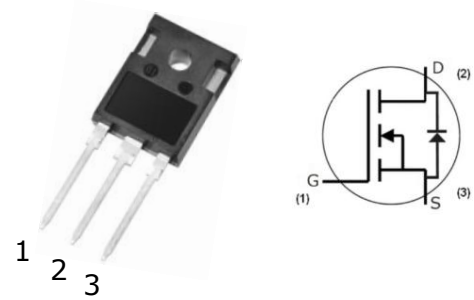


1200V Silicon Carbide Power MOSFET 1200V G1 (N Channel Enhancement)

Features

- High speed switching
- Very low switching losses
- IGBT-compatible driving voltage (15V for turn-on)
- Fully controllable dv/dt
- High blocking voltage with low on-resistance
- Fast intrinsic diode with low reverse recovery (Qrr)
- Temperature independent turn-off switching losses
- Halogen free, RoHS compliant



TO-247-3L

Benefits

- Cooling effort reduction
- Efficiency improvement
- Reduced cooling requirements
- Increased power density
- Increased system switching frequency



Applications

- On-board charger/PFC
- EV battery chargers
- Booster/DC-DC converter
- Switch mode power supplies

Table 1 Key performance and package parameters

| Type | V _{DS} | I _{DS} (T _C = 25°C, R _{th(j-c,max)}) | R _{DS(ON)} , typ (V _{GS} = 15 V, I _D = 33.3 A, T _J = 25°C) | T _{j,max} | Marking | Package |
|------------|-----------------|--|--|--------------------|------------|----------|
| NF3M40120D | 1200 V | 73 A | 40 mΩ | 175°C | NF3M40120D | TO247-3L |

NF3M40120D

1200V SiC Power MOSFET

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NF3M40120D

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1、Maximum ratings

Table 2 Maximum rating ($T_c = 25^\circ\text{C}$ unless otherwise specified)

| Symbol | Parameter | Value | Unit | Test Conditions | Note |
|---------------------|--|-------------|------------------|---|--------|
| $V_{DS,max}$ | Drain source voltage | 1200 | V | $V_{GS} = 0V, I_D = 100\mu\text{A}$ | |
| $V_{GS,max}$ | Gate source voltage | -8 /+22 | V | Absolute maximum values | Note 1 |
| V_{GSop} | Gate source voltage | -4 /+15 | V | Recommended operational values | |
| I_D | Continuous drain current | 73 | A | $V_{GS} = 15V, T_C = 25^\circ\text{C}$ | Fig.19 |
| | | 51 | | $V_{GS} = 15V, T_C = 100^\circ\text{C}$ | |
| $I_D(\text{pulse})$ | Pulsed drain current | 120 | A | Pulse width t_P limited by $T_{j,max}$ | Fig.22 |
| P_D | Power dissipation | 326 | W | $T_C = 25^\circ\text{C}, T_J = 175^\circ\text{C}$ | Fig.20 |
| T_J, T_{stg} | Operating Junction and storage temperature | -55 to +175 | $^\circ\text{C}$ | | |
| T_L | Soldering temperature | 260 | $^\circ\text{C}$ | 1.6mm (0.063") from case for 10s | |
| T_M | Mounting torque | 1 | Nm | M3 or 6-32 screw | |
| | | 8.8 | lbf-in | | |

Note 1: when using MOSFET Body Diode $V_{GS,max} = -4 / +22V$

2、Thermal characteristics

Table 3 Thermal characteristics¹

| Symbol | Parameter | Value | Unit | Test Conditions | Note |
|---------------|---|-------|---------------------------|-----------------|--------|
| $R_{th(j-c)}$ | Thermal resistance from junction to case | 0.46 | $^\circ\text{C}/\text{W}$ | | Fig.21 |
| $R_{th(j-a)}$ | Thermal resistance from junction to ambient | 39 | | | |

¹ Not subject to production test. Parameter verified by design/characterization.

1200V SiC Power MOSFET

3、Electrical characteristics

3.1 Static characteristics

Table 4 Static characteristics (Tc = 25°C unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Test Conditions | Note |
|---------------|--|------|------|------|------------|--|-------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | 1200 | - | - | V | $V_{GS} = 0V, I_D = 100\mu A$ | |
| $V_{GS(th)}$ | Gate threshold voltage | 2.3 | 2.8 | 3.6 | V | $V_{DS} = V_{GS}, I_D = 10mA$ | Fig.11 |
| | | - | 2.0 | - | V | $V_{DS} = V_{GS}, I_D = 10mA$ $T_J = 175^\circ C$ | |
| I_{DSS} | Zero gate voltage drain current | - | 1 | 10 | μA | $V_{DS} = 1200V, V_{GS} = 0V$ | |
| I_{GSS} | Gate source leakage current | - | - | 100 | nA | $V_{GS} = 15V, V_{DS} = 0V$ | |
| $R_{DS(on)}$ | Current drain-source on-state resistance | - | 40 | 50 | m Ω | $V_{GS} = 15V, I_D = 33.3A$ | Fig.4, 5,6 |
| | | - | 62 | - | | $V_{GS} = 15V, I_D = 33.3A, T_J = 175^\circ C$ | |
| | | - | 32 | 40 | | $V_{GS} = 18V, I_D = 33.3A$ | |
| | | - | 59 | - | | $V_{GS} = 18V, I_D = 33.3A, T_J = 175^\circ C$ | |
| gfs | Transconductance | - | 17 | - | S | $V_{DS} = 20V, I_D = 33.3A$ | Fig.7 |
| | | - | 16 | - | | $V_{DS} = 20V, I_D = 33.3A, T_J = 175^\circ C$ | |
| $R_{g,int}$ | Internal gate resistance | - | 0.9 | - | Ω | $V_{AC} = 25mV, f = 1MHz$ | |
| V_{SD} | Diode forward voltage | - | 3.8 | - | V | $V_{GS} = -4V, I_{SD} = 20A$ | Fig.8,9, 10 |
| | | - | 3.4 | - | | $V_{GS} = -4V, I_{SD} = 20A, T_J = 175^\circ C$ | |

