

## Silicon Carbide Power MOSFET N-Channel Enhancement Mode

### Features

- ★ 3rd generation SiC MOSFET technology
- ★ High blocking voltage with low on-resistance
- ★ High-speed switching with low capacitances
- ★ Fast intrinsic diode with low reverse recovery ( $Q_{rr}$ )
- ★ Halogen Free, RoHS Compliant

### Benefits

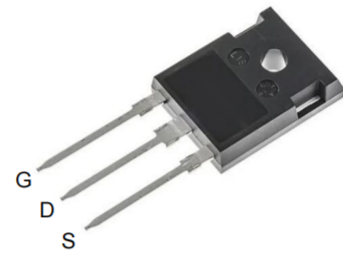
- ★ Reduce switching losses and minimize gate ringing
- ★ Higher system efficiency
- ★ Reduced cooling requirements
- ★ Increase power density
- ★ Increase system switching frequency

### Applications

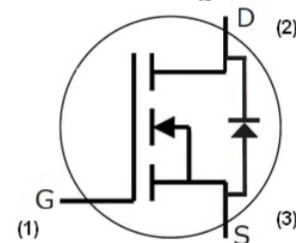
- ★ Solar inverters
- ★ EV motor drive
- ★ High voltage DC/DC converters
- ★ Switched mode power supplies
- ★ Load switch

### Product Summary

| $V_{DS}$ | $R_{DS(on)}$ | $I_D @ 25^\circ$ |
|----------|--------------|------------------|
| 1200V    | 21m $\Omega$ | 81A              |



TO-247-3  
Package



### Maximum Ratings ( $T_C = 25^\circ\text{C}$ unless otherwise specified)

| Symbol         | Parameter                                  | Value       | Unit             | Test Conditions                                     | Note              |
|----------------|--------------------------------------------|-------------|------------------|-----------------------------------------------------|-------------------|
| $V_{DSmax}$    | Drain - Source Voltage                     | 1200        | V                | $V_{GS} = 0\text{ V}, I_b = 100\text{ }\mu\text{A}$ |                   |
| $V_{GSmax}$    | Gate - Source Voltage                      | -8/+19      | V                | AC ( $f > 1\text{ Hz}$ )                            |                   |
| $V_{GSop}$     | Gate - Source Voltage                      | -4/+15      | V                | Static                                              | Note 2            |
| $I_D$          | Continuous Drain Current                   | 81          | A                | $V_{GS} = 20\text{ V}, T_C = 25^\circ\text{C}$      | Fig. 19<br>Note 3 |
|                |                                            | 56          |                  | $V_{GS} = 20\text{ V}, T_C = 100^\circ\text{C}$     |                   |
| $I_{D(pulse)}$ | Pulsed Drain Current                       | 200         | A                | Pulse width $t_p$ limited by $T_{jmax}$             |                   |
| $P_D$          | Power Dissipation                          | 469         | W                | $T_C = 25^\circ\text{C}, T_J = 150^\circ\text{C}$   | Fig. 20           |
| $T_J, T_{stg}$ | Operating Junction and Storage Temperature | -40 to +175 | $^\circ\text{C}$ |                                                     |                   |
| $T_L$          | Solder Temperature                         | 260         | $^\circ\text{C}$ | 1.6mm (0.063") from case for 10s                    |                   |
| $M_d$          | Mounting Torque                            | 1<br>8.8    | Nm<br>lbf-in     | M3 or 6-32 screw                                    |                   |

Note (1): When using MOSFET Body Diode  $V_{GSmax} = -4\text{V}/+19\text{V}$

Note (2): MOSFET can also safely operate at 0/+15 V

Note (3): Die limits are 100A (25°C) and 74A (100°C)

## Electrical Characteristics (T<sub>C</sub> = 25 °C unless otherwise specified)

| Symbol               | Parameter                                  | Min. | Typ. | Max. | Unit | Test Conditions                                                                                                                                         | Note         |
|----------------------|--------------------------------------------|------|------|------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| V <sub>(BR)DSS</sub> | Drain-Source Breakdown Voltage             | 1200 |      |      | V    | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 100 μA                                                                                                          |              |
| V <sub>GS(th)</sub>  | Gate Threshold Voltage                     | 1.8  | 2.5  | 3.6  | V    | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 17.7 mA                                                                                            | Fig. 11      |
|                      |                                            |      | 2.0  |      | V    | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 17.7 mA, T <sub>J</sub> = 175°C                                                                    |              |
| I <sub>DSS</sub>     | Zero Gate Voltage Drain Current            |      | 1    | 50   | μA   | V <sub>DS</sub> = 1200 V, V <sub>GS</sub> = 0 V                                                                                                         |              |
| I <sub>GSS</sub>     | Gate-Source Leakage Current                |      | 10   | 250  | nA   | V <sub>GS</sub> = 15 V, V <sub>DS</sub> = 0 V                                                                                                           |              |
| R <sub>DS(on)</sub>  | Drain-Source On-State Resistance           | 14.7 | 21   | 28.8 | mΩ   | V <sub>GS</sub> = 15 V, I <sub>D</sub> = 50 A                                                                                                           | Fig. 4, 5, 6 |
|                      |                                            |      | 38   |      |      | V <sub>GS</sub> = 15 V, I <sub>D</sub> = 50 A, T <sub>J</sub> = 175°C                                                                                   |              |
| g <sub>fs</sub>      | Transconductance                           |      | 35   |      | S    | V <sub>DS</sub> = 20 V, I <sub>DS</sub> = 50 A                                                                                                          | Fig. 7       |
|                      |                                            |      | 33   |      |      | V <sub>DS</sub> = 20 V, I <sub>DS</sub> = 50 A, T <sub>J</sub> = 175°C                                                                                  |              |
| C <sub>iss</sub>     | Input Capacitance                          |      | 4818 |      | pF   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 1000 V<br>f = 100 KHz<br>V <sub>AC</sub> = 25 mV                                                               | Fig. 17, 18  |
| C <sub>oss</sub>     | Output Capacitance                         |      | 180  |      |      |                                                                                                                                                         |              |
| C <sub>rss</sub>     | Reverse Transfer Capacitance               |      | 12   |      |      |                                                                                                                                                         |              |
| E <sub>oss</sub>     | C <sub>oss</sub> Stored Energy             |      | 99   |      | μJ   |                                                                                                                                                         | Fig. 16      |
| E <sub>ON</sub>      | Turn-On Switching Energy (SiC Diode FWD)   |      | 3.05 |      | mJ   | V <sub>DS</sub> = 800 V, V <sub>GS</sub> = -4 V/+15 V, I <sub>D</sub> = 50 A,<br>R <sub>G(ext)</sub> = 5Ω, L = 65.7 μH, T <sub>J</sub> = 175°C          | Fig. 26, 29  |
| E <sub>OFF</sub>     | Turn Off Switching Energy (SiC Diode FWD)  |      | 1.67 |      |      |                                                                                                                                                         |              |
| E <sub>ON</sub>      | Turn-On Switching Energy (Body Diode FWD)  |      | 4.65 |      | mJ   | V <sub>DS</sub> = 800 V, V <sub>GS</sub> = -4 V/+15 V, I <sub>D</sub> = 50 A,<br>R <sub>G(ext)</sub> = 5Ω, L = 65.7 μH, T <sub>J</sub> = 175°C          | Fig. 26, 29  |
| E <sub>OFF</sub>     | Turn Off Switching Energy (Body Diode FWD) |      | 1.58 |      |      |                                                                                                                                                         |              |
| t <sub>d(on)</sub>   | Turn-On Delay Time                         |      | 142  |      | ns   | V <sub>DD</sub> = 800 V, V <sub>GS</sub> = -4 V/15 V<br>R <sub>G(ext)</sub> = 2.5 Ω, L = 65.7 μH<br>Timing relative to V <sub>DS</sub> , Inductive load | Fig. 27      |
| t <sub>r</sub>       | Rise Time                                  |      | 27   |      |      |                                                                                                                                                         |              |
| t <sub>d(off)</sub>  | Turn-Off Delay Time                        |      | 72   |      |      |                                                                                                                                                         |              |
| t <sub>f</sub>       | Fall Time                                  |      | 25   |      |      |                                                                                                                                                         |              |
| R <sub>G(int)</sub>  | Internal Gate Resistance                   |      | 3.3  |      | Ω    | f = 1 MHz, V <sub>AC</sub> = 25 mV                                                                                                                      |              |
| Q <sub>gs</sub>      | Gate to Source Charge                      |      | 51   |      | nC   | V <sub>DS</sub> = 800 V, V <sub>GS</sub> = -4 V/15 V<br>I <sub>D</sub> = 50 A<br>Per IEC60747-8-4 pg 21                                                 | Fig. 12      |
| Q <sub>gd</sub>      | Gate to Drain Charge                       |      | 54   |      |      |                                                                                                                                                         |              |
| Q <sub>g</sub>       | Total Gate Charge                          |      | 160  |      |      |                                                                                                                                                         |              |

