

## Power MOSFET



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
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


 Available  
**RoHS\***  
 Available

### APPLICATIONS

- Switch mode power supply (SMPS)
- Uninterruptible power supply
- High speed power switching

### APPLICABLE OFF LINE SMPS TOPOLOGIES

- Active clamped forward
- Main switch

| PRODUCT SUMMARY           |                             |
|---------------------------|-----------------------------|
| $V_{DS}$ (V)              | 600                         |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$ 0.75 |
| $Q_g$ max. (nC)           | 49                          |
| $Q_{gs}$ (nC)             | 13                          |
| $Q_{gd}$ (nC)             | 20                          |
| Configuration             | Single                      |


| ORDERING INFORMATION            |                  |
|---------------------------------|------------------|
| Package                         | TO-220AB         |
| Lead (Pb)-free                  | IRFB9N60APbF     |
| Lead (Pb)-free and halogen-free | IRFB9N60APbF-BE3 |

| ABSOLUTE MAXIMUM RATINGS ( $T_C = 25\text{ }^\circ\text{C}$ , unless otherwise noted) |                                  |                |                                   |                     |          |
|---|----------------------------------|----------------|-----------------------------------|---------------------|----------|
| PARAMETER   |                                  | SYMBOL         | LIMIT                             | UNIT                |          |
| Drain-source voltage  |                                  | $V_{DS}$       | 600                               | V                   |          |
| Gate-source voltage   |                                  | $V_{GS}$       | $\pm 30$                          |                     |          |
| Continuous drain current  | $V_{GS}$ at 10 V                 | $I_D$          | $T_C = 25\text{ }^\circ\text{C}$  | 9.2                 | A        |
|   |                                  |                | $T_C = 100\text{ }^\circ\text{C}$ | 5.8                 |          |
| Pulsed drain current <sup>a</sup>   |                                  | $I_{DM}$       | 37                                |                     |          |
| Linear derating factor  |                                  |                | 1.3                               | W/ $^\circ\text{C}$ |          |
| Single pulse avalanche energy <sup>b</sup>  |                                  | $E_{AS}$       | 290                               | mJ                  |          |
| Repetitive avalanche current <sup>a</sup>   |                                  | $I_{AR}$       | 9.2                               | A                   |          |
| Repetitive avalanche energy <sup>a</sup>  |                                  | $E_{AR}$       | 17                                | mJ                  |          |
| Maximum power dissipation   | $T_C = 25\text{ }^\circ\text{C}$ | $P_D$          | 170                               | W                   |          |
| Peak diode recovery $dV/dt$ <sup>c</sup>  |                                  | $dV/dt$        | 5.0                               | V/ns                |          |
| Operating junction and storage temperature range                                      |                                  | $T_J, T_{stg}$ | -55 to +150                       | $^\circ\text{C}$    |          |
| Soldering recommendations (peak temperature) <sup>d</sup>                             | For 10 s                         |                | 300                               |                     |          |
| Mounting torque   | 6-32 or M3 screw                 |                | 10                                |                     | lbf · in |
|   |                                  |                | 1.1                               | N · m               |          |

### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- Starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 6.8\text{ mH}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 9.2\text{ A}$  (see fig. 12)
- $I_{SD} \leq 9.2\text{ A}$ ,  $dI/dt \leq 50\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$
- 1.6 mm from case