3.2 Dynamic characteristics

Table 5 Dynamic characteristics (Tc = 25°C unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Test Conditions | Note |
|-----------|---------------------|------|------|------|---------|--|-----------|
| C_{iss} | Input capacitance | - | 2159 | - | pF | $V_{DS} = 1000V, V_{GS} = 0V$ $T_J = 25^\circ C, V_{AC} = 25mV$ $f = 100KHz$ | Fig.17,18 |
| C_{oss} | Output capacitance | - | 127 | - | | | |
| C_{rss} | Reverse capacitance | - | 10 | - | | | |
| E_{oss} | Coss stored energy | - | 79 | - | μJ | | Fig.16 |

1200V SiC Power MOSFET

| | | | | | | | |
|----------|--------------------|---|----|---|----|--|--------|
| Q_{gs} | Gate source charge | - | 16 | - | nC | $V_{DS} = 800V, V_{GS} = -4/+15V$ $I_D = 33.3A$ | Fig.12 |
| Q_{gd} | Gate drain charge | - | 36 | - | | | |
| Q_g | Gate charge | - | 76 | - | | | |

3.3 Switching characteristics

Table 6 Dynamic characteristics($T_c = 25^\circ C$ unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Test Conditions | Note |
|--------------|---------------------------|------|------|------|---------|---|--------|
| E_{on} | Turn on switching energy | - | 934 | - | μJ | $V_{DS} = 800V, V_{GS} = -4/+15V$ $I_D = 33.3A, R_g = 2.5\Omega$ $L = 120\mu H$ | Fig.26 |
| E_{off} | Turn off switching energy | - | 60 | - | | | |
| $t_{d(on)}$ | Turn on delay time | - | 40 | - | ns | | Fig.27 |
| t_r | Rise time | - | 16 | - | | | |
| $t_{d(off)}$ | Turn off delay time | - | 23 | - | | | |
| t_f | Fall time | - | 8.8 | - | | | |

Table 7 Body diode characteristics

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Test Conditions | Note |
|-----------|----------------------------------|------|------|------|------|---|------------|
| V_{SD} | Diode forward voltage | - | 3.8 | - | V | $V_{GS} = -4V, I_{SD} = 20A$ | Fig.8,9,10 |
| | | - | 3.4 | - | V | $V_{GS} = -4V, I_{SD} = 20A$ $T_J = 175^\circ C$ | |
| I_S | Continuous diode forward current | - | 76 | - | A | $V_{GS} = -4V, T_c = 25^\circ C$ | Note1 |
| t_{rr} | Reverse recovery time | - | 40 | - | nS | $V_R = 800V, V_{GS} = -4V$ $I_D = 33.3A$ $di/dt = 1947A/\mu S$ $T_J = 175^\circ C$ | |
| Q_{rr} | Reverse recovery charge | - | 640 | - | nC | | |
| I_{rrm} | Peak reverse recovery current | - | 32 | - | A | | |

