

## Features

- High blocking voltage with low on-resistance
- High speed switching with low capacitances
- Fast intrinsic diode with low reverse recovery (Qrr)
- Halogen free, RoHS compliant

## Benefits

- Higher system efficiency
- Reduced cooling requirements
- Increased power density
- Increased system switching frequency
- Easy to parallel and simple to drive
- Enable new hard switching PFC topologies (Totem-Pole)

## Applications

- EV charging
- Server power supplies
- Solar PV inverters
- UPS
- DC/DC converters

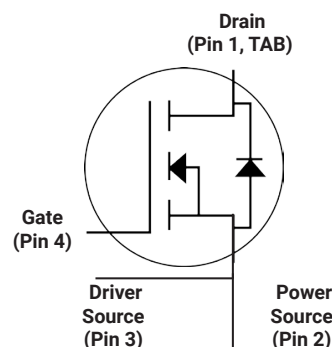
| Part Number  | Package  | Marking     |
|--------------|----------|-------------|
| GC3M0060065K | TO-247-4 | GC3M0060065 |

|                          |       |
|--------------------------|-------|
| $V_{DS}$                 | 650 V |
| $I_D @ 25^\circ\text{C}$ | 37 A  |
| $R_{DS(on)}$             | 60 mΩ |



TO-247-4

## Package



## Maximum Ratings

| Symbol         | Parameter                                                                    | Value       | Unit             | Note    |
|----------------|------------------------------------------------------------------------------|-------------|------------------|---------|
| $V_{DSS}$      | Drain - Source Voltage, $T_C = 25^\circ\text{C}$                             | 650         | V                |         |
| $V_{GS}$       | Gate - Source voltage (Under transient events < 100 ns)                      | -8/+19      | V                | Fig. 29 |
| $I_D$          | Continuous Drain Current, $V_{GS} = 15\text{ V}$ , $T_C = 25^\circ\text{C}$  | 37          | A                | Fig. 19 |
|                | Continuous Drain Current, $V_{GS} = 15\text{ V}$ , $T_C = 100^\circ\text{C}$ | 27          |                  |         |
| $I_{D(pulse)}$ | Pulsed Drain Current, Pulse width $t_p$ limited by $T_{jmax}$                | 99          | A                |         |
| $P_D$          | Power Dissipation, $T_C=25^\circ\text{C}$ , $T_J = 175^\circ\text{C}$        | 150         | W                | Fig. 20 |
| $T_J, T_{stg}$ | Operating Junction and Storage Temperature                                   | -40 to +175 | $^\circ\text{C}$ |         |
| $T_L$          | Solder Temperature, 1.6mm (0.063") from case for 10s                         | 260         | $^\circ\text{C}$ |         |
| $M_d$          | Mounting Torque, (M3 or 6-32 screw)                                          | 1<br>8.8    | Nm<br>lbf-in     |         |

**Electrical Characteristics** ( $T_c = 25^\circ\text{C}$  unless otherwise specified)

| Symbol        | Parameter                                      | Min. | Typ. | Max. | Unit          | Test Conditions                                                                                                                                                                                         | Note         |
|---------------|------------------------------------------------|------|------|------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| $V_{(BR)DSS}$ | Drain-Source Breakdown Voltage                 | 650  |      |      | V             | $V_{GS} = 0\text{ V}, I_D = 100\text{ }\mu\text{A}$                                                                                                                                                     |              |
| $V_{GSon}$    | Gate-Source Recommended Turn-On Voltage        |      | 15   |      | V             | Static                                                                                                                                                                                                  | Fig. 29      |
| $V_{GSoff}$   | Gate-Source Recommended Turn-Off Voltage       |      | -4   |      | V             |                                                                                                                                                                                                         |              |
| $V_{GS(th)}$  | Gate Threshold Voltage                         | 1.8  | 2.3  | 3.6  | V             | $V_{DS} = V_{GS}, I_D = 5\text{ mA}$                                                                                                                                                                    | Fig. 11      |
|               |                                                |      | 1.9  |      | V             | $V_{DS} = V_{GS}, I_D = 5\text{ mA}, T_J = 175^\circ\text{C}$                                                                                                                                           |              |
| $I_{DSS}$     | Zero Gate Voltage Drain Current                |      | 1    | 50   | $\mu\text{A}$ | $V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$                                                                                                                                                            |              |
| $I_{GSS}$     | Gate-Source Leakage Current                    |      | 10   | 250  | nA            | $V_{GS} = 15\text{ V}, V_{DS} = 0\text{ V}$                                                                                                                                                             |              |
| $R_{DS(on)}$  | Drain-Source On-State Resistance               | 42   | 60   | 79   | m $\Omega$    | $V_{GS} = 15\text{ V}, I_D = 13.2\text{ A}$                                                                                                                                                             | Fig. 4, 5, 6 |
|               |                                                |      | 80   |      |               | $V_{GS} = 15\text{ V}, I_D = 13.2\text{ A}, T_J = 175^\circ\text{C}$                                                                                                                                    |              |
| $g_{fs}$      | Transconductance                               |      | 10   |      | S             | $V_{DS} = 20\text{ V}, I_{DS} = 13.2\text{ A}$                                                                                                                                                          | Fig. 7       |
|               |                                                |      | 9    |      |               | $V_{DS} = 20\text{ V}, I_{DS} = 13.2\text{ A}, T_J = 175^\circ\text{C}$                                                                                                                                 |              |
| $C_{iss}$     | Input Capacitance                              |      | 1020 |      | pF            | $V_{GS} = 0\text{ V}, V_{DS} = 600\text{ V}$<br>$f = 1\text{ MHz}$<br>$V_{AC} = 25\text{ mV}$                                                                                                           | Fig. 17, 18  |
| $C_{oss}$     | Output Capacitance                             |      | 80   |      |               |                                                                                                                                                                                                         |              |
| $C_{rss}$     | Reverse Transfer Capacitance                   |      | 9    |      |               |                                                                                                                                                                                                         |              |
| $C_{o(er)}$   | Effective Output Capacitance (Energy Related)  |      | 95   |      | pF            | $V_{GS} = 0\text{ V}, V_{DS} = 0\text{ V to } 400\text{ V}$                                                                                                                                             | Note 1       |
| $C_{o(tr)}$   | Effective Output Capacitance (Time Related)    |      | 132  |      |               |                                                                                                                                                                                                         |              |
| $E_{oss}$     | $C_{oss}$ Stored Energy                        |      | 15   |      | $\mu\text{J}$ | $V_{DS} = 600\text{ V}, 1\text{ MHz}$                                                                                                                                                                   | Fig. 16      |
| $E_{ON}$      | Turn-On Switching Energy (Body Diode)          |      | 70   |      | $\mu\text{J}$ | $V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}, I_D = 13.2\text{ A},$<br>$R_{G(ext)} = 2.5\Omega, L = 135\text{ }\mu\text{H}, T_J = 175^\circ\text{C}$<br>FWD = Internal Body Diode of MOSFET | Fig. 25      |
| $E_{OFF}$     | Turn Off Switching Energy (Body Diode)         |      | 5    |      |               |                                                                                                                                                                                                         |              |
| $E_{ON}$      | Turn-On Switching Energy (External SiC Diode)  |      | 67   |      | $\mu\text{J}$ | $V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}, I_D = 13.2\text{ A},$<br>$R_{G(ext)} = 2.5\Omega, L = 135\text{ }\mu\text{H}, T_J = 175^\circ\text{C}$<br>FWD = External SiC Diode            | Fig. 25      |
| $E_{OFF}$     | Turn Off Switching Energy (External SiC Diode) |      | 6    |      |               |                                                                                                                                                                                                         |              |
| $t_{d(on)}$   | Turn-On Delay Time                             |      | 8    |      | ns            | $V_{DD} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}$<br>$I_D = 13.2\text{ A}, R_{G(ext)} = 2.5\Omega, L = 135\text{ }\mu\text{H}$<br>Timing relative to $V_{DS}$<br>Inductive load                 | Fig. 26      |
| $t_r$         | Rise Time                                      |      | 11   |      |               |                                                                                                                                                                                                         |              |
| $t_{d(off)}$  | Turn-Off Delay Time                            |      | 17   |      |               |                                                                                                                                                                                                         |              |
| $t_f$         | Fall Time                                      |      | 5    |      |               |                                                                                                                                                                                                         |              |
| $R_{G(int)}$  | Internal Gate Resistance                       |      | 3    |      | $\Omega$      | $f = 1\text{ MHz}, V_{AC} = 25\text{ mV}$                                                                                                                                                               |              |
| $Q_{gs}$      | Gate to Source Charge                          |      | 13   |      | nC            | $V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}$<br>$I_D = 13.2\text{ A}$<br>Per IEC60747-8-4 pg 21                                                                                            | Fig. 12      |
| $Q_{gd}$      | Gate to Drain Charge                           |      | 17   |      |               |                                                                                                                                                                                                         |              |
| $Q_g$         | Total Gate Charge                              |      | 46   |      |               |                                                                                                                                                                                                         |              |

