

International  
**IR** Rectifier

SMPS MOSFET

PD - 91814A  
**IRFSL9N60A**

HEXFET® Power MOSFET

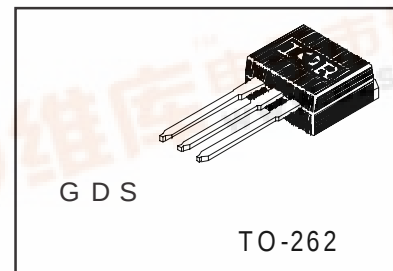
#### Applications

- Switch Mode Power Supply ( SMPS )
- Uninterruptable Power Supply
- High speed power switching
- This device is only for through hole application.

| $V_{DSS}$ | $R_{ds(on)}$ max | $I_D$ |
|-----------|------------------|-------|
| 600V      | 0.75Ω            | 9.2A  |

#### Benefits

- 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



#### Absolute Maximum Ratings

|                                   | Parameter                                | Max.                   | Units |
|-----------------------------------|------------------------------------------|------------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V | 9.2                    | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V | 5.8                    |       |
| $I_{DM}$                          | Pulsed Drain Current ①                   | 37                     |       |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Power Dissipation                        | 170                    | W     |
|                                   | Linear Derating Factor                   | 1.3                    | W/°C  |
| $V_{GS}$                          | Gate-to-Source Voltage                   | ± 30                   | V     |
| $dv/dt$                           | Peak Diode Recovery $dv/dt$ ③            | 5.0                    | V/ns  |
| $T_J$                             | Operating Junction and                   | -55 to + 150           | °C    |
| $T_{STG}$                         | Storage Temperature Range                |                        |       |
|                                   | Soldering Temperature, for 10 seconds    | 300 (1.6mm from case ) |       |

#### Applicable Off Line SMPS Topologies:

- Active Clamped Forward
- Main Switch

Notes ① through ⑤ are on page 8

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12/23/98



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Static @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

|               | Parameter                            | Min. | Typ. | Max. | Units    | Conditions                                            |
|---------------|--------------------------------------|------|------|------|----------|-------------------------------------------------------|
| $V_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage    | 600  | —    | —    | V        | $V_{GS} = 0V, I_D = 250\mu A$                         |
| $R_{DS(on)}$  | Static Drain-to-Source On-Resistance | —    | —    | 0.75 | $\Omega$ | $V_{GS} = 10V, I_D = 5.5A$ ④                          |
| $V_{GS(th)}$  | Gate Threshold Voltage               | 2.0  | —    | 4.0  | V        | $V_{DS} = V_{GS}, I_D = 250\mu A$                     |
| $I_{DSS}$     | Drain-to-Source Leakage Current      | —    | —    | 25   | $\mu A$  | $V_{DS} = 600V, V_{GS} = 0V$                          |
|               |                                      | —    | —    | 250  |          | $V_{DS} = 480V, V_{GS} = 0V, T_J = 150^\circ\text{C}$ |
| $I_{GSS}$     | Gate-to-Source Forward Leakage       | —    | —    | 100  | nA       | $V_{GS} = 30V$                                        |
|               | Gate-to-Source Reverse Leakage       | —    | —    | -100 |          | $V_{GS} = -30V$                                       |

