High Speed Controller (HSC)
a GaN ready single chip dc-dc controller

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Custom Integrated Power Management Solutions

Date: 17/6/2025 M.Fo.
Ref: HSC-RUN2-TASB-PPT-0169
Template: 83230347-DOC-TAS-EN-010

HSC a lot more than a “PWM controller”
➔ Swiss knife for dc-dc designer

Several Band gap voltage reference: segregation regulation & protection

Protections:

- OVER-VOLTAGE & UNDER-VOLTAGE
- OVER-CURRENT
- OVER-TEMPERATURE: 2X EXTERNAL & 1 INTERNAL

HF signals to cross galvanic barrier

- OPTO-COUPLERS ➔ 20MHZ ULTRA COMPACT TRANSFORMERS
- 2X ALARMS + 1X PWM

RC Oscillator + ext. Sync input

VCO ➔ LLC variable Switching freq. converter

Soft Start

Bus undervoltage lock out (UVLO)

Auto-restart with HICCUP / TC on & TC off control.

Power requirement < 30mA / 5V

No need for additional active control / monitoring devices whatever the dc-dc type.

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HSC High voltage features

Half-bridge GaN → new dc-dc topologies & higher speed

/// Capable to control complex topologies

- Phase shifted full bridge
- SMART: ZVS buck + ZVS push-pull
- LLC: half bridge or full bridge

/// Ready for MHz switching GaN HEMT technology

- On chip oscillator
- High BW current sensing amplifier
- High speed PWM comparator
- Current leading edge blanking function

/// Multiple regulation/control schemes

- Current average mode
- Current peak mode + slope compensation & edge blanking
- New PVCC peak & valley current control

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ThalesAlenia Space

HSC High voltage features

/// High voltage transistors used & managed such as to be tolerant to radiations

➔ **Nothing (no discrete semiconductor) else required in dc-dc design than power devices**

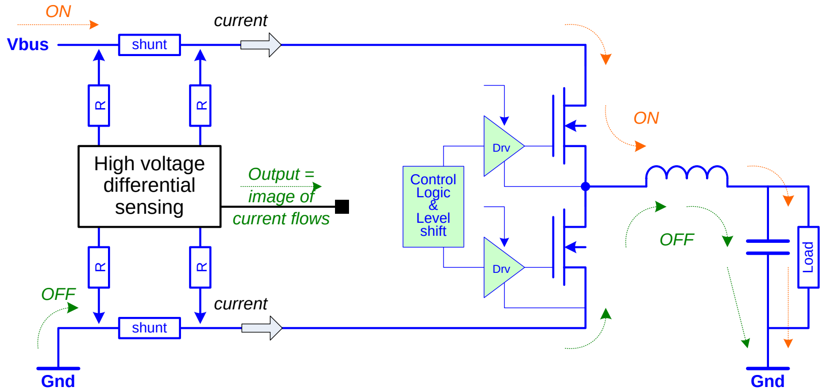
OK for power diodes & transistors, Mosfet or GaN

/// Connection to Vbus

Up to +70V

/// High voltage drop / low current linear regulator to enable supply of …

- Startup of the dc-dc
- Holding of the On/Off status of the dc-dc
- Bus under-voltage protection & over T° protection



/// Current sensing on a shunt in the hot Vbus line

- Double differential amplifier with very high common mode.

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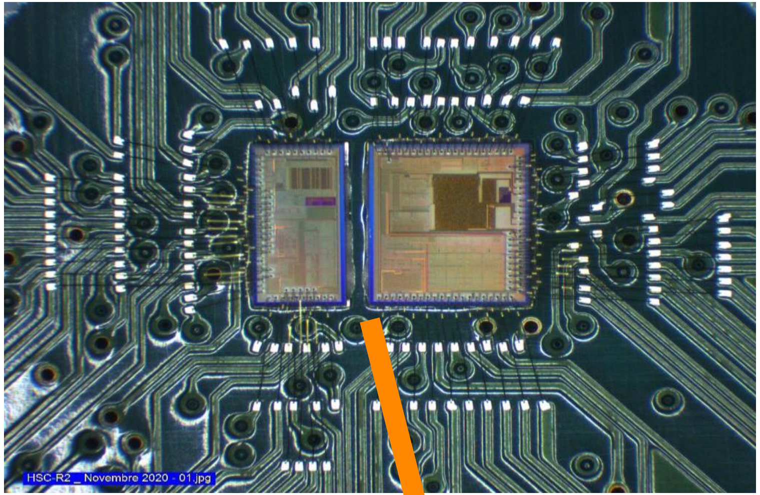
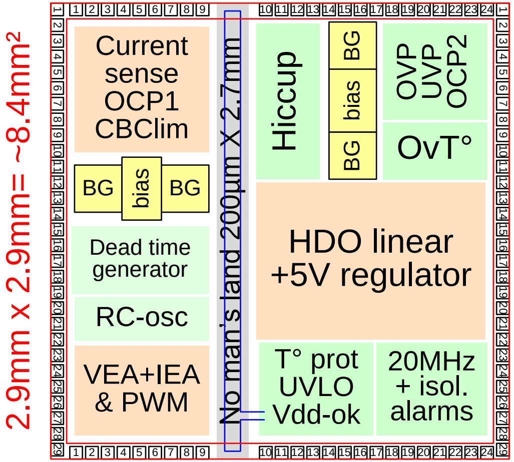
HSC Failure mode management through physical segregation