Note (1):  $C_{o(er)}$ , a lumped capacitance that gives same stored energy as  $C_{oss}$  while  $V_{ds}$  is rising from 0 to 400V

$C_{o(tr)}$ , a lumped capacitance that gives same charging time as  $C_{oss}$  while  $V_{ds}$  is rising from 0 to 400V

**Reverse Diode Characteristics** ( $T_c = 25^\circ\text{C}$  unless otherwise specified)

| Symbol                | Parameter                        | Typ. | Max. | Unit | Test Conditions                                                                                                                     | Note          |
|-----------------------|----------------------------------|------|------|------|-------------------------------------------------------------------------------------------------------------------------------------|---------------|
| $V_{SD}$              | Diode Forward Voltage            | 5.1  |      | V    | $V_{GS} = -4\text{ V}, I_{SD} = 6.6\text{ A}, T_J = 25^\circ\text{C}$                                                               | Fig. 8, 9, 10 |
|                       |                                  | 4.8  |      | V    | $V_{GS} = -4\text{ V}, I_{SD} = 6.6\text{ A}, T_J = 175^\circ\text{C}$                                                              |               |
| $I_S$                 | Continuous Diode Forward Current |      | 23   | A    | $V_{GS} = -4\text{ V}, T_c = 25^\circ\text{C}$                                                                                      |               |
| $I_{S, \text{pulse}}$ | Diode pulse Current              |      | 99   | A    | $V_{GS} = -4\text{ V}$ , pulse width $t_p$ limited by $T_{Jmax}$                                                                    |               |
| $t_{rr}$              | Reverse Recover time             | 11   |      | ns   | $V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$<br>$dif/dt = 4500\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$ |               |
| $Q_{rr}$              | Reverse Recovery Charge          | 151  |      | nC   |                                                                                                                                     |               |
| $I_{rrm}$             | Peak Reverse Recovery Current    | 27   |      | A    |                                                                                                                                     |               |
| $t_{rr}$              | Reverse Recover time             | 16   |      | ns   | $V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$<br>$dif/dt = 2400\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$ |               |
| $Q_{rr}$              | Reverse Recovery Charge          | 110  |      | nC   |                                                                                                                                     |               |
| $I_{rrm}$             | Peak Reverse Recovery Current    | 12   |      | A    |                                                                                                                                     |               |

**Thermal Characteristics**

| Symbol          | Parameter                                   | Typ. | Unit                      | Test Conditions | Note    |
|-----------------|---------------------------------------------|------|---------------------------|-----------------|---------|
| $R_{\theta JC}$ | Thermal Resistance from Junction to Case    | 0.99 | $^\circ\text{C}/\text{W}$ |                 | Fig. 21 |
| $R_{\theta JA}$ | Thermal Resistance From Junction to Ambient | 40   |                           |                 |         |

