# N-Chnnnel 650 V (D-S) Power MOSFET

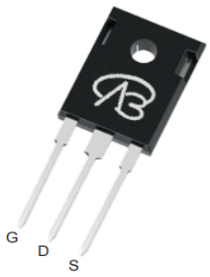
| PRODUCT SUMMARY | | |
|---|---|---|
| $V_{DS}$ (V) | 650 | |
| $R_{DS(on)}$ (Ω) | $V_{GS}$ = 10 V | 0.350 |
| $Q_g$ (Max.) (nC) | 150 | |
| $Q_{gs}$ (nC) | 45 | |
| $Q_{gd}$ (nC) | 76 | |
| Configuration | Single | |

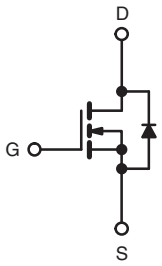
## FEATURES

- Low Gate Charge $Q_g$ Results in Simple Drive Requirement
- Improved Gate, Avalanche and Dynamic dV/dt Ruggedness
- Fully Characterized Capacitance and Avalanche Voltage and Current
- Enhanced Body Diode dV/dt Capability
- Compliant to RoHS Directive 2002/95/EC

Available
RoHS* COMPLIANT

TO-247




N-Channel MOSFET

## BENEFITS

- Hard Switching Primary or PFS Switch
- Switch Mode Power Supply (SMPS)
- Uninterruptible Power Supply
- High Speed Power Switching
- Motor Drive

| ABSOLUTE MAXIMUM RATINGS ($T_C$ = 25 °C, unless otherwise noted) | | | | | |
|---|---|---|---|---|---|
| PARAMETER | | | SYMBOL | LIMIT | UNIT |
| Drain-Source Voltage | | | $V_{DS}$ | 650 | V |
| Gate-Source Voltage | | | $V_{GS}$ | ± 30 | |
| Continuous Drain Current | $V_{GS}$ at 10 V | $T_C$ = 25 °C | $I_D$ | 22 | A |
| | | $T_C$ = 100 °C | | 14 | |
| Pulsed Drain Current[a] | | | $I_{DM}$ | 88 | |
| Linear Derating Factor | | | | 2.9 | W/°C |
| Single Pulse Avalanche Energy[b] | | | $E_{AS}$ | 380 | mJ |
| Repetitive Avalanche Current[a] | | | $I_{AR}$ | 22 | A |
| Repetitive Avalanche Energy[a] | | | $E_{AR}$ | 37 | mJ |
| Maximum Power Dissipation | $T_C$ = 25 °C | | $P_D$ | 370 | W |
| Peak Diode Recovery dV/dt[c] | | | dV/dt | 15 | V/ns |
| Operating Junction and Storage Temperature Range | | | $T_J$, $T_{stg}$ | - 55 to + 150 | °C |
| Soldering Recommendations (Peak Temperature) | for 10 s | | | 300[d] | |

**Notes**

a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
b. Starting $T_J$ = 25 °C, L = 1.5 mH, $R_g$ = 25 Ω, $I_{AS}$ = 22 A (see fig. 12).
c. $I_{SD}$ ≤ 22 A, dI/dt ≤ 360 A/μs, $V_{DD}$ ≤ $V_{DS}$, $T_J$ ≤ 150 °C.
d. 1.6 mm from case.

| THERMAL RESISTANCE RATINGS | | | | |
|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TYP.** | **MAX.** | **UNIT** |
| Maximum Junction-to-Ambient | $R_{thJA}$ | - | 40 | °C/W |
| Case-to-Sink, Flat, Greased Surface | $R_{thCS}$ | 0.24 | - | |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | - | 0.34 | |

