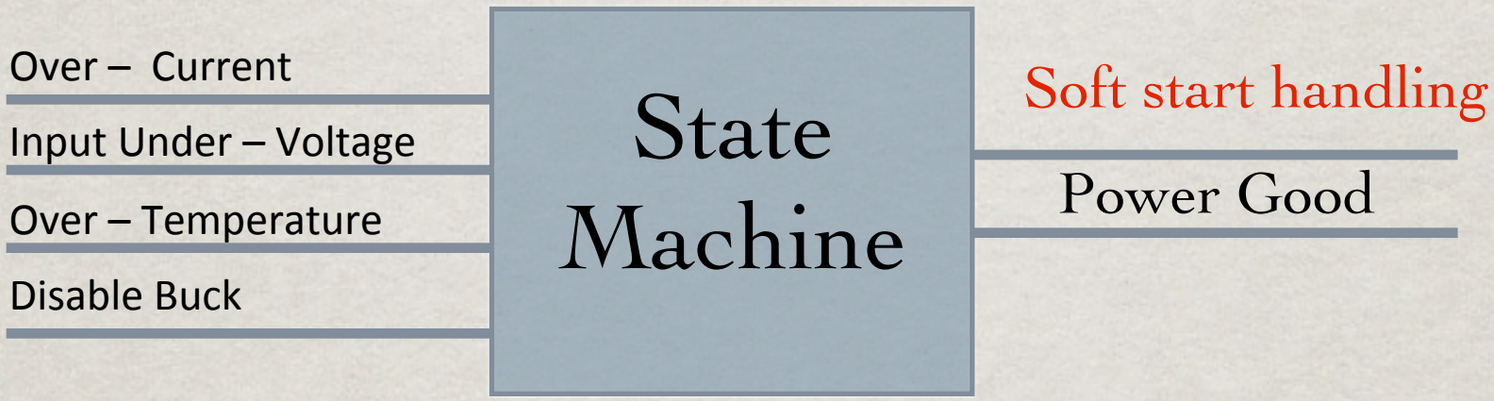
Linear regulators

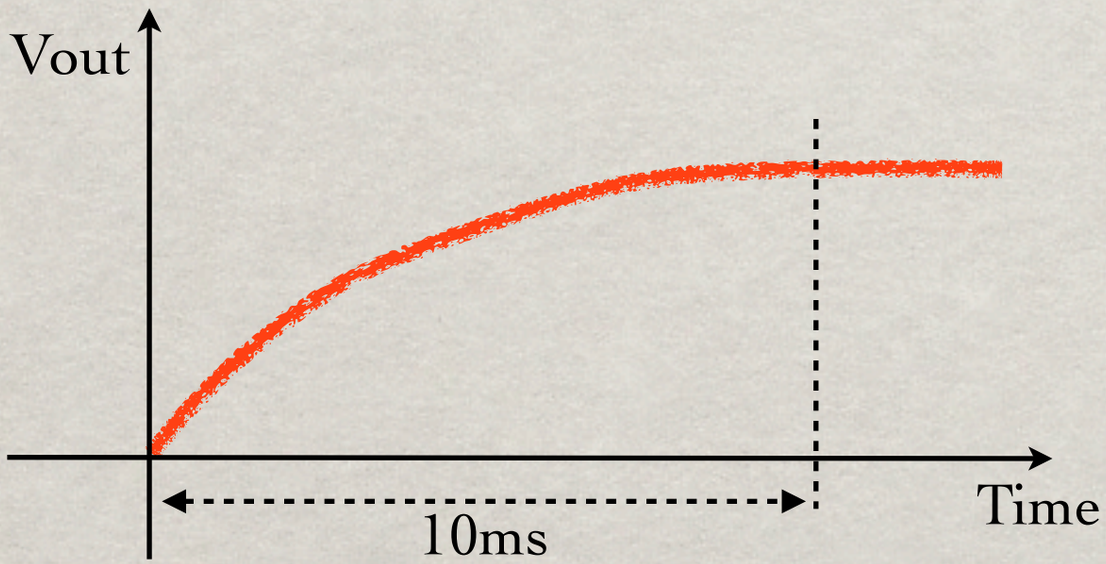


Reg_HV, Reg_Controls are designed with fully integrated output capacitor

Reg_Driver requires 100nF external capacitor

