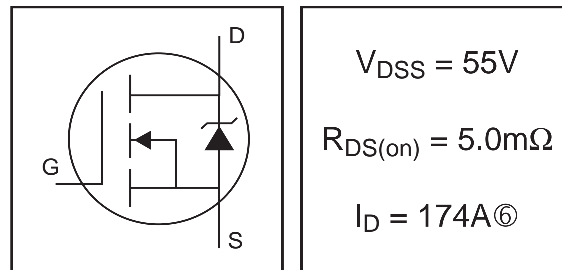
International
IOR Rectifier

**AUTOMOTIVE MOSFET**

# IRFBA1405P

HEXFET® Power MOSFET




## Typical Applications

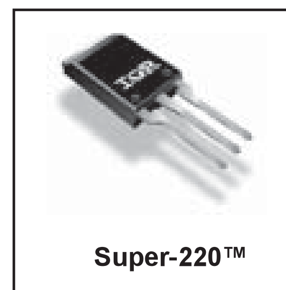
- Electric Power Steering (EPS)
- Anti-lock Braking System (ABS)
- Wiper Control
- Climate Control
- Power Door

## Benefits

- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to Tjmax

## Description

Specifically designed for Automotive applications, this Stripe Planar design of HEXFET® Power MOSFETs utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this MOSFET are a 175°C junction operating temperature, fast switching speed and improved ruggedness in single and repetitive avalanche. The Super-220 ™ is a package that has been designed to have the same mechanical outline and pinout as the industry standard TO-220 but can house a considerably larger silicon die. The result is significantly increased current handling capability over both the TO-220 and the much larger TO-247 package. The combination of extremely low on-resistance silicon and the Super-220 ™ package makes it ideal to reduce the component count in multiparalled TO-220 applications, reduce system power dissipation, upgrade existing designs or have TO-247 performance in a TO-220 outline. This package has been designed to meet automotive, Q101, qualification standard.
These benefits make this design an extremely efficient and reliable device for use in Automotive applications and a wide variety of other applications.



**Super-220™**

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current, $V_{GS}$ @ 10V | 174⑥ | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current, $V_{GS}$ @ 10V | 123⑥ | |
| $I_{DM}$ | Pulsed Drain Current ① | 680 | |
| $P_D$ @$T_C$ = 25°C | Power Dissipation | 330 | W |
| | Linear Derating Factor | 2.2 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 20 | V |
| $E_{AS}$ | Single Pulse Avalanche Energy② | 560 | mJ |
| $I_{AR}$ | Avalanche Current | See Fig.12a, 12b, 15, 16 | A |
| $E_{AR}$ | Repetitive Avalanche Energy⑦ | | mJ |
| dv/dt | Peak Diode Recovery dv/dt ③ | 5.0 | V/ns |
| $T_J$<br>$T_{STG}$ | Operating Junction and<br>Storage Temperature Range | -40 to + 175<br>-55 to + 175 | °C |
| | Soldering Temperature, for 10 seconds | 300 (1.6mm from case ) | |
| | Recommended clip force | 20 | N |



