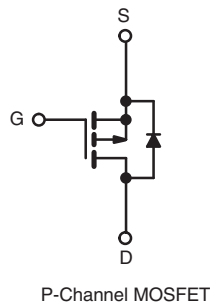
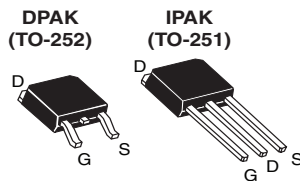


## Power MOSFET

| PRODUCT SUMMARY           |                         |
|---------------------------|-------------------------|
| $V_{DS}$ (V)              | - 200                   |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = - 10$ V   1.5 |
| $Q_g$ (Max.) (nC)         | 20                      |
| $Q_{gs}$ (nC)             | 3.3                     |
| $Q_{gd}$ (nC)             | 11                      |
| Configuration             | Single                  |



### FEATURES

- Halogen-free According to IEC 61249-2-21 Definition
- Dynamic  $dV/dt$  Rating
- Repetitive Avalanche Rated
- Surface Mount (IRFR9220, SiHFR9220)
- Straight Lead (IRFU9220, SiHFU9220)
- Available in Tape and Reel
- P-Channel
- Fast Switching
- Compliant to RoHS Directive 2002/95/EC



### DESCRIPTION

Third Power MOSFETs technology is the key to Vishay advanced line of Power MOSFET transistors. The efficient geometry and unique processing of the Power MOSFETs design achieve very low on-state resistance combined with high transconductance and extreme device ruggedness. The DPAK is designed for surface mounting using vapor phase, infrared, or wave soldering techniques. The straight lead version (IRFU, SiHFU series) is for through-hole mounting applications. Power dissipation levels up to 1.5 W are possible in typical surface mount applications.

| ORDERING INFORMATION            |               |                               |                               |                              |               |
|---------------------------------|---------------|-------------------------------|-------------------------------|------------------------------|---------------|
| Package                         | DPAK (TO-252) | DPAK (TO-252)                 | DPAK (TO-252)                 | DPAK (TO-252)                | IPAK (TO-251) |
| Lead (Pb)-free and Halogen-free | SiHFR9220-GE3 | SiHFR9220TRL-GE3 <sup>a</sup> | SiHFR9220TRR-GE3 <sup>a</sup> | SiHFR9220TR-GE3 <sup>a</sup> | SiHFU9220-GE3 |
| Lead (Pb)-free                  | IRFR9220PbF   | IRFR9220TRLPbF <sup>a</sup>   | IRFR9220TRRPbF <sup>a</sup>   | IRFR9220TRPbF <sup>a</sup>   | IRFU9220PbF   |
|                                 | SiHFR9220-E3  | SiHFR9220TL-E3 <sup>a</sup>   | SiHFR9220TR-E3 <sup>a</sup>   | SiHFR9220T-E3 <sup>a</sup>   | SiHFU9220-E3  |
| SnPb                            | IRFR9220      | IRFR9220TRL <sup>a</sup>      | IRFR9220TRR <sup>a</sup>      | IRFR9220TR <sup>a</sup>      | IRFU9220      |
|                                 | SiHFR9220     | SiHFR9220TL <sup>a</sup>      | SiHFR9220TR <sup>a</sup>      | SiHFR9220T <sup>a</sup>      | SiHFU9220     |

#### Note

a. See device orientation.

| ABSOLUTE MAXIMUM RATINGS $T_C = 25$ °C, unless otherwise noted |                    |                             |       |
|--|--------------------|-----------------------------|-------|
| PARAMETER  | SYMBOL             | LIMIT                       | UNIT  |
| Drain-Source Voltage   | $V_{DS}$           | - 200                       | V     |
| Gate-Source Voltage  | $V_{GS}$           | $\pm 20$                    |       |
| Continuous Drain Current                                       | $V_{GS}$ at - 10 V | $T_C = 25$ °C               | - 3.6 |
|  |                    | $T_C = 100$ °C              | - 2.3 |
| Pulsed Drain Current <sup>a</sup>                              | $I_{DM}$           | - 14                        | A     |
| Linear Derating Factor   |                    | 0.33                        |       |
| Linear Derating Factor (PCB Mount) <sup>e</sup>                |                    | 0.020                       | W/°C  |
| Single Pulse Avalanche Energy <sup>b</sup>                     | $E_{AS}$           | 310                         | mJ    |
| Repetitive Avalanche Current <sup>a</sup>                      | $I_{AR}$           | - 3.6                       | A     |
| Repetitive Avalanche Energy <sup>a</sup>                       | $E_{AR}$           | 4.2                         | mJ    |
| Maximum Power Dissipation                                      | $P_D$              | $T_C = 25$ °C               | 42    |
| Maximum Power Dissipation (PCB Mount) <sup>e</sup>             |                    | $T_A = 25$ °C               | 2.5   |
| Peak Diode Recovery $dV/dt^c$                                  |                    | - 5.0                       | V/ns  |
| Operating Junction and Storage Temperature Range               | $T_J, T_{stg}$     | - 55 to + 150               | °C    |
| Soldering Recommendations (Peak Temperature)                   |                    | for 10 s   260 <sup>d</sup> |       |

