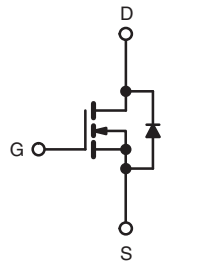
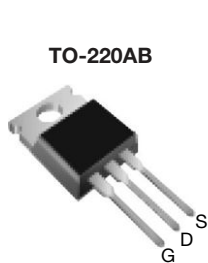


## Power MOSFET

| PRODUCT SUMMARY           |                        |      |
|---------------------------|------------------------|------|
| $V_{DS}$ (V)              | 650                    |      |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$ | 0.93 |
| $Q_g$ (Max.) (nC)         | 48                     |      |
| $Q_{gs}$ (nC)             | 12                     |      |
| $Q_{gd}$ (nC)             | 19                     |      |
| Configuration             | Single                 |      |



N-Channel MOSFET

### 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


**RoHS\***  
COMPLIANT

### APPLICATIONS

- Switch Mode Power Supply (SMPS)
- Uninterruptible Power Supply
- High Speed Power Switching

### TYPICAL SMPS TOPOLOGIES

- Single Transistor Flyback
- Single Transistor Forward

| ORDERING INFORMATION |               |
|----------------------|---------------|
| Package              | TO-220AB      |
| Lead (Pb)-free       | IRFB9N65APbF  |
|                      | SiHFB9N65A-E3 |
| SnPb                 | IRFB9N65A     |
|                      | SiHFB9N65A    |


| 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  |                                  | 1.3                               | W/ $^\circ\text{C}$ |   |
| Single Pulse Avalanche Energy <sup>b</sup>  | $E_{AS}$                         | 325                               | mJ                  |   |
| Repetitive Avalanche Current <sup>a</sup>   | $I_{AR}$                         | 5.2                               | A                   |   |
| Repetitive Avalanche Energy <sup>a</sup>  | $E_{AR}$                         | 16                                | mJ                  |   |
| Maximum Power Dissipation   | $T_C = 25\text{ }^\circ\text{C}$ | $P_D$                             | 167                 | W |
| Peak Diode Recovery $dV/dt^c$   | $dV/dt$                          | 2.8                               | 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>                  |                     |   |
| Mounting Torque   | 6-32 or M3 screw                 | 10                                |                     |   |
|   |                                  | 1.1                               |                     |   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- Starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 24\text{ mH}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 5.2\text{ A}$  (see fig. 12).
- $I_{SD} \leq 5.2\text{ A}$ ,  $dI/dt \leq 90\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$ .
- 1.6 mm from case.

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

| THERMAL RESISTANCE RATINGS          |            |      |      |      |
|-------------------------------------|------------|------|------|------|
| PARAMETER                           | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient         | $R_{thJA}$ | -    | 62   | °C/W |
| Case-to-Sink, Flat, Greased Surface | $R_{thCS}$ | 0.50 | -    |      |
| Maximum Junction-to-Case (Drain)    | $R_{thJC}$ | -    | 0.75 |      |

| 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  | $R_{DS(on)}$          | $V_{GS} = 10\text{ V}$   | $I_D = 5.1\text{ A}^b$  | -    | -    | 0.93      | $\Omega$      |
| Forward Transconductance  | $g_{fs}$              | $V_{DS} = 50\text{ V}, I_D = 3.1\text{ A}$   |   | 3.9  | -    | -         | S             |
| <b>Dynamic</b>  |                       |  |   |      |      |           |               |
| Input Capacitance   | $C_{iss}$             | $V_{GS} = 0\text{ V},$<br>$V_{DS} = 25\text{ V},$<br>$f = 1.0\text{ MHz}$ , see fig. 5   |   | -    | 1417 | -         | pF            |
| Output Capacitance  | $C_{oss}$             |  |   | -    | 177  | -         |               |
| Reverse Transfer Capacitance  | $C_{rss}$             |  |   | -    | 7.0  | -         |               |
| Output Capacitance  | $C_{oss}$             | $V_{GS} = 0\text{ V}$  | $V_{DS} = 1.0\text{ V}, f = 1.0\text{ MHz}$                                   | -    | 1912 | -         | 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   | $Q_g$                 | $V_{GS} = 10\text{ V}$   | $I_D = 5.2\text{ A}, V_{DS} = 400\text{ V}$<br>see fig. 6 and 13 <sup>b</sup> | -    | -    | 48        | nC            |
| Gate-Source Charge  | $Q_{gs}$              |  |   | -    | -    | 12        |               |
| Gate-Drain Charge   | $Q_{gd}$              |  |   | -    | -    | 19        |               |
| Turn-On Delay Time  | $t_{d(on)}$           | $V_{DD} = 325\text{ V}, I_D = 5.2\text{ A}$<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  |   | -    | -    | 5.2       | A             |
| Pulsed Diode Forward Current <sup>a</sup>                                   | $I_{SM}$              |  |   | -    | -    | 21        |               |
| Body Diode Voltage  | $V_{SD}$              | $T_J = 25\text{ }^\circ\text{C}, I_S = 5.2\text{ A}, V_{GS} = 0\text{ V}^b$  |   | -    | -    | 1.5       | V             |
| Body Diode Reverse Recovery Time  | $t_{rr}$              | $T_J = 25\text{ }^\circ\text{C}, I_F = 5.2\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}^b$   |   | -    | 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 %  $V_{DS}$ .
- Uses SiHFIB5N65A data and test conditions.