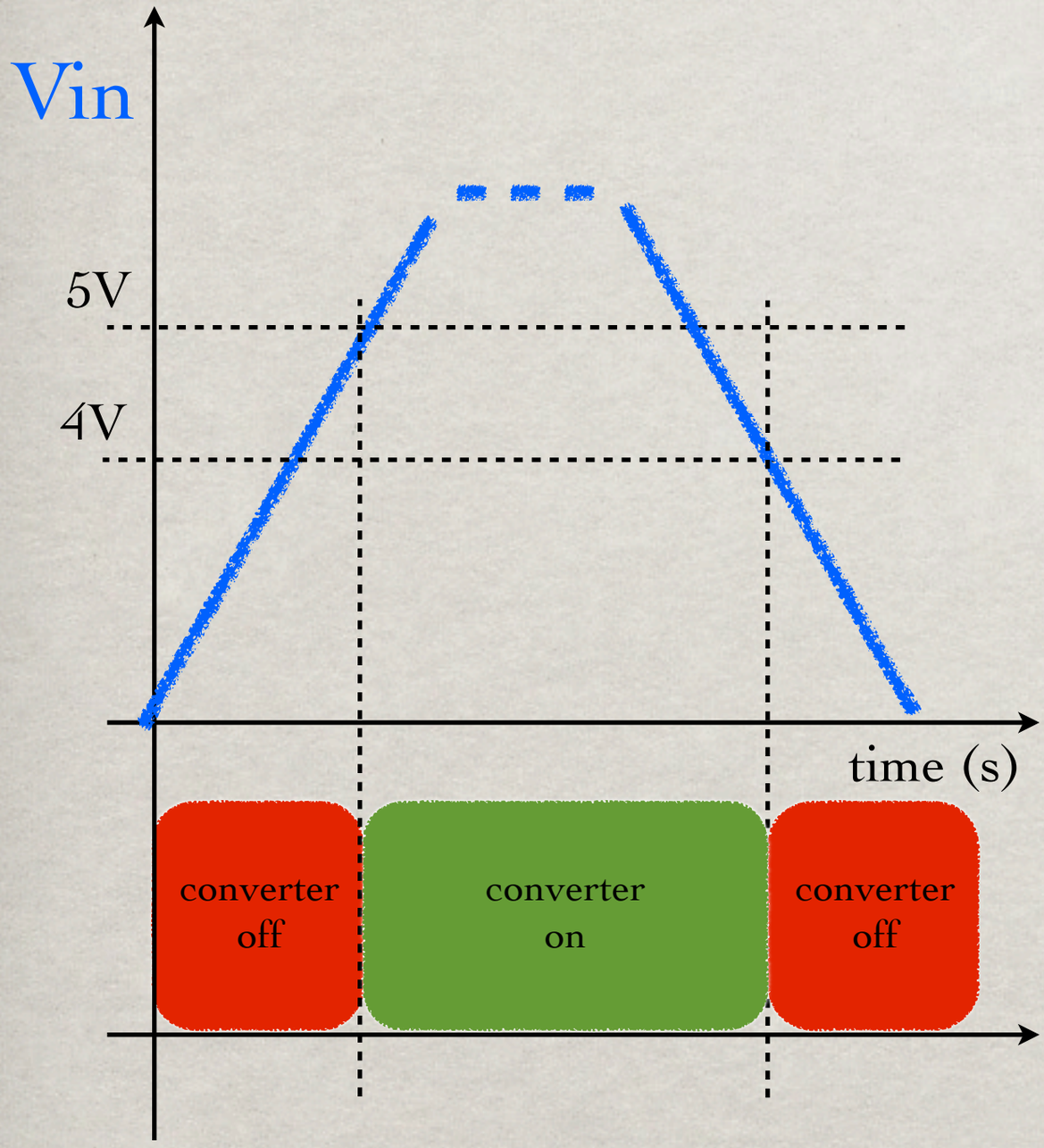
State Machine

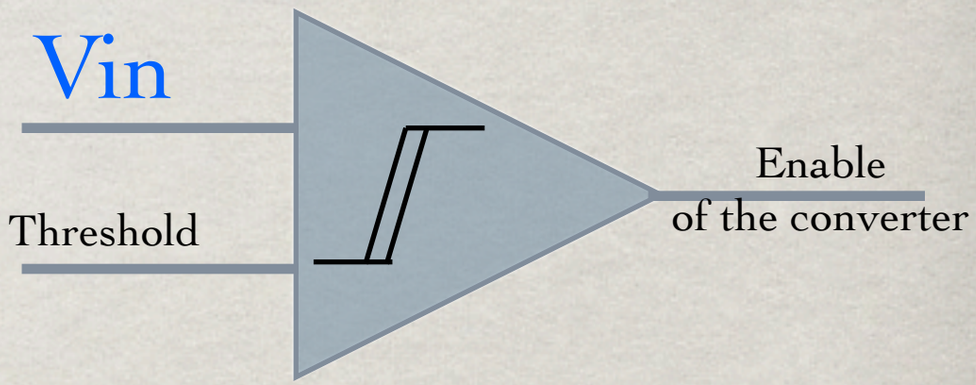




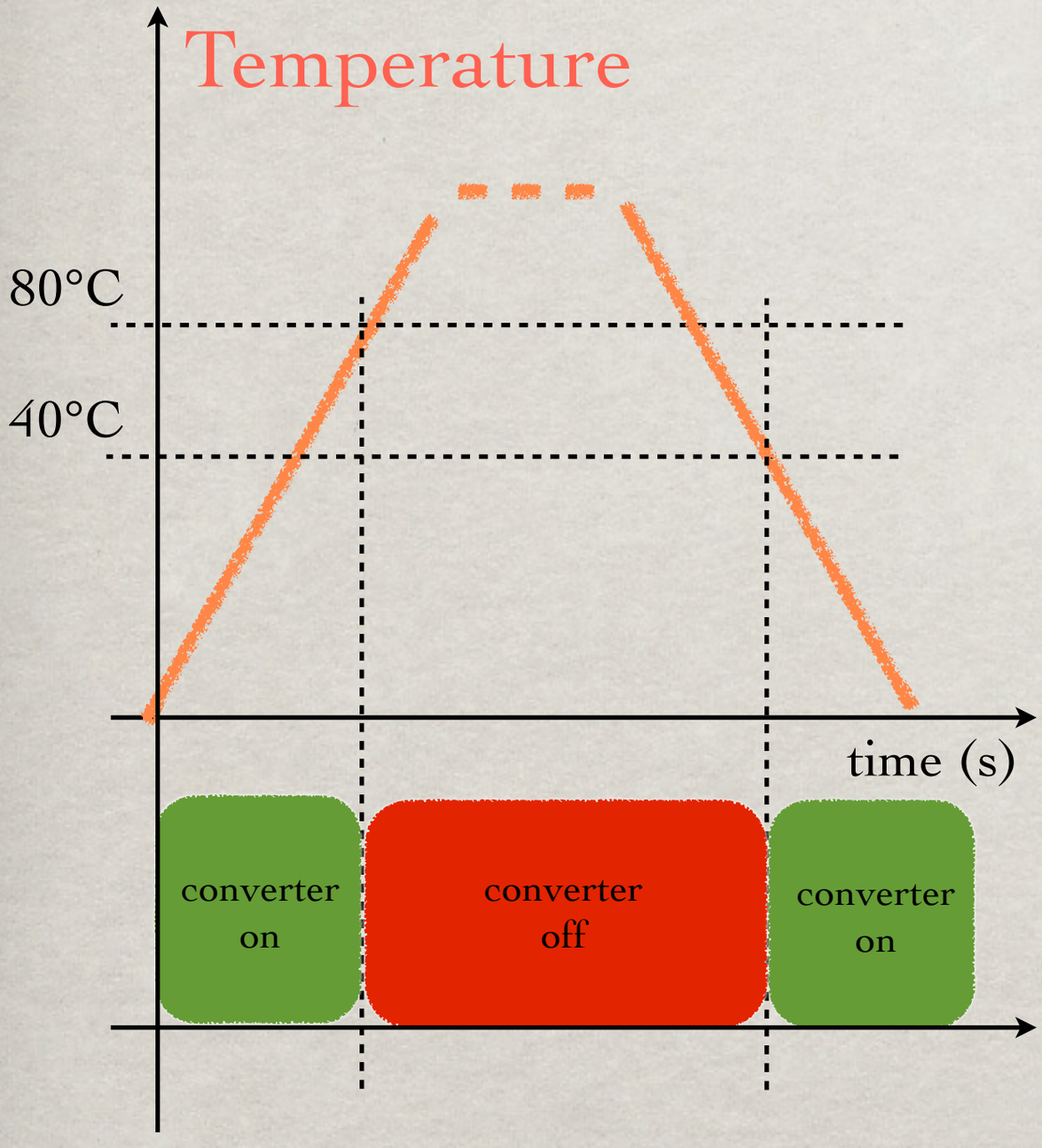
Soft start allows a rise time of the Vout in around 10ms, avoiding too high in-rush current at the start-up