| **SPECIFICATIONS** ($T_J$ = 25 °C, unless otherwise noted) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Static** | | | | | | | |
| Drain-Source Breakdown Voltage | $V_{DS}$ | $V_{GS}$ = 0 V, $I_D$ = 250 µA | | 650 | - | - | V |
| $V_{DS}$ Temperature Coefficient | $\Delta V_{DS}/T_J$ | Reference to 25 °C, $I_D$ = 1 mA[d] | | - | 0.30 | - | V/°C |
| Gate-Source Threshold Voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | | 3.0 | - | 5.0 | V |
| Gate-Source Leakage | $I_{GSS}$ | $V_{GS}$ = ± 30 V | | - | - | ± 100 | nA |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{DS}$ = 600 V, $V_{GS}$ = 0 V | | - | - | 50 | µA |
| | | $V_{DS}$ = 480 V, $V_{GS}$ = 0 V, $T_J$ = 125 °C | | - | - | 250 | |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | $V_{GS}$ = 10 V | $I_D$ = 13 A[b] | - | 0.350 | - | Ω |
| Forward Transconductance | $g_{fs}$ | $V_{DS}$ = 50 V, $I_D$ = 13 A[b] | | 11 | - | - | S |
| **Dynamic** | | | | | | | |
| Input Capacitance | $C_{iss}$ | $V_{GS}$ = 0 V, $V_{DS}$ = 25 V, f = 1.0 MHz, see fig. 5 | | - | 3300 | - | pF |
| Output Capacitance | $C_{oss}$ | | | - | 350 | - | |
| Reverse Transfer Capacitance | $C_{rss}$ | | | - | 36 | - | |
| Output Capacitance | $C_{oss}$ | $V_{GS}$ = 0 V | $V_{DS}$ = 1.0 V , f = 1.0 MHz | - | 4710 | - | |
| | | | $V_{DS}$ = 480 V , f = 1.0 MHz | - | 92 | - | |
| Effective Output Capacitance | $C_{oss}$ eff. | | $V_{DS}$ = 0 V to 480 V | - | 180 | - | |
| Total Gate Charge | $Q_g$ | $V_{GS}$ = 10 V | $I_D$ = 22 A, $V_{DS}$ = 480 V see fig. 6 and 13[b] | - | - | 150 | nC |
| Gate-Source Charge | $Q_{gs}$ | | | - | - | 45 | |
| Gate-Drain Charge | $Q_{gd}$ | | | - | - | 76 | |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD}$ = 300 V, $I_D$ = 22 A, $R_g$ = 6.2, $V_{GS}$ = 10 V, see fig. 10[b] | | - | 26 | - | ns |
| Rise Time | $t_r$ | | | - | 99 | - | |
| Turn-Off Delay Time | $t_{d(off)}$ | | | - | 48 | - | |
| Fall Time | $t_f$ | | | - | 37 | - | |
| **Drain-Source Body Diode Characteristics** | | | | | | | |
| Continuous Source-Drain Diode Current | $I_S$ | MOSFET symbol showing the integral reverse p - n junction diode | | - | - | 22 | A |
| Pulsed Diode Forward Current[a] | $I_{SM}$ | | | - | - | 88 | |
| Body Diode Voltage | $V_{SD}$ | $T_J$ = 25 °C, $I_S$ = 22 A, $V_{GS}$ = 0 V[b] | | - | - | 1.5 | V |
| Body Diode Reverse Recovery Time | $t_{rr}$ | $T_J$ = 25 °C | $I_F$ = 22 A, dI/dt = 100 A/µs[b] | - | 60 | 120 | ns |
| | | $T_J$ = 125 °C | | - | 80 | 140 | |
| Body Diode Reverse Recovery Charge | $Q_{rr}$ | $T_J$ = 25 °C | | - | 7.2 | 11 | µC |
| | | $T_J$ =1 25 °C | | - | 8.5 | 13 | |
| Reverse Recovery Current | $I_{RRM}$ | $T_J$ = 25 °C | | - | 26 | 39 | |
| Forward Turn-On Time | $t_{on}$ | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$ and $L_D$) | | | | | |

**Notes**

a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
b. Pulse width ≤ 300 µs; duty cycle ≤ 2 %.
c. $C_{oss}$ eff. is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 % to 80 % $V_{DS}$.