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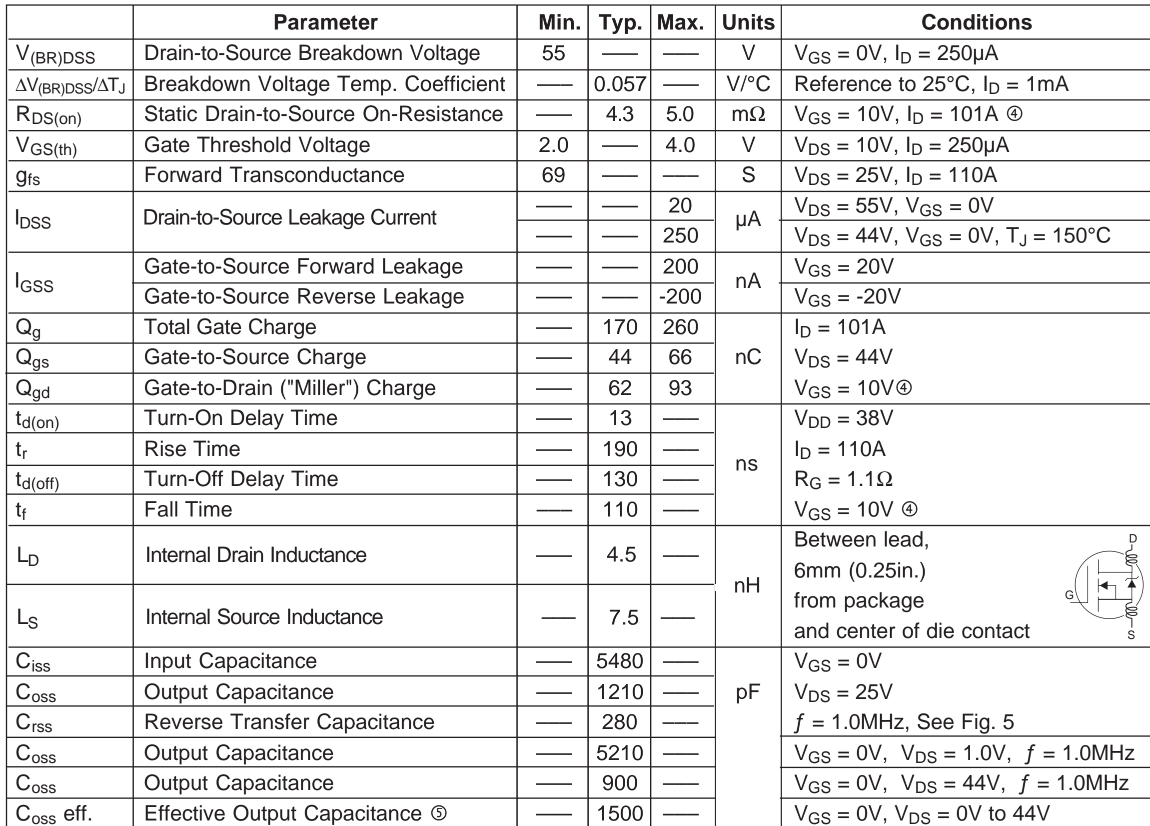
## Electrical Characteristics @ $T_J$ = 25°C (unless otherwise specified)



| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage | 55 | ––– | ––– | V | $V_{GS}$ = 0V, $I_D$ = 250µA |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | ––– | 0.057 | ––– | V/°C | Reference to 25°C, $I_D$ = 1mA |
| $R_{DS(on)}$ | Static Drain-to-Source On-Resistance | ––– | 4.3 | 5.0 | mΩ | $V_{GS}$ = 10V, $I_D$ = 101A ④ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | ––– | 4.0 | V | $V_{DS}$ = 10V, $I_D$ = 250µA |
| $g_{fs}$ | Forward Transconductance | 69 | ––– | ––– | S | $V_{DS}$ = 25V, $I_D$ = 110A |
| $I_{DSS}$ | Drain-to-Source Leakage Current | ––– | ––– | 20 | µA | $V_{DS}$ = 55V, $V_{GS}$ = 0V |
| | | ––– | ––– | 250 | | $V_{DS}$ = 44V, $V_{GS}$ = 0V, $T_J$ = 150°C |
| $I_{GSS}$ | Gate-to-Source Forward Leakage | ––– | ––– | 200 | nA | $V_{GS}$ = 20V |
| | Gate-to-Source Reverse Leakage | ––– | ––– | -200 | | $V_{GS}$ = -20V |
| $Q_g$ | Total Gate Charge | ––– | 170 | 260 | nC | $I_D$ = 101A |
| $Q_{gs}$ | Gate-to-Source Charge | ––– | 44 | 66 | | $V_{DS}$ = 44V |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | ––– | 62 | 93 | | $V_{GS}$ = 10V④ |
| $t_{d(on)}$ | Turn-On Delay Time | ––– | 13 | ––– | ns | $V_{DD}$ = 38V |
| $t_r$ | Rise Time | ––– | 190 | ––– | | $I_D$ = 110A |
| $t_{d(off)}$ | Turn-Off Delay Time | ––– | 130 | ––– | | $R_G$ = 1.1Ω |
| $t_f$ | Fall Time | ––– | 110 | ––– | | $V_{GS}$ = 10V ④ |
| $L_D$ | Internal Drain Inductance | ––– | 4.5 | ––– | nH | Between lead, 6mm (0.25in.) |
| $L_S$ | Internal Source Inductance | ––– | 7.5 | ––– | | from package and center of die contact |
| $C_{iss}$ | Input Capacitance | ––– | 5480 | ––– | pF | $V_{GS}$ = 0V |
| $C_{oss}$ | Output Capacitance | ––– | 1210 | ––– | | $V_{DS}$ = 25V |
| $C_{rss}$ | Reverse Transfer Capacitance | ––– | 280 | ––– | | ƒ = 1.0MHz, See Fig. 5 |
| $C_{oss}$ | Output Capacitance | ––– | 5210 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 1.0V, ƒ = 1.0MHz |
| $C_{oss}$ | Output Capacitance | ––– | 900 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 44V, ƒ = 1.0MHz |
| $C_{oss}$ eff. | Effective Output Capacitance ⑤ | ––– | 1500 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 44V |

