

## VBN165R07 Datasheet

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

| PRODUCT SUMMARY           |                        |     |
|---------------------------|------------------------|-----|
| $V_{DS}$ (V)              | 650                    |     |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$ | 1.3 |
| $Q_g$ (Max.) (nC)         | 210                    |     |
| $Q_{gs}$ (nC)             | 80                     |     |
| $Q_{gd}$ (nC)             | 110                    |     |
| Configuration             | Single                 |     |

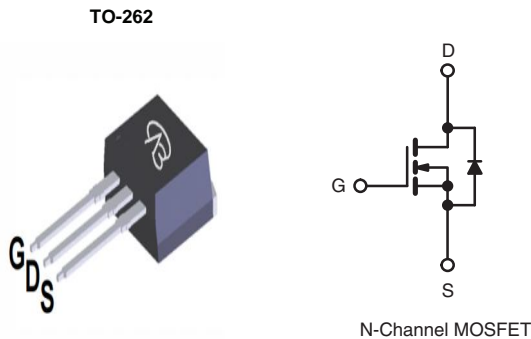
#### FEATURES

- 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
- Low  $R_{DS(on)}$
- Compliant to RoHS Directive 2002/95/EC



#### APPLICATIONS

- Switch Mode Power Supply (SMPS)
- Uninterruptible Power Supply
- High Speed Power Switching
- Hard Switched and High Frequency Circuits




| ABSOLUTE MAXIMUM RATINGS ( $T_C = 25\text{ }^\circ\text{C}$ , unless otherwise noted) |                                  |                                   |                     |   |
|---|----------------------------------|-----------------------------------|---------------------|---|
| PARAMETER   | SYMBOL                           | LIMIT                             | UNIT                |   |
| Drain-Source Voltage  | $V_{DS}$                         | 650                               | V                   |   |
| Gate-Source Voltage   | $V_{GS}$                         | $\pm 30$                          |                     |   |
| Continuous Drain Current  | $V_{GS}$ at 10 V                 | $T_C = 25\text{ }^\circ\text{C}$  | A                   |   |
|   |                                  | $T_C = 100\text{ }^\circ\text{C}$ |                     |   |
| Pulsed Drain Current <sup>a</sup>   | $I_{DM}$                         | 21                                |                     |   |
| Linear Derating Factor  |                                  | 4.3                               | W/ $^\circ\text{C}$ |   |
| Single Pulse Avalanche Energy <sup>b</sup>  | $E_{AS}$                         | 760                               | mJ                  |   |
| Repetitive Avalanche Current <sup>a</sup>   | $I_{AR}$                         | 50                                | A                   |   |
| Repetitive Avalanche Energy <sup>a</sup>  | $E_{AR}$                         | 51                                | mJ                  |   |
| Maximum Power Dissipation   | $T_C = 25\text{ }^\circ\text{C}$ | $P_D$                             | 530                 | W |
| Peak Diode Recovery $dV/dt^c$   | $dV/dt$                          | 9.0                               | V/ns                |   |
| Operating Junction and Storage Temperature Range                                      | $T_J, T_{stg}$                   | - 55 to + 150                     | $^\circ\text{C}$    |   |
| Soldering Recommendations (Peak Temperature)  | for 10 s                         | 300 <sup>d</sup>                  |                     |   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- Starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 0.82\text{ mH}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 47\text{ A}$  (see fig. 12c).
- $I_{SD} \leq 47\text{ A}$ ,  $dI/dt \leq 230\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$ .
- 1.6 mm from case.