Regulation & protection may not share an element potentially leading to simultaneous failure

- /// Regulation
- /// Band-gap
- /// OSC + PWM
- /// Current sense



- /// High voltage drop bootstrap supply
- /// Band-gap
- /// Protections



Physical rupture of the mono-crystalline wafer due to defect or crack at edges during dicing.

Physical split: 1/3 left & 2/3 right

Each side ➔ bandgap

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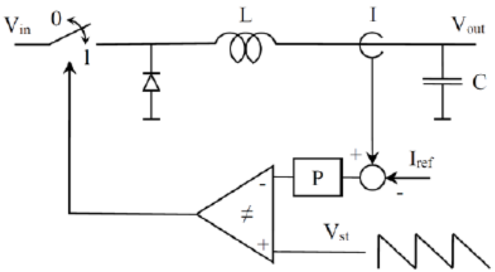
2. Current Control Loops

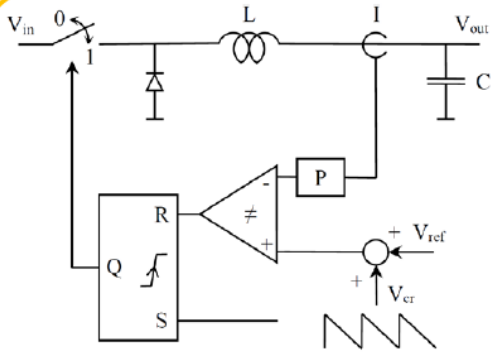


ACC

Average Current Control [2]

- ✓ Much used on spacecraft PF with symmetrical sawtooth

Slide reprint from :
AVERAGE CURRENT CONTROL WITH ASYMMETRICAL SAWTOOTH OR PEAK CURRENT CONTROL
Christophe Delepaut, Hadrien Carbonnier
ESPC 03/10/2019



PCC

Peak Current Control [1]

- ✓ Sawtooth called compensation ramp
- ✓ Much used for terrestrial applications

[2] "PWM Conductance Control", D. O'Sullivan, H. Spruyt, A. Crausaz, IEEE Power Electronics Specialists Conference, Kyoto, Japan, 11-14 April 1988

[1] "Simple Switching Control Method Changes Power Converter Into a Current Source", C. W. Deisch, IEEE Power Electronics Specialists Conference, Syracuse, New York, 13-15 June 1978

PEAK & VALLEY CURRENT CONTROL SCHEME

Higher closed loop BW ~2x

Average current control with single sawtooth & single comparator
➔ limited loop gain (stability)
➔ limited closed loop BW

