GeneSiC SEMICONDUCTOR

# GA10SICP12-247

## Silicon Carbide Junction Transistor/Schottky Diode Co-pack

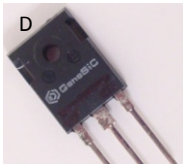
| | | |
|---|---|---|
| $V_{DS}$ | = | 1200 V |
| $R_{DS(ON)}$ | = | 120 mΩ |
| $I_{D\ (Tc = 25°C)}$ | = | 25 A |
| $h_{FE\ (Tc = 25°C)}$ | | 100 |

### Features

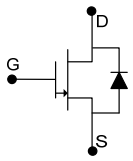
- 175°C Maximum Operating Temperature
- Gate Oxide free SiC switch
- Exceptional Safe Operating Area
- Integrated SiC Schottky Rectifier
- Excellent Gain Linearity
- Temperature Independent Switching Performance
- Low output capacitance
- Positive temperature co-efficient of $R_{DS,ON}$
- Suitable for connecting an anti-parallel diode

### Package

- RoHS Compliant




TO-247AB




### Advantages

- Compatible with Si MOSFET/IGBT Gate Drive ICs
- > 20 µs Short-Circuit Withstand Capability
- Lowest-in-class Conduction Losses
- High Circuit Efficiency
- Minimal Input Signal distortion
- High Amplifier Bandwidth
- Reduced cooling requirements
- Reduced system size

### Applications

- Down Hole Oil Drilling, Geothermal Instrumentation
- Hybrid Electric Vehicles (HEV)
- Solar Inverters
- Switched-Mode Power Supply (SMPS)
- Power Factor Correction (PFC)
- Induction Heating
- Uninterruptible Power Supply (UPS)
- Motor Drives

### Maximum Ratings at $T_j$ = 175 °C, unless otherwise specified

| Parameter | Symbol | Conditions | Values | Unit |
|---|---|---|---|---|
| **SiC Junction Transistor** | | | | |
| Drain – Source Voltage | $V_{DS}$ | $V_{GS}$ = 0 V | 1200 | V |
| Continuous Drain Current | $I_D$ | $T_{C,MAX}$ = 95 °C | 10 | A |
| Gate Peak Current | $I_{GM}$ | | 10 | A |
| Turn-Off Safe Operating Area | RBSOA | $T_{VJ}$ = 175 °C, $I_G$ = 1 A, Clamped Inductive Load | $I_{D,max}$ = 10 @ $V_{DS} \leq V_{DSmax}$ | A |
| Short Circuit Safe Operating Area | SCSOA | $T_{VJ}$ = 175 °C, $I_G$ = 1 A, $V_{DS}$ = 800 V, Non Repetitive | 20 | µs |
| Reverse Gate – Source Voltage | $V_{SG}$ | | 30 | V |
| Reverse Drain – Source Voltage | $V_{SD}$ | | 25 | V |
| Power Dissipation | $P_{tot}$ | $T_C$ = 95 °C | 91 | W |
| Storage Temperature | $T_{stg}$ | | -55 to 175 | °C |
| **Free-wheeling Silicon Carbide diode** | | | | |
| DC-Forward Current | $I_F$ | $T_C \leq$ 150 °C | 10 | A |
| Non Repetitive Peak Forward Current | $I_{FM}$ | $T_C$ = 25 °C, $t_P$ = 10 µs | 280 | A |
| Surge Non Repetitive Forward Current | $I_{F,SM}$ | $t_P$ = 10 ms, half sine, $T_C$ = 25 °C | 65 | A |

### Thermal Characteristics

| | | | | |
|---|---|---|---|---|
| Thermal resistance, junction - case | $R_{thJC}$ | SiC Junction Transistor | 0.88 | °C/W |
| Thermal resistance, junction - case | $R_{thJC}$ | SiC Diode | 0.85 | °C/W |

