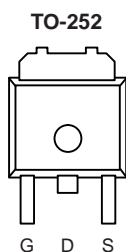


## N-Channel 650 V (D-S)MOSFET

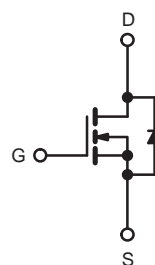
| PRODUCT SUMMARY           |                 |     |
|---------------------------|-----------------|-----|
| $V_{DS}$ (V)              | 650             |     |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10$ V | 3.8 |
| $Q_g$ (Max.) (nC)         | 15              |     |
| $Q_{gs}$ (nC)             | 3               |     |
| $Q_{gd}$ (nC)             | 6               |     |
| 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
- Compliant to RoHS directive 2002/95/EC


 Available  
**RoHS**


Top View




N-Channel MOSFET

| ABSOLUTE MAXIMUM RATINGS $T_C = 25$ °C, unless otherwise noted |                  |                |               |       |
|--|------------------|----------------|---------------|-------|
| PARAMETER  | SYMBOL           | LIMIT          | UNIT          |       |
| Drain-Source Voltage   | $V_{DS}$         | 650            | V             |       |
| Gate-Source Voltage  | $V_{GS}$         | $\pm 30$       |               |       |
| Continuous Drain Current <sup>e</sup>                          | $V_{GS}$ at 10 V | $T_C = 25$ °C  | A             |       |
| Continuous Drain Current                                       |                  | $T_C = 100$ °C |               |       |
| Pulsed Drain Current <sup>a</sup>                              | $I_{DM}$         | 8.0            |               |       |
| Linear Derating Factor   |                  | 0.48           | W/°C          |       |
| Single Pulse Avalanche Energy <sup>b</sup>                     | $E_{AS}$         | 165            | mJ            |       |
| Repetitive Avalanche Current <sup>a</sup>                      | $I_{AR}$         | 2              | A             |       |
| Repetitive Avalanche Energy <sup>a</sup>                       | $E_{AR}$         | 4              | mJ            |       |
| Maximum Power Dissipation                                      | $T_C = 25$ °C    | $P_D$          | 60            | W     |
| Peak Diode Recovery $dV/dt$ <sup>c</sup>                       |                  | $dV/dt$        | 2.8           | V/ns  |
| Operating Junction and Storage Temperature Range               | $T_J, T_{stg}$   |                | - 55 to + 150 | °C    |
| Soldering Recommendations (Peak Temperature) <sup>d</sup>      | for 10 s         |                | 300           |       |
| Mounting Torque  | 6-32 or M3 screw |                | 10            |       |
|  |                  |                | 1.1           | N · m |

### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- Starting  $T_J = 25$  °C,  $L = 24$  mH,  $R_G = 25$   $\Omega$ ,  $I_{AS} = 3.2$  A (see fig. 12).
- $I_{SD} \leq 3.2$  A,  $dI/dt \leq 90$  A/ $\mu$ s,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150$  °C.
- 1.6 mm from case.
- Drain current limited by maximum junction temperature.