## Reverse Diode Characteristics (T<sub>C</sub> = 25°C unless otherwise specified)

| Symbol                | Parameter                        | Typ. | Max. | Unit | Test Conditions                                                                                                       | Note          |
|-----------------------|----------------------------------|------|------|------|-----------------------------------------------------------------------------------------------------------------------|---------------|
| V <sub>SD</sub>       | Diode Forward Voltage            | 4.6  |      | V    | V <sub>GS</sub> = -4 V, I <sub>SD</sub> = 25 A, T <sub>J</sub> = 25 °C                                                | Fig. 8, 9, 10 |
|                       |                                  | 4.2  |      | V    | V <sub>GS</sub> = -4 V, I <sub>SD</sub> = 25 A, T <sub>J</sub> = 175 °C                                               |               |
| I <sub>S</sub>        | Continuous Diode Forward Current |      | 90   | A    | V <sub>GS</sub> = -4 V, T <sub>C</sub> = 25°C                                                                         | Note 1        |
| I <sub>S, pulse</sub> | Diode pulse Current              |      | 200  | A    | V <sub>GS</sub> = -4 V, pulse width t <sub>p</sub> limited by T <sub>Jmax</sub>                                       | Note 1        |
| t <sub>rr</sub>       | Reverse Recover time             | 81   |      | ns   | V <sub>GS</sub> = -4 V, I <sub>SD</sub> = 50 A, V <sub>R</sub> = 800 V<br>dif/dt = 1000 A/μs, T <sub>J</sub> = 175 °C | Note 1        |
| Q <sub>rr</sub>       | Reverse Recovery Charge          | 879  |      | nC   |                                                                                                                       |               |
| I <sub>rrm</sub>      | Peak Reverse Recovery Current    | 19   |      | A    |                                                                                                                       |               |

## Thermal Characteristics

| Symbol           | Parameter                                   | Typ. | Unit | Test Conditions | Note    |
|------------------|---------------------------------------------|------|------|-----------------|---------|
| R <sub>θJC</sub> | Thermal Resistance from Junction to Case    | 0.32 | °C/W |                 | Fig. 21 |
| R <sub>θJA</sub> | Thermal Resistance From Junction to Ambient | 40   |      |                 |         |