### Mechanical Properties

| | | | | |
|---|---|---|---|---|
| Mounting torque | M | | 0.6 | Nm |

## Electrical Characteristics at $T_j$ = 175 °C, unless otherwise specified

| Parameter | Symbol | Conditions | Values min. | Values typ. | Values max. | Unit |
|---|---|---|---|---|---|---|
| **SJT On-State Characteristics** | | | | | | |
| Drain – Source On Resistance | $R_{DS(ON)}$ | $I_D$ = 10 A, $I_G$ = 200 mA, $T_j$ = 25 °C | | 120 | | mΩ |
| | | $I_D$ = 10 A, $I_G$ = 400 mA, $T_j$ = 125 °C | | 150 | | |
| | | $I_D$ = 10 A, $I_G$ = 800 mA, $T_j$ = 175 °C | | 220 | | |
| Gate Forward Voltage | $V_{GS(FWD)}$ | $I_G$ = 500 mA, $T_j$ = 25 °C | | 3.3 | | V |
| | | $I_G$ = 500 mA, $T_j$ = 175 °C | | 3.1 | | |
| DC Current Gain | $h_{FE}$ | $V_{DS}$ = 5 V, $I_D$ = 10 A, $T_j$ = 25 °C | | 100 | | |
| | | $V_{DS}$ = 5 V, $I_D$ = 10 A, $T_j$ = 175 °C | | TBD | | |
| **SJT Off-State Characteristics** | | | | | | |
| Drain Leakage Current | $I_{DSS}$ | $V_R$ = 1200 V, $V_{GS}$ = 0 V, $T_j$ = 25 °C | | 350 | | nA |
| | | $V_R$ = 1200 V, $V_{GS}$ = 0 V, $T_j$ = 125 °C | | 530 | | |
| | | $V_R$ = 1200 V, $V_{GS}$ = 0 V, $T_j$ = 175 °C | | 700 | | |
| Gate Leakage Current | $I_{SG}$ | $V_{SG}$ = 20 V, $T_j$ = 25 °C | | 20 | | nA |
| **SJT Capacitance Characteristics** | | | | | | |
| Input Capacitance | $C_{iss}$ | $V_{GS}$ = 0 V, $V_D$ = 1 V, f = 1 MHz | | tbd | | pF |
| Reverse Transfer/Output Capacitance | $C_{rss}/C_{oss}$ | $V_D$ = 1 V, f = 1 MHz | | tbd | | pF |
| **SJT Switching Characteristics** | | | | | | |
| Turn On Delay Time | $t_{d(on)}$ | $V_{DD}$ = 800 V, $I_D$ = 10 A, $R_{G(on)}$ = $R_{G(off)}$ = tbd Ω, FWD = GB10SLT12, $T_j$ = 25 ºC, Refer to Figure 15 for gate current waveform | | tbd | | ns |
| Rise Time | $t_r$ | | | tbd | | ns |
| Turn Off Delay Time | $t_{d(off)}$ | | | tbd | | ns |
| Fall Time | $t_f$ | | | tbd | | ns |
| Turn-On Energy Per Pulse | $E_{on}$ | | | tbd | | µJ |
| Turn-Off Energy Per Pulse | $E_{off}$ | | | tbd | | µJ |
| Total Switching Energy | $E_{ts}$ | | | tbd | | µJ |
| Turn On Delay Time | $t_{d(on)}$ | $V_{DD}$ = 800 V, $I_D$ = 10 A, $R_{G(on)}$ = $R_{G(off)}$ = tbd Ω, FWD = GB10SLT12, $T_j$ = 175 ºC, Refer to Figure 15 for gate current waveform | | tbd | | |
| Rise Time | $t_r$ | | | tbd | | ns |
| Turn Off Delay Time | $t_{d(off)}$ | | | tbd | | ns |
| Fall Time | $t_f$ | | | tbd | | ns |
| Turn-On Energy Per Pulse | $E_{on}$ | | | tbd | | µJ |
| Turn-Off Energy Per Pulse | $E_{off}$ | | | tbd | | µJ |
| Total Switching Energy | $E_{ts}$ | | | tbd | | µJ |
| **Free-wheeling Silicon Carbide Schottky Diode** | | | | | | |
| Forward Voltage | $V_F$ | $I_F$ = 10 A, $V_{GE}$ = 0 V, $T_j$ = 25 ºC (175 ºC ) | | 1.55 | | V |
| Diode Knee Voltage | $V_{D(knee)}$ | $T_j$ = 25 ºC, $I_F$ = 1 mA | | 0.8 | | V |
| Peak Reverse Recovery Current | $I_{rrm}$ | $I_F$ = 10 A, $V_{GE}$ = 0 V, $V_R$ = 800 V, $-dI_F/dt$ = 625 A/µs, $T_j$ = 175 ºC | | tbd | | A |
| Reverse Recovery Time | $t_{rr}$ | | | tbd | | ns |
| Rise Time | $t_r$ | $V_{DD}$= 800 V, $I_D$ = 10 A, $R_{gon}$ = $R_{goff}$ = tbd Ω, $T_j$= 25 ºC | | tbd | | ns |
| Fall Time | $t_f$ | | | tbd | | ns |
| Turn-On Energy Loss Per Pulse | $E_{on}$ | | | tbd | | µJ |
| Turn-Off Energy Loss Per Pulse | $E_{off}$ | | | tbd | | µJ |
| Reverse Recovery Charge | $Q_{rr}$ | | | tbd | | nC |
| Rise Time | $t_r$ | $V_{DD}$= 800 V, $I_D$ = 10 A, $R_{gon}$ = $R_{goff}$ = tbd Ω, $T_j$= 175 ºC | | tbd | | ns |
| Fall Time | $t_f$ | | | tbd | | ns |
| Turn-On Energy Loss Per Pulse | $E_{on}$ | | | tbd | | µJ |
| Turn-Off Energy Loss Per Pulse | $E_{off}$ | | | tbd | | µJ |
| Reverse Recovery Charge | $Q_{rr}$ | | | tbd | | nC |