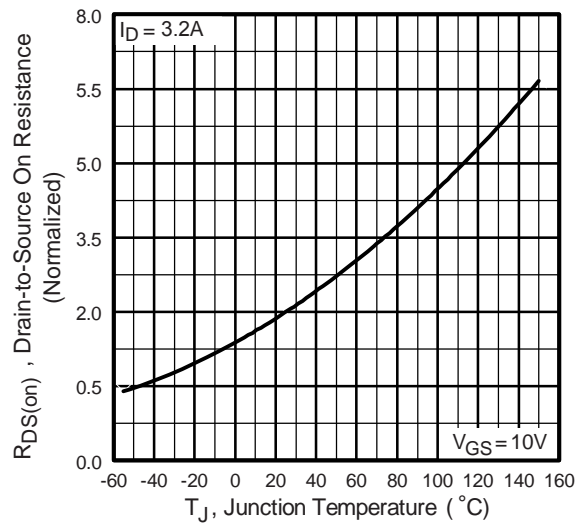
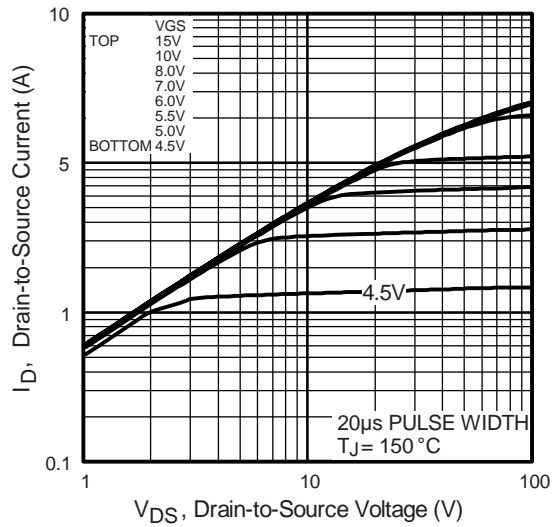
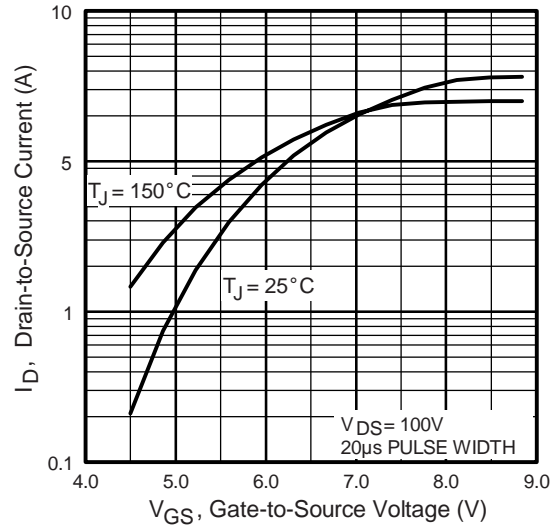
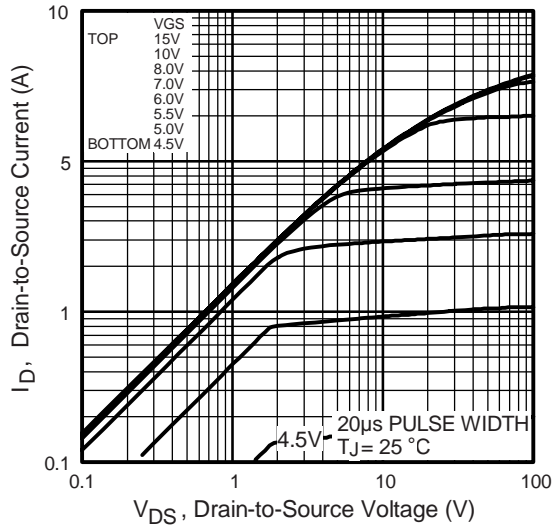
| THERMAL RESISTANCE RATINGS       |            |      |      |      |
|----------------------------------|------------|------|------|------|
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 65   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 2.1  |      |