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

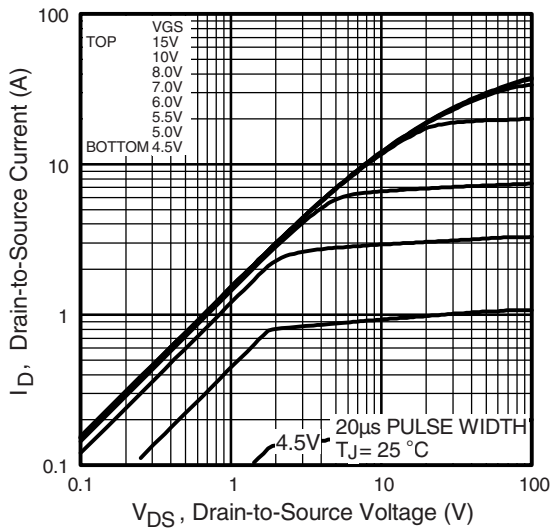


Fig. 1 - Typical Output Characteristics

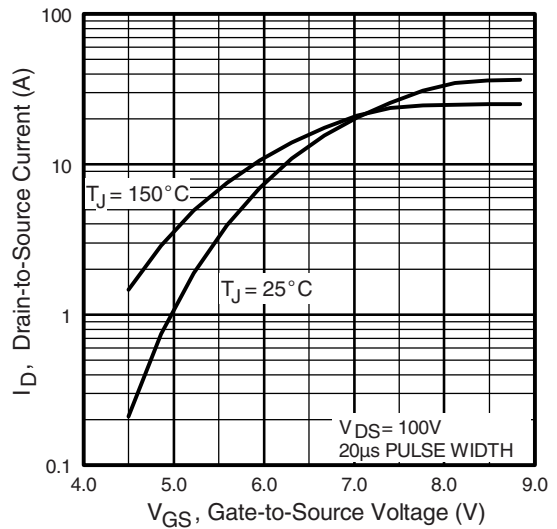


Fig. 3 - Typical Transfer Characteristics

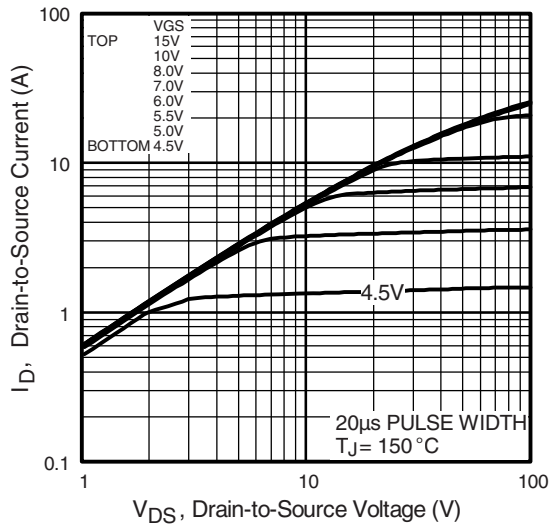


Fig. 2 - Typical Output Characteristics

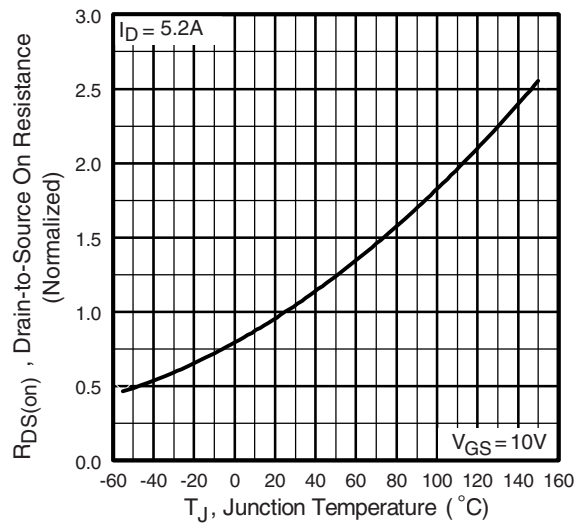


Fig. 4 - Normalized On-Resistance vs. Temperature