Dynamic @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

|                        | Parameter                       | Min. | Typ. | Max. | Units | Conditions                                      |
|------------------------|---------------------------------|------|------|------|-------|-------------------------------------------------|
| $g_{fs}$               | Forward Transconductance        | 5.5  | —    | —    | S     | $V_{DS} = 25V, I_D = 3.1A$                      |
| $Q_g$                  | Total Gate Charge               | —    | —    | 49   | nC    | $I_D = 9.2A$                                    |
| $Q_{gs}$               | Gate-to-Source Charge           | —    | —    | 13   |       | $V_{DS} = 400V$                                 |
| $Q_{gd}$               | Gate-to-Drain ("Miller") Charge | —    | —    | 20   |       | $V_{GS} = 10V$ , See Fig. 6 and 13 ④            |
| $t_{d(on)}$            | Turn-On Delay Time              | —    | 13   | —    | ns    | $V_{DD} = 300V$                                 |
| $t_r$                  | Rise Time                       | —    | 25   | —    |       | $I_D = 9.2A$                                    |
| $t_{d(off)}$           | Turn-Off Delay Time             | —    | 30   | —    |       | $R_G = 9.1\Omega$                               |
| $t_f$                  | Fall Time                       | —    | 22   | —    |       | $R_D = 35.5\Omega$ , See Fig. 10 ④              |
| $C_{iss}$              | Input Capacitance               | —    | 1400 | —    | pF    | $V_{GS} = 0V$                                   |
| $C_{oss}$              | Output Capacitance              | —    | 180  | —    |       | $V_{DS} = 25V$                                  |
| $C_{rss}$              | Reverse Transfer Capacitance    | —    | 7.1  | —    |       | $f = 1.0\text{MHz}$ , See Fig. 5                |
| $C_{oss}$              | Output Capacitance              | —    | 1957 | —    |       | $V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0\text{MHz}$ |
| $C_{oss}$              | Output Capacitance              | —    | 49   | —    |       | $V_{GS} = 0V, V_{DS} = 480V, f = 1.0\text{MHz}$ |
| $C_{oss \text{ eff.}}$ | Effective Output Capacitance    | —    | 96   | —    |       | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 480V$ ⑤   |

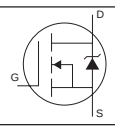
## Avalanche Characteristics

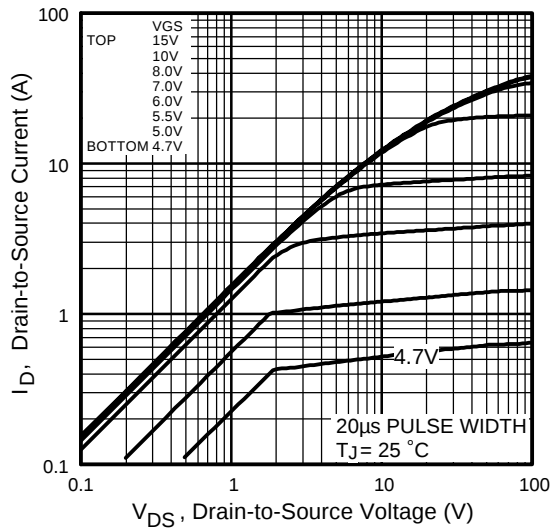
|          | Parameter                      | Typ. | Max. | Units |
|----------|--------------------------------|------|------|-------|
| $E_{AS}$ | Single Pulse Avalanche Energy② | —    | 290  | mJ    |
| $I_{AR}$ | Avalanche Current①             | —    | 9.2  | A     |
| $E_{AR}$ | Repetitive Avalanche Energy①   | —    | 17   | mJ    |

## Thermal Resistance

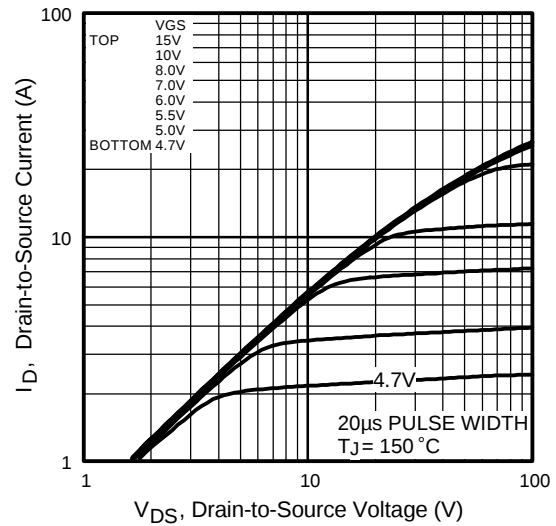
|                 | Parameter                                       | Typ. | Max. | Units              |
|-----------------|-------------------------------------------------|------|------|--------------------|
| $R_{\theta JC}$ | Junction-to-Case                                | —    | 0.75 | $^\circ\text{C/W}$ |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mounted, steady-state) | —    | 40   |                    |

