GeneSiC SEMICONDUCTOR

GR1500JT17-247

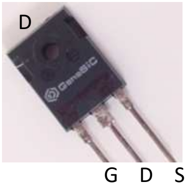
Normally – OFF Silicon Carbide Junction Transistor

V_{DS} = 1700 V
$R_{DS(ON)}$ = 1.5 Ω
$I_{D\ (@\ 25°C)}$ = 2 A
$h_{FE\ (@\ 25°C)}$ = 100

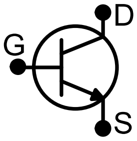
Features

- 175 °C Maximum Operating Temperature
- Gate Oxide Free SiC Switch
- Exceptional Safe Operating Area
- Excellent Gain Linearity
- Temperature Independent Switching Performance
- Low Output Capacitance
- Positive Temperature Coefficient of $R_{DS,ON}$
- Suitable for Connecting an Anti-parallel Diode

Package



TO-247



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

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

Table of Contents

Section I: Absolute Maximum Ratings

Parameter	Symbol	Conditions	Value	Unit	Notes
Drain – Source Voltage	V_{DS}	V_{GS} = 0 V	1700	V	
Continuous Drain Current	I_D	T_C = 25°C	2	A	
Continuous Gate Current	I_G		0.1	A	
Turn-Off Safe Operating Area	RBSOA	T_{VJ} = 175°C, Clamped Inductive Load	$I_{D,max}$ = 2 @ $V_{DS} \le V_{DSmax}$	A	Fig. 9
Short Circuit Safe Operating Area	SCSOA	T_{VJ} = 175°C, I_G = 0.2 A, V_{DS} = 1200 V, Non Repetitive	> 20	µs	
Reverse Gate – Source Voltage	V_{SG}		30	V	
Reverse Drain – Source Voltage	V_{SD}		25	V	
Storage Temperature	T_{stg}		-55 to 175	°C	

Section II: Static Electrical Characteristics

Parameter	Symbol	Conditions	Value			Unit	Notes
			Min.	Typical	Max.		
A: On State							
Drain – Source On Resistance	$R_{DS(ON)}$	I_D = 1 A, T_j = 25 °C		1.5		Ω	
Gate – Source Saturation Voltage	$V_{GS,SAT}$	I_D = 1 A, I_D/I_G = 40, T_j = 25 °C I_D = 1 A, I_D/I_G = 30, T_j = 175 °C		3.45 3.22		V	Fig. 4
DC Current Gain	h_{FE}	V_{DS} = 5 V, I_D = 1 A, T_j = 25 °C		100		–	Fig. 2
B: Off State							
Drain Leakage Current	I_{DSS}	V_{DS} = 1700 V, V_{GS} = 0 V, T_j = 25 °C		0.03		µA	Fig. 5
Gate Leakage Current	I_{SG}	V_{SG} = 20 V, T_j = 25 °C		20		nA	
C: Thermal							
Thermal resistance, junction - case	R_{thJC}			4.83		°C/W	Fig. 7