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

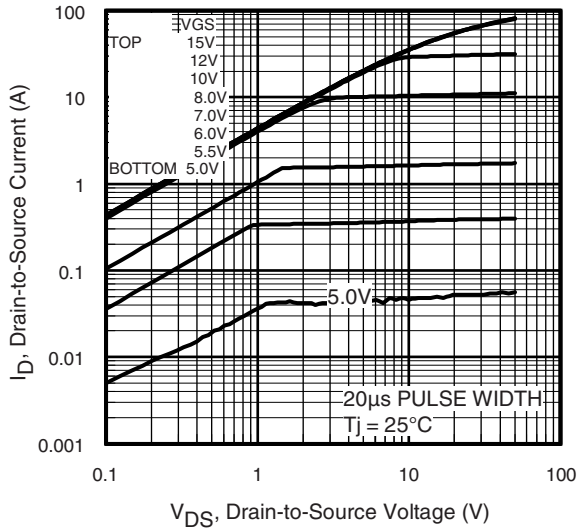



**Fig. 1 - Typical Output Characteristics**

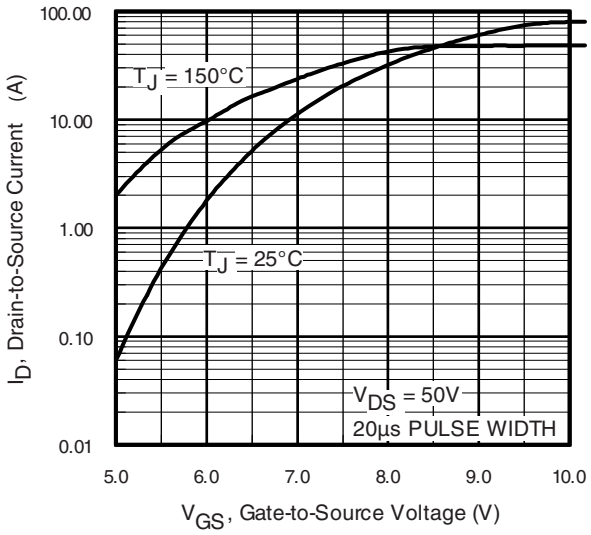



**Fig. 3 - Typical Transfer Characteristics**

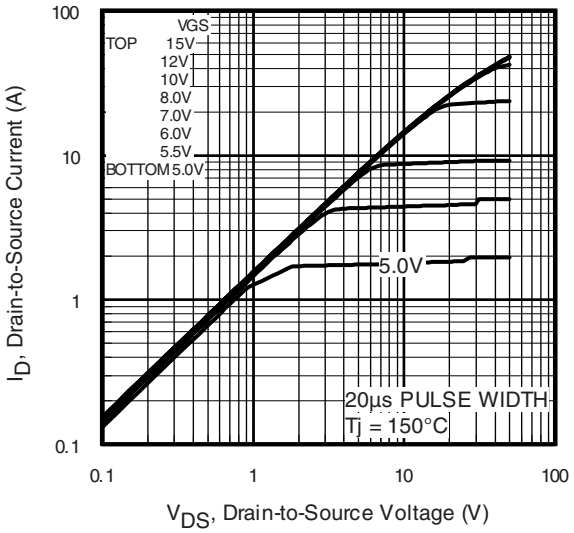



**Fig. 2 - Typical Output Characteristics**

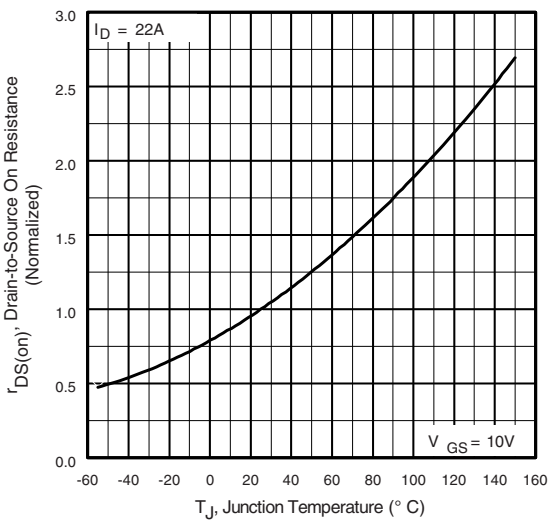