## Typical Performance

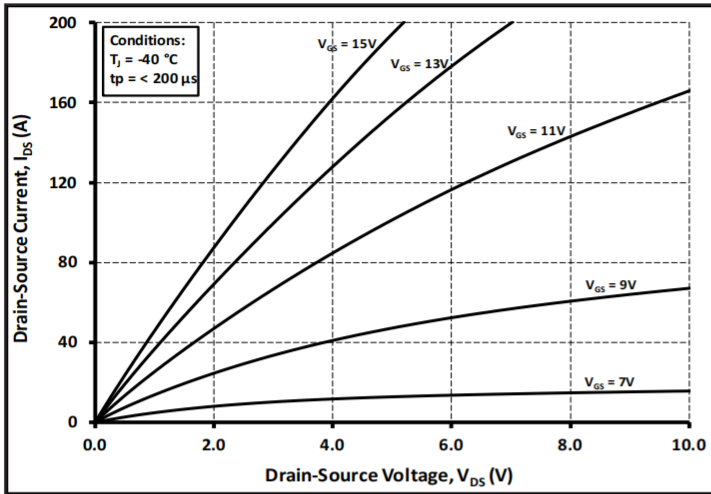


Figure 1. Output Characteristics  $T_J = -40\text{ }^{\circ}\text{C}$

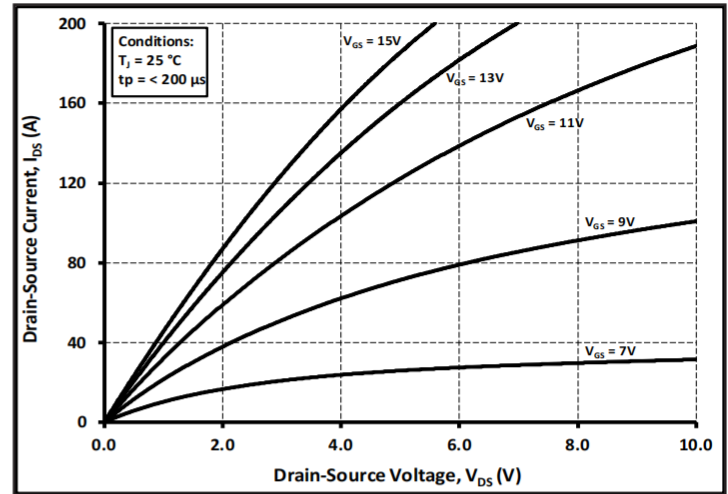


Figure 2. Output Characteristics  $T_J = 25\text{ }^{\circ}\text{C}$

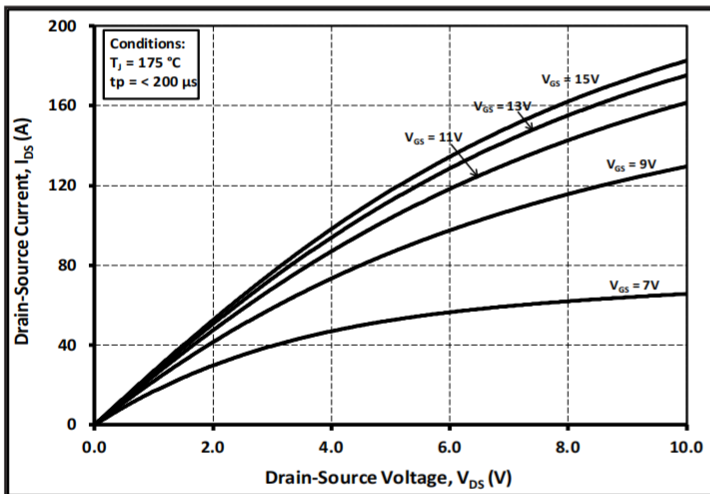


Figure 3. Output Characteristics  $T_J = 175\text{ }^{\circ}\text{C}$

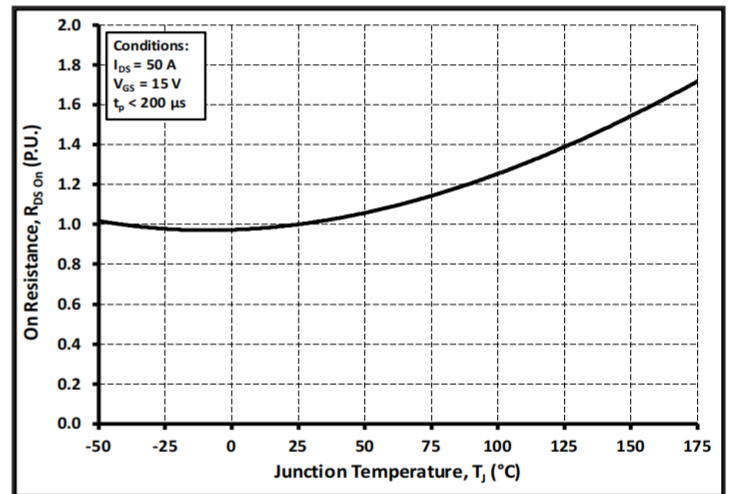


Figure 4. Normalized On-Resistance vs. Temperature

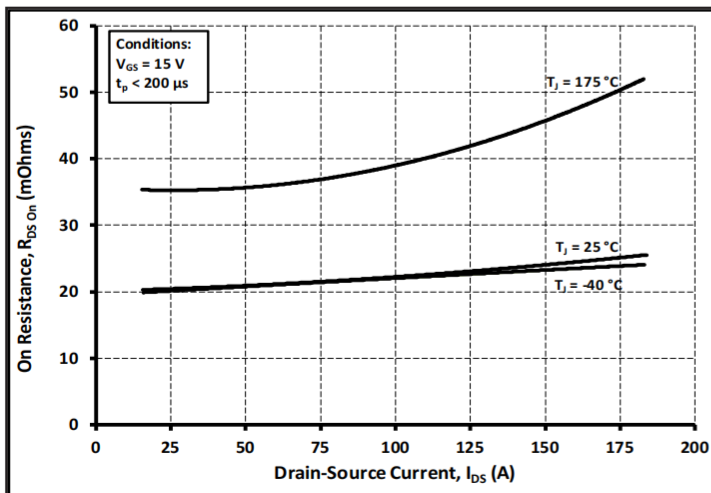


Figure 5. On-Resistance vs. Drain Current For Various Temperatures