## Figures


**Figure 1: Typical Output Characteristics at 25 °C**


**Figure 2: Typical Output Characteristics at 125 °C**


**Figure 3: Typical Output Characteristics at 175 °C**


**Figure 4: Typical Gate Source I-V Characteristics vs. Temperature**


**Figure 5: Normalized On-Resistance and Current Gain vs. Temperature**


**Figure 6: Typical Blocking Characteristics**


**Figure 7: Capacitance Characteristics**


**Figure 8: Capacitance Characteristics**


**Figure 9: Typical Hard-switched Turn On Waveforms**


**Figure 10: Typical Hard-switched Turn Off Waveforms**


**Figure 11: Typical Turn On Energy Losses and Switching Times vs. Temperature**


**Figure 12: Typical Turn Off Energy Losses and Switching Times vs. Temperature**


**Figure 13: Typical Turn On Energy Losses vs. Drain Current**


**Figure 14: Typical Turn Off Energy Losses vs. Drain Current**


**Figure 15: Typical Gate Current Waveform**


**Figure 16: Typical Hard Switched Device Power Loss vs. Switching Frequency [1]**


**Figure 17: Power Derating Curve**


**Figure 18: Forward Bias Safe Operating Area**

[1] – Representative values based on device switching energy loss. Actual losses will depend on gate drive conditions, device load, and circuit topology.

TBD

TBD

**Figure 19: Turn-Off Safe Operating Area**

**Figure 20: Transient Thermal Impedance**

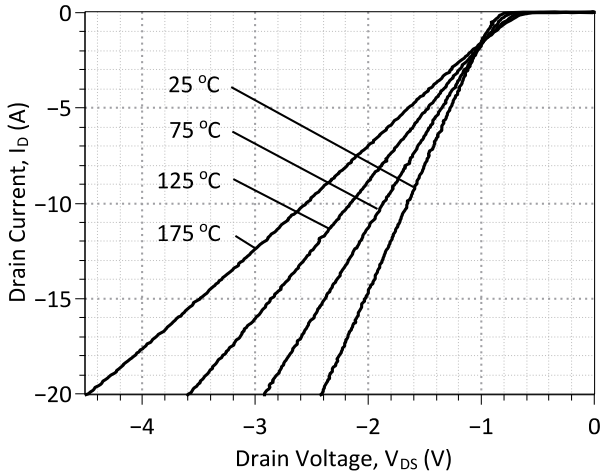



**Figure 21: Typical FWD Forward Characteristics**

## Gate Drive Theory of Operation for the GA10SICP12-263

The SJT transistor is a current controlled transistor which requires a positive gate current for turn-on as well as to remain in on-state. An ideal gate current waveform for ultra-fast switching of the SJT, while maintaining low gate drive losses, is shown in Figure 22.