## Source-Drain Ratings and Characteristics

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | ––– | ––– | 174⑥ | A | MOSFET symbol showing the |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ① | ––– | ––– | 680 | | integral reverse p-n junction diode. |
| $V_{SD}$ | Diode Forward Voltage | ––– | ––– | 1.3 | V | $T_J$ = 25°C, $I_S$ = 101A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | ––– | 88 | 130 | ns | $T_J$ = 25°C, $I_F$ = 101A |
| $Q_{rr}$ | Reverse RecoveryCharge | ––– | 250 | 380 | nC | di/dt = 100A/µs ④ |
| $t_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$+$L_D$) | | | | |

## Thermal Resistance

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case | ––– | 0.45 | °C/W |
| $R_{\theta CS}$ | Case-to-Sink, Flat, Greased Surface | 0.50 | ––– | |
| $R_{\theta JA}$ | Junction-to-Ambient | ––– | 58 | |



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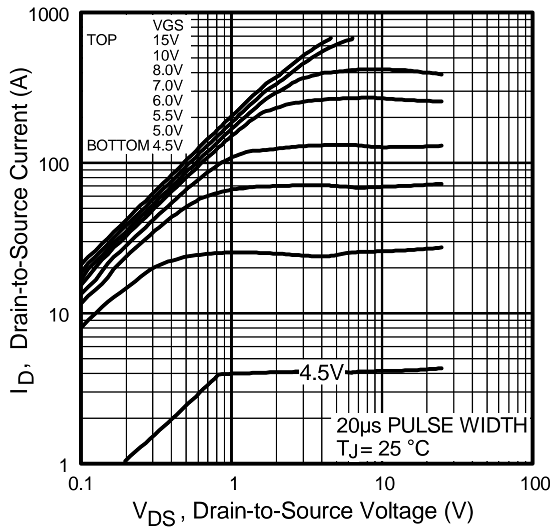


