E-mobility SiC Traction Inverter

March 2020
SiC Traction Inverter Overview

Highlights

• E-mobility Power Blocks
• SiC benefits in Traction Inverter
• Full System Power Board SiC for Traction
SiC key applications in electric vehicles

Traction Inverter
- High power inverter stage to drive the traction motor of the vehicle
- Replace Si IGBTs and Diodes by SiC MOSFETs results in:
  - Higher efficiency
  - Smaller form factor
  - Less cooling efforts

On Board Charger
- Charging the battery of plug-in HEVs and EVs from the 1-phase or 3-phase power grid
- Different architectures and topologies in automotive require supporting scalable solutions
- Smaller form factor & weight
Main Inverter for HEV/EV

E-mobility: SiC Traction Inverter

- Usually 3-phase permanent magnet motors are used for traction
- Operating voltage from 48V to 800V
- Bi-directional
  - Feed the electric motor when driving the wheels
  - Stream energy back on HV Bus when braking the vehicle
- Nominal power ranging from 10 kW (ICE assistance) to 200 kW (pure EV)

<table>
<thead>
<tr>
<th>Vbus</th>
<th>400V</th>
<th>700-800V</th>
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<tbody>
<tr>
<td>SiC MOSFET</td>
<td>650V / 750V</td>
<td>1200V</td>
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Si IGBT vs SiC MOSFET—Traction Inverter

**SiC Gen 3**

- 750V ~ 3x smaller die area
- 1200V ~ 5x smaller die area

**SiC 2 to 4% higher efficiency**

- Vbus = 400V 160kW peak, MI=0.5
- Vbus = 750V 210kW peak, MI=0.5

**IGBT + Diode**

- Si

**SiC Gen 3**

- SiC

**400V DC Bus**

- IGBT 250 Miles
- SiC 250 Miles

**3.5 to 8% higher efficiency**
Power Loss Traction Inverter SiC vs IGBT

SiC Significant Lower Power Loss at all Loads

Overall energy losses comparison @ 10kHz vs working load

Typical Load at Driving Cycle
80% Lower Loss

Power [W] vs Load (%):
- ADP86012W2 10%
- IGBT 1200V 25%
- 1200V SiC 50%
- IGBT 1200V 100%
- 1200V SiC 100%

Comparison between P switching and P conduction
ACEPACK Drive Six-pack Module

Smaller Size & Lower Losses → More Power Achievable with SiC

- DC-link: 750Vdc
- PWM Strategy: Bipolar
- 10kHz
- Peak Power 10 sec
- MI = 1, Cos(\phi) = 0.8
- $T_{\text{fluid}} = 65^\circ C$

ACEPACK™ DRIVE

1200V IGBT+Diode based

110kW (220kW peak)

ACEPACK DRIVE
ADP86012W2
1200V Gen2

140kW (280kW peak)

180kW (360kW peak)

ACEPACK DRIVE
ADP450120W3
1200V Gen3

1200V Gen2

1200V Gen3
SiC Traction Inverter Eval Board

Highlights

• Compact High Power Motor Drive
• 400V and 700-800V bus
• Driving Board and Motor Control included
Power Inverter Traction Eval Board

ADPxxxxW2 + STEVAL-APD001K1

**Power Module**
ADP86012W2 – 1200V
ADP50075W2 – 750V

**Power Board Block Diagram**
12 V
Power Supply protection → Voltage Regulator → Power Supply protection
CAN bus
Gasoline ECU protection
CAN transmitter
Serial EEPROM
Control Unit
Gate Driver → Gate protection
Inverter
Current Sensor signal
Position Sensor signal
Analog & Logic ICs

**Control Board**
SPC58NN4E7
Motor Control FW Included

**Driving Board**
STGAP1AS / L95xx
Isolated Gate Drivers
Power Inverter Traction Eval Board

KEY PRODUCTS

1. ADP86012W2 (1,200V 3.5 mOhm), ADP50075W2 (750V 2.0 mOhm): ACEPACK DRIVE SiC Modules
2. STGAP1AS or L95xx: isolated single gate drivers
3. A7986: Buck Boost switching regulator up to 3A
4. A6902: Buck switching regulator up to 1°
5. SPC58xx: 32 bit Automotive MCU
6. TVS and Diodes

Liquid Cooling Case Included
Thank you