Note 1: When using SiC Body Diode the maximum recommended $V_{GS} = -4V$

4、Electrical characteristic diagrams

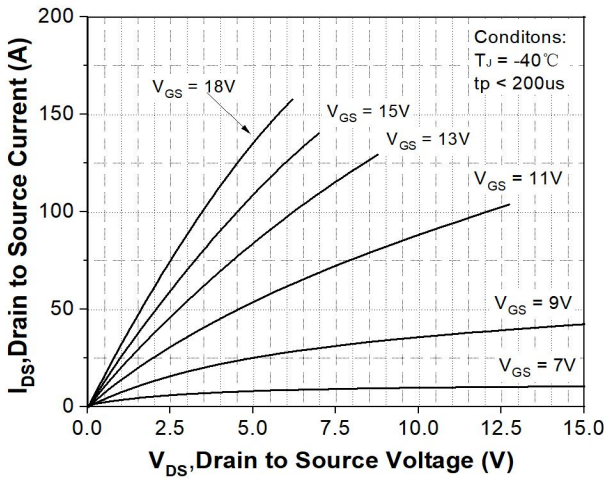


Figure 1. Output characteristics $T_J = -40^\circ\text{C}$

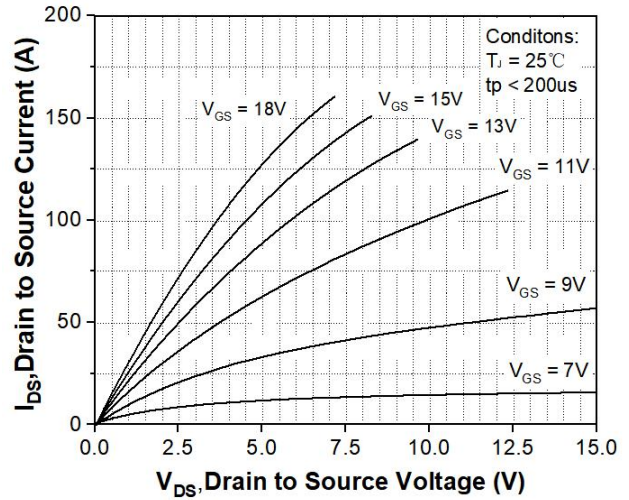


Figure 2. Output characteristics $T_J = 25^\circ\text{C}$

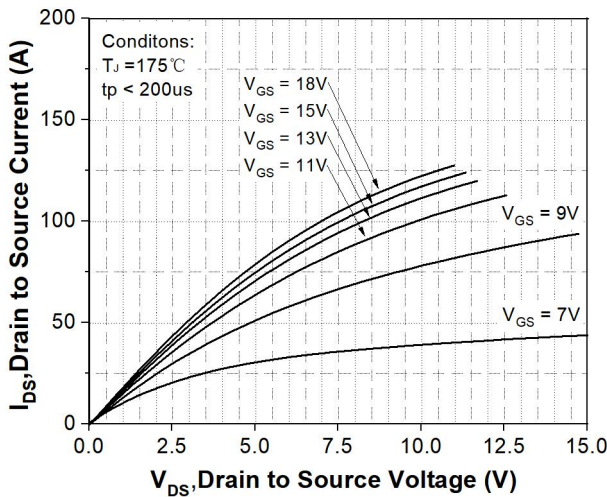


Figure 3. Output characteristics $T_J = 175^\circ\text{C}$

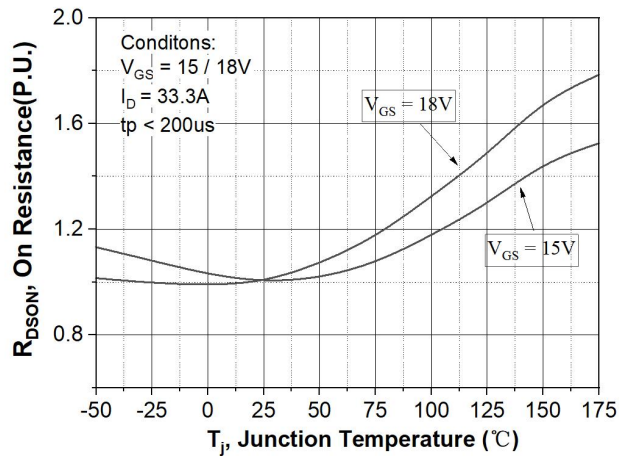


Figure 4. Normalized on-resistance vs. temperature

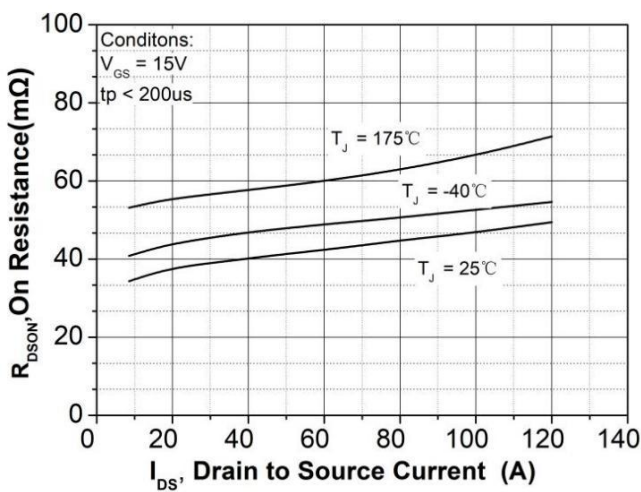


Figure 5. On-resistance vs. drain current for various temperatures