**Fig 1.** Typical Output Characteristics

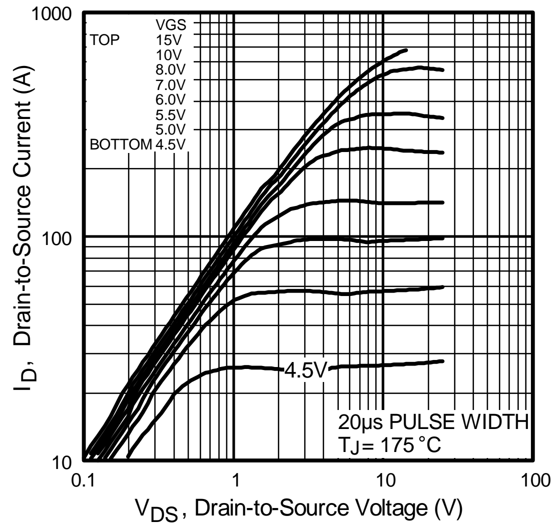


**Fig 2.** Typical Output Characteristics

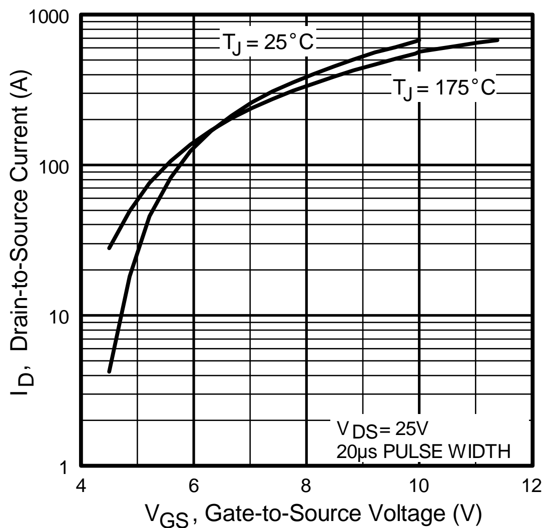


**Fig 3.** Typical Transfer Characteristics

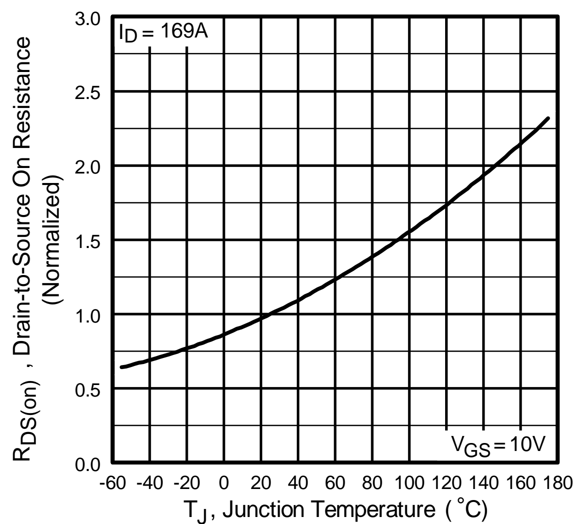


**Fig 4.** Normalized On-Resistance Vs. Temperature



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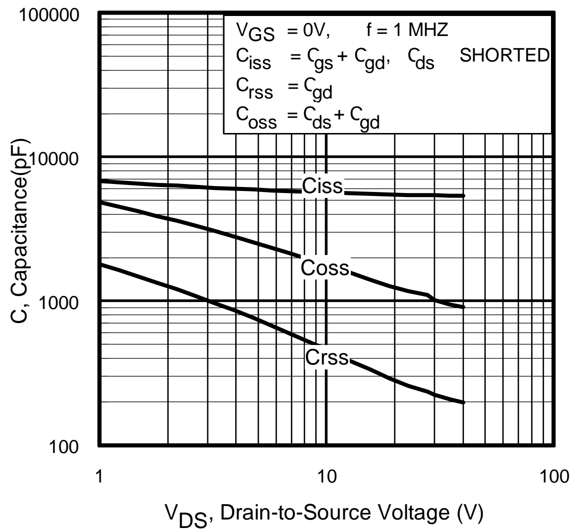


