An integrated sliding-mode buck converter with switching frequency control for battery-powered applications

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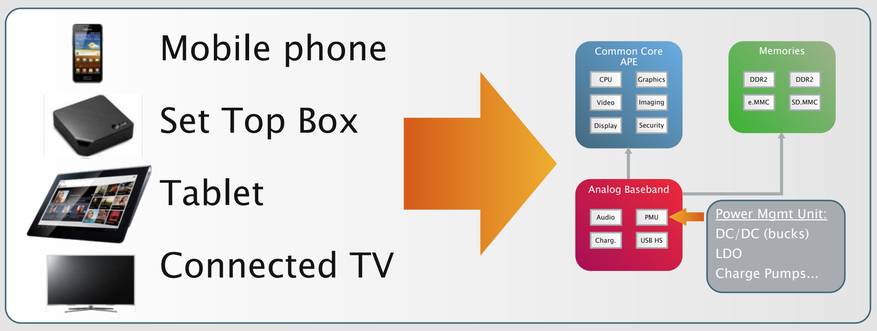
Context: mobile oriented digital-core power supply



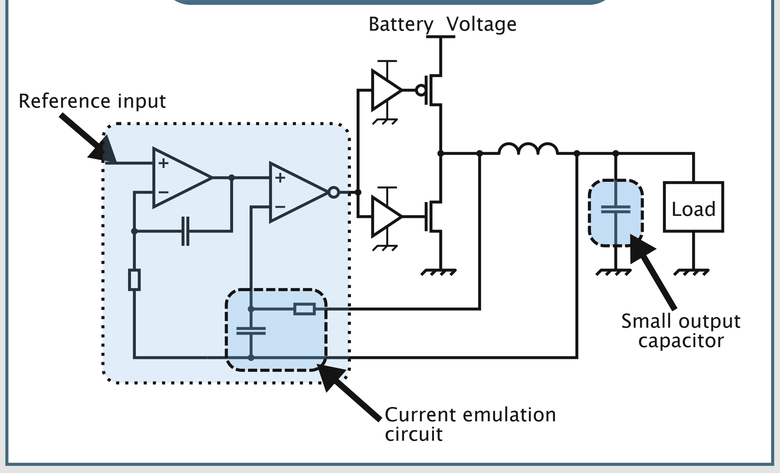
Problems:

1. Increase the load an line transient performances
2. Reduce the external passive components footprint
3. Control the switching frequency

Objective: Synchronize a sliding-mode buck controller while keeping its transient performances

Sliding-mode converter

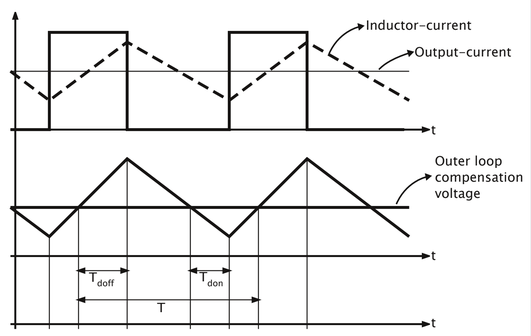
Free-running topology



- An inner loop provides fast transient response
- An outer loop provides a high DC accuracy
- Uncontrolled switching frequency

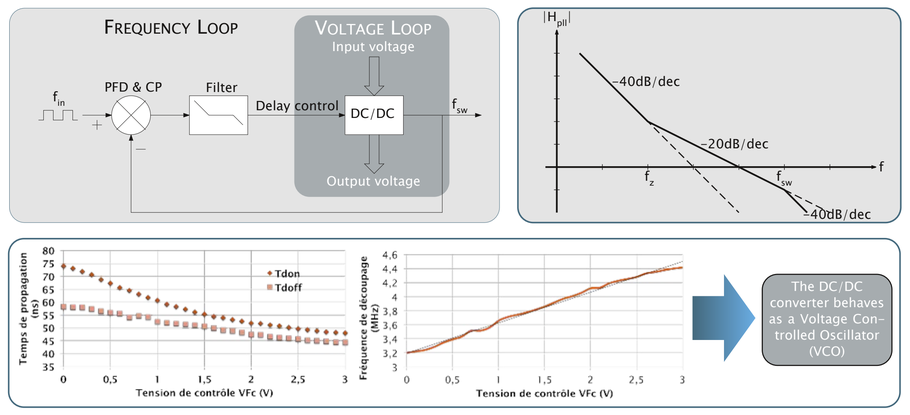
Switching frequency control

Oscillator characterization



- Switching frequency related to propagation delay
- Control the loop delay -> controlable frequency
- The DC/DC converter looks like an oscillator

