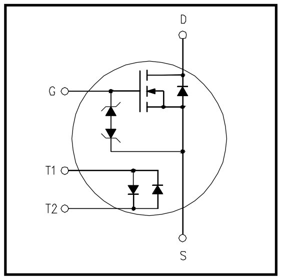
International
IOR Rectifier

PD-93910B

# IRLBD59N04E

HEXFET® Power MOSFET

- Integrated Temperature Sensing Diode
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fully Avalanche Rated
- Zener Gate Protected




$V_{DSS}$ = 40V

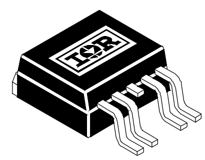
$R_{DS(on)}$ = 0.018Ω

$I_D$ = 59A⑤

## Description

The IRLBD59N04E is a 40V, N-channel HEXFET® power MOSFET with gate protection provided by integrated back to back zener diodes. Temperature sensing is given by the change in forward voltage drop of two antiparallel electrically isolated poly-silicon diodes.

The IRLBD59N04E provides cost effective temperature sensing for system protection along with the quality and ruggedness you expect from a HEXFET power MOSFET.



**5 Lead-D²Pak**

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current, $V_{GS}$ @ 10V | 59⑥ | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current, $V_{GS}$ @ 10V | 41 | |
| $I_{DM}$ | Pulsed Drain Current ① | 230 | |
| $P_D$ @$T_C$ = 25°C | Power Dissipation | 130 | W |
| | Linear Derating Factor | 0.89 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 10 | V |
| $E_{AS}$ | Single Pulse Avalanche Energy② | 340 | mJ |
| $I_{AR}$ | Avalanche Current① | 35 | A |
| $E_{AR}$ | Repetitive Avalanche Energy① | 13 | mJ |
| dv/dt | Peak Diode Recovery dv/dt ③ | 3.6 | V/ns |
| $I_G$ | $V_{GS}$ Clamp Current | ± 50 | mA |
| $V_{ESD}$ | Electrostatic Votage Rating⑥ | ± 2.0 | kV |
| $T_J$ | Operating Junction and | -55 to + 175 | °C |
| $T_{STG}$ | Storage Temperature Range | | °C |
| | Soldering Temperature, for 10 seconds | 300 (1.6mm from case ) | |
| | Mounting torque, 6-32 or M3 srew | 10 lbf•in (1.1N•m) | |

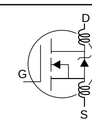
## Thermal Resistance

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case | —— | 1.12 | °C/W |
| $R_{\theta JA}$ | Junction-to-Ambient ( PCB Mounted,steady-state)** | —— | 40 | |

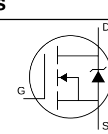


11/13/01

## Electrical Characteristics @ $T_J$ = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage | 40 | —— | —— | V | $V_{GS}$ = 0V, $I_D$ = 250µA |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | —— | 0.044 | —— | V/°C | Reference to 25°C, $I_D$ = 1mA |
| $R_{DS(on)}$ | Static Drain-to-Source On-Resistance | —— | —— | 0.018 | Ω | $V_{GS}$ = 10V, $I_D$ = 35A ④ |
| | | —— | —— | 0.021 | | $V_{GS}$ = 5.0V, $I_D$ = 30A ④ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 1.0 | —— | 2.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 250µA |
| $V_{GS}$ | Clamp Voltage | 10 | —— | 20 | V | $I_{GSS}$ = 20µA |
| $g_{fs}$ | Forward Transconductance | 29 | —— | —— | S | $V_{DS}$ = 25V, $I_D$ = 35A |
| $I_{DSS}$ | Drain-to-Source Leakage Current | —— | —— | 25 | µA | $V_{DS}$ = 40V, $V_{GS}$ = 0V |
| | | —— | —— | 250 | | $V_{DS}$ = 32V, $V_{GS}$ = 0V, $T_J$ = 150°C |
| $I_{GSS}$ | Gate-to-Source Forward Leakage | —— | —— | 1.0 | µA | $V_{GS}$ = 5.0V |
| | Gate-to-Source Reverse Leakage | —— | —— | -1.0 | | $V_{GS}$ = -5.0V |
| $Q_g$ | Total Gate Charge | —— | —— | 50 | nC | $I_D$ = 35A |
| $Q_{gs}$ | Gate-to-Source Charge | —— | —— | 13 | | $V_{DS}$ = 32V |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | —— | —— | 18 | | $V_{GS}$ = 5.0V, See Fig. 6 and 13 ④ |
| $t_{d(on)}$ | Turn-On Delay Time | —— | 7.8 | —— | ns | $V_{DD}$ = 20V |
| $t_r$ | Rise Time | —— | 84 | —— | | $I_D$ = 35A |
| $t_{d(off)}$ | Turn-Off Delay Time | —— | 33 | —— | | $R_G$ = 5.1Ω, |
| $t_f$ | Fall Time | —— | 67 | —— | | $V_{GS}$ = 5.0V, See Fig.10 ④ |
| $L_D$ | Internal Drain Inductance | —— | 2.0 | —— | nH | Between lead, 6mm (0.25in.) from package and center of die contact  |
| $L_S$ | Internal Source Inductance | —— | 5.0 | —— | | |
| $C_{iss}$ | Input Capacitance | —— | 2190 | —— | pF | $V_{GS}$ = 0V |
| $C_{oss}$ | Output Capacitance | —— | 670 | —— | | $V_{DS}$ = 25V |
| $C_{rss}$ | Reverse Transfer Capacitance | —— | 130 | —— | | ƒ = 1.0MHz, See Fig. 5 |