## Typical Performance

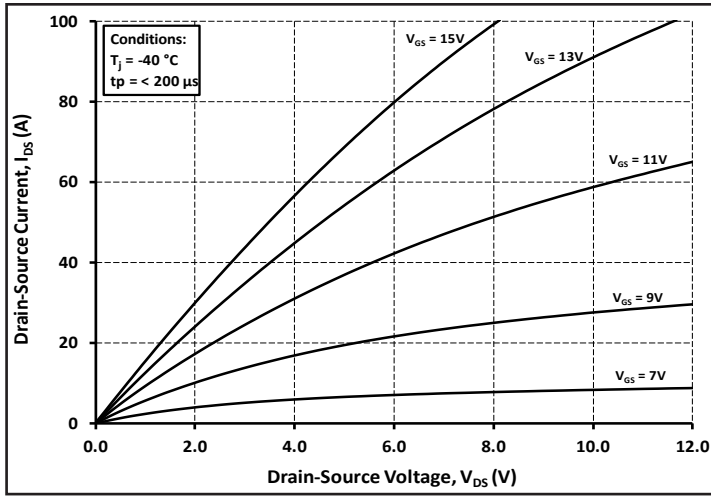


Figure 1. Output Characteristics  $T_J = -40\text{ }^{\circ}\text{C}$

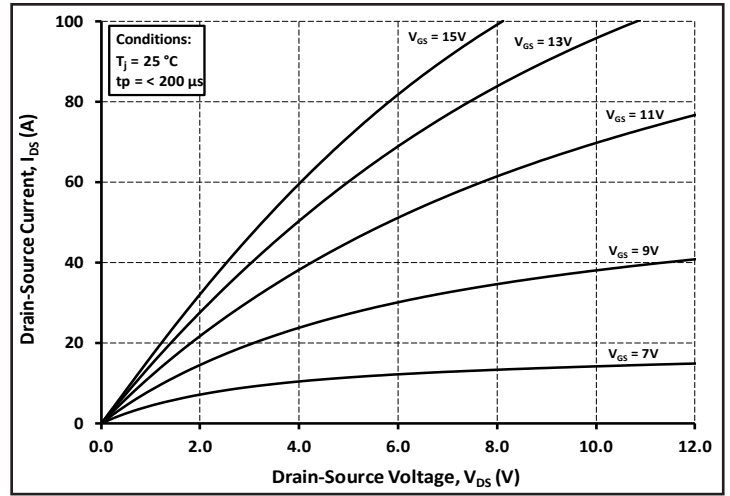


Figure 2. Output Characteristics  $T_J = 25\text{ }^{\circ}\text{C}$

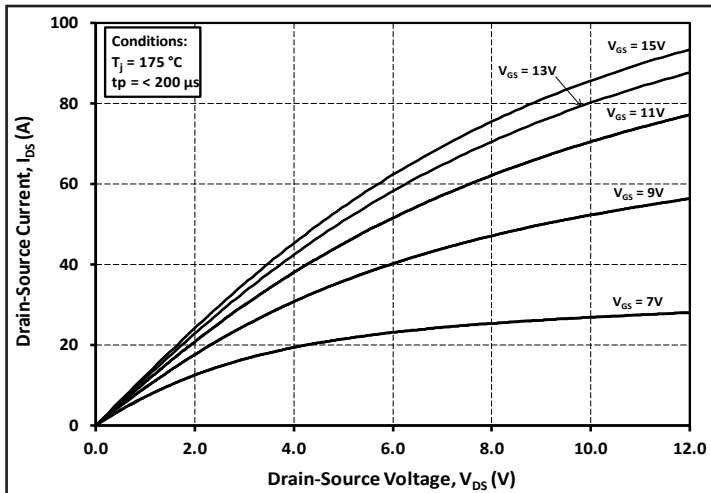


Figure 3. Output Characteristics  $T_J = 175\text{ }^{\circ}\text{C}$

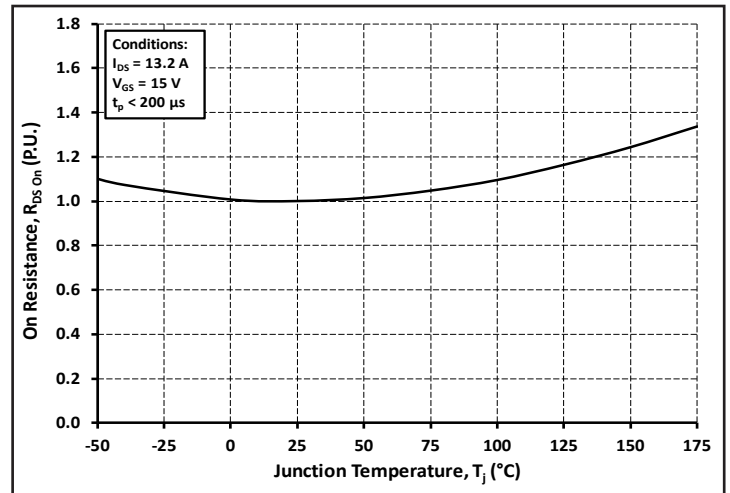


Figure 4. Normalized On-Resistance vs. Temperature

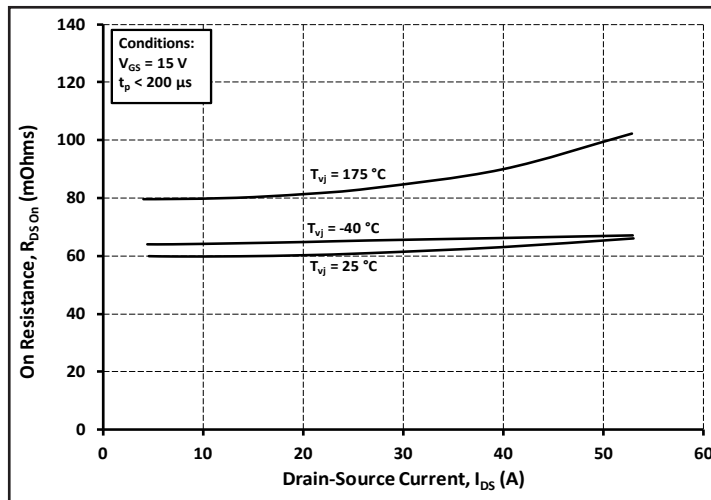


Figure 5. On-Resistance vs. Drain Current  
For Various Temperatures