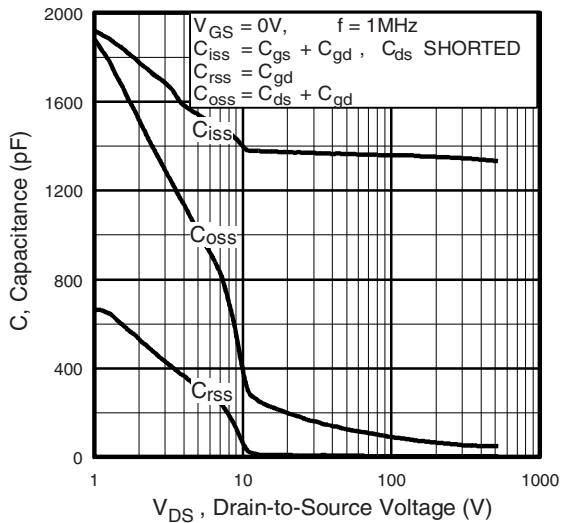


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

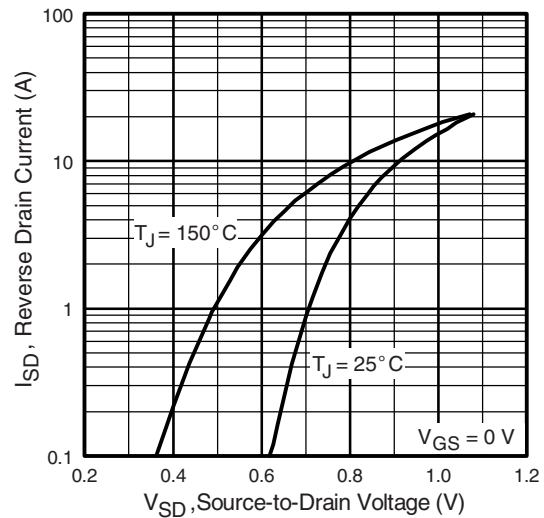


Fig. 7 - Typical Source-Drain Diode Forward Voltage

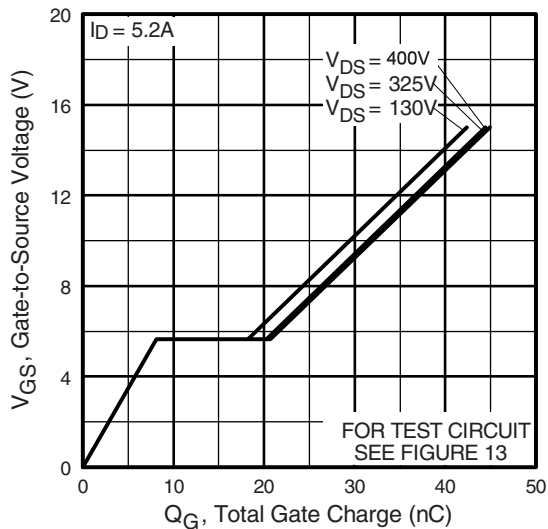


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

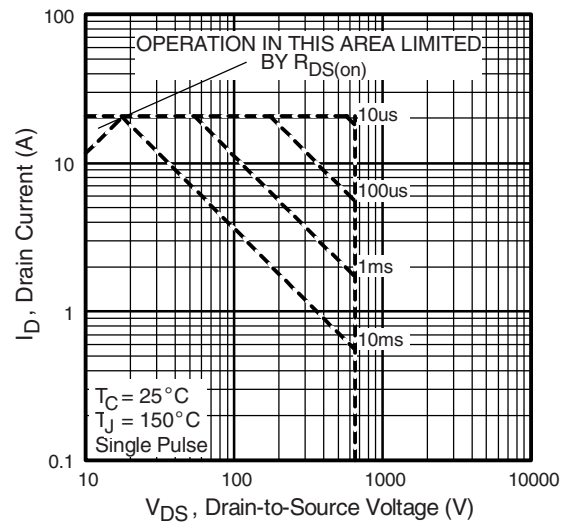


Fig. 8 - Maximum Safe Operating Area