## Diode Characteristics

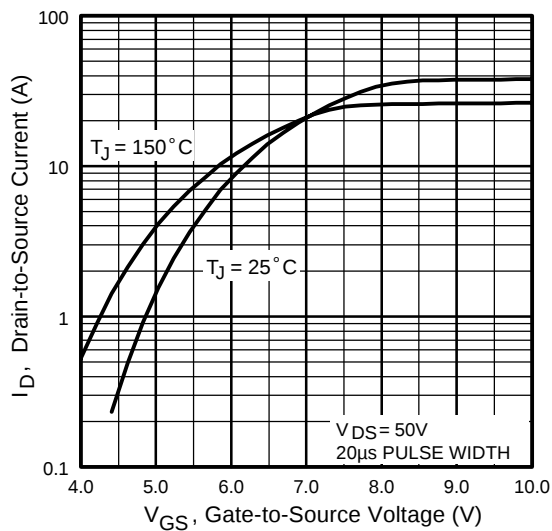
|          | Parameter                              | Min.                                                                        | Typ. | Max. | Units   | Conditions                                                                                                                                           |
|----------|----------------------------------------|-----------------------------------------------------------------------------|------|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current (Body Diode) | —                                                                           | —    | 9.2  | A       | MOSFET symbol showing the integral reverse p-n junction diode.  |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ①   | —                                                                           | —    | 37   |         |                                                                                                                                                      |
| $V_{SD}$ | Diode Forward Voltage                  | —                                                                           | —    | 1.5  | V       | $T_J = 25^\circ\text{C}, I_S = 9.2A, V_{GS} = 0V$ ④                                                                                                  |
| $t_{rr}$ | Reverse Recovery Time                  | —                                                                           | 530  | 800  | ns      | $T_J = 25^\circ\text{C}, I_F = 9.2A$                                                                                                                 |
| $Q_{rr}$ | Reverse Recovery Charge                | —                                                                           | 3.0  | 4.4  | $\mu C$ | $di/dt = 100A/\mu s$ ④                                                                                                                               |
| $t_{on}$ | Forward Turn-On Time                   | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ ) |      |      |         |                                                                                                                                                      |



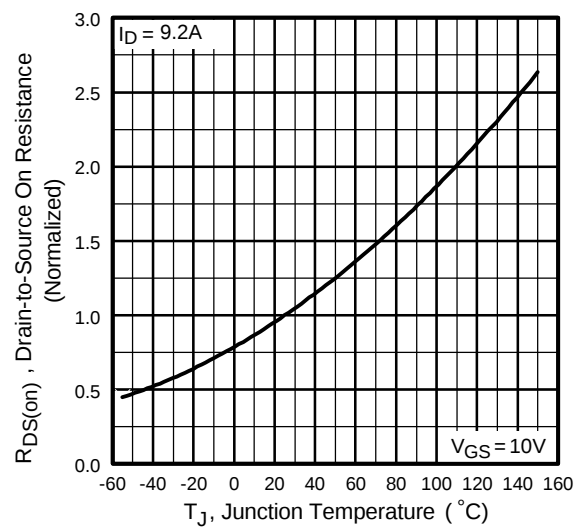
**Fig 1.** Typical Output Characteristics



**Fig 2.** Typical Output Characteristics



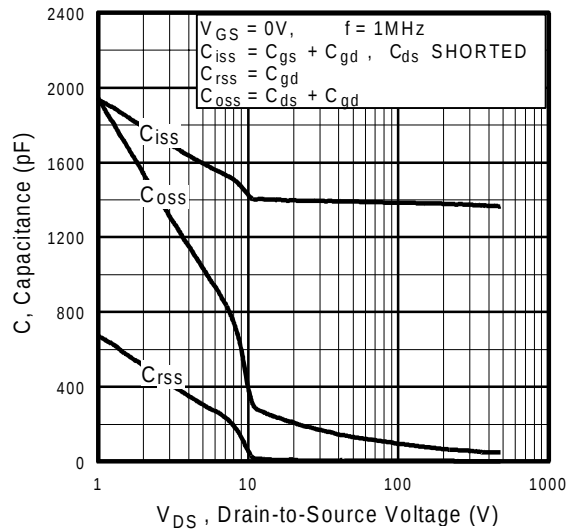
**Fig 3.** Typical Transfer Characteristics