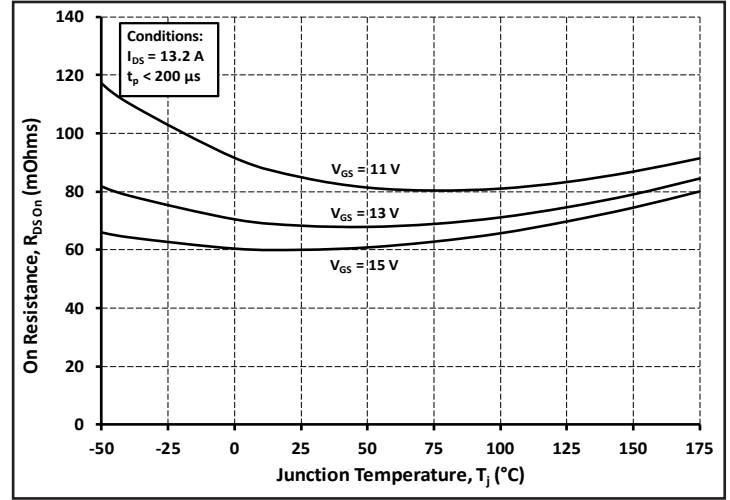


Figure 6. On-Resistance vs. Temperature  
For Various Gate Voltage

## Typical Performance

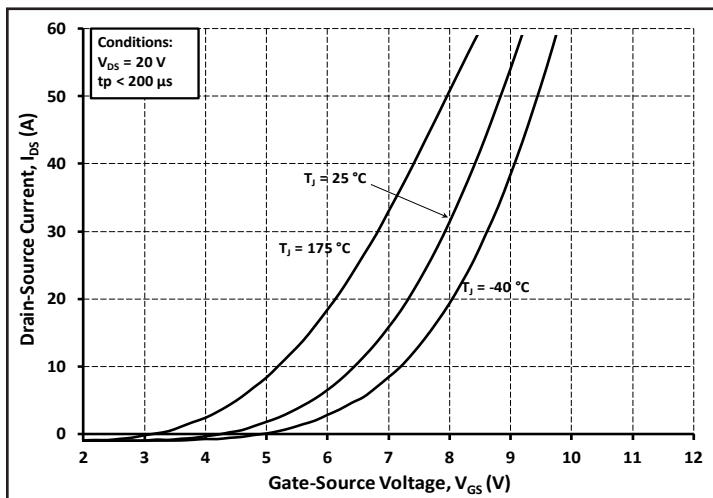


Figure 7. Transfer Characteristic for Various Junction Temperatures

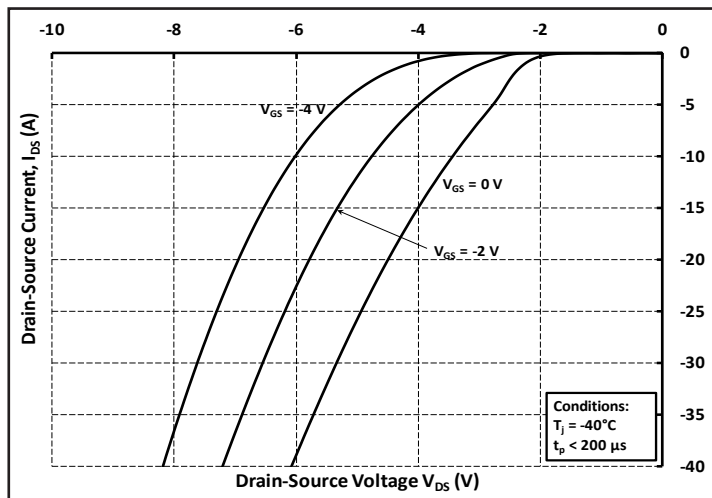


Figure 8. Body Diode Characteristic at -40 °C

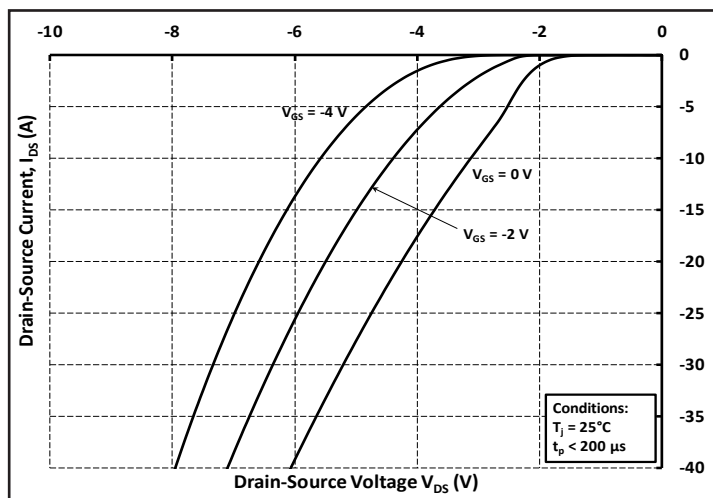


Figure 9. Body Diode Characteristic at 25 °C

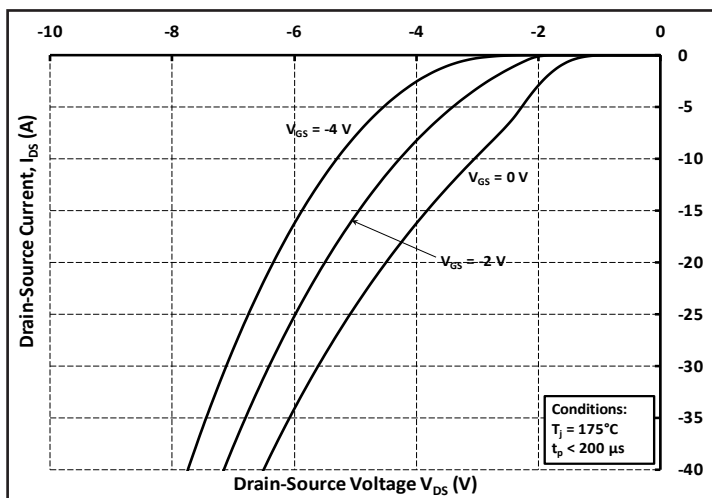


Figure 10. Body Diode Characteristic at 175 °C

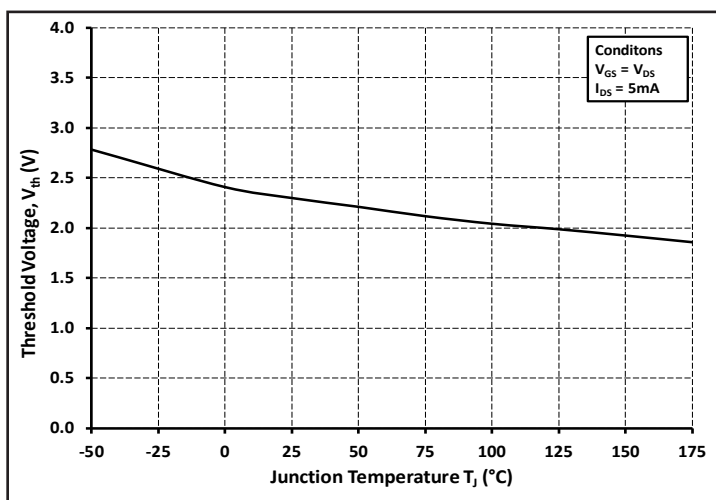


Figure 11. Threshold Voltage vs. Temperature