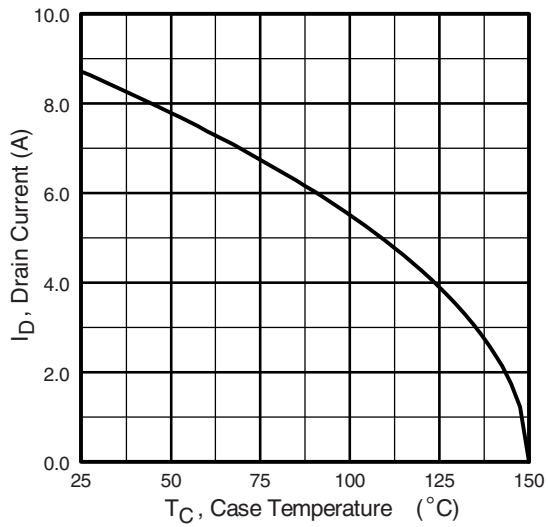


Fig. 9 - Maximum Drain Current vs. Case Temperature

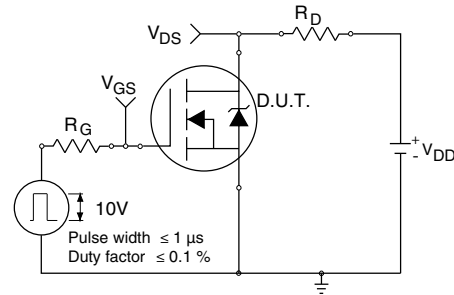


Fig. 10a - Switching Time Test Circuit

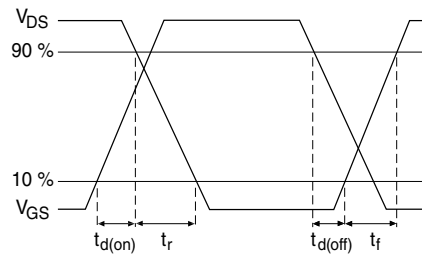


Fig. 10b - Switching Time Waveforms

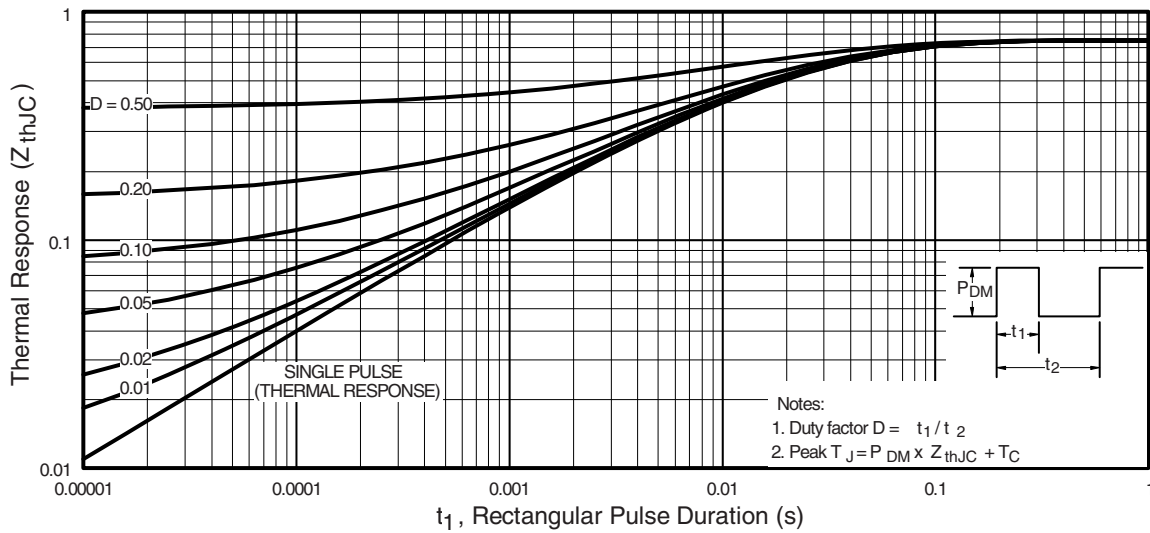
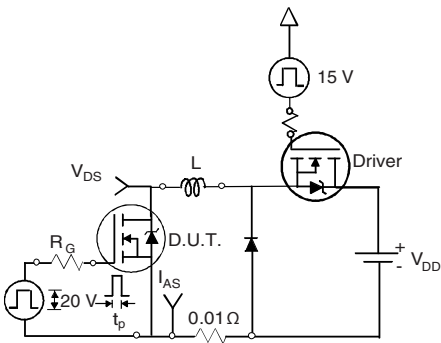
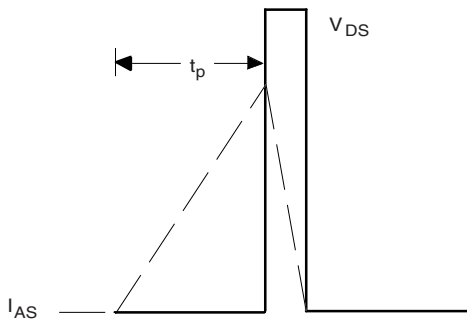