| THERMAL RESISTANCE RATINGS          |            |      |      |      |
|-------------------------------------|------------|------|------|------|
| PARAMETER                           | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient         | $R_{thJA}$ | -    | 40   | °C/W |
| Case-to-Sink, Flat, Greased Surface | $R_{thCS}$ | 0.24 | -    |      |
| Maximum Junction-to-Case (Drain)    | $R_{thJC}$ | -    | 0.23 |      |

| 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  | -    | -         | A             |    |
| $V_{DS}$ Temperature Coefficient  | $\Delta V_{DS}/T_J$   | Reference to $25\text{ }^\circ\text{C}, I_D = 1\text{ mA}$   | -  | 0.60 | -         | V/°C          |    |
| Gate-Source Threshold Voltage   | $V_{GS(th)}$          | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$  | 3.0  | -    | 5.0       | V             |    |
| Gate-Source Leakage   | $I_{GSS}$             | $V_{GS} = \pm 30\text{ V}$   | -  | -    | $\pm 100$ | nA            |    |
| Zero Gate Voltage Drain Current   | $I_{DSS}$             | $V_{DS} = 520\text{ V}, V_{GS} = 0\text{ V}$   | -  | -    | 50        | $\mu\text{A}$ |    |
|   |                       | $V_{DS} = 520\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$  | -  | -    | 250       |               |    |
| Drain-Source On-State Resistance  | $R_{DS(on)}$          | $V_{GS} = 10\text{ V}, I_D = 28\text{ A}^b$  | -  | 1.3  | -         | $\Omega$      |    |
| Forward Transconductance  | $g_{fs}$              | $V_{DS} = 50\text{ V}, I_D = 28\text{ A}$  | 23   | -    | -         | S             |    |
| <b>Dynamic</b>  |                       |  |  |      |           |               |    |
| Input Capacitance   | $C_{iss}$             | $V_{GS} = 0\text{ V}, V_{DS} = 25\text{ V}, f = 1.0\text{ MHz}, \text{ see fig. 5}$  | -  | 1400 | -         | pF            |    |
| Output Capacitance  | $C_{oss}$             |  | -  | 960  | -         |               |    |
| Reverse Transfer Capacitance  | $C_{rss}$             |  | -  | 120  | -         |               |    |
| Output Capacitance  | $C_{oss}$             | $V_{GS} = 0\text{ V}$  | $V_{DS} = 1.0\text{ V}, f = 1.0\text{ MHz}$  | -    | 270       | -             |    |
| Effective Output Capacitance  | $C_{oss\text{ eff.}}$ |  | $V_{DS} = 400\text{ V}, f = 1.0\text{ MHz}$  | -    | 240       | -             |    |
| Total Gate Charge   | $Q_g$                 | $V_{GS} = 10\text{ V}$   | $V_{DS} = 0\text{ V to } 400\text{ V}^c$   | -    | 440       | -             |    |
| Gate-Source Charge  | $Q_{gs}$              |  | $I_D = 47\text{ A}, V_{DS} = 400\text{ V}, \text{ see fig. 6 and 13}^b$                    | -    | -         | 350           | nC |
| Gate-Drain Charge   | $Q_{gd}$              |  |  | -    | -         | 85            |    |
| Turn-On Delay Time  | $t_{d(on)}$           | $V_{GS} = 10\text{ V}$   | $V_{DD} = 250\text{ V}, I_D = 47\text{ A}, R_G = 1.0\text{ }\Omega, \text{ see fig. 10}^b$ | -    | 25        | -             |    |
| Rise Time   | $t_r$                 |  |  | -    | 140       | -             |    |
| Turn-Off Delay Time   | $t_{d(off)}$          |  |  | -    | 55        | -             |    |
| Fall Time   | $t_f$                 |  |  | -    | 74        | -             |    |
| <b>Drain-Source Body Diode Characteristics</b>                              |                       |  |  |      |           |               |    |
| Continuous Source-Drain Diode Current                                       | $I_S$                 | MOSFET symbol showing the integral reverse p - n junction diode  | -  | -    | 7         | A             |    |
| Pulsed Diode Forward Current <sup>a</sup>                                   | $I_{SM}$              |  | -  | -    | 21        |               |    |
| Body Diode Voltage  | $V_{SD}$              | $T_J = 25\text{ }^\circ\text{C}, I_S = 47\text{ A}, V_{GS} = 0\text{ V}^b$   | -  | -    | 1.5       | V             |    |
| Body Diode Reverse Recovery Time  | $t_{rr}$              | $T_J = 25\text{ }^\circ\text{C}, I_F = 47\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$  | -  | 35   | 70        | ns            |    |
| Body Diode Reverse Recovery Charge  | $Q_{rr}$              |  | -  | 14   | 21        | $\mu\text{C}$ |    |
| Body Diode Recovery Current   | $I_{RRM}$             |  | -  | 38   | -         | A             |    |
| 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  $\leq 400\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- c.  $C_{oss\text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DS}$ .