**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage

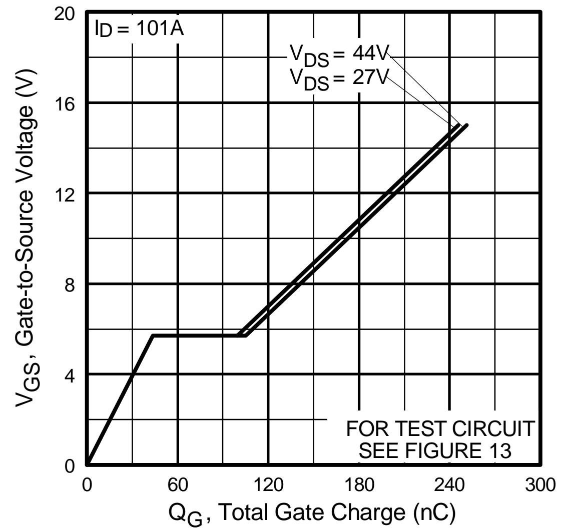


**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage

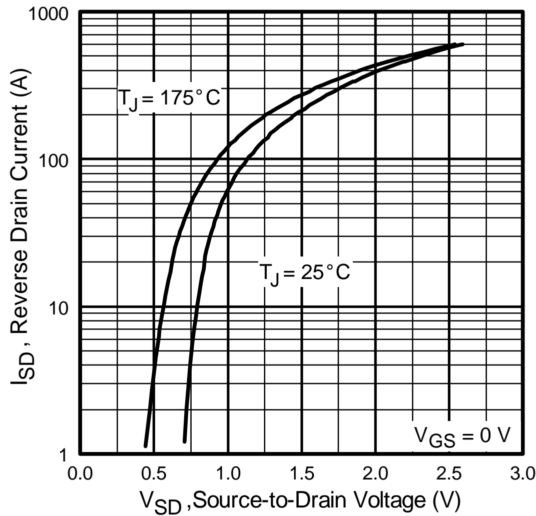


**Fig 7.** Typical Source-Drain Diode Forward Voltage

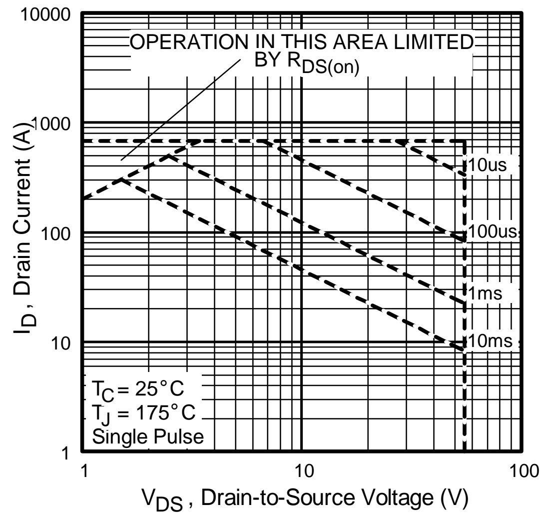


**Fig 8.** Maximum Safe Operating Area





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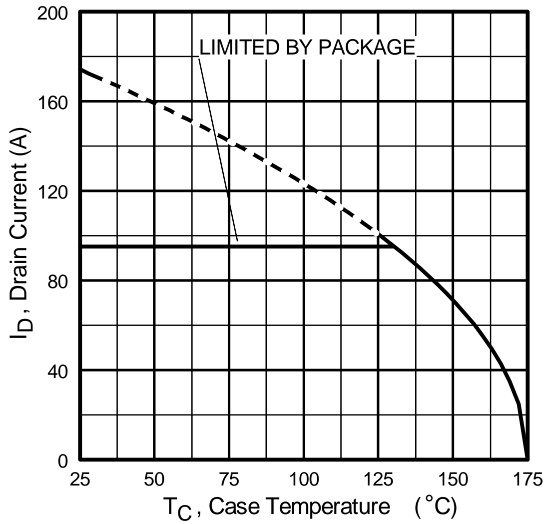


**Fig 9.** Maximum Drain Current Vs. Case Temperature

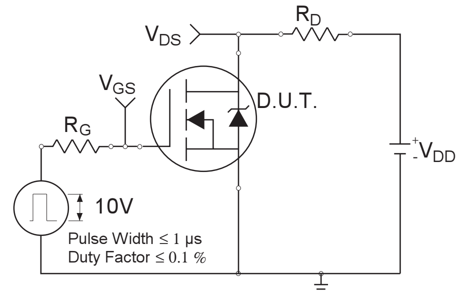


**Fig 10a.** Switching Time Test Circuit

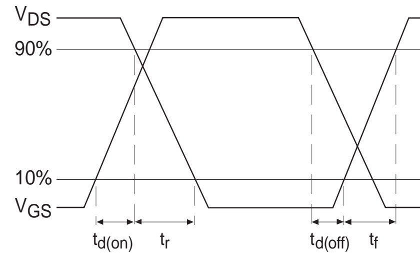


**Fig 10b.** Switching Time Waveforms

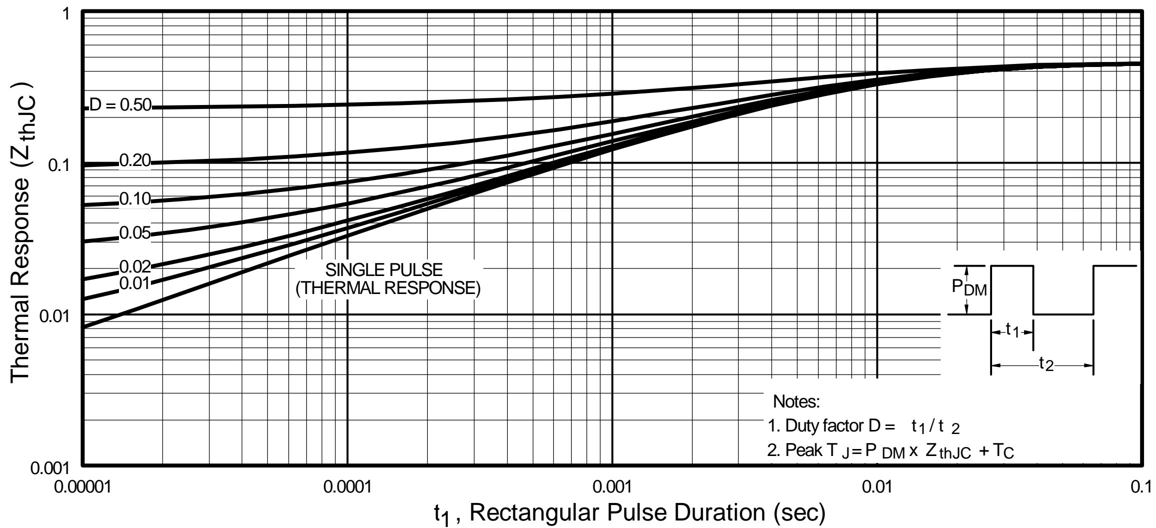


**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



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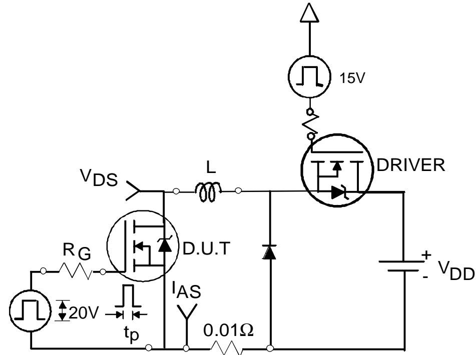