#### Notes

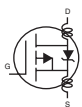
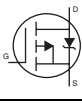
- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- $V_{DD} = - 50$  V, Starting  $T_J = 25$  °C,  $L = 35$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = - 3.6$  A (see fig. 12).
- $I_{SD} \leq - 3.9$  A,  $dI/dt \leq 95$  A/ $\mu$ s,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150$  °C.
- 1.6 mm from case.
- When mounted on 1" square PCB (FR-4 or G-10 material).

\* Pb containing terminations are not RoHS compliant, exemptions may apply

| THERMAL RESISTANCE RATINGS                           |            |      |      |      |      |  |
|--|------------|------|------|------|------|--|
| PARAMETER  | SYMBOL     | MIN. | TYP. | MAX. | UNIT |  |
| Maximum Junction-to-Ambient                          | $R_{thJA}$ | -    | -    | 110  | °C/W |  |
| Maximum Junction-to-Ambient (PCB Mount) <sup>a</sup> | $R_{thJA}$ | -    | -    | 50   |      |  |
| Maximum Junction-to-Case (Drain)                     | $R_{thJC}$ | -    | -    | 3.0  |      |  |

**Note**

a. When mounted on 1" square PCB (FR-4 or G-10 material).

| SPECIFICATIONS $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted |                     |  |  |       |        |                      |    |
|--|---------------------|--|--|-------|--------|----------------------|----|
| PARAMETER  | SYMBOL              | TEST CONDITIONS  |  | MIN.  | TYP.   | MAX. UNIT            |    |
| <b>Static</b>  |                     |  |  |       |        |                      |    |
| Drain-Source Breakdown Voltage   | $V_{DS}$            | $V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$   |  | - 200 | -      | - V                  |    |
| $V_{DS}$ Temperature Coefficient   | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$ , $I_D = -1\text{ mA}$   |  | -     | - 0.22 | - $V/^\circ\text{C}$ |    |
| Gate-Source Threshold Voltage  | $V_{GS(th)}$        | $V_{DS} = V_{GS}, I_D = -250\text{ }\mu\text{A}$   |  | - 2.0 | -      | - 4.0 V              |    |
| Gate-Source Leakage  | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$   |  | -     | -      | $\pm 100\text{ nA}$  |    |
| Zero Gate Voltage Drain Current  | $I_{DSS}$           | $V_{DS} = -200\text{ V}, V_{GS} = 0\text{ V}$  |  | -     | -      | - 100 $\mu\text{A}$  |    |
|  |                     | $V_{DS} = -160\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$   |  | -     | -      | - 500 $\mu\text{A}$  |    |
| Drain-Source On-State Resistance   | $R_{DS(on)}$        | $V_{GS} = -10\text{ V}$  | $I_D = -2.2\text{ A}^b$  | -     | -      | 1.5 $\Omega$         |    |
| Forward Transconductance   | $g_{fs}$            | $V_{DS} = -50\text{ V}, I_D = -2.2\text{ A}$   |  | 1.1   | -      | - S                  |    |
| <b>Dynamic</b>   |                     |  |  |       |        |                      |    |
| Input Capacitance  | $C_{iss}$           | $V_{GS} = 0\text{ V}, V_{DS} = -25\text{ V}, f = 1.0\text{ MHz}$ , see fig. 5  |  | -     | 340    | -                    |    |
| Output Capacitance   | $C_{oss}$           |  |  | -     | 110    | -                    | pF |
| Reverse Transfer Capacitance   | $C_{rss}$           |  |  | -     | 33     | -                    |    |
| Total Gate Charge  | $Q_g$               | $V_{GS} = -10\text{ V}$  | $I_D = -3.9\text{ A}, V_{DS} = -160\text{ V}$ , see fig. 6 and 13 <sup>b</sup> | -     | -      | 20                   |    |
| Gate-Source Charge   | $Q_{gs}$            |  |  | -     | -      | 3.3                  | nC |
| Gate-Drain Charge  | $Q_{gd}$            |  |  | -     | -      | 11                   |    |
| Turn-On Delay Time   | $t_{d(on)}$         | $V_{DD} = -100\text{ V}, I_D = -3.9\text{ A}, R_g = 18\text{ }\Omega, R_D = 24\text{ }\Omega$ , see fig. 10 <sup>b</sup>                               |  | -     | 8.8    | -                    |    |
| Rise Time  | $t_r$               |  |  | -     | 27     | -                    | ns |
| Turn-Off Delay Time  | $t_{d(off)}$        |  |  | -     | 7.3    | -                    |    |
| Fall Time  | $t_f$               |  |  | -     | 19     | -                    |    |
| Internal Drain Inductance  | $L_D$               | Between lead, 6 mm (0.25") from package and center of die contact  |  | -     | 4.5    | -                    |    |
| Internal Source Inductance   | $L_S$               |  |  | -     | 7.5    | -                    | nH |
| <b>Drain-Source Body Diode Characteristics</b>                           |                     |  |  |       |        |                      |    |
| Continuous Source-Drain Diode Current                                    | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode    |  | -     | -      | - 3.6                |    |
| Pulsed Diode Forward Current <sup>a</sup>                                | $I_{SM}$            |  |  | -     | -      | - 14                 | A  |
| Body Diode Voltage   | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}, I_S = -3.6\text{ A}, V_{GS} = 0\text{ V}^b$   |  | -     | -      | - 6.3 V              |    |
| Body Diode Reverse Recovery Time   | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}, I_F = -3.9\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$  |  | -     | 150    | 300 ns               |    |
| Body Diode Reverse Recovery Charge                                       | $Q_{rr}$            |  |  | -     | 0.97   | 2.0 $\mu\text{C}$    |    |
| 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  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