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

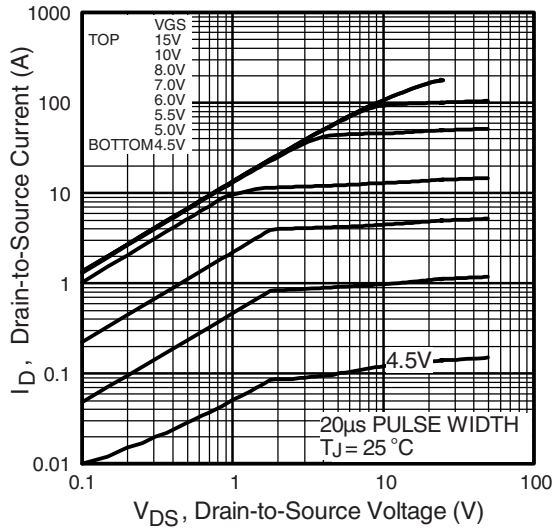


Fig. 1 - Typical Output Characteristics

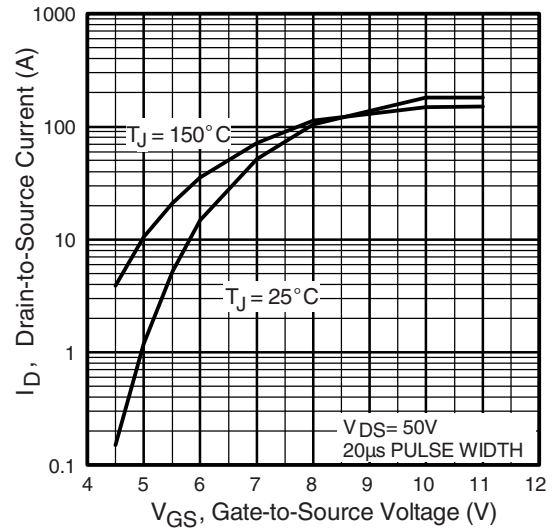


Fig. 3 - Typical Transfer Characteristics

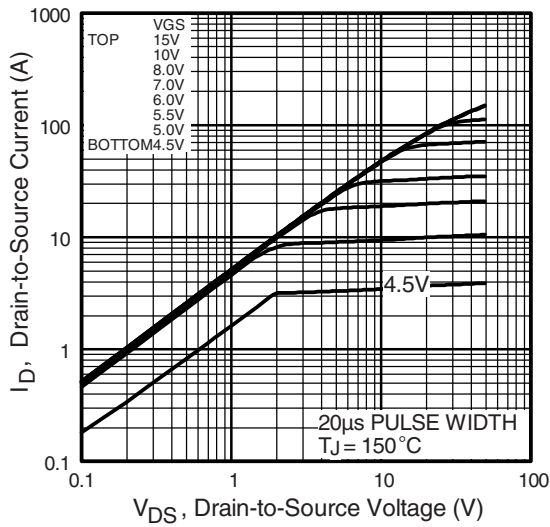


Fig. 2 - Typical Output Characteristics