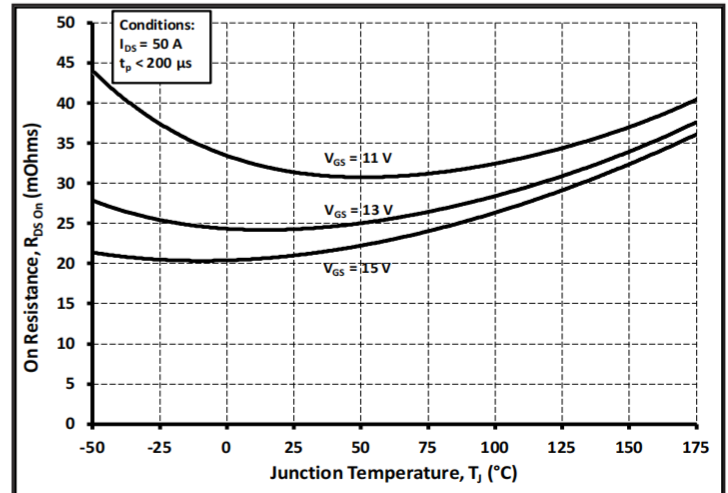


Figure 6. On-Resistance vs. Temperature For Various Gate Voltage

## Typical Performance

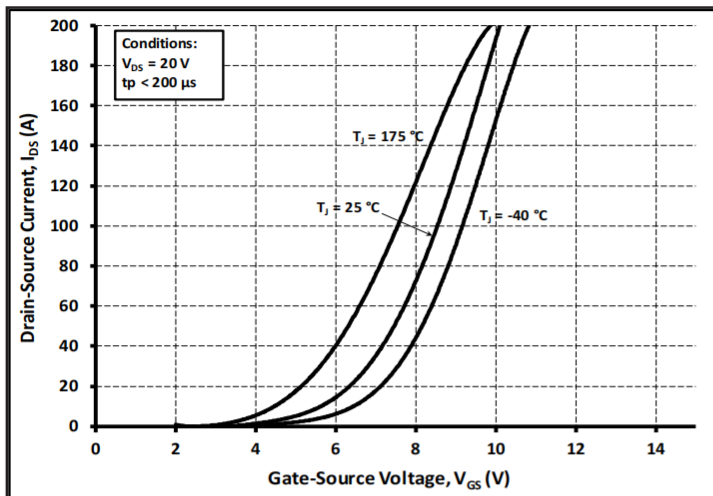


Figure 7. Transfer Characteristic for Various Junction Temperatures

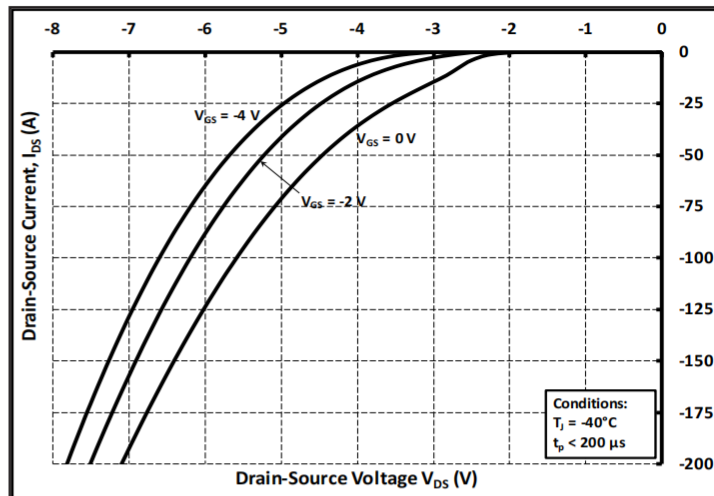


Figure 8. Body Diode Characteristic at -40 °C

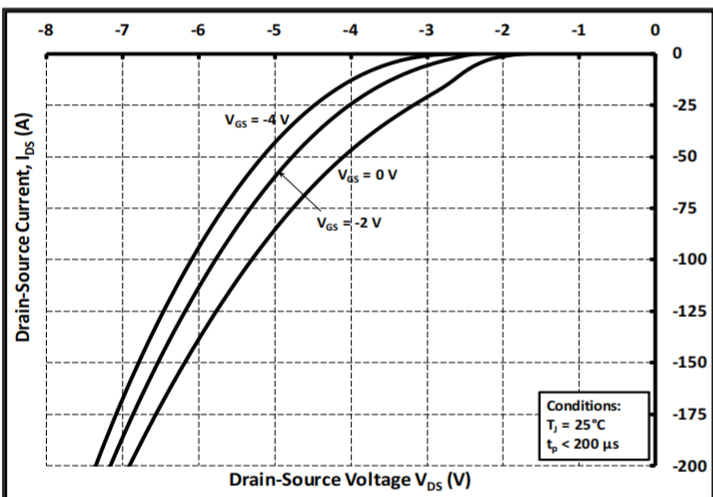


Figure 9. Body Diode Characteristic at 25 °C

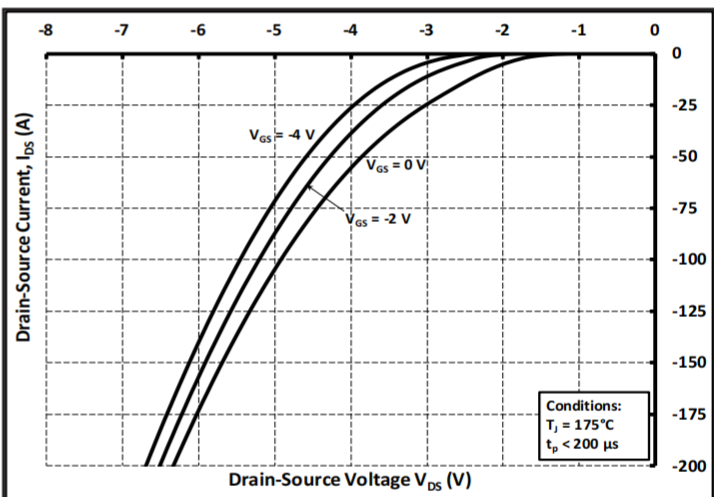


Figure 10. Body Diode Characteristic at 175 °C

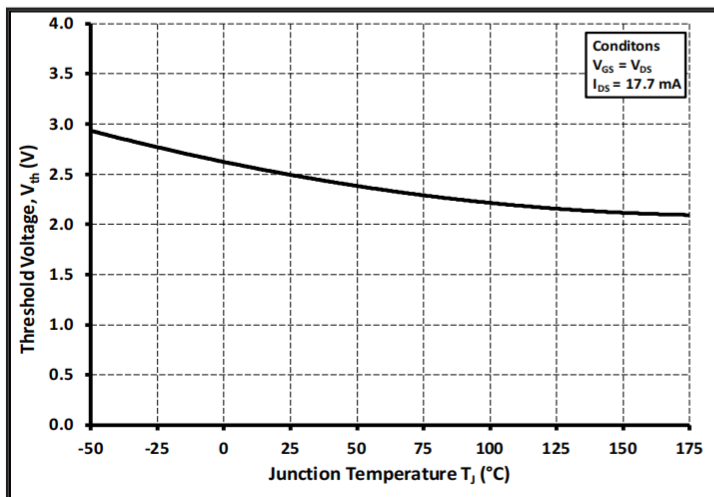


Figure 11. Threshold Voltage vs. Temperature