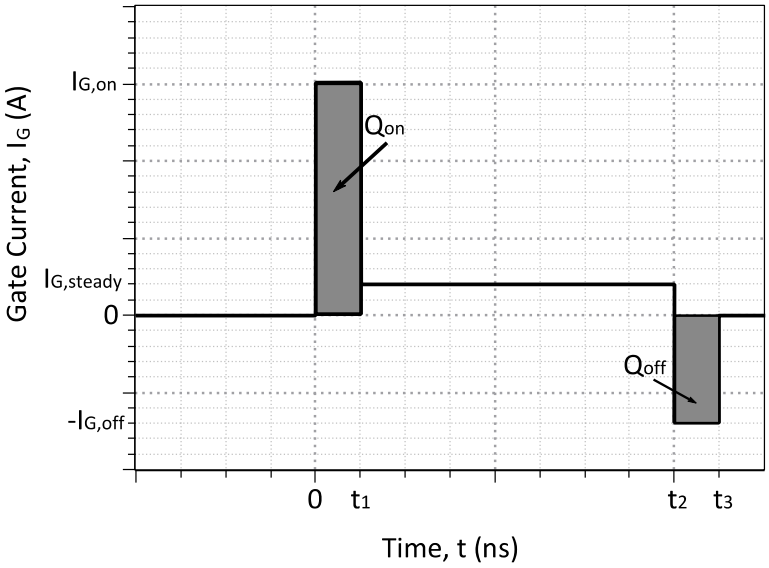



**Figure 22: Idealized Gate Current Waveform**

**Gate Currents, $I_{G,pk}$/$-I_{G,pk}$ and Voltages during Turn-On and Turn-Off**

An SJT is rapidly switched from its blocking state to on-state, when the necessary gate charge, $Q_G$, for turn-on is supplied by a burst of high gate current, $I_{G,on}$, until the gate-source capacitance, $C_{GS}$, and gate-drain capacitance, $C_{GD}$, are fully charged.

$$I_{G,on} * t_1 \geq Q_{gs} + Q_{gd}$$

The $I_{G,pon}$ pulse should ideally terminate, when the drain voltage falls to its on-state value, in order to avoid unnecessary drive losses during the steady on-state. In practice, the rise time of the $I_{G,on}$ pulse is affected by the parasitic inductances, $L_{par}$ in the module and drive circuit. A voltage developed across the parasitic inductance in the source path, $L_s$, can de-bias the gate-source junction, when high drain currents begin to flow through the device. The applied gate voltage should be maintained high enough, above the $V_{GS,ON}$ level to counter these effects.

A high negative peak current, $-I_{G,off}$ is recommended at the start of the turn-off transition, in order to rapidly sweep out the injected carriers from the gate, and achieve rapid turn-off. While satisfactory turn off can be achieved with $V_{GS}$ = 0 V, a negative gate voltage $V_{GS}$ may be used in order to speed up the turn-off transition.

**Steady On-State**

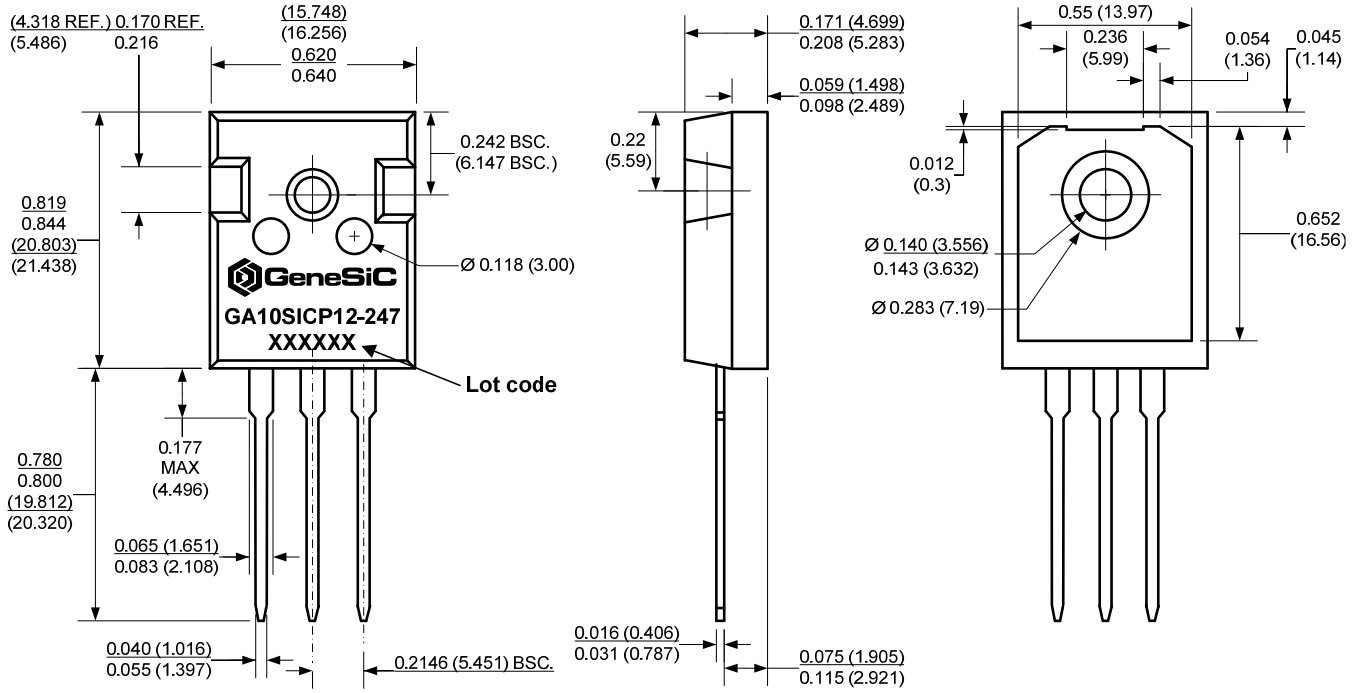
After the device is turned on, $I_G$ may be advantageously lowered to $I_{G,steady}$ for reducing unnecessary gate drive losses. The $I_{G,steady}$ is determined by noting the DC current gain, $h_{FE}$, of the device