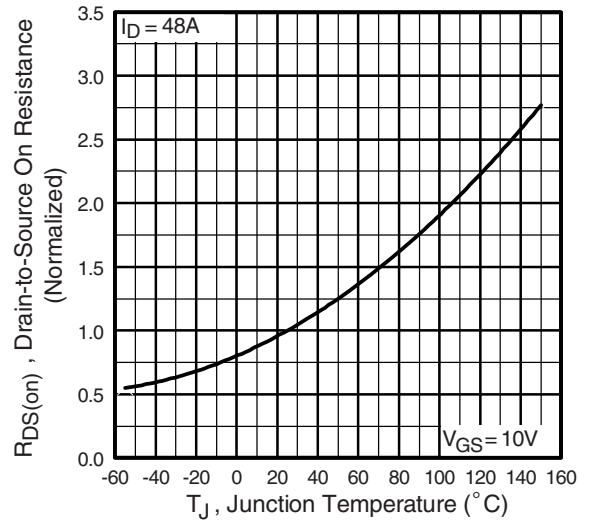


Fig. 4 - Normalized On-Resistance vs. Temperature

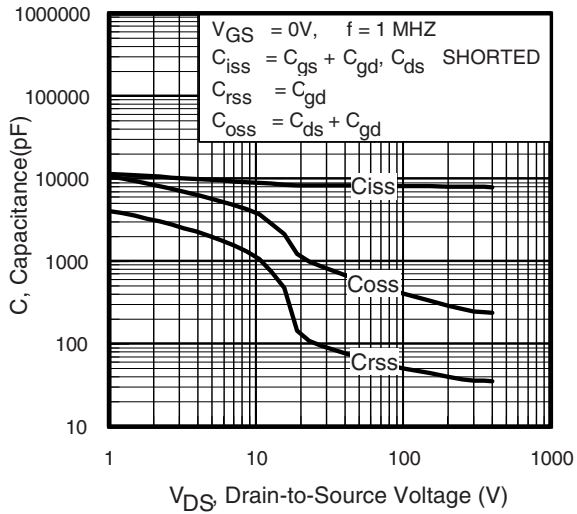


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

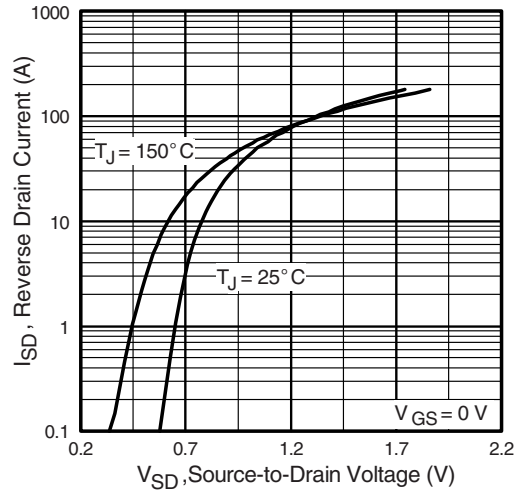


Fig. 7 - Typical Source-Drain Diode Forward Voltage

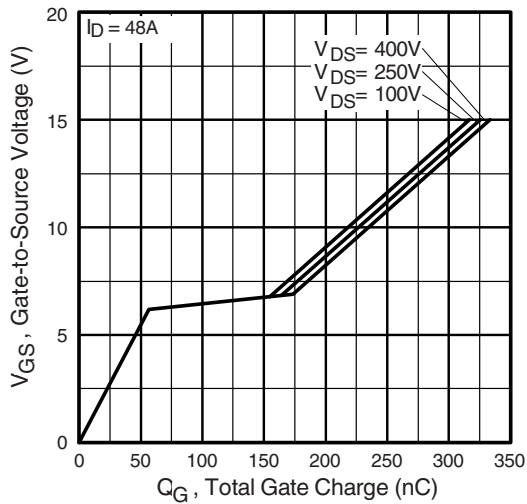