| 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   | $V_{DS}$              | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$  |  | 650  | -    | -         | V             |
| $V_{DS}$ Temperature Coefficient   | $\Delta V_{DS}/T_J$   | Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}^d$  |  | -    | 670  | -         | mV/°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  | $I_{GSS}$             | $V_{GS} = \pm 30\text{ V}$   |  | -    | -    | $\pm 100$ | nA            |
| Zero Gate Voltage Drain Current  | $I_{DSS}$             | $V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$   |  | -    | -    | 25        | $\mu\text{A}$ |
|  |                       | $V_{DS} = 520\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$  |  | -    | -    | 250       |               |
| Drain-Source On-State Resistance   | $R_{DS(on)}$          | $V_{GS} = 10\text{ V}$   | $I_D = 3.1\text{ A}^b$   | -    | 3.8  | -         | $\Omega$      |
| Forward Transconductance   | $g_{fs}$              | $V_{DS} = 50\text{ V}, I_D = 3.1\text{ A}$   |  | 3.9  | -    | -         | 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   |  | -    | 330  | -         | pF            |
| Output Capacitance   | $C_{oss}$             |  |  | -    | 40   | -         |               |
| Reverse Transfer Capacitance   | $C_{rss}$             |  |  | -    | 5.0  | -         |               |
| Output Capacitance   | $C_{oss}$             | $V_{GS} = 0\text{ V}$  | $V_{DS} = 1.0\text{ V}, f = 1.0\text{ MHz}$  | -    | 912  | -         | pF            |
|  |                       |  | $V_{DS} = 520\text{ V}, f = 1.0\text{ MHz}$  | -    | 48   | -         |               |
| Effective Output Capacitance   | $C_{oss\text{ eff.}}$ | $V_{DS} = 0\text{ V to } 520\text{ V}^c$   |  | -    | 84   | -         |               |
| Total Gate Charge  | $Q_g$                 | $V_{GS} = 10\text{ V}$   | $I_D = 3.2\text{ A}, V_{DS} = 400\text{ V}$<br>see fig. 6 and 13 <sup>b</sup>        | -    | -    | 15        | nC            |
| Gate-Source Charge   | $Q_{gs}$              |  |  | -    | -    | 3         |               |
| Gate-Drain Charge  | $Q_{gd}$              |  |  | -    | -    | 6         |               |
| Turn-On Delay Time   | $t_{d(on)}$           | $V_{DD} = 325\text{ V}, I_D = 3.2\text{ A}$<br>$R_G = 9.1\text{ }\Omega, R_D = 62\text{ }\Omega$ ,<br>see fig. 10 <sup>b</sup> |  | -    | 14   | -         | ns            |
| Rise Time  | $t_r$                 |  |  | -    | 20   | -         |               |
| Turn-Off Delay Time  | $t_{d(off)}$          |  |  | -    | 34   | -         |               |
| Fall Time  | $t_f$                 |  |  | -    | 18   | -         |               |
| <b>Drain-Source Body Diode Characteristics</b>                           |                       |  |  |      |      |           |               |
| Continuous Source-Drain Diode Current                                    | $I_S$                 | MOSFET symbol showing the integral reverse p - n junction diode  |  | -    | -    | 4         | A             |
| Pulsed Diode Forward Current <sup>a</sup>                                | $I_{SM}$              |  |  | -    | -    | 21        |               |
| Body Diode Voltage   | $V_{SD}$              | $T_J = 25\text{ }^\circ\text{C}, I_S = 3.2\text{ A}, V_{GS} = 0\text{ V}^b$  |  | -    | -    | 1.5       | V             |
| Body Diode Reverse Recovery Time   | $t_{rr}$              | $T_J = 25\text{ }^\circ\text{C}, I_F = 3.2\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$                                       |  | -    | 493  | 739       | ns            |
| Body Diode Reverse Recovery Charge                                       | $Q_{rr}$              |  |  | -    | 2.1  | 3.2       | $\mu\text{C}$ |
| Forward Turn-On Time   | $t_{on}$              | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$ and $L_D$ )  |  |      |      |           |               |

**Notes**

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- $C_{oss\text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DS}$ .
- $t = 60\text{ s}, f = 60\text{ Hz}$ .