**Fig 12a.** Unclamped Inductive Test Circuit

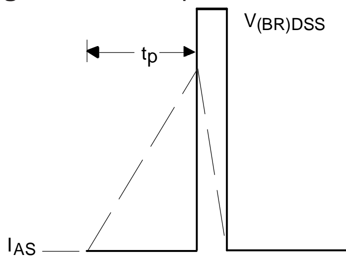


**Fig 12b.** Unclamped Inductive Waveforms

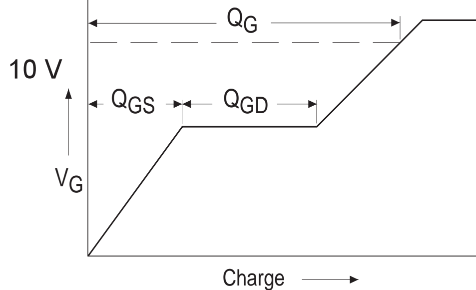


**Fig 13a.** Basic Gate Charge Waveform

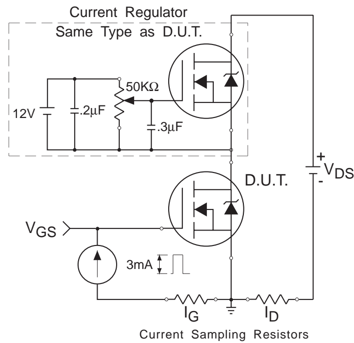


**Fig 13b.** Gate Charge Test Circuit

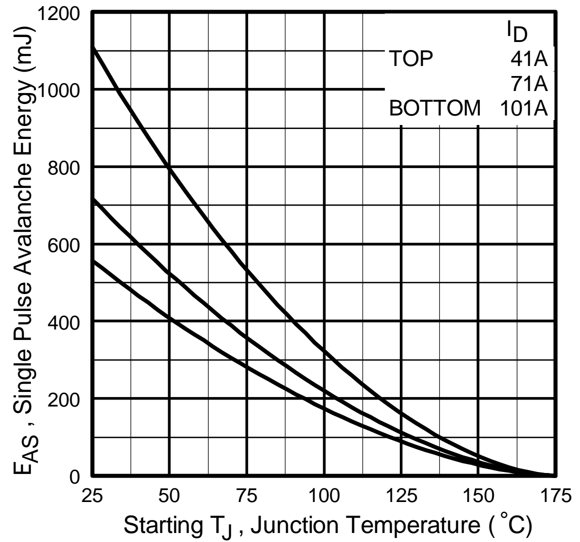


**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current

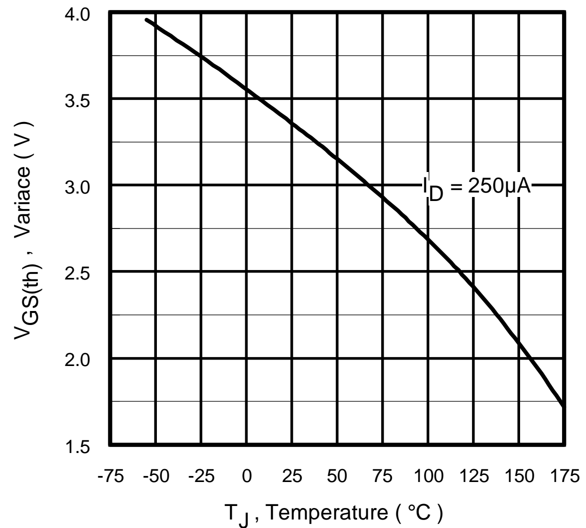


**Fig 14.** Threshold Voltage Vs. Temperature



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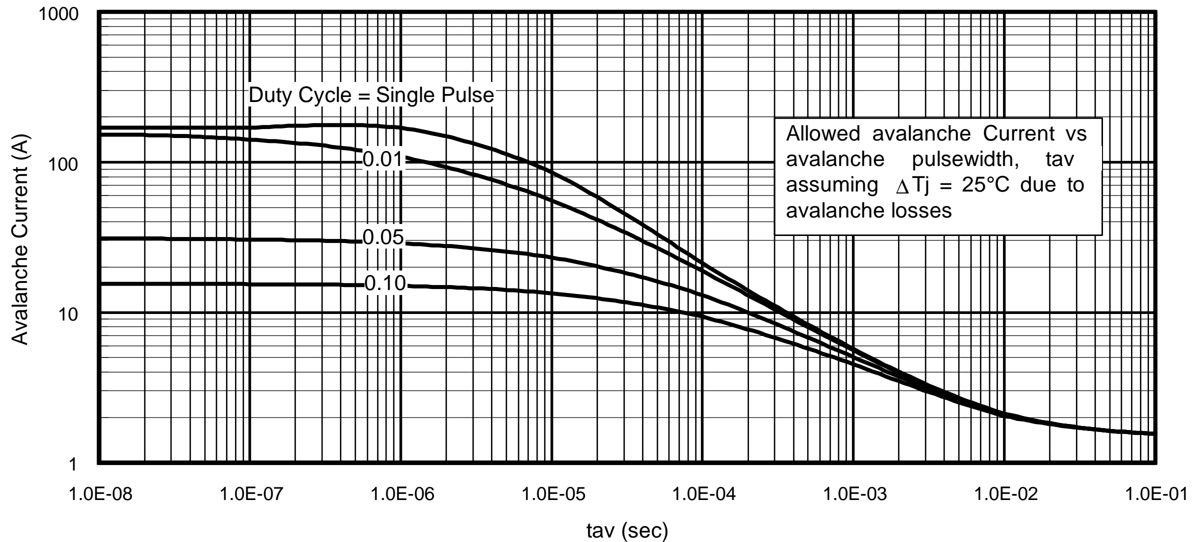