**Fig. 4 - Normalized On-Resistance vs. Temperature**

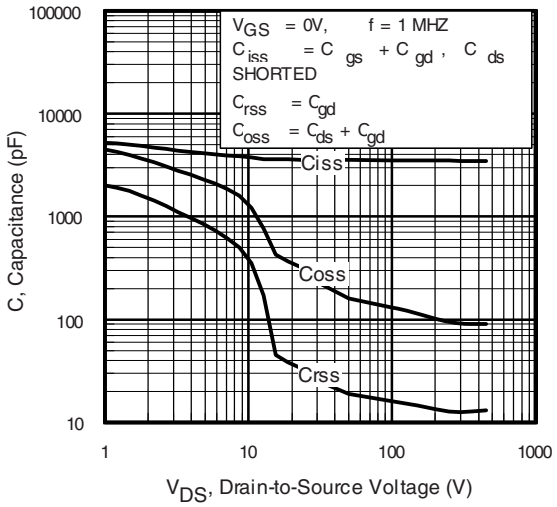



**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

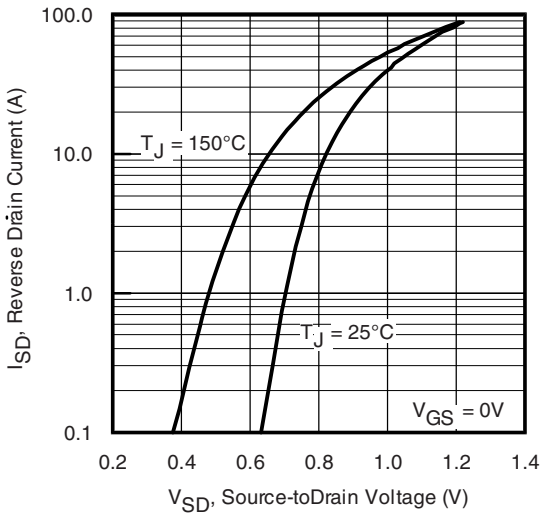



**Fig. 7 - Typical Source-Drain Diode Forward Voltage**

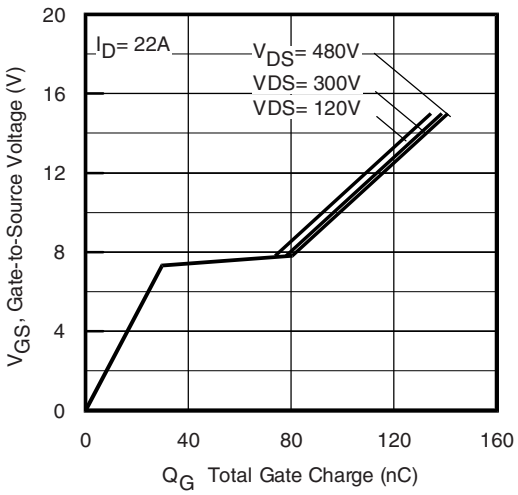



**Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage**

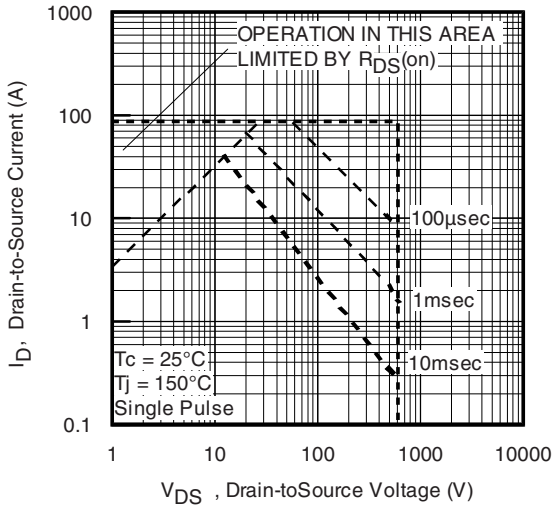



**Fig. 8 - Maximum Safe Operating Area**

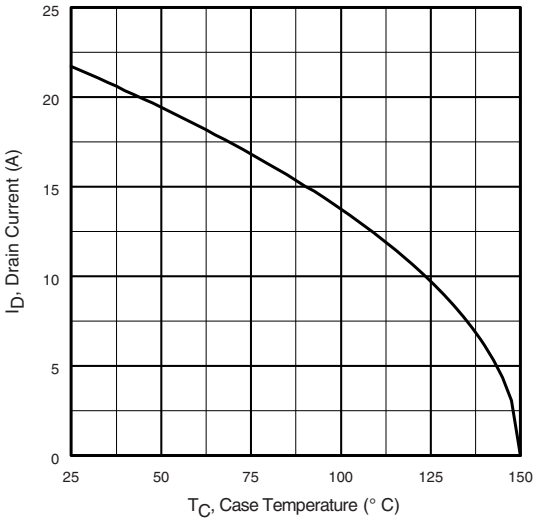



**Fig. 9 - Maximum Drain Current vs. Case Temperature**

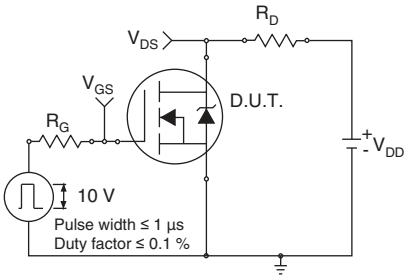



