Traction Inverter

ST New Solutions
• **SPC58NN**
  - GTM V3 for fully programmable and flexible timer system designed to unload the CPU
  - SAR ADC & Σ-Δ ADC support Software
  - Resolver in evaluation

• **SBC L9396**
  - Multiple Power Supply IC

• **SIC/ IGBT**
  - 750V SiC MOSFETs
    - Gen 2 High Voltage Product Family
  - 1200V SiC MOSFETs
    - Gen 2 High Voltage High Performance Product

• **L9502**
  - Single isolated Gate Driver (6kV) for TRACTION With protection, diagnostics and communication

• Designed for ISO26262 compliance

• Kit Solution approach

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**System Block diagram**

- **SPC58**
- **L9396**
- **SIC/ IGBT**
- **L9502**
- Various components and connections indicated in the diagram, including IGBTs and sensors.
**Core**
- 3x 200 MHz Power Architecture™ ISA e200z4d Core (VLE)
- Dual Issue Core with Floating Point Unit & LSP(DSP)
- 3x (16k-Instruction Cache, 8k-Data Cache)
- 3x (32k Local i-RAM, 128k Local d-RAM)
- 2x Lock Step configuration

**I/O**
- Generic Timer Module (High-End Version)
- Dual Channel FlexRay (10MB/s), 128 buffers
- 7 x (FD)M-CAN, 1 x (FD)M-TTCAN
- 7 x LINFlex, 8 x DSIPI including 2 x μSD
- 1 x Ethernet, 1 x I2C
- 15 x SENT, 2 x PSI5, 1 x PSI5-S
- 61/64 channel ECC (QFP176/GA292)
- 4 SAR ADC, 12-bit, TUE ±4LSB
- 1 Supervisor ADC, 12-bit, TUE ±1.5LSB
- 6 Σ-Δ ADC with OSR x32-64

**Memory**
- 6M byte RWW Flash with ECC
  - +4x64k+2x16k Data Flash with ECC
- 512k RAM (128k SRAM, 384k Local d-RAM) with ECC
  - +61k SRAM on Timer Module
  - +32k Overlay RAM

**System**
- Security Module (HSM)
- FM-PLL
- MPU
- AMU
- 96 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT
- 1x LFAST (Interprocessor bus)
- Nexus Class 3+
- EBI only for Calibration (High speed debug interface)
- Designed for eLQFP176, LFBGA292 and KGD

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**Superset Block Diagram**

[Diagram showing various components and connections, including cores, memory, I/O interfaces, and system architecture.]
Technical information

- Boost Converter, 9V, up to 0.3A - 2MHz with spread spectrum
- Buck Converter, 6.5V/7.2V, up to 1.0A – 465KHz with spread spectrum
- LDO VCC5 (5V +/-2%, 250mA), LDO VCC (3.3V / 5V +/-2%, 100mA), VCORE (0.8V / 5V +/-2% - µC core supply, max 1000mA in switching mode, max 750mA in linear mode)
- 4 WSS regulated interface /2 tracking regulators (120mA)
- Integrated 10-bit ADC
- HS pre-drivers for fail safe relay and for motor pump
- Configurable Watchdog (Time-out / Window / Periods) & configurable Fail-Safe Functionality
- Fail-Safe Output (FSN), Wake-up input
- Voltage monitoring UV/OV on all regulated rails
- Temp. monitoring and Thermal Shutdown

Timing information

- Commercial samples : available
- In production

Key Value

- Designed for ISO26262 compliance
- Flexible solution to 3 configurable voltage rails
- Boost - Buck topology for low battery functionality for Start/Stop systems
- BOM selection optimized on output current needs
- Low emission design

Application Note
Demo board w/ GUI
Safety Manual
FMEDA / DFA
L9502B / L9502
Isolated Gate Driver for Traction Inverter

- 15A driver sink/source current capability
- Miller clamp
- Advanced Diagnostic and Protection
- 10-bit A/D Converter with 2 external inputs
- BRAKE pin with programmable safe state
- 5MHz SPI interface with enhanced safety
- Output flyback voltage 23V (-5V 18V; -8V 15V) on L9502

Single channel isolated gate driver

AEC-Q100 Grade 1

ASIL D systems ready

6kV galvanic isolation

Flyback controller on L9502
VIPower™ H-Bridges Solution for High Power

VNHD7008AY / VNHD7012AY

- **Optimized Standby** current
- **PWM** operations up to 20kHz
- Tailored and compact full bridges in combination with latest dual-channel F7 technology PowerMOS
  - STL64DN4F7AG 8mΩmax
  - STL76DN4LF7AG 6mΩmax
- **Charge Pump Out** for reverse polarity protection
- Drain and Source voltage Monitoring of external PMOSFETs
- **Gate Slope Control** through external Resistor To Optimize EMI
- PSSO36 Package
Power & Discrete Group (PDG)
Wide Power Product Portfolio