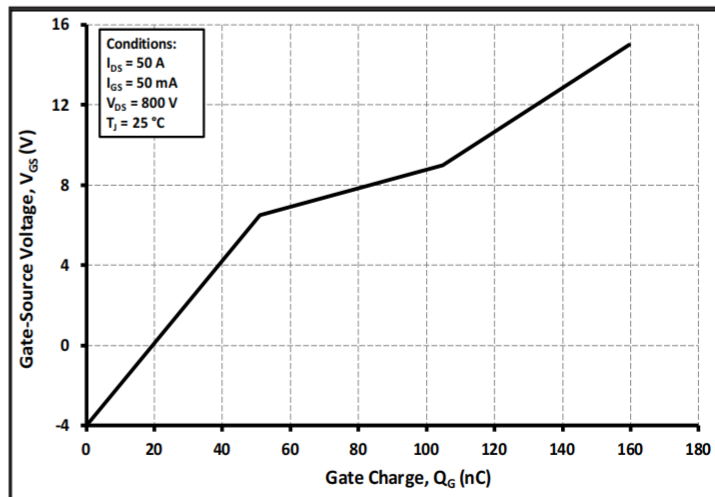


Figure 12. Gate Charge Characteristics

## Typical Performance

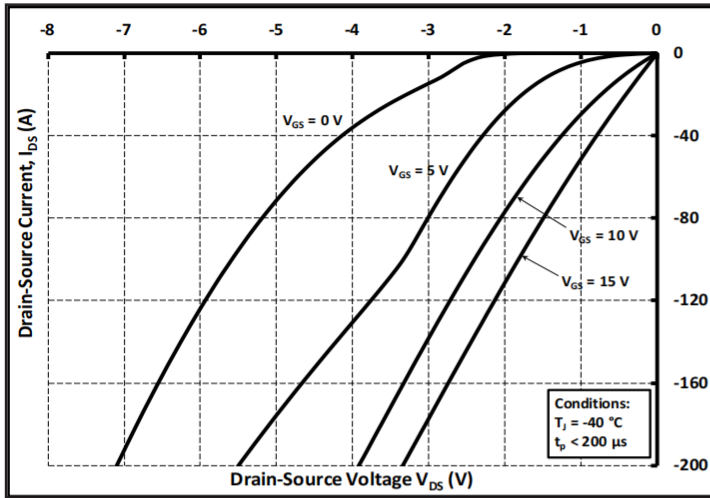


Figure 13. 3rd Quadrant Characteristic at -40 °C

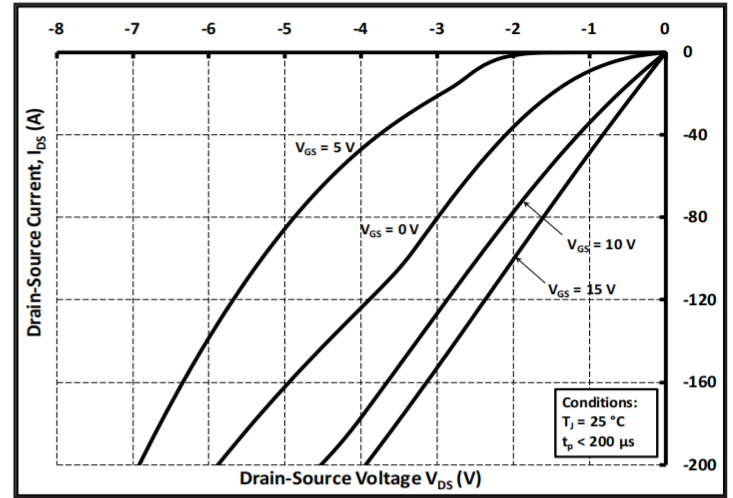


Figure 14. 3rd Quadrant Characteristic at 25 °C

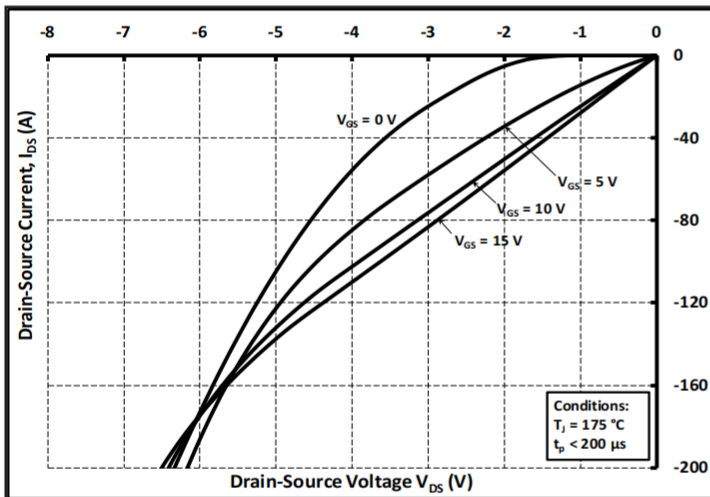


Figure 15. 3rd Quadrant Characteristic at 175 °C

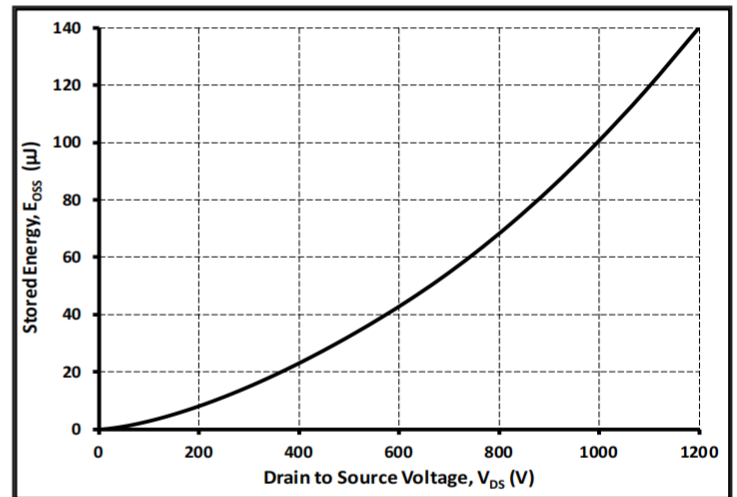


Figure 16. Output Capacitor Stored Energy

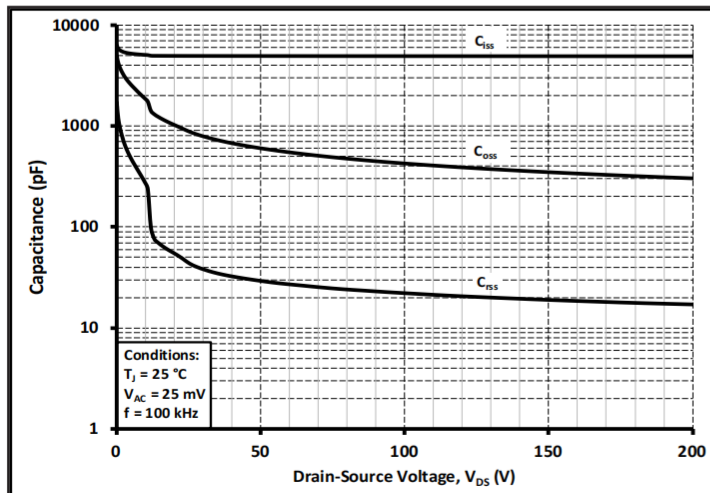


Figure 17. Capacitances vs. Drain-Source Voltage (0 - 200V)

