IGBT-Gate Driver Solutions for High Power IGBTs and SiC-MOSFET-Applications

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2015-06-26, PCIM Asia
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SCALE™-2 Portfolio
Driver Core – e.g. 2SC0435T

**Primary side**
- (controller)
  - Power supply input
  - PWM signals input
  - Failure signals output
  - Blocking time adjustment
  - Half-bridge or direct mode selection

**Secondary side**
- (power module)
  - ±35A N-channel booster
  - New SCALE™-2+ IGD
  - Functional insulation between both channels

**Primary side to peripheries connector:**
- Power supply input
- PWM signals input
- Failure signals output
- Blocking time adjustment
- Half-bridge or direct mode selection

**Secondary side to peripheries connector:**
- Supply voltage capacitors
- Short Circuit detection
- Advanced Active Clamping (AAC)
- Soft Shut Down (SSD)
- Gate resistors connection
- Other functions like reference voltage adjustment

**DC/DC MOSFET push-pull booster stage**

**New SCALE™-2+ LDI**

**Ring core transformers**

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IGBT – Trends for Traction & Renewables

- Majority of IGBT applications: Low Voltage up to 1700V-class
- Higher currents
- n-times paralleling of small modules instead of using one big module
- Ready-made modules for 3L-NPC2
- First commercial projects with SiC-MOSFETs
- New module packages

PI’s answer:
Design support through Application Notes and Reference Designs (RDHP)
General Trend of New Package Designs

- **Module suppliers are focusing on the following aspects**
  - Module paralleling capability (e.g. low inductive designs, easy mechanical arrangement of DC-link system)
  - Increase of power density (e.g. new IGBT generation)
  - Implementation of new topologies (e.g. 3-Level NPC2)

- **Module suppliers are NOT focusing on gate-drive aspects**
  - Interconnection to the gate driver stage
  - Creepage and clearance requirements of attached PCBs
Based on 2x 2SC0106T Semikron’s 3-level NPC2 SKIM 4 TLMI power modules
- Short-circuit protection with soft shutdown
- Basic Active Clamping
- Electrical interface with separate NTC read-out
- Up to 1.2kA_{pk} at 800V DC-link voltage

**Highlights**
- Ultra-compact design
- 3-level NPC2 topology

**Applications**
- Solar power
- UPS
- Industrial drives
Parallelizing 3L-NPC2 - RDHP-1505

**Features**
- Based on 2x 2SC0435T
- **2 x Fuji** or **Danfoss 3-level NPC2 PrimePACK™3** power modules in parallel
- Short-circuit protection
- Advanced Active Clamping
- Electrical interface with separate NTC read-out
- Up to $3.6kA_{pk}$ at 900V DC-link voltage

**Applications**
- Renewables (wind, solar)
- Energy storage
- Industrial drives

**Highlights**
- Single platform for Fuji and Danfoss modules
- 3-level NPC2 topology

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Paralleling - RDHP-1420

**Features**
- Based on 2SC0435T
- **4 x 17mm dual power modules** in parallel
- Short-circuit protection
- Dynamic Advanced Active Clamping
- Electrical interface with separate NTC read-out
- Up to 4.8kA\(\text{pk}\) at 850V DC-link voltage

**Applications**
- Renewables (wind, solar)
- Industrial drives
- Traction (auxiliary inverters)

**Highlights**
- Demonstrator stack for n-paralleled power modules with Advanced Power Paralleling
Paralleling - RDHP-1511

**Features**
- Based on 2SC0535T
- **4x Infineon or Mitsubishi new high voltage** power modules in parallel
- Short-circuit protection
- Dynamic Advanced Active Clamping
- Electrical interface
- Up to 3.6kA_{pk} at 2.2kV DC-link voltage

**Applications**
- Traction (main and auxiliary inverters)
- Medium voltage drives
- FACTS

**Highlights**
- Scalable design for 1 to 4 or even more power modules in parallel
Parallelizing - RDHP-1513

Features
- Based on 2SC0435T
- 2 x Infineon’s FF1800R17IP5 PrimePACK™3+ power modules in parallel
- Short-circuit protection
- Dynamic Advanced Active Clamping
- Electrical interface with separate NTC read-out
- Up to 3.6kA_{pk} at 1.2kV DC-link voltage

Highlights
- First design with new IGBT5 from Infineon
- First design with new PrimePACK™3+ package

Applications
- Renewables (wind, solar)
- Industrial drives
- Traction (main and auxiliary inverters)

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SiC-MOSFET - Motivation

- **SiC-MOSFETs have smaller switching losses than IGBTs**
  - No tail current for MOSFETs during turn-off events
  - Enables higher switching frequencies

- **SiC-MOSFETs can be operated at higher switching frequencies than IGBTs**
  - Line and phase filters can be reduced in size ➔ System cost benefit

- **SiC-MOSFETs can be operated at higher temperatures than IGBTs**
  - Natural Air cooled system possible ➔ System cost benefit

- **SiC provides a higher breakdown voltage as Si**
  - Enabler for MOSFETs and Schottky diodes for high power applications
SiC-MOSFET - Gate Drive Characteristics

- SiC MOSFETs require different gate voltages than IGBTs
  - Turn-on: 18V…20V (to reduce conduction losses)
  - Turn-off: -6V…-8V (lower levels often not possible due to gate oxide limitations)

- At time being basically all available SiC-MOSFET power modules are officially not SC rated

- Information from suppliers indicated “tolerated” SC durations of typically 2µs
# SiC-MOSFET - RDHP-1417

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<td>SiC MOSFET gate driver solution</td>
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Due to various available Plug’n’Play- and Core-Drivers and a profound design support PI is able to offer gate-drive solutions for any kind of converter design. Such as ...

- Paralleling of IGBT-Modules
- 3L-NPC-Modules
- Paralleling of 3L-NPC-Modules
- New IGBT-Packages
- SiC-MOSFETs
- etc.