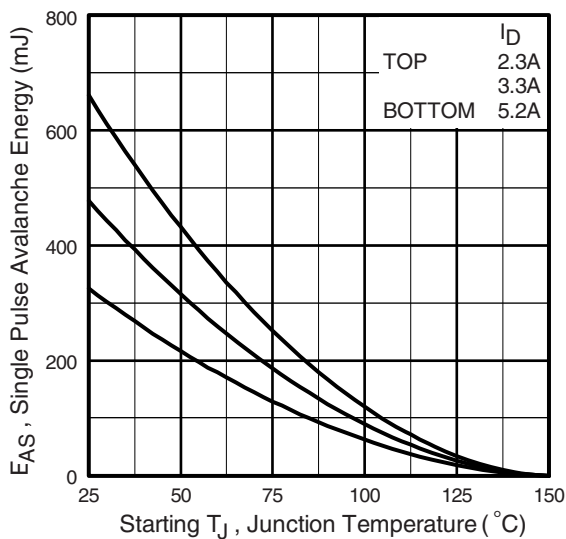
Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case



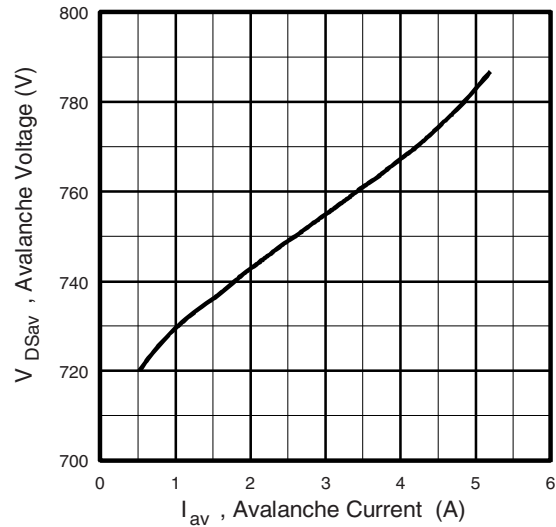
**Fig. 12a - Unclamped Inductive Test Circuit**



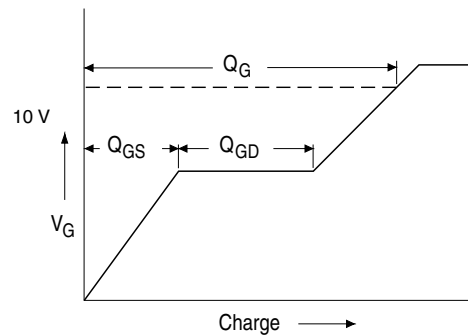
**Fig. 12b - Unclamped Inductive Waveforms**



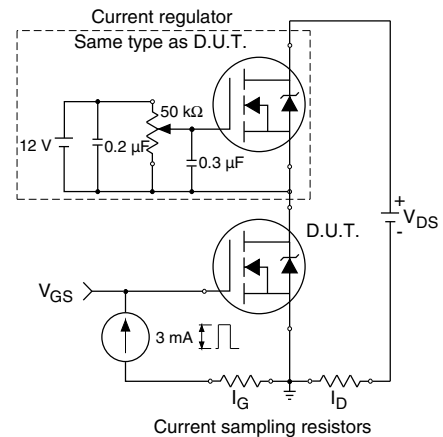
**Fig. 12c - Maximum Avalanche Energy vs. Drain Current**