## Source-Drain Ratings and Characteristics

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | —— | —— | 59⑥ | A | MOSFET symbol showing the integral reverse p-n junction diode.  |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ① | —— | —— | 230 | | |
| $V_{SD}$ | Diode Forward Voltage | —— | —— | 1.3 | V | $T_J$ = 25°C, $I_S$ = 35A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | —— | 57 | 86 | ns | $T_J$ = 25°C, $I_F$ = 35A |
| $Q_{rr}$ | Reverse Recovery Charge | —— | 84 | 130 | nC | di/dt = 100A/µs ④ |
| $t_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$+$L_D$) | | | | |

## Sense Diode Rating

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $V_{FM}$ | Sense Diode Maximum Voltage Drop | 675 | —— | 725 | mV | $I_F$ = 250µA, $T_J$ = 25°C |
| $\Delta V_F/\Delta T_J$ | Sense Diode Temperature Coefficient | -1.30 | -1.40 | -1.58 | mV/°C | $I_F$ = 250µA, ($T_J$ = 25°C and 160°C) |

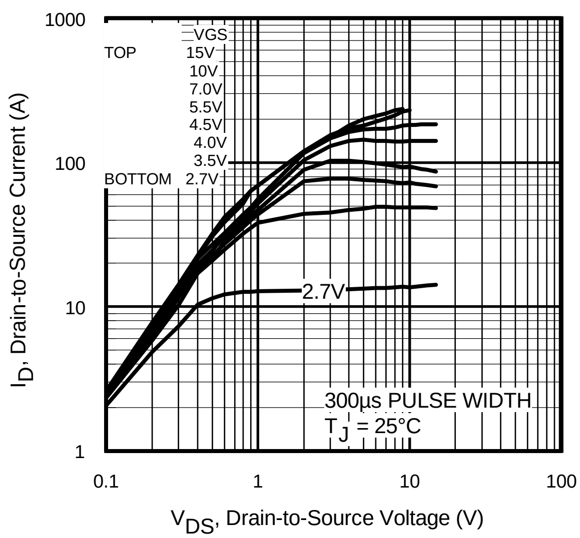



**Fig 1.** Typical Output Characteristics

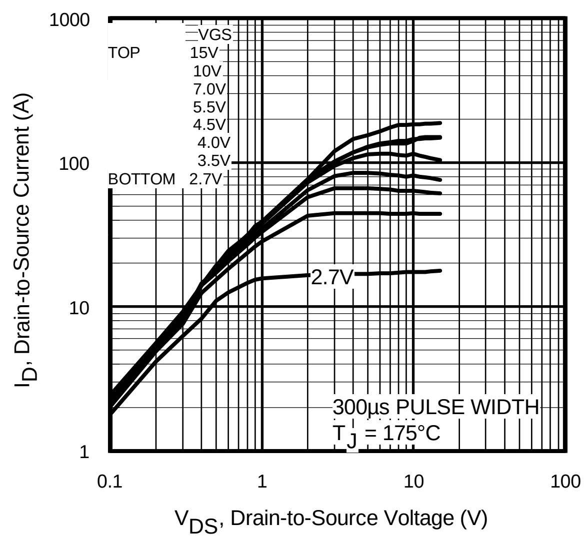



**Fig 2.** Typical Output Characteristics

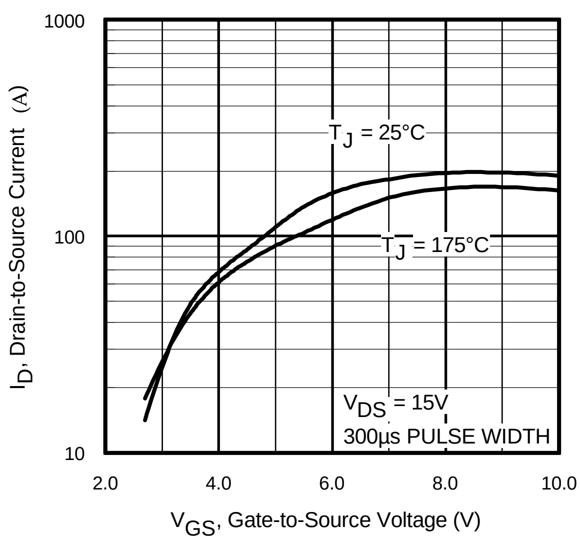



**Fig 3.** Typical Transfer Characteristics

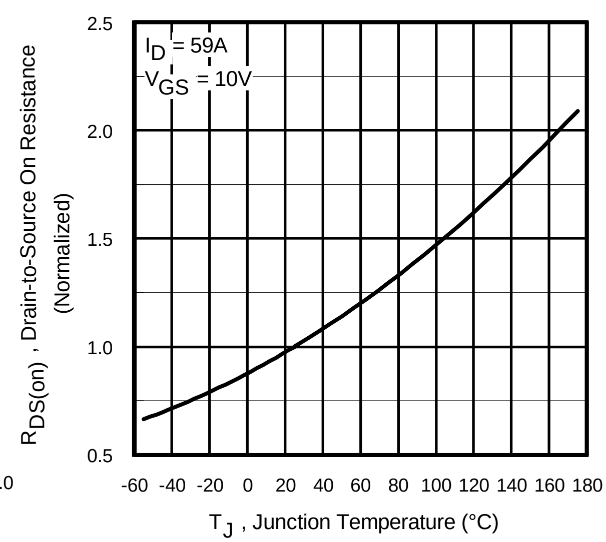



