Single chip dc-dc controller with high voltage input Primary

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HIGH SPEED CONTROLLER (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 ~20mA / 5V

No need for additional active control / monitoring devices whatever the dc-dc type.
HIGH SPEED CONTROLLER (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

⇒ continuous operation on +100V bus with ripple & 33% transients ie. >135V peak

/// 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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HIGH SPEED CONTROLLER (HSC)

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 1MHz 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
PRODUCT CONSTRUCTION ROADMAP

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

/// HSC-run1: Functionnal validation in real dc-dc applications
Characterization over T° / dose & heavy ions

/// HSC-run2: bug fixes + new feature = PVCC

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SEGREGATION

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

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

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
2. Current Control Loops

**ACC**

Average Current Control [2]

- Much used on spacecraft PF with symmetrical sawtooth

**PCC**

Peak Current Control [1]

- Sawtooth called compensation ramp
- Much used for terrestrial applications

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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

New implementation requires 2 sawtooth & 2 comparators + set / reset logic

- loop gain increase without stability issues

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

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

Formal performance verifications engaged

/// First electrical functional test completed:

/// ~1000 BGA packages expected in June

/// Electrical detailed characterization

/// Development of automated recurrent production test means

/// ESD & Radiation (dose + heavy ion) tests

/// 1st batch Qualification according to ESCC-Q60-13C
ACKNOWLEDGMENTS

Project = 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”

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