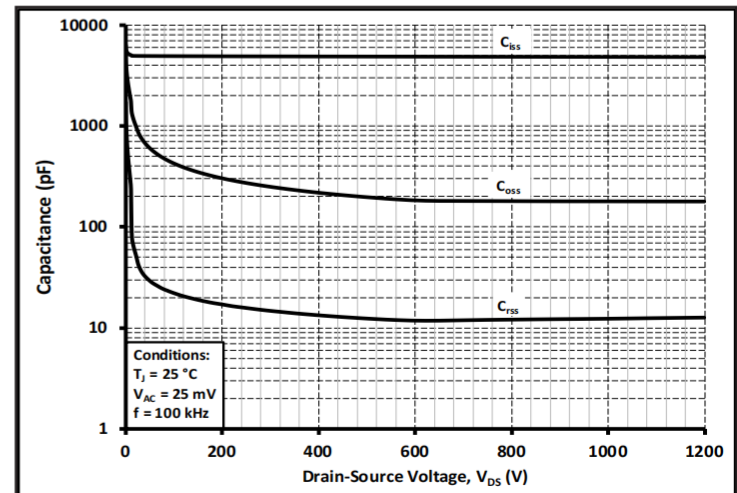


Figure 18. Capacitances vs. Drain-Source Voltage (0 - 1000V)

## Typical Performance

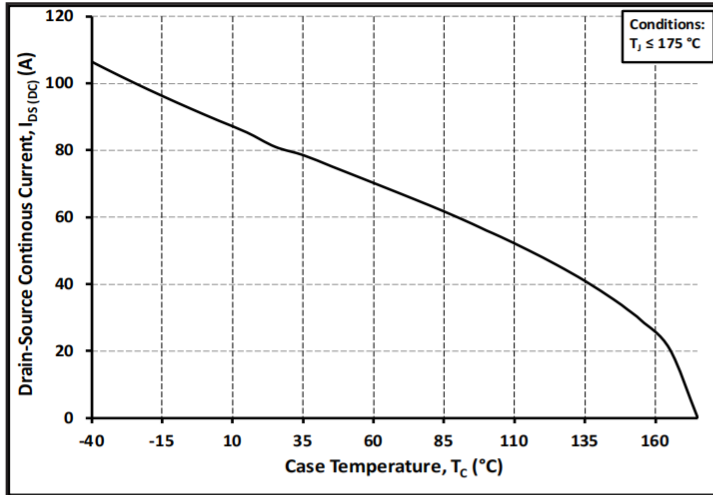


Figure 19. Continuous Drain Current Derating vs. Case Temperature

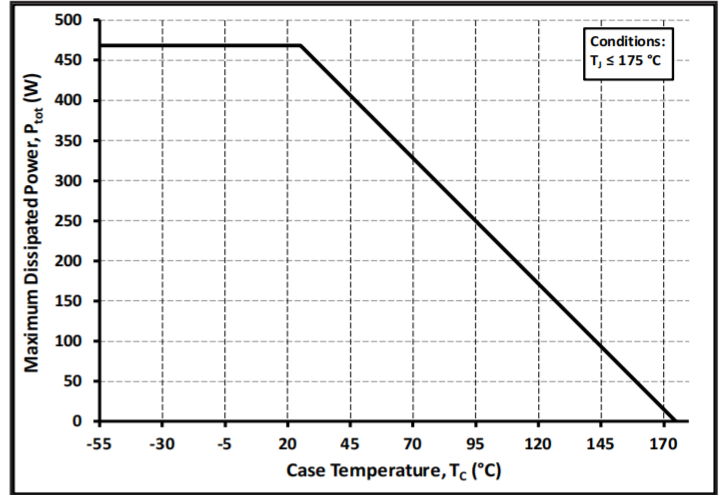


Figure 20. Maximum Power Dissipation Derating vs. Case Temperature

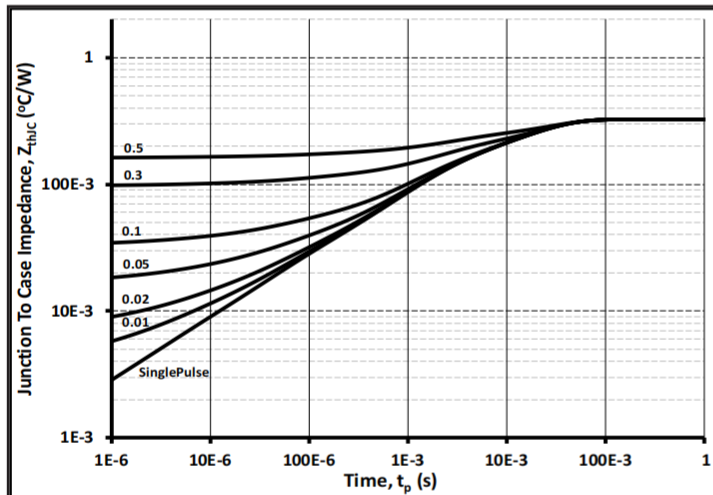


Figure 21. Transient Thermal Impedance (Junction - Case)

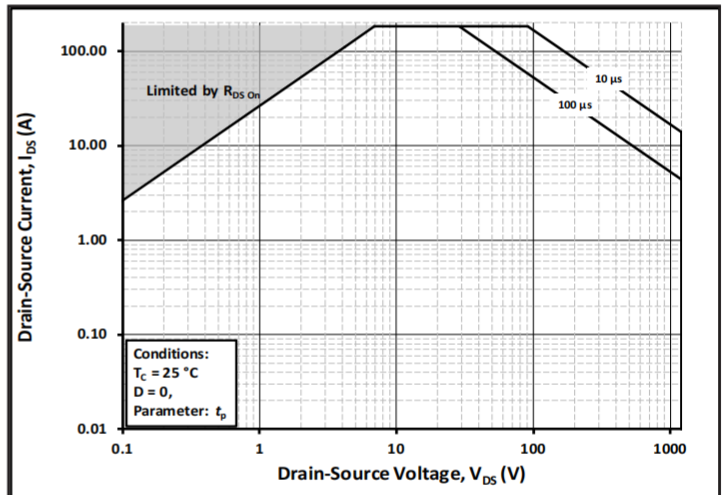


Figure 22. Safe Operating Area

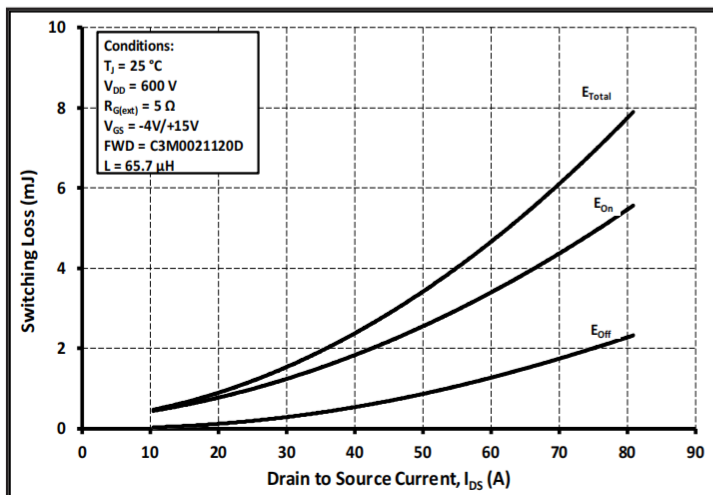


Figure 23. Clamped Inductive Switching Energy vs. Drain Current ( $V_{DD} = 600V$ )