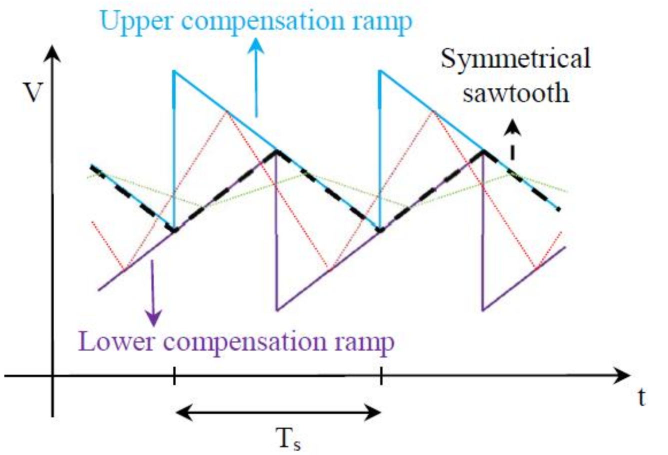
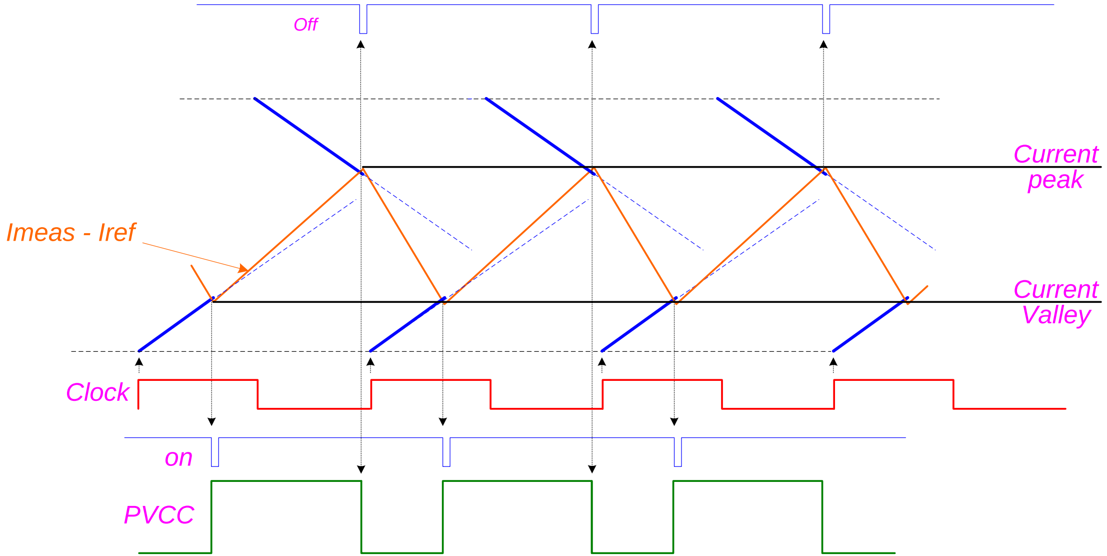


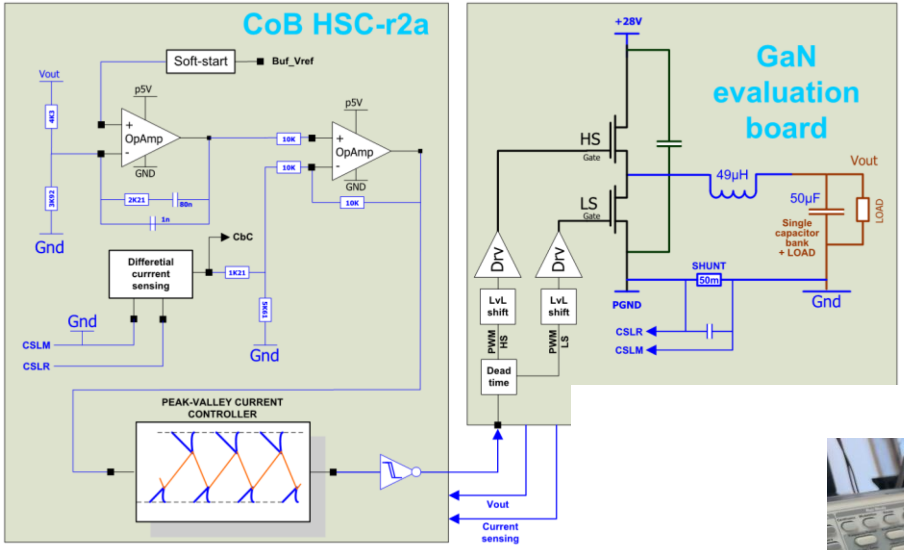
Fig. 9. Symmetrical sawtooth or upper and lower compensation ramps