**Fig 15.** Typical Avalanche Current Vs.Pulsewidth

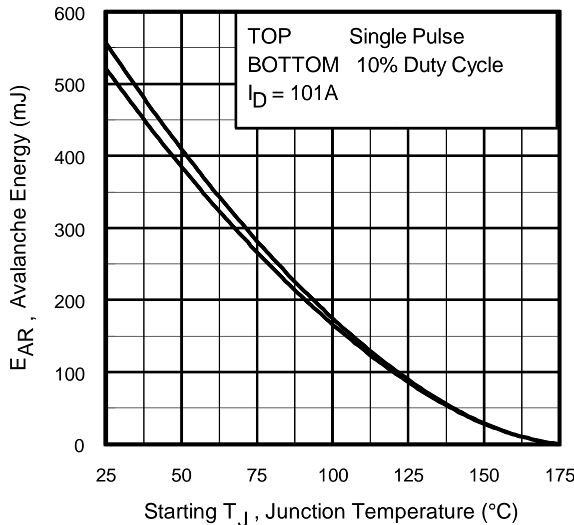


**Fig 16.** Maximum Avalanche Energy Vs. Temperature

**Notes on Repetitive Avalanche Curves , Figures 15, 16:**
**(For further info, see AN-1005 at www.irf.com)**

1. Avalanche failures assumption:
   Purely a thermal phenomenon and failure occurs at a temperature far in excess of $T_{jmax}$. This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as $T_{jmax}$ is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 12a, 12b.
4. $P_{D\ (ave)}$ = Average power dissipation per single avalanche pulse.
5. BV = Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).
6. $I_{av}$ = Allowable avalanche current.
7. $\Delta T$ = Allowable rise in junction temperature, not to exceed $T_{jmax}$ (assumed as 25°C in Figure 15, 16).
   $t_{av}$ = Average time in avalanche.
   D = Duty cycle in avalanche = $t_{av} \cdot f$
   $Z_{thJC}(D, t_{av})$ = Transient thermal resistance, see figure 11)

$$P_{D\ (ave)} = 1/2\ (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$
$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$
$$E_{AS\ (AR)} = P_{D\ (ave)} \cdot t_{av}$$