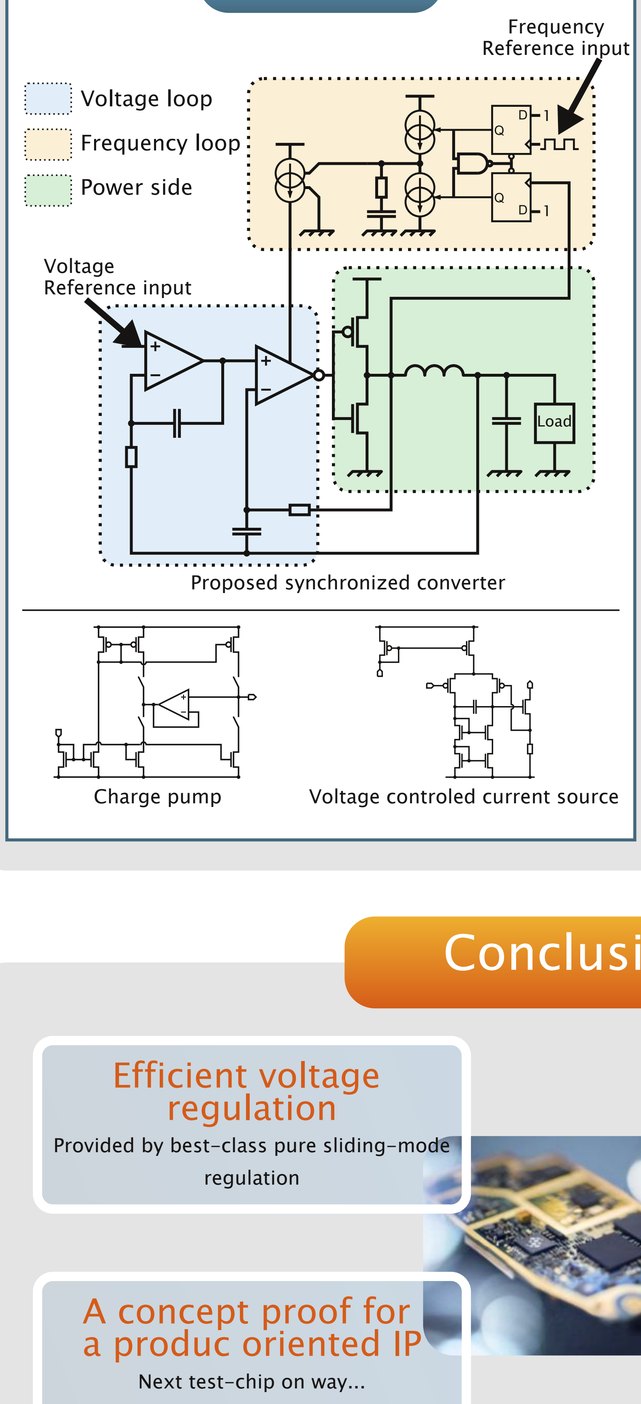
Phase loop control



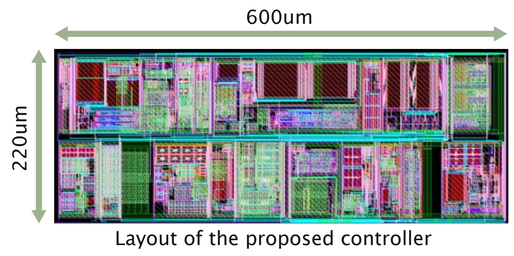
A sliding-mode voltage loop provides good voltage performances **+** A phase loop controls the whole converter's switching frequency **=** A two independent loop model