| THERMAL RESISTANCE RATINGS          |            |      |      |      |
|-------------------------------------|------------|------|------|------|
| PARAMETER                           | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum junction-to-ambient         | $R_{thJA}$ | -    | 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  | $V_{DS}$              | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$   |   | 600  | -    | -         | V             |
| $V_{DS}$ temperature coefficient  | $\Delta V_{DS}/T_J$   | Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$   |   | -    | 660  | -         | 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   | $I_{DSS}$             | $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}$  |   | -    | -    | 25        | $\mu\text{A}$ |
|   |                       | $V_{DS} = 480\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$   |   | -    | -    | 250       |               |
| Drain-source on-state resistance  | $R_{DS(on)}$          | $V_{GS} = 10\text{ V}$  | $I_D = 5.5\text{ A}^b$  | -    | -    | 0.75      | $\Omega$      |
| Forward transconductance  | $g_{fs}$              | $V_{DS} = 50\text{ V}, I_D = 5.5\text{ A}$  |   | 5.5  | -    | -         | 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  |   | -    | 1400 | -         | pF            |
| Output capacitance  | $C_{oss}$             |   |   | -    | 180  | -         |               |
| Reverse transfer capacitance  | $C_{rss}$             |   |   | -    | 7.1  | -         |               |
| Output capacitance  | $C_{oss}$             | $V_{GS} = 0\text{ V}$   | $V_{DS} = 1.0\text{ V}, f = 1.0\text{ MHz}$                                   | -    | 1957 | -         | pF            |
| Effective output capacitance  | $C_{oss\text{ eff.}}$ |   | $V_{DS} = 480\text{ V}, f = 1.0\text{ MHz}$                                   | -    | 49   | -         |               |
| Total gate charge   | $Q_g$                 | $V_{GS} = 10\text{ V}$  | $I_D = 9.2\text{ A}, V_{DS} = 400\text{ V}$<br>see fig. 6 and 13 <sup>b</sup> | -    | -    | 49        | nC            |
| Gate-source charge  | $Q_{gs}$              |   |   | -    | -    | 13        |               |
| Gate-drain charge   | $Q_{gd}$              |   |   | -    | -    | 20        |               |
| Turn-on delay time  | $t_{d(on)}$           | $V_{DD} = 300\text{ V}, I_D = 9.2\text{ A}$<br>$R_g = 9.1\text{ }\Omega, R_D = 35.5\text{ }\Omega$ , see fig. 10 <sup>b</sup>                       |   | -    | 13   | -         | ns            |
| Rise time   | $t_r$                 |   |   | -    | 25   | -         |               |
| Turn-off delay time   | $t_{d(off)}$          |   |   | -    | 30   | -         |               |
| Fall time   | $t_f$                 |   |   | -    | 22   | -         |               |
| Gate input resistance   | $R_g$                 | $f = 1\text{ MHz}$ , open drain   |   | 0.5  | -    | 3.2       | $\Omega$      |
| <b>Drain-Source Body Diode Characteristics</b>                              |                       |   |   |      |      |           |               |
| Continuous source-drain diode current                                       | $I_S$                 | MOSFET symbol showing the integral reverse p-n junction diode  |   | -    | -    | 9.2       | A             |
| Pulsed diode forward current <sup>a</sup>                                   | $I_{SM}$              |   |   | -    | -    | 37        |               |
| Body diode voltage  | $V_{SD}$              | $T_J = 25\text{ }^\circ\text{C}, I_S = 9.2\text{ A}, V_{GS} = 0\text{ V}^b$   |   | -    | -    | 1.5       | V             |
| Body diode reverse recovery time  | $t_{rr}$              | $T_J = 25\text{ }^\circ\text{C}, I_F = 9.2\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}^b$  |   | -    | 530  | 800       | ns            |
| Body diode reverse recovery charge  | $Q_{rr}$              |   |   | -    | 3.0  | 4.4       | $\mu\text{C}$ |
| 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  $\leq 2\%$
- $C_{oss}$  effective 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)