Section III: Figures

A: Static Characteristics

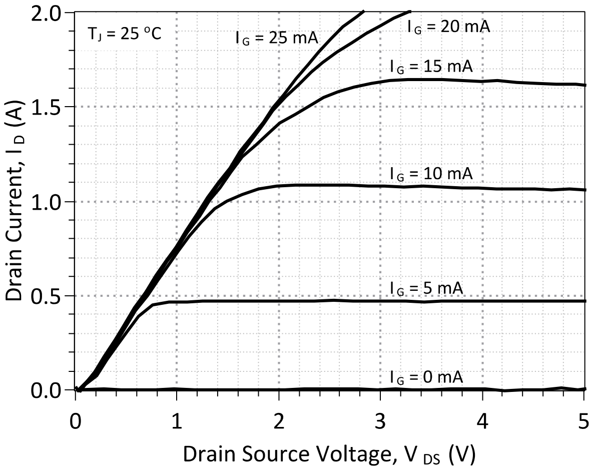


Figure 1: Typical Output Characteristics at 25 °C

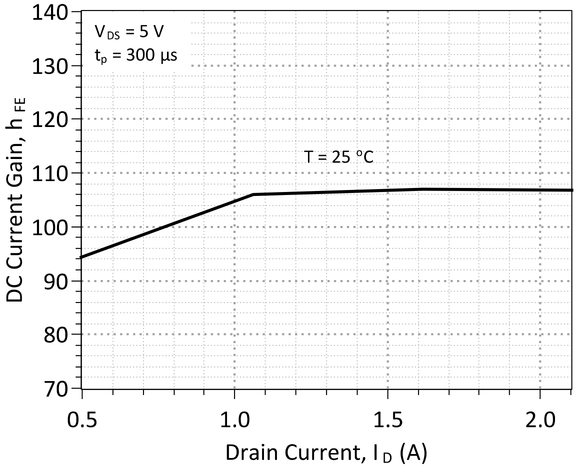


Figure 2: DC Current Gain vs. Drain Current

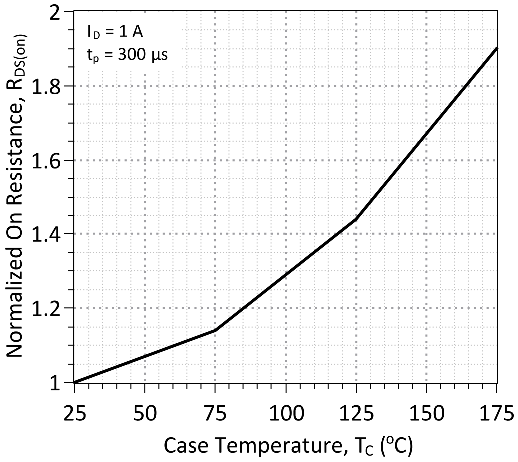


Figure 3: On-Resistance vs. Temperature

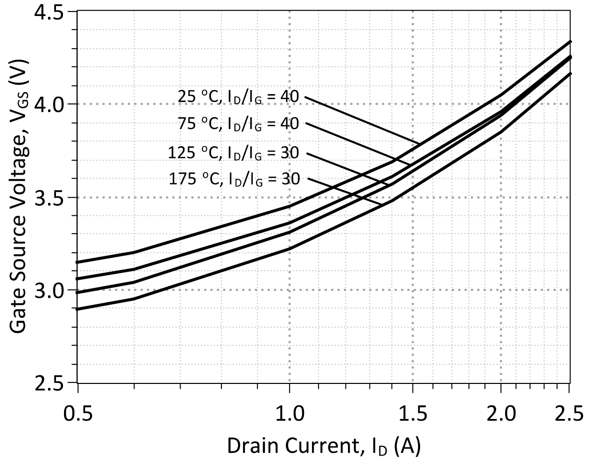


Figure 4: Typical Gate – Source Saturation Voltage

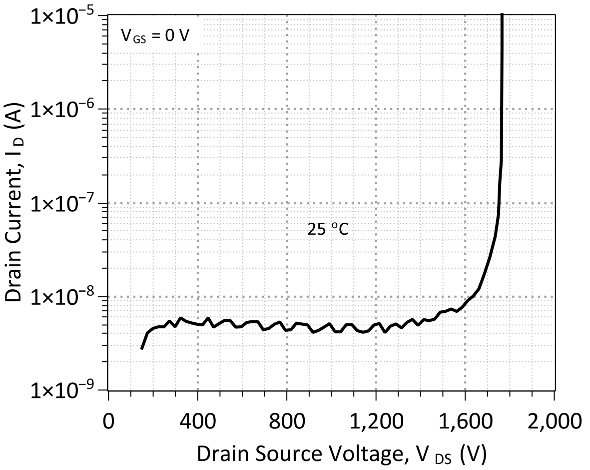


Figure 5: Typical Blocking Characteristics

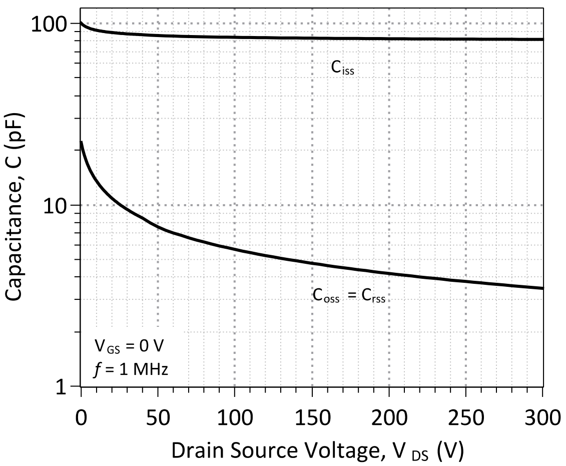


Figure 6: Input, Output, and Reverse Transfer Capacitance

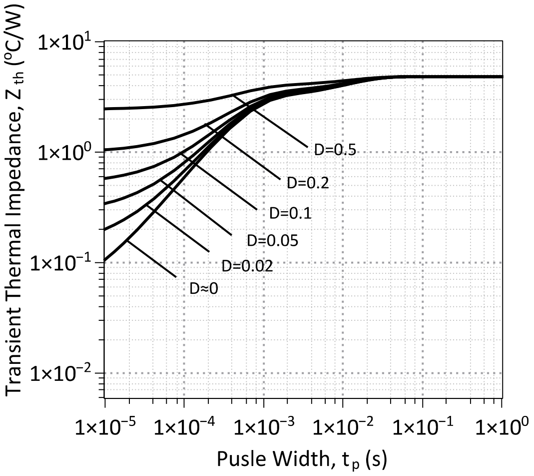


Figure 7: Transient Thermal Impedance

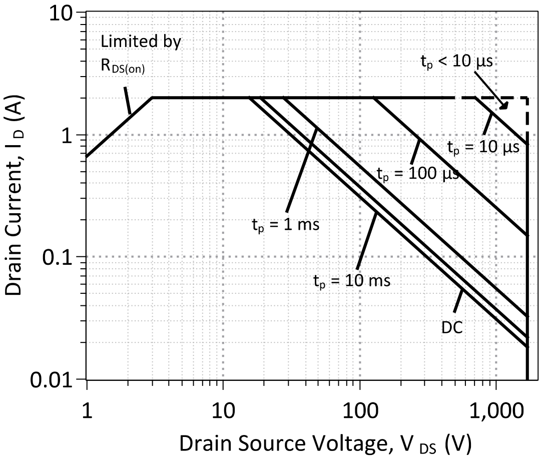


Figure 8: Forward Bias Safe Operating Area at T_c= 25°C

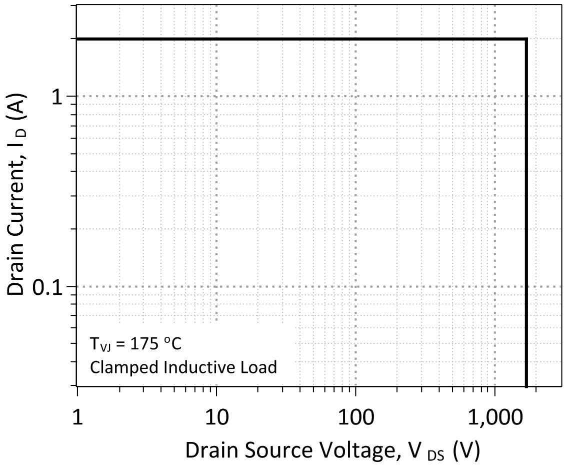


Figure 9: Turn-Off Safe Operating Area

Section IV: Driving the GR1500JT17-247

Drive Topology	Gate Drive Power Consumption	Switching Frequency	Application Emphasis
TTL Logic	High	Low	Wide Temperature Range
Constant Current	Medium	Medium	Wide Temperature Range
High Speed – Boost Capacitor	Medium	High	Fast Switching
High Speed – Boost Inductor	Low	High	Ultra Fast Switching
Proportional	Lowest	High	Wide Drain Current Range
Pulsed Power	Medium	N/A	Pulse Power

Static TTL Logic Driving