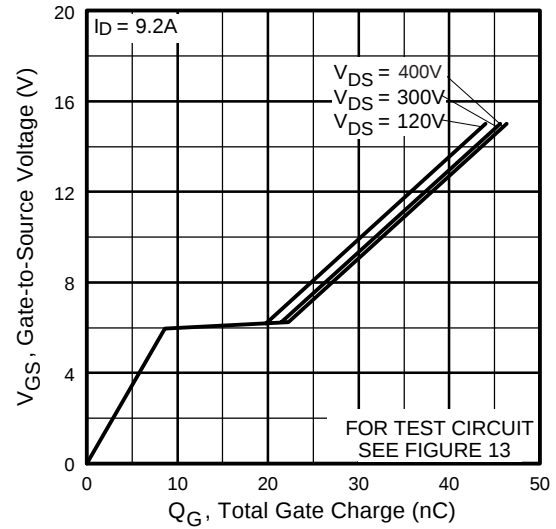
**Fig 4.** Normalized On-Resistance  
Vs. Temperature

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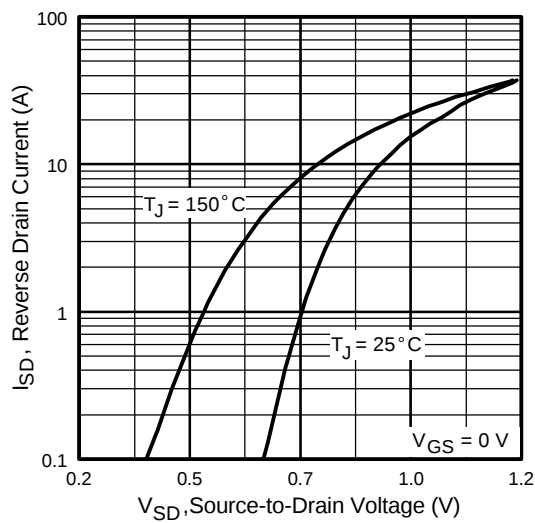
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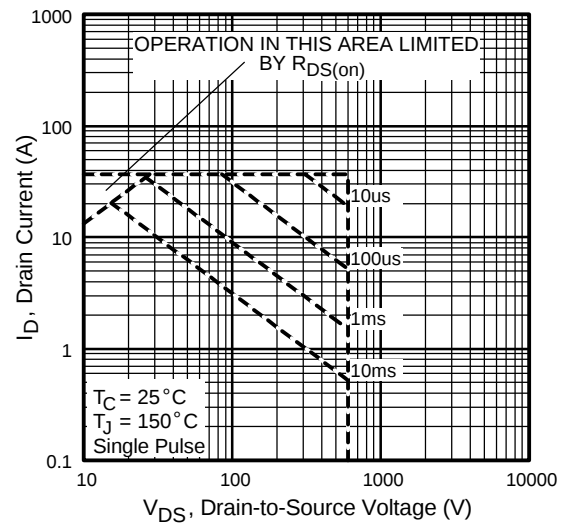
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



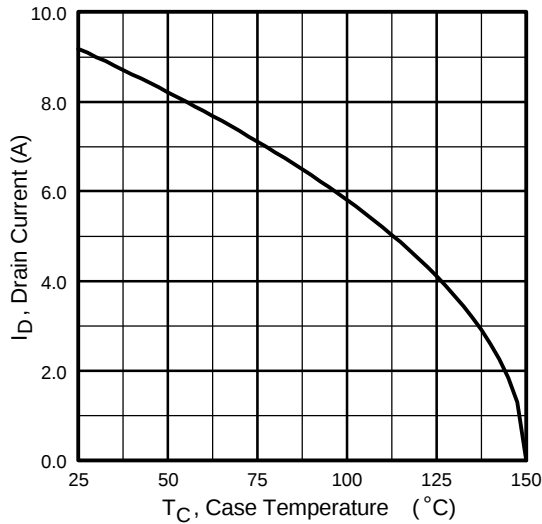
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