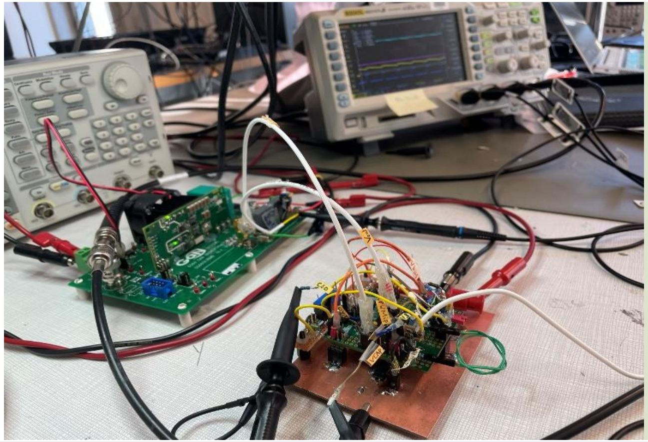


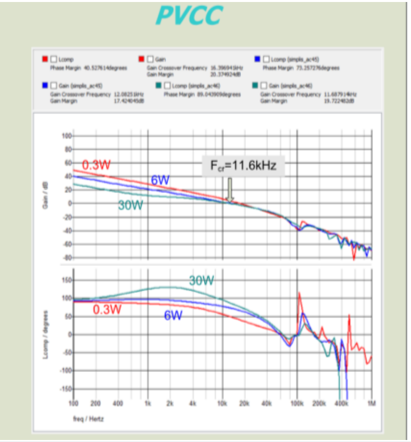
New implementation requires 2 sawtooth & 2 comparators + set / reset logic
➔ loop gain increase without stability issues

Average Current Control with Symmetrical Sawtooth or Peak and Valley Current Control
Christophe Delepaut & Hadrien Carbonnier ESTEC, ESA

PVCC Lab testing







Switching frequency 100kHz
Vin 28V +/- 20%
Duty cycle 10..90%

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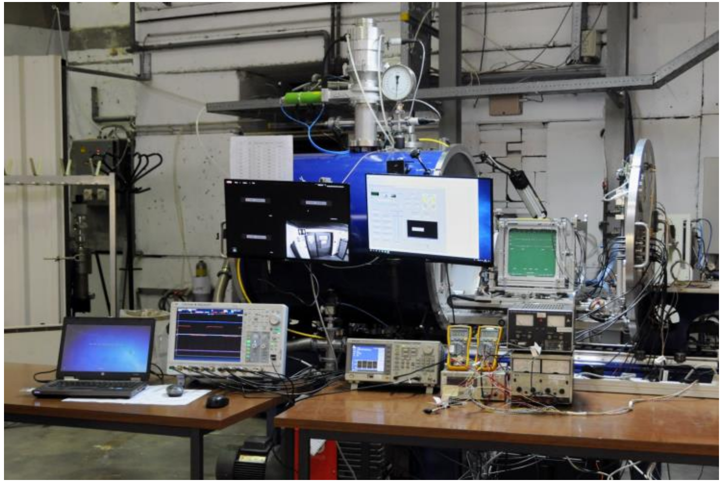
HSC Heavy ion tests

Design methodology that consist of systematic 1,2pC charge injection on each junction of the circuit offers a strong guarantee to get true robustness against transient heavy ion effects



/// Band-gaps

- Stable behavior: no transients, no turn-off

/// Fast comparators

- No toggle, no jitter: even the CBC & PWM comparators do not show any SET although not duplicated

/// Slow comparators

- No undesired toggles
- The comparator redundancy perfectly plays it role of masking the some transients seen on single branches.

/// OpAmp

- Minor transients seen on high bandwidth current amplifier

/// Regulators

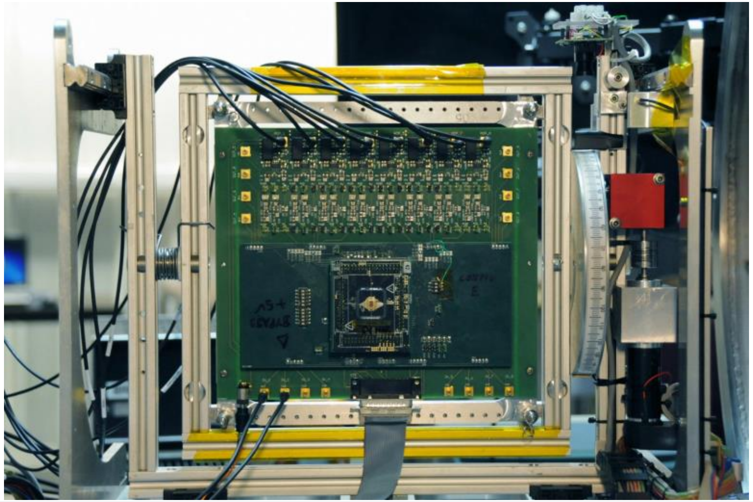
- No effects

/// Logic, dead-time, master clock oscillator

- Fully immune no effects.