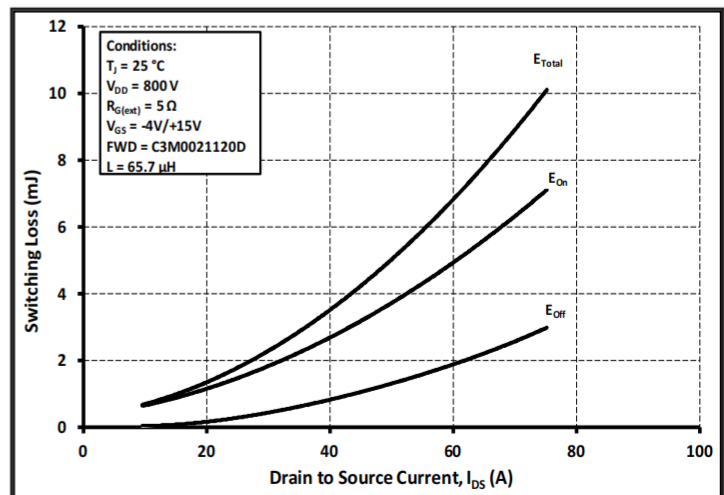


Figure 24. Clamped Inductive Switching Energy vs. Drain Current ( $V_{DD} = 800V$ )