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



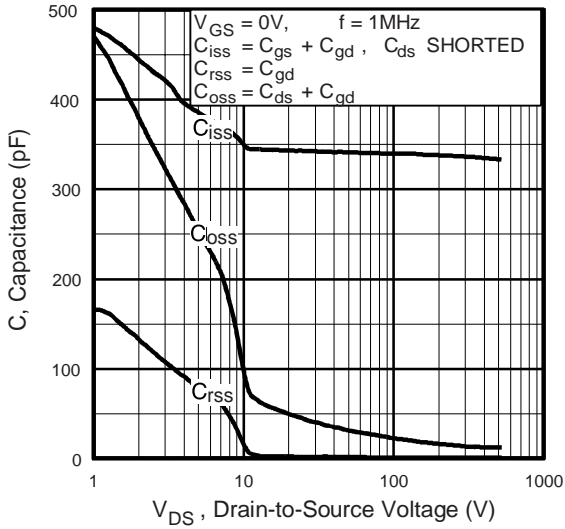


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage



Fig. 7 - Typical Source-Drain Diode Forward Voltage

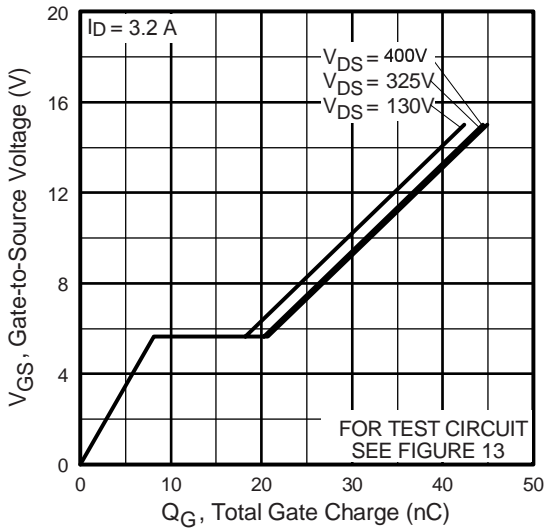


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

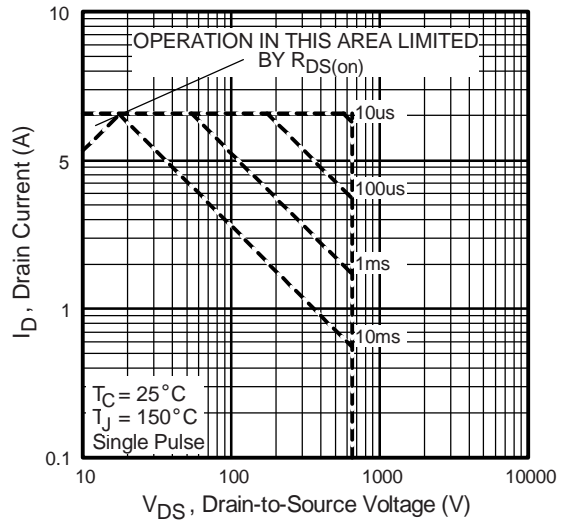


Fig. 8 - Maximum Safe Operating Area



Fig. 9 - Maximum Drain Current vs. Case Temperature

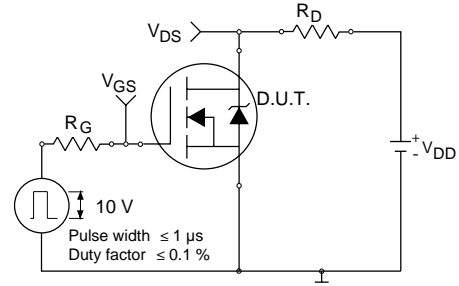


Fig. 10a - Switching Time Test Circuit



Fig. 10b - Switching Time Waveforms