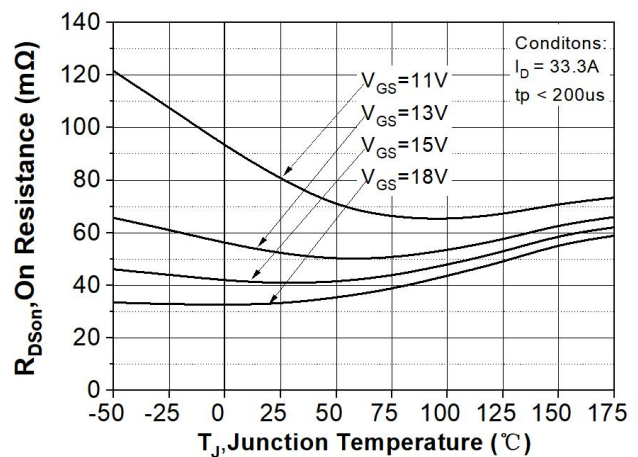


Figure 6. On-resistance vs. temperature for various gate voltage

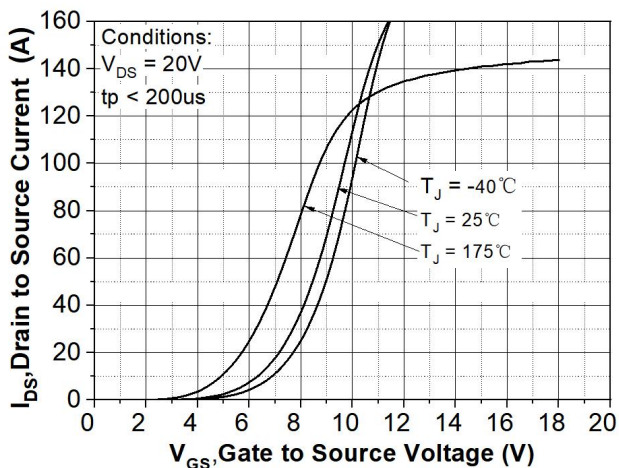


Figure 7. Transfer characteristic for various junction temperatures

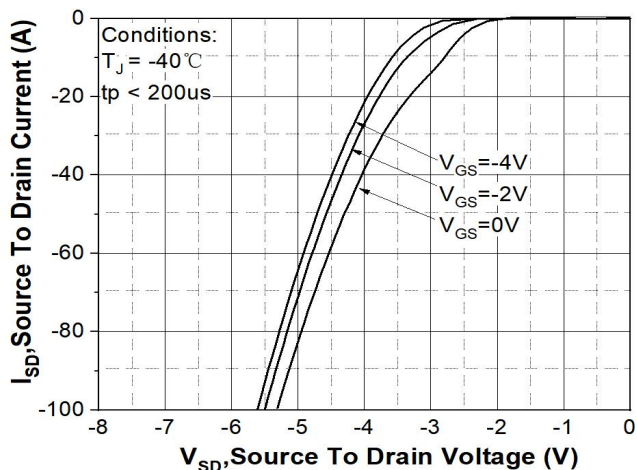


Figure 8. Body diode characteristic at $T_J = -40^\circ C$

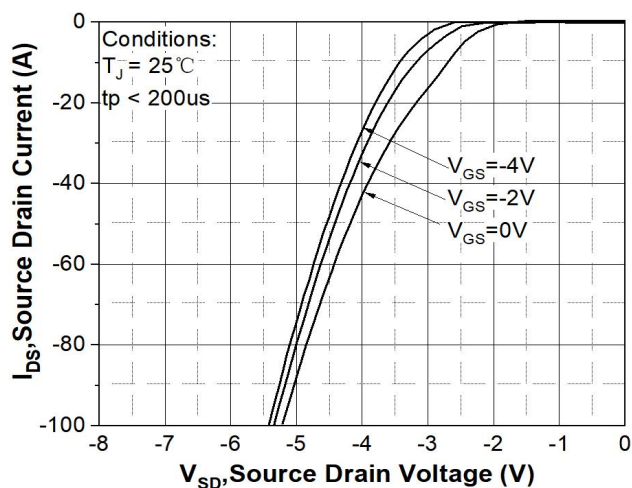


Figure 9. Body diode characteristic at $T_J = 25^\circ C$

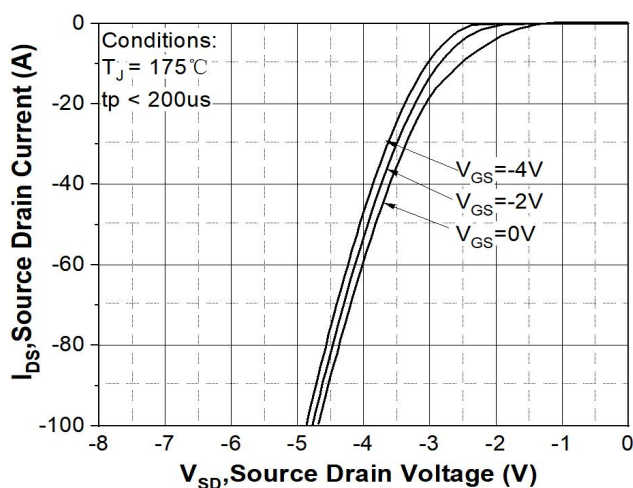


Figure 10. Body diode characteristic at $T_J = 175^\circ C$

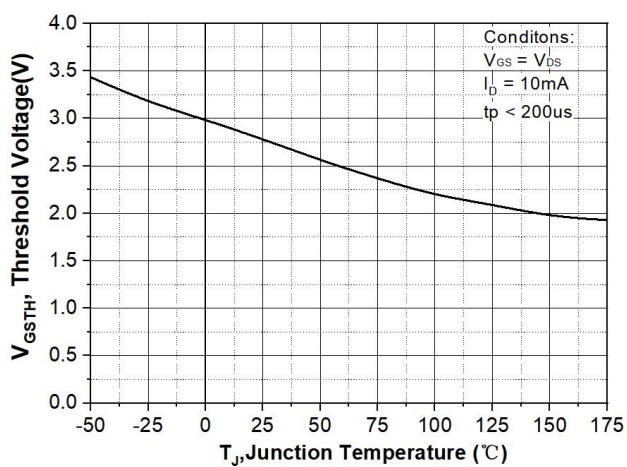


Figure 11. Threshold voltage vs. temperature