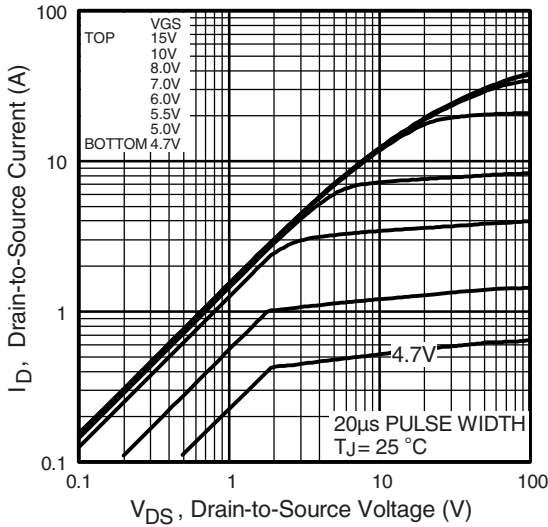


Fig. 1 - Typical Output Characteristics

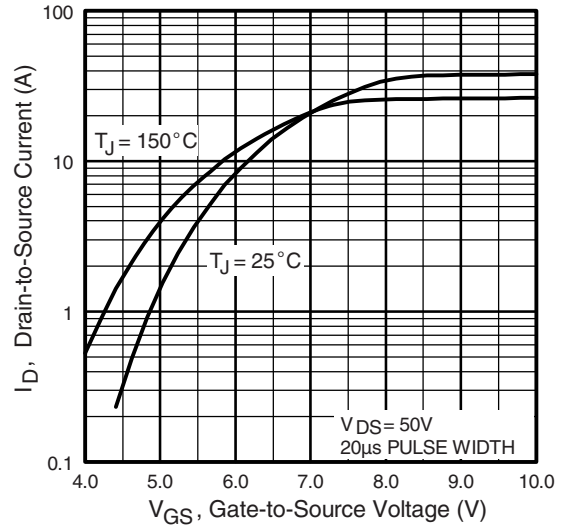


Fig. 3 - Typical Transfer Characteristics

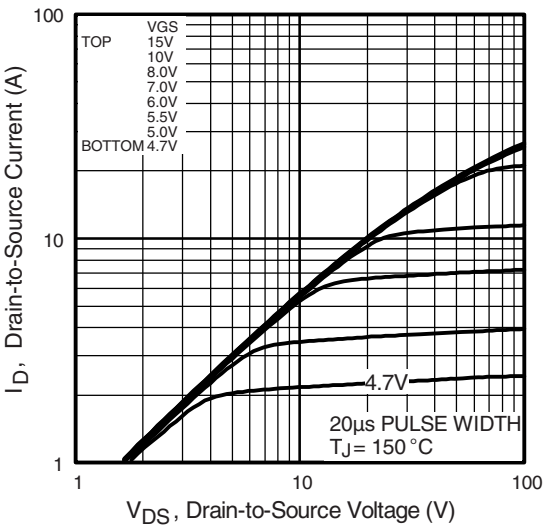


Fig. 2 - Typical Output Characteristics

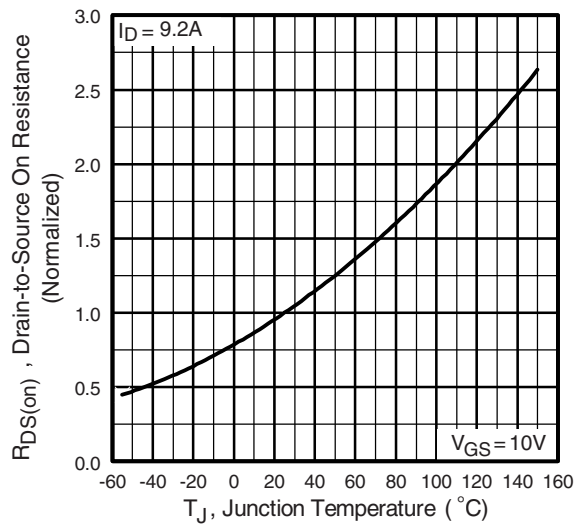


Fig. 4 - Normalized On-Resistance vs. Temperature

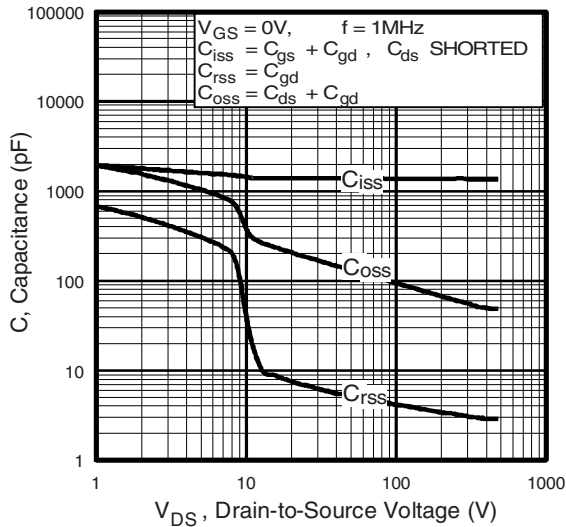


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

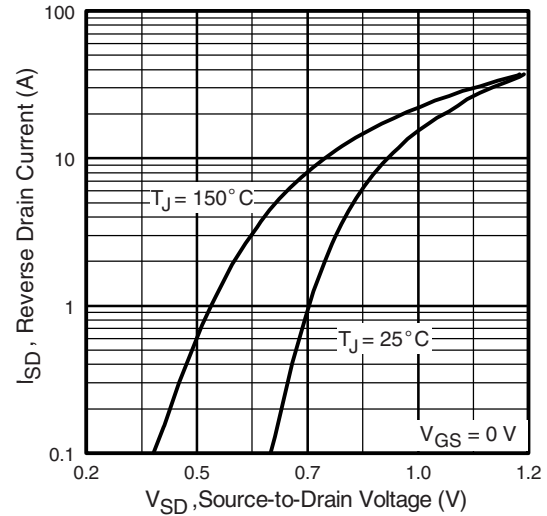


Fig. 7 - Typical Source-Drain Diode Forward Voltage

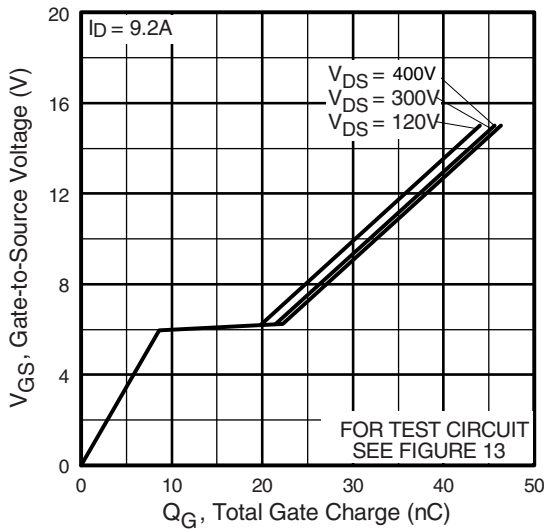