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

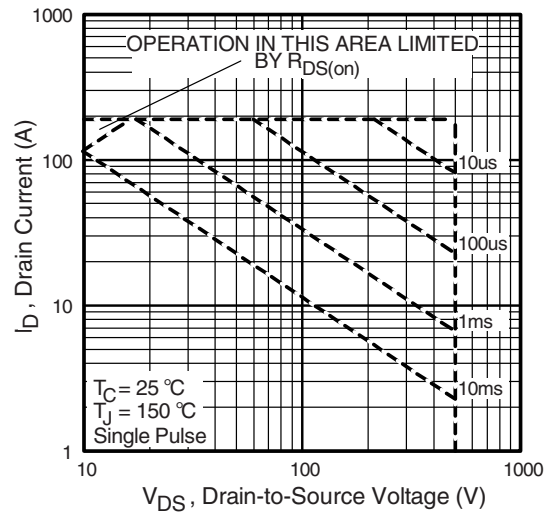


Fig. 8 - Maximum Safe Operating Area

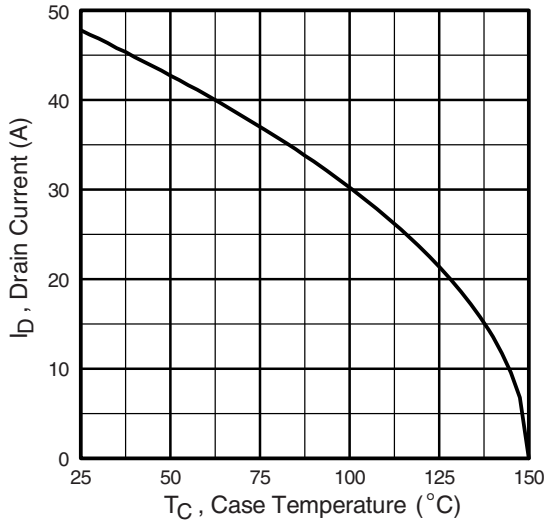


Fig. 9 - Maximum Drain Current vs. Case Temperature

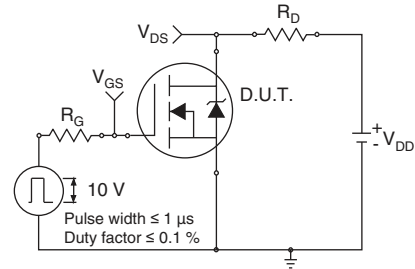


Fig. 10a - Switching Time Test Circuit