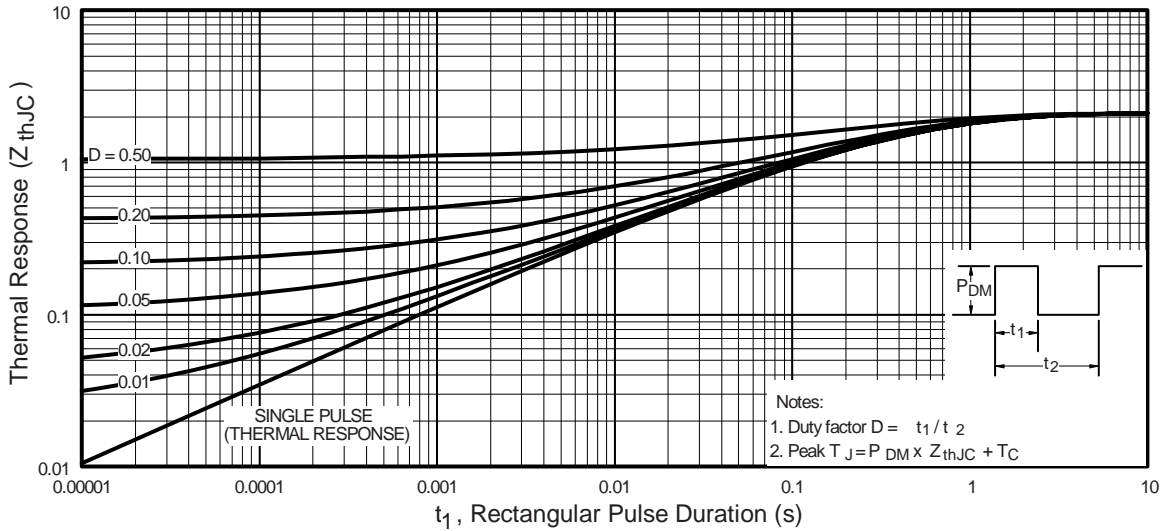


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

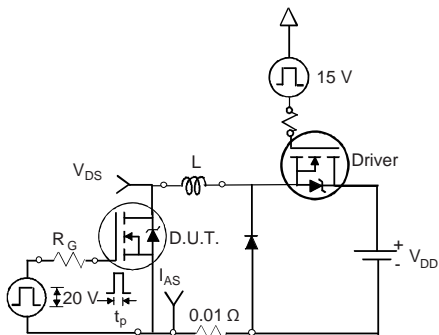


Fig. 12a - Unclamped Inductive Test Circuit

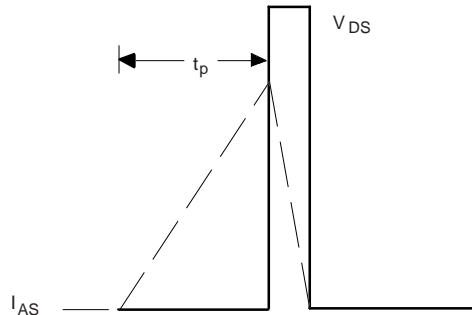


Fig. 12b - Unclamped Inductive Waveforms

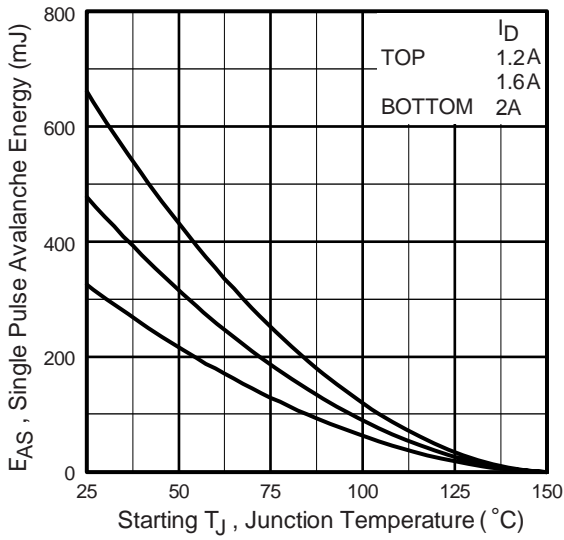


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

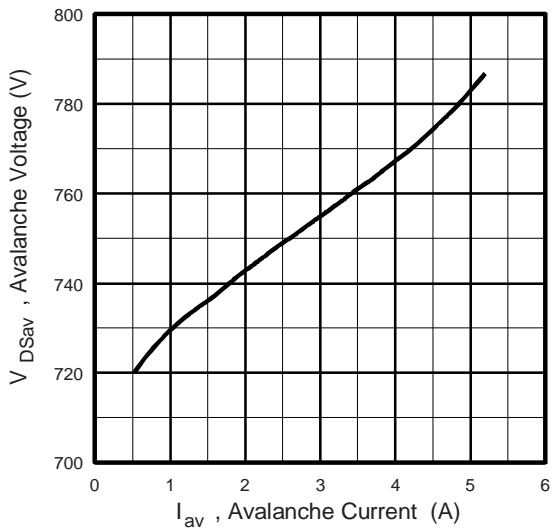


Fig. 12d - Typical Drain-to Source Voltage vs. Avalanche Current



Fig. 13a - Basic Gate Charge Waveform

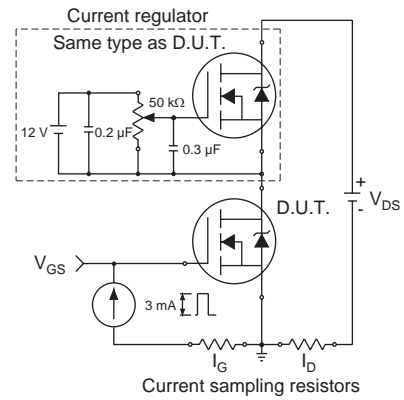
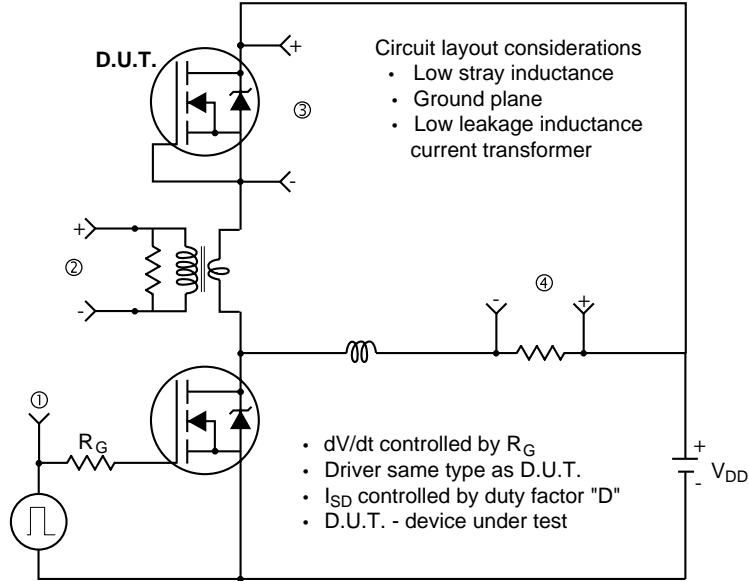