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

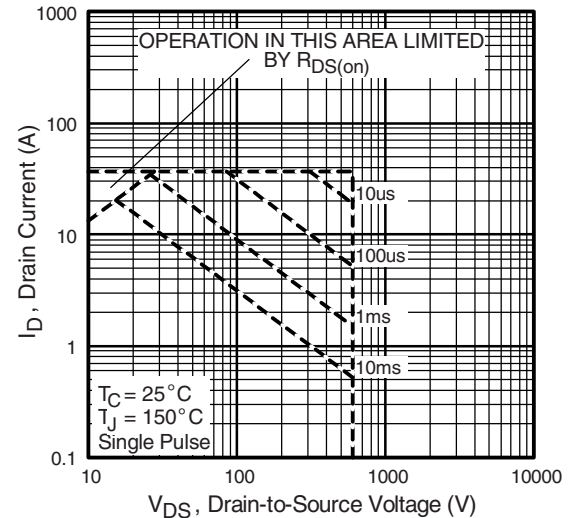


Fig. 8 - Maximum Safe Operating Area

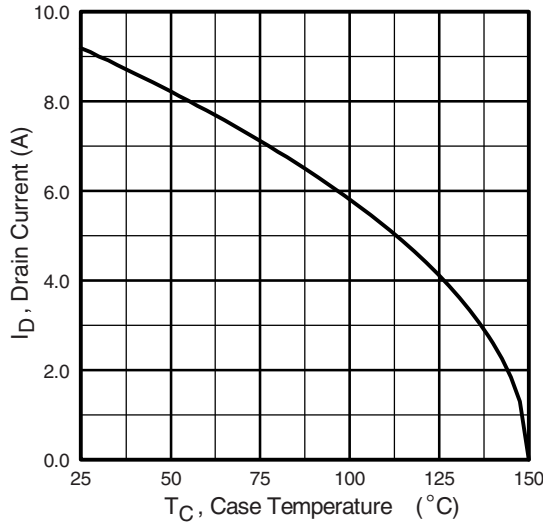


Fig. 9 - Maximum Drain Current vs. Case Temperature

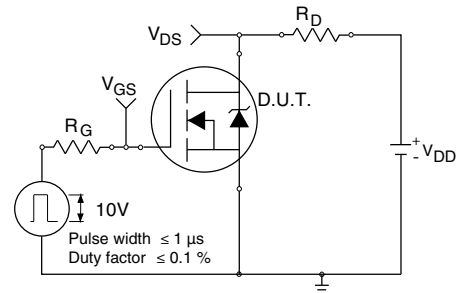


Fig. 10a - Switching Time Test Circuit

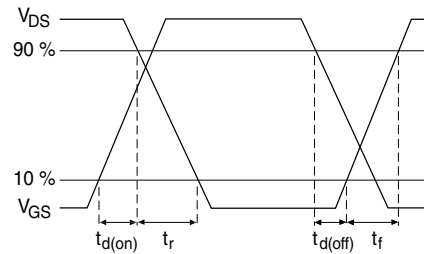


Fig. 10b - Switching Time Waveforms

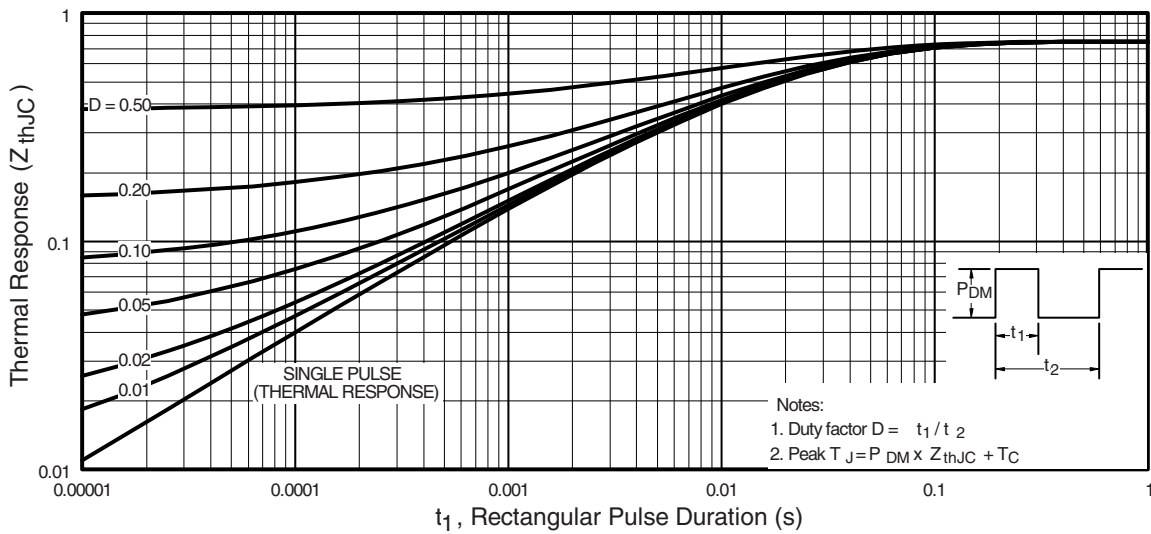


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

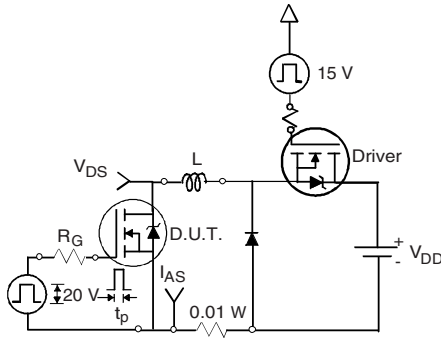


Fig. 12a - Unclamped Inductive Test Circuit