## Typical Performance

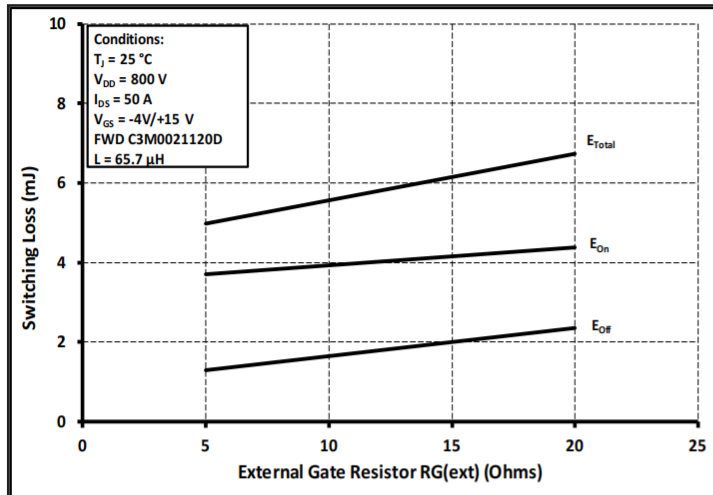


Figure 25. Clamped Inductive Switching Energy vs.  $R_{G(ext)}$

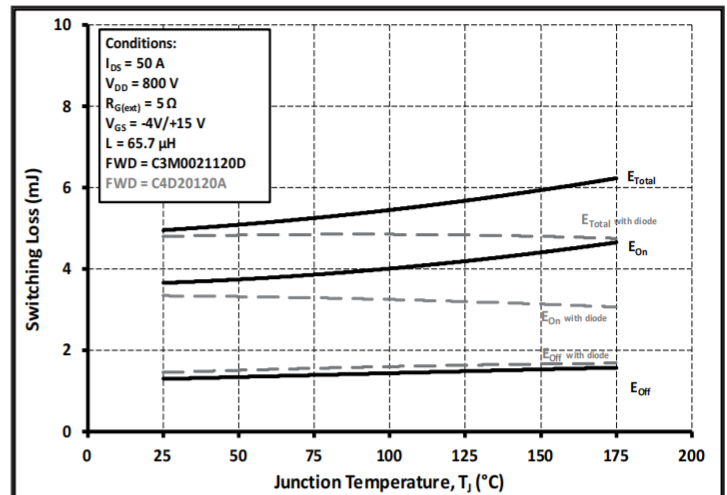


Figure 26. Clamped Inductive Switching Energy vs. Temperature

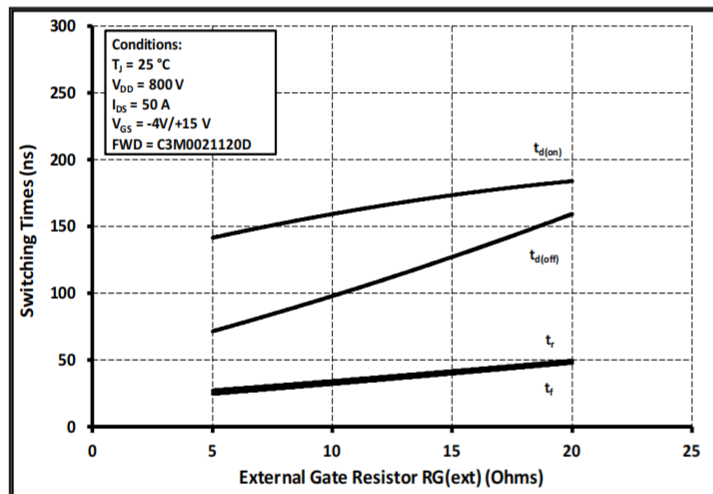


Figure 27. Switching Times vs.  $R_{G(ext)}$

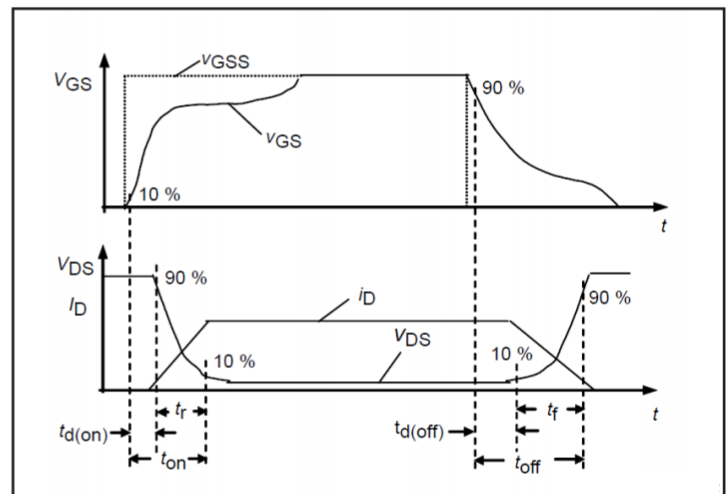


Figure 28. Switching Times Definition

## Test Circuit Schematic

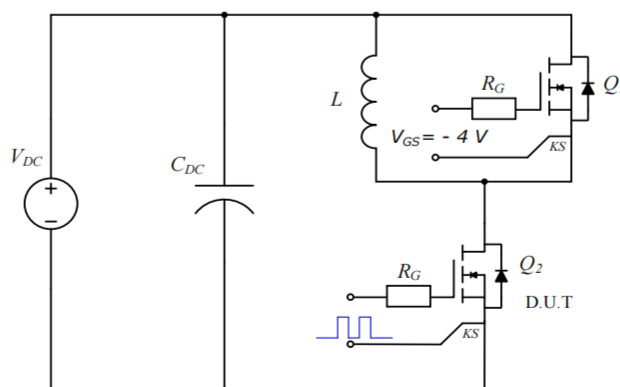
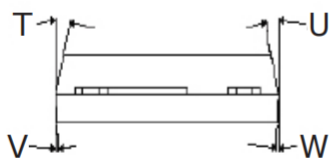
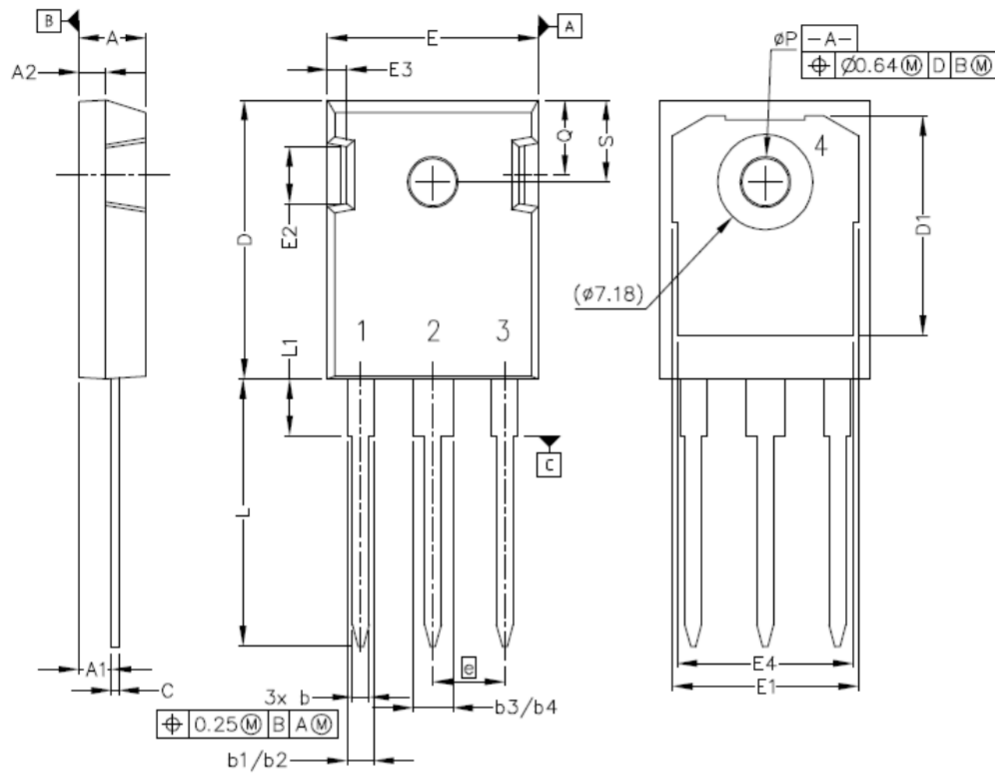


Figure 29. Clamped Inductive Switching Waveform Test Circuit

Note (4): Turn-off and Turn-on switching energy and timing values measured using SiC MOSFET Body Diode as shown above.

## Package Dimensions

Package TO-247-3



### Pinout Information:

- Pin 1 = Gate
- Pin 2, 4 = Drain
- Pin 3 = Source

## Package Dimensions

Package TO-247-3

| POS | Inches   |      | Millimeters |       |
|-----|----------|------|-------------|-------|
|     | Min      | Max  | Min         | Max   |
| A   | .190     | .205 | 4.83        | 5.21  |
| A1  | .090     | .100 | 2.29        | 2.54  |
| A2  | .075     | .085 | 1.91        | 2.16  |
| b   | .042     | .052 | 1.07        | 1.33  |
| b1  | .075     | .095 | 1.91        | 2.41  |
| b2  | .075     | .085 | 1.91        | 2.16  |
| b3  | .113     | .133 | 2.87        | 3.38  |
| b4  | .113     | .123 | 2.87        | 3.13  |
| c   | .022     | .027 | 0.55        | 0.68  |
| D   | .819     | .831 | 20.80       | 21.10 |
| D1  | .640     | .695 | 16.25       | 17.65 |
| D2  | .037     | .049 | 0.95        | 1.25  |
| E   | .620     | .635 | 15.75       | 16.13 |
| E1  | .516     | .557 | 13.10       | 14.15 |
| E2  | .145     | .201 | 3.68        | 5.10  |
| E3  | .039     | .075 | 1.00        | 1.90  |
| E4  | .487     | .529 | 12.38       | 13.43 |
| e   | .214 BSC |      | 5.44 BSC    |       |
| N   | 3        |      | 3           |       |
| L   | .780     | .800 | 19.81       | 20.32 |
| L1  | .161     | .173 | 4.10        | 4.40  |
| ØP  | .138     | .144 | 3.51        | 3.65  |
| Q   | .216     | .236 | 5.49        | 6.00  |
| S   | .238     | .248 | 6.04        | 6.30  |
| T   | 9°       | 11°  | 9°          | 11°   |
| U   | 9°       | 11°  | 9°          | 11°   |
| V   | 2°       | 8°   | 2°          | 8°    |
| W   | 2°       | 8°   | 2°          | 8°    |

## Recommended Solder Pad Layout