The GR1500JT17-247 may be driven with direct (5 V) TTL logic and current amplification. The amplified current level of the supply must meet or exceed the steady state gate current ($I_{G,steady}$) required to operate the GR1500JT17-247. Minimum $I_{G,steady}$ is dependent on the anticipated drain current I_D through the SJT and the DC current gain h_{FE}, it may be calculated from the following equation. An accurate value of the h_{FE} may be read from Figure 2. An optional resistor R_G may be used in series with the gate pin to trim $I_{G,steady}$, also an optional capacitor C_G may be added in parallel with R_G to facilitate faster SJT switching if desired, further details on these options are given in the following section.

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

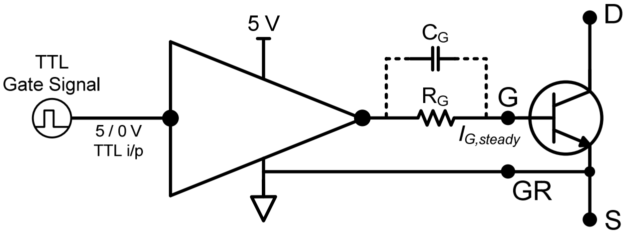


Figure 10: TTL Gate Drive Schematic

High Speed Driving

The SJT is a current controlled transistor which requires a positive gate current for turn-on and to remain in on-state. An idealized gate current waveform for ultra-fast switching of the SJT while maintaining low gate drive losses is shown in Figure 11, it features a positive current peak during turn-on, a negative current peak during turn-off, and continuous gate current during on-state.