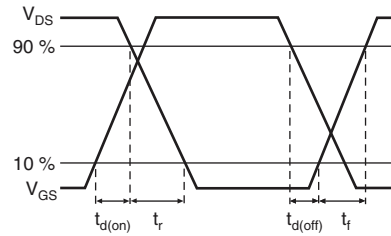


Fig. 10b - Switching Time Waveforms

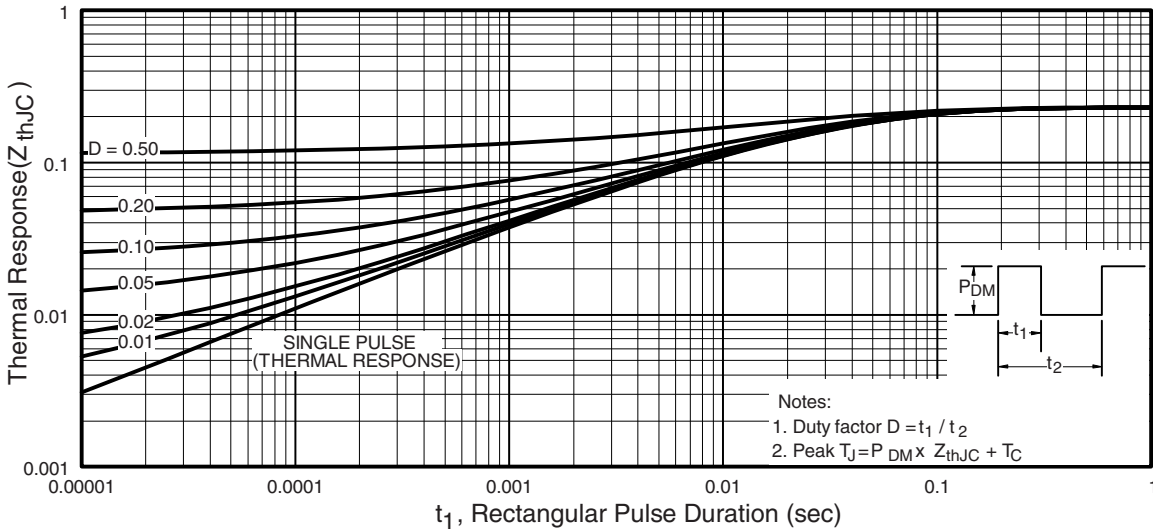


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

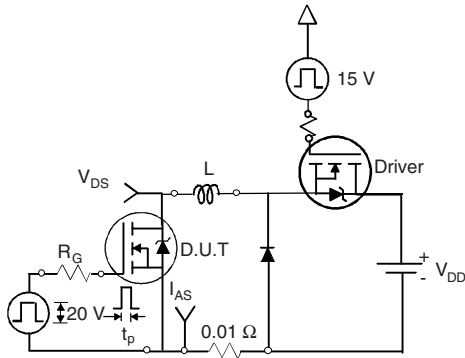


Fig. 12a - Unclamped Inductive Test Circuit

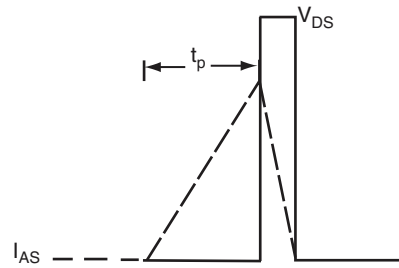


Fig. 12b - Unclamped Inductive Waveforms