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

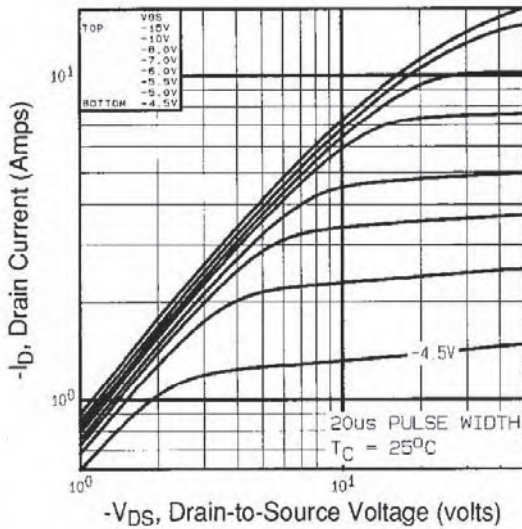


Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$

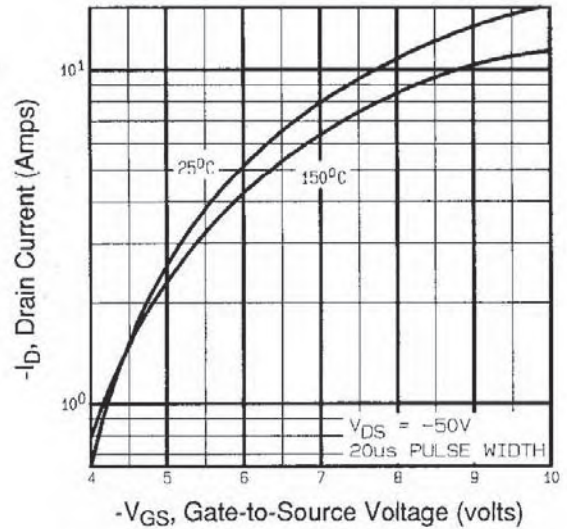


Fig. 3 - Typical Transfer Characteristics

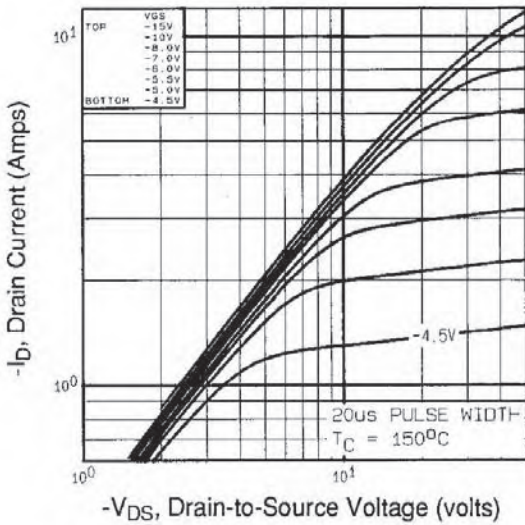


Fig. 2 - Typical Output Characteristics,  $T_C = 150^\circ\text{C}$