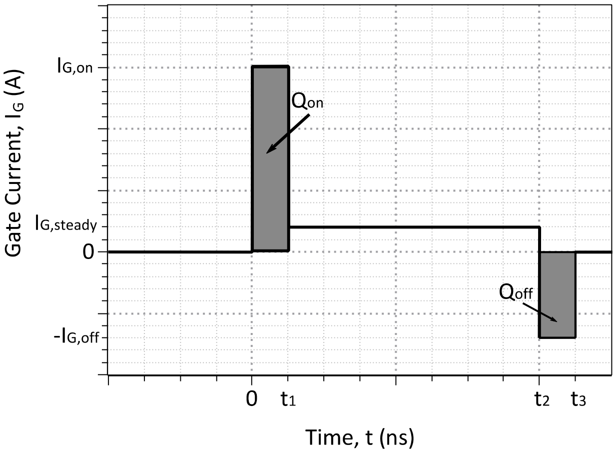


Figure 11: An idealized gate current waveform for fast switching of an SJT.

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 SJT gate-source capacitance, C_{GS}, and gate-drain capacitance, C_{GD}, are fully charged.

$$Q_{on} = I_{G,on} * t_1$$

$$Q_{on} \geq Q_{gs} + Q_{gd}$$

Ideally, $I_{G,on}$ should 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 device package 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 voltage applied to the gate pin should be maintained high enough, above the $V_{GS,sat}$ (see Figure 7) 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. Turn off can be achieved with V_{GS} = 0 V, however a negative gate voltage V_{GS} may be used in order to speed up the turn-off transition.

A:1: High Speed, Low Loss Drive with Boost Capacitor

The GR1500JT17-247 may be driven using a High Speed, Low Loss Drive with Boost Capacitor topology in which multiple voltage levels, a gate resistor, and a gate capacitor are used to provide fast switching current peaks at turn-on and turn-off and a continuous gate current while in on-state. An example of this topology is shown in Figure 12.

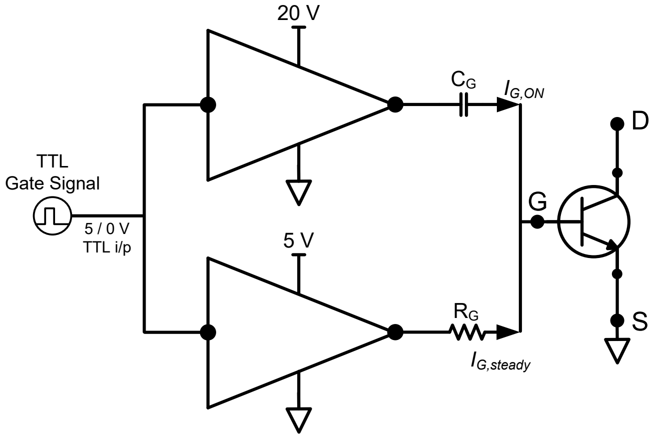


Figure 12: Simplified Boost Capacitor Drive Topology.

A:2: High Speed, Low Loss Drive with Boost Inductor

A High Speed, Low-Loss Driver with Boost Inductor is also capable of driving the GR1500JT17-247 at high-speed. It utilizes a gate drive inductor instead of a capacitor to provide the high-current gate current pulses $I_{G,on}$ and $I_{G,off}$. During operation, inductor L is charged to a specified $I_{G,on}$ current value then made to discharge I_L into the SJT gate pin using logic control of S_1, S_2, S_3, and S_4, as shown in Figure 13. After turn on, while the device remains on the necessary steady state gate current $I_{G,steady}$ is supplied from source V_{CC} through R_G. Please refer to the article "A current-source concept for fast and efficient driving of silicon carbide transistors" by Dr. Jacek Rąbkowski for additional information on this driving topology.[3]