**Fig 4.** Normalized On-Resistance Vs. Temperature

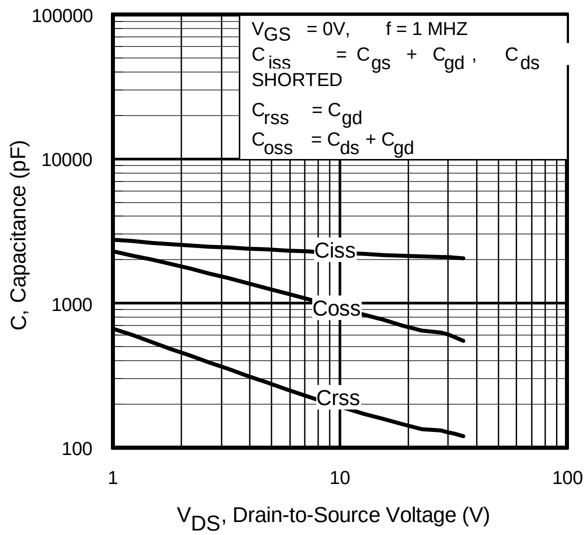



**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage

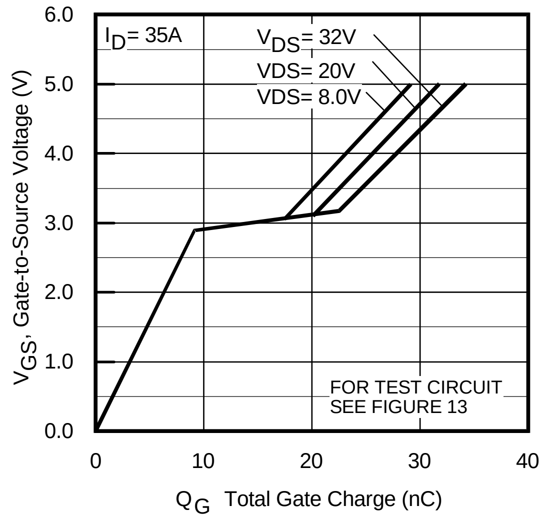



**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage

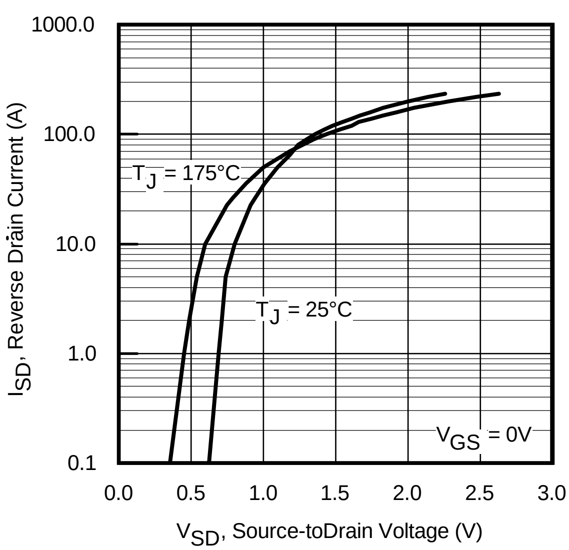



**Fig 7.** Typical Source-Drain Diode Forward Voltage

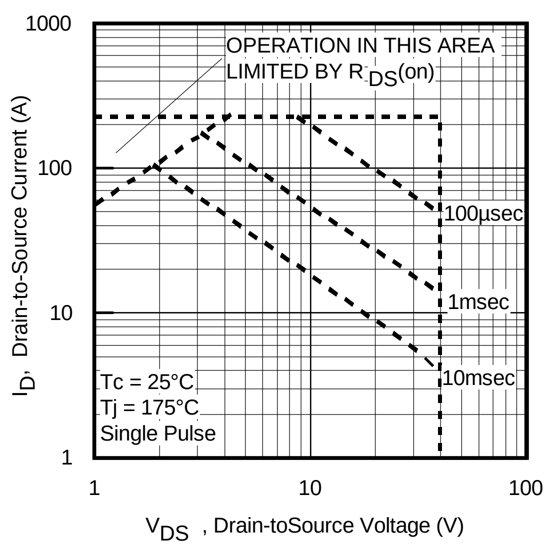



**Fig 8.** Maximum Safe Operating Area

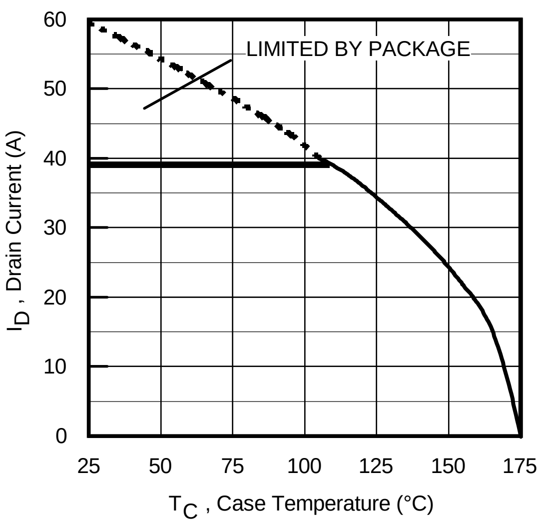
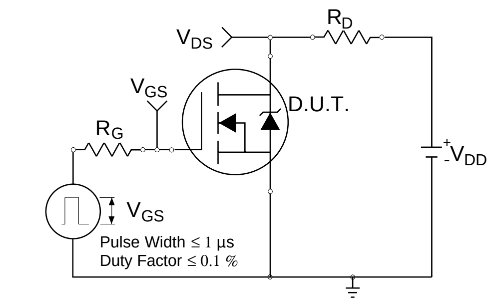
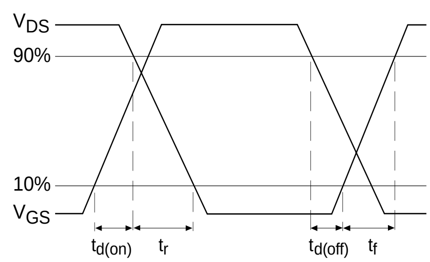