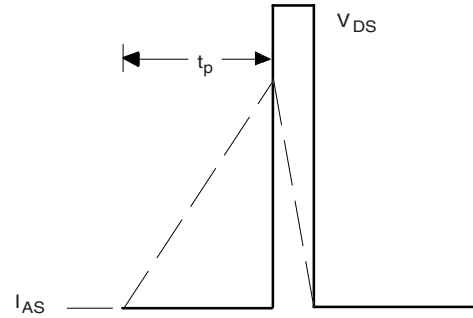


Fig. 12b - Unclamped Inductive Waveforms

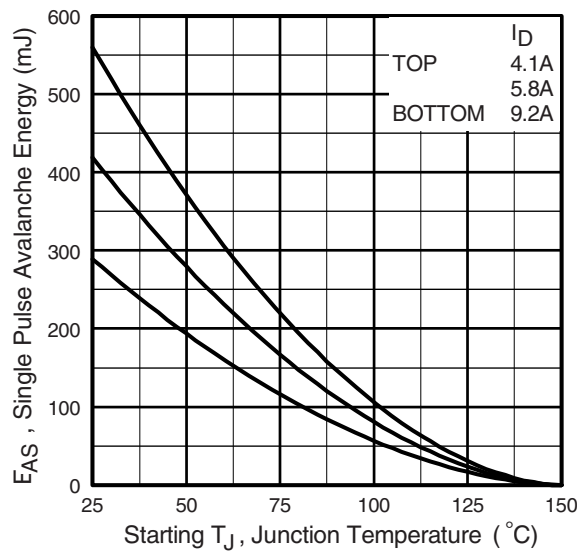


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

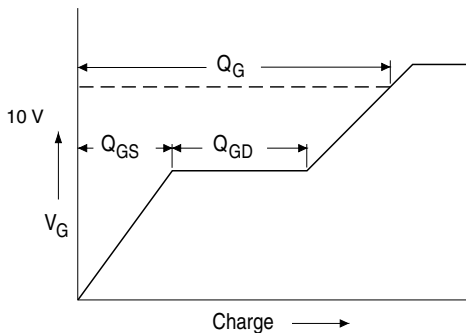


Fig. 13a - Basic Gate Charge Waveform

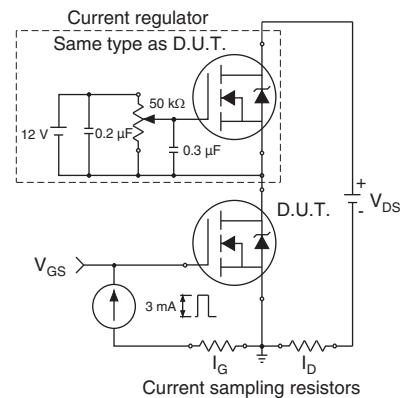
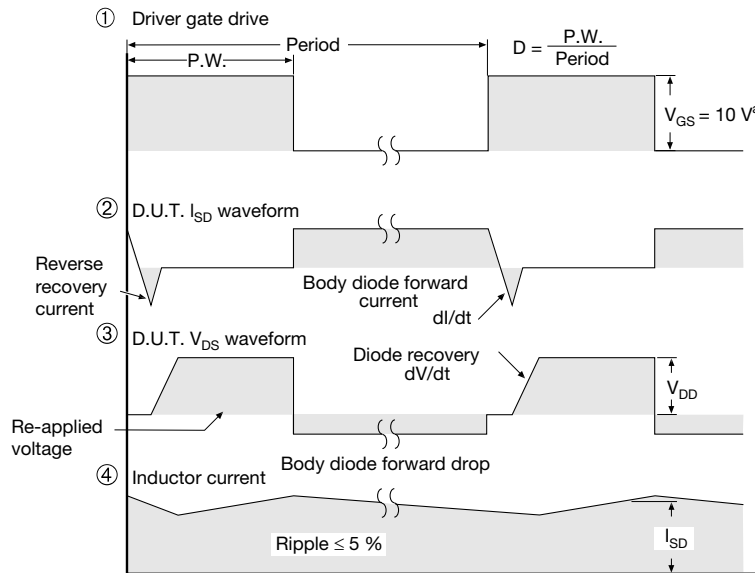
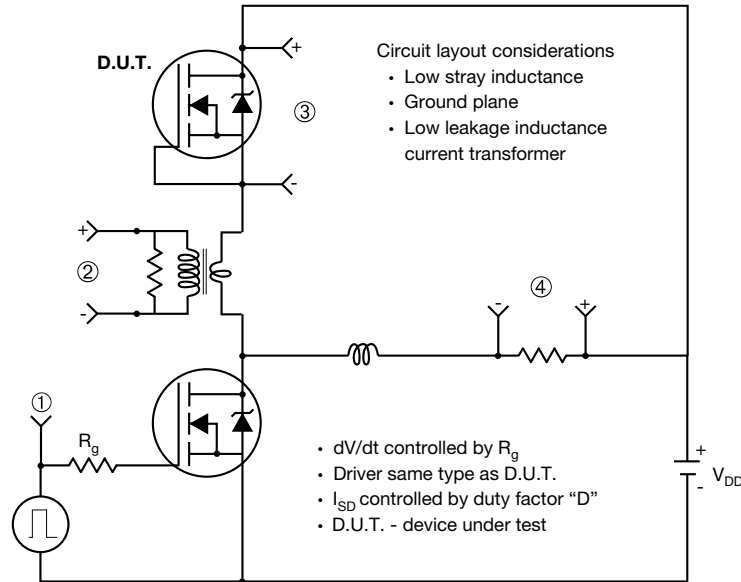


Fig. 13b - Gate Charge Test Circuit

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



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

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