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

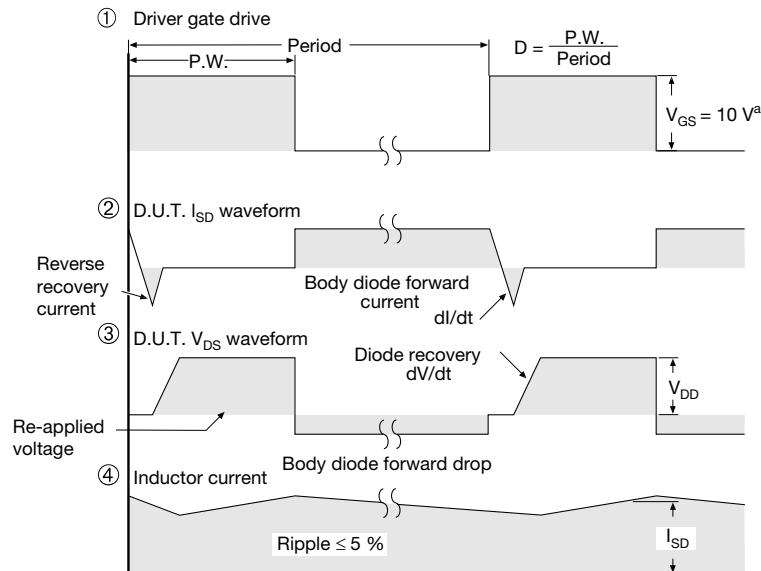
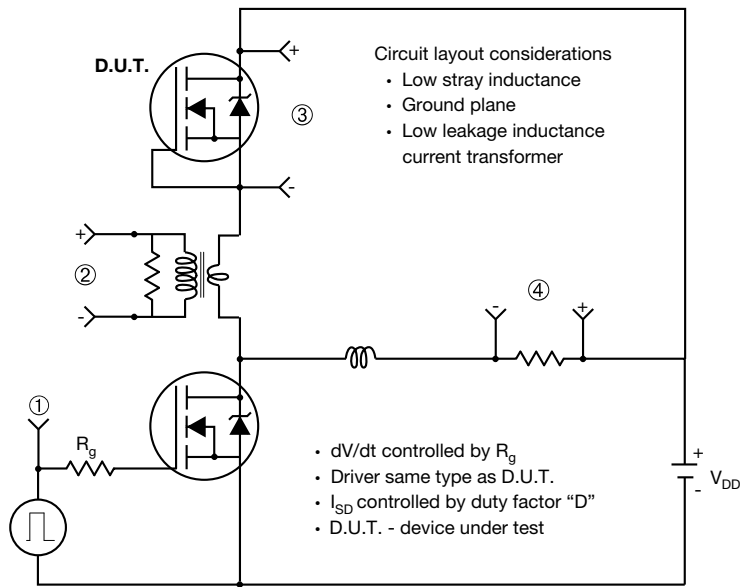


**Fig. 13a - Basic Gate Charge Waveform**



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

### Peak Diode Recovery dV/dt Test Circuit



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

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

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## TO-220AB



| DIM. | MILLIMETERS |       | INCHES |       |
|------|-------------|-------|--------|-------|
|      | MIN.        | MAX.  | MIN.   | MAX.  |
| A    | 4.25        | 4.65  | 0.167  | 0.183 |
| b    | 0.69        | 1.01  | 0.027  | 0.040 |
| b(1) | 1.20        | 1.73  | 0.047  | 0.068 |
| c    | 0.36        | 0.61  | 0.014  | 0.024 |
| D    | 14.85       | 15.49 | 0.585  | 0.610 |
| E    | 10.04       | 10.51 | 0.395  | 0.414 |
| e    | 2.41        | 2.67  | 0.095  | 0.105 |
| e(1) | 4.88        | 5.28  | 0.192  | 0.208 |
| F    | 1.14        | 1.40  | 0.045  | 0.055 |
| H(1) | 6.09        | 6.48  | 0.240  | 0.255 |
| J(1) | 2.41        | 2.92  | 0.095  | 0.115 |
| L    | 13.35       | 14.02 | 0.526  | 0.552 |
| L(1) | 3.32        | 3.82  | 0.131  | 0.150 |
| Ø P  | 3.54        | 3.94  | 0.139  | 0.155 |
| Q    | 2.60        | 3.00  | 0.102  | 0.118 |

ECN: X10-0416-Rev. M, 01-Nov-10  
DWG: 5471

**Note**

\* M = 1.32 mm to 1.62 mm (dimension including protrusion)  
Heatsink hole for HVM





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