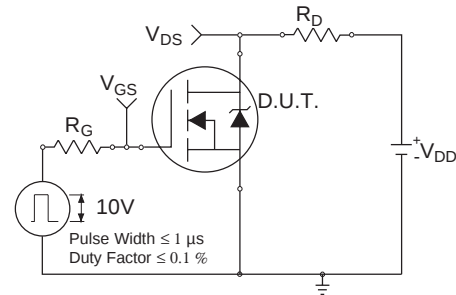
**Fig 7.** Typical Source-Drain Diode Forward Voltage



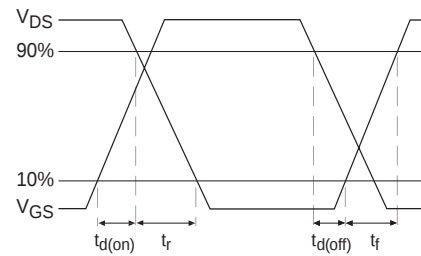
**Fig 8.** Maximum Safe Operating Area



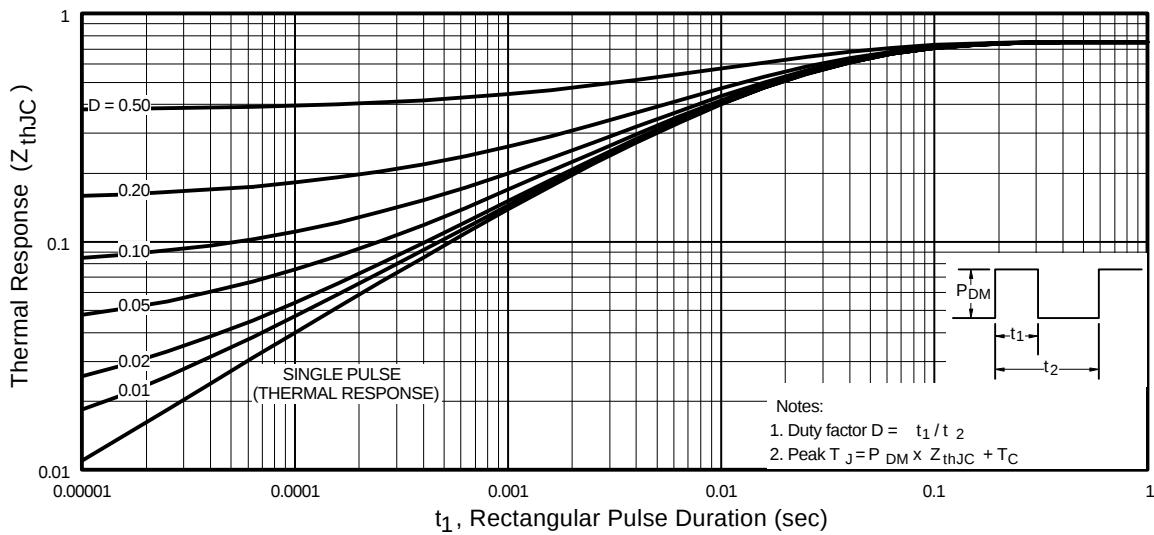
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



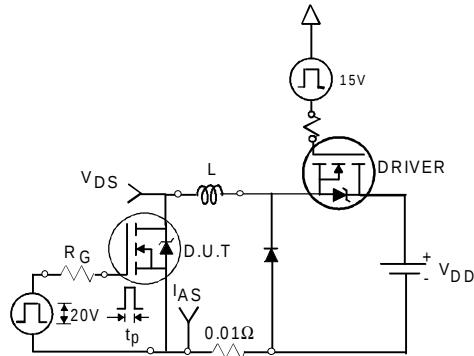
**Fig 10b.** Switching Time Waveforms



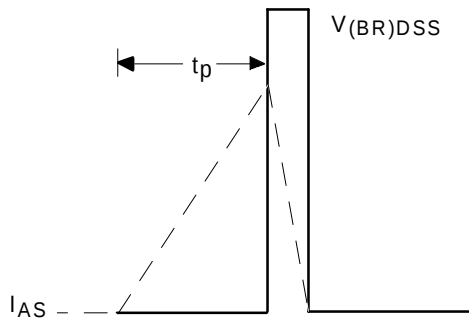
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