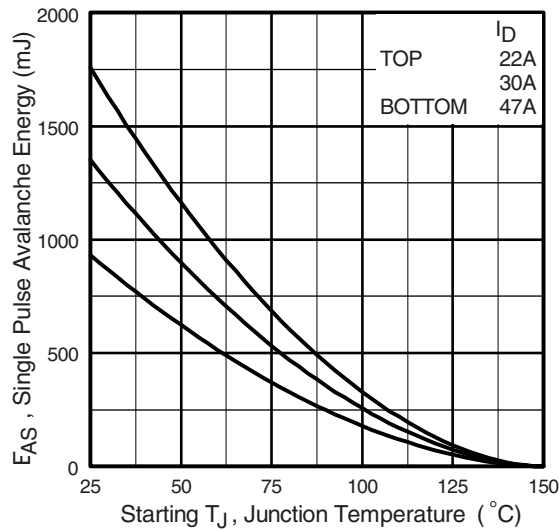


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

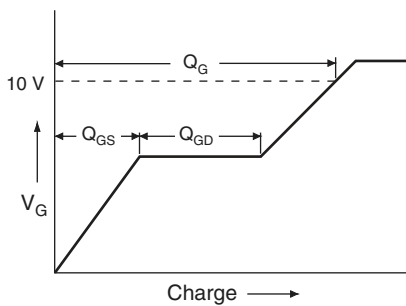


Fig. 13a - Basic Gate Charge Waveform

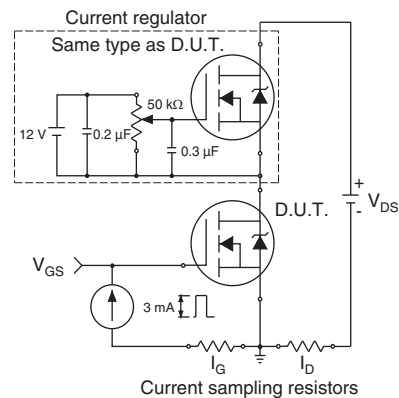
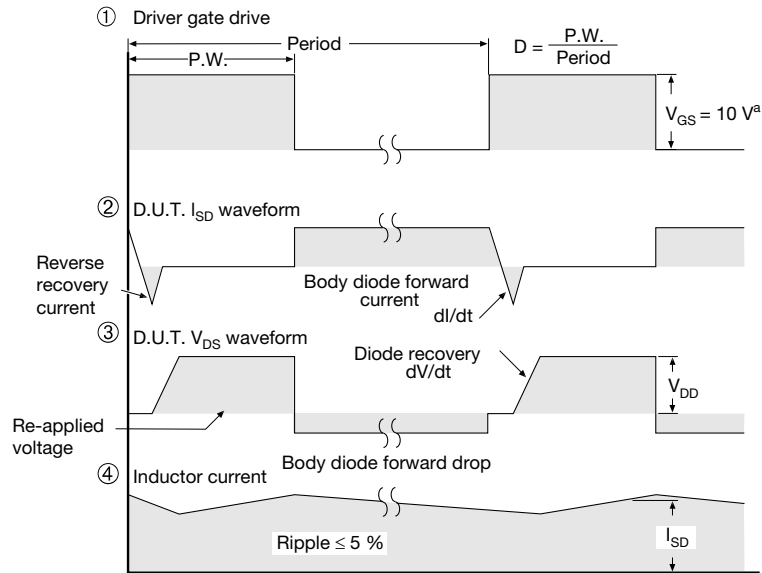
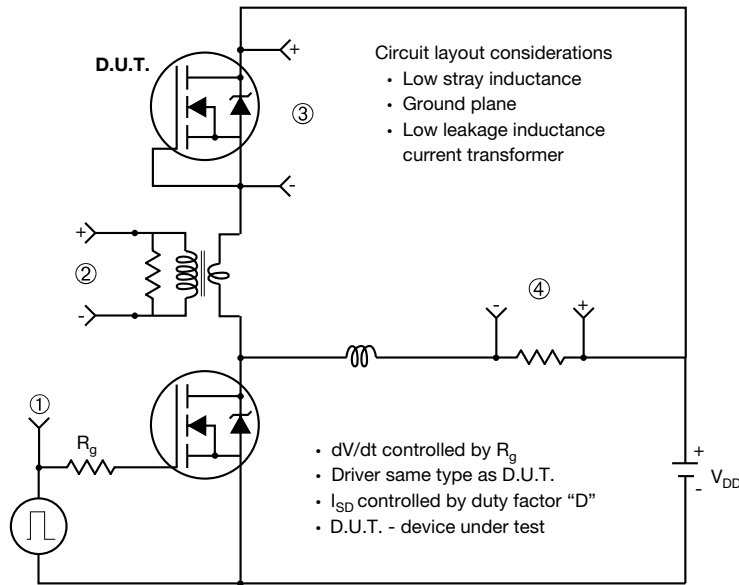