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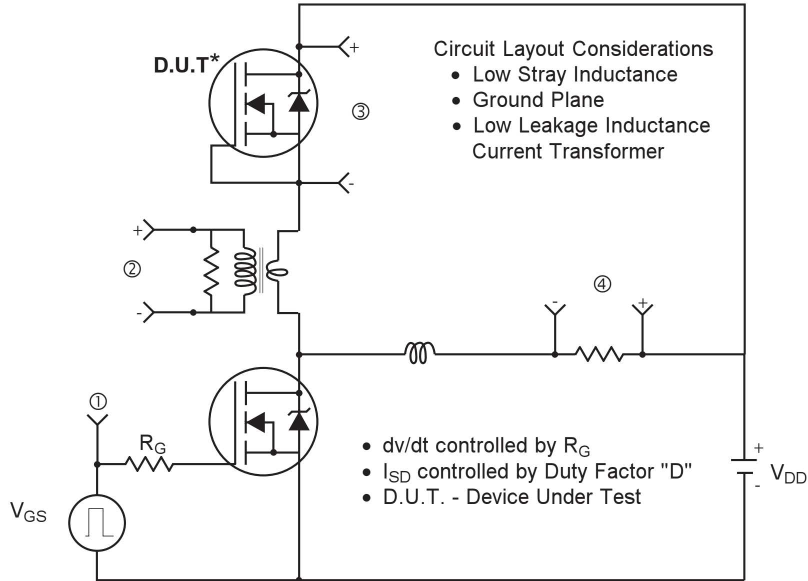
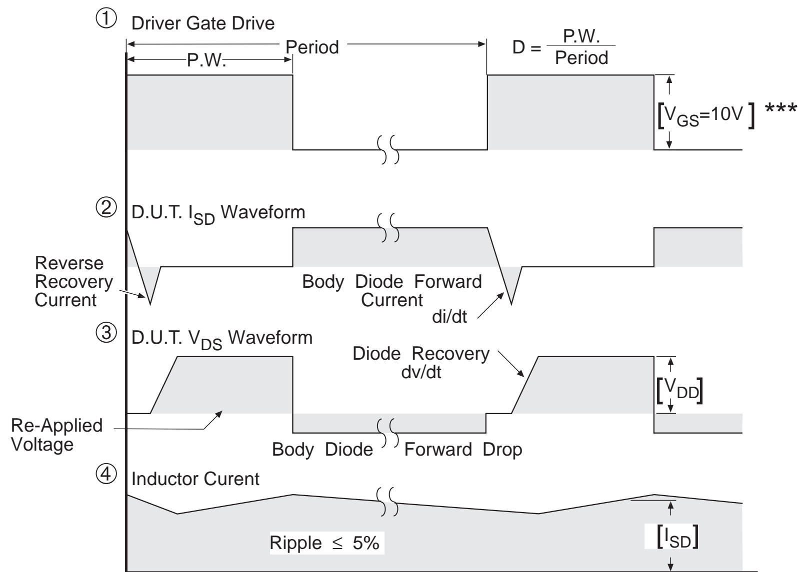
## Peak Diode Recovery dv/dt Test Circuit




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




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

**Fig 17.** For N-channel HEXFET® power MOSFETs



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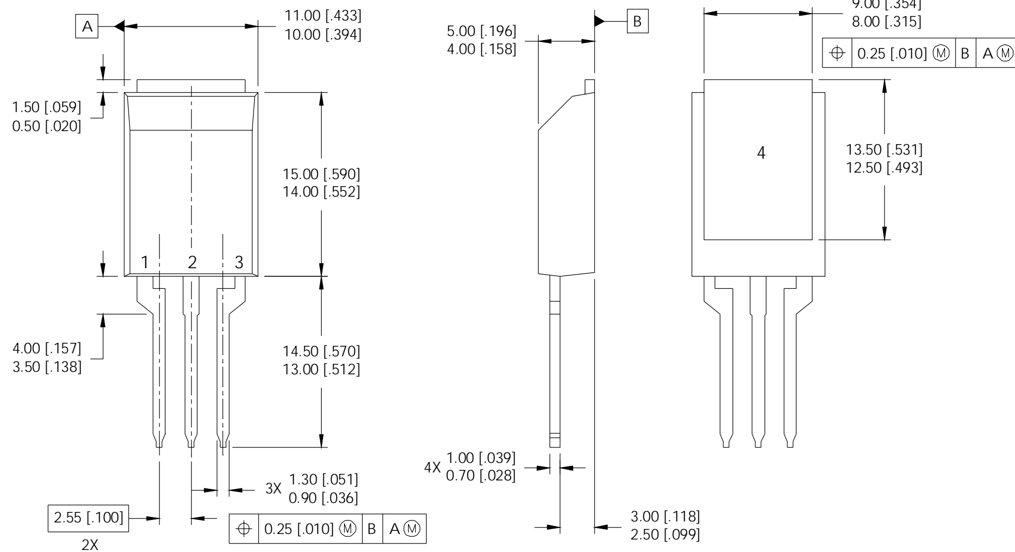
## Super-220™ Package Outline




NOTES:

1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. OUTLINE CONFORMS TO JEDEC OUTLINE TO-273AA.

LEAD ASSIGNMENTS

| MOSFET | IGBT |
|---|---|
| 1 - GATE | 1 - GATE |
| 2 - DRAIN | 2 - COLLECTOR |
| 3 - SOURCE | 3 - EMITTER |
| 4 - DRAIN | 4 - COLLECTOR |

**Notes:**

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

② Starting $T_J$ = 25°C, L = 0.11mH $R_G$ = 25Ω, $I_{AS}$ = 101A. (See Figure 12).

③ $I_{SD} \leq$ 101A, di/dt ≤ 210A/μs, $V_{DD} \leq V_{(BR)DSS}$, $T_J \leq$ 175°C

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

⑤ $C_{oss}$ eff. is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$ .Refer to AN-1001

⑥ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 95A.

⑦ Limited by $T_{Jmax}$ , see Fig.12a, 12b, 15, 16 for typical repetitive avalanche performance.

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.

Super-220™ not recommended for surface mount application

International
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