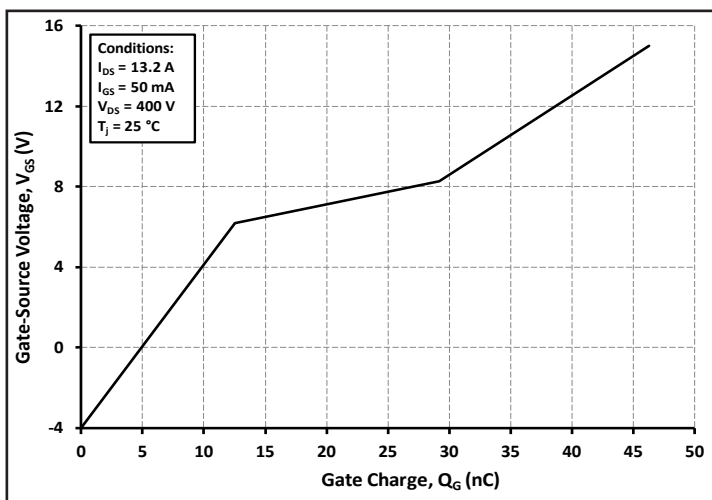


Figure 12. Gate Charge Characteristics

## Typical Performance

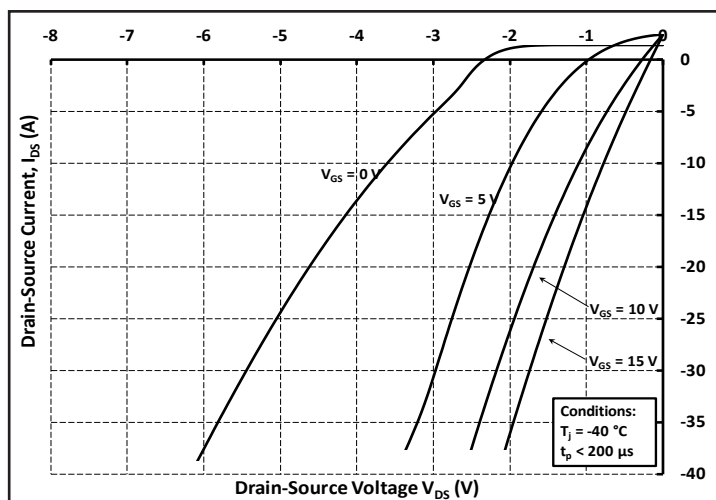


Figure 13. 3rd Quadrant Characteristic at -40 °C

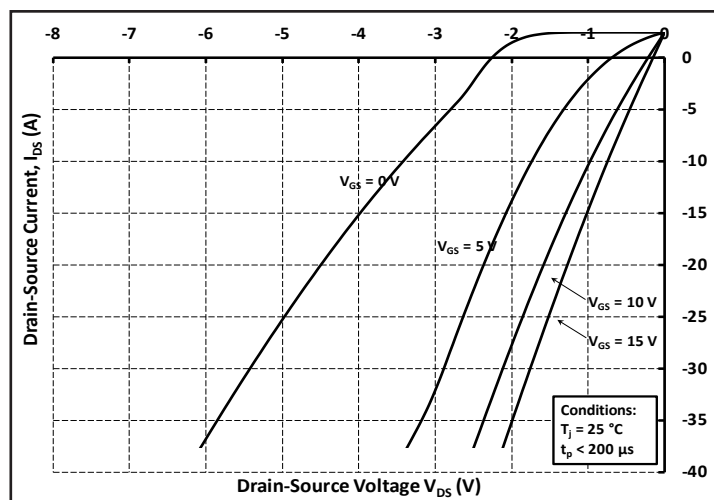


Figure 14. 3rd Quadrant Characteristic at 25 °C

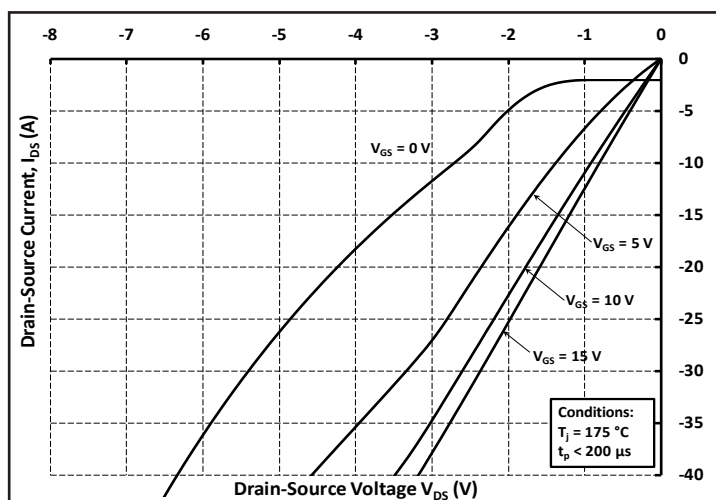


Figure 15. 3rd Quadrant Characteristic at 175 °C

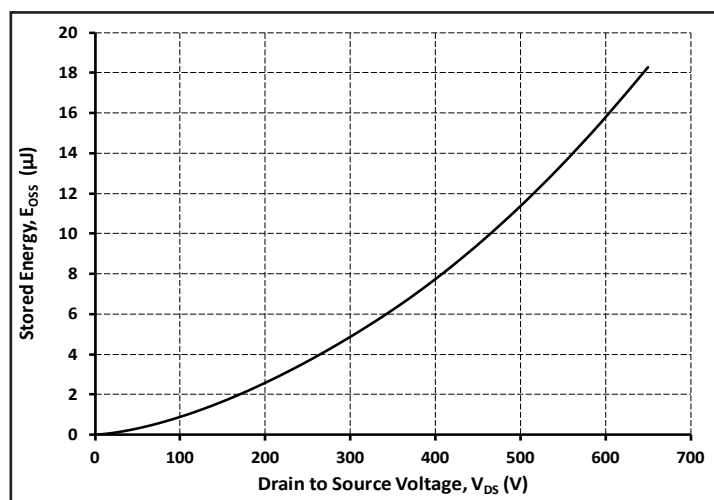


Figure 16. Output Capacitor Stored Energy

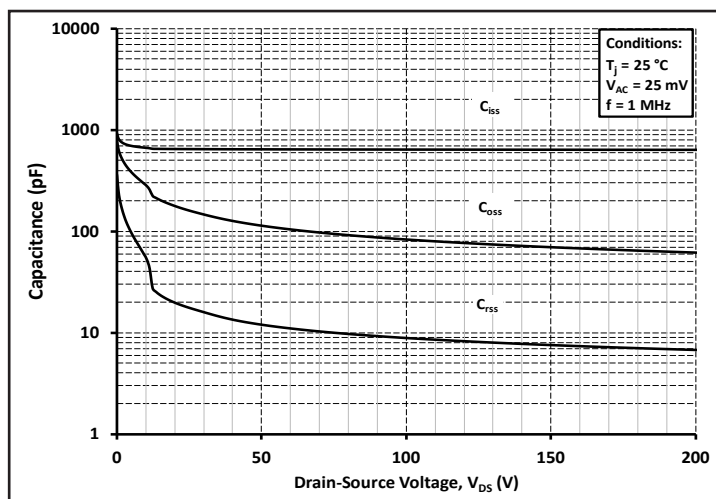


Figure 17. Capacitances vs. Drain-Source Voltage (0 - 200V)