**Fig 9.** Maximum Drain Current Vs. Case Temperature



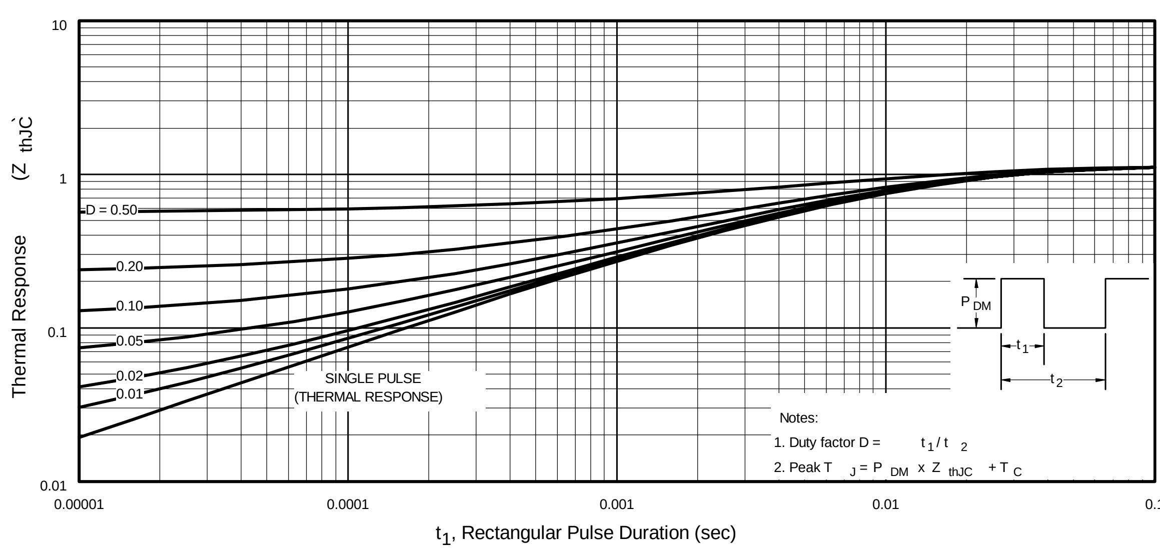




**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

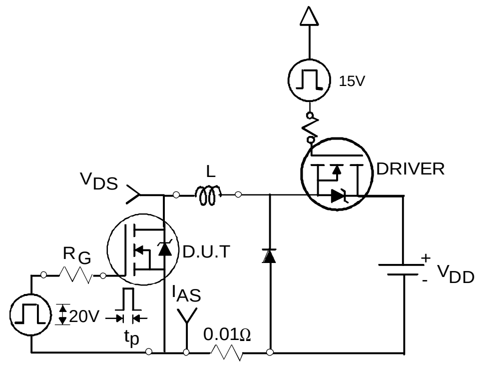



Fig 12a. Unclamped Inductive Test Circuit

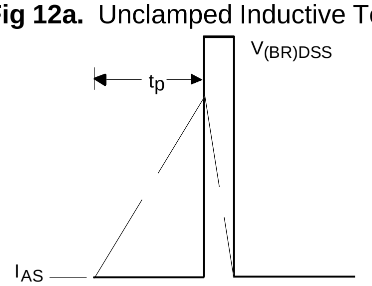



Fig 12b. Unclamped Inductive Waveforms

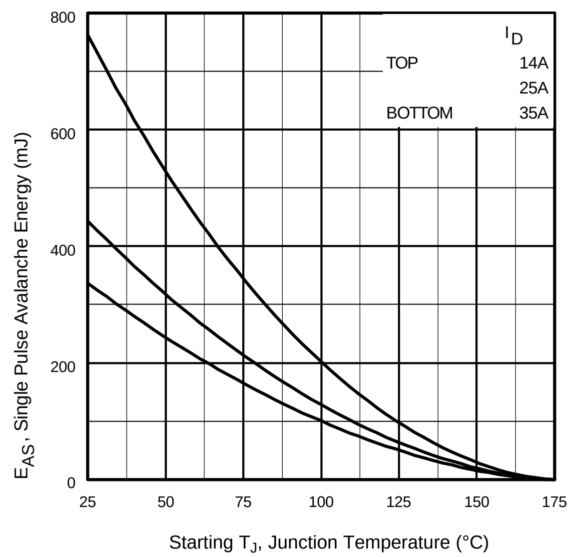