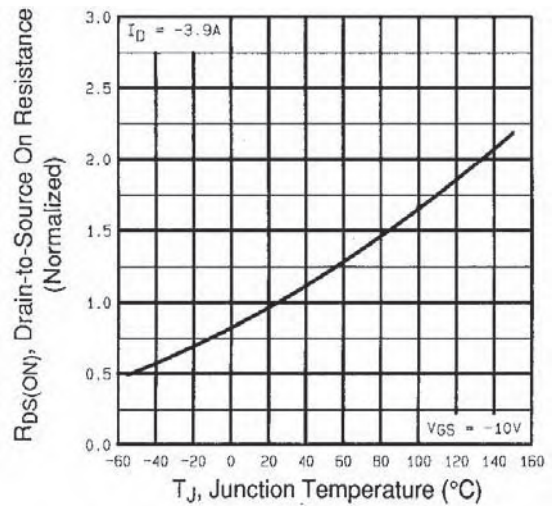


Fig. 4 - Normalized On-Resistance vs. Temperature

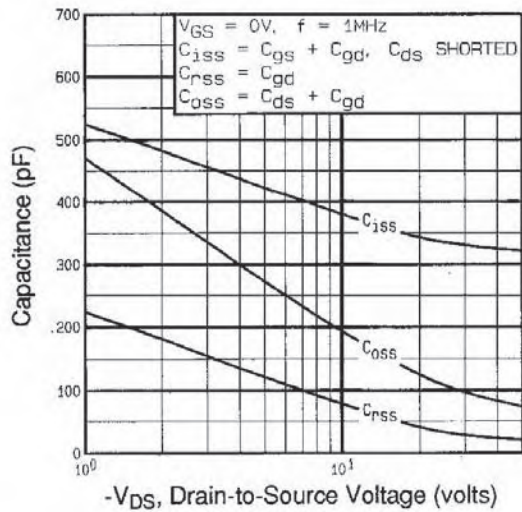


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

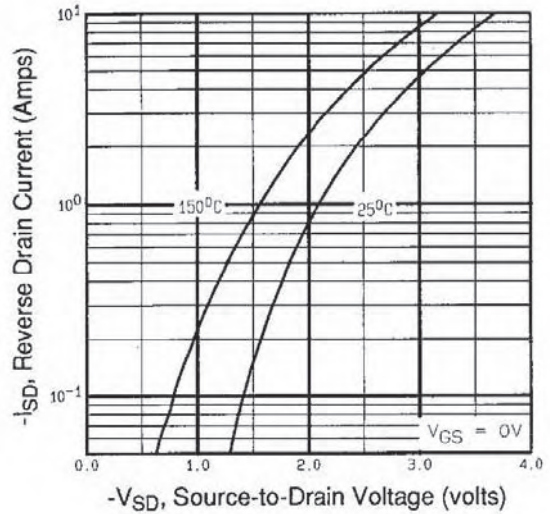


Fig. 7 - Typical Source-Drain Diode Forward Voltage

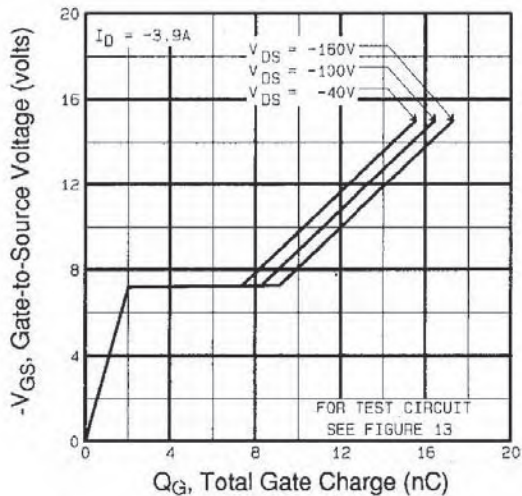


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