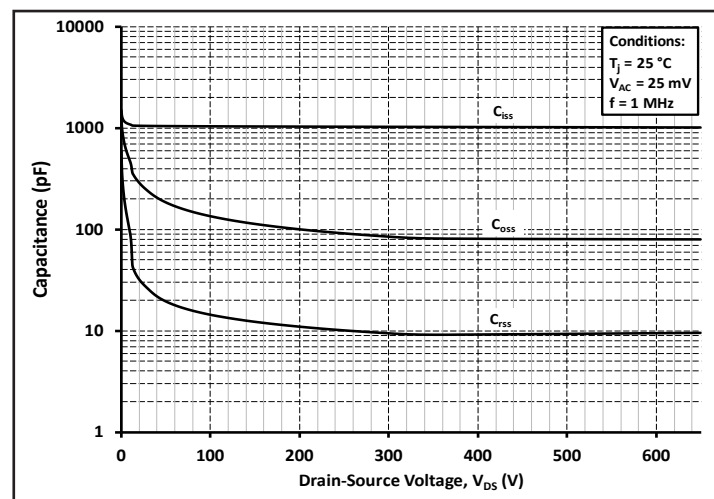


Figure 18. Capacitances vs. Drain-Source Voltage (0 - 650V)

## Typical Performance

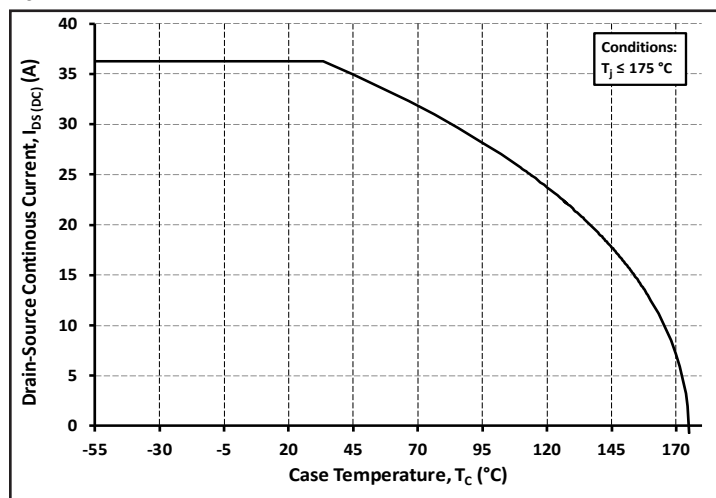


Figure 19. Continuous Drain Current Derating vs. Case Temperature

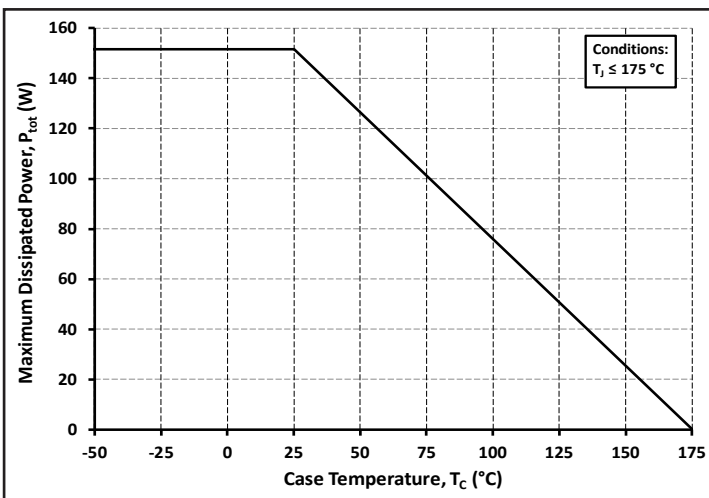


Figure 20. Maximum Power Dissipation Derating Vs Case Temperature

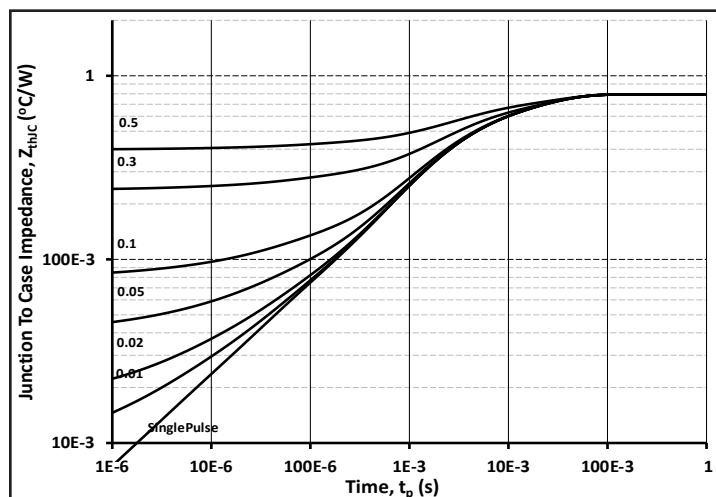


Figure 21. Transient Thermal Impedance (Junction - Case)

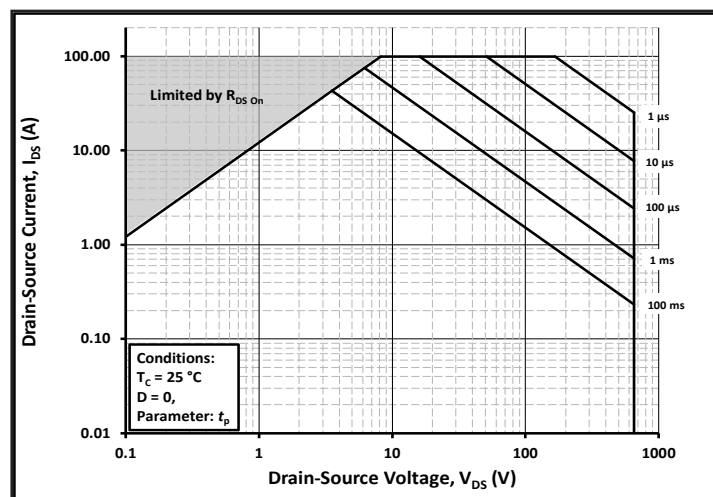


Figure 22. Safe Operating Area

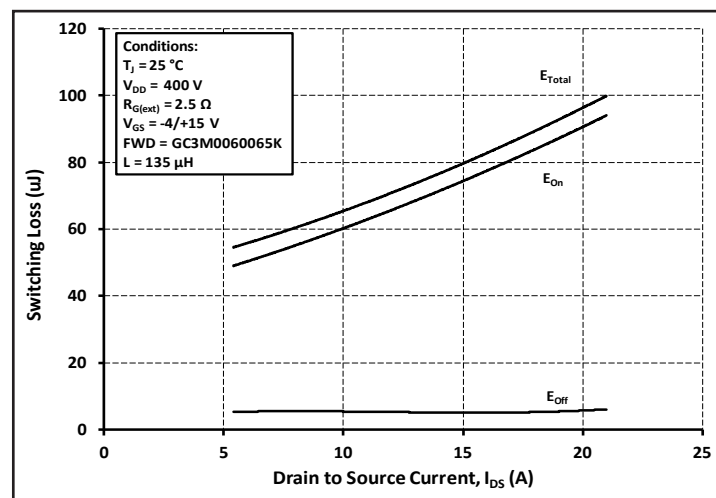


Figure 23. Clamped Inductive Switching Energy vs. Drain Current ( $V_{DD} = 400V$ )

