Wireless Charging

Witricity Electric Vehicle Charger
SiC EV Wireless Charging

SiC
High Efficiency
Better Thermal
High Frequency Switching

Advanced Topology for High Efficiency Power Transfer

Silicon Carbide MOSFET Technology

High Current Silicon Carbide and Ultrafast Rectifiers

Silicon Carbide Driving Methods
### Advanced Topology for High Efficiency Power Transfer

**11kW EV Charging System**

**Switch**
- 2x D1, D2: STPSC20H065C 650 V power Schottky silicon carbide diode
- 2x Q1, Q2: SCTW90N65G2V N-channel 650 V, 0.029 Ohm typ., 90 A SiC MOSFET
- Q3, Q4, Q5, Q6: SCTW90N65G2V N-channel 650 V, 0.029 Ohm typ., 90 A SiC MOSFET
- D3, D4, D5, D6: STTH30L06WY 30A 600V Fast Rectifiers
- U1, U2, U3, U4, U5, U6: TD350 1.5A IGBT, MOSFET advanced gate driver 26V -10V
- MCU: STM32F405 Cortex M4

**Part Numbers**
- STPSC20H065C 650 V power Schottky silicon carbide diode
- SCTW90N65G2V N-channel 650 V, 0.029 Ohm typ., 90 A SiC MOSFET
- STTH30L06WY 30A 600V Fast Rectifiers
- TD350 1.5A IGBT, MOSFET advanced gate driver 26V -10V
- STM32F405 Cortex M4
Automotive Solution

Highlights

• Delivers 3.3kW, 6.6kW, 11kW or more power wirelessly to compatible electric vehicle

• WiTricity is working on wireless charging standards with SAE and other organizations

• Spatial freedom for “park-and-charge” user experience with high efficiency (92%-94%)

• Foreign Object Detection (FOD)
Automotive Solution

Specifications

- 3.3kW, 6.6kW and 11kW+ continuously variable ground assembly units (GA)
- Efficiency: Up to 98% coil-to-coil
- Operating Frequency: 85 kHz
- Operating Height: 9 - 28cm vehicle ground clearance
- Communications: WiFi
- Foreign Object Detection: Yes
- Standards: SAE, ISO, IEC pending
- Regulatory: meets FCC, CISPR, ICNIRP guidelines for Emissions and human safety
Silicon Carbide MOSFET Technology

**Benefits**

**Extremely low Power Loss and Low Ron especially at very high Tj**

Higher operating frequency for Smaller and lighter systems

**Thermal Performance**

High operating temperature (T_{j\text{max}} = 200°C)

- Reduced cooling requirements & heat-sink
- Increased life time

**Easy to Drive**

- Fully compatible with standard Gate Drivers
Silicon Carbide MOSFET Technology

**SCTW90N65G2V**

- **SCT3W90N65G2V** - SiC Power MOSFET, 90A, 650V, 25mΩ

- **Key parameters:**
  - \( V_{BR} > 650V \)
  - \( I_{ds} = 90A \)
  - \( R_{on\text{typ.}} @ 150°C = 29mΩ \)
  - \( Q_{g\text{typ.}} < 190nC \)
  - Gate driving voltage = 20V
  - HiP247™ package → \( T_{j\text{max}} = 200°C \)

- **Key features:**
  - Very tight variation of on-resistance vs. temperature
  - Slight variation of switching losses vs. temperature
  - Very high operating temperature capability (200°C)
  - Very fast and robust intrinsic body diode
  - Low capacitance
  - Easy to drive

- **Schedule:**
  - Full Production June 2016
Silicon Carbide Diodes

Low switching losses
Best efficiency

Full Series
600-1200V & AG
High Peak Current – Low Vf

Insulated Packages
Better Thermal - Lower Cost

<table>
<thead>
<tr>
<th>STPSC</th>
<th>bb</th>
<th>H</th>
<th>065</th>
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<tbody>
<tr>
<td>SiC diode</td>
<td>Current rating</td>
<td>blank</td>
<td>H</td>
<td>Voltage: 06: 600V 065:650V 12: 1200V</td>
<td>Blank: single diode C: dual-diode with common cathode</td>
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Reverse recovery charging dependent on Ti, d/dt & Io
Capacitive type current independent of the Ti
3A/sx 10kOhm
STPSC6H065D
STTH8T06DI
STTH606DI
STTHR060D

Insulated TD-220AC
New 1200V Silicon Carbide Diodes

Best in class Forward voltage characteristics

Excellent Robustness with high $I_{FSM}$ level
Ultrafast Rectifiers

STTHxxx 200-1200V, 1-200A, 175°C

Pt doped for low leakage (1/100)

0.85V / 80ns

0.85V / 80ns

L series

R series

S series

W series

AC series

Tandem

Low $V_F$

Low $Q_{RR}$

Mainstream
Silicon Carbide Driving Methods

• Driving a SiC MOSFET is almost easy as driving a silicon MOSFET:
  • Just need $V_{gs} = 20V$ to get the right $R_{on}$
  • Adequate current capability to ensure high speed (2-3 A would be the best)
  • Recommended -4Vgs drive on turn off to minimize effects of high $dv/dt$ on gate

• Very simple and very mature standard gate drivers can be used
  • ST TD350 + push-pull stage (to increase current capability) in production
  • The new ST isolated GAPdriver: STGAP1S

• An Application Note focused on “How to Drive a SiC MOSFET” has been published on st.com.
Driving SiC MOSFET with TD350E

The ST **TD350E** is an advanced gate driver for IGBTs and power MOSFETs.

To drive a SiC MOSFET, simply need to add an external push-pull network to increase the current capability. The optimal value of the resistors of the push/pull stage ($R_{G-on}$ & $R_{G-off}$) are between 2.2Ω/6.8Ω according to dv/dt requirements.

SiC MOSFET driving circuit