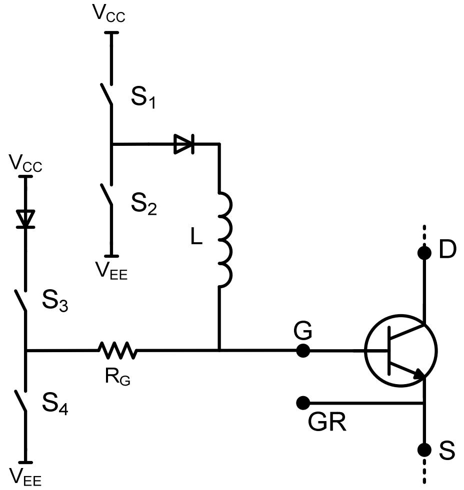


Figure 13: Simplified Inductive Pulsed Drive Topology

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[3] – Archives of Electrical Engineering. Volume 62, Issue 2, Pages 333–343, ISSN (Print) 0004-0746, DOI: 10.2478/aee-2013-0026, June 2013

B: Proportional Gate Current Driving

For applications in which the GR1500JT17-247 will operate over a wide range of drain current conditions, it may be beneficial to drive the device using a proportional gate drive topology to optimize gate drive power consumption. A proportional gate driver relies on instantaneous drain current I_D feedback to vary the steady state gate current $I_{G,steady}$ supplied to the GR1500JT17-247

Voltage Controlled Proportional Driver

The voltage controlled proportional driver relies on a gate drive IC to detect the GR1500JT17-247 drain-source voltage V_{DS} during on-state to sense I_D. The gate drive IC will then increase or decrease $I_{G,steady}$ in response to I_D. This allows $I_{G,steady}$, and thus the gate drive power consumption, to be reduced while I_D is relatively low or for $I_{G,steady}$ to increase when is I_D higher. A high voltage diode connected between the drain and sense protects the IC from high-voltage when the driver and GR1500JT17-247 are in off-state. A simplified version of this topology is shown in Figure 14, additional information will be available in the future at http://www.genesicsemi.com/commercial-sic/sic-junction-transistors/

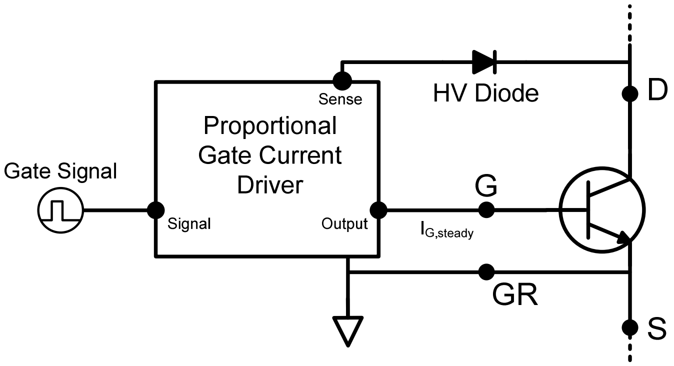


Figure 14: Simplified Voltage Controlled Proportional Driver

Current Controlled Proportional Driver

The current controlled proportional driver relies on a low-loss transformer in the drain or source path to provide feedback I_D of the GR1500JT17-247 during on-state to supply $I_{G,steady}$ into the device gate. $I_{G,steady}$ will then increase or decrease in response to I_D at a fixed forced current gain which is set be the turns ratio of the transformer, $h_{force} = I_D / I_G = N_2 / N_1$. GR1500JT17-247 is initially turned-on using a gate current pulse supplied into an RC drive circuit to allow I_D current to begin flowing. This topology allows $I_{G,steady}$, and thus the gate drive power consumption, to be reduced while I_D is relatively low or for $I_{G,steady}$ to increase when is I_D higher. A simplified version of this topology is shown in Figure 15, additional information will be available in the future at http://www.genesicsemi.com/commercial-sic/sic-junction-transistors/.