Design and results

Design



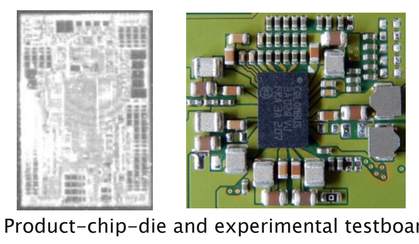
1st Prototype characteristics



Layout of the proposed controller

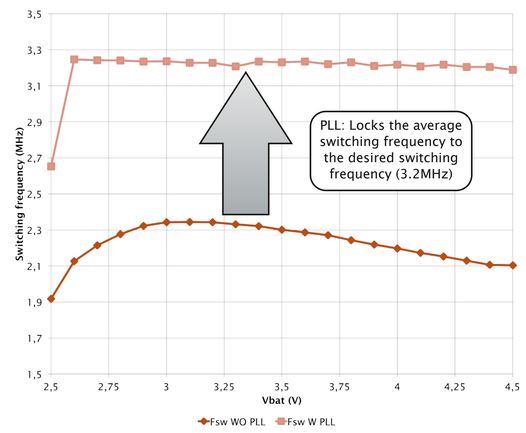
V_{bat}	Nominal Input Voltage	3.6V
V_{out}	Output Voltage	1.8V
$I_{out-max}$	Max Output Current	2A
f_{in}	Reference Frequency	3.2 MHz
f_{sw}	Switching Frequency	3.2 MHz
L	Power Inductor	330 nH
C_o	Output Capacitor	10 uF
R_f	Current emulation resistor	500 kOhm
C_f	Current emulation capacitor	10 pF
S_{int}	Control Part Silicon Area	0.132 mm^2

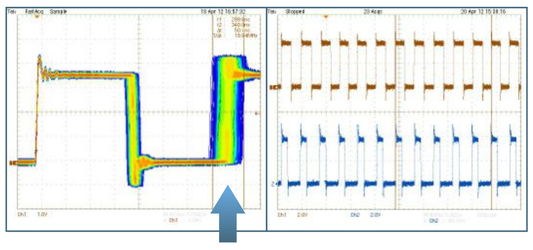
Design Values



Product-chip-die and experimental testboard

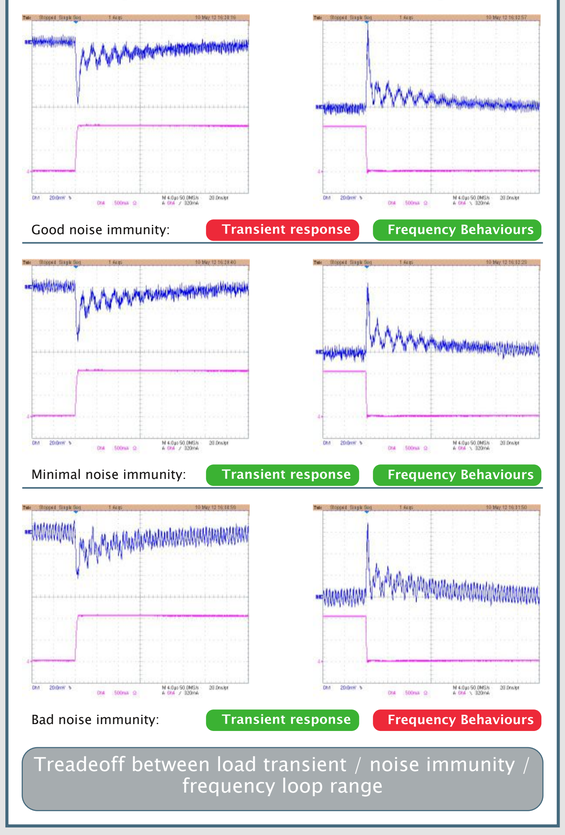
Synchronization results





PLL operation => Jitter/Frequency Noise etc...

Load transients



Treadeoff between load transient / noise immunity / frequency loop range

Conclusion

Efficient voltage regulation
Provided by best-class pure sliding-mode regulation

Fixed switching frequency
Provided by an analog phase locked loop circuitry

A concept proof for a produc oriented IP
Next test-chip on way...

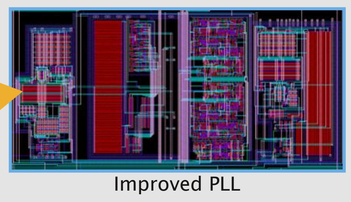
On silicon implementation
A fully integrated low silicon area controller

Future

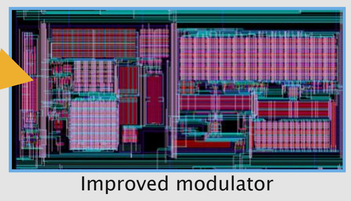
New prototype (PG: 12/2012)

Discontinuous Conduction Mode
Improved Phase Locked Loop
Improved modulator design

New controller layout (up to metal 3)



Improved PLL



Improved modulator