**Fig. 10a - Switching Time Test Circuit**

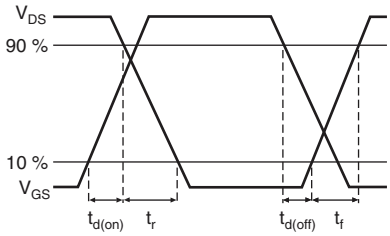



**Fig. 10b - Switching Time Waveforms**

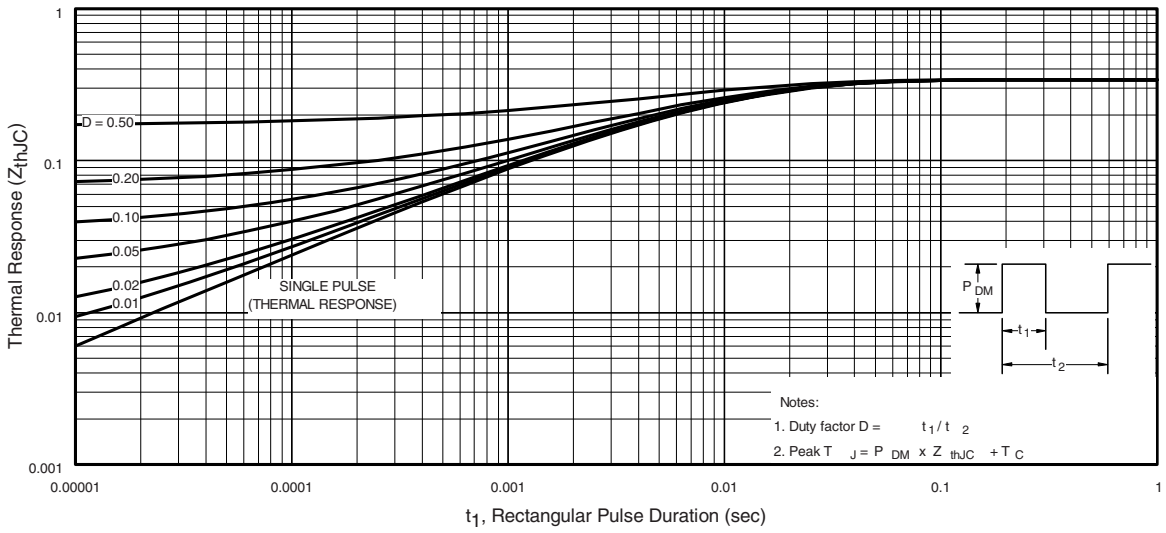



**Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**

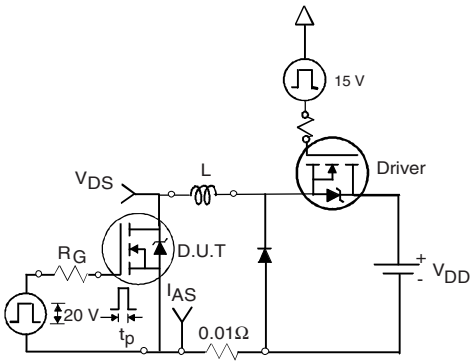



Fig. 12a - Unclamped Inductive Test Circuit

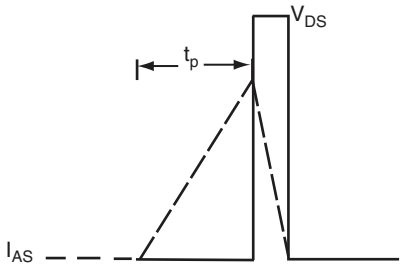