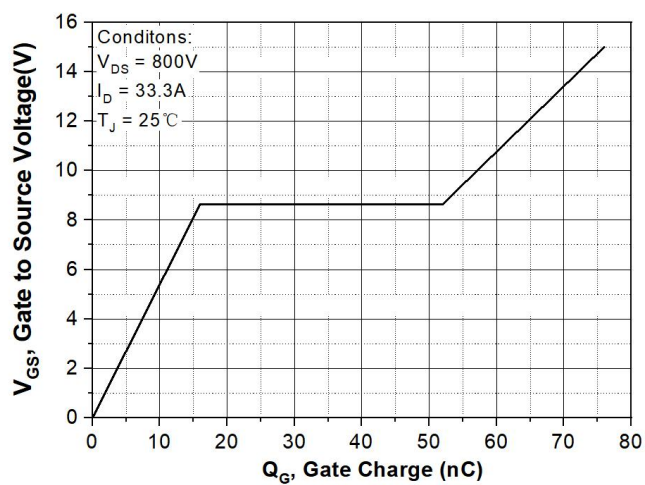


Figure 12. Gate charge characteristic

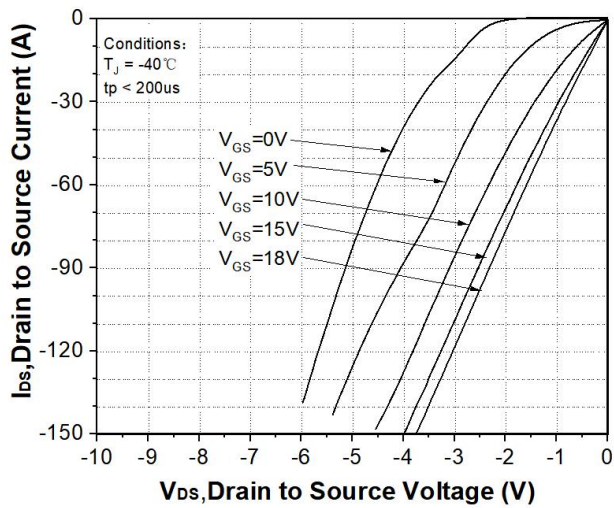


Figure 13. 3rd quadrant characteristic at $T_J = -40\text{ }^\circ\text{C}$

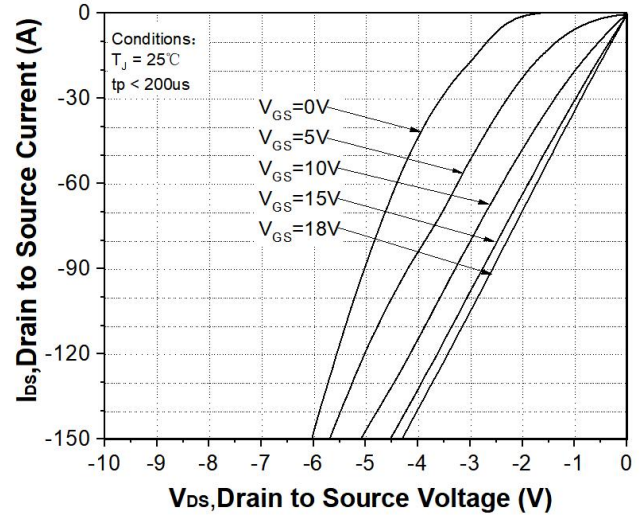


Figure 14. 3rd quadrant characteristic at $T_J = 25\text{ }^\circ\text{C}$

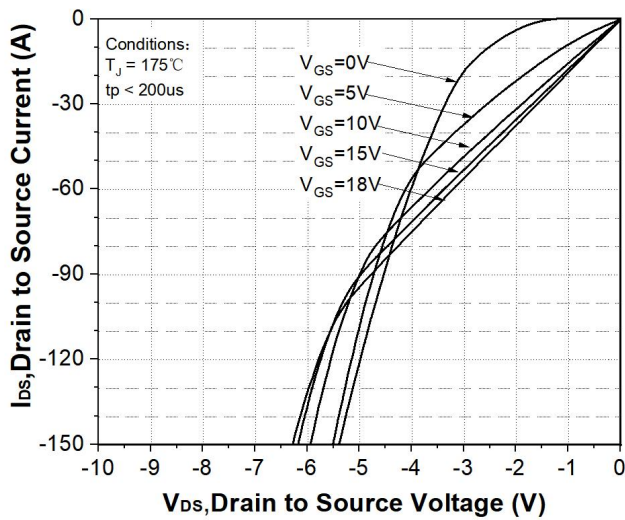


Figure 15. 3rd quadrant characteristic at $T_J = 175\text{ }^\circ\text{C}$

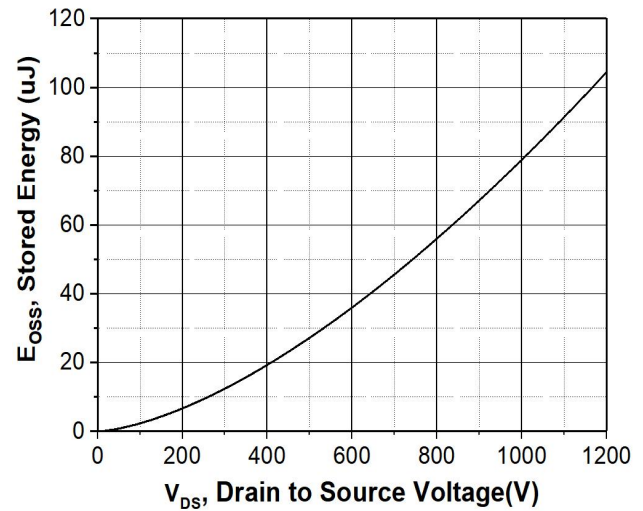


Figure 16. Output capacitor stored energy

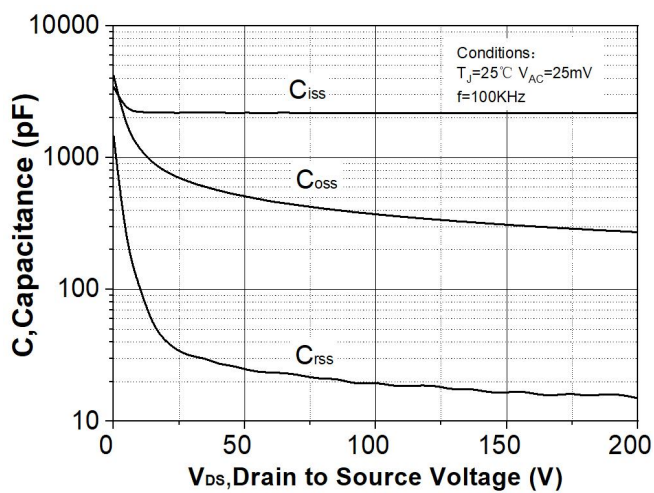


Figure 17. Capacitances vs. drain-source voltage (0 - 200V)