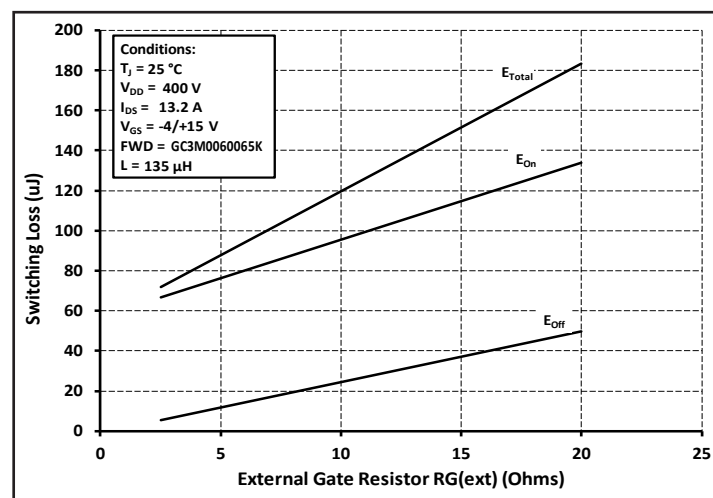


Figure 24. Clamped Inductive Switching Energy vs.  $R_{G(ext)}$

## Typical Performance

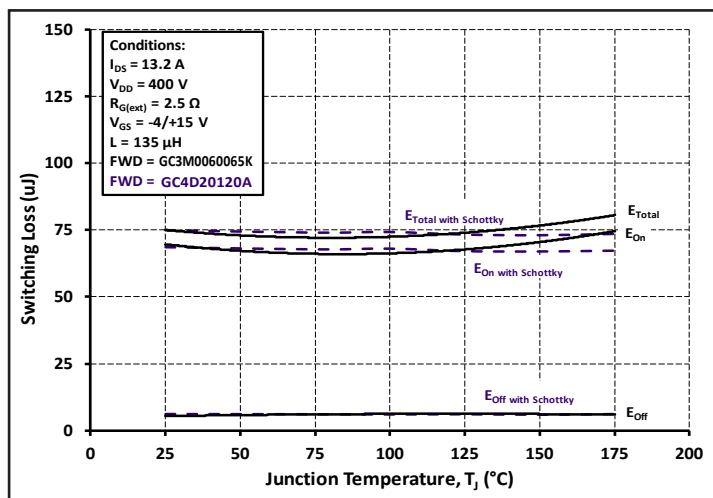


Figure 25. Clamped Inductive Switching Energy vs. Temperature

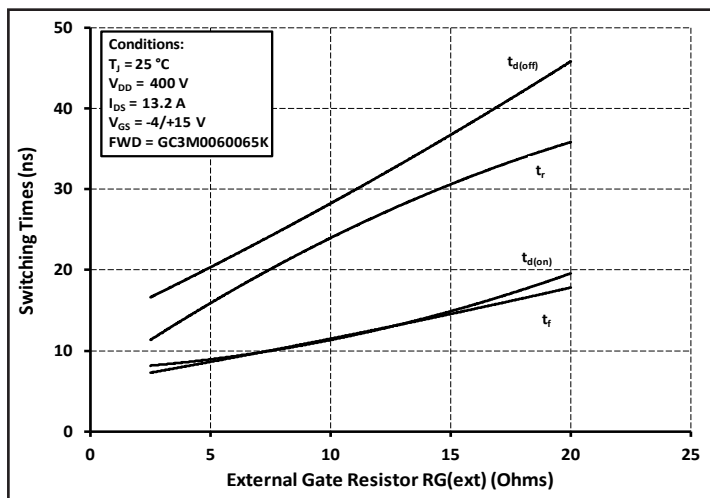


Figure 26. Switching Times vs.  $R_{G(\text{ext})}$



## Test Circuit Schematic

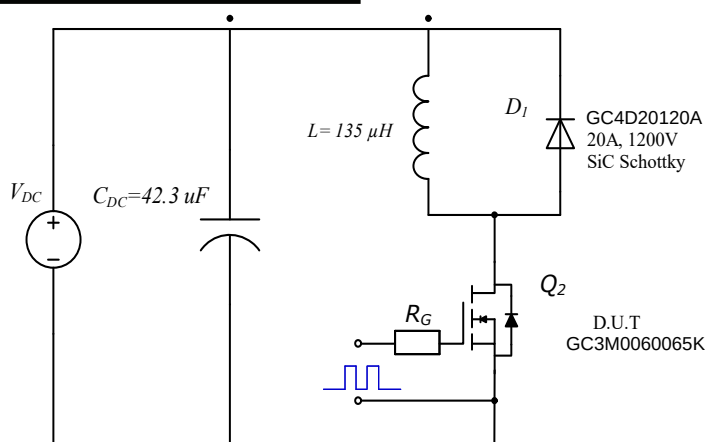


Figure 27. Clamped Inductive Switching  
Waveform Test Circuit

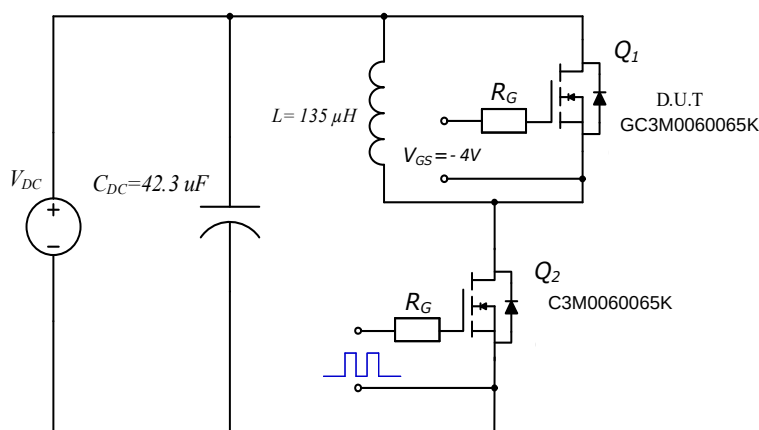


Figure 28. Body Diode Recovery Test Circuit

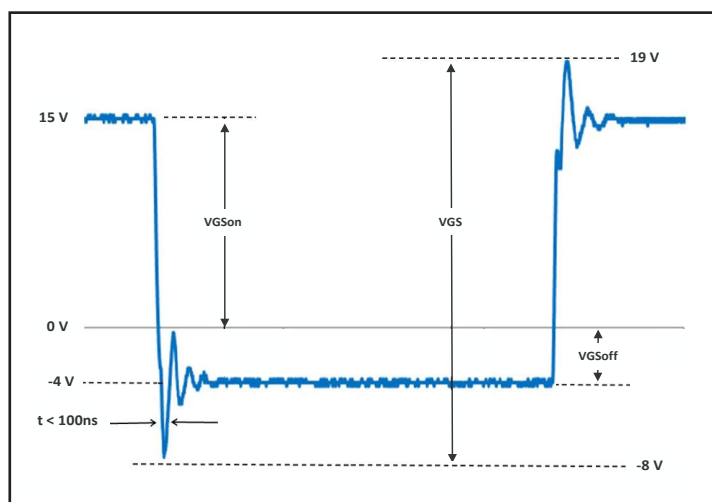
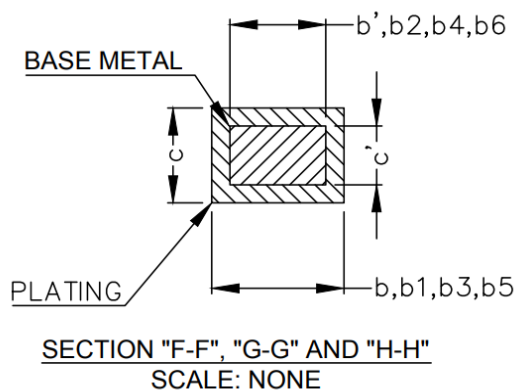
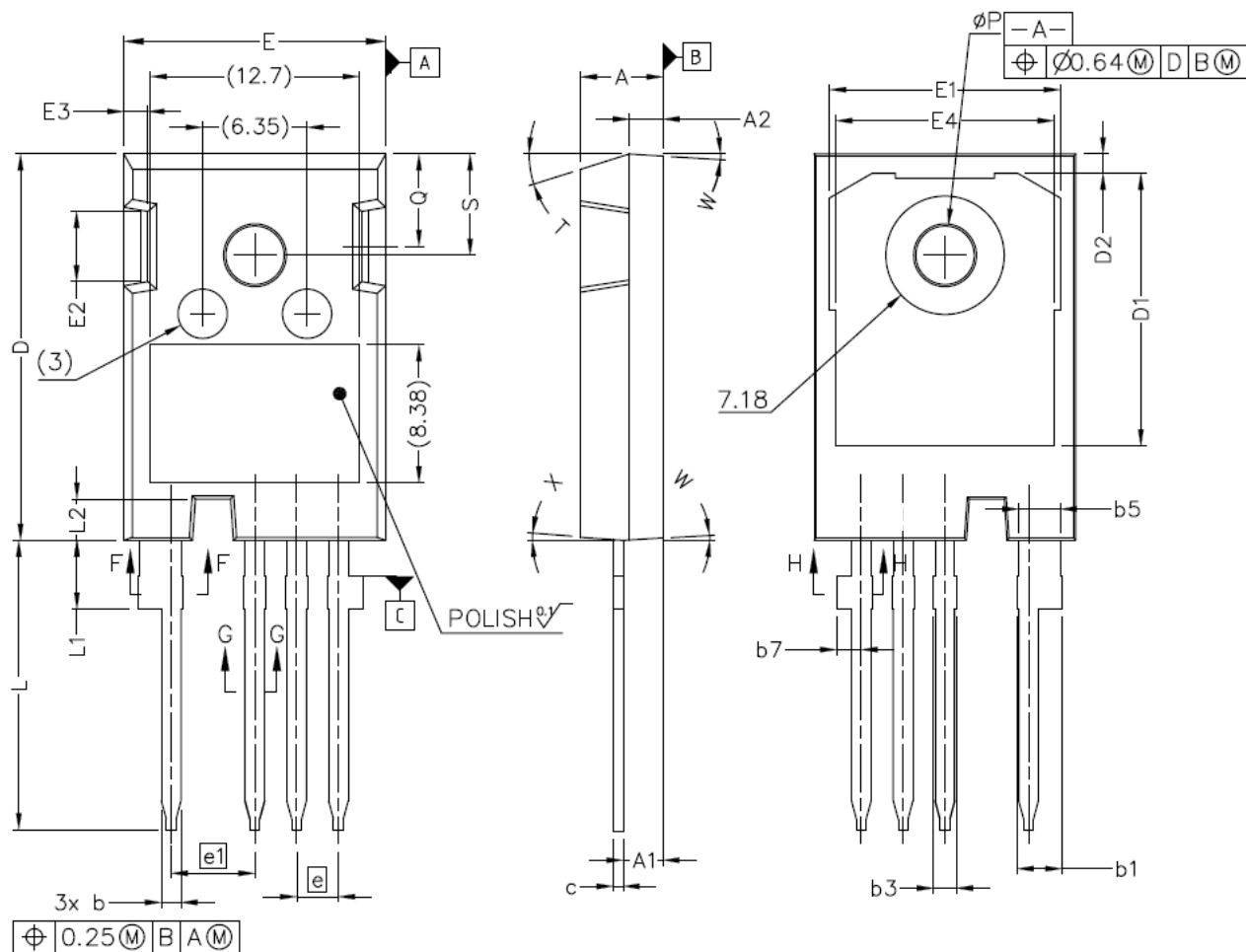


Figure 29.  $V_{GS}$  Waveform Example

## Package Dimensions

Package TO-247-4L



## Package Dimensions

Package TO-247-4L

| SYM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| A   | 4.83        | 5.21  |
| A1  | 2.29        | 2.54  |
| A2  | 1.91        | 2.16  |
| b`  | 1.07        | 1.28  |