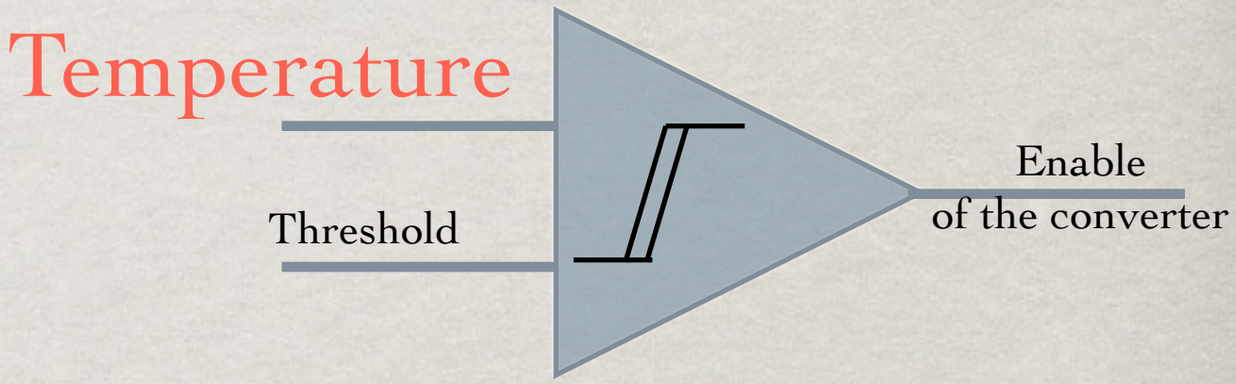
Input Under – Voltage Protection





Over-Temperature Protection





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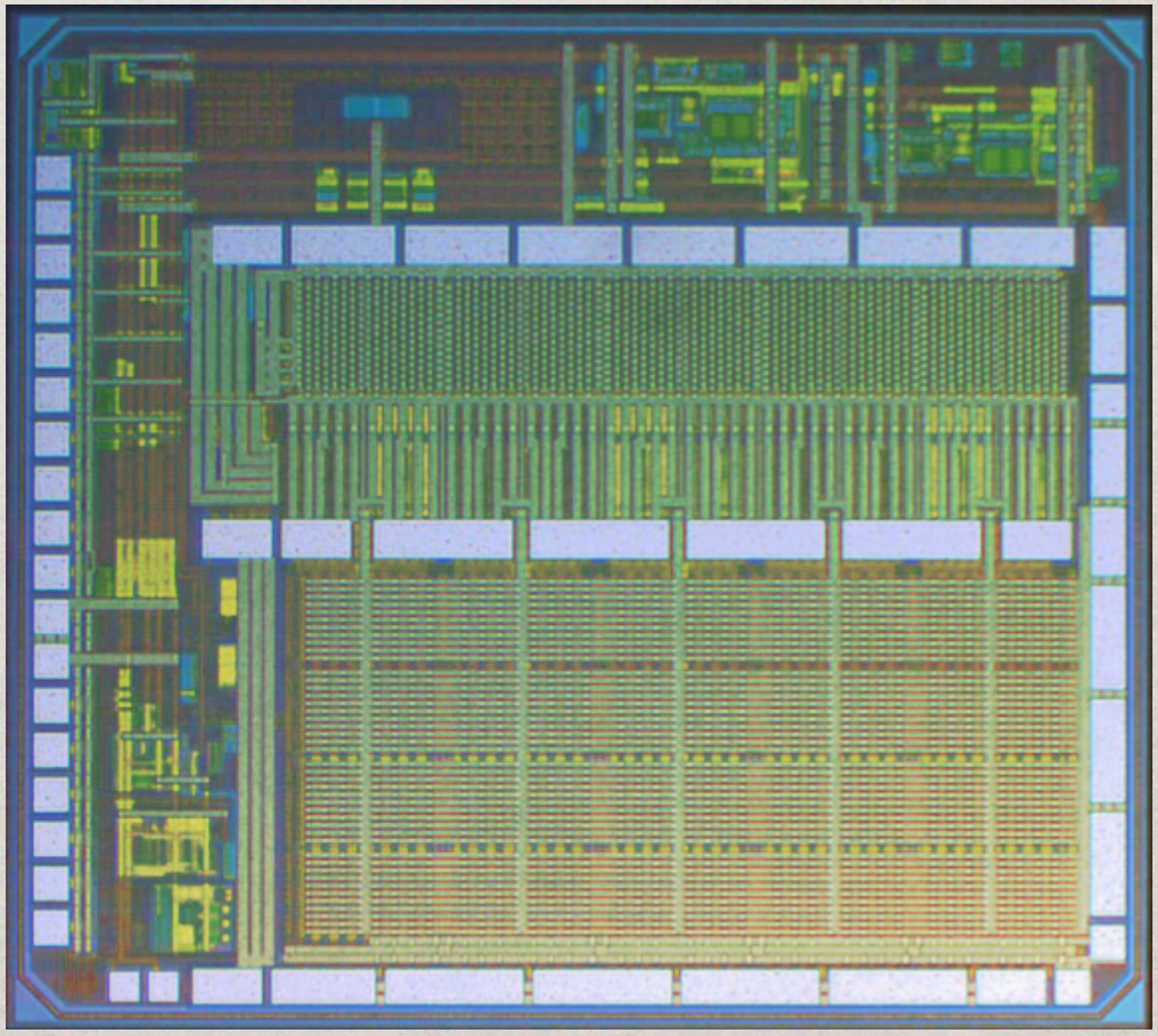
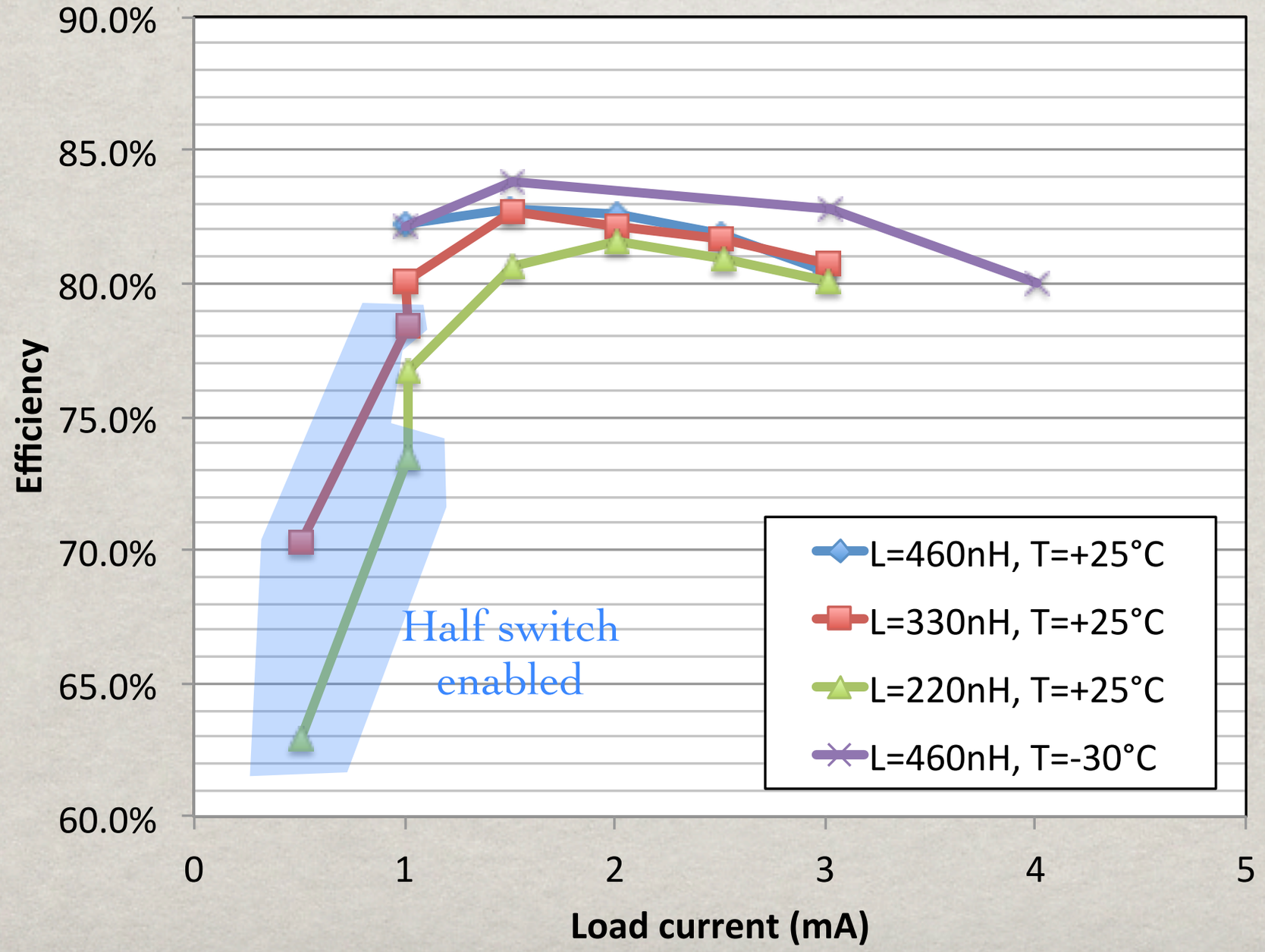
AMIS4