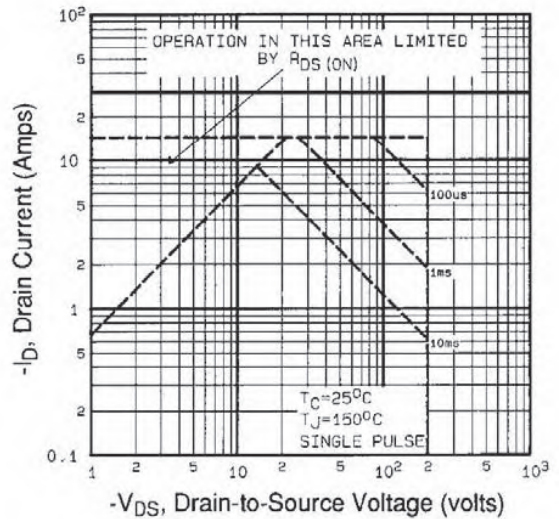


Fig. 8 - Maximum Safe Operating Area



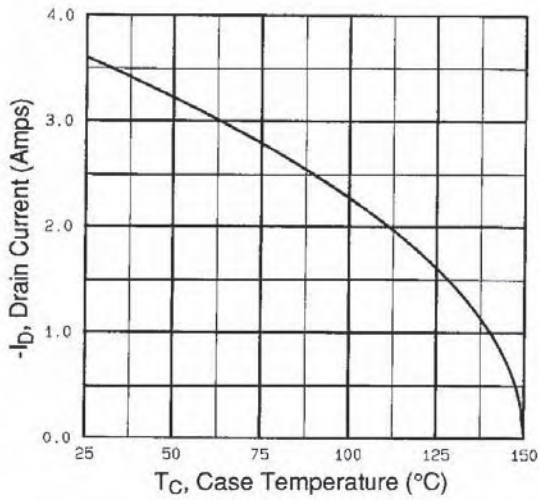


Fig. 9 - Maximum Drain Current vs. Case Temperature

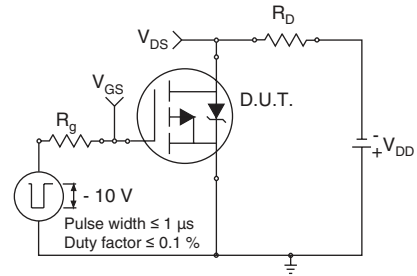


Fig. 10a - Switching Time Test Circuit

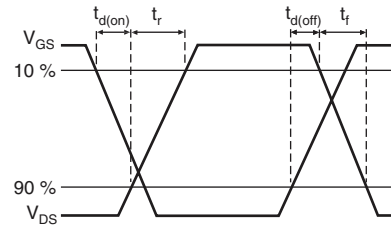


Fig. 10b - Switching Time Waveforms

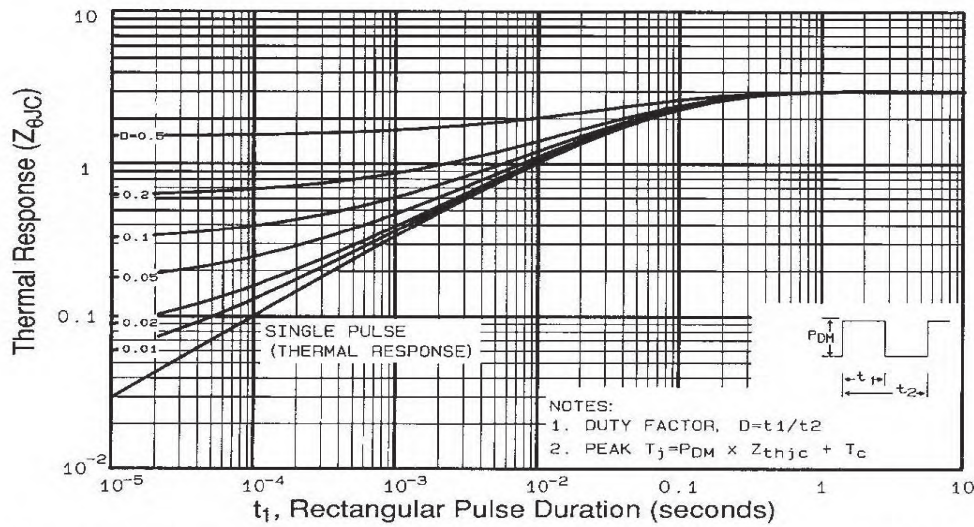