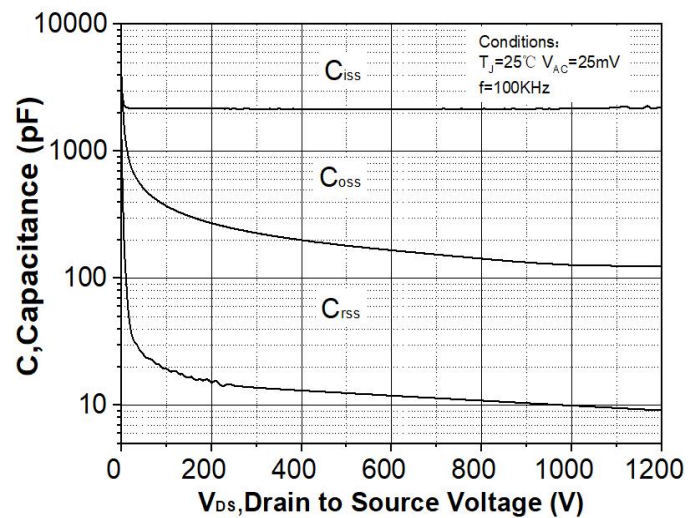


Figure 18. Capacitances vs. drain-source voltage (0 - 1200V)

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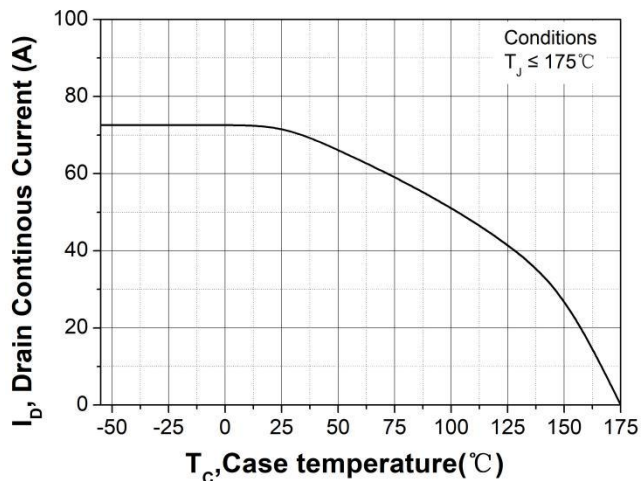


Figure 19. Continuous drain current derating vs. case temperature

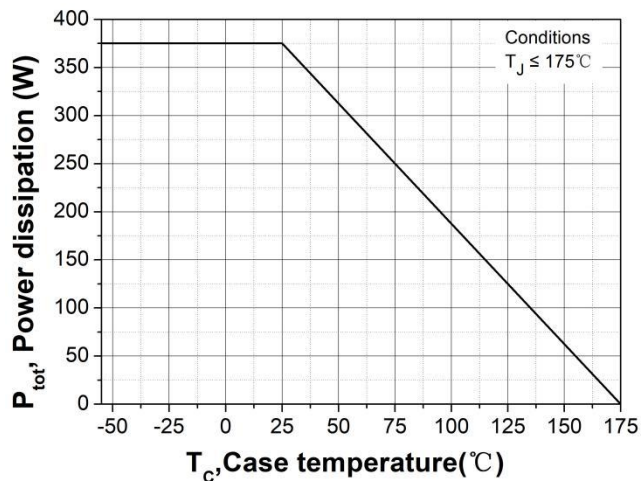


Figure 20. Maximum power dissipation derating vs. case temperature

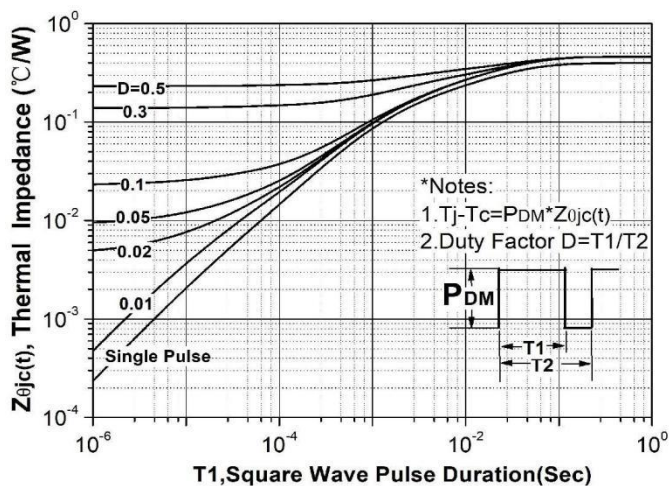


Figure 21. Transient thermal impedance (junction - case)