Fig. 12b - Unclamped Inductive Waveforms

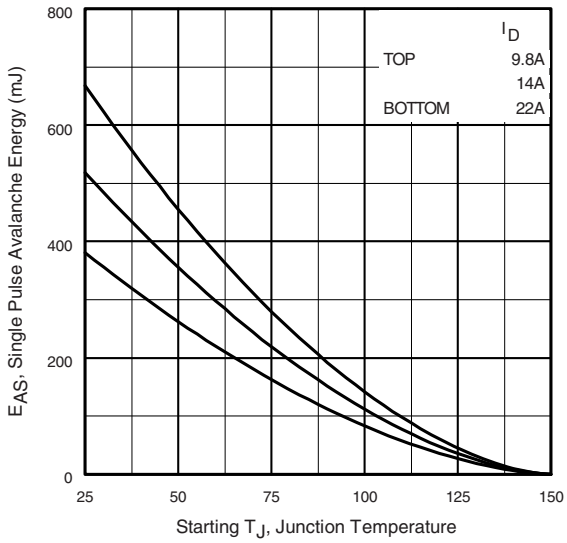



Fig. 12c - Maximum Avalanche Energy vs. Drain Current

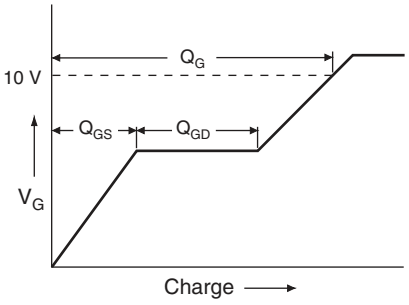



Fig. 13a - Basic Gate Charge Waveform

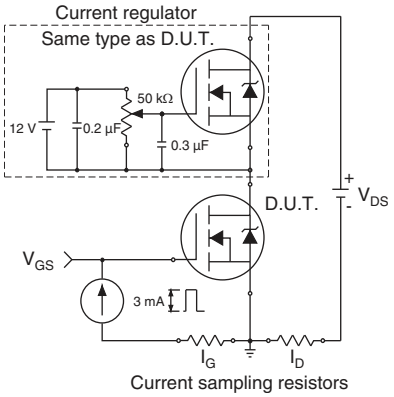
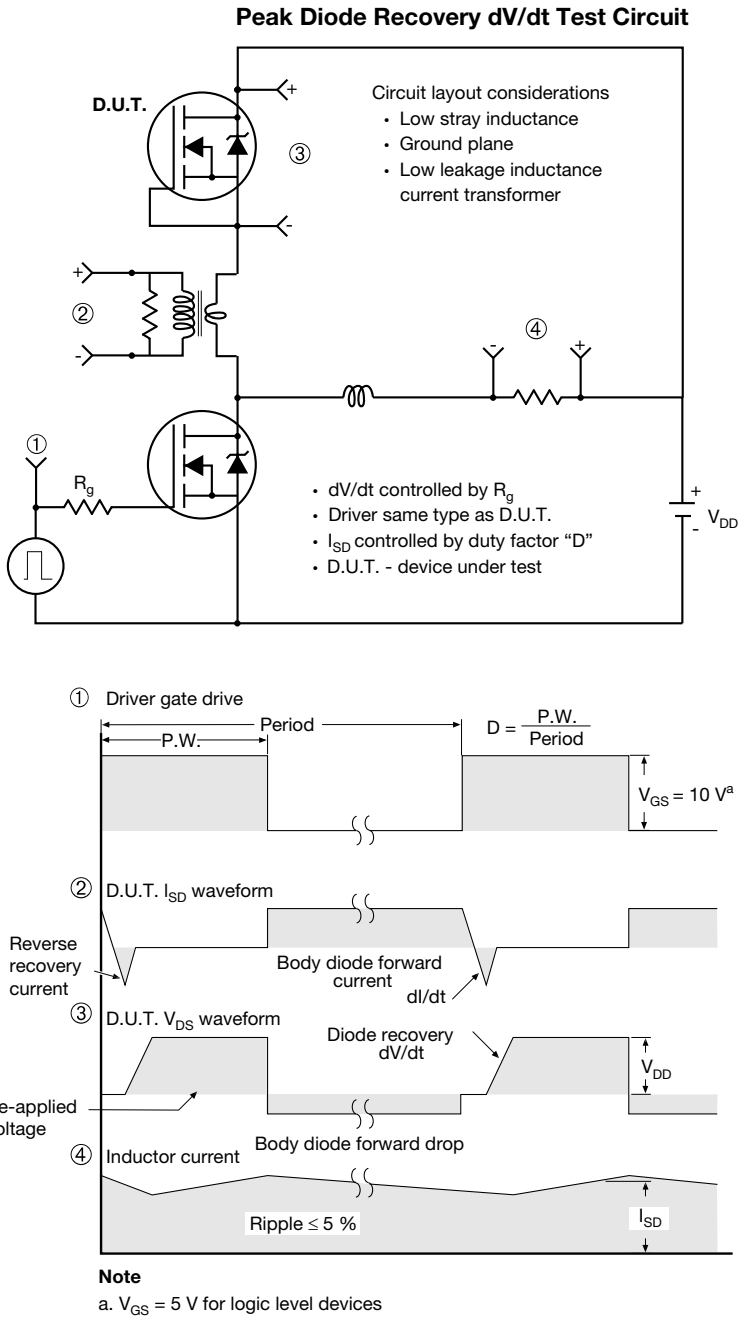