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

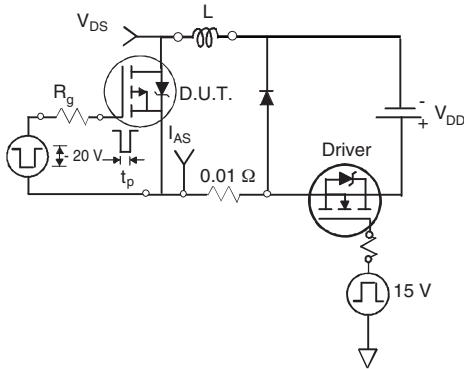


Fig. 12a - Unclamped Inductive Test Circuit

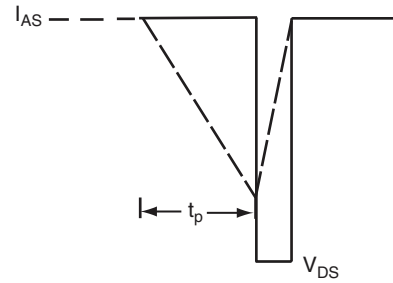


Fig. 12b - Unclamped Inductive Waveforms

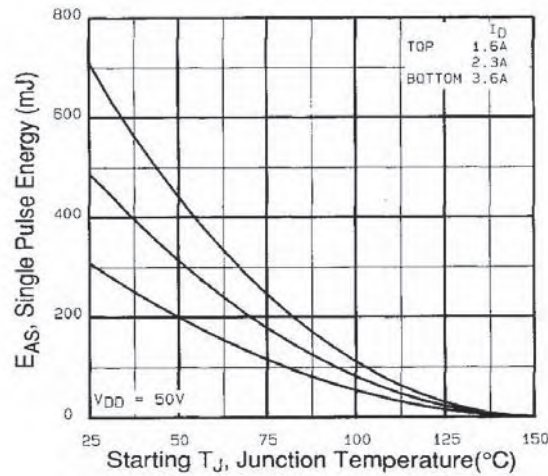


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

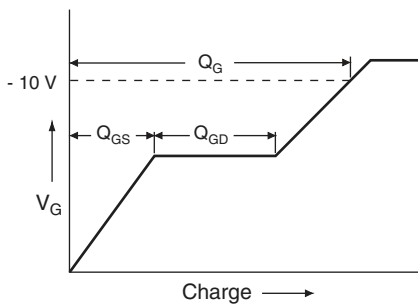