Chip available beginning of August
Still under test, preliminary results



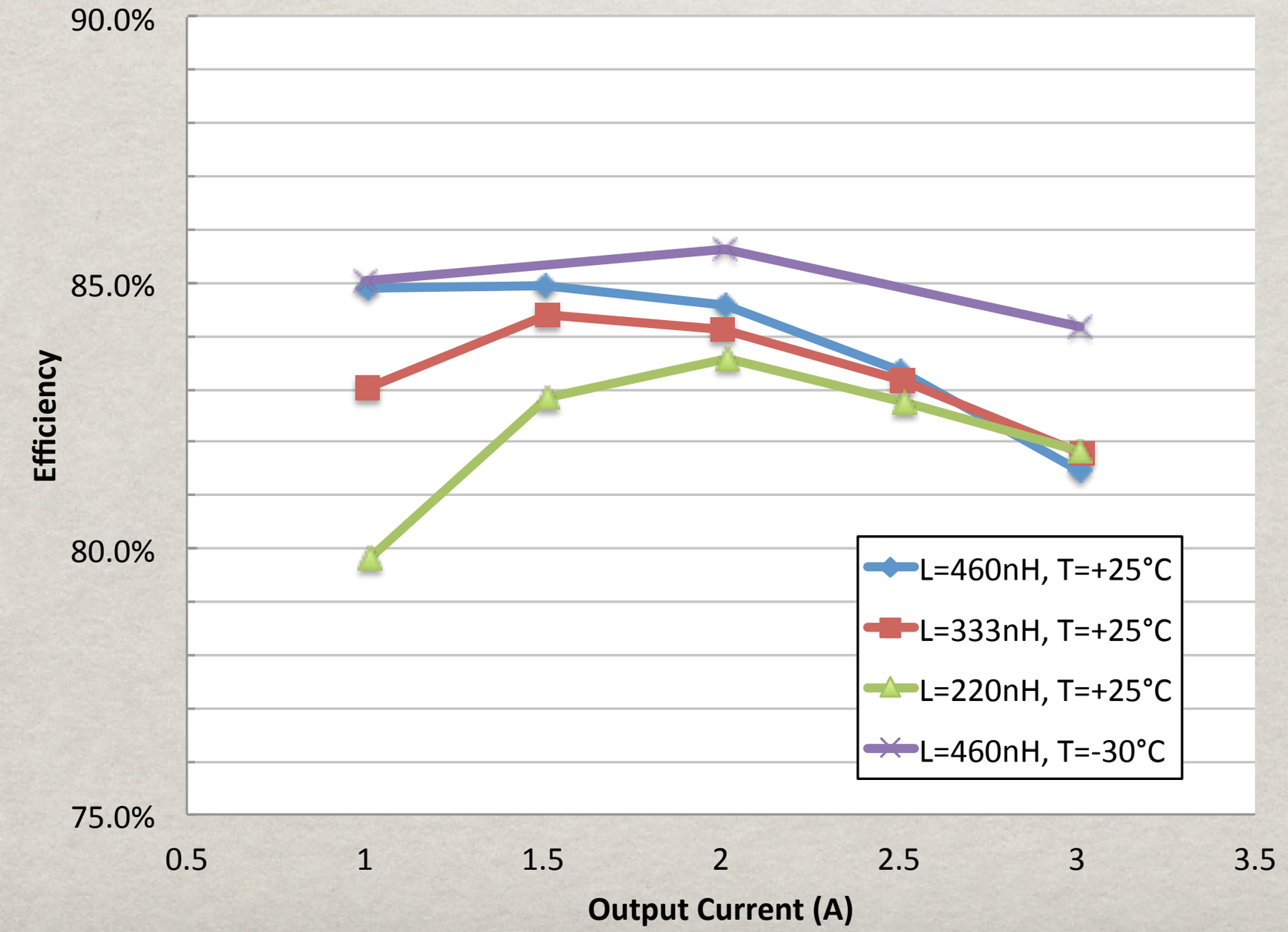
Efficiency AMIS4 QFN48(1/2)

Vin=10V, Vout=2.6V, L=460nH, f=1.35MHz, QFN48



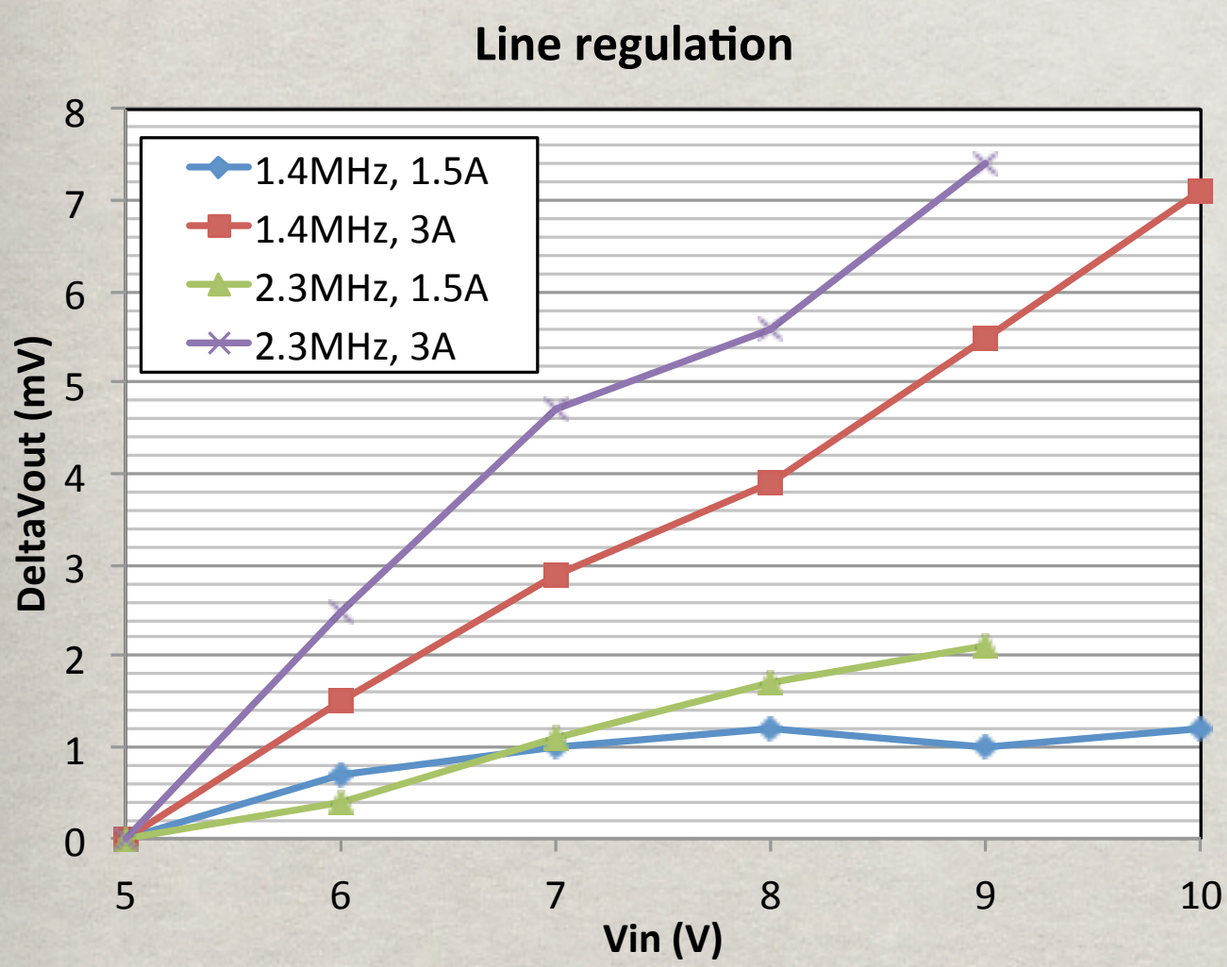
Efficiency
AMIS4 QFN48 (2/2)