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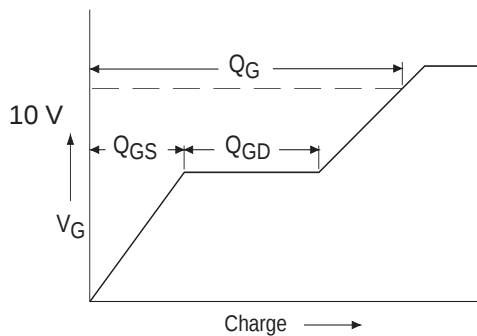
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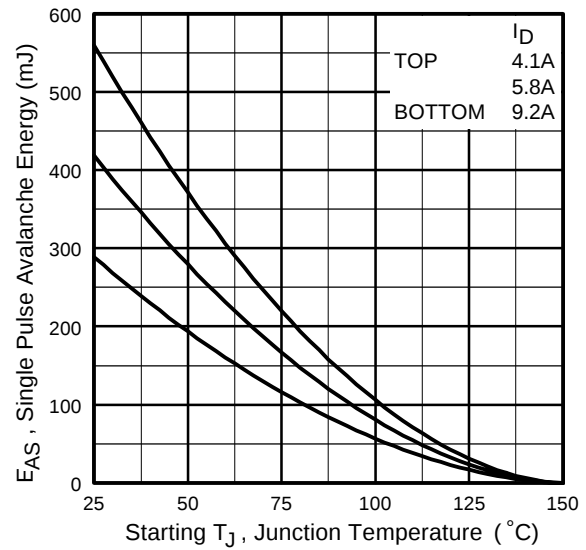
**Fig 12a.** Unclamped Inductive Test Circuit



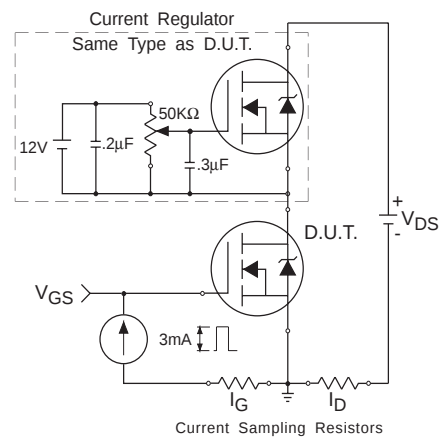
**Fig 12b.** Unclamped Inductive Waveforms