Fig. 13a - Basic Gate Charge Waveform

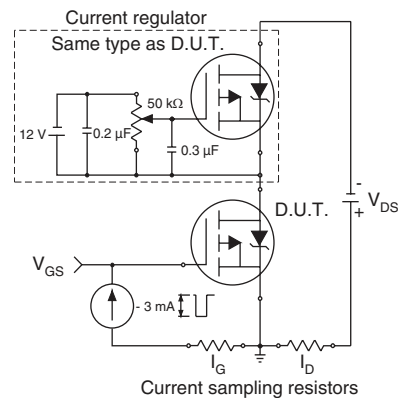
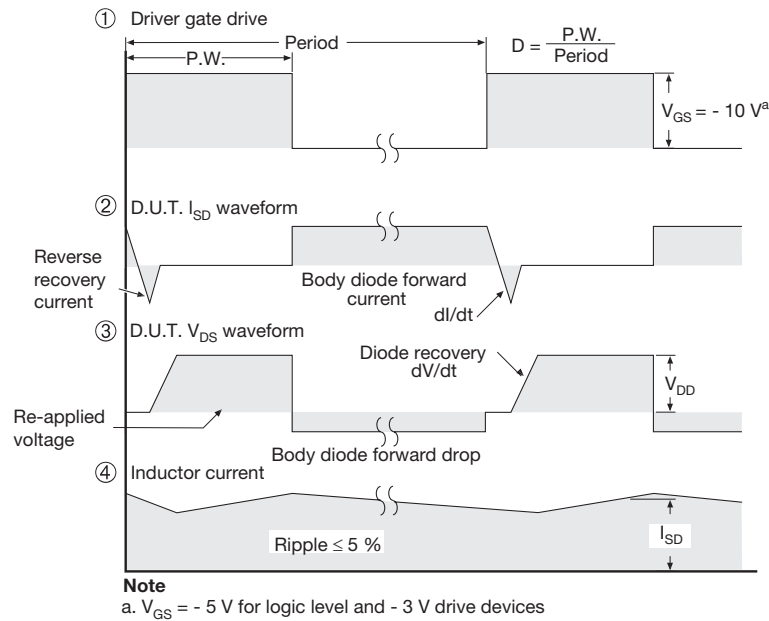
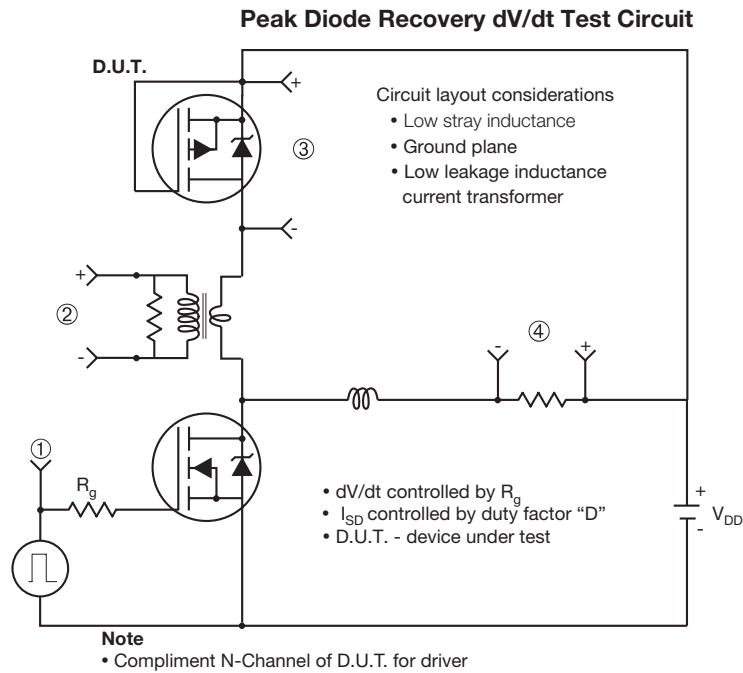


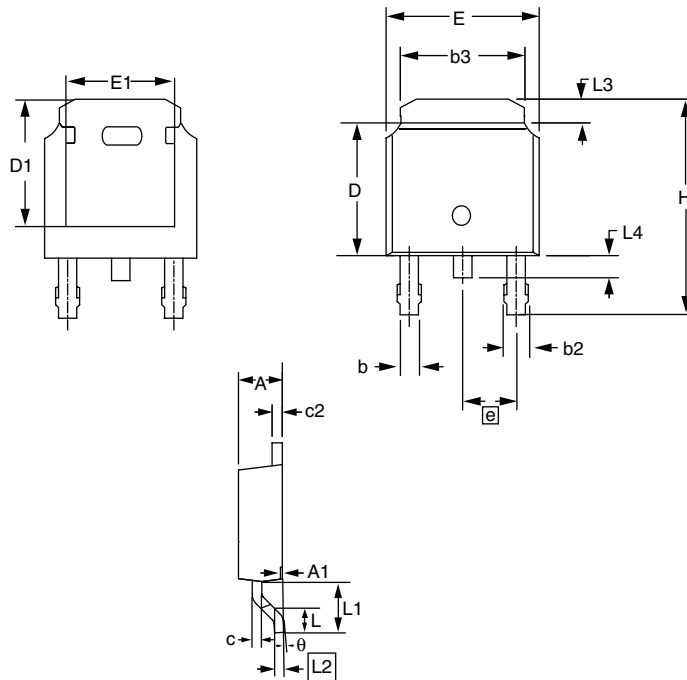
Fig. 13b - Gate Charge Test Circuit



**Fig. 14 - For P-Channel**

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## TO-252AA (HIGH VOLTAGE)