From Discrete to Power Modules, ST leads the innovation

Discrete & Drivers & SIP
Typical Power: 10 W ÷ 10 kW

SLLIMM™ IPM
Typical Power: 20 W ÷ 3 kW

ACEPACK™ Power Modules
Typical Power: 3 kW ÷ > 30 kW
### ACEPACK™ modules

**Adaptable, Compact and Easier PACKage**

#### Outlook

- 100% controlled by ST for silicon (SiC, MOSFET, IGBT and Diodes)
- Compact design and cost-effective system approach for a plug & play system solution
- Configuration flexibility
- 2500Vrms electrical isolation

#### Key features

- 100% controlled by ST for silicon (SiC, MOSFET, IGBT and Diodes)
- 2500Vrms electrical isolation
- SMD assembly
- Top side cooling
- Low thermal resistance
- 750 - 1200V SiC MOSFET based switch
- Improved light load power losses for extended EV driving ranges
- AMB frame for better thermal dissipation
- 3 different lead configuration options
- Extreme low conduction losses
- Direct Cooled Cu Base Plate with pin fins

#### Configurations

- CIB
- Six-pack
- Three level Boost
- Bridge rectifier
- Half Bridge
- Boost
- Six-pack

#### Target Applications

- EV
- Industrial
- Power Generation
- Renewable Energy
- Marine
- aerospace
ACEPACK DRIVE
Direct liquid cooled high performance power module

Press FIT connections for high reliable and long lasting connection
SiC-MOSFET based, 750V and 1200V
Pin-fin for direct cooling
Dedicated NTC for each single substrate
Unequalled $R_{DS(on)}$

Internal layout optimized for minimized stray inductance
High reliability and robustness: Dice sintered to substrate
Different bus bar available to fit welding or screwing connection methods.
AMB substrates for better thermal management
Incredible high power density

Traction inverter for (H)EV, Trucks, Bus
ST solutions for traction inverter

From scalable solutions to ACEPACK DRIVE

- **Multi Sintering Package: STPAK™**
  - Very good thermal resistance, no TIM material needed
  - Very high current capability

- **Top Side Cooling Package: ACEPACK™ SMIT**
  - Customizable and versatile insulated power module

- **Sintering needed to get best thermal performances**

- **In both cases several devices in parallel has to be connected to realize an high power system**
  - Connections introduces stray inductance which will limit speed
  - Inverter room occupation will increase accordingly

- **ACEPACK DRIVE**
  - Represents an easy-to-use solutions, with direct cooling thanks to pin-fin structure integrated in base plate
  - Several device are connected in parallel in the same substrate, minimizing stray inductances and boosting speed capabilities
  - Thanks to small footprint, power module can be easily integrated in motor chassis
  - No soldering or sintering needed, improved manufacturability:
    - Press fit avoids soldering process
    - Need only to be screwed onto a waterjacked for liquid cooling
    - Differnt bus bar options for final used convenience, compatible with Hall-effect current

- **PCB must be designed to deal with very high current level**
ACEPACK DRIVE case selection

Short tab option

Long tab option

Possibility to use an Hall-current sensor thanks to longer tabs

Long tab w/o AC bar holes

AC bus bar to be welded to motor connections
Six-pack Module at 750V DC-link
1200V Si IGBT vs. SiC MOSFET

- Topology: Three phase inverter
- DC-link: 750V
- PWM Strategy: Bipolar
- Switching frequency: 12kHz
- $T_J < 80\%$ of $T_{j\max}$ at any condition
- Peak Power for 10 sec
- $MI = 1, \cos(\phi) = 0.8$
- $T_{\text{fluid}} = 70°C$

* HybridPACK 2 is 30% bigger than ACEPACK DRIVE

** Six-pack Module at 750V DC-Link
1200V Si IGBT vs. SiC MOSFET

- Power

ACEPACK™ DRIVE

Gen 2 SiC 1200V AMB $Si_3N_4$

- 1200V Si based HybridPACK™ 2 (*)

- 120kW (240kW peak)

- 85kW (170kW peak)

- 160kW (320kW peak)

- Including coming Gen 3 1200V SiC MOSFET

- ACEPACK™ DRIVE

- Power Six-pack Module at 750V DC-link
1200V Si IGBT vs. SiC MOSFET

- 1200V Si IGBT vs. SiC MOSFET (*)

- HybridPACK 2 is 30% bigger than ACEPACK DRIVE
600mm² IGBT+Diode each switch

- 2 times higher power with the first Silicon Carbide module version based on SiC MOSFET Gen 3