| b   | 1.07        | 1.33  |
| b1  | 2.39        | 2.94  |
| b2  | 2.39        | 2.84  |
| b3  | 1.07        | 1.60  |
| b4  | 1.07        | 1.50  |
| b5  | 2.39        | 2.69  |
| b6  | 2.39        | 2.64  |
| b7  | 1.30        | 1.70  |
| c`  | 0.55        | 0.65  |
| c   | 0.55        | 0.68  |
| D   | 23.30       | 23.60 |
| D1  | 16.25       | 17.65 |
| D2  | 0.95        | 1.25  |
| E   | 15.75       | 16.13 |

| SYM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| E1  | 13.10       | 14.15 |
| E2  | 3.68        | 5.10  |
| E3  | 1.00        | 1.90  |
| E4  | 12.38       | 13.43 |
| e   | 2.54 BSC    |       |
| e1  | 5.08 BSC    |       |
| N*  | 4           |       |
| L   | 17.31       | 17.82 |
| L1  | 3.97        | 4.37  |
| L2  | 2.35        | 2.65  |
| Ø P | 3.51        | 3.65  |
| Q   | 5.49        | 6.00  |
| S   | 6.04        | 6.30  |
| T   | 17.5° REF.  |       |
| W   | 3.5° REF.   |       |
| X   | 4° REF.     |       |