Fig 12c. Maximum Avalanche Energy Vs. Drain Current

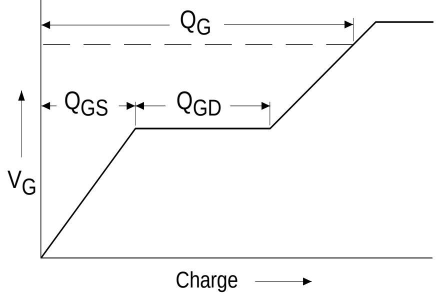



Fig 13a. Basic Gate Charge Waveform

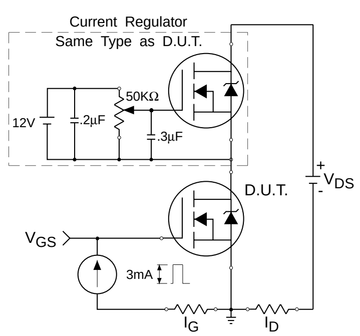



Fig 13b. Gate Charge Test Circuit

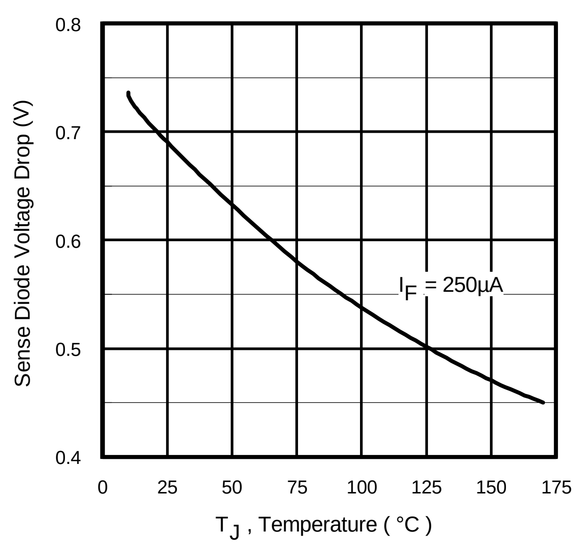
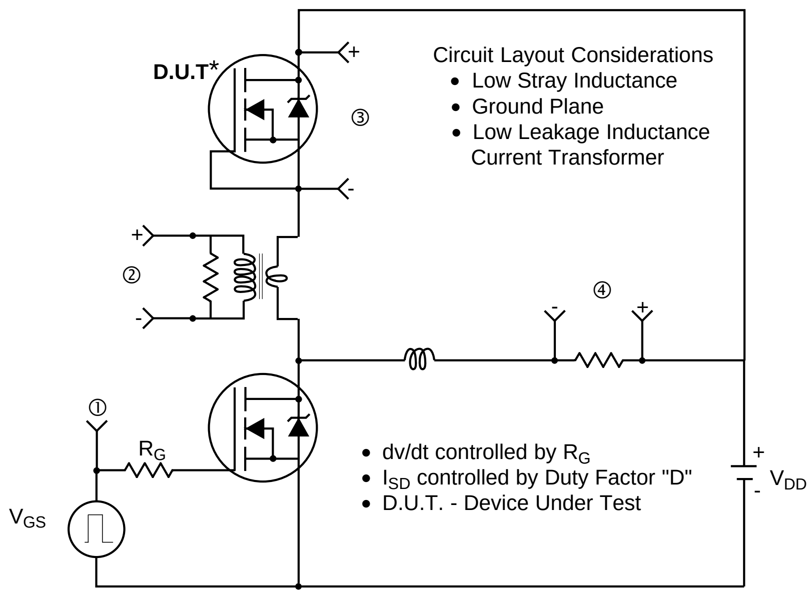
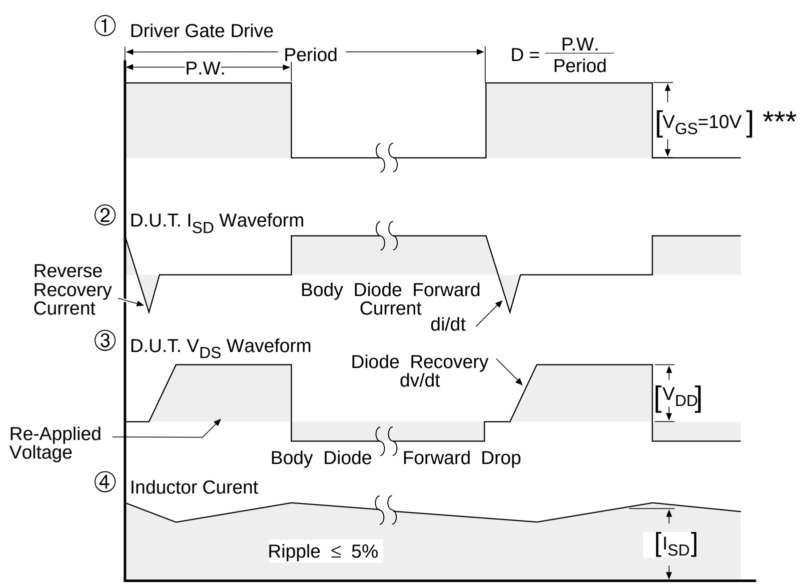