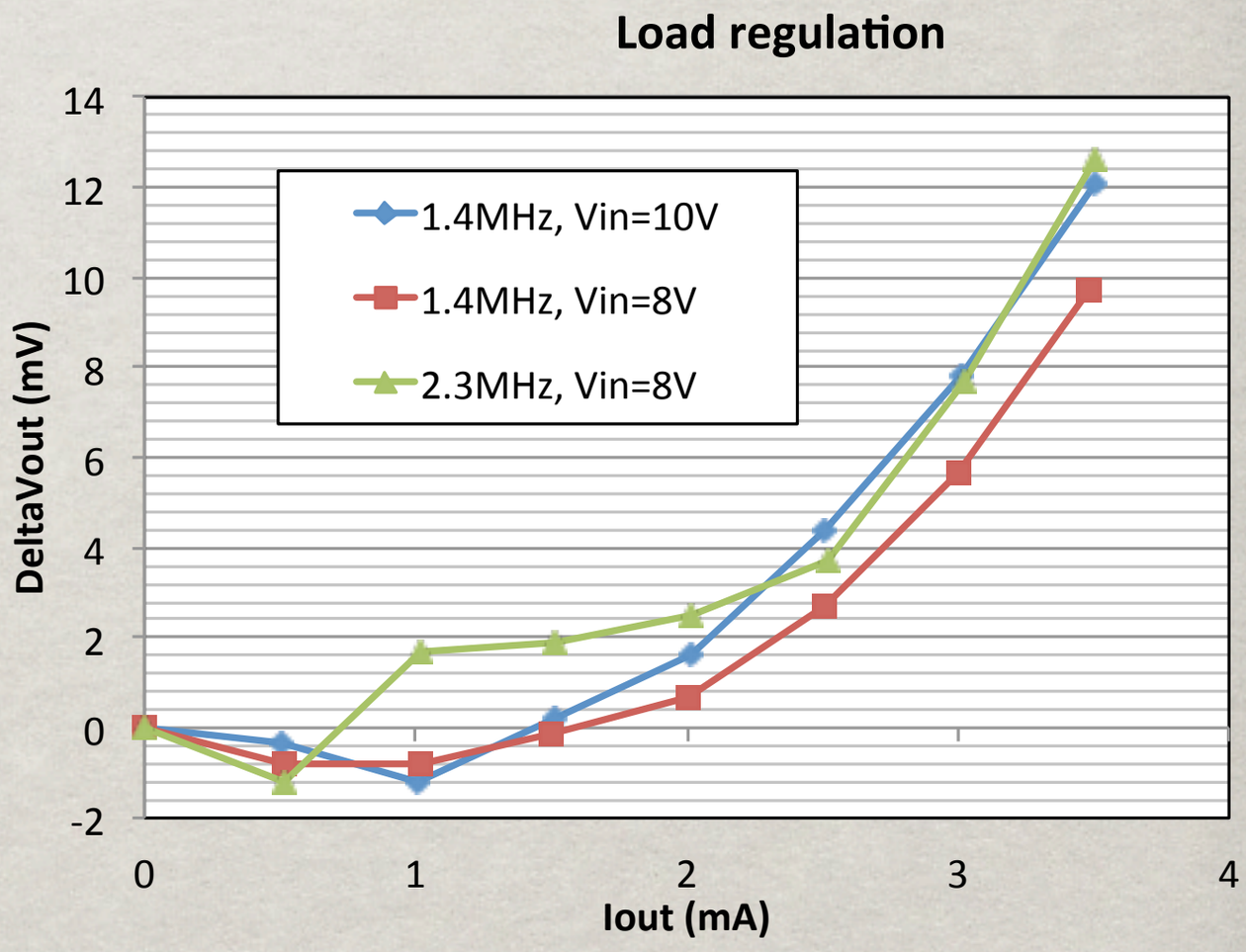
Vin=8V, Vout=2.6V, L=460nH, f=1.35MHz, QFN48