| DIM. | MILLIMETERS |       | INCHES    |       |
|------|-------------|-------|-----------|-------|
|      | MIN.        | MAX.  | MIN.      | MAX.  |
| E    | 6.40        | 6.73  | 0.252     | 0.265 |
| L    | 1.40        | 1.77  | 0.055     | 0.070 |
| L1   | 2.743 REF   |       | 0.108 REF |       |
| L2   | 0.508 BSC   |       | 0.020 BSC |       |
| L3   | 0.89        | 1.27  | 0.035     | 0.050 |
| L4   | 0.64        | 1.01  | 0.025     | 0.040 |
| D    | 6.00        | 6.22  | 0.236     | 0.245 |
| H    | 9.40        | 10.40 | 0.370     | 0.409 |
| b    | 0.64        | 0.88  | 0.025     | 0.035 |
| b2   | 0.77        | 1.14  | 0.030     | 0.045 |
| b3   | 5.21        | 5.46  | 0.205     | 0.215 |
| e    | 2.286 BSC   |       | 0.090 BSC |       |
| A    | 2.20        | 2.38  | 0.087     | 0.094 |
| A1   | 0.00        | 0.13  | 0.000     | 0.005 |
| c    | 0.45        | 0.60  | 0.018     | 0.024 |
| c2   | 0.45        | 0.58  | 0.018     | 0.023 |
| D1   | 5.30        | -     | 0.209     | -     |
| E1   | 4.40        | -     | 0.173     | -     |
| θ    | 0'          | 10'   | 0'        | 10'   |

ECN: S-81965-Rev. A, 15-Sep-08  
 DWG: 5973

### Notes

1. Package body sizes exclude mold flash, protrusion or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 0.10 mm per side.
2. Package body sizes determined at the outermost extremes of the plastic body exclusive of mold flash, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body.
3. The package top may be smaller than the package bottom.
4. Dimension "b" does not include dambar protrusion. Allowable dambar protrusion shall be 0.10 mm total in excess of "b" dimension at maximum material condition. The dambar cannot be located on the lower radius of the foot.



### TO-251AA (HIGH VOLTAGE)



| DIM. | MILLIMETERS |      | INCHES |       |
|------|-------------|------|--------|-------|
|      | MIN.        | MAX. | MIN.   | MAX.  |
| A    | 2.18        | 2.39 | 0.086  | 0.094 |
| A1   | 0.89        | 1.14 | 0.035  | 0.045 |
| b    | 0.64        | 0.89 | 0.025  | 0.035 |
| b1   | 0.65        | 0.79 | 0.026  | 0.031 |
| b2   | 0.76        | 1.14 | 0.030  | 0.045 |
| b3   | 0.76        | 1.04 | 0.030  | 0.041 |
| b4   | 4.95        | 5.46 | 0.195  | 0.215 |
| c    | 0.46        | 0.61 | 0.018  | 0.024 |
| c1   | 0.41        | 0.56 | 0.016  | 0.022 |
| c2   | 0.46        | 0.86 | 0.018  | 0.034 |
| D    | 5.97        | 6.22 | 0.235  | 0.245 |

| DIM.   | MILLIMETERS |      | INCHES   |       |
|--------|-------------|------|----------|-------|
|        | MIN.        | MAX. | MIN.     | MAX.  |
| D1     | 5.21        | -    | 0.205    | -     |
| E      | 6.35        | 6.73 | 0.250    | 0.265 |
| E1     | 4.32        | -    | 0.170    | -     |
| e      | 2.29 BSC    |      | 2.29 BSC |       |
| L      | 8.89        | 9.65 | 0.350    | 0.380 |
| L1     | 1.91        | 2.29 | 0.075    | 0.090 |
| L2     | 0.89        | 1.27 | 0.035    | 0.050 |
| L3     | 1.14        | 1.52 | 0.045    | 0.060 |
| theta1 | 0'          | 15'  | 0'       | 15'   |
| theta2 | 25'         | 35'  | 25'      | 35'   |

ECN: S-82111-Rev. A, 15-Sep-08  
 DWG: 5968

#### Notes

1. Dimensioning and tolerancing per ASME Y14.5M-1994.
2. Dimension are shown in inches and millimeters.
3. Dimension D and E do not include mold flash. Mold flash shall not exceed 0.13 mm (0.005") per side. These dimensions are measured at the outermost extremes of the plastic body.
4. Thermal pad contour optional with dimensions b4, L2, E1 and D1.
5. Lead dimension uncontrolled in L3.
6. Dimension b1, b3 and c1 apply to base metal only.
7. Outline conforms to JEDEC outline TO-251AA.



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