The desired $I_{G,steady}$ is determined by the peak device junction temperature $T_J$ during operation, drain current $I_D$, DC current gain $h_{FE}$, and a 50 % safety margin to ensure operating the device in the saturation region with low on-state voltage drop by the equation:

$$I_{G,steady} \approx \frac{I_D}{h_{FE}(T, I_D)} * 1.5$$

## Package Dimensions:

**TO-247AB** **PACKAGE OUTLINE**




**NOTE**
1. CONTROLLED DIMENSION IS INCH. DIMENSION IN BRACKET IS MILLIMETER.
2. DIMENSIONS DO NOT INCLUDE END FLASH, MOLD FLASH, MATERIAL PROTRUSIONS

| Revision History | | | |
|---|---|---|---|
| Date | Revision | Comments | Supersedes |
| 2014/08/25 | 1 | Gate Drive Theory Update | |
| 2013/09/12 | 0 | Initial release | |
| | | | |

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## SPICE Model Parameters

This is a secure document. Please copy this code from the SPICE model PDF file on our website (http://www.genesicsemi.com/images/products_sic/igbt_copack/GA10SICP12-247_spice.pdf) into LTSPICE (version 4) software for simulation of the GA10SICP12-247.

```
*     MODEL OF GeneSiC Semiconductor Inc.
*
*     $Revision:   1.1           $
*     $Date:   23-JUN-2014       $
*
*     GeneSiC Semiconductor Inc.
*     43670 Trade Center Place Ste. 155
*     Dulles, VA 20166
*     http://www.genesicsemi.com/index.php/sic-products/copack
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* These models are provided "AS IS, WHERE IS, AND WITH NO WARRANTY
* OF ANY KIND EITHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED
* TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A
* PARTICULAR PURPOSE."
* Models accurate up to 2 times rated drain current.
*
* Start of GA10SICP12-247 SPICE Model
*
.SUBCKT GA10SIPC12 DRAIN GATE SOURCE
Q1 DRAIN GATE SOURCE GA10SIPC12_Q
D1 SOURCE DRAIN GA10SIPC12_D1
D2 SOURCE DRAIN GA10SIPC12_D2
.model GA10SIPC12_Q NPN
+ IS       5.00E-47        ISE        1.26E-28        EG         3.23
+ BF       100             BR         0.55            IKF        350
+ NF       1               NE         2               RB         6.97
+ RE       0.01            RC         0.1             CJC        3.5E-10
+ VJC      3               MJC        0.5             CJE        1.11E-09
+ VJE      3               MJE        0.5             XTI        3
+ XTB      -1.2            TRC1       7.00E-03        MFG   GeneSiC_Semi
.MODEL GA10SIPC12_D1 D
+ IS       4.55E-15        RS         0.0736          N          1
+ IKF      1000            EG         1.2             XTI        -2
+ TRS1     0.005434        TRS2       2.71739E-05     CJO        6.40E-10
+ VJ       0.469           M          1.508           FC         0.5
+ TT       1.00E-10
.MODEL GA10SIPC12_D2 D
+ IS       1.54E-22        RS         0.19       TRS1       -0.004
+ N        3.941           EG         3.23       IKF        19
+ XTI      0               FC         0.5        TT         0
.ENDS
* End of GA10SICP12-247 SPICE Model
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