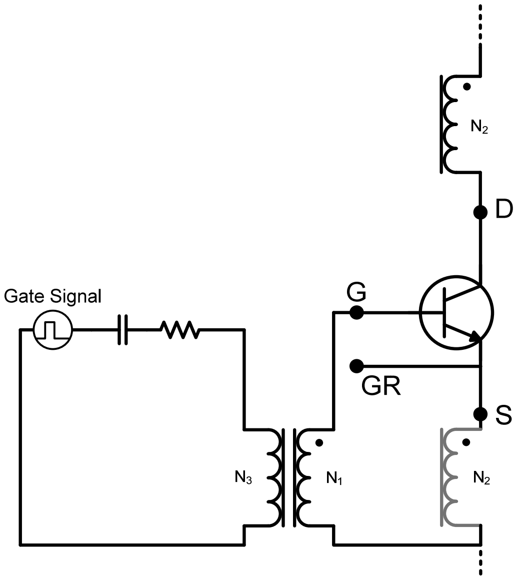
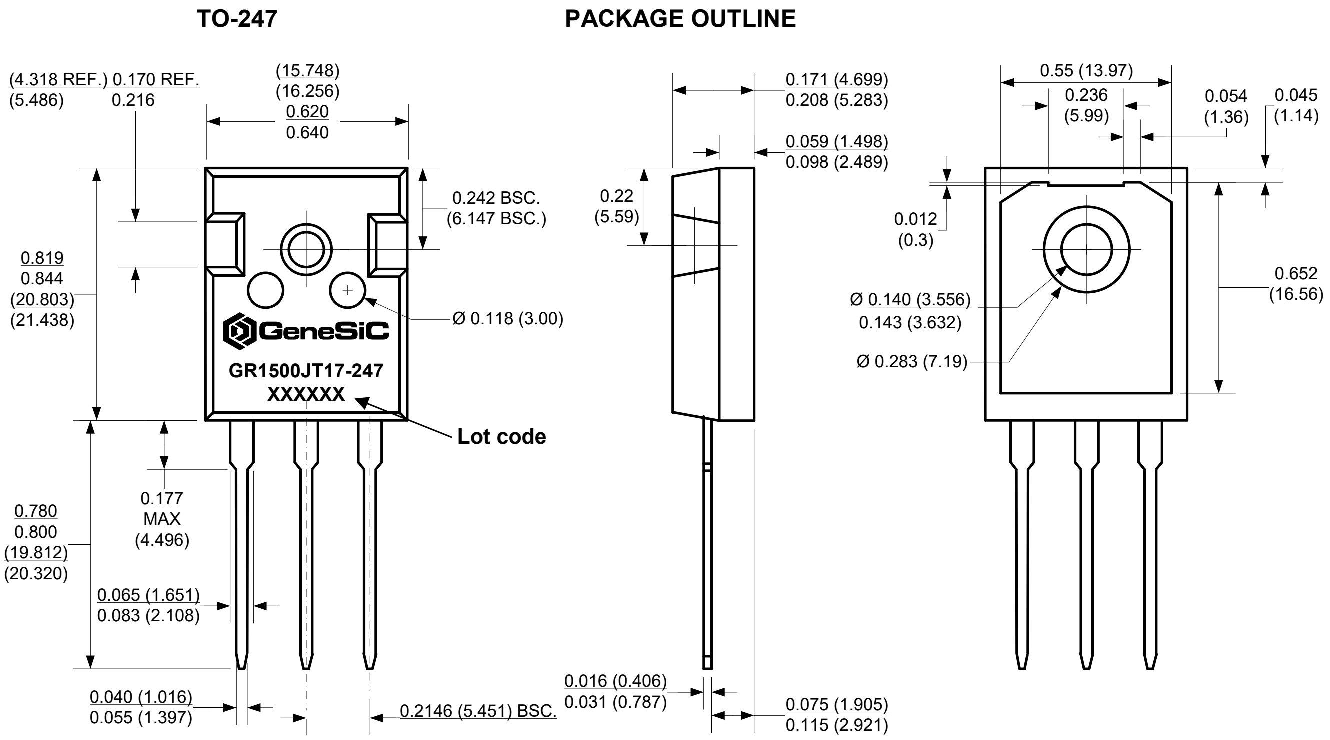


Figure 15: Simplified Current Controlled Proportional Driver

Section V: Package Dimensions



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
2016/04/04	0	Initial release	

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Section VI: 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/sjt/GR1500JT17-247_SPICE.pdf) into LTSPICE (version 4) software for simulation of the GR1500JT17-247.

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*    MODEL OF GeneSiC Semiconductor Inc.
*
*    $Revision:   1.0           $
*    $Date:   04-APR-2016       $
*
*    GeneSiC Semiconductor Inc.
*    43670 Trade Center Place Ste. 155
*    Dulles, VA 20166
*
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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.
*
.model GR1500JT12 NPN
+ IS       9.8338E-48
+ ISE      1.0733E-26
+ EG       3.23
+ BF       110
+ BR       0.55
+ IKF      5000
+ NF       1
+ NE       2
+ RB       20
+ IRB      0.002
+ RBM      0.6
+ RE       0.003
+ RC       1.5
+ CJC      25E-12
+ VJC      3
+ MJC      0.5
+ CJE      80E-12
+ VJE      3
+ MJE      0.5
+ XTI      3
+ XTB      -1.5
+ TRC1     6.5E-3
+ VCEO     1700
+ MFG      GeneSiC_Semiconductor
*
* End of GR1500JT12 SPICE Model
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