Fig. 13b - Gate Charge Test Circuit

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

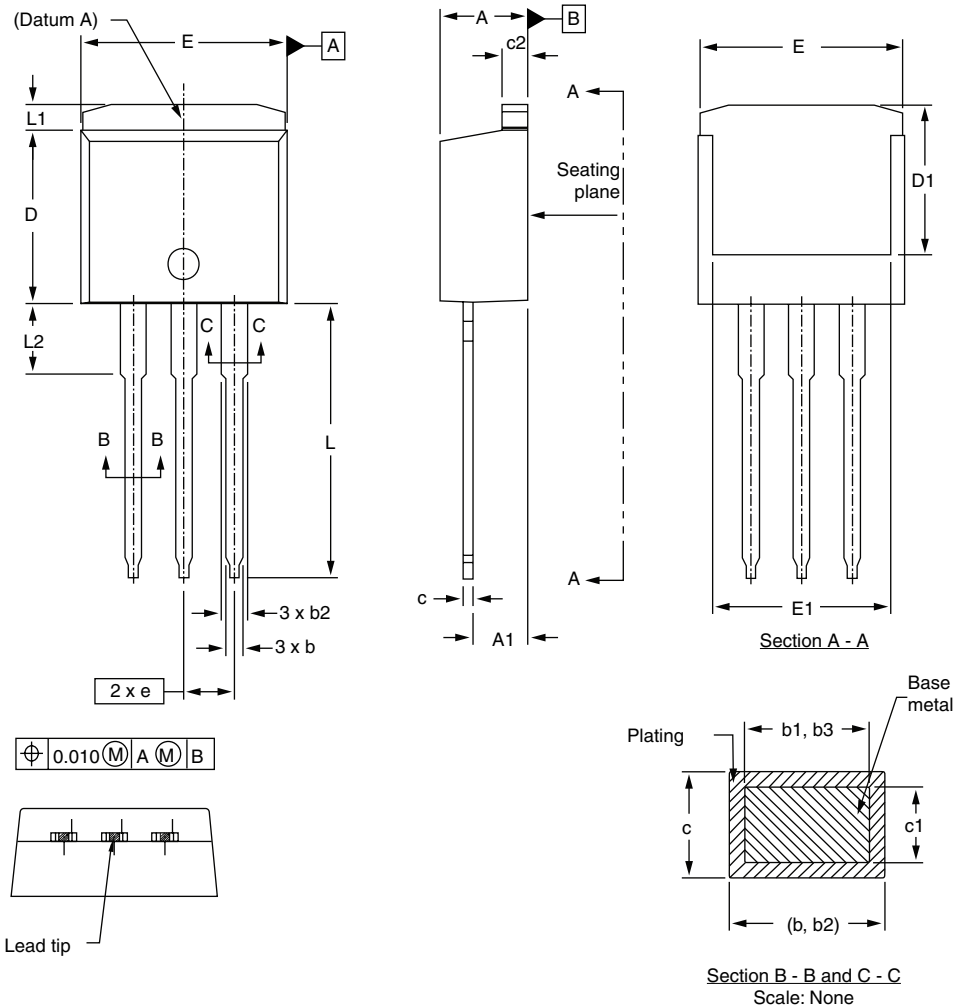


**Note**

a.  $V_{GS} = 5 V$  for logic level devices

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

**I<sup>2</sup>PAK (TO-262)**



| DIM. | MILLIMETERS |      | INCHES |       |
|------|-------------|------|--------|-------|
|      | MIN.        | MAX. | MIN.   | MAX.  |
| A    | 4.06        | 4.83 | 0.160  | 0.190 |
| A1   | 2.03        | 3.02 | 0.080  | 0.119 |
| b    | 0.51        | 0.99 | 0.020  | 0.039 |
| b1   | 0.51        | 0.89 | 0.020  | 0.035 |
| b2   | 1.14        | 1.78 | 0.045  | 0.070 |
| b3   | 1.14        | 1.73 | 0.045  | 0.068 |
| c    | 0.38        | 0.74 | 0.015  | 0.029 |
| c1   | 0.38        | 0.58 | 0.015  | 0.023 |
| c2   | 1.14        | 1.65 | 0.045  | 0.065 |

| DIM. | MILLIMETERS |       | INCHES    |       |
|------|-------------|-------|-----------|-------|
|      | MIN.        | MAX.  | MIN.      | MAX.  |
| D    | 8.38        | 9.65  | 0.330     | 0.380 |
| D1   | 6.86        | -     | 0.270     | -     |
| E    | 9.65        | 10.67 | 0.380     | 0.420 |
| E1   | 6.22        | -     | 0.245     | -     |
| e    | 2.54 BSC    |       | 0.100 BSC |       |
| L    | 13.46       | 14.10 | 0.530     | 0.555 |
| L1   | -           | 1.65  | -         | 0.065 |
| L2   | 3.56        | 3.71  | 0.140     | 0.146 |

**Notes**

1. Dimensioning and tolerancing per ASME Y14.5M-1994.
2. Dimension D and E do not include mold flash. Mold flash shall not exceed 0.127 mm per side. These dimensions are measured at the outmost extremes of the plastic body.
3. Thermal pad contour optional within dimension E, L1, D1, and E1.
4. Dimension b1 and c1 apply to base metal only.



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