Fig. 13b - Gate Charge Test Circuit

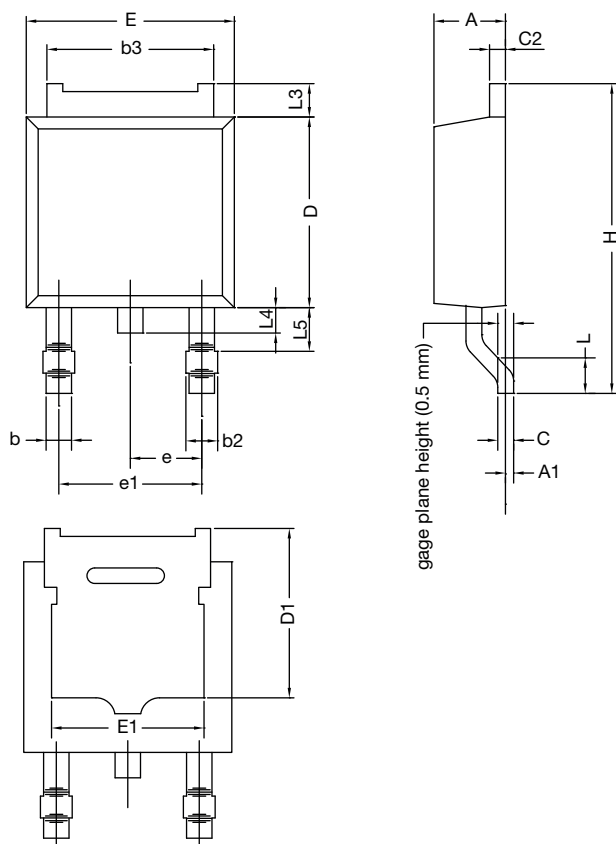
**Peak Diode Recovery dV/dt Test Circuit**



\*  $V_{GS} = 5 V$  for logic level devices

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

## TO-252AA CASE OUTLINE



| DIM.   | MILLIMETERS |       | INCHES    |       |
|--|-------------|-------|-----------|-------|
|  | MIN.        | MAX.  | MIN.      | MAX.  |
| A  | 2.18        | 2.38  | 0.086     | 0.094 |
| A1   | -           | 0.127 | -         | 0.005 |
| b  | 0.64        | 0.88  | 0.025     | 0.035 |
| b2   | 0.76        | 1.14  | 0.030     | 0.045 |
| b3   | 4.95        | 5.46  | 0.195     | 0.215 |
| C  | 0.46        | 0.61  | 0.018     | 0.024 |
| C2   | 0.46        | 0.89  | 0.018     | 0.035 |
| D  | 5.97        | 6.22  | 0.235     | 0.245 |
| D1   | 5.21        | -     | 0.205     | -     |
| E  | 6.35        | 6.73  | 0.250     | 0.265 |
| E1   | 4.32        | -     | 0.170     | -     |
| H  | 9.40        | 10.41 | 0.370     | 0.410 |
| e  | 2.28 BSC    |       | 0.090 BSC |       |
| e1   | 4.56 BSC    |       | 0.180 BSC |       |
| L  | 1.40        | 1.78  | 0.055     | 0.070 |
| L3   | 0.89        | 1.27  | 0.035     | 0.050 |
| L4   | -           | 1.02  | -         | 0.040 |
| L5   | 1.14        | 1.52  | 0.045     | 0.060 |
| ECN: X12-0247-Rev. M, 24-Dec-12<br>DWG: 5347 |             |       |           |       |

**Note**

- Dimension L3 is for reference only.



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