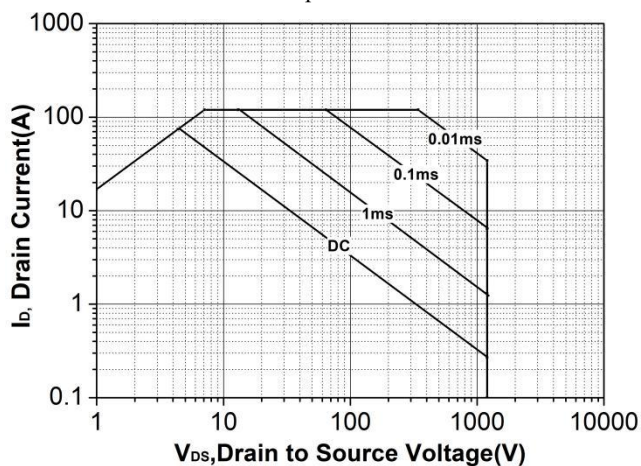


Figure 22. Safe operating area

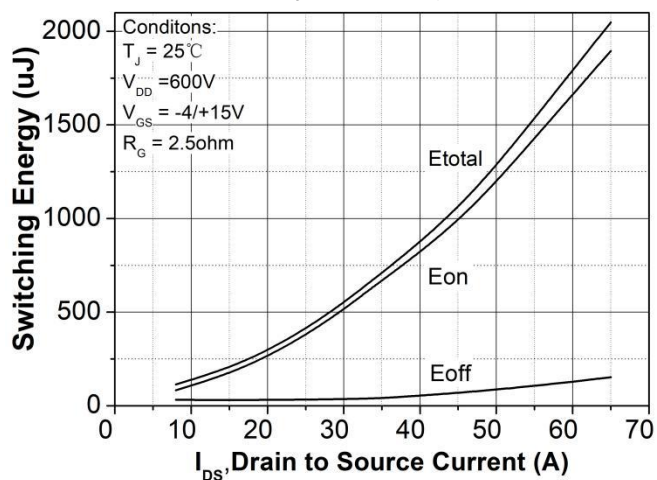


Figure 23. Clamped inductive switching energy vs. drain current ($V_{DD} = 600V$)

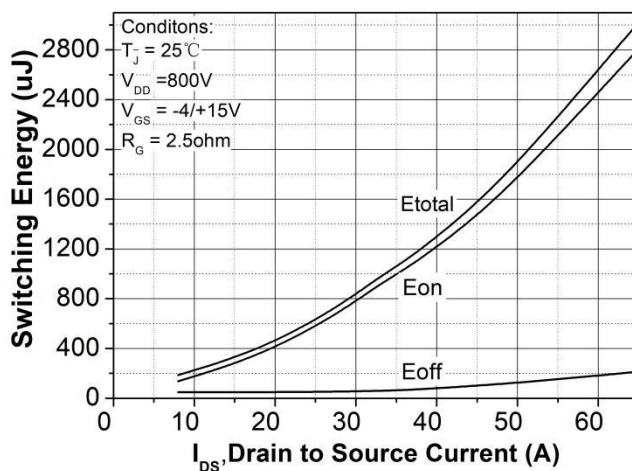


Figure 24. Clamped inductive switching energy vs. drain current ($V_{DD} = 800V$)