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



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



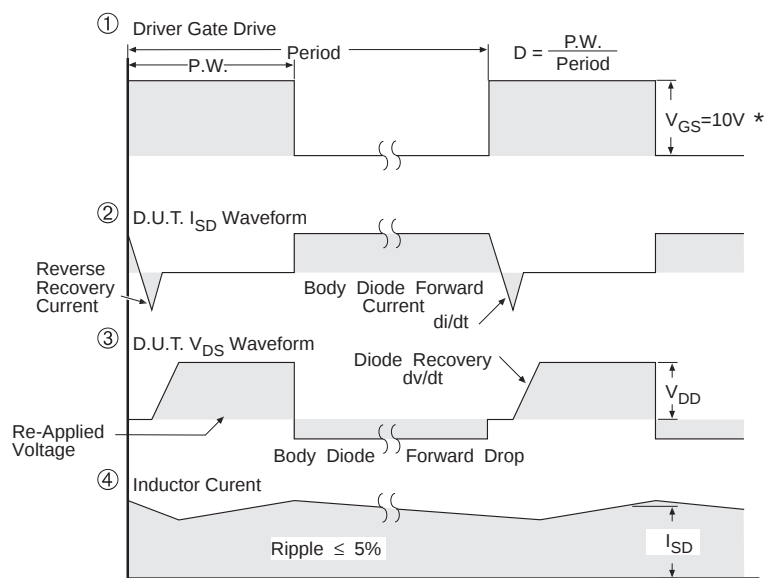
**Fig 13b.** Gate Charge Test Circuit

**Circuit Layout Considerations**

- Low Stray Inductance
- Ground Plane
- Low Leakage Inductance

**Current Transformer**

- $dv/dt$  controlled by  $R_G$
- Driver same type as D.U.T.
- $I_{SD}$  controlled by Duty Factor "D"
- D.U.T. - Device Under Test



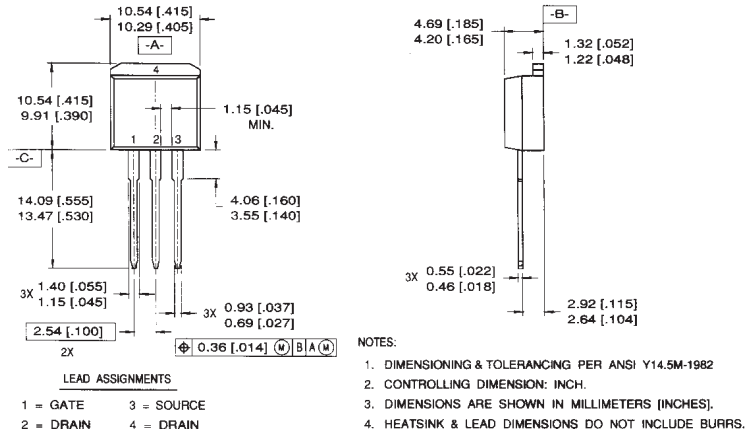
**Fig 14.** For N-Channel HEXFETS

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## Package Outline

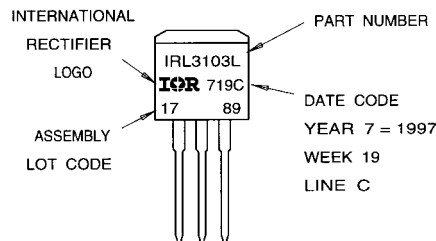
### TO-262 Outline



## Part Marking Information

### TO-262

EXAMPLE: THIS IS AN IRL3103L  
LOT CODE 1789  
ASSEMBLED ON WW 19, 1997  
IN THE ASSEMBLY LINE "C"



#### Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature. ( See fig. 11 )
- ② Starting  $T_J = 25^\circ\text{C}$ ,  $L = 6.8\text{mH}$   
 $R_G = 25\Omega$ ,  $I_{AS} = 9.2\text{A}$ . (See Figure 12)
- ③  $I_{SD} \leq 9.2\text{A}$ ,  $di/dt \leq 50\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  
 $T_J \leq 150^\circ\text{C}$
- ④ Pulse width  $\leq 300\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- 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%  $V_{DSS}$

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**WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, Tel: (310) 322 3331

**IR GREAT BRITAIN:** Hurst Green, Oxted, Surrey RH8 9BB, UK Tel: ++ 44 1883 732020

**IR CANADA:** 15 Lincoln Court, Brampton, Ontario L6T3Z2, Tel: (905) 453 2200

**IR GERMANY:** Saalburgstrasse 157, 61350 Bad Homburg Tel: ++ 49 6172 96590

**IR ITALY:** Via Liguria 49, 10071 Borgaro, Torino Tel: ++ 39 11 451 0111

**IR FAR EAST:** K&H Bldg., 2F, 30-4 Nishi-Ikebukuro 3-Chome, Toshima-Ku, Tokyo Japan 171 Tel: 81 3 3983 0086

**IR SOUTHEAST ASIA:** 1 Kim Seng Promenade, Great World City West Tower, 13-11, Singapore 237994 Tel: ++ 65 838 4630

**IR TAIWAN:** 16 Fl. Suite D. 207, Sec. 2, Tun Haw South Road, Taipei, 10673, Taiwan Tel: 886-2-2377-9936

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