Fig. 13b - Gate Charge Test Circuit

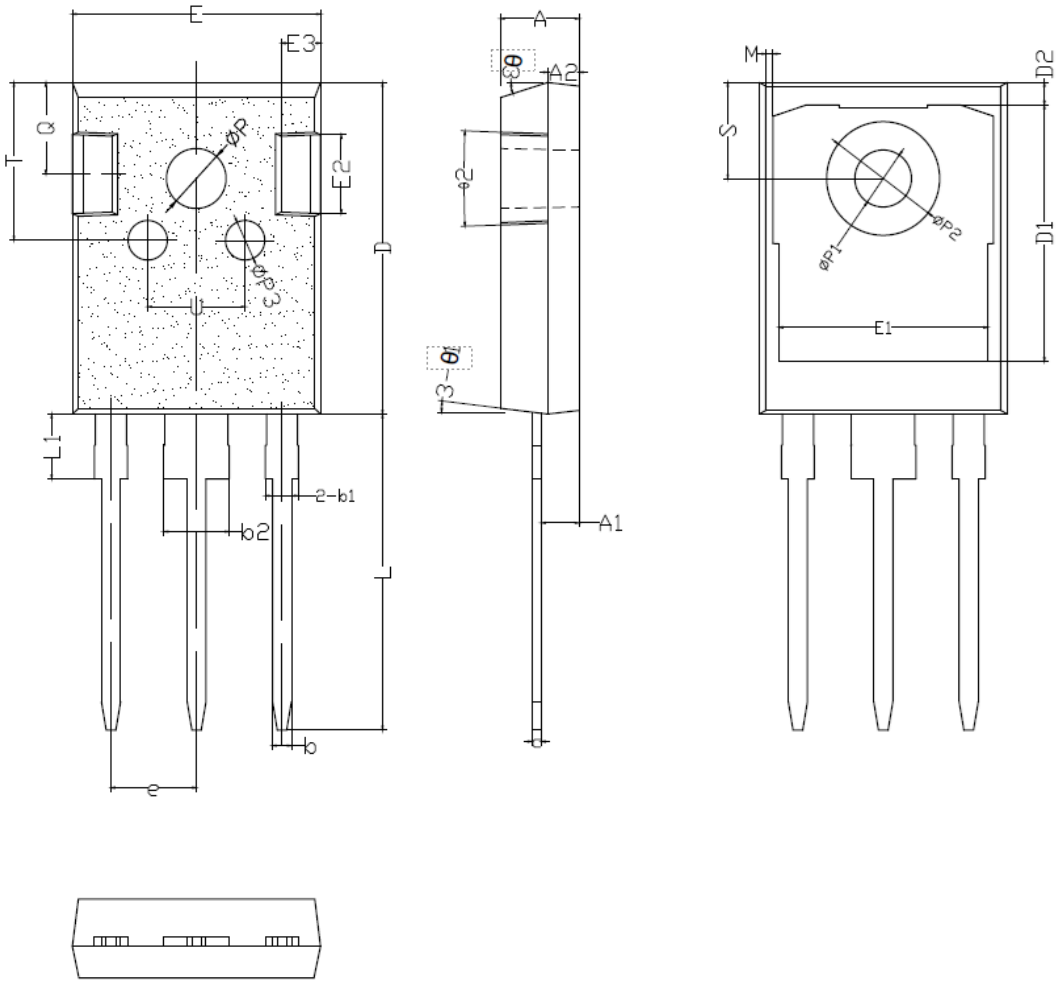



**Note**

a. $V_{GS}$ = 5 V for logic level devices

**Fig. 14 - For N-Channel**

## TO-247 PACKAGE OUTLINE DIMENSIONS




| SYMBOL | mm | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| *A | 4.90 | 5.00 | 5.10 |
| *A1 | 2.31 | 2.41 | 2.51 |
| A2 | 1.90 | 2.00 | 2.10 |
| *b | 1.15 | 1.20 | 1.25 |
| *b1 | 1.95 | 2.10 | 2.25 |
| *b2 | 2.95 | 3.10 | 3.25 |
| *c | 0.55 | 0.60 | 0.65 |
| *D | 20.90 | 21.00 | 21.10 |
| D1 | 16.35 | 16.55 | 16.75 |
| D2 | 1.05 | 1.20 | 1.35 |

| | | | |
|---|---|---|---|
| *E | 15.70 | 15.80 | 15.90 |
| E1 | 13.10 | 13.25 | 13.40 |
| E2 | 4.85 | 4.95 | 5.10 |
| E3 | 2.40 | 2.50 | 2.60 |
| *e | 5.40 | 5.44 | 5.48 |
| *L | 19.80 | 19.98 | 20.15 |
| *L1 | - | - | 4.30 |
| *ΦP | 3.40 | 3.50 | 3.60 |
| *ΦP1 | 6.90 | 7.10 | 7.30 |
| ΦP2 | 2.40 | 2.50 | 2.60 |
| ΦP3 | 2.40 | 2.50 | 2.60 |
| Q | 5.60 | 5.80 | 6.00 |
| *S | 6.05 | 6.15 | 6.25 |
| T | 9.80 | 10.00 | 10.20 |
| U | 6.00 | 6.20 | 6.40 |
| θ1 | 5° | 7° | 9° |
| θ2 | 1° | 3° | 5° |
| θ3 | 13° | 15° | 17° |
| | | | |

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