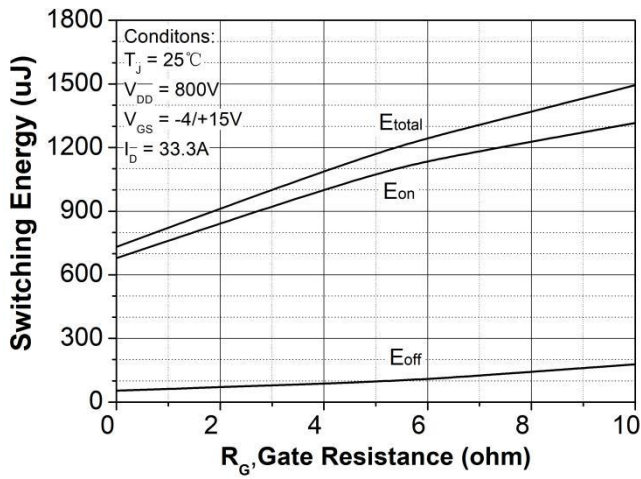


Figure 25. Clamped inductive switching energy vs. $R_G(ext)$

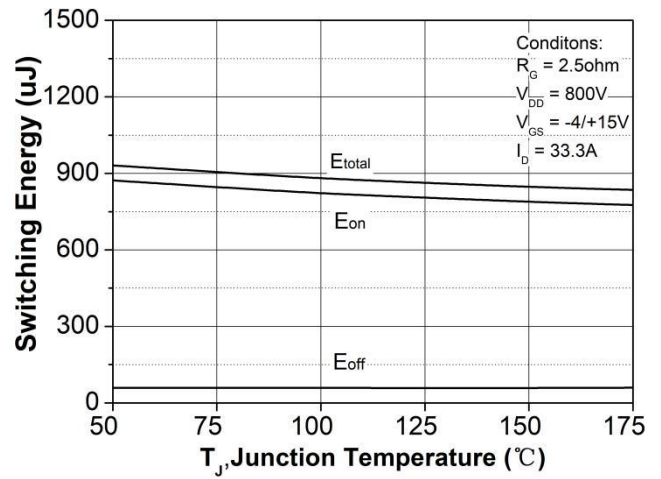


Figure 26. Clamped inductive switching energy vs. temperature

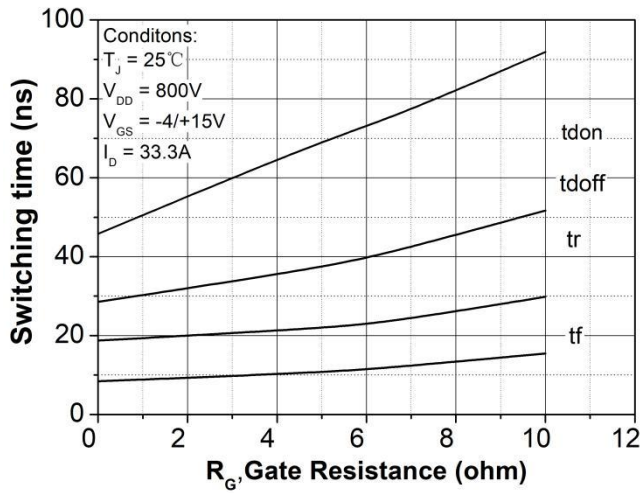
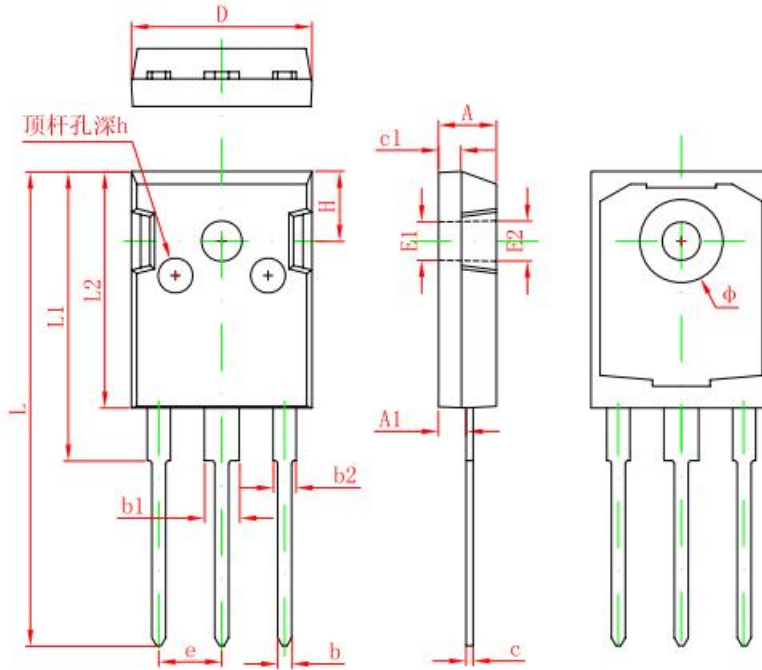


Figure 27. Switching times vs. $R_G(ext)$

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5、 Package drawing (TO-247-3L)



| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|---------------------------|--------|----------------------|-------|
| | Min | Max | Min | Max |
| A | 4.850 | 5.150 | 0.191 | 0.200 |
| A1 | 2.200 | 2.600 | 0.087 | 0.102 |
| b | 1.000 | 1.400 | 0.039 | 0.055 |
| b1 | 2.800 | 3.200 | 0.110 | 0.126 |
| b2 | 1.800 | 2.200 | 0.071 | 0.087 |
| c | 0.500 | 0.700 | 0.020 | 0.028 |
| c1 | 1.900 | 2.100 | 0.075 | 0.083 |
| D | 15.450 | 15.750 | 0.608 | 0.620 |
| E1 | 3.500 REF | | 0.138 REF | |
| E2 | 3.600 REF | | 0.142 REF | |
| L | 40.900 | 41.300 | 1.610 | 1.626 |
| L1 | 24.800 | 25.100 | 0.976 | 0.988 |
| L2 | 20.300 | 20.600 | 0.799 | 0.811 |
| φ | 7.100 | 7.300 | 0.280 | 0.287 |
| e | 5.450 TYP | | 0.215 TYP | |
| H | 5.980 REF | | 0.235 REF | |
| h | 0.000 | 0.300 | 0.000 | 0.012 |

6、 Test conditions

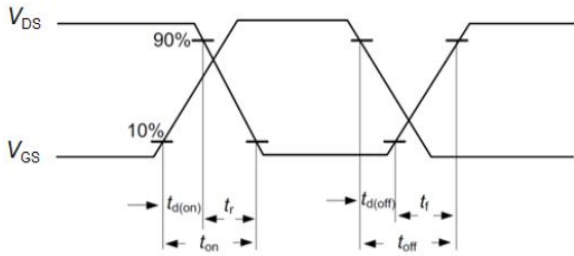


Figure A. Definition of switching times

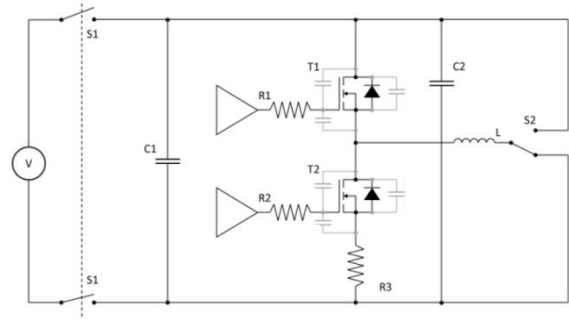


Figure B. Dynamic test circuit

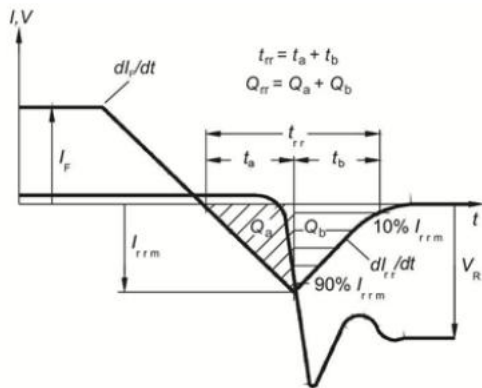


Figure C. Definition of diode switching characteristics

Figure C. Definition of body diode switching characteristics