Line and Load regulation

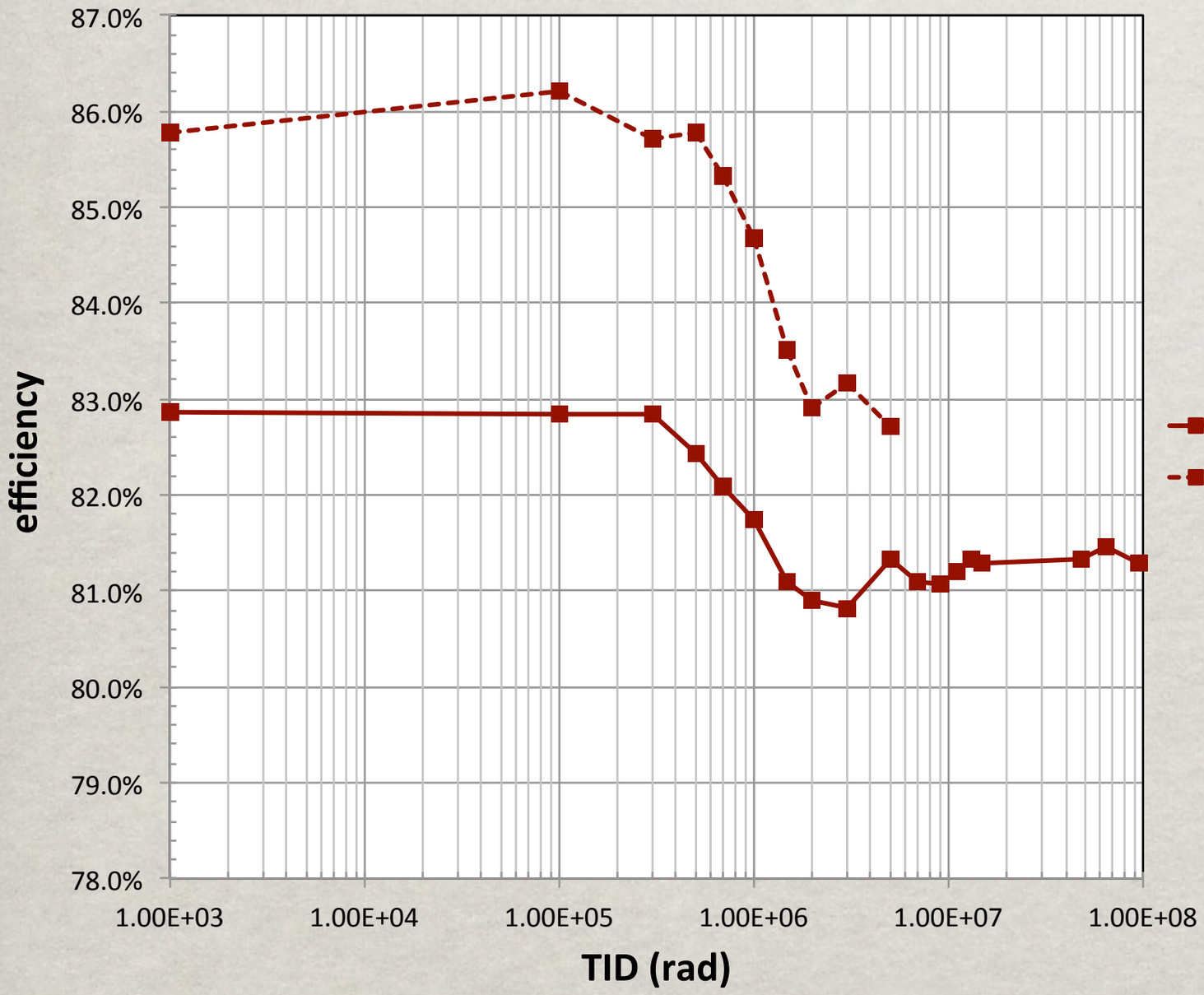
Vout=2.604V, L=460nH





Efficiency vs TID

L=397nH, f=1.35MHz, Vout=2.5V

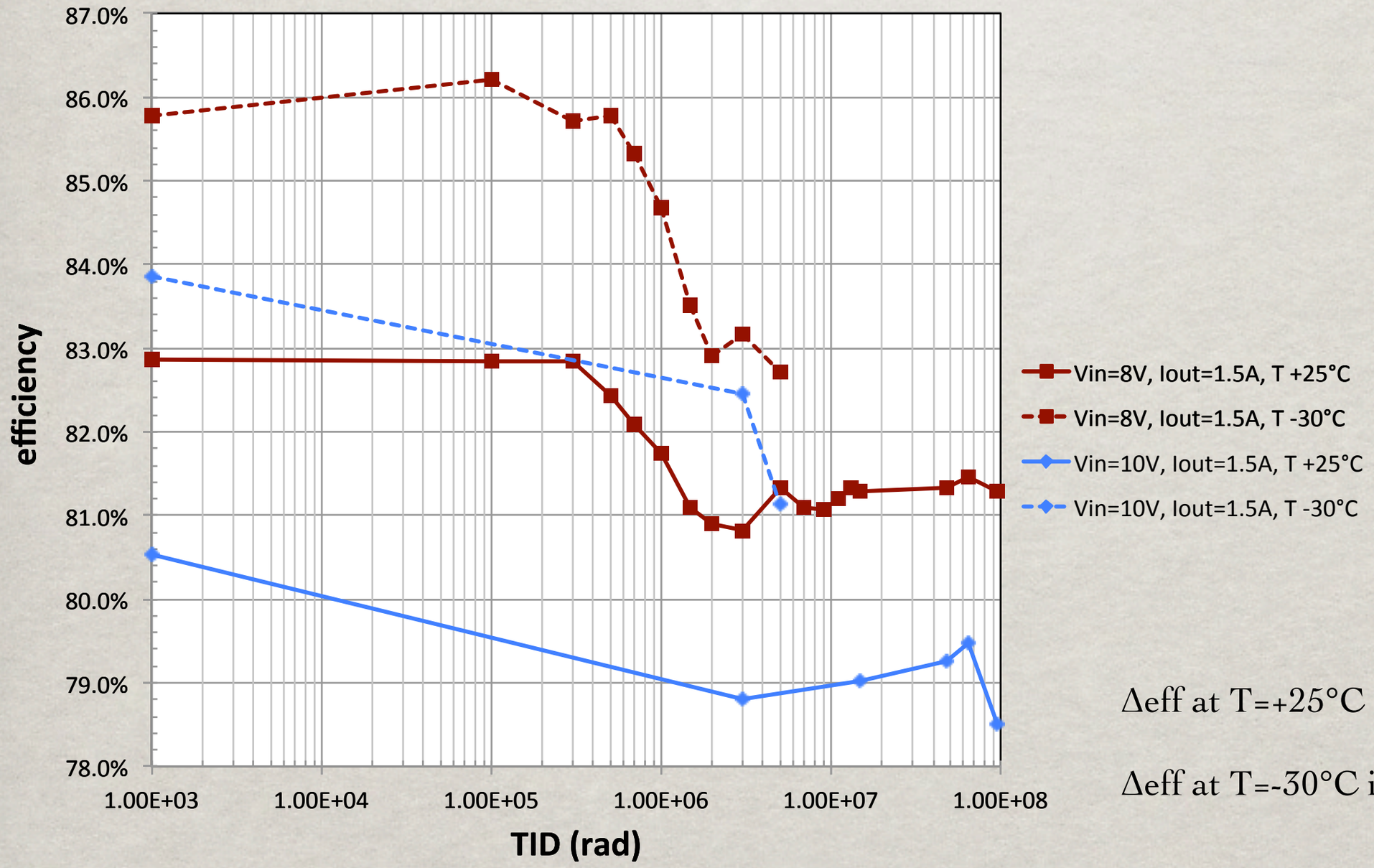


Δeff at T=+25°C is 2.4%
(max TID 96Mrad)

Δeff at T=-30°C is 31%
(max TID 5Mrad)

Efficiency vs TID

L=397nH, f=1.35MHz, Vout=2.5V



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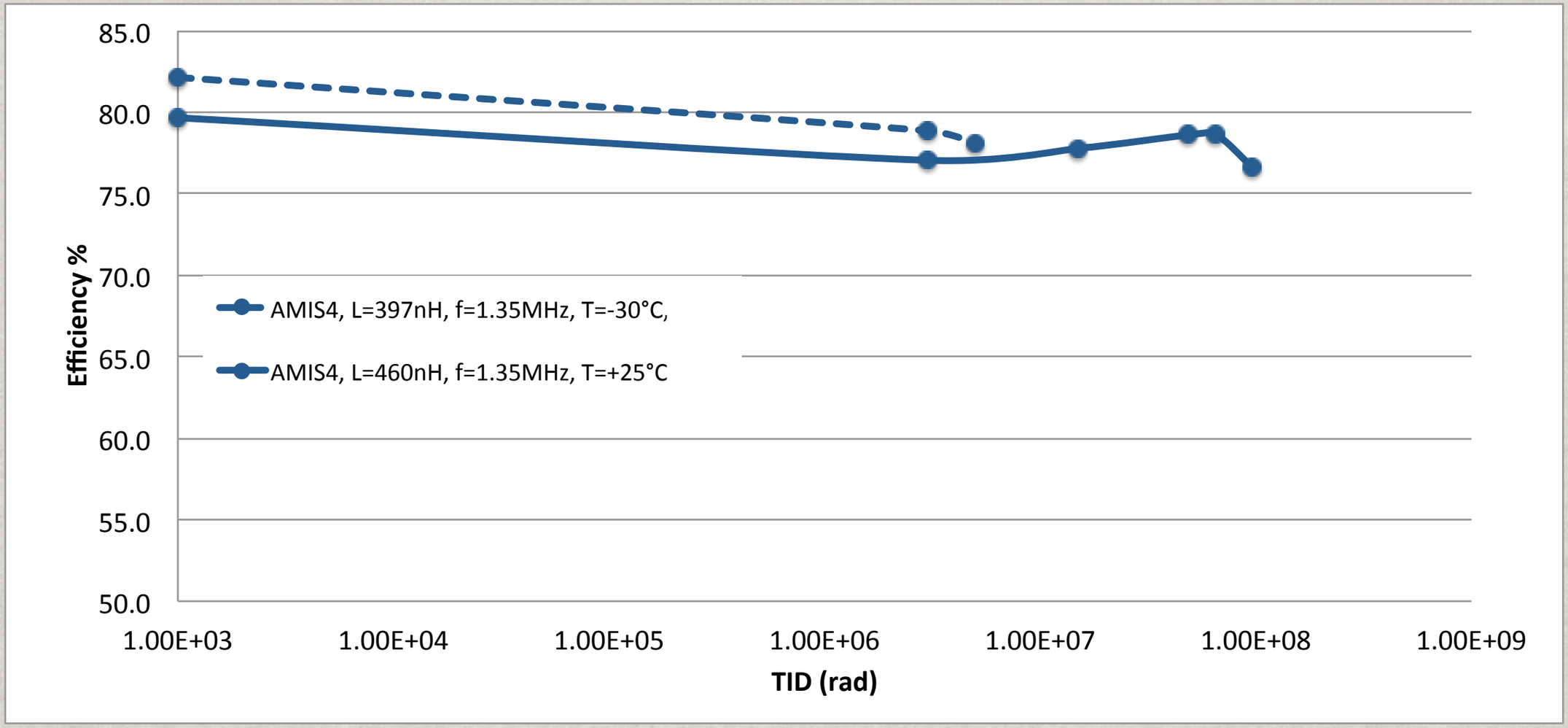
Efficiency vs TID comparison AMIS2-AMIS4