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### TO-220-1



| DIM.            | MILLIMETERS |       | INCHES |       |
|-----------------|-------------|-------|--------|-------|
|                 | MIN.        | MAX.  | MIN.   | MAX.  |
| A               | 4.24        | 4.65  | 0.167  | 0.183 |
| b               | 0.69        | 1.02  | 0.027  | 0.040 |
| b(1)            | 1.14        | 1.78  | 0.045  | 0.070 |
| c               | 0.36        | 0.61  | 0.014  | 0.024 |
| D               | 14.33       | 15.85 | 0.564  | 0.624 |
| E               | 9.96        | 10.52 | 0.392  | 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)            | 6.10        | 6.71  | 0.240  | 0.264 |
| J(1)            | 2.41        | 2.92  | 0.095  | 0.115 |
| L               | 13.36       | 14.40 | 0.526  | 0.567 |
| L(1)            | 3.33        | 4.04  | 0.131  | 0.159 |
| $\varnothing P$ | 3.53        | 3.94  | 0.139  | 0.155 |
| Q               | 2.54        | 3.00  | 0.100  | 0.118 |

ECN: E21-0621-Rev. D, 04-Nov-2021  
DWG: 6031

#### Note

- $M^*$  = 0.052 inches to 0.064 inches (dimension including protrusion), heatsink hole for HVM





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