Fig 14. Sense Diode Voltage Drop Vs.Temperature

## Peak Diode Recovery dv/dt Test Circuit



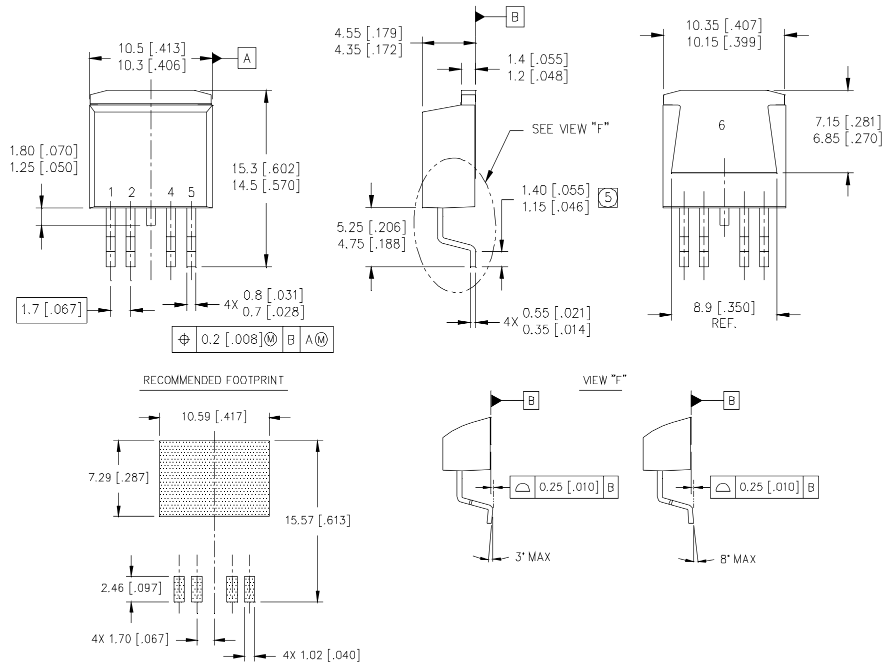

* Reverse Polarity of D.U.T for P-Channel




*** $V_{GS}$ = 5.0V for Logic Level and 3V Drive Devices

**Fig 15.** For N-channel HEXFET® power MOSFETs

## Case Outline 5 Lead-D$^2$Pak (SMD-220)




NOTES:
1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. OUTLINE SIMILAR TO JEDEC OUTLINE SERIES TO-263.
5. DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.

PIN ASSIGNMENTS

1 - G - GATE
2 - T1 - ANODE
3 - D - DRAIN
4 - T2 - CATHODE
5 - S - SOURCE

**Notes:**

① Repetitive rating; pulse width limited by max. junction temperature. ( See fig. 11 )

② Starting $T_J$ = 25°C, L = 0.55mH $R_G$ = 25Ω, $I_{AS}$ = 35A. (See Figure 12)

③ $I_{SD} \leq 35A$, di/dt ≤ 150A/µs, $V_{DD} \leq V_{(BR)DSS}$, $T_J \leq 175°C$

④ Pulse width ≤ 400µs; duty cycle ≤ 2%.

⑤ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 39A

⑥ C = 100pF, R = 1.5kΩ

** When mounted on 1" square PCB ( FR-4 or G-10 Material ).
For recommended soldering techniques refer to application note #AN-994.

Data and specifications subject to change without notice.
This product has been designed and qualified for the Automotive [Q101] market.
Qualification Standards can be found on IR's Web site.

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