Vin=10V, Vout=2.5A, Iout=1A



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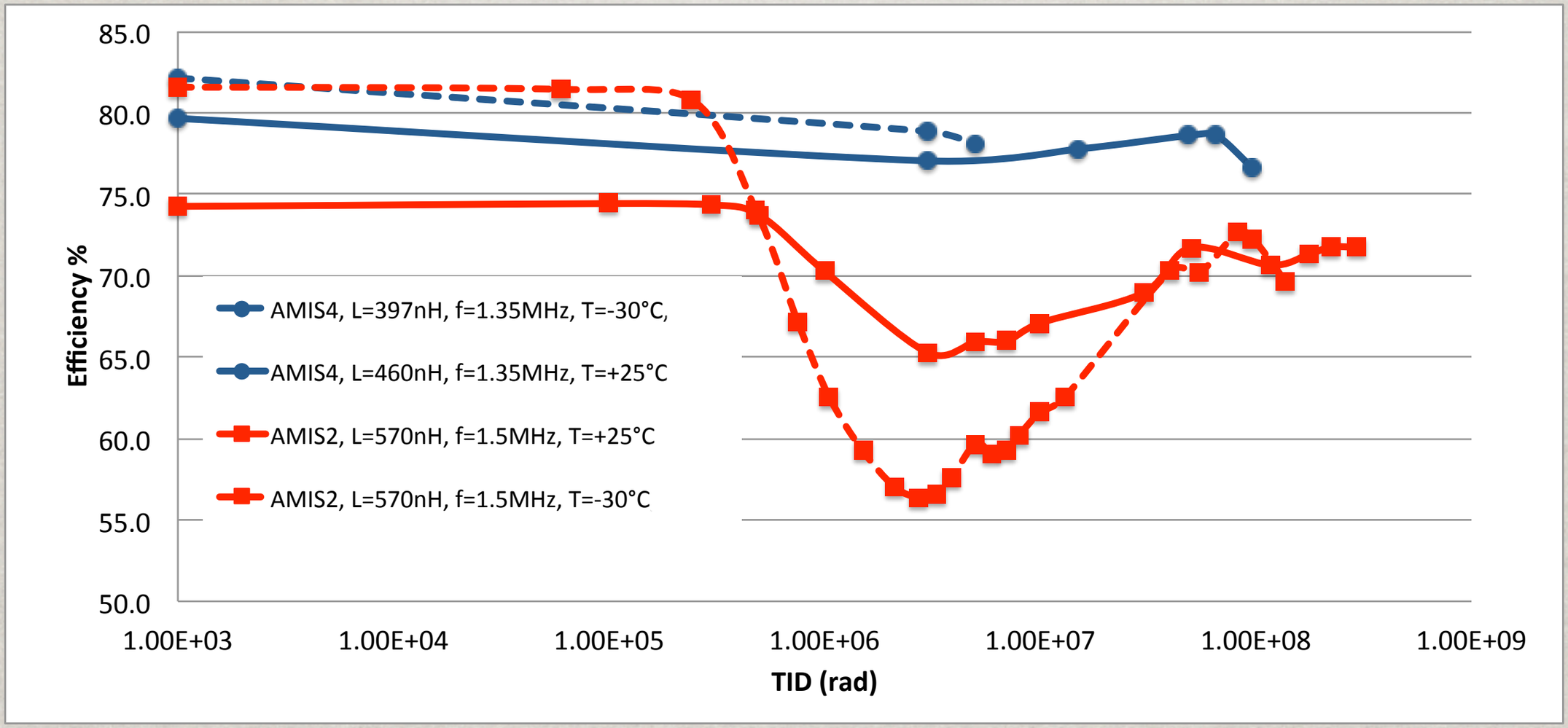
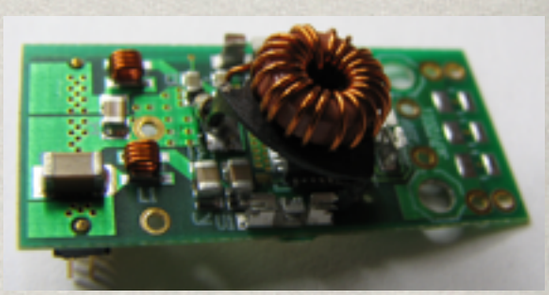


Possible Issues

First tests have been done on a not optimized board (used for having easy access to all the pins)

In this board a large input voltage ripple has been detected.

A new compact board has been designed by Georges and in this days under tests

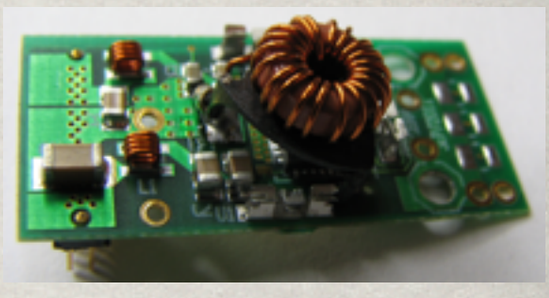


Preliminary tests show that the ripple is drastically reduced

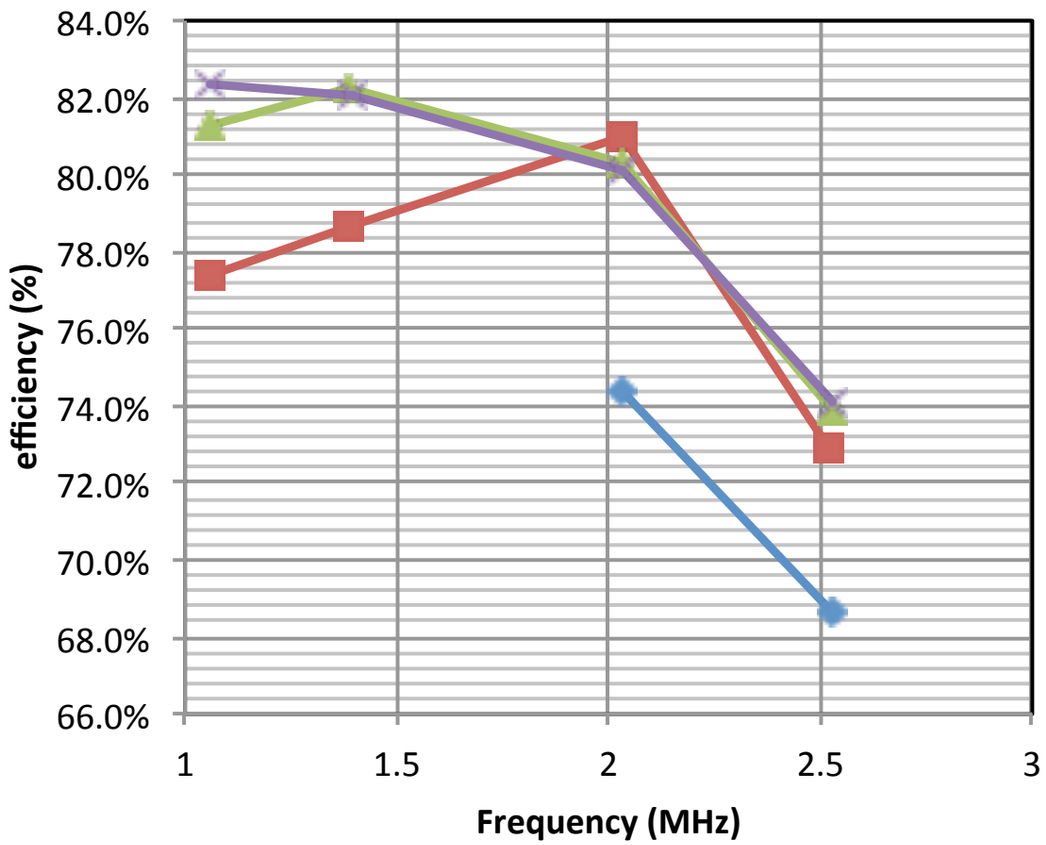
Some issues sawn with large board need to be checked in the new board:

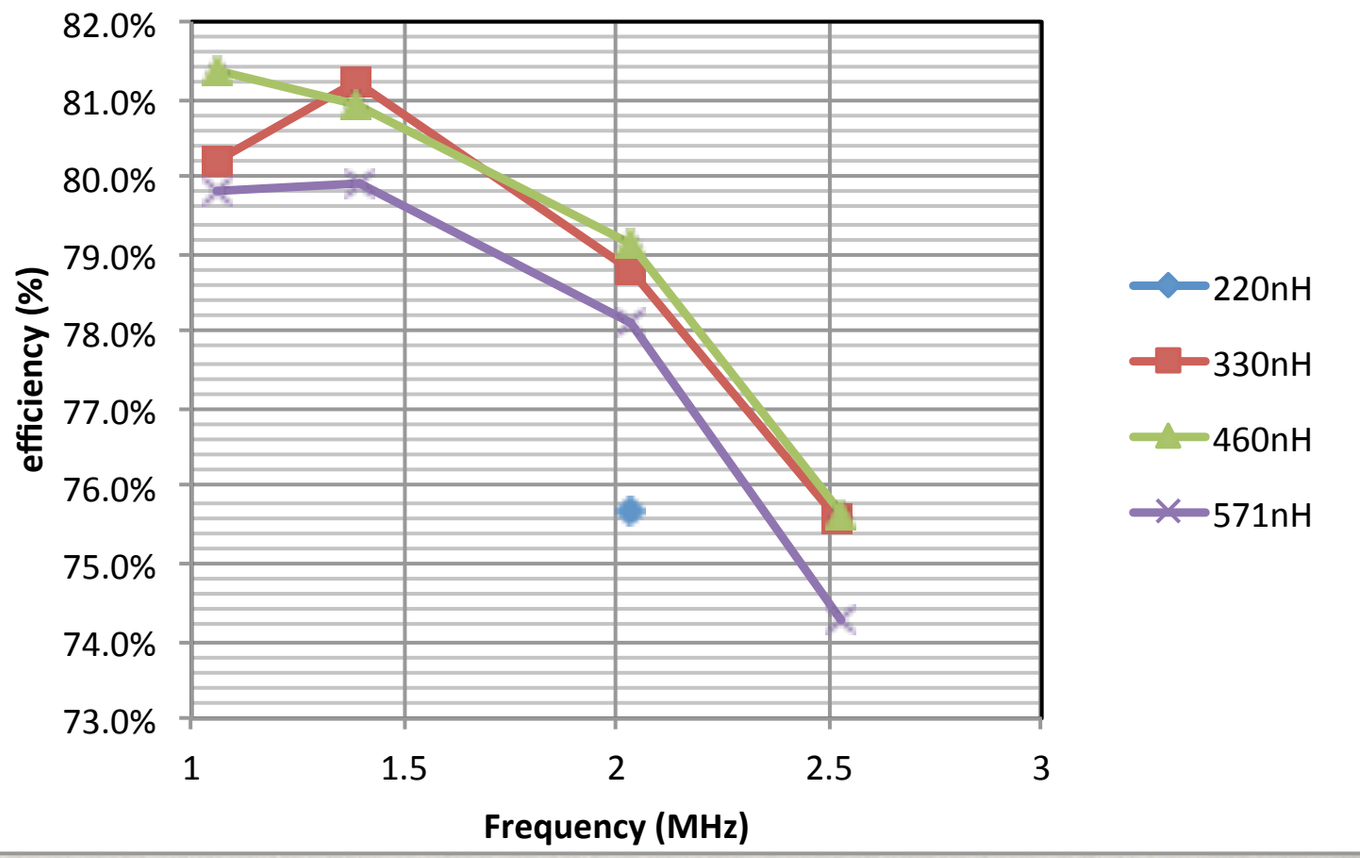
- noise in the VregHV (first regulator). It can be cleaned with an external capacitor
- inappropriate turn-off of the High-Side power transistor at f >2MHz with Vin>9V (this decrease the efficiency)
- over-current does not work (it can be disabled with a pin)

Efficiency AMIS4 QFN32



Plots I received few minutes ago from F. Faccio…





Future plans

Work to be done in AMIS4

A Focused Ion Beam will be used to modify some connection. This should solve some of the issues.

Irradiation test under Heavy ions and protons are foreseen in fall 2011

Definition of the bond-diagram for user applications (next weeks)

packaging (Europractice, ASE?) for system tests (fall 2011)

Work for AMIS5

Design of AMIS (fall 2011)

Submission (January 2012)

Conclusions

- A new DC/DC converter ASIC called AMIS4 has been designed in a High Voltage 0.35um technology for automotive application. This technology has been successfully tested for TID, protons and heavy ions.

- AMIS4 is a fully integrated synchronous buck converter which contains internal linear regulators, bandgaps, adaptive logic and a state machine to handle signals form the protection circuitry

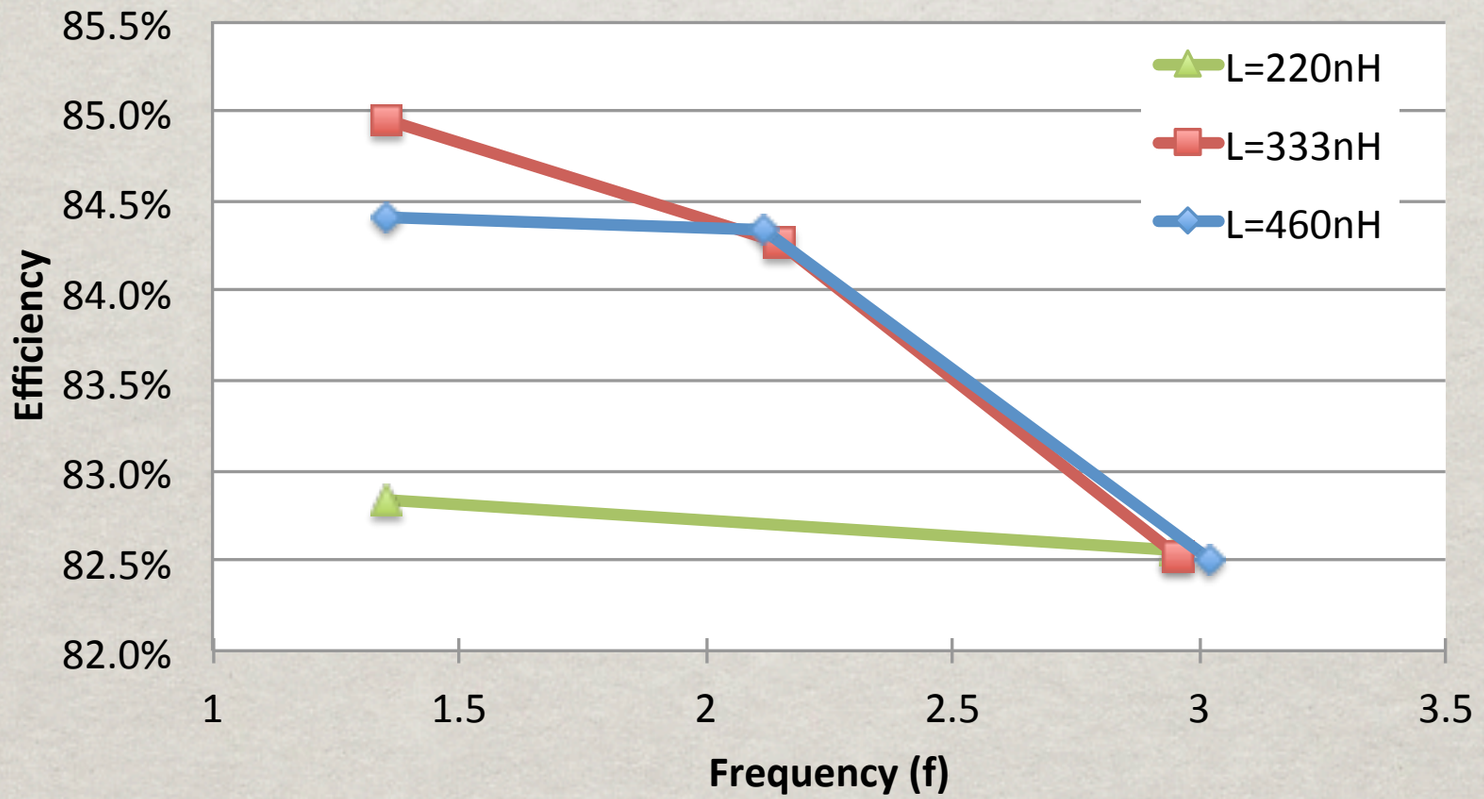
- The converter is functional at for f≤2MHz (only the Over-current is not working). Some issues have been detected at f >2MHz with Vin>9V. A new test board has been designed and now under tests.

- Efficiency is high (above 80%, also for high load 3-4A)

- Radiation effects are limited (2-3% loss of efficiency over 100Mrad)

- line regulation is good (7 mV for Vin variation from 5 to 10V)

- load regulation is good (12 mV for Iout variation from 0 to 3.5A)

Efficiency (3/3)

Vin=8V, Vout=2.6V, Iout=1.5A, T=+25°C