/// Isolated transmission through transformers (instead of optocouplers) & 20MHz ring oscillator

- No toggle, no jitter



Latchup free ! & 60krad TiD

HSC Packaging & screening tests

Ready & sized for N x1000 parts

/// Plastic BGA

- 11 x 11 balls / pitch 1.27mm
- Size 15 x 15 x 2 mm
- 2 dies + resistors & decoupling capacitors

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STATSChipPAC

A JCET Company

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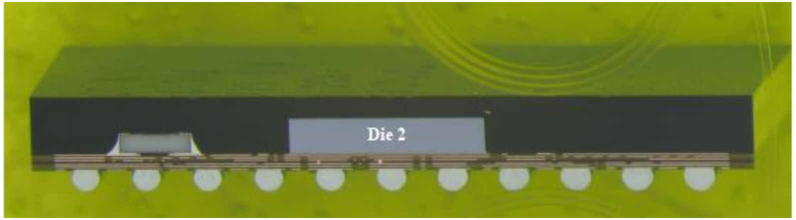

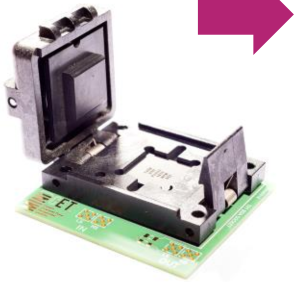

- Fully automated robotic handling
- 3T° ➔ -40°C, room & +125°C electrical parameters verification
- Pre-heat / cool roulette
- CCD camera serial number reading
- JEDEC tray in, tray out (pass/fail in separate trays)

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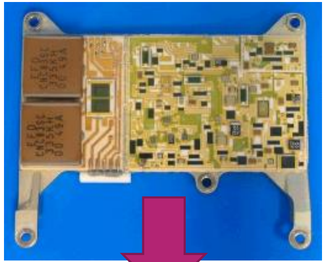
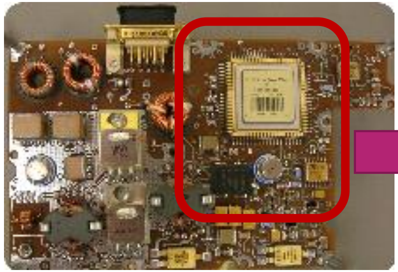
HSC Product construction time line

= IC design house
+ characterization &
volume production testing
Commercialization

Return of experience from 20 years TAS-be dc-dc designs included





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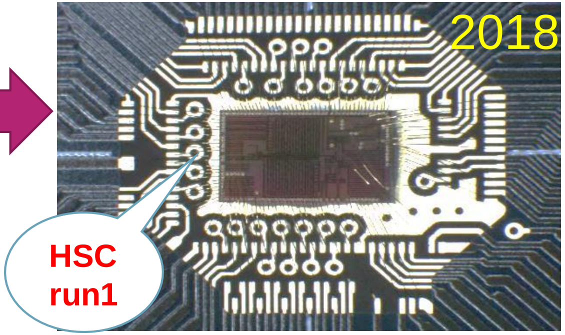

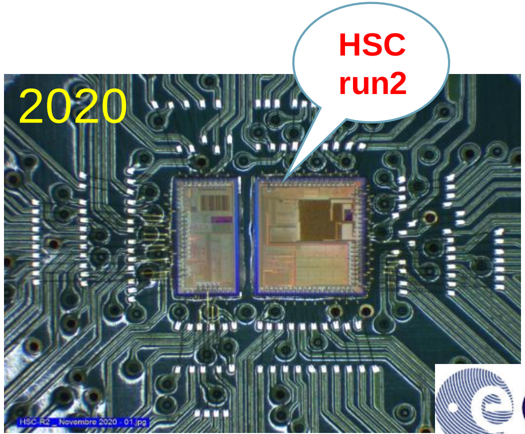

- /// HSC-run1: Functionnal validation in real dc-dc applications
  Characterization over T° / dose & heavy ions
- /// HSC-run2: bug fixes + new feature = PVCC

ACKNOWLEDGMENTS

Belgian Science Policy Office

Project 2 = High Speed integrated analog dc-dc Controller for space applications = HSC-run2

ESA Contract No. 4000126321/19/NL/AF

“Integrated power switch ASIC for small dc-dc converters”

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Project 1 = High Voltage Silicon for Radiation Hardened applications = HV-Si-Rad

INTERESTED

➔ Contact MinDCet

MINDCET. Custom Integrated Power Management Solutions

David Czajkowski <david@mindcet.com>

European !!!

Export classification « Uncontrolled »

ThalesAlenia a Thales / Leonardo company Space